



## International Commission on Stratigraphy

### ANNUAL REPORT 2023

#### 1. TITLE OF CONSTITUENT BODY

The International Commission on Stratigraphy (ICS)

*Summary and compilation of subcommission reports submitted jointly by:*

Chair: David Harper

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#### 2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY

##### Objectives

The International Commission on Stratigraphy (ICS) is a body of expert stratigraphers founded for the purpose of promoting and coordinating long-term international cooperation and establishing standards in stratigraphy. Its principal objectives are:

- (a) Establishment and publication of a standard global stratigraphic time scale and the preparation and publication of global correlation charts, with explanatory notes.
- (b) Compilation and maintenance of a stratigraphic database centre for the global earth sciences.
- (c) Unification of regional chronostratigraphic nomenclature by organizing and documenting stratigraphic units on a global database.
- (d) Promotion of education in stratigraphic methods, and the dissemination of stratigraphic knowledge.
- (e) Evaluation of new stratigraphic methods and their integration into a multidisciplinary stratigraphy.
- (f) Definition of principles of stratigraphic classification, terminology and procedure and their publication in guides and glossaries.

##### Fit within IUGS Science Policy

The objectives satisfy the IUGS mandates of:

- Fostering international agreement on nomenclature and classification in stratigraphy.
- Facilitating international co-operation in geological research.

- Improving publication, dissemination, and use of geological information internationally.
- Encouraging new relationships between and among disciplines of science that relate to geology worldwide.
- Attracting competent students and research workers to the discipline.
- Fostering an increased awareness among individual scientists worldwide of what related programmes are being undertaken.

In particular, the current objectives of ICS relate to three main aspects of IUGS policy:

- (a) Development of an internationally agreed scale of chronostratigraphic units, fully defined by Global Stratotype Sections and Points (GSSPs) where appropriate and related to a hierarchy of units to maximize resolution throughout geological time.
- (b) Promotion of international consensus on stratigraphic classification and terminology, which is essential for advancement of earth-science research and education.
- (c) Establishment of frameworks and systems to encourage international collaboration in understanding the evolution of the Earth.

### 3. ORGANISATION

ICS is organised in two types of constituent bodies: Subcommissions for longer-term study, and Executive Task Groups (working groups) for more limited, shorter-term tasks. ICS is managed by the Executive Committee, which consists of elected and appointed officers. The current structure of ICS consists of the Executive Committee of three voting and three non-voting members, and 17 Subcommissions that deal with the major chronostratigraphic units and aspects of stratigraphic classification. The ICS Executive has initiated a new Executive ex-officio position of Treasurer and appointed a new webmaster. The webmaster is revising the ICS website and transferring the webpages of the subcommissions to the main ICS site.

Subcommissions:

Quaternary  
 Neogene  
 Paleogene  
 Cretaceous  
 Jurassic  
 Triassic  
 Permian  
 Carboniferous  
 Devonian  
 Silurian  
 Ordovician  
 Cambrian  
 Ediacaran  
 Cryogenian  
 Pre-Cryogenian  
 Stratigraphic Classification  
 Timescale Calibration

- (a) Establishment and publication of a standard global stratigraphic time scale and the preparation and publication of global correlation charts, with explanatory notes.
- (b) Compilation and maintenance of a stratigraphic database centre for the global earth sciences.
- (c) Unification of regional chronostratigraphic nomenclature by organising and documenting stratigraphic units on a global database.
- (d) Promotion of education in stratigraphic methods, and the dissemination of stratigraphic knowledge.

## INTERNATIONAL UNION OF GEOLOGICAL SCIENCES

The reports of each Subcommittee are appended to this ICS summary compilation. The ICS subcommittees together include approximately 350 titular members. When the corresponding members of Subcommittees are added, several thousand stratigraphers worldwide participate in the activities of ICS, and several thousand more over the 60-year history of ICS. In addition, ICS maintains contacts with many national stratigraphic committees. The members of the Full Commission (i.e. the 3 voting members and 3 non-voting members of the Executive, and the chairs of the 17 Subcommittees) represent 12 countries: United Kingdom (5 members), Canada (1), Italy (2), USA (3), China (4), Sweden (1), France (1), Netherlands (1), Spain (1), Austria (1), Australia (1) and Czechia (2). Among all subcommittee officers and the ICS executive, 18 countries are represented: United Kingdom (7 members), Canada (3), USA (7), China (11), Italy (7), Australia (1), Spain (3), Poland (2), Russia (1), Czech Republic (2), France (3), Belgium (1), Germany (3), Brazil (3), Sweden (2), Austria (2) and Norway (1). The voting members of ICS, i.e. all voting members of all subcommittees who replied to our request to report include officers, represent over 42 countries: USA (71), China (38), United Kingdom (25), Ireland (1), Russia (29), Canada (15), Germany (24), Italy (25), Australia (12), Spain (8), France (11), Japan (9), New Zealand (4), Argentina (3), Belgium (8), Netherlands (7), Brazil (10), Poland (10), Czech Republic (5), Denmark (3), Sweden (8), Switzerland (5), United Arab Emirates (1), Hungary (2), India (4), South Africa (3), Austria (4), Slovenia (1), Tunisia (1), Swaziland (1), Estonia (2), Finland (3), Iran (2), Jordan (1), Korea (1), Mexico (1), Croatia (1), Algeria (1), Namibia (1), Greece (1), Turkey (1) and Columbia (1). The ICS subcommittees are continuing the process of reinstalling their websites on the main ICS site (noted previously), and some continue to maintain their own websites; the URLs of the websites are as follows:

Websites:

|                       |  |
|-----------------------|--|
| ICS main site:        | <a href="http://www.stratigraphy.org">www.stratigraphy.org</a>                               |
| Quaternary:           | <a href="http://www.quaternary.stratigraphy.org">www.quaternary.stratigraphy.org</a>         |
| Neogene:              | <a href="http://www.geo.uu.nl/SNS">www.geo.uu.nl/SNS</a>                                     |
| Paleogene:            | <a href="http://wzar.unizar.es/isps/">wzar.unizar.es/isps/</a>                               |
| Cretaceous:           | <a href="http://www.univ-brest.fr/geoscience/?ISCS/">www.univ-brest.fr/geoscience/?ISCS/</a> |
| Jurassic:             | <a href="http://www.jurassic.stratigraphy.org">www.jurassic.stratigraphy.org</a>             |
| Triassic:             | <a href="http://paleo.cortland.edu/sts/">paleo.cortland.edu/sts/</a>                         |
| Permian (newsletter): | <a href="http://www.permian.stratigraphy.org">www.permian.stratigraphy.org</a>               |
| Carboniferous         | <a href="http://www.stratigraphy.org/carboniferous/">www.stratigraphy.org/carboniferous/</a> |
| Devonian:             | <a href="http://www.unica.it/sds/">www.unica.it/sds/</a>                                     |
| Silurian:             | <a href="http://www.silurian.stratigraphy.org">www.silurian.stratigraphy.org</a>             |

|                               |  |
|-------------------------------|--|
| Ordovician:                   | <a href="http://www.ordovician.stratigraphy.org">www.ordovician.stratigraphy.org</a>                                 |
| Cambrian:                     | <a href="http://www.palaeontology.geo.uu.se/ISCS/ISCS_home.html">www.palaeontology.geo.uu.se/ISCS/ISCS_home.html</a> |
| Ediacaran:                    | <a href="http://www.paleo.geos.vt.edu/Ediacaran/">www.paleo.geos.vt.edu/Ediacaran/</a>                               |
| Cryogenian:                   | being established  |
| Precambrian:                  | <a href="http://www.precambrian.stratigraphy.org">www.precambrian.stratigraphy.org</a>                               |
| Stratigraphic Classification: | <a href="http://issc.uni-graz.at/">issc.uni-graz.at/</a>   |
| Timescale calibration         | being established  |

### 3a. ICS Executive Officers for 2020-2024:

Chair: David Harper (Durham, England)

Vice-Chair: Shuzhong Shen (Nanjing, China)

Secretary General: Philip Gibbard (Cambridge, England)

Non-voting officers:

Information Officer: Nicholas Car (Brisbane, Australia)

Graphics Officer: Kim Cohen (Utrecht, Netherlands)

Treasurer: Stuart Jones (Durham, England)

ICS Subcommission officers:

A full listing of current officers (with addresses) is given at the end of this main ICS report. The individual subcommission reports appended include a listing of all voting members (typically *c.* 20 in each subcommission).

## 4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS

Few of the subcommissions have formal financial contributions from external sources other than IUGS (through ICS), and they are very limited and listed in the individual reports. Some activities that are associated with ICS goals, such as distributing charts of the Geological Time Scale and placing this information onto public websites, have received some minimal support from private companies and professional organisations. Informally, every officer and member of ICS donates their own time, office space, institutional facilities, and other components to the activities of the organisation. No officer nor executive receives any salary compensation from IUGS or other ICS funds. Indeed, most officers personally contribute towards their own travel and operational expenses.

## 5. INTERFACES WITH OTHER INTERNATIONAL PROJECTS

Active and highly fruitful interfaces with many international organisations and geo-projects are a standard feature of ICS activities. ICS maintains strong links with the International Quaternary Association (INQUA) Commission on Stratigraphy regarding the stratigraphy of the Quaternary, and with the Commission for the Geological Map of the World (CGMW) in Paris regarding standardisation of chronostratigraphy and its colour scheme on charts, as well as producing the ICS International Chronostratigraphic Chart. In addition, ICS is collaborating with the IUGS Commission on Geoscience Information (CGI) as it develops GeoSciML as an

interchange format for geoscience data. ICS subcommissions are traditionally affiliated with a considerable number of IUGS and IGCP activities. For example, ICS members lead or participate or have participated in numerous, active IGCP projects and others serve on IGCP national committees and the scientific board. ICS members maintains active links with international research groups, including The Micropalaeontology Society (TMS), the North American Micropaleontology Society (NAMS), International Nannoplankton Association (INA) and the Association of American Stratigraphic Palynologists (AASP), and international palaeontological research groups on Graptolites, Conodonts, Brachiopods, Ammonites, Radiolarians (Interrad), Nannofossils, Foraminifers, etc., and many ICS members serve on national stratigraphic commissions and as editors of journals. There are close links between many ICS stratigraphers and the International Ocean Drilling Project (IODP). ODP cores routinely test the global correlation potential of a great number of bio-events since the Jurassic, and this record is vital to develop integrated timescales at several scales of resolution, and global palaeo-climate models. The designation of GSSPs necessitates close interaction with local and international groups concerned with conservation, such as UNESCO (Geoparks Programme), IUGS (Geosites Programme) and ProGEO (Geosites and Geoparks initiatives).

## 6. CHRONOSTRATIGRAPHIC STAGE AND SERIES NAMES AND DEFINITIONS ESTABLISHED BY ICS

### Quaternary:

- Base Meghalayan Stage (= Base Upper Holocene Subseries)
- Base Northgrippian Stage (= Base Middle Holocene Subseries)
- Base Greenlandian Stage (= Base Lower Holocene Subseries)
- Base Holocene Series
- Base of Lower and Upper Pleistocene Subseries
- Base Chibanian Stage (= base Middle Pleistocene Subseries)
- Base Calabrian Stage
- Base Gelasian Stage (= Base Pleistocene Series and Base Quaternary System)

### Neogene:

- Base Piacenzian Stage
- Base Zanclean Stage (= Base Pliocene Series)
- Base Messinian Stage
- Base Tortonian Stage
- Base Serravallian Stage
- Base Langhian Stage
- Base Aquitanian Stage (= Base Miocene Series and Base Neogene System)

### Paleogene:

- Base Chattian Stage
- Base Rupelian Stage (= Base Oligocene Series)
- Base Priabonian Stage
- Base Lutetian Stage
- Base Ypresian Stage (= Base Eocene Series)
- Base Thanetian Stage
- Base Selandian Stage
- Base Danian Stage (= Base Paleocene Series and Base Paleogene System)

### Cretaceous:

- Base Maastrichtian Stage
- Base Campanian Stage

Base Santonian Stage  
 Base Coniacian Stage  
 Base Turonian Stage  
 Base Cenomanian Stage (= Base Upper Cretaceous Series and Base Cretaceous System)  
 Base Barremian Stage  
 Base Hauterivian Stage

Jurassic:

Base Kimmeridgian Stage  
 Base Bathonian Stage  
 Base Bajocian Stage  
 Base Aalenian Stage (= Base of Middle Jurassic Series)  
 Base Toarcian Stage  
 Base Pliensbachian Stage  
 Base Sinemurian Stage  
 Base Hettangian Stage (= Base Lower Jurassic System and Base Jurassic Series)

Triassic:

Base Carnian Stage (= Base Upper Triassic System)  
 Base Ladinian Stage  
 Base Induan Stage (= Base Triassic System)

Permian:

Base Changhsingian Stage  
 Base Wuchiapingian Stage (= Base Lopingian Series)  
 Base Capitanian Stage  
 Base Wordian Stage  
 Base Roadian Stage (= Base Guadalupian Series)  
 Base Artinskian Stage  
 Base Sakmarian Stage  
 Base Asselian Stage (= Base Cisuralian Series and Base Permian System)

Carboniferous:

Base of Bashkirian Stage (= Base Lower Pennsylvanian Series and Base Pennsylvanian Subsystem)  
 Base Viséan Stage  
 Base Tournaisian Stage (= Base Lower Mississippian Series and Base Mississippian Subsystem and Base Carboniferous System)

Devonian:

Base Famennian Stage  
 Base Frasnian Stage (= Base Upper Devonian Series)  
 Base Givetian Stage  
 Base Eifelian Stage (= Base Middle Devonian Series)  
 Base Emsian Stage  
 Base Pragian Stage  
 Base Lochkovian Stage (= Base Lower Devonian Series and Base Devonian System)

Silurian:

Base Pridoli Series  
 Base Ludfordian Stage  
 Base Gorstian Stage (= Base Ludlow Series)  
 Base Homerian Stage  
 Base Sheinwoodian Stage (= Base Wenlock Series)  
 Base Telychian Stage  
 Base Aeronian Stage  
 Base Rhuddanian Stage (= Base Llandovery Series and Base Silurian System)

Ordovician:

|                 |  |
|-----------------|--|
|                 | Base Hirnantian Stage  |
|                 | Base Katian Stage  |
|                 | Base Sandbian Stage (= Base Upper Ordovician Series)                               |
|                 | Base Darriwilian Stage   |
|                 | Base Dapingian Stage (= Base Middle Ordovician Series)                             |
|                 | Base Floian Stage  |
|                 | Base Tremadocian Stage (= Base Lower Ordovician Series and Base Ordovician System) |
| Cambrian:       | Base Jiangshanian Stage  |
|                 | Base Paibian Stage (= Base Furongian Series)                                       |
|                 | Base Guzhangian Stage  |
|                 | Base Drumian Stage   |
|                 | Base Wuliuan Stage (= Base Miaolingian Series)                                     |
|                 | Name Terreneuvian Series   |
|                 | Base Fortunian Stage (= Base Terreneuvian Series and Base Cambrian System)         |
| Neoproterozoic: | Base Ediacaran System  |
| Archean:        | Base Archean Eon (GSSA)  |
| Hadean:         | Base Hadean Eon (GSSA)   |

## 7. CHIEF ACCOMPLISHMENTS IN 2023

### *Full commission*

- The 2023 version of ICS Chronostratigraphic Chart, which includes revised numerical ages, was posted on the ICS website (there were 3 versions of the chart in 2023, including one specifically for the STRATI 2023 meeting in Lille). An interactive chart is also available on the website.
- Most of the translated versions of the ICS chart have been updated to the 2023/10 version. The Catalan and Turkish translations were particularly renewed.
- Several authors, university teachers and other educators and professional societies were granted permission to use and reproduce the ICS International Chronostratigraphic Chart in their productions.
- Redefinition the Global Stratotype Section and Point (GSSP) for the base of the Wuchiapingian Stage (and Lopingian Series) was ratified by the IUGS Executive Committee on 24 July 2023.
- Celebration of GSSPs – in particular for the Upper Cretaceous Coniacian and Campanian stages.
- New executive officers proposed for the period 2024-2028: Professor Elisabetta Erba, Full Professor at the University of Milan, Italy (Chair), and Professor Shuzhong Shen, Academician of the Chinese Academy of Sciences, Nanjing University, China (Vice-Chair).

### *Quaternary Subcommission.*

- Participation in STRATI 2023 Meeting, Lille. SQS-led sessions included: Developments in Quaternary chronostratigraphy (convenors Martin Head, Adele Bertini, Liping Zhou and Jan Zalasiewicz). The Anthropocene:

stratigraphical concepts and evidence (convenors Colin Waters, Simon Turner, Jan Zalasiewicz and Martin Head).

- Participation in INQUA XXI, 2023, Rome. SQS-led sessions 6B – GSSPs and stratotypes. Session 8: A second stage for the Middle Pleistocene Subseries? Session 17: Fine-scale subdivision of the Quaternary: a land-sea perspective. Session 19: Global characterization of the Neogene–Quaternary (Pliocene–Pleistocene) transition: to presentations describing SQS-sponsored reanalysis of Monte San Nicola stratotype. Session 40: The Anthropocene as a tool for characterising recent planetary change and predicting future environmental challenges. Martin Head presented an update of SQS activities during the SACCOM meeting at INQUA. This substituted for the SQS business meeting at STRATI which had to be cancelled owing to an overrun of the preceding session, and was a better venue for this presentation. Colin Waters gave a keynote presentation at the Magna conference of the Brazilian Academy of Sciences May 2023.
- A proposal, and approval by the SQS, of the Ideale section, Montalbano Jonico (southern Italy) as a Standard Auxiliary Boundary Stratotype (SABS) for the Middle Pleistocene Series of the Quaternary System (Marino *et al.* 2023, below).
- Submission on 31 October by the Anthropocene Working Group of a discussion and information document to the SQS for a possible Crawfordian Stage and Anthropocene Series.

#### *Neogene Subcommission*

- In 2020 the Langhian and Burdigalian GSSP Working Group succeeded in finding a consensus on a proposal to place the Langhian GSSP in the La Vedova section in Italy close to the top of C5Cn, the selected guiding criterium to recognize the base of the Langhian (Turco *et al.*, 2017). Uncertainty related to the choice of calcareous planktonic events associated with the top of Chronzone C5Cn, and useful for the recognition of the Langhian base at low-latitudes, is still matter of debate. As an example, the taxonomic issues related to the *Praeorbulina* datum (the historical criterion for recognising the base of Langhian) are overt, as well as the low reliability for global correlation of the Last Common Occurrence (LCO) of *Helicosphaera ampliapertura*, an event proposed for the best approximation of the top of C5Cn in the Mediterranean.
- Potential problems in correlation to the pending La Vedova GSSP requires a Standard Auxiliary Boundary Stratotype (SABS) in a Pacific IODP core, at the corresponding stratigraphic level, providing direct correlation to the open ocean benthic isotope record and low-latitude calcareous plankton events. Site U1337 will be designated as auxiliary open ocean boundary stratotype, as its continuous succession across the Burdigalian-Langhian boundary provides a good-quality benthic isotope record that has been astronomically tuned (Holbourn *et al.*, 2015). The lack of magnetostratigraphy for Site 1337 can be overcome by through detailed cyclostratigraphic correlations (stable isotopes, CaCO<sub>3</sub>) to Site U1336 that has a reliable magnetostratigraphy across the boundary interval and is in good agreement with La Vedova section. However, these detailed correlations highlighted a missing 100-kyr cycle in the splice of Site U1337 just above the level that corresponds to the GSSP.



- In 2023, the SNS voted unanimously to approve both the La Vedova GSSP and the SABS in Site U1337. ICS voted unanimously to approve both. The paper documenting the GSSP The Global Stratotype Section and Point (GSSP) of the Langhian Stage and of the Middle Miocene Subseries by Turco E. *et al.* was published in *Episodes* in November 2023. The following summary is from the press release announcing the GSSP:
- The IUGS Executive Committee voted unanimously on 29 May 2023 to ratify the proposal by the Subcommittee on Neogene Stratigraphy (SNS) for defining the GSSP of the base of the Langhian Stage (and Middle Miocene Subseries) of the Miocene Series and Neogene System in the Mediterranean Lower La Vedova Beach section (Ancona, Italy). The Langhian GSSP is defined as level 17.84 m from the base of the section, in the middle of the dark coloured marly interval overlying Megabed IV. This stratigraphic level is astronomically calibrated to the most prominent ~100-kyr eccentricity maximum around 16 Ma and lies close to the Chron C5Cn/C5Br magnetic reversal boundary. This astrochronological approach guarantees that the Langhian GSSP is directly incorporated in the integrated, astronomically dated stratigraphic framework that currently underlies the standard Cenozoic Geological Time Scale. In addition, Integrated Ocean Drilling Program (IODP) Site U1337 in the eastern equatorial Pacific, was designated Standard Auxiliary Boundary Stratotype (SABS) with the objective of directly linking the Langhian GSSP to the astronomically calibrated open ocean benthic foraminiferal stable isotope record and, hence, to the Earth's climate evolution. Located in the open ocean, the SABS shows that the GSSP for the base of Langhian Stage and Middle Miocene Subseries/Subepoch at around 16 Ma falls within the Miocene Climate Optimum (MCO) - a particularly intriguing interval of peak global warmth which began in the preceding Burdigalian Stage at 17 Ma - and is ~400-kyr older than the most prominent eccentricity paced hyperthermal event within the MCO, and which is astronomically dated at 15.6 Ma. Further, the GSSP level is close to M12, a transient glacial [and cooling] event that punctuated the MCO. The golden spike (nail) at the base of the Langhian Stage and Middle Miocene Subseries/Subepoch, constitutes a global reference point for both, precisely and accurately dating and correlating these long- and short-term climatic events, and anchoring astronomical chronologies.
- The discussion on the definition Burdigalian GSSP is still wide open since no suitable candidate section (astronomically tuned deep marine section, possibly in the Mediterranean, that would guarantee the stratigraphic contiguity with the other GSSP sections) is available. The working group will move on to evaluating placing the Burdigalian GSSP in a Pacific IODP site.
- At STRATI 2023 in Lille the SNS executive organised a scientific session on Neogene stratigraphy and palaeoceanography. Contributions to this session were very diverse dealing with different stratigraphic and/or palaeoceanographic tools and covering almost all the intervals of the Neogene. A. Caruso (University of Palermo, Italy), invited to give a presentation, after a review of the reference sections for the Pliocene focused on the ongoing high-resolution study across the Neogene/Quaternary boundary at the Monte San Nicola Gela section (Sicily). Vice-Chair Turco and Voting Member Drury convened the session.
- The Business Meeting of SNS was also held at STRATI 2023 and was mainly related to the activity of the Burdigalian-Langhian WG. The ratification by IUGS of the Langhian GSSP at La Vedova section (Italy) and the SABS at Site U 1337 (eastern equatorial Pacific) were announced, and the main features of the sections and the criteria to recognize the base of the stage were shown. The state of the art of

Burdigalian GSSP, the last Neogene stage to be formally defined, was presented in detail as well as all the issues that still have to be discussed within the WG.

- Formalisation of Neogene Subseries/Subepochs. The International Commission on Stratigraphic Classification (ISSC) voted to recognise the rank of subseries as formal and to be integrated in the International Chronostratigraphic Chart (ICC) in 2021. This was approved by the ICS in 2022. Accordingly, the SNS voted positively for formalisation as reported in *Episodes* in 2022: Ratification of Neogene subseries as formal units in international chronostratigraphy by Aubry, M.-P.*et al.* This was followed by a 2023 paper on the implications of the 2022 ratification, Unifying Cenozoic chronostratigraphy and geochronology: applying the rules in *Newsletter on Stratigraphy* also by Aubry, M.-P.*et al.*

#### *Paleogene Subcommission*

- After receiving input from the board of ISPS on a previously submitted proposal for the GSSP of the Bartonian, the only stage of the Paleogene pending formal definition, the WG on the Bartonian carried out further analyses in 2023 and reformulated the proposal on the basis of additional sedimentological and magneto-biostratigraphic data from the critical interval of both the Bottaccione section and the Contessa Highway section (Coccioni et al., 2022). The WG recently confirmed they are about to re-submit the proposal for the Bartonian GSSP to the ISPS.
- A new reference section for the correlation of marine and continental biostratigraphy of the Bartonian has been investigated. The Pontils fossil site (Spain) represents a mangrove swamp environment with increasing marine influence towards the top of the sequence, and it contains a diverse vertebrate assemblage (including primates) as well as non-vertebrate fossils. The occurrence of larger benthic foraminifera allows the assignment of Pontils to Shallow Benthic Zone 17 (Bartonian), solving the debate about the age of the locality, previously assigned either to the Bartonian or the Lutetian. Correlation to chrons C18r or C18n.1r constrains the age of Pontils to 39.58 - 41 Ma, and make it a new reference section for the marine - continental correlation of the Bartonian.
- A specific session ‘SC5 Advances in Paleogene research’ dedicated to the Paleogene was organised by the ISPS during the 4th International Congress on Stratigraphy, STRATI 2023 in Lille, France.
- The ISPS created 3D models of some of the most significant outcrops of the Paleogene GSSPs, which are now available at the ISPS website. This project was presented during the 4th International Congress on Stratigraphy, STRATI23 (Alegret, Payros, Agnini, Monechi, Scaduto, Rossi, 3D outcrop modelling as a tool for GSSP promotion and communication: A case study from Spain and Italy).
- Ten out of the twenty voting members (50%) of the Subcommission have been replaced, reaching parity (50% female, 50% male), and three working groups have been closed because they have finished their tasks.
- In order to address some questions raised about the reliability of the GSSP for the base of the Lutetian Stage at Gorrondatxe, the calcareous nannofossil biostratigraphy and magnetostratigraphy were revisited and new cyclostratigraphic and astrochronological calibrations were carried out.

#### *Cretaceous Subcommission*

- Maastrichtian GSSP. The ratified GSSP locality for the base of the Maastrichtian is the abandoned quarry at Tercis-les-Bains in SW France. The stage boundary lacks a primary marker for the definition of its base, and the main task of the Maastrichtian WG is the search for a useful primary marker. In March 2023, WG members sampled the Tercis-les-Bains section, which is located in a Regional Natural Reserve requiring a permit for any geological fieldwork and sampling. The WG warmly thanks C. Gréaume, J. Le Breton and M. Lo Cascio of the Regional Natural Reserve for welcoming and providing scientific and logistic support.  
About 500 samples were taken along a 70-m interval with a resolution of 20-40 cm to establish modern biozonations for calcareous nannofossils, planktonic and benthic foraminifera, inoceramids and palynomorphs. Further samples were collected to determine the mineralogical composition and microtexture of the lithology, to resolve orbital cyclicity, and to improve the resolution of carbon isotope stratigraphy. Some of the analyses are finished (measurements of magnetic susceptibility, XRF), as well as the sample preparation for palynomorphs. The time-consuming washing of foraminiferal samples is still in progress. The stable isotope analyses will be finalized by the end of 2023. First results were presented at STRATI2023 in Lille in July 2023 (see below).  
The German Science Foundation DFG granted a research proposal to S. Voigt in August 2023 that will support the analytical work and the scientific exchange among the WG members. The work on the collected samples will provide students the opportunity to perform their master thesis project. Voigt, et al. (2023). Reassessment of the base of the Maastrichtian Stage at the GSSP locality Tercis-les-Bains (SW France).
- Campanian GSSP. The GSSP proposal for the base of the Campanian Stage in the Bottaccione Gorge section at Gubbio, Umbria-Marche Basin (Italy) was ratified by IUGS in October 2022 and includes 5 auxiliary sections. The golden spike ceremony was held on July 26, 2023, in Gubbio (Italy), see <https://cretaceous.stratigraphy.org/news/campanian-ceremony> Gale, A.S., *et al.*, (2023). The Global Boundary Stratotype Section and Point (GSSP) of the Campanian Stage at Bottaccione (Gubbio, Italy) and its auxiliary sections (Seaford Head, U.K.), Bocieniec (Poland), Postalm (Austria), Smoky Hill, Kansas (U.S.A.) and Tepeyac (Mexico). *Episodes*, vol. 46, n. 3, p. 451-490, <https://doi.org/10.18814/epiiugs/2022/022048>.
- The GSSP proposal for the base of the Coniacian Stage in the Salzgitter-Salder section (Germany) was ratified by IUGS in May 2021 and includes 3 auxiliary sections. The golden spike ceremony was held on September 19, 2023, at Salzgitter-Salder. Walaszczyk, I., *et al.* (2022). The Global Boundary Stratotype Section and Point (GSSP) for the base of the Coniacian Stage (Salzgitter-Salder, Germany) and its auxiliary sections (Słupia Nadbrzeźna, central Poland; Sřteleč, Czech Republic; and El Rosario, NE Mexico). *Episodes*, vol. 45, n., 2, p. 181-220, <https://doi.org/10.18814/epiiugs/2021/021022>.
- Aptian GSSP. In July, at the STRATI 23 conference in Lille, the members of the WG confirmed the earlier decision to take the negative C-isotope spike at the base of OAE1a as the new primary marker for the base of the Aptian. The WG agreed to vote on the location of the Aptian GSSP and, on the selection of the auxiliary sections. The following five sections are proposed as potential

sites for a GSSP: Gorgo a Cerbara (Italy), Cismon (Italy), La Bedoule (France), Cau (Spain) and El Pui (N Spain). Erba and Weissert are currently preparing fact sheets for the five sections identified as possible sites for the Aptian GSSP. The WG will vote on the preferred candidate GSSP section before the end of 2023.

- Barremian GSSP. The GSSP of the base of the Barremian Stage (at the base of bed 171 of the Rio Argos section, near Caravaca, SE Spain, marked by the first appearance of the ammonite *Taveraidiscus hugii*), was ratified by IUGS in March 2023. Secondary criteria include: bioevents (foraminifera, calcareous nannofossils), C isotope stratigraphy, sequence stratigraphy, and astrochronology. A new calibration of the Hauterivian/Barremian boundary against the magnetostratigraphic scale is proposed. The protection of the Río Argos section is ensured by the municipality of Caravaca, and its recognition at the regional and national level is also being processed. The publication of the GSSP has been accepted by Episodes and will be published soon. Company *et al.* (2024). The Global Boundary Stratotype Section and Point (GSSP) of the Barremian Stage at Río Argos (Caravaca, SE Spain). Episodes, proof corrected.
- Valanginian GSSP. In 2023, two informal GSSP proposals were prepared by two teams and submitted to the Valanginian WG for voting: 1) Vergol section (Montbrun-les-Bains, Drôme, SE France) by: Reboulet (reporter of the proposal, (bio-)stratigraphy, ammonites), Adate (chemostratigraphy, phosphorus), Baudin (organic geochemistry), Company ((bio-)stratigraphy), Deconinck (clay mineral assemblages), Duxbury (biostratigraphy, palynomorphs), Grabowski (magnetic stratigraphy), Granier (bio-)stratigraphy), Janssen (biostratigraphy, belemnites), Klein (biostratigraphy, ammonites), Leng (isotope stratigraphy), Lodowski (magnetic stratigraphy), Martinez (cyclostratigraphy, astrochronology), Mattioli (biostratigraphy, calcareous nannofossils), McArthur (isotope stratigraphy), Olivero (biostratigraphy, ichnofossils) and Reháková (biostratigraphy, calpionellids); 2) Cañada Luenga section (Cehegín, Region of Murcia, SE Spain) by: Company (reporter of the proposal, ammonite biostratigraphy), Adate (chemostratigraphy), Aguado (calcareous nannofossil biostratigraphy), Duxbury (organic dinoflagellate biostratigraphy), de Gea (chemostratigraphy), Ivanova (calcareous dinoflagellate and benthic foraminifera biostratigraphy), Janssen (belemnite biostratigraphy), Lakova (calpionellid biostratigraphy), Martinez (cyclostratigraphy, astrochronology) and Tavera (ammonite biostratigraphy).  
The Vergol section was selected by the Valanginian WG as the candidate GSSP for the base of the Valanginian and Cañada Luenga was selected as the Standard Auxiliary Boundary Stratotype (SABS). The FAD of '*Thurmanniceras*' *pertransiens* (ammonite) was selected as the primary marker. Its FO is recorded in layer VGL-B136 (Vergol) and CL 9 (Cañada Luenga). Main secondary markers are: FAD of *Calpionellites darderi* (calpionellid); FAD of *Calcicalathina oblongata* (calcareous nannofossil), FAD of *Neocomites premolicus* (ammonite) and base of magnetic chron M14r.
- Berriasian (Jurassic-Cretaceous J/K boundary) GSSP. The Berriasian WG started its work in February 2021. The WG keep being focused on organizing database and ideas concerning possible definitions and placing the

Tithonian/Berriasian boundary, as well as its global and regional palaeoenvironmental context. In the first half of 2023, the BWG completed a discussion on which level (not yet the primary marker) should be the best choice for the global J/K boundary definition. The three levels under considerations were: 1) a boundary in the upper Tithonian (between magnetozones M20n1r and M19r)/base *Crassicollaria* Zone or base Intermedia Subzone; 2) present day Tithonian/Berriasian boundary (base *Calpionella alpina* Subzone); 3) the lower/middle Berriasian boundary (base M17r/base zone *Calpionella elliptica*/base zone *Subthurmannia occitanica*). A two-step voting was organised, with the following results: First voting: 1st option (upper Tithonian) – 7 votes; 2nd option (Tith/Berr) – 4 votes; 3rd option (low/mid Berr) – 3 votes; No vote – 3. Second voting: 1st option (upper Tithonian) – 9 votes; 2nd option (Tith/Berr) – 5 votes; abstain – 1, no vote – 2. As a result, the upper Tithonian option was accepted as a working version of the J/K boundary, which will be elaborated in more detail in 2024. The BWG in 2022/2023 met online, usually with 1-2 keynote talks and discussion. Up to now 19 meetings were organised (the 20th is scheduled for Dec 2023) with the following presentations: 16th meeting (30.11.2022), Grabowski – J/K boundary in the upper Tithonian? 17th meeting (22.02.2023), Grabowski – Summary of the J/K boundary: three options for voting; Deconinck – Organic  $\delta^{13}\text{C}$  stratigraphy in Boulonnais section, NW France; Grabowski – News about VOICE isotopic excursion; 18th meeting (22.05.2023), Grabowski – results of indicative voting and report for the Cretaceous Subcommittee in Lille; 19th meeting (6.10.2023), Galloway - The Volgian Carbon Isotopic Excursion: the VOICE; Pellenard – The VOICE isotopic excursion in Argentina: astrochronologic calibration and correlation to Global Polarity Time Scale. The presentations and short reports from the meetings are archived and accessible on dedicated web page, accessible only to BWG members.

#### *Jurassic Subcommittee*

- The Oxfordian Working Group: Data from 60 sections have been studied; from these two candidate areas/sites were chosen (Redcliff Point, Weymouth, England; Thuoux with Saint-Pierre d'Argençon and Lazer, Serres, SE France) for further studies and consideration. Neither section satisfies all the key criteria so one is likely to be proposed as a stratotype and the other as an auxiliary section. A further section Dubki, Saratov Region, Russia was previously proposed but is currently on hold as advised by IUGS because of the war. A primary marker has yet to be formally selected but ammonites are favoured. Cardioceratidae ammonites provide widespread markers and evolved rapidly during this interval. Peltoceratidae and Hecticoceratidae are also important for this period. Other data that is either available or being collected includes microfossil groups, geochemistry, magnetostratigraphy and cyclostratigraphy. The ISJS chair called a business meeting at Strati with key parties and as a result of this, all ammonites are now in publicly accessible collections and the first of many c. bimonthly regular online meetings for all members of the working group was arranged for October. This meeting helped to inspire members and established priorities for future research and documentation; it is hoped by all parties that rapid progress can now be made.
- The Callovian Working Group: It is proving difficult to find a Callovian

section that satisfies sufficient GSSP criteria. The previously favoured and intensively studied Albstadt-Pfeffingen section in Germany with its excellent ammonite faunas is too condensed and is not suitable for primary geochemical and magnetostratigraphical studies. Open access is also problematic. An excellent expanded section with radio-isotopic dates has been identified in Argentina, but the endemism of the ammonites and possibly other fossil groups is problematic. The membership of the Callovian Working Group is therefore being renewed and other sections considered.

- The Tithonian Working Group: We are pleased to announce that the Tithonian Working Group now have a new chair, Verónica Vennari. We are very grateful to the outgoing chair, Fredrico Olóriz for his work and for kindly agreeing to stay on as a voting member and to help the incoming chair. Work on the neighbouring Berrasian GSSP is proving helpful.
- The Berriasian Working Group presented an update at Strati 2023. The group are currently considering a boundary within what has historically been considered Tithonian (See <https://cretaceous.stratigraphy.org/news/berriasian-wg-meetings>), the logic of this line of enquiry has the approval of the executive of the ISJS following joint discussion at the 11th International Jurassic congress in Budapest in 2022.
- A successful Jurassic session and business meeting was held at Strati 2023. There were 27 talks and posters. Similar to the Jurassic congress in 2022 there was a lot of focus on the Toarcian Oceanic Anoxic Event. One of the Jurassic researchers, Aisha Al-Suwaidi, ran a workshop on geochronology building on an idea from the Jurassic congress in 2022. A particularly useful aspect of the Strati meeting was to be able to attend presentations by colleagues in neighbouring geological periods (e.g. see below). It would be helpful to ensure for future Strati meetings that sessions on neighbouring periods did not overlap
- Planning for the 12th Jurassic congress that will be held in Exeter, UK in 2026 is underway. Arrangements have been made to base the conference at the main Exeter University campus. There will be long field trips all main sites of Jurassic strata in the UK and a mid-conference field trip to the Hettangian to Pliensbachian strata at Lyme Regis and Charmouth. Discussions are underway with two publishers for the field guide.

#### *Triassic Subcommission.*

- A total of 134 papers that are closely related to stratigraphy and extreme biotic, environmental and climatic events within the Triassic have been published by STS members in 2023.
- New achievements in I-O boundary: Lyu et al. (2023a) recognised 9 unitary associations across the IOB interval worldwide using species of *Neospathodus* and *Novispathodus*, with the probable IOB being calibrated within UAZ-2. Both the West Pingdingshan section, South China and the Mud section near Spiti, India are currently considered as the candidates for the base-Olenekian GSSP. Unitary association analysis indicates that the West Pingdingshan is the most complete and reproducible site for the GSSP of IOB based on the first appearances of *E. costatus*, *Ns. posterolongatus*, *Nv. waageni eowaageni*, and *Nv. waageni waageni*. They all co-occur in UAZ-2, which is calibrated to a 5-m-interval from Beds 23–4 to 25–30 at West Pingdingshan. The same UAZ is confined to Beds 12b to 14a in the Mud section. *Ns. posterolongatus* may

serve as an auxiliary marker, and *Eu. costatus* approximates the IOB in shallow-water settings. Lyu et al. (2023b) proposed two evolutionary lineages of conodonts as the basis for global correlation and eliminates the possibility that the first occurrence of species in one lineage or the other is simply a migration event. The new results and selection of GSSP of IOB have been hotly debated at the STS session and business meeting joint with the Strati 2023. A formal proposal for the GSSP of IOB will be completed for ratification with the task group of IOB in 2024.

- Primary publications: Lyu, Z., et al., 2023a. High-resolution conodont unitary association zonations (UAZs) across the Induan-Olenekian boundary (Lower Triassic): A global correlation. *Palaeogeography, Palaeoclimatology, Palaeoecology* 627, 111721. Lyu et al., 2023b. New conodont faunas and two proposed conodont evolutionary lineages improve the accuracy of global correlation to IOB (Lower Triassic).
- New achievements in O-A boundary: Four candidates for GSSP of OAB: the Wantou section and Guandao section in South China, the Desli Caira section in Romania and Kcira section in Albania. Chen et al. (2023) reported the updated information for the Wantou section at STRATI 2023. Multidisciplinary studies on this section provide a considerable amount multi-proxies of biostratigraphy, magnetostratigraphy, and chemostratigraphy constraining the OAB, with the FAD of conodont *Chiosella timorensis sensu stricto* at Bed 15e (9.16 m), with other proxies including 1) the peak of the carbon isotope positive excursion and 2) base of brief normal polarity prior to the normal polarity dominated interval. FAD of *Ch. timorensis* has advanced on the global synchronous correlation compared to other proposed alternative index species, and the Wantou section is more suitable for the GSSP of OAB than others worldwide. In contrast, Horacek and Gradinaru (2023) updated the existing data from the Desli Caira section in Romania and added a high-resolution  $\delta^{13}\text{C}$  curve to aid the correlation of OAB. They found that two different levels for OAB based on turnovers of conodont, ammonoid and foraminifera species associated with a maximum in  $\delta^{13}\text{C}$  excursion. When compared with the Kcira and Wantou sections that both lack a detailed ammonoid stratigraphy, the Desli Caira is the better suited section for GSSP of OAB, once the problem with the two boundary levels is solved (Horacek and Gradinaru, 2023). However, Dr. M. Balini (2023, in oral) reported that the ammonoids from Desli Caira are rather confused and it is difficult to define the OAB at the Strati2023. The new work by Golding (2023) shows that conodont biostratigraphy from Desli Caira is also rather confused. Thus, additional field workshops are planned in South China and Romania in 2024 to sort out the marker of OAB.
- New achievements in C-N and N-R boundaries: After a formal voting procedure within the working group, the Pizzo Mondello section was selected as the GSSP for the base of the Norian. A team led by Dr. Marco Balini is preparing a formal proposal for the GSSP of CNB for the ratification within voting members of STS at the moment. Regarding the GSSB for NRB, two candidates are the Pignola Abriola in Italy and Steinbergkogel in Austria, which both utilize the FO of conodont *Misikella posthernsteini* as a proxy for the boundary. Golding (2023) reported conodont data from New York Canyon of USA, which placed the NRB at the FO of *Mi. posthernsteini*. However, this species was recovered well above the FO of Rhaetian ammonoids

(*Paracochloceras amoenum*). Additional work therefore is needed to clarify these discrepancies.

- Two indoor meetings and one international summer school: 1) SC9: Triassic integrated stratigraphy, GSSPs and extreme climatic, environmental and biotic events (July 12th, 2023, Lille, France), with 65 participants. This session has attracted 24 abstracts which are the highest number of papers presented among all sessions at ICS. This symposium offered a great platform for STS members to communicate the advanced results on various GSSPs and stratigraphy of Triassic. All members have discussed the definitions and possible selectivity of GSSPs for several stage-boundaries within Triassic. In particular, the I-O, O-A and C-N boundaries have been hotly debated, and various stages of GSSP proposals have been achieved. 2) STS business meeting (July 12th, 2023, Lille, France): 1) summarizing STS works in 2023 by Chair; 2) working progress reports on GSSPs (task completed and future plan); 3) Corresponding/voting member list updated, recommending replacement of STS voting member; 4) collecting activity information and publications for STS Newsletter/*Albertiana*; and 4) launching Serial books “The Triassic of the World”. Chairs of the IOB (C. Henderson), OAB (S. Lucas, represented by H. Jiang and M. Balini), CNB (M. Balini), and NRB (Y. Sun) introduced the progresses, problems and perspectives on their GSSP studies. The voting members of the working groups of these GSSPs have been updated, and the IOB task group has selected a new secretary (Dr. Zhengyi Lyu) to organize activities within this task group (led by Prof. Charles Henderson). The new working/voting members were also selected or nominated for the OAB task group led by Dr. Spencer Lucas. The CNB working group pushed Dr Marco Balini’s team to complete the formal proposal of the GSSP for the CNB so that it can be ratified within STS in 2024. 3) STS sponsored the International Geological Summer School “Millions of years before the Silk Road”, 13-25 August 2023 in Madygen, Kyrgyzstan, Central Asia, organized under the auspices of UNESCO by the Tian Shan Geological Society. Participants were 10 graduate and PhD students from Germany, United Kingdom, Uzbekistan and Kyrgyzstan.

#### *Permian Subcommission*

- The redefinition the Global Stratotype Section and Point (GSSP) for the base of the Wuchiapingian Stage (and Lopingian Series) was ratified by the IUGS Executive Committee on 24 July 2023.
- A Standard Auxiliary Boundary Stratotype (SABS) for the base of the Wuchiapingian Stage at the Fengshan Section, China, was approved by SPS on 16 April 2023.
- The paper "Proposal for the Global Stratotype Section and Point (GSSP) for the base-Artinskian Stage (Lower Permian)" by Chernykh *et al.* was published online in Episodes, 15 June, 2023.
- The paper “Redefinition of the Global Stratotype Section and Point (GSSP) and new Standard Auxiliary Boundary Stratotype (SABS) for the base of Wuchiapingian Stage (Lopingian Series, Permian) in South China” by Shen *et al.* was published online in Episodes, 1 November, 2023.
- Four new voting members were selected based on their extensive research in Permian stratigraphy (Neil Griffis, USA; Hana Jurikova, United Kingdom; Lorenzo Marchetti, Germany; Michael Read, USA). A Newsletter Editor has



- been invited (Elizabeth Weldon, Australia).
- A new Working Group was organized: Kungurian-base GSSP Working Group.
- The Permian Time Scale was kept updated <https://permian.stratigraphy.org/gssps>, the SPS website was kept updated, and two issues of *Permophiles* were published (SPS Newsletters *Permophiles* 74 and 75, the latter a special issue with “Permian Perspectives”).
- Two webinars were organised, one on The IUGS Deep-time Digital Earth Programme by Stephenson and one on Progress, problems and perspectives for the base-Roadian and base-Wordian GSSPs by Shen & Henderson (<https://permian.stratigraphy.org/interest>).

#### *Carboniferous Subcommission*

- The work of SCCS has been strongly impacted by the current political and sanitary situation. Almost half of the SCCS voting members and officers are directly impacted, and the search for GSSPs has been slowed down due to temporary inaccessible of key sections in several countries.
- A book titled “Ice ages, climate dynamics and biotic events: the Late Pennsylvanian World” was published in 2023 by Geological Society, London, Special Publications 535. The special issue is edited by Spencer G. Lucas (VM of SCCS), William A. DiMichele (CM of SCCS), Joerg W. Schneider (CM of SCCS), Stanislav Opluštil (CM of SCCS), and Xiangdong Wang (Chair of SCCS) and comprises 18 articles included in seven sections: I. Introduction, II. Timescale, III. The Cantabrian Stage, IV. Geological context, V. Palaeobotany, VI. Invertebrate palaeontology, VII. Vertebrate palaeontology.
- The Devonian-Carboniferous boundary  
The working group for the revision of the base of the Carboniferous has continued to work on a revised boundary definition and its global correlation. The working hypothesis of a revised boundary level and criterion has been tested and can be upheld; additionally, a calendar listing a succession of particular points in time defined by physical and/or biological criteria has been developed for the latest Famennian and earliest Tournaisian (DCB interval). This calendar is meant to help to place at least approximately the future boundary if a section lacks critical boundary criteria.  
Following the disruption by the pandemic period, the working group has started to visit key sections in the field. This year, before the STRATI meeting in Lille, the working group organized a field conference in Germany and Belgium to study and discuss classical sections in the Rhenish Mountains and the Ardennes for the definition of the DCB in different facies realms. The work in the field has demonstrated the applicability not only of a revised boundary level and criteria, but also the usefulness of the calendar and its multitude of physical and biological criteria.
- The Kasimovian-Gzhelian boundary  
The manuscript of proposal to define the Kasimovian-Gzhelian boundary is now finished and revising among working group members. The potential GSSP is defined at the Naqing section, Guizhou Province, South China to present conodont lineage of the index taxon, fusulinid biostratigraphy, carbon, oxygen, strontium, and uranium isotopic stratigraphy, and cyclostratigraphy. The boundary level between the Kasimovian and Gzhelian

stages, the FAD of *Idiognathodus simulator*, is defined within a lineage from *I. abdivitus* to *I. simulator* based on evolutionary palaeontology and platform landmark analysis (PLA) at the horizon of 220.45 meters in the Naqing Section. The proposal will be submitted to be voted hopefully in the early 2024.

- The Moscovian-Kasimovian boundary  
A primary difficulty when correlating the Kasimovian Stage at a global scale is that potential index fossils provide variable levels of precision. Compared with benthic faunas, the pelagic conodonts have better potential to correlate the base of the Kasimovian. The conodont species *Swadelina subexcelsa*, *Idiognathodus heckeli*, *I. turbatus*, and *I. sagittalis* are possibly boundary markers, and all have different advantages. By evaluating all aspects of the taxonomy, biostratigraphy, and palaeobiogeography of those species, *I. heckeli* is considered to be the best marker for the base boundary of the Kasimovian Stage because it has a wide geographic distribution, clear taxonomic definition within the phylogenetic lineage *I. swadei*-*I. heckeli*-*I. turbatus*, and its FO marks a globally recognized bioevent. The chemostratigraphic proxies, however, provide less correlation potential based on current studies. The Naqing section, South China is the most appropriate candidate because of its complete deep-water succession that has been studied in detail on bio-, chemo- and cyclostratigraphy, and provides a complete lineages of the potential boundary markers *I. heckeli*. A proposal to define the boundary will be prepared within the next two years.
- The Bashkirian-Moscovian boundary  
Two potential index taxon *Diplognathodus ellesmerensis* and *Declinognathodus donetzianus* have been recorded from multiple basins, and are the only taxa still being considered by the Task Group. Both occur as minor components in the conodont assemblages in the boundary level. *Diplognathodus ellesmerensis* has a slightly longer range and a much wider distribution than that of *De. donetzianus*.  
Outside eastern Europe, *De. donetzianus* is very rare, usually being represented by single specimens. It is entirely absent from the primary stable continent of North America (it only occurs in accreted terranes) and Asia. Even by adding the equivocal occurrences of *De. donetzianus* from North America and South America, the palaeogeographic distribution of *De. donetzianus* remains significantly more limited than that of the widespread *D. ellesmerensis*. The lineage *De. marginodosus*-*De. donetzianus* has been recorded in the Russian Platform, i.e., the Donets Basin, Volga region and South Urals. However, the current BMB in the Russian Platform was not defined by the earliest evolutionary appearance of *De. donetzianus*.  
The lineage *D. benderi*-*D. ellesmerensis* is known in South China and South Urals. In the former area a morphocline of the lineage has been well recorded. In the latter area, *D. ellesmerensis* and *De. donetzianus* co-occur. In other areas, e.g., the Arctic, North America, and South America, the *D. benderi*-*D. ellesmerensis* lineage may also be tested due to both species were both recorded there. Currently, *D. ellesmerensis* has a higher potential for the BMB index fossil due to its global distribution, an abundance of supplementary marker species at similar stratigraphic levels, and the close stratigraphic proximity of the FAD to the traditional BMB, thus largely preserving the original concept for the base of the Moscovian Stage. The

proposal for the boundary will be prepared next year.

- The Viséan-Serpukhovian boundary  
Coordinated progress of the working group for this boundary has not been possible due to the current political situation. Hence, activities have been reduced to mostly individual work of working group members.

#### *Devonian Subcommission*

- The annual business meeting of the SDS took place on 30 July in Geneseo, NY, USA in conjunction with the Devonian conference meeting in Geneseo, with field trips from Ohio to the New York State. It was the most important event for our community directly focussed on the Devonian. The conference was very successful, perfectly organized, and both scientific sessions and fieldtrips were highly attended.
- The SDS meeting, in conjunction with the STRATI, was held on 12 July.
- At both SDS meetings the Chair informed about major points in the business meeting agenda and the current situation in our Devonian community, on-going Devonian projects (mostly reports on biostratigraphical, petrophysical and geochemical data from the key areas and progress in the Basal Emsian boundary redefinition), Devonian publications and forthcoming meetings. We had altogether around 40 participants including guests, 14 new Corresponding members were recruited from Belgium, Colombia, Portugal and USA.
- Update of the new SDS website – hosted on the ICS web (stratigraphy.org)
- Publications: SDS Newsletter No. 38, and an extensive monograph titled ‘Devonian of New York’, edited by C. A. Ver Straeten, D. J. Over & D. Woodrow in 3 volumes of the Bulletins of American Paleontology has been published.
- Formal election of the SDS executive (officers and voting members) for 2024-2028. The elections took place in September and October 2023.

#### *Silurian Subcommission*

- Silurian Times No 30 was edited by the secretary, David Ray, and distributed in April, 2023, posted on the web site for the ISSS, and circulated as an email attachment to all titular and corresponding members of the Subcommission. It contained the reports on previous meetings, announcements of planned meetings, the latest news and recent publications on Silurian research.
- The Aeronian working group accomplished its task by submission of two parallel proposals for new base Aeronian GSSP which should replace current GSSP located in the Trefawr track cutting in Wales, UK (Melchin *et al.* 2023, Štorch *et al.* 2023). Of the two candidate sections - Rheidol Gorge in Wales, UK and Hlásná Třebaň in the Czech Republic - the latter has been selected by subsequent voting by the titular members of the ISSS and submitted to the ICS for further discussion and approval.
- The Telychian working group has completed its work by formal proposal of the El Pintado 1 section in Spain for new GSSP for the Telychian Stage to replace present GSSP in the Cefn Cerig quarry section in Wales, UK (Loydell *et al.* 2023). The new GSSP has been approved by voting by the titular members of the ISSS and the proposal has been submitted to ICS for further discussion and formal approval.

### *Ordovician Subcommission*

- The 14<sup>th</sup> edition of the major congress of the Subcommission, which takes place every four years, the International Symposium on the Ordovician System (ISOS), was organized in Tallinn, Estonia, in late July. It included scientific sessions and excursions, and was attended by over 100 Ordovician specialists.
- The Subcommission organised a scientific session during the main meeting of the ICS, STRATI 2023, which was organized in Lille, France, in mid-July.
- The second Auxiliary Boundary Stratigraphic Section and Point (ASSP) for the base of the Ordovician System at the Dayangcha section (Northern China), has been accepted to be an official Standard Auxiliary Boundary Stratotype (SABS) by the Subcommission in 2023. The official inauguration of the stratotype was postponed a few times, but is now scheduled to take place in June 2024.
- In accordance with ICS Rules, the voting members of SOS were replaced in 2020, and the voting membership voted to select a new Executive and voting members for the term 2020–2024. The voting membership was increased to 20. During the Covid pandemic, online meetings were organised. The second online business meeting was organized in late March 2022, and the third one in early May 2023, attended by most voting members.
- In accordance with ICS Rules, the SOS Executive started in late 2023 to prepare the replacement of the Voting Members. The objective is to reach a perfect gender balance and a best possible global coverage for the period 2024–2028.
- Two ‘in person’ meetings of part of the Executive and voting members of SOS took place during the 4<sup>th</sup> International Congress on Stratigraphy in Lille (France, mid-July 2023) and during the ISOS14 (Estonia, late July 2023). During the latter symposium, the voting members who were present took part at a business dinner organised by the Subcommission.
- A major accomplishment during 2023 was the publication of two volumes (532 and 533) of the *Geological Society Special Publication* series, dedicated to a global Ordovician synthesis. Launched by the Ordovician Subcommission in 2021, all manuscripts for chapters have been deposited between January and November 2022. The publication was released in March (on-line) and in June (in print) 2023. All participants of ISOS14 at Tallinn were invited at a reception organised by the Subcommission to celebrate the publication of the two volumes.
- Following the final meeting of the International Geoscience Programme (IGCP) 653 ‘The onset of the Great Ordovician Biodiversification Event’ and the kickoff meeting of the IGCP 735 “Rocks n’ ROL (Filling knowledge gaps in the Early Palaeozoic Biodiversification)” organized jointly as a videoconference congress in Lille (France) on September 13<sup>th</sup>-16<sup>th</sup> 2021, two thematic volumes were scheduled in *Palaeogeography Palaeoclimatology Palaeoecology* and in *Geobios*. Both special issues are focused on the Ordovician radiations, and are co-guest-edited by current and former executive officers of the Subcommission. During 2022, numerous contributions were submitted to these two volumes, which have been both published in 2023.
- The second Annual Meeting of the International Geoscience Programme (IGCP) 735 “Rocks n’ ROL (Filling knowledge gaps in the Early Palaeozoic Biodiversification)”, which took place in Morocco (Oct. 2022) gave rise to a thematic volume issued in 2023 in *Frontiers in Ecology and Evolution*.
- The 14<sup>th</sup> International Symposium on the Ordovician System in Tallinn (Estonia, July 2023), which coincided with the third Annual Meeting of the International Geoscience

Programme (IGCP) 735 “Rocks n’ ROL”, was followed by a thematic issue in *Estonian Journal of Earth Sciences*, also published in 2023.

- *Ordovician News* 40 (for 2022) was published in April 2023 and is available from the SOS webpage (<http://ordovician.stratigraphy.org/>).
- The SOS webpage changed its host, and is now managed as a separate page of the webpage of the ICS (<http://stratigraphy.org/>).

#### *Cambrian Subcommission*

- In October 2022, the IUGS ratified the new executive officers of the International Subcommission on Cambrian Stratigraphy (ISCS). During January and February 2023, the new Chair, Vice-Chair and Secretary compiled a list of potential Voting Members and sent invitations. The Subcommission now consists of 21 Voting Members, with excellent ethnic, gender and geographic diversity (see Appendix), as well as expertise across a range of topics and fields that will be necessary for defining the remaining unnamed Cambrian stages.
- The ISCS organised a Cambrian session at the 4th International Congress on Stratigraphy (Strati 2023) in Lille, France, in July 2023. Six talks and three posters were presented, including two talks on trilobites and biostratigraphy in Cambrian Series 2 of Spain, a poster on the SPICE event, and a talk on biodiversity across space and time in the Cambrian. A brief subcommission meeting was held in the evening of 12 July, unfortunately with very few attendants.
- The ISCS has set up a multipurpose communication platform using MS Teams, which is being used for online meetings and file sharing. In early November 2023, the Executive and other Voting Members met during two online sessions to discuss current issues and future strategies (cf. also Appendix sections 9 and 10 below). Key among these matters was the status and membership of the Working Groups for Cambrian Stages 2, 3, 4 and 10. It was decided that the Working Groups for Stages 2, 3 and 4 should have new Chairs and memberships be rebuilt for each one. Former ISCS Chair, Per Ahlberg, reported on the status of Cambrian Stage 10, noting that much work has already been done and the current Voting Members should continue on with deciding which marker—that is, either the FAD of *Lotagnostus americanus* or the FAD of *Eoconodontus notchpeakensis* (just below the onset of the HERB/TOCE isotope excursion)—best defines the base. Thus, it was agreed that an active Stage 10 Working Group is not required at this point in time. The Subcommission will continue to work closely with P. Ahlberg on evaluating the existing Cambrian Stage 10 proposals and assessing current research in this area in order to move forward with a definition of this important boundary.

#### *Ediacaran Subcommission*

- The Subcommittee will finally undertake its fieldtrip to Brazil in November 2023. It has now become a joint Ediacaran/Cryogenian trip, with voting members from both SC joining.
- The website continues to grow: as part of the Executive transition, we wished to transfer the website to new ownership. We also solicited our colleague Dr. Tara Selly to act as web-developer. <http://ediacaran.stratigraphy.org/>
- The construction of a database of known late-Ediacaran sections has been put on hold as we re-evaluate the likely geochemical and geobiological tools used to define the boundaries. We will have a new survey of our voting members in January 2024, leading to a submission to Episodes once complete (similar to Xiao *et al.*, 2016).
- A special issue of the Journal of Paleontology with the executive members (Laflamme, Schiffbauer, Warren, Selly) and voting member (Liu) as guest editors is finally complete. All eight manuscripts have successfully gone through the peer-review process.
- We held a SC meeting in conjunction with GSA2023 in Pittsburg USA. It was attended by several voting members including Marc Laflamme, Jim Schiffbauer, Guy Narbonne, Shuhai Xiao, Jay Kaufman, Luis Buatois and Tara Selly in attendance, in addition to a large group of potential corresponding members as it was held in conjunction with an Ediacaran ‘meet and greet’ event organised by voting member Mary Droser (not in attendance) and her students.

#### *Cryogenian Subcommittee*

- Business meeting and a session in STRATI 2023, Lille (July): resulted in updated version of criteria for Tonian/Cryogenian boundary and action plan for the joint Ediacaran and Cryogenian Subcommissions fieldtrip to Brazil.
- Field excursion to Scotland (July): 6 voting members and 6 corresponding members joined the fieldtrip which resulted in documents “field guide to the proposed Cryogenian boundary section: I.J. Fairchild, A.M. Spencer, N. Rees-Doherty, D. Webster et al. Chapter 7: Stratigraphy below the Port Askaig Formation (in preparation).
- Field excursion to Central Brazil sponsored jointly with Ediacaran subcommittee (November 20-26): led by Lucas Warren and Fabricio Caxito, 5 voting members and 3 corresponding members of the Cryogenian subcommittee joined. Visits to outcrops of possible Cryogenian/Ediacaran transition of the Bambui Group and discussions among members of two subcommittee. Resulted in documents: Lucas Warren and Fabricio Caxito, 2023, Field guide of the Joint International Subcommittee on Ediacaran and Cryogenian Stratigraphy Field Trip to Brazil.
- A book by voting member Graham Shields on the Cryogenian was published: *Born of Ice and Fire -- How Glaciers and Volcanoes (with a Pinch of Salt) Drove Animal Evolution*. Yale University Press. 2023.

#### *Precryogenian Subcommittee*

- The lower boundary of the Hadean Eon was established at the age of 4,567.30 ± 0.16 My. This Global Standard Stratigraphic Age or GSSA represents a chronological reference point numerical date used to define the basal boundary of the Eon. This numerical age is derived from the weighted mean

U-corrected Pb–Pb age for calcium-aluminium inclusions in primitive meteorites. The suggestion for the lower boundary of the Hadean Eon is the age of the Solar System based on the oldest solid CAIs in the protoplanetary disc. This  $4,567.30 \pm 0.16$  My age date is supported by the 4568–4567 Ma U-corrected Pb–Pb ages of chondrules found in Northwest African meteorites. These dates set an upper lifetime for the protoplanetary disc and timing of planet formation.

- The revision of the base-Archean Eonothem/Eon GSSA was identified in the Acasta Gneiss Complex Formation, Slave Province, Canadian Shield, on the Acasta River, Northwestern Territory, Canada. WGS84 coordinates: Lat:  $65^{\circ}10.43'$  N; Lon:  $115^{\circ}33.23'$  W. Rock type: tonalite-trondhjemite-granodiorite (TTG). Ten oldest zircon U-Pb ages of felsic rocks on Earth indicate that the Hadean-Archean Boundary occurs at:  $4031 \pm 3.0$  Ma (the oldest reliably dated piece of felsic crust) in samples obtained from the Acasta gneisses.
- The subcommission are actively finalising the establishment of a Lower/Upper Paleoproterozoic boundary. In this context the 'Eoarchean' will be regarded henceforth as an informal term.
- Two manuscripts have been submitted to *Episodes* led by Jaana Halla and Humberto Reis.
- At the STRATI 2023 in Lille, France, and at the 6th International Symposium on Archean in Perth, the current work of the Subcommission was discussed and presented to the scientific community.
- A proposal has been submitted by the Subcommission to establish an IUGS Geoheritage site in South Africa, led by Noffke, Smit and Nhleko.

#### *Stratigraphic Classification Subcommission*

- Biostratigraphy: After the workshop 2022 the organisers and editors (Piller, Erbacher) received the first manuscripts in autumn 2023 submitted to *Newsletters on Stratigraphy* which are currently under review.
- Chronostratigraphy: The working group established end of 2020 (core: Marie-Pierre Aubry, Martin Head, Werner E. Piller) was discussing the topic and started to discuss some chapters in detail. The manuscript will be ready in 2024.
- ISSC Business Meeting. A business meeting with an in-depth report by the chair was held during STRATI 2023 in Lille (France).
- Conference participation - ISSC co-organised the technical session (on-site presentations and posters) SSP2.1 "Integrated Stratigraphy - Reconstructing environmental change across the Earth System" at EGU 2022 in Vienna (oral: Thursday, 27 April, 8:30 – 12:25; posters on site: Thursday, 27 April, 14:00 – 15:45; posters virtual: Thursday, 27 April, 14:00 – 15:45).

#### *Timescale Calibration*

- The discussion with the other subcommission chairs at the STRATI2023 meeting regarding the plans for the future of the Geologic Time Scale book volumes. All chairs agreed that this should be pursued and should be considered by the ISTC as a potential objective of the subcommission. Initial conversations with the executive committee of the ISTC, in addition to initial conversations with publishers has begun and will continue into 2024. A

decision on the concrete plans for the next iteration of a GTS volume will be made in 2024.

*Graphics Officer (Cohen) and Web Officer (Car) contributions*

- The ICS Chronostratigraphic Chart, which included newly ratified GSSPs and revised numerical ages, was kept actual on [www.stratigraphy.org](http://www.stratigraphy.org) (versions released: 2023/04, 2023/06, 2023/09), as was a changelog (LINK).
- The ICS website since 2020 also features digitally generated web chart representations, based on its Semantic Web representation, which was kept up to date to the 2020 chart.
- Ten out of seventeen Subcommissions are operating their own websites within the new website system. The status of Subcommissions' website standardisations can be seen online (LINK).
- Most of the translated versions of the ICS chart have been updated to the 2023/10 version. The Catalan and Turkish translations were particularly renewed.
- The Graphic Officer attended business meetings and sessions at STRATI congress in Lille (France) in July 2023 (July). In the ICS business meeting it was decided that an upcoming chart will include cross-check of numeric ages against GTS-2020 and the upcoming GTS-2024 publication. We aim to have done this before the IGC in Busan Korea (2024) and communicate this on the chart and as part of a publication in Episodes.org, updating the aging Cohen et al. (2013) reference. The outline of this publication was discussed within the executive, and a draft exists with the graphic officer.
- The Informatics officer visited DDE facility in Suzhou China as part of IUGS meeting there in November 2023.
- Up-to-date Data version of the Chart. A simple Semantic Web (SKOS) vocabulary version of the 2023-09 ICS Chart has been produced from the Semantic Web Geological Timescale Ontology originally produced in 2020 by CGI but with updated chart data and colour information. It also contains additional properties to assist more communities to use it more powerfully, for example special codes per Chart element as used by the Geological Map of the World to colour code the map based on rock unit age. More may be added upon request. It is available for download at <https://stratigraphy.org/chart> and temporarily published online at <https://vocabulary.gswa.kurrawong.ai/v/vocab/ics:ischart>  
This will be maintained as current as the Chart is updated.

## 8. SUMMARY OF INCOME and EXPENDITURE IN 2023

The IUGS Executive Committee awarded ICS a budget of **\$60,000**. Thus, \$60,000 was available for ICS activities (expenditures across all 17 subcommissions and the executive, some 500 scientists) in 2023. No additional income to the ICS is declared. Expenditure of the ICS vote of **\$60141.3** is detailed in the appended financial spreadsheet (see Expenditure\_Budgets). The majority of costs, however, were met by research grants to individuals and institutional and other external support. We are extremely grateful for the core funding that the IUGS provides.



## 9. BUDGET PROPOSALS FROM ICS IN 2024

These have been itemised in detail in the attached spreadsheet (Expenditure\_Budgets). This is the final year of an 8-year cycle for the ICS executive. The global request is **\$96339**, to cover the activities of the 17 subcommissions and the executive. However **\$42150** of this sum has been requested to support the attendance of commission and subcommission executives at the IGC in Busan.

## 10. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED IN 2024

### *Quaternary Subcommission*

- Rapid progress was made in the analysis of candidate stratotypes for the Anthropocene, the next major GSSP decision for the SQS. Voting by the Anthropocene Working Group led to selection of a candidate GSSP, in annually varved sediments of Crawford Lake, Canada, at a level representing 1952 CE and the beginning of the major, globally correlatable plutonium peak that represents the primary marker for this proposed chronostratigraphic unit. Three accompanying proposed SABSs were also voted on, and accompany 8 reference sections that demonstrate the precise correlation possible of this level across diverse sedimentary environments, both marine and non-marine.
- Selection of a GSSP for the Upper Pleistocene Subseries and its corresponding stage. Two potential candidates have already been identified (Fronte Section, Taranto, Italy; and an ice core in Antarctica). The aim is to have proposals developed for these potential candidates as soon as possible. The Upper Pleistocene Working Group is being reformed under the co-convenership of Martin Head.
- Development of a nascent Working Group on a potential second stage for the Middle Pleistocene Subseries and its corresponding stage. This working group was formed this year under the co-convenership of Martin Head and Leszek Marks, and will begin by: 1) completing the membership, 2) analysing whether a case can be made for a second stage, and 3) if so, the compilation of potential GSSP sections.

### *Neogene Subcommission*

- The major plan is to identify a boundary stratotype for the Burdigalian stage in an IODP archived borehole. Discussions with WG Chair Hilgen suggest that we will ask A. Holbourn to take the lead on this task.

### *Paleogene Subcommission*

- Full support will be given to studies related to the Bartonian GSSP, the only Paleogene Stage pending definition. Fieldwork is planned in several Italian and Spanish sections, and on-going studies of the Bartonian WG will likely lead to the resubmission of an improved proposal in 2024.

- An *ad hoc* working group will evaluate sections of the base of the Ypresian from different paleogeographic areas and depositional settings as potential auxiliary sections.
- Contribute to the International Geological Meeting in South Korea 2024, and participate in the business meetings of the ICS.
- Potential funding sources external to IUGS: Most of the research that is currently being done by the ISPS members is financially supported by their home countries' research grants.

#### *Cretaceous Subcommission*

- Maastrichtian GSSP. Milestones to achieve in 2024 are centered around the documentation of the Tercis section and comprise the (1) accomplishment of sample processing for micropaleontology, (2) biostratigraphic work on the calcareous nannofossils and foraminifera, (3) cyclostratigraphy of the different time series with the scope of the development of an astrochronology for the Maastrichtian stage, (4) further field work at Tercis for macrofossils particularly inoceramids, (5) dissemination of results at conferences and possibly a first manuscript about cyclostratigraphy. A second part of the work plan deals with data compilation for the development of auxiliary sections for correlation. Potential candidate sections are the Vistula and Krons Moor sections (Poland, Germany), Gubbio section (Italy), and the stratigraphic record of ODP Site 1210 (central Pacific Ocean).
- Aptian GSSP. Selection of the auxiliary sections following a second round of discussions after the selection of the candidate GSSP.
- Valanginian GSSP. A formal proposal (Vergol as GSSP and Cañada Luenga as SABS) is currently being written. It should be finished by Jan/Feb 2024 and sent to the Valanginian WG for discussion. If approved, the formal proposal will be submitted (Spring 2024) to the SCS for voting. We hope that by the end of 2024 the proposal will be formally voted and approved by ICS.
- Berriasian (J/K boundary) GSSP. In 2024, detailed elaboration of the 'upper Tithonian' option will be performed with special attention to possible primary markers in the Tethyan area: calpionellid, calcareous nannofossil events and magnetostratigraphy. A discussion on large-scale climatic events and trends and their correlation potential will be continued, as well as possible identification of the VOICE isotopic event in the Tethyan record. Thanks to the economic support from ICS and IUGS, dating of the volcanic rocks is planned, and considering possibilities of astrochronological calibrations of the J/K boundary interval, which has just started (manuscript in preparation about Neuquen Basin, unpublished data from a Carpathian section in Poland).
- Kilian Group. The Kilian meetings are usually held every 3 or 4 years (2002; 2005; 2008; 2010; 2013; 2017; 2022). The next Kilian Group meeting will be held in 2025 in Hannover, prior to the first day of the 12th International Symposium on the Cretaceous System.

#### *Jurassic Subcommission*

- Executive and voting members: Approval of extension of term of office for the chair, or election of a new chair depending on view of voting members (currently ongoing). Appointment of new vice chair and replacement of six voting members.

- Callovian GSSP: Formation of refreshed working groups following constructive discussion at the 11th Jurassic Congress and Strati 23 followed by the search for other possible sections and primary markers facilitated by online meetings.
- Oxfordian GSSP: A field meeting is planned for March 2024 at the Redcliff Point candidate to carry out a new high-resolution sampling programme, both to look for a cyclostratigraphical/ orbital chronology as well as to provide chemostratigraphical data at a chronostratigraphical resolution similar to the sections in SE France. Work is also continuing on the section SE France including photographing the many ammonite specimens. Discussion of a primary marker. Preparation of one or two proposals for the working group to vote on.
- Kimmeridgian GSSP: Delayed celebration and promotion of the Kimmeridgian GSSP on the Isle of Skye, Scotland.
- Tithonian GSSP: Online meetings and field work within the new working group to establish possible sections and markers. This will include re-assessment of the evidence at Mount Crussol and Canjuers in SE France, and Fornazzo, Sicily all of which have previously been suggested and have some data. Consideration of possible new sections in South America.
- High resolution subdivision and correlation of the Jurassic: Formation of a new working group to consider a variety and a system of markers for high-resolution correlation of the Jurassic including suggested nomenclature.
- Next Jurassic congress: Preparation for and promotion of the 12th International Jurassic congress in Exeter, UK in 2024. Further advancement of the field guides.

#### *Triassic Subcommittee*

- Organising the STS Symposium/Sessions: Mid-Phanerozoic mass extinction, recovery, extreme environmental events and integrated stratigraphic correlations, joint with the 37th International Geological Congress, 24th-31st August, 2024, Busan, Korea, in which STS business meeting is held, progresses on GSSPs for IOB, OAB, CNB, and NRB are reported.
- Organising the STS Field Workshops: The Olenekian-Anisian Boundary Successions in Romania (14th -16th July, 2023) and in South China (10th -16th October, 2023).
- GSSPs: The plan is to move towards a vote on the GSSP for CNB in 2024 within STS. The IOB, OAB and NRB GSSPs move towards preparing a discussion document among the working group members at the Busan meeting in 2024, as a prelude to moving towards a vote on the candidate markers and sections.

#### *Permian Subcommittee*

- We plan to have the proposal of the base Kungurian GSSP published in *Permophiles* and voted by SPS voting members.
- We plan to begin the revision of the Guadalupian base Roadian and base Wordian GSSPs.
- We plan to organise several webinars.
- We plan to support the activity of the working groups.
- We plan to renew the composition of the voting members bringing in more younger members of the Permian community.

- We plan to publish two *Permophiles* issues.

#### *Carboniferous Subcommittee*

- The re-definition of the Devonian-Carboniferous boundary will be summarised by the working group leaders, and they form the base of a proposal to be submitted to the subcommission in January 2024. It is anticipated that SCCS will vote on the proposal during February, which if validated, would allow the working group to initiate the search for a suitable GSSP. Seeing the amount of data accumulated for very different facies realms and palaeogeographical situations over the last years, a proposal for a GSSP should be elaborated in a timely manner.
- A detailed proposal for the GSSP defining the base of the Gzhelian stages will be provided and be voted by both the task group and SCCS, and the result should be submitted to the ICS in 2024.
- Evaluation on selecting boundary markers of the Bashkirian-Moscovian boundary will be discussed among the working group. The conodont lineage *D. benderi*–*D. ellesmerensis* is high-potentially selected as the boundary marker and will be send out for voting among working group and voting members.
- Since a four-days online meeting in May 2021 dedicated to the Kasimovian Stage, its lower boundary has been widely investigated. Within the phylogenetic lineage *I. swadei*–*I. heckeli*–*I. turbatus*, *I. heckeli* is considered to be the best marker for the basal boundary of the Kasimovian Stage. It will be discussed among working group and voting members. The formal proposal will be voted by the working group and subcommission hopefully in 2024, at last in 2025.

#### *Devonian Subcommittee*

- Work on formal proposals or progress reports submitted from key areas for the revision of the basal Emsian GSSP.
- Revision of the D/C boundary with the D/C Boundary Task Group in close collaboration with the Carboniferous Subcommittee. Progress towards selection of candidate stratotypes.
- Real SDS business meeting and Devonian symposia.

#### *Silurian Subcommittee*

- ISSS working group focused on restudy of the base of the Homeric GSSP will be established and working group for base Wenlock GSSP will be reactivated.
- Division of the Přídolí Series into Jarovian and Radotinian stages proposed by Manda *et al.* (2023) will be discussed. The Silurian Subcommittee will be hopefully able to complete this work by submission of the formal proposal of the Hvížd'alka section as a GSSP for the upper Přídolí unit - Radotinian Stage.
- Joint ISSS-SDS conference with field-meeting and business meeting in Sofia, Bulgaria, postponed due to Covid related travel restrictions and subsequent Russian war, will take place in September 2024 in collaboration with Geological Institute of Bulgarian Academy of Sciences and University of Mining and Geology, Sofia.

Continuing updates of the website for Silurian Subcommittee by webmaster Huang Bing.

#### *Ordovician Subcommittee*

- Elections to select a new Executive board (2024–2028).
- Partial replacement of Voting Members for the term 2024–2028; the objective is to reach a perfect gender balance and the best possible global coverage.
- Official inauguration of the second Auxiliary Boundary Stratigraphic Section and Point (ASSP) for the base of the Ordovician System at the Dayangcha section (Northern China), June 2024.
- Participation of SOS to the 37th International Geological Congress (IGC37), Busan (Korea), August 2024.
- Support of the 4th Annual Meeting of IGCP 735 to be held in Córdoba, Argentina, October 2024.
- Data will be gathered for Ordovician News 41 (to be published in March 2024).

#### *Cambrian Subcommittee*

- The Cambrian Subcommittee will continue work toward defining GSSPs for its remaining provisional stages. The key objectives are as follows:
- Decide on how to define Stage 10, then begin discussions on candidate GSSP sites, with the aim of naming and ratifying this stage over the next 12–18 months.
- Re-establish the Working Groups for Stages 2, 3 and 4, including new chairs, and commence discussions on how best to define these stages.
- Continue examining issues surrounding the definition of the basal Cambrian GSSP
- Update and enhance the Cambrian Subcommittee website.

#### *Ediacaran Subcommittee*

- Field workshop to examine Ediacaran successions in Brazil. This trip will run in November 2023 (Previously 2020). Focus will be on the Corumba and Bambui groups in Brazil. The Corumba and Bambui groups contain Cloudina and other tubular fossils that are being considered as key biostratigraphic criteria to define the terminal Ediacaran stage (TES), and thus they are highly relevant to the missions of the Subcommittee. The field workshop will be organised and led by Subcommittee Secretary Lucas Warren and his colleagues in Brazil. The field guide is attached (Appendix).
- Developing and managing a special issue (most likely in *Episodes*) that brings our membership up to speed on the progress made over the past 5 years (since Xiao *et al.*, 2016. Towards an Ediacaran time scale: problems, protocols, and prospects. *Episodes*, 39(4), pp.540-555). This special issue will also summarise regional Ediacaran stratigraphy and potential criteria for the definition of the terminal Ediacaran stage (TES). Each manuscript will be formatted identically and designed as a facts-only short format where all proposed defining characters of the Series and Stages are identified and compared across sections. Importantly, recent recalibration and dating of the global Shuram negative excursion (Rooney *et al.*, 2020, Calibrating the coevolution of Ediacaran life and environment. Proceedings of the National

Academy of Sciences. 2020 Jul 21;117(29):16824-30) may finally provide a strong correlative character for the base of the Series and Stage. We believe we are close to a final vote and wish to have all the facts in one place before voting. With the change in leadership, we also require a change in our subcommittees. These committees will be tasked with setting realistic boundaries within both proposed Series. This work is ongoing from last report.

- Construction of a database of all known end-Ediacaran sections worldwide. This includes fact-finding searches concerning the geology, geochemistry, and palaeontology of each section. This is currently underway and continues as new data arises and will be instrumental to the ‘white paper’ listed above. This task was listed last year but we had residual difficulties at organizing the members following Covid. Our most recent meeting at GSA represents the first one since 2020, and was viewed as a ‘relaunch’ by the executive. The past few years have been particularly difficult for members of the executive, especially in terms of being able to attend conference due to the high costs of these events. We hope to be able to have more in person events and meetings in 2024.
- Holding a vote for new/renewed executives and voting members for 2025-2028.

#### *Cryogenian Subcommission*

- Working on and voting for criteria to define the base of the Cryogenian System before March 2024. A white paper to propose three-fold subdivision of the Cryogenian System is planned to be submitted to ICS and published in *Episodes*.
- Field trip to Namibia jointly sponsored by Cryogenian and Ediacaran subcommissions, led by voting members Galen Halverson and Marc Laflamme, possibly during June, 2024. The ca.10 days excursion will aim to examine classic Tonian-Ediacaran successions in northern Namibia, as well key sections in southern Namibia.
- South China field trip jointly sponsored by Cryogenian and Ediacaran subcommissions, led by voting members Maoyan Zhu and his colleagues. A 6-day field trip after 37th ICS to look at sections covers critical intervals during the Tonian, Cryogenian and Ediacaran periods in the western Hubei, South China.
- Cryogenian Webinar Series. During 2020 and 2021, the webinar series are proven to be a great way to introduce the up-to-date research of the Tonian/Cryogenian records worldwide, and offer good opportunities for discussion among researchers. Each time, we have up to 50 attendees. The subcommission decides to reactivate the webinar series during 2024, and aim to cover another two key Cryogenian groups. The webinar series will be organised by Ying Zhou.

#### *Precryogenian Subcommission*

- The subcommission will proceed with the ICS vote on the following subdivisions of the Archean Eon: the Lower/Upper Paleoproterozoic (the final proposal for a vote by our subcommission is in progress), the Paleoproterozoic/Mesoproterozoic boundary, the Mesoproterozoic/Neoproterozoic boundary.

- A working group on the Mesoproterozoic has been established.
- It is intended to establish the GSSA on Eo-/Paleoarchean rocks for example in the Buick Geoheritage Reserve, Western Australia, and in the Barberton Greenstone Belt, South Africa.
- The Subcommittee is exploring Meso- and Neo-Proterozoic rock successions in collaboration with the Geological Survey of Western Australia. For this, Noffke will discuss in the field with Sara Martin and Heidi Allen, both of the Geological Survey, in Perth. An invitation by the Survey and the trip is in preparation.
- The results of these discussions will be presented at the meeting of the IAS in Aberdeen, Scotland.
- Currently there are 3 manuscripts that are in the process of being published in 2024: a manuscript lead by Halla and Reis on the base of the Hadean Eon (submitted to *Episodes*); an a manuscript on the basal Archean boundary (finalised and submission to *Episodes* is in preparation); and a manuscript led by Reis and Noffke on the Lower/Upper Paleoarchean boundary (in progress).

#### *Stratigraphic classification*

- For the chapter Biostratigraphy some of the manuscripts are already submitted and are currently under review. Nine manuscripts are expected in total which have to be reviewed and edited. Publication of the special volume in *Newsletters on Stratigraphy* is expected in late autumn 2024.
- For the chapter Chronostratigraphy several meetings and workshops are planned. The manuscript should be ready in autumn 2024.
- The chapters altogether represent the base for the new version of the *International Stratigraphic Guide* which will also be outlined during 2024.
- Potential funding sources external to IUGS. The Subcommittee does not envisage being able, as an organisation, to obtain significant funding from outside IUGS/ICS sources. Some financial support could be obtained by individual members from their host institutions and/or their personal research funds. There is, however, a considerable amount of in-kind funds supporting the activities of all ISSC members, such as covering of travel costs to our workshops etc.

#### *Timescale Calibration*

- Session to be organized at the GSA National Meeting in 2024.
- Holding the first ISTC digital subcommittee meeting to be held online in 2024.
- Making a concrete plan and securing a publisher for the next iteration of the GTS.
- 

#### *Graphics Officer and Webmaster*

- For the upcoming year, points of attention and plans of the officers are:
- Keeping the ICS website up to date with chart status and downloads, ICS activities and news items, ICS output, ICS subcommittee activities and content, stratigraphic guide text and downloads, statutes and annual report archives, and so on.
- Further integrating the workflows that follow each IUGS ratification, ICS Executive and ICS subcommittee chair approved requests to change chart

content, namely cross-check if with a new GSSP also the numeric age is wished to be amended.

- The updating of the chart PDF/JPEG (editing and exports from graphics software)
- The updating of the chart in Semantic Web representation (pushing edits on GitHub).
- The uploading of the chart on the websites (emailing and web-admin).
- Updating the interactive chart connection to the latest GitHub-stored version.
- Release of updated translations of the ICS chart.
- Improved digital representation (structuring and accessibility of the chart).
- Continued data remodelling work on the Semantic Web representation of the Chart (LINK) to better represent stratigraphic and temporal typologies has commenced with a new Knowledge Graph of Chart and related information being built at LINK. Co-authoring this remodelling with Nicholas Car is Steve Richard, one of the two main contributors of the Semantic Web form of the Chart.
- *Episodes* paper on developments on the ICS chart over the last 10 years, to succeed the 2013 paper (i.e. a paper at meta-level: formal administrative, distribution-technical, digital-era representation-diversity and diversity-of-usage orientated).
- CGI has agreed to provide a technical facility for the publication of machine-readable vocabularies for its peer organisation's products, such as the Up-to-date Data version of the Chart.
- The ICS Webmaster has submitted the Up-to-date Data version of the Chart for publication there.
- Enhancements to the Up-to-date Data version of the Chart will be made in 2024 such as further language annotations to allow for eventual auto-generation of the PDF Chart from the data version.

## 11. OBJECTIVES AND WORK PLAN FOR THE CURRENT 4 YEAR TERM (2020-2024)

The following is a summary of objectives of the ICS Executive Commission and a selection of key goals noted in the detailed reports of each subcommission.

### *ICS Executive*

- Define a substantial number of GSSPs, particularly for stages in the Carboniferous, Triassic, Jurassic, Cretaceous, and Cambrian systems; re-evaluate GSSPs for the several Silurian stages and the Devonian-Carboniferous boundary, and of the Cambrian System (Paleozoic Erathem, Phanerozoic Eonothem), and select GSSP-defined subdivisions of the Precambrian.
- Maintain website (and the ICS App) and its formal, permanent archive of the global geostandards - GSSPs and the ICS International Chronostratigraphic Chart.
- Continue coordinating websites and the information they contain among all subcommissions and the Commission in order that they become the primary



global web-based entry point to information on the activities and accomplishments of the subcommissions and ICS.

- Encourage subcommissions to re-assess regularly GSSPs and to develop new initiatives and projects that utilise the refined International Stratigraphic Chart.
- Encourage the recruitment by subcommissions of members from under-represented countries/regions and of those at early career stages.
- Promote the preservation of GSSPs by local communities and national stratigraphic commissions and dedication ceremonies, including the placement of permanent markers, at all ratified GSSPs.
- Produce a new edition of the *International Stratigraphic Guide* with its joint publication by IUGS and the Geological Society of America
- Continue development of a strong link between ICS and the Geobiodiversity DataBase (GBDB) at the Nanjing Institute of Geology & Palaeontology
- Maintain close collaboration with all national stratigraphic commissions.
- Cooperate with One-Geology, One-Stratigraphy and the Commission on the Geologic Map of the World to ensure that these projects continually incorporate the latest revisions to the International Stratigraphic Chart.
- Serve as the primary international body setting global standards and illustrating best practices in stratigraphy.
- To continue to integrate fully the new Subcommission on Timescale Calibration (ISTC) under the leadership of Dr Brad Cramer (cf. below) into the ICS structure.

#### *Quaternary Subcommission*

- Develop and submit a GSSP proposal for definition of the Upper/ Late Pleistocene and its respective Stage/Age.
- Analyse candidate GSSPs for the Anthropocene, and submit a proposal for formalisation to the SQS
- Re-investigate the GSSP for the Gelasian Stage (and Lower Pleistocene Subseries, Pleistocene Series, Quaternary System) at Monte San Nicola, Sicily.
- Explore the possibility of a second stage for the Middle Pleistocene, based around the increasingly well-recognised Mid-Brunhes Transition.
- Continue to examine the fine-scale subdivision of the Quaternary.
- Continue to develop/update detailed correlation charts for the Quaternary (Cohen & Gibbard, 2019, *Quaternary International*, is the latest version).

#### *Neogene Subcommission*

- We will hold a virtual meeting with members in spring 2022 and a tentative field trip to La Vedova section Conero Riviera, Italy after Sept. 2022. As noted above, we have three action items to:
- submit the final proposal for La Vedova as the Langhian boundary stratotype and to subsequently vet and vote on the proposal;
- evaluate possible boundary stratotypes and criteria for the definition of the base of the Burdigalian Stage;
- submit a preproposal to ICDP to drill the Gelasian, Piacenzian, and Zanclean stages in Sicily.

#### *Paleogene Subcommission*

- To find a type section and agree on the criteria for the formal definition of the base of the Bartonian, and submit a GSSP proposal to the Paleogene Subcommission voting members and ICS.
- To prepare the report on the Bartonian GSSP proposal to be submitted to the ICS and the IUGS.
- To celebrate the official ceremony to place the Golden Spike at the GSSP for the base of the Priabonian in Alano di Piave section, Italy.
- To produce an updated version of an integrated Paleogene Time Scale.
- Preparation of standardised regional correlation charts and palaeogeographic maps by the regional Committees.
- To support studies for the completion of the Paleogene astronomical time scale. This will contribute to filling the so-called “middle Eocene astronomical timescale gap” and will help to connect existing floating calibrations with the astronomically tuned standard Neogene time scale.
- Update the status of Paleogene working groups, creating new working groups as necessary and closing those which have completed their task and/or are inactive.
- Revisit existing GSSPs and, if necessary, define new GSSPs and/or SABSs in order to characterise better the following boundaries:
  - Thanetian/Ypresian (P/E) boundary (i.e., Alamedilla, Caravaca and Zumaia sections in Spain; Forada and Contessa Highway sections in Italy; Polecat Bench in Wyoming);
  - Danian/Selandian boundary: Contessa and Bottaccione sections in Italy; Caravaca and Sopelana sections in Spain;
  - Selandian/Thanetian boundary: Contessa, Italy.
  - Base of the Rupelian (E/O boundary): Monte Cagnero and Monte Vaccaro sections in Italy.

#### *Cretaceous Subcommission*

- Spring 2024: Vote by the SCS of the Valanginian GSSP.
- 29 June 2024: official ceremonies for the inauguration and placement of the golden spikes of the Albian and Hauterivian GSSPs.
- 2024: Finalisation of the GSSP proposal for the base Aptian and vote within the WG.
- October 2024: golden spike ceremony of the Barremian GSSP.
- 2024–2026: Research activities toward the preparation of the GSSP proposal for the base of the Berriasian and Maastrichtian Stages.
- 2025: Vote by the SCS of the Aptian GSSP.
- 2026-2028: Finalisation of the GSSP proposal for the base Berriasian and Maastrichtian and vote within the WG and SCS.

#### *Jurassic Subcommission*

- Complete or significantly advance the defining of the remaining Jurassic GSSPs (Calloviaian, Oxfordian, and Tithonian) through revitalising the working

groups and facilitating progress by encouraging constructive collaboration and raising funds.

- Increase diversity and facilitate research aspirations at all career stages by championing representation through the new official positions, providing a diversity of opportunities, role models and subject specialist champions.
- Facilitate communication on the Jurassic for both specialist and non-specialist audiences. including promoting the Jurassic GSSPs. This will be achieved through meetings, workshops, *Volumina Jurassica*, outreach activities and maintaining an up-to-date and informative subcommission website.
- Improve resolution and correlation of the integrated stratigraphy for the Jurassic.
- Further our understanding of the Earth system during the Jurassic especially palaeoclimate change.
- Provide support to IGCP 655 (Toarcian) and future IGCP projects related to the Jurassic.
- Work with the Cretaceous Subcommission to help them define the base of the Berriasian Stage and the Jurassic/Cretaceous boundary.
- Work with national and international bodies to protect Jurassic geological sites, asses and promote their natural capital.

#### *Triassic Subcommission*

- A total of two international symposia, 2-3 STS sessions, 1-2 thematic issues, significant progresses on 4 GSSPs (2 of them can be ratified) are anticipated to be achieved:
- Organisation of the International Symposium on Triassic Integrated Stratigraphy and Bio-Environmental Events in Wuhan, China on 03-07 November, 2022.
- Organisation of the International Symposium and Field Workshop on Triassic Stratigraphy and Bioevents in Albuquerque, New Mexico, USA in June-August, 2024.
- Launching global Triassic book series: *Triassic of the World*, and inviting the Triassic workers from around the world to write various volumes and chapters in 2022-2024.
- Organisation of the STS sessions in major conferences, and journal special issues in 2022-24.
- Norian GSSP: This GSSP is anticipated to move towards a vote in late 2022.
- Olenekian GSSP: Completing the GSSP proposal and submitting to STS for ratification in 2023.
- Anisian GSSP: The GSSP of OAB is to be voted in 2023-2024.
- Rhaetian GSSP: A long-time stasis in this group has seen no significant prospects of change. If this continues into early 2022, a new chair of this working group will be sought to move forward at a faster pace.

#### *Permian Subcommission*

- Establish the Artinskian and Kungurian GSSPs.
- Revise the Permian timescale where it needs to be improved (Guadalupian stages, replacement GSSP section of the base-Lopingian).
- Establish a robust palaeogeographic frameworks for the Permian and focus on N-S correlations.

- Propose DDE-sponsored informatics support for biostratigraphic data management and palaeogeographic reconstructions.
- Organise webinars to increase the size, diversity and international coverage of the Permian Community
- Publish at least two *Permophiles* issues each year.

#### *Carboniferous Subcommission*

- We intend to combine high-resolution biostratigraphy and other stratigraphic methods in multi-proxy approaches to establish as many of the remaining GSSPs as possible. It should be possible to select the defining events for one to two stage boundaries and to make significant progress toward selecting candidate sections for the GSSPs.
- We will encourage and pay more attention to finding volcanic ash beds for radiometric dating, in order to establish a more precise Carboniferous time scale and facilitate the correlation of important Carboniferous events at global scale.
- Using multi-discipline methods including palynological studies, U-Pb dating and stable isotope studies, we will further promote marine and non-marine correlation.
- Integrate the Carboniferous databases from the entire world, combining the Geobiodiversity Database (GBDB, a large compilation of data about sections) at Nanjing Institute of Geology and Palaeontology, the Palaeobiology Database (a large compilation of data about fossils) at the University of Wisconsin-Madison, DDE (Deep Time Digital Earth) and other major databases, to facilitate the studies on Carboniferous biota and stratigraphy.

#### *Devonian Subcommission*

- Annual business meeting of the SDS took place on 30 July in Geneseo, NY, USA in conjunction with this meeting field trips from Ohio to the New York State were held. It was the most important event for our community directly focussed on the Devonian. The conference was very successful, perfectly organised, and both scientific sessions and fieldtrips were highly attended.
- The SDS meeting in conjunction with the STRATI was held on 12 July.
- At both SDS meetings the Chair informed about major points in the business meeting agenda and the current situation in our Devonian community, on-going Devonian projects (mostly reports on biostratigraphical, petrophysical and geochemical data from the key areas and progress in the Basal Emsian boundary redefinition), Devonian publications and forthcoming meetings. We had altogether around 40 participants including guests, 14 new corresponding members were recruited from Belgium, Colombia, Portugal and USA.
- Update of the new SDS website – hosted on the ICS web (stratigraphy.org)
- Publications: SDS Newsletter No. 38, and an extensive monograph titled ‘Devonian of New York’, edited by C. A. Ver Straeten, D. J. Over & D. Woodrow in 3 volumes of the *Bulletins of American Paleontology* has been published.
- Formal election of the SDS executive (officers and voting members) for 2024-2028. The elections took place in September and October 2023.

#### *Silurian Subcommission*

- Principal work will be devoted to GSSP-related research activities – restudy of some previously ratified but currently inadequate stratotypes and search for sections suitable for auxiliary stratotypes.
- Base Wenlock working group will be reactivated in order to examine stratigraphic and correlation potential of the new Telychian-Sheinwoodian boundary section discovered in Prague-Vyskočilka.
- Restudy of the Homeric GSSP will join the programme.
- Establishment of working groups for the replacement base Gorstian GSSP and base Ludfordian GSSP.
- Work on higher-resolution correlation of principal Silurian biozonations (graptolite, conodont, and chitinozoan) with carbon isotope excursions in the timeframe provided by presumed new radiometric data.

#### *Ordovician Subcommission*

- After previous meetings in Lisbon, Portugal (2013), Graz, Austria (2015) and Milan, Italy (2019), Thomas Servais (Chair) will be organising the fourth international congress on stratigraphy (STRATI 2023) under the auspices of the International Commission on Stratigraphy (ICS). STRATI 2023 will take place in Lille, France (11–13 July, 2023). The field excursion to the Ordovician of Estonia (15–18 July, 2023) is co-organised with ISOS 14 (see below). The Ordovician Subcommissions schedules both a business meeting and a scientific session.
- Support of the joint ISOS 14 and 3rd Annual Meeting of IGCP 735 to be held in Tallinn, Estonia (19–21 July, 2023), including field excursions to the Ordovician of Estonia (15–18 July, 2023) and Sweden (23–26 July, 2023).
- Data will be gathered for Ordovician News 40 (to be published in March 2023).

#### *Cambrian Subcommission*

- The principal objective of the Subcommission is to recognise and scrutinise the possibilities for horizons and GSSP stratotypes for the remaining undefined stages, which are provisionally identified as Stages 2, 3, 4, and 10. The ISCS has developed a prioritised plan for formalizing definition of the remaining undefined stages and their GSSPs. The plan is as follows:
- Provisional Stage 10 is expected to be defined next, and a decision on a GSSP will likely be made in late 2024 or 2025
- Following a decision on Stage 10, provisional Stages 2, 3, and 4 are expected to be defined in fairly rapid succession. A decision on the preferred GSSP horizon of any one of these three stages will restrict choices for the remaining two stages, so the ISCS is approaching work toward definition of the three stages as closely linked
- A longer-term objective is to re-examine the basal Cambrian GSSP (Terreneuvian Series, Fortunian Stage). Imprecision in correlating the lower boundary of the Cambrian System has been encountered on all palaeocontinents, and the ISCS is now engaged in seeking a practical solution to remedy the problem, in collaboration with the Ediacaran Subcommission.

#### *Ediacaran Subcommission*

- The Subcommittee will finally undertake its fieldtrip to Brazil in November 2023. It has now become a joint Ediacaran/Cryogenian trip, with voting members from both SC joining.
- The website continues to grow: as part of the Executive transition, we wished to transfer the website to new ownership. We also solicited our colleague Dr. Tara Selly to act as web-developer. <http://ediacaran.stratigraphy.org/>
- The construction of a database of known late-Ediacaran sections has been put on hold as we re-evaluate the likely geochemical and geobiological tools used to define the boundaries. We will have a new survey of our voting members in January 2024, leading to a submission to Episodes once complete (similar to Xiao *et al.*, 2016).
- A special issue of the Journal of Paleontology with the executive members (Laflamme, Schiffbauer, Warren, Selly) and voting member (Liu) as guest editors is finally complete. All eight manuscripts have successfully gone through the peer-review process.
- We held a SC meeting in conjunction with GSA2023 in Pittsburg USA. It was attended by several voting members including Marc Laflamme, Jim Schiffbauer, Guy Narbonne, Shuhai Xiao, Jay Kaufman, Luis Buatois and Tara Selly in attendance, in addition to a large group of potential corresponding members as it was held in conjunction with an Ediacaran ‘meet and greet’ event organised by voting member Mary Droser (not in attendance) and her students.

#### *Cryogenian Subcommittee*

- Voting for criteria to define the base of the Cryogenian System (2021)
- Call for proposals for basal Cryogenian GSSP candidates (2022).
- Voting and ratification of basal Cryogenian GSSP (2023).
- Establishment of working groups on Cryogenian subdivision (2022)
- Voting and ratification of Cryogenian series (2023-2024).
- Interface with other international projects / groups.
- Field trips planned: (1) Utavi, Namibia field trip, mid-July, 2021 (organised by Karl-Henz Hoffman and Galen Halverson); Scotland field trip, May 2021 (virtual and already in planning, organised by Ian Fairchild and Tony Spencer); Tonian Urals field trip, 2022 (organised by Anton Kuznetsov); South China field trip, 2023 (organised by Maoyan Zhu).

#### *Precryogenian Subcommittee*

- The Subcommittee has made significant progress in evaluating the possible venues of subdividing the Hadean and Archean stratigraphy. The subcommittee is finalising a manuscript that will discuss the problematic and present possible solutions. Submission is geared towards the beginning of 2022. The commission will submit also a proposal to fund a virtual field trip programme to a major funding agency in the USA and in Brazil. After final voting on the Hadean and Archean on the ICS level, the Subcommittee will re-organise to focus specifically onto the Mesoproterozoic. Several colleagues, including Linda Kah, University of Tennessee, have expressed interest in leadership roles.

#### *Stratigraphic Classification*

- For the Biostratigraphy chapter the next steps (define potential reviewers for special volume and finalise publication) have to be done.
- The session “Phanerozoic stratigraphy, palaeoceanography, and palaeoclimate” will be held at the EGU General Assembly 2023 (EGU 2023), 23-28 April 2023, Vienna, Austria.
- A business meeting will be held during STRATI 23 in Lille, France.
- All the remaining review papers on the various branches of stratigraphy will be submitted 2023.

#### *Timescale Calibration*

- Organising a major position volume to be focused on current best practices in timescale calibration as well as where we see the future of timescale calibration. This is to be a printed volume following on from the first subcommission meeting.
- Integrate the ISTC with other international as well as national and regional organizations. For example EARTHTIME, EARTHTIME EU, EARTHTIME China, Geochronology Division of the GSA, SEPM, The Palaeontological Association, The Paleontological Society, etc.

## APPENDIX 1: ICS DIRECTORY OF OFFICERS 2020-2024

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## **SUBCOMMISSION ON TIMESCALE CALIBRATION**

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P.L. Gibbard  
University of Cambridge  
4.01.24

D.A.T. Harper  
University of Durham  
4.01.24

## **APPENDICES: REPORTS OF INDIVIDUAL SUBCOMMISSIONS**

These reports were edited by the respective officers of the named subcommissions, and lightly edited by the ICS executive. This section includes a detailed report on the highly successful STRATI meeting in Lille 2023. These are presented here as submitted.





# International Commission on Stratigraphy Subcommission on Quaternary Stratigraphy

## ANNUAL REPORT 2023

### 1. TITLE OF CONSTITUENT BODY and NAME OF REPORTER

Subcommission on Quaternary Stratigraphy (SQS)  
Reporting Officer: Jan Zalasiewicz, Chair SQS

### 2. OVERALL OBJECTIVES, AND FIT WITHIN IUGS SCIENCE POLICY

1. Chronostratigraphic subdivision of the Quaternary System/Period facilitated by the intercalibration of biostratigraphies, construction of integrated zonations, and recognition of global datum points, allowing correlation worldwide and between terrestrial and marine sequences.
2. Definition of Series/Subseries/Stage and, where appropriate Substage, boundaries through the selection of recommended GSSPs.
3. Promoting SQS's activities within the wider Quaternary geoscience community through publications, symposia, and the SQS website, and creating opportunities to study and compare stratigraphic sections by means of field meetings.
4. The objectives satisfy the IUGS mandate of fostering international agreement on nomenclature and classification in stratigraphy; facilitating international co-operation in geological research; improving publication, dissemination, and use of geological information internationally; encouraging new relationships between and among disciplines of science that relate to Quaternary geology world-wide; attracting competent students and research workers to the discipline; and fostering an increased awareness among individual scientists world-wide of those related programs being undertaken.

### 3. ORGANISATION - interface with other international projects / groups

SQS works closely with the International Union for Quaternary Research (INQUA), which represents and serves the interests of Quaternarists worldwide. INQUA provides advice and crucial feedback on the stratigraphic needs of the wider Quaternary community. Prof. Thijs van Kolfschoten is both a voting member of SQS and President of INQUA, allowing direct and rapid liaison with the SQS on stratigraphic issues. An account of SQS progress and plans was published in the INQUA Newsletter, to help the exchange of information.

#### 3a. Nominated Officers for 2020-2024 period:

Chair: Professor Jan A. Zalasiewicz  
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Secretary: Professor Adele Bertini  
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#### 4. NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS

INQUA provides feedback and advice on SQS activities. INQUA's Stratigraphy and Chronology Commission (SACCOM) potentially offers modest financial support through its grants program, thereby assisting the work of SQS. Funding to assist with a field workshop intended to inaugurate new research on the Gelasian GSSP has been obtained from INQUA. The award to the Anthropocene Working Group of €800 000 from the Haus Kulturen der Welt, Berlin facilitated the administration and analysis of potential candidate GSSPs. Analyses of candidate sites have been completed (see below), and incorporated into the Anthropocene Working Group's formal proposal document, submitted to the Secretary, SQS on 31 October 2023.

#### 5. CHIEF ACCOMPLISHMENTS AND PRODUCTS

Participation in STRATI 2023 Meeting, Lille

SQS-led sessions:

1. Developments in Quaternary chronostratigraphy (convenors Martin Head, Adele Bertini, Liping Zhou and Jan Zalasiewicz)
2. The Anthropocene: stratigraphical concepts and evidence (convenors Colin Waters, Simon Turner, Jan Zalasiewicz and Martin Head)

Participation in INQUA XXI, 2023, Rome

SQS-led sessions

6B – GSSPs and stratotypes

Session 8: A second stage for the Middle Pleistocene Subseries?

Session 17: Fine-scale subdivision of the Quaternary: a land-sea perspective.

Session 19: Global characterization of the Neogene–Quaternary (Pliocene–Pleistocene)

transition: to presentations describing SQS-sponsored reanalysis of Monte San Nicola stratotype.

Session 40: The Anthropocene as a tool for characterizing recent planetary change and predicting future environmental challenges.



Martin Head presented an update of SQS activities during the SACCOM meeting at INQUA. This substituted for the SQS business meeting at STRATI which had to be cancelled owing to an overrun of the preceding session, and was a better venue for this presentation.

Colin Waters gave a keynote presentation at the Magna conference of the Brazilian Academy of Sciences May 2023

Proposal, and approval by the SQS, of the Ideale section, Montalbano Jonico (southern Italy) as a Standard Auxiliary Boundary Stratotype (SABS) for the Middle Pleistocene Series of the Quaternary System (Marino *et al.* 2023, below).

Submission by the Anthropocene Working Group of a formal proposal to the SQS for a Crawfordian Stage and Anthropocene Series.

### **SQS publications and conference abstracts:**

#### **(a) Published papers in thematic set on the candidate stratotypes for the Anthropocene**

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Waters, C.N., Head, M.J., Zalasiewicz J., McCarthy, F.M.G., Wing, S.L., Haff, P.K., Williams, M., Barnosky, A.D., Fiałkiewicz-Kozieł, B., Leinfelder, R., McNeill, J.R. Rose, N.L., Steffen, W., Summerhayes, C.P., Wagreich, M., An, Z., Cearreta, A., Cundy, A.B., Fairchild, I.J., Gałuszka, A., Hajdas, I., Han, Y., Ivar do Sul, J.A., Jeandel, C., Syvitski, J., Turner, S.D., Zinke, J. 2023b. Response to Merritts *et al.* (2023): The Anthropocene is complex. Defining it is not. *Earth-Science Reviews* **238**: 104335. <https://doi.org/10.1016/j.earscirev.2023.104335>

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Zalasiewicz, J., Head, M., Turner, S., Waters, C., Williams, M., 2023. On the starting point for a new geological epoch (1). *New Scientist* [Published online September 20, 2023; <https://www.newscientist.com/letter/mg25934570-300-on-the-starting-point-for-a-new-geological-epoch-1/>]

Zalasiewicz, J., Head, M.J., Waters, C.N., Turner, S.D., Haff, P., Summerhayes, C.P., Williams, M., Cearreta, A., Wagreich, M., Fairchild, I.J., Rose, N.L., Saito, Y., Leinfelder, R., Fiałkiewicz-Kozieł, B., An, Z., Syvitski, J., Gałuszka, A., McCarthy, F.M.G., Ivar do Sul, J.A., Barnosky, A.D., Cundy, A.B., McNeill, J.R., Zinke, J. 2023. The Anthropocene within the Geological Time Scale: analysis of fundamental questions. *Episodes* <https://doi.org/10.18814/epiiugs/2023/023025>

Zalasiewicz, J., Head, M.J., Waters, C.N., Turner, S., Williams, M., McNeill, J.R., Syvitski, J., Barnosky, A., Oreskes, N. and Haff, P., 2023. The Anthropocene: a changed planet. *Desert Report*, May 2023, 3-5. Sierra Club.

Zalasiewicz, J., Waters, C.N., Turner, S., Williams, M. and Head, M.J. 2023. Anthropocene Working Group. In: Wallenhorst, N. and Wulf, C. (eds.) *Handbook of the Anthropocene*, pp. 315-322. Springer.

Zalasiewicz, J., Williams, M. and Waters, C. 2023. Anthropocene patterns in stratigraphy as a perspective on human success. In: Desmond, H. and Ramsey, G. (eds.) *Human Success: Evolutionary Origins and Ethical Implications*. Oxford University Press: New York, pp. 205-223. DOI: 10.1093/oso/9780190096168.001.0001

Zalasiewicz, J. and Waters, C. 2023. Time and the Question of the Anthropocene. In: *Time and Science. Vol. 1, The Metaphysics of Time and its Evolution* (eds. Lestienne, R. and Harris, P.), pp. 311-331. World Scientific Publishing Europe Ltd.

Zalasiewicz, J., Williams, M., Waters, C.N., Barnosky, A.D. and Haff, P. 2023. Anthropocene. In: *Origins. The Origins of all Things* (eds., Harper, D. and Seberg, O.), pp. 409-422. ISBN 9788762819931.

## 6. SUMMARY OF EXPENDITURE IN 2023

Martin Head attendance at both INQUA/STRATI meetings = \$2938.91

Adele Bertini attendance at both INQUA/STRATI meetings = \$2290.00

Liping Zhou attendance at INQUA meeting = \$1500 (€1361.9)

Colin Waters attendance at STRATI meeting = \$875 comprising SQS registration \$400, travel \$250 and accommodation \$225)

Simon Turner attendance at INQUA meeting = £811 sterling for registration, travel and accommodation.

## 7. SUMMARY OF INCOME IN 2023

No other income in 2023

## 8. BUDGET REQUESTED FROM ICS IN 2024

Martin Head attendance at IGC: \$3100 (Registration \$700, flights \$1500, accommodation \$900)

Colin Waters attendance at IGC: \$3100 (Registration \$700, flights \$1500, accommodation \$900)

Adele Bertini attendance at IGC: \$3100 (Registration \$700, flights \$1500, accommodation \$900)

Liping Zhou attendance of IGC: \$2200 (Registration \$450, flights \$850, accommodation \$900)

**Total requested \$11,500**

## 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR:

- Rapid progress was made in the analysis of candidate stratotypes for the Anthropocene, the next major GSSP decision for the SQS. Voting by the Anthropocene Working Group led to selection of a candidate GSSP, in annually varved sediments of Crawford Lake, Canada, at a level representing 1952 CE and the beginning of the major, globally correlatable plutonium peak that represents the primary marker for this proposed chronostratigraphic unit. Three accompanying proposed SABSs were also voted on, and accompany 8 reference sections that demonstrate the precise correlation possible of this level across diverse sedimentary environments, both marine and non-marine. A resulting formal proposal was submitted to SQS on October 31<sup>st</sup> 2023. Extensive, deliberative, and open discussion/consultation within and beyond SQS will now begin prior to SQS voting.
- Selection of a GSSP for the Upper Pleistocene Subseries and its corresponding stage. Two potential candidates have already been identified (Fronte Section, Taranto, Italy; and

an ice core in Antarctica). The aim is to have proposals developed for these potential candidates as soon as possible. The Upper Pleistocene Working Group is being reformed under the co-convenership of Martin Head.

- Development of a nascent Working Group on a potential second stage for the Middle Pleistocene Subseries and its corresponding stage. This Working Group was formed this year under the co-convenership of Martin Head and Leszek Marks, and will begin by 1) completing the membership, 2) analysing whether a case can be made for a second stage, and 3) if so, the compilation of potential GSSP sections.

Conference involvement:

IGC 37, Busan, Korea: Invited keynote talk (C. Waters, AWG)

Session 2-87. Current and future directions in Quaternary chronostratigraphy. Conveners: Martin J. Head, Jan A. Zalasiewicz, Adele Bertini, and Liping Zhou.

Session 2-88. A global perspective on the Neogene–Quaternary (Pliocene–Pleistocene) boundary. Conveners: Antonio Caruso, Adele Bertini, Patrizia Maiorano and Wiesława Radmacher.

Session 2-72. UNESCO IGCP 732 and the Stratigraphy of the University of Anthropocene. Lead convener, Michael Wagnreich.

SQS Business meeting. Chair: Martin J. Head.

## 10. KEY OBJECTIVES AND WORK PLAN FOR THE PERIOD 2020–2024

- Develop and submit a GSSP proposal for definition of the Upper/ Late Pleistocene and its respective Stage/Age.
- Commence SQS deliberation process, prior to voting, following submission of the GSSP proposal for the Anthropocene
- Continue re-investigation of the GSSP for the Gelasian Stage (and Lower Pleistocene Subseries, Pleistocene Series, Quaternary System) at Monte San Nicola, Sicily.
- Explore the possibility of a second stage for the Middle Pleistocene, based around the increasingly well-recognized Mid-Brunhes Transition.
- Continue to examine the fine-scale subdivision of the Quaternary.
- Continue to develop/update detailed correlation charts for the Quaternary (Cohen & Gibbard, 2019, *Quaternary International*, is the latest version).

Respectfully submitted:

Jan Zalasiewicz, Chair SQS; Adele Bertini, Secretary SQS, Liping Zhou, Vice-Chair SQS, Martin Head, Vice-Chair SQS

19 November, 2023

## APPENDIX

Names and Addresses of Current Officers and Voting Members of SQS

## *Officers of SQS*

Chair: Professor Jan A. Zalasiewicz  
Department of Geology  
University of Leicester  
Leicester UK, LE1 7RH, UK  
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Vice-Chair: Professor Liping Zhou  
Department of Geography  
Peking University  
100871 Beijing  
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Vice-Chair (website): Professor Martin J. Head  
Department of Earth Sciences  
Brock University  
1812 Sir Isaac Brock Way  
St. Catharines  
Ontario L2S 3A1, Canada  
Phone: 905-688-5550 ext. 5216  
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Secretary: Professor Adele Bertini  
Dipartimento di Scienze della Terra  
Università degli Studi Firenze  
via La Pira 4,  
50121 Firenze, Italy  
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## *Other Voting Members of SQS*

Professor Helen Bostock<sup>[1]</sup><sub>[SEP]</sub>  
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Steele Building, The University of Queensland  
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Fax: + 31 (0)71 527 2928<sup>SEP</sup>  
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Fax: +44 1570 423669

Professor Cari Zazo  
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Museo Nacional de Ciencias Naturales (CSIC)  
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Fax: ++.34.91.5644740  
Email: mcncz65@mncn.csic.es

## List of Working (Task) Groups and their Officers

### *SQS Working Group on the “Anthropocene”*

Convener: Professor Colin Waters

School of Geography, Geology and the Environment



University of Leicester  
University Road, Leicester LE1 7RH, U.K.  
Phone: +44 (0)116 2523933 (School office)  
Email: cw398@le.ac.uk

Department of Geography  
University College London  
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London WC1E 6BT, UK.  
Phone: +44 (0)20 7679 0522  
Email: simon.turner@ucl.ac.uk

Secretary: Dr. Simon Turner

Voting membership of the Working Group: Tony Barnosky (USA), Alejandro Cearreta (Spain), Andy Cundy (UK), Ian Fairchild (UK), Barbara Fiałkiewicz-Kozieł (Poland), Agnieszka Gałuszka (Poland), Irka Hajdas (Switzerland), Han Yongming (China), Martin J. Head (Canada), Reinhold Leinfelder (Berlin), Francine McCarthy (Canada), Neil Rose (UK), Yoshiki Saito (Japan), Colin Summerhayes (UK), Jaia Syvitski (USA), Simon Turner (Secretary, UK), Michael Wagreich (Austria), Colin Waters (Chair, UK), Mark Williams (UK), Scott Wing (USA), Jan Zalasiewicz (UK), Jens Zinke (UK).

Non-voting, advisory membership of the Working Group: Jacques Grinevald (Switzerland), Peter Haff (USA), Juliana Assunção Ivar do Sul (Germany), Catherine Jeandel (France), John McNeill (USA), Eric Odada (Kenya), Naomi Oreskes (USA), Clément Poirier (France), Dan Richter (USA), William Shotyk (Canada), Davor Vidas (Norway), An Zhisheng (China),

### *Working Group on the Middle/Upper Pleistocene Subseries Boundary*

Co-convener: Professor Martin J. Head  
Department of Earth Sciences  
Brock University  
1812 Sir Isaac Brock Way  
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Ontario L2S 3A1, Canada  
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Co-convener: Professor Thomas Litt

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Email: t.litt@uni-bonn.de

Membership of the Working Group (in revision): Art Bettis (USA), Aleid Bosch (Netherlands), Philip Gibbard (UK), Liu Jiaqi (China), Peter Kershaw (Australia), Wighart von Koenigswald (Germany), Thomas Litt (Co-convener, Germany), Jerry McManus (USA), Alessandra Negri (Italy), Charles Turner (UK), Martin J. Head (Canada), and Jan A. Zalasiewicz, Liping Zhou (China).

### *Working Group on a Potential Second Stage for the Middle Pleistocene Subseries*

Co-convener: Professor Martin J. Head  
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Co-convener: Professor Leszek Marks  
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Email: lmar@pgi.gov.pl

Membership of the Working Group (in progress): Andriy Bogucki (Ukraine), Hai Cheng (China), Liping Zhou (China), Adele Bertini (Italy), Jan Zalasiewicz (UK), Kim Cohen (Netherlands), Yusuke Suganuma (Japan), Maria-Fernanda Sanchez-Goñi (France), Freek Buschers (Netherlands).

## Subcommission on Neogene Stratigraphy Annual Report 2023

### 1. TITLE OF CONSTITUENT BODY and NAME OF REPORTER

#### Subcommission on Neogene Stratigraphy (SNS)

Kenneth G Miller, Chair (since July 2020)

Department of Earth & Planetary Sciences, Rutgers, The State University of New Jersey

610 Taylor Rd., Piscataway, NJ 08854-8066 848 445 3622 cell 609 577 3297

[kgm@rutgers.edu](mailto:kgm@rutgers.edu)

Reporting: Kenneth Miller, Chair; Elena Turco, Vice Chair; Marie-Pierre Aubry, Secretary

### 2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY

The SNS is the primary body responsible for providing optimum clarity and stability in the Neogene Chronostratigraphic Scale by selecting and defining Global Stratotype Sections and Points (GSSPs) for Series, Subseries, and Stages and promulgating information on major events of the Neogene.

### 3. ORGANIZATION - interface with other international projects or groups

The SNS is a subcommission of the ICS, founded in 1971. Reference is made to the annual report of 1995 for a brief historical resume of the SNS and to recent updates of the SNS website <https://neogene.stratigraphy.org>. Including the three executives (Chair, Vice Chair, and Secretary), the SNS has 19 voting members, in addition to 23 corresponding members (*see Appendix for full list of officers and voting and corresponding members*). In reconstituting the SNS in 2020, we strove to include early career researchers) and ensure international balance (with 12 countries represented). The SNS has one active working group for defining the GSSPs for the Langhian and Burdigalian Stages, chaired by Frits Hilgen (University of Utrecht), with 11 members (listed in the *Appendix*). The SNS web site is used for news release and contains the following sections: Home, News, Board, Members, Newsletters, GSSP's, and Links. We have progressively updated the website including fall of 2023 and will continue this task through 2023 and into 2024.

Website: <http://neogene.stratigraphy.org>

#### 3a. Officers for 2020-2024:

**Chair:** Prof. Kenneth Miller, Department of Earth & Planetary Sciences and Institute of Earth, Oceans, and Atmospheric Sciences, Rutgers, The State University of New Jersey, 610 Taylor Rd., Piscataway, NJ 08854-8066, ph. 848 445 3622, cell 609 577 3297, [kgm@rutgers.edu](mailto:kgm@rutgers.edu)

**Vice Chair:** Prof. Elena Turco, Dipartimento di Scienze Chimiche, della Vita e della Sostenibilità Ambientale, Università degli Studi di Parma, Parco Area delle Scienze 157/A, 43124 Parma, Italy, Tel: +39 0521905366, cell +39 3396122117, [elena.turco@unipr.it](mailto:elena.turco@unipr.it)

**Secretary:** Prof. Marie-Pierre Aubry, Department of Earth & Planetary Sciences and Institute of Earth, Oceans, and Atmospheric Sciences, Rutgers, The State University of New Jersey, 610 Taylor Rd., Piscataway, NJ 08854-8066, ph 848 445 3622, cell 508 274 1406, [aubry@rutgers.edu](mailto:aubry@rutgers.edu)

#### 4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS

SNS travel of Secretary Elena Turco to the Strati meeting in Lille, France was supported independently. Miller and Aubry were not able to attend because of prior commitments and the extreme travel costs to Europe in summer 2023 (airfares more than doubling).

#### 5. CHIEF ACCOMPLISHMENTS

**Background.** In 2020 the Langhian and Burdigalian GSSP Working Group (chair: Frits Hilgen) succeeded in finding a consensus on a proposal to place the Langhian GSSP in the La Vedova section in Italy close to the top of C5Cn, the selected guiding criterium to recognize the base of the Langhian (Turco et al., 2017). Uncertainty related to the choice of calcareous planktonic events associated with the top of Chronzone C5Cn, and useful for the recognition of the Langhian base at low-latitudes, is still matter of debate. As an example, the taxonomic issues related to the *Praeorbulina* datum (the historical criterium for recognising the base of Langhian) are overt, as well as the low reliability for global correlation of the Last Common Occurrence (LCO) of *Helicosphaera ampliaperta*, an event proposed for the best approximation of the top of C5Cn in the Mediterranean.

Potential problems in correlation to the pending La Vedova GSSP requires a Standard Auxiliary Boundary Stratotype (SABS) in a Pacific IODP core, at the corresponding stratigraphic level, providing direct correlation to the open ocean benthic isotope record and low-latitude calcareous plankton events. Site U1337 will be designated as auxiliary open ocean boundary stratotype, as its continuous succession across the Burdigalian-Langhian boundary provides a good-quality benthic isotope record that has been astronomically tuned (Holbourn et al., 2015). The lack of magnetostratigraphy for Site 1337 can be overcome by through detailed cyclostratigraphic correlations (stable isotopes, CaCO<sub>3</sub>) to Site U1336 that has a reliable magnetostratigraphy across the boundary interval and is in good agreement with La Vedova section. However, these detailed correlations highlighted a missing 100-kyr cycle in the splice of Site U1337 just above the level that corresponds to the GSSP.

**Action in 2023.** In 2023, the SNS voted unanimously to approve both the La Vedova GSSP and the SABS in Site U1337. ICS voted unanimously to approve both. The paper documenting the GSSP *The Global Stratotype Section and Point (GSSP) of the Langhian Stage and of the Middle Miocene Subseries* by Turco E., Hilgen F., Raffi, Di Stefano A., Foresi L.M, Holbourn A., Iaccarino S.M., and Lirer F. was published in Episodes in November 2023.

<https://www.episodes.org/journal/view.html?uid=2344&vmd=Full> T

The following summary is from the press release announcing the GSSP:

*The IUGS Executive Committee voted unanimously on 29 May 2023 to ratify the proposal by the Subcommittee on Neogene Stratigraphy (SNS) for defining the GSSP of the base of the Langhian Stage (and Middle Miocene Subseries) of the Miocene Series and Neogene System in the Mediterranean Lower La Vedova Beach section (Ancona, Italy).*

*The Langhian GSSP is defined as level 17.84 m from the base of the section, in the middle of the dark coloured marly interval overlying Megabed IV. This stratigraphic level is astronomically calibrated to the most prominent ~100-kyr eccentricity maximum around 16 Ma and lies close to the Chron C5Cn/C5Br magnetic reversal boundary. This astrochronologic approach guarantees that the Langhian GSSP is directly incorporated in the integrated, astronomically dated stratigraphic framework that presently underlies the standard Cenozoic Geological Time Scale. In addition, Integrated Ocean Drilling Program (IODP) Site U1337 in the eastern equatorial Pacific, was designated Standard Auxiliary Boundary Stratotype (SABS) with the objective of directly linking the Langhian GSSP to the astronomically calibrated open ocean benthic foraminiferal stable isotope record and, hence, to the Earth's climate evolution.*

*Located in the open ocean, the SABS shows that the GSSP for the base of Langhian Stage and Middle Miocene Subseries/Subepoch at around 16 Ma falls within the Miocene Climate Optimum (MCO) - a particularly intriguing interval of peak global warmth which began in the preceding Burdigalian Stage at 17 Ma - and is ~400-kyr older than the most prominent eccentricity paced hyperthermal event within the MCO, and which is astronomically dated at 15.6 Ma. Further, the GSSP level is close to M12, a transient glacial [and cooling] event that punctuated the MCO.*

*The golden spike at the base of the Langhian Stage and Middle Miocene Subseries/Subepoch, constitutes a global reference point for both, precisely and accurately dating and correlating these long- and short-term climatic events, and anchoring astronomical chronologies. This is critical in view of the fact that the MCO may provide the best analog for understanding global warmth of the 21<sup>st</sup> century as atmospheric carbon dioxide levels were high (>500 ppm) and global temperatures were >5°C warmer than the 20<sup>th</sup> century averages.*

The discussion on the definition Burdigalian GSSP is still wide open since no suitable candidate section (astronomically tuned deep marine section, possibly in the Mediterranean, that would guarantee the stratigraphic contiguity with the other GSSP sections) is available. The working group will move on to evaluating placing the Burdigalian GSSP in a Pacific IODP site.

### **Session at STRATI 2023 Lille**

The executive board of SNS organized a scientific session at STRATI 2023 Congress, held in Lille (France). The session, related to SNS themes, was SC4: SNS *Neogene stratigraphy and paleoceanography*. Contributions to this session were very diverse dealing with different stratigraphic and/or paleoceanographic tools and covering almost all the intervals of the Neogene. A. Caruso (University of Palermo, Italy), invited to give a presentation, after a review of the reference sections for the Pliocene focused on the ongoing high-resolution study across the Neogene/Quaternary boundary at the Monte San Nicola Gela section (Sicily). Vice Chair Turco and Voting Member Drury convened the session, since Chair Miller and Secretary Aubry were not able to attend Strati 2023.

The Business Meeting of SNS was also held at STRATI 2023 and it was mainly related to the activity of the Burdigalian-Langhian WG. The ratification by IUGS of the Langhian GSSP at La Vedova section (Italy) and the SABS at Site U 1337 (eastern equatorial Pacific) were announced, and the main features of the sections and the criteria to recognize the base of the stage were shown. The state of the art of Burdigalian GSSP, the last Neogene stage to be formally defined, was presented in detail as well as all the issues that still have to be discussed within the WG.

### **Formalization of Neogene Subseries/Subepochs**

The International Commission on Stratigraphic Classification (ISSC) voted to recognize the rank of subseries as formal and to be integrated in the International Chronostratigraphic Chart (ICC) in 2021. This was approved by the ICS in 2022. Accordingly, the SNS voted positively for formalization as recorded in a contribution to *Episodes in 2022: Ratification of Neogene subseries as formal units in international chronostratigraphy* by Aubry, M.-P., Miller, K.G., Turco, E., Flores, J.A., Gladenkov, A., Grunert, P., Hilgen, F., Nishi, H., Holbourn, A., Krijgsman, W., Lirer, F., Piller, W.E., Quillévéré, F., Raffi, I., Robinson, M., Rook, L., Tian, J., Triantaphyllou, M., and Vallejo, F.

This was followed up by a 2023 paper on the implications of our 2022 ratification, *Unifying Cenozoic chronostratigraphy and geochronology: applying the rules* in Newsletter on Stratigraphy by Aubry, M.-P., Piller, W. E., Van Couvering, J.A., Berggren, W.A., Flynn, J.J., Head, M.J., Hilgen, F., Tian, J., Kent, D.V., and Miller, K.G.

### Planned drilling by the ICDP

Due to commitments for PETM drilling proposal to ICDP in Jan. 2023, we plan to submit a workshop proposal in Jan. 15, 2025 and run a workshop in late 2025 in Sicily.

### 6. SUMMARY OF EXPENDITURE IN 2020

|                            |            |           |
|----------------------------|------------|-----------|
| <b>Balance in Nov 2022</b> | <b>USD</b> | \$4175.90 |
| <b>Received in 2023:</b>   |            | \$0       |
| <b>Expenses in 2023:</b>   |            | \$        |
| <b>Balance in Nov 2023</b> |            | \$4175.95 |

Funds were allocated for the executive to attend Strati but not expended.

### 7. SUMMARY OF INCOME IN 2023

None

### 8. BUDGET REQUESTED FROM ICS IN 2024

We plan to use request additional funds \$4,000 to support two executives of SNS (Chair, Vice Chair, or Secretary) to travel to Busan for the International geological congress in 2024.

### 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR

The major plan is to identify a boundary stratotype for the Burdigalian stage in an IODP archived corehole. Discussions with WG Chair Hilgen suggest that we will ask A. Holbourn to take the lead on this task.

### 10. KEY OBJECTIVES AND WORK PLAN FOR THE PERIOD 2020-2024

We have three action items to:

- 1) Vote on the final proposal for La Vedova as the Langhian boundary stratotype. The proposal was vetted, discussed, and approved.
  - 2) Continue to evaluate possible boundary stratotypes and criteria for the definition of the base of the Burdigalian Stage; we plan to develop the proposal in 2024;
  - 3) Submit a Workshop to ICDP to drill the Gelasian, Piacenzian, and Zanclean stages in Sicily in Jan. 2024.
-

## **APPENDIX**

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## 1. SUBCOMMISSION ON PALEOGENE STRATIGRAPHY (ISPS)

*Submitted by:* Laia Alegret, Aitor Payros, Claudia Agnini

### 2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY

The ISPS is the primary body for facilitation of international communication and scientific cooperation in Paleogene Stratigraphy. In order to better understand the evolution of the Earth during the Paleogene Period, its first priority is the unambiguous definition, by means of agreed GSSPs, of a hierarchy of chronostratigraphic units, which provide the framework for global correlation. Its primary goals are:

- a) to agree on an international set of stages and series for the Paleogene.
- b) to formally define basal boundary stratotypes (GSSPs) of the Paleogene stages and series.
- c) to encourage research into the Paleogene by setting up and supporting Working Groups and Regional Committees to study and report on specific problems.
- d) to organise symposia and workshops on subjects of Paleogene stratigraphy.
- e) maintain a website informing on progress in Paleogene stratigraphy (<http://www.paleogene.org>).

The objectives of the Subcommittee relate to three main aspects of IUGS policy:

- 1) Establishment of an internationally agreed scale of chronostratigraphic units, defined by GSSPs.
- 2) Establishment of frameworks and mechanisms to encourage international collaboration in understanding the evolution of the Earth during the Paleogene Period.
- 3) Working towards an international policy concerning conservation of geologically and paleontologically important sites such as GSSPs. This relates to, inter alia, the IUGS Geosites Programme and the UNESCO Geoparks Programme.

### 3. ORGANISATION - interface with other international projects / groups

Members of the Paleogene Subcommittee interface with the International Ocean Discovery Program (IODP), International Subcommissions on Cretaceous and Neogene Stratigraphy, Int. Geoscience Programme (IGCP), ProGEO, Geosites and Geoparks Initiatives, UNESCO World Heritage Sites.

The ISPS consists of 20 Voting Members elected for their expertise and experience and about 100 Corresponding Members, who have a responsibility for communication in both directions between the Subcommittee and researchers on Paleogene topics in their region. Voting and Corresponding Members are selected regionally to provide expertise in the Paleogene stratigraphy of each major area and according to their speciality to cover the main fields of stratigraphic tools used in the Paleogene.

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### 4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM OTHER SOURCES

The ISPS board and the voting members get support from their own universities/institutes (facilities and staff), and have financial support for Paleogene research from their own research grants, mainly funded by national science agencies.

### 5. CHIEF ACCOMPLISHMENTS IN 2023 (including any publications arising from ICS WGs)

- After getting input from the board of ISPS on a previously submitted proposal for the GSSP of the Bartonian, the only stage of the Paleogene pending formal definition, the WG on the Bartonian carried out further analyses in 2023 and reformulated the proposal on the basis of additional sedimentological and magneto-biostratigraphic data from the critical interval of both the Bottaccione section and the Contessa Highway section (Coccioni et al., 2022). The WG recently confirmed they are about to re-submit to the ISPS the proposal for the Bartonian GSSP.
- A new reference section for the correlation of marine and continental biostratigraphy of the Bartonian has been investigated. The Pontils fossil site (Spain) represents a mangrove swamp environment with increasing marine influence towards the top of the sequence, and it contains a diverse vertebrate assemblage (including primates) as well as non-vertebrate fossils. The occurrence of larger benthic

foraminifera allows the assignment of Pontils to Shallow Benthic Zone 17 (Bartonian), solving the debate about the age of the locality, previously assigned either to the Bartonian or the Lutetian. Correlation to chrons C18r or C18n.1r constrains the age of Pontils to 39.58 - 41 Ma, and make it a new reference section for the marine - continental correlation of the Bartonian.

- A specific session “SC5 *Advances in Paleogene research*” dedicated to the Paleogene was organised by the ISPS during the 4<sup>th</sup> *International Congress on Stratigraphy, STRATI 2023* in Lille, France.
- The ISPS created 3D models of some of the most significant outcrops of the Paleogene GSSPs, which are now available at the ISPS website. This project was presented during the 4<sup>th</sup> *International Congress on Stratigraphy, STRATI23* (Alegret, Payros, Agnini, Monechi, Scaduto, Rossi, *3D outcrop modelling as a tool for GSSP promotion and communication: A case study from Spain and Italy*).
- Ten out of twenty voting members (50%) of the Subcommittee have been renovated, reaching parity (50% female, 50% male), and three working groups have been closed because they have finished their tasks.
- In order to address some questions raised about the reliability of the GSSP for the base of the Lutetian Stage at Gorrondatxe, the calcareous nannofossil biostratigraphy and magnetostratigraphy were revisited and new cyclostratigraphic and astrochronological calibrations were carried out.

Selection of the most relevant publications of subcommission work:

- Brachert, T.C., **Agnini, C.**, Gagnaison, C., Gély, J.-P., Henehan, M., **Westerhold, T.**, in press. Astronomical pacing of middle Eocene sea-level fluctuations: inferences from shallow-water carbonate ramp deposits. *Paleoceanography and Paleoclimatology*.
- Chiarenza A.A., Waterson A.M., Schmidt D.N., Valdes P.J., Yesson C., Holroyd P.A., **Collinson M.E.**, Farnsworth A., Nicholson D.B., Varela S., Barrett P.M., 2023. 100 million years of turtle paleoniche dynamics enable the prediction of latitudinal range shifts in a warming world (2023) *Current Biology*, 33 (1), pp. 109 - 121.e3, doi: 10.1016/j.cub.2022.11.056.
- De Vleeschouwer D., Penman D.E., D'haenens S., Wu F., **Westerhold T.**, Vahlenkamp M., Cappelli C., **Agnini C.**, Kordesch W.E.C., King D.J., van der Ploeg R., Pälke H., Turner S.K., Wilson P., Norris R.D., **Zachos J.C.**, Bohaty S.M., Hull P.M., 2023. North Atlantic Drift Sediments Constrain Eocene Tidal Dissipation and the Evolution of the Earth-Moon System. *Paleoceanography and Paleoclimatology*, 38 (2), e2022PA004555, doi: 10.1029/2022PA004555.
- Gladenkov A.Y.**, Ustinova M.A., Bordunov S.I., Olshanetskiy D.M., 2023. Calcareous Nannoplankton from the Upper Cretaceous and Paleogene Deposits of the Kamchatsky Mys Peninsula (Eastern Kamchatka). *Russian Jour. Pacific Geology*, 17 (1): 19 - 29, doi: 10.1134/S1819714023010037.
- Hartkopf-Fröder C., Martini E., **Heilmann-Clausen C.**, Neumann F.H., Schäfer P., Wilkes H., Böcker J., Hottenrott M., 2023. Eocene sediments and a fresh to brackish water biota from the early rifting stage of the Upper Rhine Graben (west of oil field Landau, southwest Germany): implications for biostratigraphy, palaeoecology and source rock potential. *Palaeobiodiversity and Palaeoenvironments*. doi: 10.1007/s12549-023-00577-z.
- Jones H.L., **Westerhold T.**, Birch H., Hull P., Negra M.H., Röhl U., Sepúlveda J., Vellekoop J., Whiteside J.H., **Alegret L.**, Henehan M., Robinson L., van Dijk J., Bralower T., 2023. Stratigraphy of the Cretaceous/Paleogene (K/Pg) boundary at the Global Stratotype Section and Point (GSSP) in El Kef, Tunisia: New insights from the El Kef Coring Project. *Bulletin of the Geological Society of America*, 135 (9-10): 2451 - 2477, doi: 10.1130/B36487.1.
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#### 6. SUMMARY OF EXPENDITURE IN 2023:

- |  |         |
|--|---------|
| 1) Attendance of 1 voting member to the STRATI 2023 meeting in Lille, France (travel + registration + accommodation).  | USD 906 |
| 2) Fieldwork Bartonian of the Isle of Wight. Car rental + ferry + 1 night accommodation 2 people   | USD 669 |
| 3) Printing costs poster ISPS about <i>3D outcrop modelling</i> for STRATI   | USD 30  |
| 4) Partial support for fieldwork in Alamedilla (S Spain) for the definition of auxiliary sections of the Ypresian (transportation only, 1400 km*0.26 euros/km).  | USD 390 |
| 5) Works to facilitate accessibility to the GSSP of the Priabonian in Alano di Piave (Italy), design and printing of a panel and a plaque to be placed near the outcrop, to be presented during the official ceremony in late 23-early 24. | USD 660 |
| 6) Early bird registration to the International Geological Congress 2024 in Busan, S Korea, for one member of the ISPS board   | USD 700 |

TOTAL ----- **USD 3355**

#### 7. SUMMARY OF INCOME IN 2023:

3169.38 euros (ca. 3361.56 USD) were transferred to the Subcommission's bank account

#### 8. BUDGET REQUESTED FROM ICS FOR 2024:

- |  |         |
|--|---------|
| 1) Support for analyses and fieldwork related to the last GSSP pending definition (the base of the Bartonian). | USD 800 |
|--|---------|

- 2) Early bird registration to the International Geological Congress 2024 in Busan, S Korea, for a second member of the ISPS board. USD 700
- 3) Support for attendance (travel and 5 nights' accommodation) to the International Geological Congress 2024 in Busan, S Korea, 2 members of the ISPS board. USD 1900

**TOTAL USD 3400**

#### 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR:

- Full support will be given to studies related to the Bartonian GSSP, the only Paleogene Stage pending definition. Fieldwork is planned in several Italian and Spanish sections, and on-going studies of the Bartonian WG will likely lead to the resubmission of an improved proposal in 2024.
- An *ad hoc* working group will evaluate sections of the base of the Ypresian from different paleogeographic areas and depositional settings as potential auxiliary sections.
- Contribute to the International Geological Meeting in South Korea 2024, and participate in the business meetings of the ICS.

Potential funding sources external to IUGS: Most of the research that is currently being done by the ISPS members is financially supported by their home countries' research grants.

#### 10. KEY OBJECTIVES AND WORK PLAN FOR THE PERIOD 2020-2024

- To find a type section and agree on the criteria for the formal definition of the base of the Bartonian, and submit a GSSP proposal to the Paleogene Subcommittee voting members and ICS.
- To prepare the report on the Bartonian GSSP proposal to be submitted to the ICS and the IUGS.
- To celebrate the official ceremony to place the Golden Spike at the GSSP for the base of the Priabonian in Alano di Piave section, Italy.
- To produce an updated version of an integrated Paleogene Time Scale.
- To prepare standardised regional correlation charts and paleogeographic maps by regional Committees.
- To support studies for the completion of the Paleogene astronomical time scale. This will contribute to filling the so-called "middle Eocene astronomical timescale gap" and will help to connect existing floating calibrations with the astronomically tuned standard Neogene timescale.
- To update the status of Paleogene WGs, closing those that have completed their task and/or are inactive.
- To revisit existing GSSPs and, if necessary, define new GSSPs and/or ASSPs to better characterise:
  - The Thanetian/Ypresian (P/E) boundary (i.e., Alamedilla, Caravaca and Zumaia sections in Spain; Forada and Contessa Highway sections in Italy; Polecat Bench in Wyoming);
  - The Danian/Selandian boundary: Contessa and Bottaccione, Caravaca and Sopolana;
  - The Selandian/Thanetian boundary: Contessa, Italy
  - The base of the Rupelian (E/O boundary): Monte Cagnero and Monte Vaccaro (Italy).

#### APPENDIX [Names and Addresses of Current Officers and Voting Members)

##### Current officers

Chair: **Laia Alegret**, Departamento de Ciencias de la Tierra, Universidad de Zaragoza, Calle Pedro Cerbuna, 12, E-50009 Zaragoza, Spain. Tel+34 876553465 [laia@unizar.es](mailto:laia@unizar.es)

Vice-Chair: **Aitor Payros**, Dept. Estratigrafía y Paleontología, University of the Basque Country (UPV/EHU), Apd. 644 P.K., E-48080 Bilbao, Spain. Tel.+34 946015427 [a.payros@ehu.eus](mailto:a.payros@ehu.eus)

Secretary: **Claudia Agnini**, Dipartimento di Geoscienze Università degli Studi di Padova Via Giovanni Gradenigo, 6 - I-35131 - Padova – Italy Tel. +390498279187 [claudia.agnini@unipd.it](mailto:claudia.agnini@unipd.it)

##### Working group leaders and corresponding members

Lutetian/Bartonian Boundary Stratotype WG. Chairman: Rick Fluegeman USA, [rfluegem@bsu.edu](mailto:rfluegem@bsu.edu)

Bartonian/Priabonian Boundary Stratotype WG. Chair: Claudia Agnini, Italy. [claudia.agnini@unipd.it](mailto:claudia.agnini@unipd.it)

Paleogene Deep-Water Benthic Foraminifera WG. Chair: Laia Alegret, Spain. [laia@unizar.es](mailto:laia@unizar.es)  
Secretary: Gabriela J. Arreguín Rodríguez, Mexico. [gjarreguin@gmail.com](mailto:gjarreguin@gmail.com)

Paleogene Calcareous Nannofossils WG. Chair: Simonetta Monechi, Italy. [simonetta.monechi@unifi.it](mailto:simonetta.monechi@unifi.it)

Paleogene Larger Foraminifera WG, Chairman: Cesare Papazzoni, Italy. [cesareandrea.papazzoni@unimore.it](mailto:cesareandrea.papazzoni@unimore.it) Secretary: Carles Ferrandez, Spain [carlesferrandez@ub.edu](mailto:carlesferrandez@ub.edu)

List of Voting Members:

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**Thomas Westerhold**, MARUM- Center for Marine Environmental Sciences, University of Bremen, Leobener Strasse, D-28359 Bremen, Germany, [twesterhold@marum.de](mailto:twesterhold@marum.de)

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## 1. TITLE OF CONSTITUENT BODY and NAME OF REPORTER

Subcommission on Cretaceous Stratigraphy (SCS) <https://cretaceous.stratigraphy.org>  
Maria Rose Petrizzo, Chair; Michael Wagreich, Vice-Chair; Francesca Falzoni, Secretary  
18 November 2023

## 2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY

- To establish a standard global stratigraphic subdivision and nomenclature for the Cretaceous, as part of the ICS standard global stratigraphic scale.
- To produce a stratigraphic table displaying agreed subdivisions to stage and substage level, marking boundaries that are defined by a GSSP.

## 3. ORGANISATION - interface with other international projects / groups

SCS has always been linked to important international Projects such as IODP, IGCP, Mesozoic Planktonic Foraminiferal Working Group, and ICDP (International Continental Scientific Drilling Project).

### 3a. Current Officers for 2020-2024:

Chair: Maria Rose Petrizzo; Vice-Chair: Michael Wagreich; Secretary: Francesca Falzoni

The elected officers for the term 2024-2028 are Michael Wagreich (Chair) and Maria Rose Petrizzo (Vice-Chair).

Voting Members are 18, from most continents. Over 150 Cretaceous scientists from all over the world and in many different disciplines belong to one or more of the Stage Working Groups and to the Kilian Group. The Stage Working Groups of the SCS are: Berriasian, Valanginian, Aptian, and Maastrichtian. All WG leaders (chairs) and members are treated as Corresponding Members of the SCS.

## 4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS

The SCS has strong links with IGCP projects.

IGCP 679 Cretaceous Earth Dynamics and Climate in Asia (new in 2019, Project Leader Prof. Gang Li, China)

IGCP 710 Western Tethys meets Eastern Tethys (new in 2020, Project Leader Prof. Michał Krobicki, Poland)

IGCP 739 The Mesozoic-Paleogene hyperthermal events (new in 2021, Project Leader Prof. Xiumian Hu, China)

## 5. CHIEF ACCOMPLISHMENTS IN 2023

### • WORKING GROUPS ACTIVITIES TOWARDS THE DEFINITION OF THE GSSPs

Chairs and updated memberships of each WG are available at <http://cretaceous.stratigraphy.org/working-groups/>  
Memberships are updated continuously by inviting active scientists who are willing to collaborate to the WG activities.

#### Maastrichtian GSSP

The ratified GSSP locality for the base of the Maastrichtian is the abandoned quarry at Tercis-les-Bains in SW France. The stage boundary lacks a primary marker for the definition of its base, and the main task of the Maastrichtian WG is the search for a useful primary marker.

In March 2023, WG members sampled the Tercis-les-Bains section, which is located in a Regional Natural Reserve requiring a permit for any geological fieldwork and sampling. The WG warmly thanks C. Gréaume, J. Le Breton and M. Lo Cascio of the Regional Natural Reserve for welcoming and providing scientific and logistic support. The staff is skilled in Earth Sciences and heritage preservation, and they strongly promote academic studies in the quarry.

About 500 samples were taken along a 70-m interval with a resolution of 20-40 cm to establish modern biozonations for calcareous nannofossils, planktonic and benthic foraminifera, inoceramids and palynomorphs. Further samples were collected to determine the mineralogical composition and microtexture of the lithology, to resolve orbital cyclicity, and to improve the resolution of carbon isotope stratigraphy. Some of the analyses are finished (measurements of magnetic susceptibility, XRF), as well as the sample preparation for palynomorphs. The time-consuming washing of foraminiferal samples is still in progress. The stable isotope analyses will be finalized by the end of 2023. First results were presented at STRATI2023 in Lille in July 2023 (see below)

The German science foundation DFG granted a research proposal to S. Voigt in August 2023 that will support the analytical work and the scientific exchange among the WG members. The work on the collected samples will provide students the opportunity to perform their master thesis project.

*Voigt, et al. (2023). Reassessment of the base of the Maastrichtian Stage at the GSSP locality Tercis-les-Bains (SW France)*  
[sciencesconf.org:strati2023:457796](https://sciencesconf.org:strati2023:457796)

#### Campanian GSSP

The GSSP proposal for the base of the Campanian Stage in the Bottaccione Gorge section at Gubbio, Umbria-Marche Basin (Italy) was ratified by IUGS in October 2022 and includes 5 auxiliary sections. The golden spike ceremony was held on July 26, 2023, in Gubbio (Italy), see <https://cretaceous.stratigraphy.org/news/campanian-ceremony>

Gale, A.S., et al., (2023). *The Global Boundary Stratotype Section and Point (GSSP) of the Campanian Stage at Bottaccione (Gubbio, Italy) and its auxiliary sections (Seaford Head, U.K.), Bocieniec (Poland), Postalm (Austria), Smoky Hill, Kansas (U.S.A.) and Tepeyac (Mexico)*. *Episodes*, vol. 46, n. 3, p. 451-490, <https://doi.org/10.18814/epiugs/2022/022048>.

#### Coniacian GSSP

The GSSP proposal for the base of the Coniacian Stage in the Salzgitter-Salder section (Germany) was ratified by IUGS in May 2021 and includes 3 auxiliary sections. The golden spike ceremony was held on September 19, 2023, at Salzgitter-Salder, see <https://cretaceous.stratigraphy.org/news/coniacian-ceremony>.

Walaszczyk, L., et al. (2022). *The Global Boundary Stratotype Section and Point (GSSP) for the base of the Coniacian Stage (Salzgitter-Salder, Germany) and its auxiliary sections (Ślupia Nadbrzeżna, central Poland; Střeleč, Czech Republic; and El Rosario, NE Mexico)*. *Episodes*, vol. 45, n., 2, p. 181-220, <https://doi.org/10.18814/epiugs/2021/021022>.

#### Aptian GSSP

In July, at the STRATI 23 conference in Lille, the members of the WG confirmed the earlier decision to take the negative C-isotope spike at the base of OAE1a as the new primary marker for the base of the Aptian. The WG agreed to vote on the location of the Aptian GSSP and, on the selection of the auxiliary sections. The following five sections are proposed as potential sites for a GSSP: Gorgo a Cerbara (Italy), Cismon (Italy), La Bedoule (France), Cau (Spain) and El Pui (N Spain). Erba and Weissert are currently preparing fact sheets for the five sections identified as possible sites for the Aptian GSSP. The WG will vote on the preferred candidate GSSP section before the end of 2023.

#### Barremian GSSP

The GSSP of the base of the Barremian Stage (at the base of bed 171 of the Río Argos section, near Caravaca, SE Spain, marked by the first appearance of the ammonite *Taveraidiscus hugii*), was ratified by IUGS in March 2023. Secondary criteria include: bioevents (foraminifera, calcareous nannofossils), C isotope stratigraphy, sequence stratigraphy, and astrochronology. A new calibration of the Hauterivian/Barremian boundary against the magnetostratigraphic scale is proposed. The protection of the Río Argos section is ensured by the municipality of Caravaca, and its recognition at the regional and national level is also being processed. The publication of the GSSP has been accepted by *Episodes* and will be published soon.

Company et al. (2024). *The Global Boundary Stratotype Section and Point (GSSP) of the Barremian Stage at Río Argos (Caravaca, SE Spain)*. *Episodes*, proof corrected.

#### Valanginian GSSP

In 2023, two informal GSSP proposals were prepared by two teams and submitted to the Valanginian WG for voting: 1) Vergol section (Montbrun-les-Bains, Drôme, SE France) by: Reboulet (reporter of the proposal, (bio-)stratigraphy, ammonites), Adatte (chemostratigraphy, phosphorus), Baudin (organic geochemistry), Company ((bio-)stratigraphy), Deconinck (clay mineral assemblages), Duxbury (biostratigraphy, palynomorphs), Grabowski (magnetic stratigraphy), Granier (bio-)stratigraphy), Janssen (biostratigraphy, belemnites), Klein (biostratigraphy, ammonites), Leng (isotope stratigraphy), Lodowski (magnetic stratigraphy), Martinez (cyclostratigraphy, astrochronology), Mattioli (biostratigraphy, calcareous nannofossils), McArthur (isotope stratigraphy), Olivero (biostratigraphy, ichnofossils) and Reháková (biostratigraphy, calpionellids); 2) Cañada Luenga section (Cehegín, Region of Murcia, SE Spain) by: Company (reporter of the proposal, ammonite biostratigraphy), Adatte (chemostratigraphy), Aguado (calcareous nannofossil biostratigraphy), Duxbury (organic dinoflagellate biostratigraphy), de Gea (chemostratigraphy), Ivanova (calcareous dinoflagellate and benthic foraminifera biostratigraphy), Janssen (belemnite biostratigraphy), Lakova (calpionellid biostratigraphy), Martinez (cyclostratigraphy, astrochronology) and Tavera (ammonite biostratigraphy).

The Vergol section was selected by the Valanginian WG as the candidate GSSP for the base of the Valanginian and Cañada Luenga was selected as the Standard Auxiliary Boundary Stratotype (SABS). The FAD of “*Thurmanniceras*” *pertransiens* (ammonite) was selected as the primary marker. Its FO is recorded in layer VGL-B136 (Vergol) and CL 9 (Cañada Luenga). Main secondary markers are: FAD of *Calpionellites darderi* (calpionellid); FAD of *Calcicalathina oblongata* (calcareous nannofossil), FAD of *Neocomites premolicus* (ammonite) and base of magnetic chron M14r.

A talk on the activity of the Valanginian WG was presented to the Cretaceous Subcommittee business meeting during the STRATI 2023 congress at Lille (France) on July 12, 2023.

#### Berriasian (J/K boundary) GSSP

The Berriasian WG started its work in February 2021. The WG keep being focused on organizing database and ideas concerning possible definitions and placing the Tithonian/Berriasian boundary, as well as its global and regional palaeoenvironmental context. In the first half of 2023, the BWG completed a discussion on which level (not yet the primary marker) should be the best choice for the global J/K boundary definition. The three levels under considerations were: 1) a boundary in the upper Tithonian (between magnetozones M20n1r and M19r)/base Crassicollaria Zone or base Intermedia Subzone; 2) present day Tithonian/Berriasian boundary (base Calpionella alpina Subzone); 3) the lower/middle Berriasian boundary (base M17r/base zone Calpionella elliptica/base zone Subthurmannia occitanica).

A two-step voting was organized, with the following results: First voting: 1<sup>st</sup> option (upper Tithonian) – 7 votes; 2<sup>nd</sup> option (Tith/Berr) – 4 votes; 3<sup>rd</sup> option (low/mid Berr) – 3 votes; No vote – 3. Second voting: 1<sup>st</sup> option (upper Tithonian) – 9 votes; 2<sup>nd</sup> option (Tith/Berr) – 5 votes; abstain – 1, no vote – 2. As a result, the upper Tithonian option was accepted as a

working version of the J/K boundary, which will be elaborated in more detail in 2024.

The BWG in 2022/2023 met online, usually with 1-2 keynote talks and discussion. Up to now 19 meetings were organized (the 20<sup>th</sup> is scheduled for Dec 2023) with the following presentations: 16<sup>th</sup> meeting (30.11.2022), Grabowski – *J/K boundary in the upper Tithonian?* 17<sup>th</sup> meeting (22.02.2023), Grabowski – *Summary of the J/K boundary: three options for voting*; Deconinck – *Organic  $\delta^{13}C$  stratigraphy in Boulonnais section, NW France*; Grabowski – *News about VOICE isotopic excursion*; 18<sup>th</sup> meeting (22.05.2023), Grabowski – *results of indicative voting and report for the Cretaceous Subcommission in Lille*; 19<sup>th</sup> meeting (6.10.2023), Galloway - *The Volgian Carbon Isotopic Excursion: the VOICE*; Pellenard – *The VOICE isotopic excursion in Argentina: astrochronologic calibration and correlation to Global Polarity Time Scale*. The presentations and short reports from the meetings are archived and accessible on dedicated web page, accessible only to BWG members.

The following presentations focused on J/K boundary were realized at STRATI 2023 in Lille (France), sessions SC6: Integrated stratigraphy and GSSPs of the Cretaceous System, SC7: Cretaceous palaeoceanography, biota, climate change and critical events, and SC8: The Jurassic events, correlation and timescale.

*Grabowski J., et al. Sedimentary events at the Jurassic/Cretaceous boundary interval in the Slovenian Basin and Transdanubian Mts (Hungary): evidences from terrigenous input and trace metal enrichments.*

*Grabowski J., et al., Calpionellid stratigraphy and microfacies in the Clue de Taulanne section (Vocontian basin, SE France).*

*Lodowski D.G., et al., Disappearance of the Saccocoma-dominated microfacies: the cause and timing in the light of paleoenvironment evolution in the Transdanubian Range (Hungary)*

*Matsuoka A., et al. Jurassic-Cretaceous transition sequences in Japan and their contribution to defining the Jurassic-Cretaceous boundary.*

*Salazar C. Bio-sequence stratigraphy of Jurassic-Cretaceous transition in central Chile.*

*Trabelsi K., et al. discovery of Purbeckian-type ostracod fauna and charophyte flora across the Jurassic-Cretaceous boundary in the Middle Atlas of Morocco (NW Africa): Biostratigraphic and biogeographic implications.*

*Verreusel R. Palynological records from marine sections across the Jurassic-Cretaceous transition in Netherlands.*

J. Grabowski presented the main points of the BWG activity during the SCS business meeting at STRATI 2023. A short summary was presented also at the Jurassic Subcommission business meeting. The “informal” meeting of the BWG was organized during this Congress.

During a private field trip in February, J. Grabowski visited key J/K boundary sections in Spain: Puerto Escano and Rio Argos. Field works are being continued on Italian sections in November 2023: Torre de Busi and Bosso mostly focused on radiolarian stratigraphy.

#### KILIAN Group

The WG met during the 11<sup>th</sup> International Cretaceous Symposium in Warsaw, Poland (22-26 August 2022). The report is published here:

*Szives et al. (2024). Report on the 7<sup>th</sup> International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the Kilian Group (Warsaw, Poland, 21<sup>st</sup> August 2022): State of the art on the current Standard Ammonite Zonation of the Western Tethyan Mediterranean Province. Cretaceous Research 105716, <https://doi.org/10.1016/j.cretres.2023.105716>.*

#### 6. SUMMARY OF EXPENDITURE IN 2023:

|  |              |
|--|--------------|
| Contribution to the 4 stages Working Groups for fieldworks + analysis for the GSSPs        | 1600.00 Euro |
| Contribution attendance cost to the Campanian GSSP golden spike ceremony in Italy          | 280.00 Euro  |
| Contribution attendance cost to the Coniacian GSSP golden spike ceremony in Germany        | 820.00 Euro  |
| Contribution to the Campanian GSSP for the organization of the ceremony (panel)            | 486.00 Euro  |
| Contribution to the Maastrichtian WG to sampling the stratotype section at Tercis (France) | 500.00 Euro  |
| Contribution for secretarial work and updating of the website                              | 512.61 Euro  |
| Bank fees for bank transfer  | 16.00 Euro   |

TOTAL expenditure in 2023 = 4214.61 Euro

#### 7. SUMMARY OF INCOME IN 2023:

ICS Subvention for 2023

US dollars 4500.00 = 4214.61 Euro

#### 8. BUDGET REQUESTED FROM ICS FOR 2024:

|   |              |
|---|--------------|
| Contribution to the stages Working Groups for fieldworks, analyses, meetings                  | 2000.00 Euro |
| Contribution attendance cost to Albian and Hauterivian GSSPs (France) golden spike ceremonies | 1000.00 Euro |
| Contribution attendance cost to Barremian GSSP (Spain) golden spike ceremony                  | 1000.00 Euro |
| Contribution for the organization of the GSSP ceremonies                                      | 500.00 Euro  |
| Contribution for secretarial work and updating of the website                                 | 500.00 Euro  |

TOTAL budget request from ICS in 2024= 5000.00 Euro

## 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR (2024):

### • STUDIES, FIELD WORK TO FINALIZE THE GSSP PROPOSALS

#### Maastrichtian GSSP

Milestones to achieve in 2024 are centered around the documentation of the Tercis section and comprise the (1) accomplishment of sample processing for micropaleontology, (2) biostratigraphic work on the calcareous nannofossils and foraminifera, (3) cyclostratigraphy of the different time series with the scope of the development of an astrochronology for the Maastrichtian stage, (4) further field work at Tercis for macrofossils particularly inoceramids, (5) dissemination of results at conferences and possibly a first manuscript about cyclostratigraphy. A second part of the work plan deals with data compilation for the development of auxiliary sections for correlation. Potential candidate sections are the Vistula and Krons Moor sections (Poland, Germany), Gubbio section (Italy), and the stratigraphic record of ODP Site 1210 (central Pacific Ocean).

#### Aptian GSSP

Selection of the auxiliary sections following a second round of discussions after the selection of the candidate GSSP.

#### Valanginian GSSP

A formal proposal (Vergol as GSSP and Cañada Luenga as SABS) is currently being written. It should be finished by Jan/Feb 2024 and sent to the Valanginian WG for discussion. If approved, the formal proposal will be submitted (Spring 2024) to the SCS for voting. We hope that by the end of 2024 the proposal will be formally voted and approved by ICS.

#### Berriasian (J/K boundary) GSSP

In 2024, detailed elaboration of the “upper Tithonian” option will be performed with special attention to possible primary markers in the Tethyan area: calpionellid, calcareous nannofossil events and magnetostratigraphy. A discussion on large-scale climatic events and trends and their correlation potential will be continued, as well as possible identification of the VOICE isotopic event in the Tethyan record. Thanks to the economic support from ICS and IUGS, dating of the volcanic rocks is planned, and considering possibilities of astrochronologic calibrations of the J/K boundary interval, which has just started (manuscript in preparation about Neuquen Basin, unpublished data from a Carpathian section in Poland).

#### Kilian Group

The Kilian meetings are usually held every 3 or 4 years (2002; 2005; 2008; 2010; 2013; 2017; 2022). The next Kilian Group meeting will be held in 2025 in Hannover, prior to the first day of the 12<sup>th</sup> International Symposium on the Cretaceous System.

### • FUTURE MEETINGS

- 2024 – 37<sup>th</sup> International Geological Congress 2024, August 25-31, 2024, Bexco, Busan, Republic of Korea.
- 2025 – 12<sup>th</sup> Cretaceous Symposium, Hannover (Germany), between August 31-September 5, 2025. The congress will include a mid-symposium field-trip to the several nearby Cretaceous outcrops.

#### Potential funding sources external to IUGS

The SCS does not envisage being able, as an organization, to obtain significant funding from outside IUGS/ICS sources. Some additional financial support beyond what is already committed could perhaps be obtained by individual members from their host institutions and/or their personal research funds.

## 10. KEY OBJECTIVES AND WORK PLAN FOR THE PERIOD 2024-2028

- Spring 2024: Vote by the SCS of the Valanginian GSSP.
- 29 June 2024: official ceremonies for the inauguration and placement of the golden spikes of the Albian and Hauterivian GSSPs.
- 2024: Finalization of the GSSP proposal for the base Aptian and vote within the WG.
- October 2024: golden spike ceremony of the Barremian GSSP.
- 2024–2026: Research activities toward the preparation of the GSSP proposal for the base of the Berriasian and Maastrichtian Stages.
- 2025: Vote by the SCS of the Aptian GSSP.
- 2026-2028: Finalization of the GSSP proposal for the base Berriasian and Maastrichtian and vote within the WG and SCS.

## APPENDIX [Names and Addresses of Current Officers and Voting Members]

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# INTERNATIONAL SUBCOMMISSION ON JURASSIC STRATIGRAPHY (ISJS) ANNUAL REPORT 2023

## 1. TITLE OF CONSTITUENT BODY and NAME OF REPORTER

### International Subcommittee on Jurassic Stratigraphy

Reported by Angela L. Coe, Subcommittee Chair, in consultation with ISJS voting members.

## 2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY

The International Subcommittee on Jurassic Stratigraphy is the primary body for facilitation of international communication and scientific cooperation in Jurassic stratigraphy, defined in the broad sense of multidisciplinary activities directed towards better understanding of the evolution of the Earth during the Jurassic.

### Objectives

1. The unambiguous definition, by means of agreed GSSPs, of a hierarchy of chronostratigraphical units that provide the framework for global correlation.
2. Provide an inclusive, diverse and supportive international community to facilitate global research and associated activities on Jurassic stratigraphy.
3. Advance understanding of the evolution of the Earth system during the Jurassic including palaeogeography, palaeoclimate change, evolution of life, and sea-level change.
4. Improve the resolution and correlation of the integrated stratigraphy for the Jurassic.
5. Facilitate communication on Jurassic stratigraphy for both specialist and non-specialist audiences.

### Fit within IUGS Science Policy

The objectives of ISJS relate to two main science objectives of IUGS policy:

- The development of an internationally agreed scale of chronostratigraphical units, fully defined by GSSPs at Series and Stage levels and related to a hierarchy of units (Substages, Standard Zones, Subzones etc.) to maximize relative time resolution within the Jurassic Period
- Establishment of frameworks and mechanisms to encourage international collaboration in understanding the evolution of the Earth during the Jurassic Period.

## 3. ORGANISATION including interface with other international projects / groups

### 3a. Current officers (2020-2024)

**Chair:** Angela L. Coe

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**Secretary:** David B. Kemp

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**Webpersons:** Angela L. Coe and David B. Kemp (see above)

### 3b. Interface with other international, regional and national projects

Members of the ISJS and the wider Jurassic stratigraphy community are involved in a number of international and national collaborative projects.

**International Continental Drilling Program (Early Jurassic Earth System and Timescale (JET)).** This International Continental Scientific Drilling Programme project, led by Stephen Hesselbo, cored 630 m in late 2020 spanning from the Norian to Pliensbachian. The aim of the project is the production of an integrated timescale and stratigraphical dataset to further our

understanding of the Lower Jurassic. The first report with an extensive range of data was published this year: <https://sd.copernicus.org/articles/32/1/2023/>. ISJS voting members Micha Ruhl, Emanuela Mattioli and Grzegorz Pieńkowski are co-authors. Website: <https://www.icdp-online.org/projects/by-continent/europe/jet-uk/>.

**IGCP project 739 The Mesozoic-Palaeogene hyperthermal events.** This project is investigating the major hyperthermal events and their associated environmental and biological responses. Episodes of Jurassic warmth (Triassic-Jurassic boundary and Toarcian Oceanic Anoxic Event) are a focus of the project. The project involves 149 researchers from 41 countries. ISJS voting members David Kemp and Micha Ruhl are co-leaders.

**UNESCO World Heritage Sites.** ISJS liaises with the management group of the UNESCO East Devon and Dorset Coast (informally known as the Jurassic Coast) World Heritage Site and engages in debates and promotional activities. See <https://jurassiccoast.org/>.

**Geoheritage.** The ISJS Geoconservation Working Group (Convenor Kevin Page) has links with international and national governmental and non-governmental authorities and advisory groups including the [International Commission on Geoheritage](#), the [Geoheritage Specialist Group of the World Commission for Protected Areas](#) and [ProGEO](#). The convenor is also Editor-in-Chief of the journal [Geoheritage](#) and with Robert Weiss is editing a thematic issue focussed on the conservation of Jurassic rocks and fossils.

**Stratigraphy Commission of the Geological Society, London.** Angela L. Coe, is chair of Stratigraphy Commission of The Geological Society, London. The Commission are currently working to raise the profile of Jurassic GSSPs in the UK and they have two stratigraphy books at the review stage: *A correlation of Jurassic rocks of Britain and Ireland and contiguous offshore areas* and *A revised correlation of the Cretaceous rocks of the British Isles*. Former and current commission members have also assisted with the production of a new edition of *Geology of Scotland*, which will include information on the Kimmeridgian GSSP in two chapters.

**German Subcommittee for Jurassic Stratigraphy.** This group has 46 members. This year's annual meeting was held in May in Altdorf. ISJS voting member Günter Schweigert is secretary of this group.

**Polish-Slovakian Working Group on the Jurassic System.** The Polish and Slovakian researchers and others working on the Jurassic meet annually. This year the meeting (15th) was in Iłża, Poland in September. It was with great sadness for this group in particular, but also the wider Jurassic community in general, to hear about the death of ISJS vice-chair Grzegorz Pieńkowski, who passed away suddenly in April 2023. His wide interests, insights and kindness to all will be greatly missed.

**Argentinian Jurassic group.** The 8th Argentinean Jurassic Symposium (held every three years) took place in July-August 2023. It was a successful and wide-ranging meeting 67 attendees and 39 presentations. The abstract volume is at: [https://drive.google.com/file/d/1RAibSMw6LW2Bo\\_YZEAQnO4av-J3VP1qO/view](https://drive.google.com/file/d/1RAibSMw6LW2Bo_YZEAQnO4av-J3VP1qO/view)

#### **4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS**

We gratefully acknowledge the continued support of the Polish Geological Institute - National Research Institute and Faculty of Geology, University of Warsaw, in editing *Volumina Jurassica*, ISSN: 1731-3708, a peer-reviewed, open access journal supported by ISJS. The journal has a new chief editor, Hubert Wierzbowski. Jacek Grabowski is our ISJS voting member representative on the board of editors.

#### **5. CHIEF ACCOMPLISHMENTS OF ISJS IN 2023**

##### **Progress of the GSSP working groups**

**The Oxfordian Working Group:** Data from 60 sections have been studied; from these two candidate areas/sites were chosen (Redcliff Point, Weymouth, England; Thuoux with Saint-Pierre d'Argençon and Lazer, Serres, SE France) for further studies and consideration. Neither section satisfies all the key criteria so one is likely to be proposed as a stratotype and the other

as an auxiliary section. A further section Dubki, Saratov Region, Russia was previously proposed but is currently on hold as advised by IUGS because of the war. A primary marker has yet to be formally selected but ammonites are favoured. Cardioceratidae ammonites provide widespread markers and evolved rapidly during this interval. Peltoceratidae and Hecticoceratidae are also important for this period. Other data that is either available or being collected includes microfossil groups, geochemistry, magnetostratigraphy and cyclostratigraphy. The ISJS chair called a business meeting at Strati with key parties and as a result of this, all ammonites are now in publically accessible collections and the first of many c. bimonthly regular online meetings for all members of the working group was arranged for October. This meeting helped to inspire members and established priorities for future research and documentation; it is hoped by all parties that rapid progress can now be made.

**The Callovian Working Group:** It is proving difficult to find a Callovian section that satisfies sufficient GSSP criteria. The previously favoured and intensively studied Albstadt-Pfeffingen section in Germany with its excellent ammonite faunas is too condensed and is not suitable for primary geochemical and magnetostratigraphical studies. Open access is also problematic. An excellent expanded section with radio-isotopic dates has been identified in Argentina, but the endemism of the ammonites and possibly other fossil groups is problematic. The membership of the Callovian Working Group is therefore being renewed and other sections considered.

**The Tithonian Working Group:** We are pleased to announce that the Tithonian Working Group now have a new chair, Verónica Vennari. We are very grateful to the outgoing chair, Fredrico Olóriz for his work and for kindly agreeing to stay on as a voting member and to help the incoming chair. Work on the neighbouring Berrasian GSSP is proving helpful.

**Research with the International Subcommittee on Cretaceous Stratigraphy (Berriasian Working Group):** The Berriasian Working Group presented an update at Strati 2023. The group are currently considering a boundary within what has historically been considered Tithonian (See <https://cretaceous.stratigraphy.org/news/berriasian-wg-meetings>), the logic of this line of enquiry has the approval of the executive of the ISJS following joint discussion at the 11th International Jurassic congress in Budapest in 2022.

**STRATI 2023:** A successful Jurassic session and business meeting was held at Strati 2023. There were 27 talks and posters. Similar to the Jurassic congress in 2022 there was a lot of focus on the Toarcian Oceanic Anoxic Event. One of the Jurassic researchers, Aisha Al-Suwaidi, ran a workshop on geochronology building on an idea from the Jurassic congress in 2022. A particularly useful aspect of the Strati meeting was to be able to attend presentations by colleagues in neighbouring geological periods (e.g. see below). It would be helpful to ensure for future Strati meetings that sessions on neighbouring periods did not overlap.

**12th Jurassic Congress:** Planning for the 12th Jurassic congress that will be held in Exeter, UK in 2026 is underway. Arrangements have been made to base the conference at the main Exeter University campus. There will be long field trips all main sites of Jurassic strata in the UK and a mid-conference field trip to the Hettangian to Pliensbachian strata at Lyme Regis and Charmouth. Discussions are underway with two publishers for the field guide.

## 6/7. SUMMARY OF INCOME and EXPENDITURE FOR 2023

| Item  | Income (\$) | Expenditure/<br>committed (\$) |
|---|-------------|--------------------------------|
| Opening balance   | 4600        |                                |
| Transfer from ICS for 2023  | 1400        |                                |
| Promotion and public engagement for the Kimmeridgian GSSP on the Isle of Skye (travel and graphics) |             | 2000 committed                 |
| Advancement of the Oxfordian GSSP - fieldwork delayed now agreed spring 2024                        |             | 2697 committed                 |
| Support for attendees at STRATI 2023 including Oxfordian WG meeting                                 |             | 1303                           |
| Closing balance   |             | 0.00                           |

## 8. BUDGET REQUESTS FROM ICS FOR 2024

We request \$2600 for 2024 to support field activities and collaboration associated with the advancement of the Tithonian GSSP under the new Tithonian Working Group Chair.

## 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS FOR 2024

- **Executive and voting members:** Approval of extension of term of office for the chair, or election of a new chair depending on view of voting members (currently ongoing). Appointment of new vice chair and replacement of six voting members.
- **Callovian GSSP:** Formation of refreshed working groups following constructive discussion at the 11<sup>th</sup> Jurassic Congress and Strati 23 followed by the search for other possible sections and primary markers facilitated by online meetings.
- **Oxfordian GSSP:** A field meeting is planned for March 2024 at the Redcliff Point candidate to carry out a new high-resolution sampling programme, both to look for a cyclostratigraphical/ orbital chronology as well as to provide chemostratigraphical data at a chronostratigraphical resolution similar to the sections in SE France. Work is also continuing on the section SE France including photographing the many ammonite specimens. Discussion of a primary marker. Preparation of one or two proposals for the working group to vote on.
- **Kimmeridgian GSSP:** Delayed celebration and promotion of the Kimmeridgian GSSP on the Isle of Skye, Scotland.
- **Tithonian GSSP:** Online meetings and field work within the new working group to establish possible sections and markers. This will include re-assessment of the evidence at Mount Crussol and Canjuers in SE France, and Fornazzo, Sicily all of which have previously been suggested and have some data. Consideration of possible new sections in S. America.
- **High-resolution subdivision and correlation of the Jurassic:** Formation of a new working group to consider a variety and a system of markers for high-resolution correlation of the Jurassic including suggested nomenclature.
- **Next Jurassic congress:** Preparation for and promotion of the 12th International Jurassic congress in Exeter, UK in 2024. Further advancement of the field guides.

## 10. KEY OBJECTIVES AND WORK PLAN FOR NEXT 4 YEARS (2020-2024)

- Achieve ratification of the Kimmeridgian GSSP.
- Complete or significantly advance the defining of the remaining Jurassic GSSPs (Callovian, Oxfordian, and Tithonian) through revitalizing the working groups and facilitating progress by encouraging constructive collaboration and raising funds.
- Increase diversity and facilitate research aspirations at all career stages by championing representation through the new official positions, providing a diversity of opportunities, role models and subject specialist champions.
- Facilitate communication on the Jurassic for both specialist and non-specialist audiences. including promoting the Jurassic GSSPs. This will be achieved through meetings, workshops, *Volumina Jurassica*, outreach activities and maintaining an up-to-date and informative ISJS website.
- Facilitate a successful and inclusive Jurassic congress in Budapest, Hungary in 2022.
- Improve resolution and correlation of the integrated stratigraphy for the Jurassic.
- Further our understanding of the Earth system during the Jurassic especially palaeoclimate change.
- Provide support to IGCP 655 (Toarcian) and future IGCP projects related to the Jurassic.
- Work with the International Subcommittee for Cretaceous Stratigraphy to help them define the base of the Berriasian and the Jurassic/Cretaceous boundary.
- Work with national and international bodies to protect Jurassic geological sites, assess and promote their natural capital.

## APPENDIX

### Names and addresses of current officers and voting members

| Executive |          |               |  |  |
|-----------|----------|---------------|--|--|
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| Marok      | Abbas     | a_marok@yahoo.fr   | Department of Earth and Univers Sciences, University of Tlemcen, P.O. Box 119, Tlemcen, Algeria<br>Tel: +213 7 71 14 84 45   |
| Mattioli   | Emanuela  | emanuela.mattioli@univ-lyon1.fr  | Laboratoire de Géologie de Lyon:, Terre, Planètes, Environment, UMR 5276 CNRS, Observatoire de Lyon, Université Lyon 1, France<br>Tel: +33 (0)4 72 44 58 00                  |
| Goričan    | Špela     | Spela@zrc-sazu.si  | Institute of Paleontology, ZRC SAZU, Novi trg 2, SI-1000 Ljubljana, Slovenia<br>Tel: +386 1 4706 371   |
| Ruhl       | Micha     | <a href="mailto:micha.ruhl@tcd.ie">micha.ruhl@tcd.ie</a>                 | Department of Geology Trinity College Dublin, The University of Dublin Dublin 2, Ireland<br>Tel: + 353 1 896 1165  |
| Shin-ichi  | Sano      | <a href="mailto:ssano@sus.u-">ssano@sus.u-</a>                           | Department of Earth System   |



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|------------|------------|--|--|
|            |            | <a href="http://toyama.ac.jp">toyama.ac.jp</a> | Science, School of Sustainable Design, University of Toyama, 3190 Gofuku, Toyama-Shi, 930-8555 Toyama, Japan<br>Tel: +81 76 411 4893   |
| Schweigert | Guenter    | guenter.schweigert@smns-bw.de                  | State Museum of Natural History Stuttgart, Rosenstein 1, 70191 Stuttgart, Germany<br>Tel: +49 (0)711 8936 147  |
| Vennari    | Verónica   | vvennari@mendoza-conicet.gob.ar                | Instituto de Estudios Andinos Don Pablo Groeber (IDEAN), Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria, Pabellón 2, C1428EGA Buenos Aires, Argentina Tel: +54 9 0260 442 1078 |
| Villaseñor | Ana Bertha | <a href="mailto:anab@unam.mx">anab@unam.mx</a> | Departamento de Paleontología, Instituto de Geología, Primer piso, Cubículo y Laboratorio de invertebrados, C.P. 04510, Ciudad de México, México<br><a href="tel:+525556224280">+52 (55) 56-22-42-80 Ext. 182</a>  |

### 11b List of Task and Working Groups and their officers

The active Working Groups are as follows:

**Callovian Working Group** Chair: Eckhard Mönning, Naturkunde-Museum Coburg, Park 6, 96450 Coburg, Germany, Tel. +49 (0)9561 8081-13, [e.moennig@naturkunde-museum-coburg.de](mailto:e.moennig@naturkunde-museum-coburg.de))

**Oxfordian Working Group** Chair: Kevin Page, Honorary Senior Research Fellow, Camborne School of Mines, University of Exeter, UK, Tel: +44 (0)1363 775354, [kevinpage@gmail.com](mailto:kevinpage@gmail.com); Secretary: Ewa Główniak, Faculty of Geology, Department of Geology of Sedimentary Basins, University of Warsaw, Warsaw, Poland (+48 22) 55 40 429 [eglownia@uw.edu.pl](mailto:eglownia@uw.edu.pl)

**Tithonian Working Group** Chair: Verónica Vennari, Instituto de Estudios Andinos Don Pablo Groeber (IDEAN), Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria, Pabellón 2, C1428EGA Buenos Aires, Argentina Tel: +54 9 0260 442 1078

**Geoconservation Working Group** Chair: Kevin Page, Camborne School of Mines, University of Exeter, Penryn Campus, Penryn TR10 9FE; Tel: +44 (0)1363 775354, [kevinpage@gmail.com](mailto:kevinpage@gmail.com))

Angela L. Coe, 19 November 2023

## **1. TITLE OF CONSTITUENT BODY and NAME OF REPORTERS**

### **Subcommission on Triassic Stratigraphy (STS)**

#### *SUBMITTED BY*

Prof. Zhong-Qiang Chen, Chairman

State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan), 388 Lumo Road, Hongshan District, Wuhan 430074, China

Tel: 86-27-67883068; E-mail: [zhong.qiang.chen@cug.edu.cn](mailto:zhong.qiang.chen@cug.edu.cn)

## **2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY**

- Definition of stage boundaries and selection of GSSP sections.
- Rationalization of chronostratigraphic classification for the Triassic.
- Inter-calibration of all stratigraphic tools and promoting globally data to achieve this.
- Establishment of physical, cyclostratigraphic, magneto- and chemo-stratigraphic scales.
- Correlations of Triassic successions and extreme events from marine to non-marine.

The objectives satisfy the IUGS mandate of fostering international agreement on nomenclature and classification in stratigraphy; facilitating international co-operation in geological research; improving publication, dissemination, and use of geological information internationally; encouraging new relationships between and among disciplines of science that relate to Triassic geology world-wide; attracting competent students and research workers to the discipline; and fostering an increased awareness among individual scientists world-wide of what related programs are being undertaken.

## **3. ORGANISATION - interface with other international projects / groups**

The STS is a Subcommission of the International Commission on Stratigraphy, with 3 executive officers and 23 voting members of the STS and about 110 corresponding members. The editor of the online journal *Albertiana* is also appointed, and he also manages the web site and posts for STS announcements and task group discussions. The *Albertiana* editor is supported by an editorial team of ten drawn from the voting and corresponding members.

#### **Interfaces:**

IGCP 739: “The Mesozoic-Palaeogene hypothermal events: lessons for understanding Anthropogene global warming”, leader Xiumian Hu, with scientists from Turkey, India, Ireland, USA. Interconnection is relevant to the joint virtual workshop of IGCP 739 on 24<sup>th</sup> of August, 2022, and joint works on the Permian-Triassic extinction and hothouse regimes.

### **3a. Nominated Officers for 2020-2024**

Chair: Zhong-Qiang Chen, State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan), Wuhan, China

Vice-Chair: Wolfram M. Kürschner, UiO Department of Geosciences, Oslo, Norway

Secretary: Yadong Sun, China University of Geosciences (Wuhan), Wuhan, China

Webperson and *Albertiana* Editor: Christopher A. McRoberts, Geology Department, SUNY, Cortland, New York, USA

## **4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS**

All publications published and research costs by TST members were sponsored by their research grants from various funding agencies.

## 5. CHIEF ACCOMPLISHMENTS IN 2023

A total of 134 papers that are closely related to stratigraphy and extreme biotic, environmental and climatic events within the Triassic have been published by STS members in 2023.

**New achievements in I-O boundary:** Lyu et al. (2023a) recognized 9 unitary associations across the IOB interval worldwide using species of *Neospathodus* and *Novispathodus*, with the probable IOB being calibrated within UAZ-2. Both the West Pingdingshan section, South China and the Mud section near Spiti, India are currently considered as the candidates for the base-Olenekian GSSP. Unitary association analysis indicates that the West Pingdingshan is the most complete and reproducible site for the GSSP of IOB based on the first appearances of *E. costatus*, *Ns. posterolongatus*, *Nv. waageni eowaageni*, and *Nv. waageni waageni*. They all co-occur in UAZ-2, which is calibrated to a 5-m-interval from Beds 23–4 to 25–30 at West Pingdingshan. The same UAZ is confined to Beds 12b to 14a in the Mud section. *Ns. posterolongatus* may serve as an auxiliary marker, and *Eu. costatus* approximates the IOB in shallow-water settings. Lyu et al. (2023b) proposed two evolutionary lineages of conodonts as the basis for global correlation and eliminates the possibility that the first occurrence of species in one lineage or the other is simply a migration event. The new results and selection of GSSP of IOB have been hotly debated at the STS session and business meeting joint with the Strati 2023. A formal proposal for the GSSP of IOB will be completed for ratification with the task group of IOB in 2024.

**Primary publications:** Lyu, Z., et al., 2023a. High-resolution conodont unitary association zonations (UAZs) across the Induan-Olenekian boundary (Lower Triassic): A global correlation. *Palaeogeography, Palaeoclimatology, Palaeoecology* 627, 111721. Lyu et al., 2023b. New conodont faunas and two proposed conodont evolutionary lineages improve the accuracy of global correlation to IOB (Lower Triassic). *Abstracts, 4<sup>th</sup> International Congress on Stratigraphy, 11<sup>th</sup>-13<sup>th</sup> July, 2023, Lille, France.*

**New achievements in O-A boundary:** Four candidates for GSSP of OAB: the Wantou section and Guandao section in South China, the Desli Caira section in Romania and Kcira section in Albania. Chen et al. (2023) reported the updated information for the Wantou section at Strati 2023. Multidisciplinary studies on this section provide a considerable amount multi-proxies of biostratigraphy, magnetostratigraphy, and chemostratigraphy constraining the OAB, with the FAD of conodont *Chiosella timorensis* sensu stricto at Bed 15e (9.16 m), with other proxies including 1) the peak of the carbon isotope positive excursion and 2) base of brief normal polarity prior to the normal polarity dominated interval. FAD of *Ch. timorensis* has advanced on the global synchronous correlation compared to other proposed alternative index species, and the Wantou section is more suitable for the GSSP of OAB than others worldwide. In contrast, Horacek and Gradinaru (2023) updated the existing data from the Desli Caira section in Romania and added a high-resolution  $\delta^{13}\text{C}$  curve to aid the correlation of OAB. They found that two different levels for OAB based on turnovers of conodont, ammonoid and foraminifera species associated with a maximum in  $\delta^{13}\text{C}$  excursion. When compared with the Kcira and Wantou sections that both lack a detailed ammonoid stratigraphy, the Desli Caira is the better suited section for GSSP of OAB, once the problem with the two boundary levels is solved (Horacek and Gradinaru, 2023). However, Dr. M.

Balini (2023, in oral) reported that the ammonoids from Desli Caira are rather confused and it is difficult to define the OAB at the Strati2023. The new work by Golding (2023) shows that conodont biostratigraphy from Desli Caira is also rather confused. Thus, additional field workshops are planned in South China and Romania in 2024 to sort out the marker of OAB.

**Primary publications:** Horacek, M., Gradinaru, E., 2023. The Spathian-Anisian (Lower-Middle Triassic) Boundary in the candidate GSSP section at Desli Caira, Romania: Review of existing data, new findings, and comparison with other candidates. *Palaeogeography, Palaeoclimatology, Palaeoecology* 613, 111612. Chen, Y., *et al.*, 2023. An updated of conodonts biostratigraphy at the Wantou section (South China)-A potential candidate of GSSP for base of Anisian. *Abstracts, 4<sup>th</sup> International Congress on Stratigraphy, 11<sup>th</sup>-13<sup>th</sup> July, 2023, Lille, France*. Golding, M., 2023. New conodont data from the Olenekian-Anisian Boundary interval at the GSSP Candidate Section at Dešli Caira, Romania. *Abstracts, 4<sup>th</sup> International Congress on Stratigraphy, 11<sup>th</sup>-13<sup>th</sup> July, 2023, Lille, France*.

**New achievements in C-N and N-R boundaries:** After a formal voting procedure within the working group, the Pizzo Mondello section was selected as the GSSP for the base of the Norian. A team led by Dr. Marco Balini is preparing a formal proposal for the GSSP of CNB for the ratification within voting members of STS at the moment. Regarding the GSSB for NRB, two candidates are the Pignola Abriola in Italy and Steinbergkogel in Austria, which both utilize the FO of conodont *Misikella posthernsteini* as a proxy for the boundary. Golding (2023) reported conodont data from New York Canyon of USA, which placed the NRB at the FO of *Mi. posthernsteini*. However, this species was recovered well above the FO of Rhaetian ammonoids (*Paracochloceras amoenum*). Additional works therefore are needed to clarify these discrepancies.

**Primary publications:** Golding, M., 2023. Late Triassic conodonts from New York Canyon, Nevada, and their relevance to the position of the Norian-Rhaetian Boundary. *Abstracts, 4<sup>th</sup> International Congress on Stratigraphy, 11<sup>th</sup>-13<sup>th</sup> July, 2023, Lille, France*.

**Two indoor meetings and one international summer school: 1) SC9: Triassic integrated stratigraphy, GSSPs and extreme climatic, environmental and biotic events** (July 12<sup>th</sup>, 2023, Lille, France), with 65 participants. This session has attracted 24 abstracts which are the highest number of papers presented among all sessions at ICS. This symposium offered a great platform for STS members to communicate the advanced results on various GSSPs and stratigraphy of Triassic. All members have discussed the definitions and possible selectivity of GSSPs for several stage-boundaries within Triassic. In particular, the I-O, O-A and C-N boundaries have been hotly debated, and various stages of GSSP proposals have been achieved. **2) STS business meeting** (July 12<sup>th</sup>, 2023, Lille, France): 1) summarizing STS works in 2023 by Chair; 2) working progress reports on GSSPs (task completed and future plan); 3) Corresponding/voting member list updated, recommending replacement of STS voting member; 4) collecting activity information and publications for STS Newsletter/Albertiana; and 4) launching Serial books “The Triassic of the World”. Chairs of the IOB (C. Henderson), OAB (S. Lucas, represented by H. Jiang and M. Balini), CNB (M. Balini), and NRB (Y. Sun) introduced the progresses, problems and perspectives on their GSSP studies. The voting members of the working groups of these GSSPs have been updated, and the IOB task group has selected a new secretary (Dr. Zhengyi Lyu) to organize activities

within this task group (led by Prof. Charles Henderson). The new working/voting members were also selected or nominated for the OAB task group led by Dr. Spencer Lucas. The CNB working group pushed Dr Marco Balini's team to complete the formal proposal of the GSSP for the CNB so that it can be ratified within STS in 2024. **3)** STS sponsored the **International Geological Summer School "Millions of years before the Silk Road"**, 13-25 August 2023 in Madygen, Kyrgyzstan, Central Asia, organized under the auspices of UNESCO by the Tian Shan Geological Society. Participants were 10 graduate and PhD students from Germany, United Kingdom, Uzbekistan and Kyrgyzstan.

## **6. SUMMARY OF EXPENDITURE IN 2023**

Total 1100 USD is used to sponsor partially three airfares for members from Japan, China and USA to travel to Lille, France to attend the STS symposium/session and business meeting joint with the 4<sup>th</sup> International Congress on Stratigraphy, 11<sup>th</sup>-13<sup>th</sup> July, 2023.

## **7. SUMMARY OF INCOME IN 2023**

Total 1,100 USD was allocated for STS activities in 2023.

## **8. BUDGET REQUESTED FROM ICS IN 2024\*\*\***

Total 3,000 USD is budgeted for organizing three major events in 2024: 1) the STS symposium at the 35<sup>th</sup> International Geological Congress, 24<sup>th</sup> to 31<sup>th</sup> August, 2024, Busan, Korea; 2) STS Field Workshop: The Olenekian-Anisian Boundary Succession in Romania, 14<sup>th</sup> -16<sup>th</sup> July, 2024, and 3) STS Field Excursion: The Olenekian-Anisian Boundary Successions in South China: from Wentou section (Guangxi) to Guandao section (Guizhou), 10<sup>th</sup> -16<sup>th</sup> October, 2023.

## **9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR:**

- Organizing the **STS Symposium/Sessions: Mid-Phanerozoic mass extinction, recovery, extreme environmental events and integrated stratigraphic correlations**, joint with the 37<sup>th</sup> International Geological Congress, 24<sup>th</sup>-31<sup>th</sup> August, 2024, Busan, Korea, in which STS business meeting is held, progresses on GSSPs for IOB, OAB, CNB, and NRB are reported.
- Organizing the **STS Field Workshops**: The Olenekian-Anisian Boundary Successions in Romania (14<sup>th</sup> -16<sup>th</sup> July, 2023) and in South China (10<sup>th</sup> -16<sup>th</sup> October, 2023).
- **GSSPs**: The plan is to move towards a vote on the GSSP for **CNB** in 2024 within STS. The IOB, OAB and NRB GSSPs move towards preparing a discussion document among the working group members at the Busan meeting in 2024, as a prelude to moving towards a vote on the candidate markers and sections.

## **10. KEY OBJECTIVES AND WORK PLAN FOR THE PERIOD 2020-2024**

Total 2 international symposia, 2-3 STS sessions, 1 thematic issue, significant progresses on 4 GSSPs (2 of them can be ratified are anticipated to be achieved):

- Organizing the webinar: **International Symposium on Triassic Integrated Stratigraphy and Bio-Environmental Events** in Wuhan, China on 03-07 Nov., 2022.
- Organizing the **Triassic Integrated Stratigraphy** session jointly with the 4<sup>th</sup> International Congress on Stratigraphy, Lille, France, in July, 2023.

- Organizing the **Field Workshops** on GSSP of OAB in South China and Romania, in July-Oct., 2024.
- Organizing the STS sessions in major conferences, and journal special issues in 2022-24.
- Launching global Triassic book series: **Triassic of the World**, and inviting the Triassic workers from around the world to write various volumes and chapters in 2022-2024.
- **Norian GSSP**: This GSSP is to move towards a vote in 2024. **Olenekian GSSP**: Completing the GSSP proposal for ratification within working group in 2024.
- **Anisian GSSP**: Completing proposal for ratification within working group in 2024. **Rhaetian GSSP**: A task group is formed to re-start the works on this GSSP.

## APPENDIX [Names and Addresses of Current Officers and Voting Members)

### Nominated officer for 2020-2024

**Chair:** Zhong-Qiang Chen, State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan), 388 Lumo Road, Hongshan District, Wuhan 430074, China; Tel: 86-27-67883068; E-mail: [zhong.qiang.chen@cug.edu.cn](mailto:zhong.qiang.chen@cug.edu.cn)

**Vice Chair:** Wolfram M. Kürschner, Department of Geosciences, P.O. Box 1047 Blindern, N-0316 Oslo, Norway; Tel: +47 22856672; E-mail: [w.m.kurschner@geo.uio.no](mailto:w.m.kurschner@geo.uio.no)

**Secretary:** Yadong Sun, Universität Erlangen-Nürnberg, Schlossgarten 5, 91054 Erlangen, Germany; Tel: +49 09131 85 23422; E-mail: [yadong.sun@fau.de](mailto:yadong.sun@fau.de)

**Albertiana Editor:** Christopher A. McRoberts, Department of Geology, State University of New York at Cortland, P.O. Box 2000, Cortland, New York 13045, USA ([mcroberts@cortland.edu](mailto:mcroberts@cortland.edu)).

### List of Voting Members (23 members):

| e-mail   | Surname   | First          | Address   |
|--|-----------|----------------|---|
| <a href="mailto:aida@cc.utsunomiya-u.ac.jp">aida@cc.utsunomiya-u.ac.jp</a>     | Aita      | Yoshiaki       | Utsunomiya University, Japan.   |
| <a href="mailto:marco.balini@unimi.it">marco.balini@unimi.it</a>               | Balini    | Marco          | Milano, Italy.  |
| <a href="mailto:onbhargava@yahoo.co.in">onbhargava@yahoo.co.in</a>             | Bhargava  | Om N.          | Panchkula 134109, India.  |
| <a href="mailto:hugo.fr.bucher@pim.uzh.ch">hugo.fr.bucher@pim.uzh.ch</a> ;     | Bucher    | Hugo           | Paläontologisches Institut und<br>Museum Karl-Schmid-Strasse 4<br>8006 Zürich, Switzerland. |
| <a href="mailto:H.Campbell@gns.cri.nz">H.Campbell@gns.cri.nz</a>               | Campbell  | Hamish         | GNS Science, Te Pū Ao, New<br>Zealand.  |
| <a href="mailto:zhong.qiang.chen@uwa.edu.cn">zhong.qiang.chen@uwa.edu.cn</a>   | Chen      | Zhong<br>Qiang | University of Geosciences<br>(Wuhan), China.  |
| <a href="mailto:dvk@rci.rutgers.edu">dvk@rci.rutgers.edu</a>                   | Kent      | Dennis         | Rutgers University Piscataway NJ<br>08854-8066 U.S.A.                                       |
|  | Henderson | Charles<br>M.  | University of Calgary, Calgary,<br>Canada   |
| <a href="mailto:m.hounslow@lancaster.ac.uk">m.hounslow@lancaster.ac.uk</a>     | Hounslow  | Mark W.        | Lancaster Environment Centre,<br>Lancaster University, UK                                   |
| <a href="mailto:leopold.krystyn@univie.ac.at">leopold.krystyn@univie.ac.at</a> | Krystyn   | Leopold        | Vienna, Austria.  |
| <a href="mailto:mclanger@ffclrp.usp.br">mclanger@ffclrp.usp.br</a>             | Langer    | Max            | Laboratório de Paleontologia,<br>Monte Alegre, Ribeirão Preto, SP,<br>Brazil.               |
| <a href="mailto:spencer.lucas@state.nm.us">spencer.lucas@state.nm.us</a>       | Lucas     | Spencer        | Albuquerque, New Mexico, USA  |
| <a href="mailto:menne@gfz-potsdam.de">menne@gfz-potsdam.de</a>                 | Menning   | Manfred        | Potsdam, Berlin.  |
| <a href="mailto:paolo.mietto@unipd.it">paolo.mietto@unipd.it</a>               | Mietto    | Paolo          | Università di Padova, Italy.  |
| <a href="mailto:Alda.nicora@unimi.it">Alda.nicora@unimi.it</a>                 | Nicora    | Alda           | Università degli Studi di Milano,<br>Italy.   |
| <a href="mailto:morchard@nrcan.gc.ca">morchard@nrcan.gc.ca</a>                 | Orchard   | Michael<br>J.  | Nat. Res. Canada, Vancouver,<br>Canada.   |
| <a href="mailto:Bruce.Rubidge@wits.ac.za">Bruce.Rubidge@wits.ac.za</a>         | Rubidge   | Bruce          | Wits University, South Africa.  |

|   |             |            |   |
|---|-------------|------------|---|
| kemami@ut.ac.ir                                 | Seyed-Emami | Kazem      | University College of Engineering.<br>University of Tehran, Iran.                                       |
| shishkin@paleo.ru                               | Shishkin    | Michael A. | Paleontological Institute, Russian Academy of Sciences,<br>Profsoyuznaya 123, 117997<br>Moscow, Russia. |
| jntong@cug.edu.cn                               | Tong        | Jinnan     | China University of Geosciences (Wuhan), China.   |
| voros@zoo.zoo.nhmus.hu                          | Voros       | Attila     | Budapest, Hungary.  |
| hfyin@cug.edu.cn                                | Yin         | Hongfu     | China University of Geosciences (Wuhan), China.   |
| yurizakh@mail.ru                                | Zakharov    | Yuri D.    | Vladivostok, Russia.  |
| ~110 STS corresponding members, not listed here |             |            |   |

### **Chairs of the Working Groups of the unresolved GSSP boundaries**

Base Rhaetian Working Group, Y. Sun, [yadong.sun@fau.de](mailto:yadong.sun@fau.de)

Base Norian Working Group, M. W. Hounslow, [m.hounslow@lancaster.ac.uk](mailto:m.hounslow@lancaster.ac.uk)

Base Anisian Working Group (and non-marine working Group), S. G. Lucas, [spencer.lucas@state.nm.us](mailto:spencer.lucas@state.nm.us)

Base Olenekian Working Group, C. M. Henderson, [cmhender@ucalgary.ca](mailto:cmhender@ucalgary.ca)

### **Appendix II: STS Symposium joint with the 37<sup>th</sup> IGC, August, 2024, and Full Publication List of STS Members in 2023**

Appendix II-1: Call for Abstract for STS Symposium joint with STRATI 2023

Appendix II-2: Full list of publications by STS Members.



## Appendix II-1:

### Mid-Phanerozoic mass extinctions, recovery, extreme environmental events and integrated stratigraphic correlations

Zhong-Qiang Chen\*, Yadong Sun, Yu Pei, Yuangeng Huang, Xueqian Feng

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Middle Phanerozoic is one of the most critical period of life and environmental evolutions in sea and on land, witnessing five mass extinctions during the Guadalupian-Lopingian (Permian), Permian-Triassic, Smithian-Spathian, mid-Carnian, and Triassic-Jurassic transitions. Marine and terrestrial organisms suffered environmental and climatic crises such as widespread anoxia, hothouse regimes and global weirding during these critical transitions, which were likely ultimately triggered by numerous volatile eruptions of large igneous traps. Marine and terrestrial ecosystems collapsed and re-built during these critical transitions, and they successfully overcame these threats, and eventually evolve to the Dinosaur era of the Mesozoic. This session intends to assemble fresh researches on all aspects of the above topics and provides new insights into the causal linking between marine and terrestrial extreme events through integrated stratigraphic correlations and better understanding of the mid-Phanerozoic biotic and environmental evolutions, which offer some lessons for the management of modern fragile ecosystems and predictions of global weirdings.

## Appendix II-2:

### Full list of 134 publications by STS members in 2023

1. Allen, B.J., Clapham, M.E., Saupe, E.E., Wignall, P.B., Hill, D.J., Dunhill, A.M., 2023. Estimating spatial variation in origination and extinction in deep time: a case study using the Permian-Triassic marine invertebrate fossil record. *Paleobiology* 49 (3), 509-526.
2. Amirhassankhani, F., Senowbari-Daryan, B., Rashidi, K., 2023. Upper Triassic (Norian-Rhaetian) Foraminifera from the Nayband Formation of the Lut Block (Garm Ab section, Northeast Iran). *Carnets De Geologie* 23 (4), 77-95.
3. Aouissi, R., Salmi-Laouar, S., 2023. The heterodont bivalve *Maghrebella forgemoli* (Coquand, 1862) from Cenomanian of Batna, Northeastern Algeria: Palaeobiogeography, biostratigraphy and palaeoenvironment. *Proceedings of the Geologists Association* 134 (2), 183-196.
4. Araújo, R., Smith, A.S., 2023. Recognising and quantifying the evolution of skeletal paedomorphosis in Plesiosauria. *Fossil Record* 26 (1), 85-101.
5. Arcucci, A.B., Mancuso, A.C., 2023. Gondwanan perspectives: Triassic ecosystems. paleobiological aspects and the context of recovery from the great extinction. *Ameghiniana* 60 (2), 111-117.
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## SUBCOMMISSION ON PERMIAN STRATIGRAPHY ANNUAL REPORT 2023

### 1. TITLE OF CONSTITUENT BODY and NAME OF REPORTER

International Subcommittee on Permian Stratigraphy (SPS)

Submitted by: Lucia Angiolini, SPS Chair

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### 2. OVERALL OBJECTIVES, AND FIT WITHIN IUGS SCIENCE POLICY

**Subcommission Objectives:** The Subcommittee’s primary objective is to define the series and stages of the Permian by means of internationally agreed GSSPs and establish a high-resolution temporal framework based on multidisciplinary (biostratigraphical, geochronologic, chemostratigraphical, magnetostratigraphical etc.) approaches, and to provide the international forum for scientific discussion and interchange on all aspects of the Permian, but specifically on refined intercontinental and regional correlations.

**Fit within IUGS Science Policy:** The objectives of the Subcommittee involve two main aspects of IUGS policy: 1) The development of an internationally agreed chronostratigraphic scale with units defined by GSSPs where appropriate and related to a hierarchy of units to maximize relative time resolution within the Permian System; and 2) the establishment of framework and systems to encourage international collaboration in understanding the evolution of the Earth and life during the Permian Period.

### 3. ORGANISATION - interface with other international projects / groups

#### 3a. Officers for 2020-2024 period:

**Prof. Lucia Angiolini (SPS Chair)**

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**Prof. Michael H. Stephenson (SPS Vice-chair)**

British Geological Survey. Keyworth, Nottingham NG12 5GG, and Stephenson Geoscience Consulting, Keyworth, Nottingham, NG12 5HU, United Kingdom, E-mail: [mikepalyno@me.com](mailto:mikepalyno@me.com)

**Prof. Yichun Zhang (SPS Secretary)**

State Key laboratory of Palaeobiology and Stratigraphy. Nanjing Institute of Geology and Palaeontology, 39 East Beijing Road, Nanjing, Jiangsu 210008, P.R. China, E-mail: [yczhang@nigpas.ac.cn](mailto:yczhang@nigpas.ac.cn)

### 4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS

Shuzhong Shen and Michael Stephenson are investigating the possibility of support for SPS through the Deep-time Digital Earth (DDE) Big Science Program of IUGS focused on informatics support for biostratigraphic data management and palaeogeographic reconstructions.

### 5. CHIEF ACCOMPLISHMENTS IN 2023 (including any relevant publications arising from ICS working groups)

- The redefinition the Global Stratotype Section and Point (GSSP) for the base of the Wuchiapingian Stage (and Lopingian Series) was ratified by the IUGS Executive

Committee on 24 July 2023.

- A Standard Auxiliary Boundary Stratotype (SABS) for the base of the Wuchiapingian Stage at the Fengshan Section, China, was approved by SPS on 16 April 2023.
- The paper "Proposal for the Global Stratotype Section and Point (GSSP) for the base-Artinskian Stage (Lower Permian)" by Chernykh et al. was published online in Episodes, June 15, 2023.
- The paper "Redefinition of the Global Stratotype Section and Point (GSSP) and new Standard Auxiliary Boundary Stratotype (SABS) for the base of Wuchiapingian Stage (Lopingian Series, Permian) in South China" by Shen et al. was published online in Episodes, November 1, 2023.
- Four new voting members were selected based on their extensive research in Permian stratigraphy (Neil Griffis, USA; Hana Jurikova, United Kingdom; Lorenzo Marchetti, Germany; Michael Read, USA). A Newsletter Editor has been invited (Elizabeth Weldon, Australia).
- A new Working Group was organized: Kungurian-base GSSP Working Group.
- The Permian Time Scale was kept updated <https://permian.stratigraphy.org/gssps>, the SPS website was kept updated, and two issues of *Permophiles* were published (SPS Newsletters *Permophiles* 74 and 75, the latter a special issue with "Permian Perspectives").
- Two webinars were organized, one on The IUGS Deep-time Digital Earth Program by Stephenson and one on Progress, problems and perspectives for the base-Roadian and base-Wordian GSSPs by Shen & Henderson (<https://permian.stratigraphy.org/interest>).

## 6. SUMMARY OF EXPENDITURE IN 2023

The amount received from ICS was spent for literature compilation, for the Standard Pro Annual ZOOM license for SPS, to support the participation to the STRATI 2023 Congress in Lille of two early career SPS corresponding members, and for funding two research projects of young SPS corresponding members on Permian topics.

The participation of Lucia Angiolini to STRATI 2023 was supported by the Organizing Committee of the STRATI 2023 Congress as she was invited to give a Plenary Talk; only subordinately SPS funds were used to support part of the field excursion expenses.

The field-trip to the Rockland section (Nevada), base Kungurian GSSP candidate, was postponed to 2024.

## 7. SUMMARY OF INCOME IN 2023

An amount of Euros 3262,56 euros was allocated from ICS in June 2023.

## 8. BUDGET REQUESTED FROM ICS IN 2024\*\*\*

We apply for 4500 US\$ from ICS for SPS activities in 2024. This will be mainly for the activities to establish the base-Kungurian GSSP at Rockland, Nevada and to organize a field trip in the area,

## 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR:

- We plan to have the proposal of the base Kungurian GSSP published in *Permophiles* and voted by SPS voting members.
- We plan to start the revision of the Guadalupian base Roadian and base Wordian GSSPs.

- We plan to organize several webinars.
- We plan to support the activity of the working groups.
- We plan to renew the composition of the voting members bringing in more younger members of the Permian community.
- We plan to publish two *Permophiles* issues.

#### **10. KEY OBJECTIVES AND WORK PLAN FOR THE PERIOD 2020-2024**

- Establish the Artinskian and Kungurian GSSPs.
- Revise the Permian timescale where it needs to be improved (Guadalupian stages, replacement GSSP section of the base-Lopingian).
- Establish a robust palaeogeographic framework for the Permian and focus on N-S correlations.
- Propose DDE-sponsored informatics support for biostratigraphic data management and palaeogeographic reconstructions.
- Organize webinars to increase the size, diversity and international coverage of the Permian Community.
- Publish at least two *Permophiles* issues each year.

#### **APPENDIX [Names and Addresses of Current Officers and Voting Members]**

##### **Prof. Lucia Angiolini (SPS Chair)**

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##### **Dr. Neil Griffis**

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##### **Prof. Charles M. Henderson**

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##### **Dr. Hana Jurikova**

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##### **Dr. Sam Lee**

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##### **Prof. Spencer G. Lucas**

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**Prof. Ausonio Ronchi**

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**Prof. Joerg W. Schneider**

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**Working group leaders**

- 1) Kungurian-base GSSP Working Group; Chair – Charles Henderson.
- 2) Correlation between marine and continental Carboniferous-Permian Transition Working Group; Chair - Joerg Schneider.
- 3) Gondwana to Euramerica correlations; Chair - Mike Stephenson.

## SPS APPLICATION FOR ICS FUNDS FOR GSSP WORKING GROUP RESEARCH

TO: Dave Harper, Chair, International Stratigraphic Commission  
FROM: Lucia Angiolini, Chair, Subcommittee on Permian Stratigraphy  
RE: Application for funds to support GSSP working group research

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This is an application for funds to support work for the proposals of the base-Kungurian (Cisuralian) GSSP at the Rockland section (Nevada, USA).

The IUGS statement in reaction to the invasion of Ukraine by the Russian Federation had consequences for the research we planned to undertake on the base-Kungurian GSSP, as we could not perform field activity at the Mechetlino section (Russia).

The geopolitical situation and the necessity to have permanent free access to a GSSP section suggest now that we focus our efforts on another base-Kungurian GSSP candidate, that is the Rockland section in Nevada.

In fact, in *Permophiles* 56, two GSSP candidates were proposed for defining the base-Kungurian: the Mechetlino section, Urals, Russia (Chernykh et al., 2012) and the Rockland section, Nevada, USA (Henderson et al., 2012), both siting the point at the FAD of the conodont *Neostreptognathodus pnevi*. Table 1 in Henderson et al. (2012) showed the comparison between the main features of the two sections, with Rockland having the merit of recording a longer time interval (all Artinskian and Kungurian), a much more expanded boundary interval in carbonate facies, and a richer benthic fossil content, also allowing correlation with the Tethyan sections. Conodonts are much better preserved in Mechetlino allowing strontium isotopic analyses and Mechetlino is within the historical type area. The progresses on the work on the Rockland section by the newly established Working Group have been reported in *Permophiles* 75.

We ask funds to support:

- A field trip to the Rockland section in May 2023.

We request funds to support the travel expenses by two 4X4 cars to the section (around 1000 USD) and the accommodation for 7 days in Nevada for the officers and 3 voting members (around 3500 USD)

We are requesting a grant from ICS for a total of \$4500 USD.

If you require any further information, please do not hesitate to contact me.

Best regards,

Lucia Angiolini, Chair, SPS



## **1. TITLE OF CONSTITUENT BODY and NAME OF REPORTER**

### **Subcommission on Carboniferous Stratigraphy (SCCS)**

#### **Prepared mainly by Xiangdong Wang, Chair of SCCS**

School of Earth Sciences and Engineering,  
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No. 163 Xianlin Avenue, Nanjing 210023, China  
Tel: 086-13605184681; Email: [xdwang@nju.edu.cn](mailto:xdwang@nju.edu.cn)

## **2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY**

### **Objective**

The SCCS promotes and coordinates international cooperation among various geologic specialists for the purpose of defining standard global chronostratigraphic boundaries within the Carboniferous System and promoting regional and intercontinental stratigraphic correlation of Carboniferous. The principal SCCS goals are:

- (a) to establish a standard global stratigraphic time scale and to select the best stage boundaries within the Carboniferous system,
- (b) to establish high-resolution integrated stratigraphic frameworks at regional scale, and
- (c) to facilitate global correlation in the system.

### **Fit within IUGS Science Policy**

The current objectives of SCCS relate to the main aspects of IUGS policy:

- (a) Establishment of a standard global stratigraphic time scale, defined by Global Stratotype Sections and Points (GSSPs).
- (b) Development of internationally acknowledged chronostratigraphic units/or boundaries.
- (c) Promotion of international cooperation in geological research.

## **3. ORGANISATION - interface with other international projects/groups**

### **3a. SCCS Officers for 2020-2024:**

Chair: Xiangdong Wang (China)  
Vice-Chair: Svetlana Nikolaeva (UK/Russia)  
Secretary: Markus Aretz (France)  
Webperson: Markus Aretz (France)

### **3b. Voting members (VM) and corresponding members (CM):**

For the 2020-2024 term, the SCCS currently has 21 voting members (including 3 officers) representing 11 countries: Australia (1), Belgium (2), Czech Republic (2), China (4), France (1), Germany (1), Japan (1), Russia (4), Spain (2), UK (1), USA (2). A full list of current voting members (with detailed contact information) is attached at the end of this report as an appendix. SCCS has almost 200 corresponding members at present. The membership, voting and corresponding, of persons affiliated with Russian institutions are currently on hold, and they are suspended from all subcommssion's activities.

### **3c. SCCS maintains an official website, and the URL is as follows:**

<http://carboniferous.stratigraphy.org/>

### **3d. Interface with other international projects/groups**

The SCCS cooperates closely with the subcommissions on Devonian (SDS) and Permian Stratigraphy (SPS) to establish common boundaries with the Carboniferous. The SCCS experts have established a closer relationship with the Deep-Time Digital Earth (DDE), the first IUGS-recognized big science program, with the primary goal of harmonizing ‘deep-time’ digital geological data and providing a novel glimpse into the Earth’s geological past and its future.

### **4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS**

SCCS has no direct financial support from other sources. All members use their own resources to cover the expenses for the work related to the goals and activities of SCCS.

### **5. CHIEF ACCOMPLISHMENTS IN 2023 (including any publications arising from ICS working groups)**

The work of SCCS has still been strongly impacted by the current political situation. The SCCS voting members and officers are directly impacted, and the search for GSSPs has been slowed down due to temporary inaccessible of key sections.

#### **5.1 A book titled “Ice ages, climate dynamics and biotic events: the Late Pennsylvanian World” was published in 2023 by Geological Society, London, Special Publications 535**

The special issue is edited by Spencer G. Lucas (VM of SCCS), William A. DiMichele (CM of SCCS), Joerg W. Schneider (CM of SCCS), Stanislav Opluštil (CM of SCCS), and Xiangdong Wang (Chair of SCCS) and comprises 18 articles included in seven sections: I. Introduction, II. Timescale, III. The Cantabrian Stage, IV. Geological context, V. Palaeobotany, VI. Invertebrate palaeontology, VII. Vertebrate palaeontology.

#### **5.2 The Devonian-Carboniferous boundary**

The working group for the revision of the base of the Carboniferous has continued to work on a revised boundary definition and its global correlation. The working hypothesis of a revised boundary level and criterion has been tested and can be upheld; additionally, a calendar listing a succession of particular points in time defined by physical and/or biological criteria has been developed for the latest Famennian and earliest Tournaisian (DCB interval). This calendar is meant to help to place at least approximately the future boundary if a section lacks critical boundary criteria.

Following the disruption by the pandemic period, the working group has started to visit key sections in the field. This year, before the STRATI meeting in Lille, the working group organized a field conference in Germany and Belgium to study and discuss classical sections in the Rhenish Mountains and the Ardennes for the definition of the DCB in different facies realms. The work in the field has demonstrated the applicability not only of a revised boundary level and criteria, but also the usefulness of the calendar and its multitude of physical and biological criteria.

#### **5.3 The Kasimovian-Gzhelian boundary**

The manuscript of proposal to define the Kasimovian-Gzhelian boundary is now finished and is being revised among working group members. The potential GSSP is defined at the

Naqing section, Guizhou Province, South China to present conodont lineage of the index taxon, fusulinid biostratigraphy, carbon, oxygen, strontium, and uranium isotopic stratigraphy, and cyclostratigraphy. The boundary level between the Kasimovian and Gzhelian stages, the FAD of *Idiognathodus simulator*, is defined within a lineage from *I. abdivitus* to *I. simulator* based on evolutionary paleontology and platform landmark analysis (PLA) at the horizon of 220.45 meters in the Naqing Section. The proposal will be submitted to be voted hopefully in the early 2024.

#### 5.4 The Moscovian-Kasimovian boundary

A primary difficulty when correlating the Kasimovian Stage at a global scale is that potential index fossils provide variable levels of precision. Compared with benthic faunas, the pelagic conodonts have better potential to correlate the base of the Kasimovian. The conodont species *Swadelina subexcelsa*, *Idiognathodus heckeli*, *I. turbatus*, and *I. sagittalis* are possibly boundary markers, and all have different advantages. By evaluating all aspects of the taxonomy, biostratigraphy, and palaeobiogeography of those species, *I. heckeli* is considered to be the best marker for the base boundary of the Kasimovian Stage because it has a wide geographic distribution, clear taxonomic definition within the phylogenetic lineage *I. swadei*-*I. heckeli*-*I. turbatus*, and its FO marks a globally recognized bioevent. The chemostratigraphic proxies, however, provide less correlation potential based on current studies. The Naqing section, South China is the most appropriate candidate because of its complete deep-water succession that has been studied in detail on bio-, chemo- and cyclostratigraphy, and provides a complete lineages of the potential boundary markers *I. heckeli*. A proposal to define the boundary will be prepared within the next two years.

#### 5.5 The Bashkirian-Moscovian boundary

Two potential index taxon *Diplognathodus ellesmerensis* and *Declinognathodus donetzianus* have been recorded from multiple basins, and are the only taxa still being considered by the Task Group. Both occur as minor components in the conodont assemblages in the boundary level. *Diplognathodus ellesmerensis* has a slightly longer range and a much wider distribution than that of *De. donetzianus*.

Outside of eastern Europe, *De. donetzianus* is very rare, usually being represented by single specimens. It is entirely absent from the primary stable continent of North America (it only occurs in accreted terranes) and Asia. Even by adding the equivocal occurrences of *De. donetzianus* from North America and South America, the palaeogeographic distribution of *De. donetzianus* remains significantly more limited than that of the widespread *D. ellesmerensis*. The lineage *De. marginodosus*-*De. donetzianus* has been recorded in the Russian Platform, i.e., the Donets Basin, Volga region and South Urals. However, the current BMB in the Russian Platform was not defined by the earliest evolutionary appearance of *De. donetzianus*.

The lineage *D. benderi*-*D. ellesmerensis* is known in South China and South Urals. In the former area a morphocline of the lineage has been well recorded. In the latter area, *D. ellesmerensis* and *De. donetzianus* co-occur. In other areas, e.g., the Arctic, North America, and South America, the *D. benderi*-*D. ellesmerensis* lineage may also be tested due to both species were both recorded there. Currently, *D. ellesmerensis* has a higher potential for the BMB index fossil due to its global distribution, an abundance of supplementary marker species at similar stratigraphic levels, and the close stratigraphic proximity of the FAD to the traditional BMB, thus largely preserving the original concept for the base of the Moscovian Stage. The proposal for the boundary will be prepared next year.

## 5.6 The Visian-Serpukhovian boundary

Coordinated progress of the working group for this boundary has not been possible due to the current political situation. Hence, activities have been reduced to mostly individual work of working group members.

## 6. SUMMARY OF EXPENDITURE IN 2023:

Prepared by Prof. Xiangdong Wang, Chair of SCCS (Accounts maintained in U.S dollar)

|                                    |               |
|------------------------------------|---------------|
| D/C boundary task group activity   | \$1460        |
| The Kasimovian task group activity | \$550         |
| The Gzhelian task group activity   | \$700         |
| SCCS Newsletter editing            | \$450         |
| <hr/>                              |               |
| <b>TOTAL EXPENDITURE</b>           | <b>\$3160</b> |

## 7. SUMMARY OF INCOME IN 2023

Prepared by Prof. Xiangdong Wang, Chair of SCCS (Accounts maintained in U.S dollar)

|                                 |               |
|---------------------------------|---------------|
| Funds carried forward from 2022 | \$ 20         |
| ICS Grant of 2023               | \$3200        |
| <hr/>                           |               |
| <b>TOTAL INCOME</b>             | <b>\$3220</b> |

## 8. BUDGET REQUEST FROM ICS FOR 2024

The 37<sup>th</sup> IGC will be held in Busan, Korea, Aug. 25-31, 2024. The officers and voting members of SCCS will meet during the venue and fully discuss problems and progress on Carboniferous GSSPs. The attendance of officers and some voting members of SCCS is going to be partly sponsored by the Subcommittee. We request **5050USD** from ICS to support attendance of SCCS members and other activities of task groups searching for the remaining GSSPs in the Carboniferous.

## 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR:

- The re-definition of the Devonian-Carboniferous boundary will be summarized by the working group leaders, and they form the base of a proposal to be submitted to the subcommittee in January 2024. It is anticipated that SCCS will vote on the proposal during February, which if validated, would allow the working group to initiate the search for a suitable GSSP. Seeing the amount of data accumulated for very different facies realms and palaeogeographic situations over the last years, a proposal for a GSSP should be elaborated in a timely manner.
- A detailed proposal for the GSSP defining the base of the Gzhelian stages will be provided and be voted by both the task group and SCCS, and the result should be submitted to the ICS in 2024.
- Evaluation on selecting boundary markers of the Bashkirian-Moscovian boundary will be discussed among the working group. The conodont lineage *D. benderi*–*D. ellesmerensis* is

high-potentially selected as the boundary marker and will be send out for voting among working group and voting members.

- Since a four-days online meeting in May 2021 dedicated to the Kasimovian Stage, its lower boundary has been widely investigated. Within the phylogenetic lineage *I. swadei-I. heckeli-I. turbatus*, *I. heckeli* is considered to be the best marker for the basal boundary of the Kasimovian Stage. It will be discussed among working group and voting members. The formal proposal will be voted in the working group and subcommission hopefully in 2024, at last in 2025.

## **10. OBJECTIVES AND WORK PLAN FOR NEXT 4 YEARS (2020-2024)**

- We intend to combine high-resolution biostratigraphy and other stratigraphic methods in multi-proxy approaches to establish as many of the remaining GSSPs as possible. It should be possible to select the defining events for one to two stage boundaries and to make significant progress toward selecting candidate sections for the GSSPs.
- We will encourage and pay more attention to finding volcanic ash beds for radiometric dating, to establish a more precise Carboniferous time scale and facilitate the correlation of important Carboniferous events at global scale.
- Using multi-disciplinary methods including palynological studies, U-Pb dating and stable isotope studies, we will further promote marine and non-marine correlation.
- Integrate the Carboniferous databases from the entire world, combining the One-Stratigraphy Database at Nanjing University, the Geobiodiversity Database (GBDB, a large compilation of data about sections) at Nanjing Institute of Geology and Palaeontology, the Paleobiology Database (a large compilation of data about fossils) at the University of Wisconsin-Madison, DDE (Deep Time Digital Earth) and other major databases, to facilitate the studies on Carboniferous biota and stratigraphy.

## **APPENDIX (Names and Addresses of Current Officers and Voting Members)**

In addition to the three executive voting members, the SCCS has eighteen rank-and-file voting members.

### **Current Officers (2020-2024):**

#### **Chair: Dr. Xiangdong Wang**

School of Earth Sciences and Engineering, Nanjing University, No. 163 Xianlin Avenue, Nanjing 210023, China; Tel: 086-13605184681; Email: [xdwang@nju.edu.cn](mailto:xdwang@nju.edu.cn)

#### **Vice-Chair: Dr. Svetlana Nikolaeva**

1) Department of Earth Sciences, the Natural History Museum, London, SW7 5BD UK;  
2) Paleontological Institute Russian Academy of Sciences Profsoyuznaya ul., 123, Moscow, 117997 Russia; E-mail: [s.nikolaeva@nhm.ac.uk](mailto:s.nikolaeva@nhm.ac.uk)

#### **Secretary: Dr. Markus Aretz**

Université Toulouse III Paul Sabatier, GET (OMP), 14, avenue Edouard Belin, 31400 Toulouse, France; Tel: +33 5 61332674; E-mail: [markus.aretz@get.omp.eu](mailto:markus.aretz@get.omp.eu)

## **Nominated officers for next four year (2024-2028)**

**Chair : Dr. Markus Aretz**

Université Toulouse III Paul Sabatier, GET (OMP), 14 avenue Edouard Belin, 31400  
Toulouse, France; Tel: +33 5 61332674; E-mail: [markus.aretz@get.omp.eu](mailto:markus.aretz@get.omp.eu)

**Vice-Chair : Dr. Jitao Chen**

Nanjing Institute of Geology & Palaeontology, Chinese Academy of Sciences, Nanjing  
210008, China; Tel: +86-18705167898; E-mail: [jtchen@nigpas.ac.cn](mailto:jtchen@nigpas.ac.cn)

**Secretary: Dr. Bernard Mottequin**

Royal Belgian Institute of Natural Sciences, O.D. Earth and History of Life, 29 rue  
Vautier, B 1000 Brussels, Belgium; E-mail: [bmottequin@naturalsciences.be](mailto:bmottequin@naturalsciences.be)

**List of Regular Voting Members (2020-2024):**

**Dr. Alexander Alekseev\***, Geology Faculty, Lomonosov Moscow State University, 119991  
Moscow GSP-1 Russia; E-mail: [aaleks@geol.msu.ru](mailto:aaleks@geol.msu.ru)

**Dr. Bernard Mottequin**, Royal Belgian Institute of Natural Sciences, O.D. Earth and History of  
Life, rue Vautier 29, B 1000 Brussels, Belgium; E-mail: [bmottequin@naturalsciences.be](mailto:bmottequin@naturalsciences.be)

**Dr. Georgy Mirantsev\***, Russian Academy of Sciences, Borissiak Paleontological Institute, The  
Higher Invertebrate Department; E-mail: [gmirantsev@gmail.com](mailto:gmirantsev@gmail.com)

**Dr. Javier Sanz-López**, Department of Geology, University of Oviedo, Arias de Velasco s/n  
33005 Oviedo, Spain; E-mail: [jasanz@geol.uniovi.es](mailto:jasanz@geol.uniovi.es)

**Dr. Jitao Chen**, State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of  
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E-mail: [jtchen@nigpas.ac.cn](mailto:jtchen@nigpas.ac.cn)

**Dr. Julien Denayer**, Palaeobiology, Evolution & Diversity Dynamics Lab, Université de Liège,  
Belgium, E-mail: [julien.denayer@uliege.be](mailto:julien.denayer@uliege.be)

**Dr. Hans-Georg Herbig**, Universität Köln, Institut für Geologie und Mineralogie, Zülpicher  
Strasse 49a, D-50674 Köln, Germany; E-mail: [herbig.paleont@uni-koeln.de](mailto:herbig.paleont@uni-koeln.de) (deceased in  
August 2023)

**Dr. Katsumi Ueno**, Department of Earth System Science, Fukuoka University, Fukuoka 814-0180  
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**Dr. Keyi Hu**, School of Earth Sciences and Engineering, Nanjing University, No. 163 Xianlin  
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**Dr. Lance L. Lambert**, Department of Geological Sciences, University of Texas at San Antonio,  
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**Dr. Ondrej Bábek**, Department of Geological Sciences, Masaryk University of Brno, Kotlarska  
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**Dr. Spencer G. Lucas**, New Mexico Museum of Natural History and Science, 1801 Mountain  
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**Dr. Tatiana Isakova\***, Geological Institute, Russian Academy of Sciences, Pyzhevsky per. 7  
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**Dr. Tomas Kumpan**, Department of Geological Sciences, Masaryk University, Kotlářská 2, 611  
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**Dr. Vera A. Konovalova\***, Russian Academy of Sciences, Profsoyuznaya 123 117997 Moscow,  
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**Dr. Wenkun Qie**, State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, CAS, No. 39 East Beijing Rd. Nanjing, Jiangsu 210008, China; E-mail: wkqie@nigpas.ac.cn

**Dr. Zhong-Qiang Chen**, (Australian Nationality), State Key Laboratory of Biology and Environmental Geology, China University of Geosciences (Wuhan), 388 Lumo Road, Wuhan 430074, China; E-mail: zhong.qiang.chen@cug.edu.cn

\* Membership currently suspended

## 1. TITLE OF CONSTITUENT BODY

### **Subcommission on Devonian Stratigraphy**

#### **Reporting Ladislav Slavík (Chair)**

## 2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY

In 2023 working groups continued to work on the revision of the GSSPs (the basal Emsian and the Devonian-Carboniferous boundary). Intensive efforts to redefine the Basal Emsian boundary continued in three areas – the Prague Synform, the Spanish Central Pyrenees and Morocco. We expect at least one GSSP proposal in the coming year. The main issues were discussed at the SDS meeting at STRATI in Lille, France on July 12<sup>th</sup> and at the regular Annual SDS Business Meeting in Geneseo, New York State, on July 30<sup>th</sup>. A comprehensive monograph entitled "Devonian of New York" was published for the New York meeting in 3 volumes of the *Bulletins of American Paleontology*. There were numerous proposals for new CMs at the 2023 meetings indicating good prospects for the future of the Devonian subcommission. Other SDS activities included the organization of the Devonian session at STRATI and future Devonian symposia, especially the joint ISSS and SDS meeting in Sofia, Bulgaria, and the publication of the SDS Newsletter, which covers all major topics related to the Devonian.

The main objectives of the Subcommission on Devonian Stratigraphy fit within IUGS science policy:

- to develop of an internationally approved chronostratigraphical timescale for the Devonian with maximum time resolution, as part of the ICS standard global stratigraphic scale;
- to produce a stratigraphic table displaying agreed subdivision to stage and substage level marking boundaries that are defined by a GSSP.
- to promote of new and modern stratigraphical techniques and their integration into Devonian multidisciplinary schemes.

## 3. ORGANISATION - interface with other international projects/groups

Actively supporting *IGCP 652, Reading geologic time in Paleozoic sedimentary rocks: the need for an integrated stratigraphy*

### 3a. Current Officers for 2020-2024 period:

Chair: Ladislav (Lada) Slavík

Vice-Chair: José Ignacio (Nacho) Valenzuela-Ríos

Secretary: Ulrich (Uli) Jansen

Webperson: Carlo Corradini

## 4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS

University of Münster continue to support the staff costs of the SDS Newsletter production and the mailing. The IUGS support pays for the printing. The Newsletter has an ISSN and



status as a publication. Since last year it is published and printed partly in colour, pdf version is published on the SDS web page hosted by the ICS web.

We have regular annual meetings (this year face to face again). SDS members support their own attendance at these.

The major part of SDS subprojects are supported from other sources (home institutes and national funding agencies).

#### 5. CHIEF ACCOMPLISHMENTS IN 2023 (including any publications arising from ICS working groups)

- **Annual business meeting of the SDS** took place on July 30<sup>th</sup> in Geneseo, NY, USA in conjunction with the Devonian conference meeting in Geneseo, with field trips from Ohio to the New York State. It was the most important event for our community directly focussed on the Devonian. The conference was very successful, perfectly organized, and both scientific sessions and fieldtrips were highly attended.
- **The SDS meeting in conjunction with the STRATI** was held on July 12<sup>th</sup>.  
At both SDS meetings the Chair informed about major points in the business meeting agenda and the current situation in our Devonian community, on-going Devonian projects (mostly reports on biostratigraphical, petrophysical and geochemical data from the key areas and progress in the Basal Emsian boundary redefinition), Devonian publications and forthcoming meetings. We had altogether around 40 participants including guests, 14 new Corresponding members were recruited from Belgium, Colombia, Portugal and USA.
- **Update of the new SDS website** – hosted on the ICS web (stratigraphy.org)
- **Publications:** SDS Newsletter No. 38, and an extensive monograph titled "Devonian of New York", edited by C. A. Ver Straeten, D. J. Over, and D. Woodrow in 3 volumes of the *Bulletins of American Paleontology* has been published.
- **Formal election of the SDS executive** (officers and voting members) for 2024-2028. The elections took place in September and October 2023.

#### 6. SUMMARY OF EXPENDITURE IN 2023 (\$USD):

|   |     |
|---|-----|
| SDS Devonian meeting in Geneseo, NY, USA and STRATI Lille, France - travel costs: |     |
| SDS Chair   | 700 |
| SDS Vice-Chair  | 700 |
| SDS Secretary   | 900 |
| SDS Newsletter  | 900 |

#### 7. SUMMARY OF INCOME IN 2023: ICS \$USD 3300

#### 8. BUDGET REQUESTED FROM ICS FOR 2024

A joint ISSS and SDS 2024 meeting "Time-schedule of the Silurian and Devonian environmental and biotic changes" is planned for September 2024 in Sofia, Bulgaria. The organization of the meeting is underway. The SDS will have a regular SDS business meeting there. Our main focus will be the discussion on the submitted proposal(s) for redefinition of the Basal Emsian GSSP and the joined Silurian and Devonian symposium. In the next year, the top event – the 37<sup>th</sup> IGC in Busan, South Korea, takes place. The SDS would like to have

a representative(s) at the Geological Congress where the new ICS officers and executives of each subcommission will officially start the 2024-2028 term.

We request contributions to travel costs for both of these events.

|  |        |
|--|--------|
| SDS Chair travel costs   | \$950  |
| SDS Vice-Chair travel costs  | \$950  |
| SDS Secretary travel costs   | \$950  |
| In addition we request part support for production of the SDS Newsletter | \$900  |
| We page maintenance  | \$150  |
| Total Sum requested from IUGS  | \$3900 |

#### 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR:

- Submission of formal proposals or progress reports from key areas for the revision of the basal Emsian GSSP.
- Revision of the D/C boundary with the D/C Boundary Task Group in close collaboration with the Carboniferous Subcommission.
- Real SDS business meeting and Devonian symposia

#### 10. KEY OBJECTIVES AND WORK PLAN FOR NEXT 4 YEARS (2020-2024)

- Redefine the base of the Emsian Stage.
- Redefinition of the Devonian/Carboniferous Boundary with the joint Task Group.
- Regular Annual Business meetings
- Comprehensive publications on Devonian

#### **APPENDIX** [Names and Addresses of Current Officers and Voting Members)

##### **NOMINATED OFFICERS**

###### **CHAIR**

LADISLAV SLAVÍK, Department of Paleobiology and Paleocology, Institute of Geology of the Czech Academy of Sciences, Rozvojová 269, CZ-165 00 Praha 6, Czech Republic, Tel.: 00420 233087247; slavik@gli.cas.cz

###### **VICE-CHAIR**

JOSÉ IGNACIO VALENZUELA-RÍOS, Dpt. De Geología, Universitat de València C/. Dr. Moliner 50, E-46100, Burjassot, Spain, Tel.: 0034 96 3543412; Jose.I.Valenzuela@uv.es

###### **SECRETARY**

ULRICH JANSEN, Palaeozoology III, Senckenberg Gesellschaft für Naturforschung, Senckenberganlage 25, 60325 Frankfurt, Germany, Tel.: 0049-69- 97075 1146; Ulrich.Jansen@senckenberg.de

###### **SDS NEWSLETTER EDITOR**

R. THOMAS BECKER, Westfälische Wilhelms-Universität, Geologisch-Paläontologisches Institut, Corrensstr. 24, D-48149 Münster, Germany, Tel.: 0049-251-83 339 51, Fax: 0049-251-83 339 68; rbecker@uni-muenster.de

###### **WEBMASTER**

CARLO CORRADINI, Dipartimento di Matematica e Geoscienze, Università di Trieste, via Weiss 2 - 34128 Trieste, Italy, Tel.: 0039 040 558-2033; ccorradin@units.it

## **Voting members, address, country, phone, email, special fields:**

R.T. BECKER, Westfälische Wilhelms-Universität, Geologisch-Paläontologisches Institut, Corrensstr. 24, D-48149 Münster, Germany, Tel.: 0049-251-83 339 51, e-mail: rbecker@uni-muenster.de; ammonoids, conodonts

C.E. BRETT, Department of Geology, University of Cincinnati, 500 Geology-Physics Bldg., Cincinnati 45221-0013 OH, U.S.A., Tel.: +1-513-5564556, e-mail: brettce@ucmail.uc.edu; sequence stratigraphy

R. BROCKE, Senckenberg Forschungsinstitut und Naturmuseum Frankfurt  
Senckenberganlage 25, D-60325 Frankfurt am Main, Germany, Tel.: 0049-69-970751162, e-mail: rainer.brocke@senckenberg.de; palynology

C. CORRADINI, Dipartimento di Matematica e Geoscienze, Università di Trieste, via Weiss 2 - 34128 Trieste, Italy, Tel.: 0039 040 558-2033, e-mail: ccorradin@units.it; conodonts

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A-C. da SILVA, Pétrologie sédimentaire, B20, Allée du Six Août, 12, Quartier Agora, Université de Liège, 4000 Liège, Belgium, Tel.: +32 - 43662258, e-mail: ac.dasilva@ulg.ac.be; astrochronology;

Y. GATOVSKY, Moscow State University, Dept. of Paleontology, Geological Faculty, Vorob'evy Gory, 1, Moscow, GSP-1, 119991, Russia, Tel.: 007 495 9394960, e-mail: gatovsky@geol.msu.ru; conodonts

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X. MA, Peking University, Department of Geology, Beijing 100871, China, e-mail: maxp@pku.edu.cn; brachiopods

J.E.A. MARSHALL, School of Ocean and Earth Science, University of Southampton, National Oceanography Centre, European Way, Southampton SO14 3 ZH, UK, Tel.: +44-23-80592015, e-mail: jeam@noc.soton.ac.uk, plants

J. OVER, SUNY Geneseo, Department of Geological Sciences, Geneseo 14454 N.Y., U.S.A., Tel.: +1-585-24552945291, e-mail: over@geneseo.edu; conodonts

W. QIE, CAS Key Laboratory of Economic Stratigraphy and Palaeogeography, Nanjing Institute of Geology and Palaeontology and Center for Excellence in Life and Palaeoenvironment, Chinese Academy of Sciences, Nanjing 210008, China, e-mail: wkqie@nigpas.ac.cn; chemostratigraphy

G. RACKI, University of Silesia, Faculty of Earth Sciences, Department of Palaeontology and Stratigraphy, Będzińska str. 60, 41-200 Sosnowiec, Poland, Tel.: 48-32-3689-229, e-mail: racki@us.edu.pl; brachiopods, event & sequence stratigraphy

C. SPALLETTA, Dipartimento di Scienze della Terra e Geologica Ambientali, Università di Bologna, I-40126 Bologna, Italy, Tel.: +39-051-2094578, e-mail: claudia.spalletta@unibo.it; conodonts

K. TRINAJSTIC, Faculty of Science and Engineering, School of Science, Department of Environment and Agriculture, Bentley Campus 311.117, Australia, Tel.: Phone: +618 9266 2492, e-mail: kate.trinajstic@uwa.edu.au; fish

## **List of Working (Task) Groups and their officers**

### **Emsian Working Group (EWG)**

The Emsian Working group has been recently re-established (2021) in order to solve the problems with the correlation of the Basal Emsian boundary. The members are expected to present and evaluate proposals for the basal Emsian GSSP redefinition. The Working group is open to other specialists involved in this task.

### **Members**

LADISLAV SLAVÍK (CZECH REPUBLIC)  
JOSÉ IGNACIO-VALENZUELA-RÍOS (SPAIN)  
THOMAS BECKER (GERMANY)  
ZHOR SARAH ABOUSSALAM (GERMANY)  
MAYA ERINA (UZBEKISTAN)  
JINDŘICH HLADIL (CZECH REPUBLIC)  
NADYA IZOKH (RUSSIA)

OLGA IZOKH (RUSSIA)  
ULRICH JANSEN (GERMANY)  
ALEKSEY KIM (UZBEKISTAN)  
TOMÁŠ WEINER (CZECH REPUBLIC)  
HEDVIKA WEINEROVÁ (CZECH REPUBLIC)

### **Devonian/Carboniferous Boundary Working Group (DCBWG)**

The DCBWG was established in 2008, with the goal to redefine the GSSP for the Tournaisian (equivalent to base of the Carboniferous System), when problems both with the type section (La Serre E', Montagne Noire, France) and the index fossil (*Siphonodella sulcata*, conodont) arose. It includes members named by the Devonian (SDS) and Carboniferous (ISCS) subcommissions. Several meetings and workshop took place up to now. The new GSSP based on the definition of multiple criteria that would work in various environments for a safe recognition of the system boundary is expected to be proposed in the near future.

### **Members**

MARKUS ARETZ (FRANCE) - CHAIR  
CARLO CORRADINI (ITALY) – VICE-CHAIR  
ONDREJ BABEK (CZECH REPUBLIC)  
R. THOMAS BECKER (GERMANY)  
RAIMUND FEIST (FRANCE)  
YURI GATOVSKY (RUSSIA)  
SANDRA I. KAISER (GERMANY)  
TOMAS KUMPAN (CZECH REPUBLIC)  
JOHN MARSHALL (UNITED KINGDOM)  
HANNA MATYJA (POLAND)  
SVETLANA NIKOLAEVA (RUSSIA)  
D. JEFFREY OVER (USA)  
WENKUN QIE (CHINA)  
EDDY POTY (BELGIUM)  
CIRILLE PRESTIANNI (BELGIUM)  
BARRY RICHARDS (CANADA)  
CLAUDIA SPALLETTA (ITALY)

## **ANNUAL REPORT 2023**

### 1. TITLE OF CONSTITUENT BODY and NAME OF REPORTER

#### **Subcommission on Silurian Stratigraphy (ISSS)**

*Submitted by:*

**Petr Štorch**, *Chair, ISSS*

Department of Palaeobiology and Stratigraphy  
Institute of Geology of the Czech Academy of Sciences  
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### 2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY

#### **Mission statement**

The objectives of the Subcommission relate to three main aspects of IUGS policy:

- (1) The development of an internationally agreed scale of chronostratigraphic units, fully defined by GSSPs at Series and Stage levels and related to a hierarchy of units (Substages, Standard Zones, Subzones etc.) to maximize relative time resolution within the Silurian Period;
- (2) Establishment of frameworks and mechanisms to encourage international collaboration in understanding the evolution of the Earth during the Silurian Period;
- (3) Working towards an international policy concerning conservation of geologically important sites (such as GSSPs, global and regional stratotype sections, *etc.*).

#### **Goals**

- Rationalization of Global chronostratigraphical classification
- Intercalibration of fossil biostratigraphies, integrated zonations, and recognition of global datums.
- Establishment of magneto- and chemo-stratigraphic scales
- Redefinition of stage boundaries and restudy of global boundary stratotype sections
- Correlation of Silurian rock successions and events, including marine and non-marine
- Application of astronomically tuned cyclostratigraphy integrated with radiometric data and biostratigraphy

### 3. ORGANISATION - interface with other international projects / groups

#### **Organisation**

The ISSS is a Subcommittee of the International Commission on Stratigraphy. The Subcommittee is organized by an Executive consisting of Chairman, Vice-Chairman, Secretary, and Webperson who are all Voting Members of the Subcommittee. In the Subcommittee elected for 2020-2024 there are eleven other Voting Members. Five members have been replaced by four new Voting members in March 2020. Broad network of Corresponding Members has first of all a responsibility for communication in both directions between the Subcommittee and researchers on Silurian topics in their region. Secondly they represent a broad spectrum of specialized stratigraphical disciplines from those countries or regions where Silurian rocks are extensively studied in relation to fundamental and/or applied geological research.

Current research activities and future plans are communicated through publication of the annual ISSS newsletter, *Silurian Times*, distributed as an email attachment and a web release. Website: <https://stratigraphy.org/subcommission-silurian/> contains newsletters, meeting announcements, discussion posting-boards, bibliography of Silurian articles, links to related sites, and other information.

### **Interface with other international projects / groups**

IGCP project no. 652 “Reading geologic time in Paleozoic sedimentary rocks” and newly established “International Subcommittee on Geochronology” under chairmanship of B. D. Cramer, titular member of the ISSS.

Collaboration will continue with stratigraphically neighbouring subcommittees on Ordovician (ISOS) and Devonian (SDS) stratigraphy. A joint ISSS-SDS conference is planned for September 2024 in Sofia, Bulgaria.

#### **3a. Current Officers for 2020-2024 period:**

Chair: Petr Štorch (second term)

Vice-Chair: Carlo Corradini (second term)

Secretary: David Ray (first term)

Webperson: Huang Bing (first term)

#### **4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS**

National/regional support has been provided to active members of Aeronian, Telychian and Wenlock GSSP working groups to facilitate their work.

#### **5. CHIEF ACCOMPLISHMENTS IN 2023 (including any publications arising from ICS working groups)**

- Silurian Times No 30 was edited by the secretary, David Ray, and distributed in April, 2023, posted on the web site for the ISSS, and circulated as an email attachment to all titular and corresponding members of the Subcommittee. It contained the reports on previous meetings, announcements of planned meetings, the latest news and recent publications on Silurian research.
- The Aeronian working group accomplished its task by submission of two parallel proposals for new base Aeronian GSSP which should replace current GSSP located

in the Trefawr track cutting in Wales, UK (Melchin et al. 2023, Štorch et al. 2023). Of the two candidate sections - Rheidol Gorge in Wales, UK and Hlásná Třebaň in the Czech Republic - the latter has been selected by subsequent voting by the titular members of the ISSS and submitted to the ICS for further discussion and approval.

- The Telychian working group has completed its work by formal proposal of the El Pintado 1 section in Spain for new GSSP for the Telychian Stage to replace present GSSP in the Cefn Cerig quarry section in Wales, UK (Loydell et al. 2023). The new GSSP has been approved by voting by the titular members of the ISSS and the proposal has been submitted to ICS for further discussion and formal approval.

Melchin, M.J., Davies, J.R., Boom, A., De Weirtdt, J., McIntyre, A.J., Russell, C., Vandenbroucke, T.R.A., & Zalasiewicz, J.A. (2023). Integrated stratigraphical study of the Rhuddanian-Aeronian (Llandovery, Silurian) boundary succession in the Rheidol Gorge, Wales: a proposed Global Stratotype Section and Point for the base of the Aeronian Stage. *Lethaia* 56(1), 1–23. <https://doi.org/10.18261/let.56.1.8>

Manda, Š., Slavík, L., Štorch, P., Tasáryová, Z., & Čáp, P. (2023). Division of Přídolí Series in Central Bohemia: graptolite and conodont biostratigraphy, faunal changes, and geochemical record. *Newsletters on Stratigraphy*, 56 (1), 89–123. <https://doi.org/10.1127/nos/2022/0695>

Melchin, M.J., Davies, J.R., Boom, A., De Weirtdt, J., McIntyre, A.J., Russell, C., Vandenbroucke, T.R.A., & Zalasiewicz, J.A. (2023). Proposed Redefinition of the Global Stratotype Section and Point (GSSP) for the Base of the Aeronian Stage (Llandovery Series, Silurian System) at the Rheidol Gorge Section, Wales, UK.

Štorch, P., Manda, Š., Vodička, J., Butcher, A., Tasáryová, Z., Frýda, J., Chadimová, L. Melchin, M.J. (2023). Formal proposal for a new Global Boundary Stratotype Section and Point (GSSP) for the Aeronian Stage at Hlásná Třebaň, Czech Republic.

Loydell, D.K., Gutiérrez-Marco, J.C., Štorch, P., Frýda, J. (2023). Proposal for a replacement Global Stratotype Section and Point (GSSP) of the Telychian Stage (Llandovery, Silurian).

## 6. SUMMARY OF EXPENDITURE IN 2023:

### Expenditures

STRATI2023 Congress in Lille: 2 x conference fee - 800 US\$; 1 x air ticket - 360 US\$; 2 x train ticket - 90 US\$; Koren' award for young Silurian researcher - 500 US\$.

Total

US\$ 1.750

## 7. SUMMARY OF INCOME IN 2023:

Carried forward from 2022

US\$ 2.750

ICS Allocation

US\$ 0

Total US\$ 2.750

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Balance (carried forward from 2023) US\$ 1.000

#### 8. BUDGET REQUESTED FROM ICS IN 2024

Requested ICS Allocation US\$ 3.000

#### 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR:

- ISSS working group focused on restudy of the base of the Homeric GSSP will be established and working group for base Wenlock GSSP will be reactivated.
- Division of the Přídolí Series into Jarovian and Radotinian stages proposed by Manda *et al.* (2023) will be discussed. The Silurian Subcommission will be hopefully able to complete this work by submission of the formal proposal of the Hvížd'alka section as a GSSP for the upper Přídolí unit - Radotinian Stage.
- Joint ISSS-SDS conference with field-meeting and business meeting in Sofia, Bulgaria, postponed due to Covid related travel restrictions and subsequent Russian war, will take place in September 2024 in collaboration with Geological Institute of Bulgarian Academy of Sciences and University of Mining and Geology, Sofia.
- Continuing updates of the website for Silurian Subcommission by webmaster Huang Bing.

#### **Potential funding sources external to IUGS**

Most of the costs of preparing Silurian Times and research activities of the working groups will be met by local support from host institutions and participation by individuals through national research grants and travel grants from their own authorities. Some minor expenses may be covered from budget carried forward from 2021.

#### 10. OBJECTIVES AND WORK PLAN FOR THE PERIOD 2024-2026

- Principal work will be devoted to GSSP-related research activities – restudy of some previously ratified but currently inadequate stratotypes and search for sections suitable for auxiliary stratotypes.
- Base Wenlock working group will be reactivated in order to examine stratigraphic and correlation potential of the new Telychian-Sheinwoodian boundary section discovered in Prague-Vyskočilka
- Restudy of the Homeric GSSP will join the program.
- Establishment of working groups for the replacement base Gorstian GSSP and base Ludfordian GSSP
- Works on higher-resolution correlation of principal Silurian biozonations (graptolite, conodont, and chitinozoan) with carbon isotope excursions in the timeframe provided by presumed new radiometric data.



APPENDIX (Names and Addresses of Current Officers and Voting Members)

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### **Working group leaders**

Base of Aeronian GSSP Restudy Working Group  
*Leader:* Petr Štorch

Base of Telychian GSSP Restudy Working Group  
*Leader:* Michael J. Melchin

Base of Wenlock GSSP Restudy Working Group  
*Leader:* David K. Loydell

### **List of corresponding members**

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**See the ISSS website <https://stratigraphy.org/subcommission-silurian/> for full list of the new officers and voting members elected for 2024-2028.**

## **ANNUAL REPORT 2023** (prepared by T. Servais & B. Lefebvre)

### **1. TITLE OF CONSTITUENT BODY**

#### **Subcommission on Ordovician Stratigraphy (SOS)**

**Chairman:**

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### **2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY**

The Subcommission promotes international cooperation on all aspects of Ordovician geology, specifically stratigraphy. Its global network involves academia, government institutions and industry.

Specific objectives are:

- a. To delimit and subdivide the Ordovician System (and Period) as a part of the overall ICS mission to elaborate the standard global stratigraphic scale. This work aims to establish boundaries (GSSPs and ASSPs), correlation of major subdivisions (Stages and Series) globally and regionally, and to periodically review the effectiveness and utility of these decisions.
- b. To promote regular international meetings on all aspects of Ordovician geology, especially those devoted to clarifying stratigraphic procedures, nomenclature and methods for use in establishing a unified global time scale and to prepare correlation charts with explanatory notes (the main phase of this latter task is now completed).

- c. To encourage, promote, and support research on all aspects of Ordovician geology worldwide and to provide outlets, including an annual newsletter (*Ordovician News*), international meetings, and a web page, for promoting discussions and reporting results of this research.
- d. To encourage, promote, and support interdisciplinary research on the Ordovician global Earth system, addressing topics that require high-resolution, global correlation.
- e. The ultimate goal of the Subcommittee is to provide a high-resolution geological time scale that will be a critical foundation for interdisciplinary research on the global Earth system during the Ordovician Period. The work is broadly based and must include specialists in palaeontology, all subdisciplines of stratigraphy (bio-, litho-, chemo-, and magneto-), sedimentology, geochemistry, and tectonics. With a large network including active participants from more than 25 countries, the Subcommittee thus involves much of the global geological community.

### **3. ORGANISATION - interface with other international projects / groups**

Since mid-2020, the Subcommittee on Ordovician Stratigraphy (SOS) comprises an Executive (Chair, Vice-Chair and Secretary), plus 17 other Voting Members (and >300 Corresponding Members). Since 2021, the Subcommittee Executive includes, for the first time, a female member, appointed by the Chair, as Internet Officer.

The Subcommittee includes a broad national representation and coverage of key fossil groups as well as specialists in interdisciplinary fields such as geochemistry, sequence stratigraphy and sedimentology.

The Subcommittee on Ordovician Stratigraphy closely cooperates with the IGCP 735 project “Rocks ‘n’ ROL (Filling knowledge gaps in the Early Palaeozoic Biodiversification)” (2021–2025). The co-leaders of IGCP 735 include four Voting Members of the SOS. The third Annual Meeting of IGCP 735 was held in Tallinn, Estonia, in coordination and collaboration with the Ordovician Subcommittee.

### **4. NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS**

Other than time allowed by employers of the Executive and Voting Members to carry out their duties and attend conferences, the Subcommittee receives no support from sources other than IUGS.

### **5. CHIEF ACCOMPLISHMENTS IN 2023**

- The 14<sup>th</sup> edition of the major congress of the Subcommittee, which takes place every four years, the International Symposium on the Ordovician System (ISOS), was organized in Tallinn, Estonia, in late July. It included scientific sessions and excursions, and was attended by over 100 Ordovician specialists.
- The Subcommittee organized a scientific session during the main meeting of the ICS, STRATI 2023, which was organized in Lille, France, in mid July.
- The second Auxiliary Boundary Stratigraphic Section and Point (ASSP) for the base of the Ordovician System at the Dayangcha section (Northern China), has been accepted to be an official Standard Auxiliary Boundary Stratotype (SABS) by the Subcommittee in 2023. The official inauguration of the stratotype was postponed a few times, but is now scheduled to take place in June 2024.
- In accordance with ICS Rules, the Voting Members of SOS were replaced in 2020, and the Voting Membership voted to select a new Executive and Voting Members for the term 2020–2024. The Voting Membership was increased to 20. During the covid pandemic, online

meetings were organized. The second online business meeting was organized in late March 2022, and the third one in early May 2023, attended by most Voting Members.

- In accordance with ICS Rules, the SOS Executive started in late 2023 to prepare the replacement of the Voting Members. The objective is to reach a perfect gender balance and a best possible global coverage for the period 2024–2028.
- Two "in person" meetings of part of the Executive and Voting Members of SOS took place during the 4<sup>th</sup> International Congress on Stratigraphy in Lille (France, mid July 2023) and during the ISOS14 (Estonia, late July 2023). During the latter symposium, the Voting Members that were present took part at a business dinner organized by the Subcommittee.
- A major accomplishment during 2023 was the publication of two volumes (532 and 533) of the *Geological Society Special Publication* series, dedicated to a global Ordovician synthesis. Launched by the Ordovician subcommittee in 2021, all manuscripts for chapters have been deposited between January and November 2022. The publication was released in March (online) and in June (print) 2023. All participants of ISOS14 at Tallinn were invited at a reception organized by the Subcommittee to celebrate the publication of the two volumes.
- Following the final meeting of the International Geoscience Programme (IGCP) 653 ‘The onset of the Great Ordovician Biodiversification Event’ and the kickoff meeting of the IGCP 735 “Rocks n’ ROL (Filling knowledge gaps in the Early Palaeozoic Biodiversification” organized jointly as a videoconference congress in Lille (France) on September 13<sup>th</sup>-16<sup>th</sup> 2021, two thematic volumes were scheduled in *Palaeogeography Palaeoclimatology Palaeoecology* and in *Geobios*. Both special issues are focused on the Ordovician radiations, and are co-guest-edited by current and former executive officers of the Subcommittee. During 2022, numerous contributions were submitted to these two volumes, which have been both published in 2023.
- The second Annual Meeting of the International Geoscience Programme (IGCP) 735 “Rocks n’ ROL (Filling knowledge gaps in the Early Palaeozoic Biodiversification”, which took place in Morocco (Oct. 2022) gave rise to a thematic volume issued in 2023 in *Frontiers in Ecology and Evolution*.
- The 14<sup>th</sup> International Symposium on the Ordovician System in Tallinn (Estonia, July 2023), which coincided with the third Annual Meeting of the International Geoscience Programme (IGCP) 735 “Rocks n’ ROL”, was followed by a thematic issue in *Estonian Journal of Earth Sciences*, also published in 2023.
- *Ordovician News* 40 (for 2022) was published in April 2023 and is available from the SOS webpage (<http://ordovician.stratigraphy.org/>).
- The SOS webpage changed its host, and is now managed as a separate page of the webpage of the ICS (<http://stratigraphy.org/>).

## **6. SUMMARY OF EXPENDITURE IN 2023:**

(all figures in USD, totals rounded due to exchange rates)

- a) Support for T. Servais (Chair) to SOS meeting (preparation of *Ordovician News* and *Geobios* special issue), Lyon (France), February 2023: **600 US \$**
- b) Support for B. Lefebvre (Secretary) to SOS meeting (preparation of STRATI2023 and ISOS14), Lille (France), April 2023: **500 US \$**
- c) Support for B. Lefebvre (Secretary) to attend STRATI2023, Lille (France), July 2023: **1000 US \$**
- d) Support for T. Servais (Chair) to attend ISOS14 and IGCP 735 Annual Meeting, Tallinn (Estonia), July 2023: **1250 US \$**
- e) Support for B. Lefebvre (Secretary) to attend ISOS14 and IGCP 735 Annual Meeting, Tallinn (Estonia), July 2023: **1250 US \$**

- f) SOS-sponsored reception for all participants of ISOS14, to celebrate the publication of the two Ordovician special issues (*Geol. Soc. Sp. Publ.* 532 and 533): **500 US \$**
- g) SOS-sponsored business dinner for all titular members present at ISOS14: **400 US \$**
- TOTAL (a–g): 5500 US \$**

## **7. SUMMARY OF INCOME IN 2023**

Same as next item (ICS was the sole source of income)

## **8. BUDGET RECEIVED FROM ICS IN 2023**

**5500 US \$**

## **9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR (2024):**

- Elections to select a new Executive board (2024–2028).
- Partial replacement of Voting Members for the term 2024–2028; the objective is to reach a perfect gender balance and the best possible global coverage.
- Official inauguration of the second Auxiliary Boundary Stratigraphic Section and Point (ASSP) for the base of the Ordovician System at the Dayangcha section (Northern China), June 2024.
- Participation of SOS to the 37<sup>th</sup> International Geological Congress (IGC37), Busan (Korea), August 2024.
- Support of the 4<sup>th</sup> Annual Meeting of IGCP 735 to be held in Córdoba, Argentina, October 2024.
- Data will be gathered for *Ordovician News* 41 (to be published in March 2024).

## **10. KEY OBJECTIVES AND WORK PLAN FOR THE PERIOD 2020–2024**

For further advancement and increased precision in correlation we need to focus on regional stratigraphy, regional scales and regional chronostratigraphic schemes. We recognise that many biotic, chemical and physical changes are not always synchronous, and that local and regional signals may vary from trends evident in global compilations. This is especially true for the Ordovician, where strong provincialism can mask biostratigraphic-based correlation. Ordovician regional stratigraphy and geology will therefore be the main goal for the period 2020–2024.

- To compile and publish an updated summary on Ordovician regional stratigraphy and geology: *A Global Synthesis of the Ordovician System*. Special attention is paid to precise correlation of the Ordovician depositional sequences and sea-level curves as well as stable isotope and regional biodiversity curves. This project was launched in 2021, and manuscripts were deposited in 2022. Two volumes (*Geological Society of London, Special Publications*), with ~600–800 pages, were compiled during 2022 and were published in 2023. The realisation of this publication, originally initiated over ten years ago, was the major objective of the Subcommission (2020–2024). The official presentation of the volumes took place at ISOS14 in Tallinn, July 2023.
- To better correlate Ordovician depositional sequences throughout the World.
- To design and execute a program of radiogenic dating of key Ordovician horizons (using Pb–Pb isotopes and CA-IDTIMS dating of zircons).
- The Ordovician website will be updated including development of a database for GSSPs and ASSPs.



## **11. Budget and ICS component requested for 2024 (all figures in USD)**

- a) Support for T. Servais (Chair) to attend IGC37 in Busan, Korea, August 2024: **4000 US \$**
- b) Support for T. Servais (Chair) to attend the inauguration of the Standard Auxiliary Boundary Stratotype (SABS) of the Cambrian-Ordovician boundary, in Dayangsha, China, June 2024: **2000 US \$**
- c) Support for B. Lefebvre (Secretary) to attend the inauguration of the Standard Auxiliary Boundary Stratotype (SABS) of the Cambrian-Ordovician boundary, in Dayangsha, China, June 2024: **2000 US \$**
- d) Support for B. Lefebvre (Secretary) to SOS business meeting in Lille, France, March 2024: **\$500**
- e) Support for T. Servais (Chair) to SOS business meeting in Lyon, France, September 2024: **\$500**

As in previous years it is envisaged that officers will supplement any aid from the ICS with their own research funds. We have not quantified this support.

TOTAL 2024 BUDGET: **9000 US \$**

REQUESTED FROM ICS: **9000 US \$**

Potential funding sources outside IUGS: None.

Subcommission officers are mainly supported by their research projects for most of their activities.

## **APPENDIX –Current Executive Officers and Voting Members (2020-2024) & contact details**

### **Executive:**

#### **Thomas Servais**

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#### **Zhan Renbin**

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## **Voting Members:**

### **Sachiko Agematsu**

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# International Commission on Stratigraphy Subcommission on Cambrian Stratigraphy

## ANNUAL REPORT 2023

### 1. TITLE OF CONSTITUENT BODY

#### **International Subcommission on Cambrian Stratigraphy**

*Prepared by:* Prof. John PATERSON, Chair, jpater20@une.edu.au

*Date:* 17 November 2023

### 2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY

#### **2.a. Mission Statement**

The Subcommission is the primary body for facilitation of international communication and scientific cooperation on Cambrian stratigraphy.

#### **2.b. Goals**

The two principal goals of the Subcommission are:

- 1) To develop a global stage-level and series-level chronostratigraphic classification of the Cambrian System.
- 2) To complete and publish regional and global correlation charts for the Cambrian System.

#### **2.c. Fit within IUGS Science Policy**

The objectives of the Subcommission fall within three main areas of IUGS policy:

- 1) The development of an internationally agreed scale of chronostratigraphic units, fully defined by GSSPs where appropriate (stages and series), and related to a hierarchy of units (zones) to maximize relative time resolution within the Cambrian Period.
- 2) Establishment of frameworks and systems to encourage international collaboration in understanding the evolution of the Earth during the Cambrian Period.
- 3) Working towards an international policy concerning conservation of geologically and paleontologically important sites such as GSSPs and Fossil-Lagerstätten.

### 3. ORGANISATION

#### **3.a. Interface with other international projects/groups**

The Cambrian Subcommission is involved jointly with the Ordovician Subcommission in *IGCP Project 653: The onset of the Great Ordovician Biodiversification Event*.

The Cambrian Subcommission is working jointly with the Ediacaran Subcommission on restudy of the base of the Cambrian. Members of both subcommissions comprise the membership of the Terreneuvian/Fortunian Working Group. In recent years, joint meetings of the Ediacaran and Cambrian subcommissions have been organized.

### **3.b. Officers for 2022–2023**

*Chair:* John Paterson (Australia) [jpater20@une.edu.au](mailto:jpater20@une.edu.au)

*Vice-Chair:* Jessica Creveling (USA) [jessica.creveling@oregonstate.edu](mailto:jessica.creveling@oregonstate.edu)

*Secretary:* Marissa Betts (Australia) [mbetts7@une.edu.au](mailto:mbetts7@une.edu.au)

*Webperson:* Michael Streng (Uppsala, Sweden), [michael.streng@geo.uu.se](mailto:michael.streng@geo.uu.se)

## **4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS**

N/A

## **5. CHIEF ACCOMPLISHMENTS AND ACTIVITIES IN 2023**

In October 2022, the IUGS ratified the new executive officers of the International Subcommittee on Cambrian Stratigraphy (ISCS). During January and February 2023, the new Chair, Vice-Chair and Secretary compiled a list of potential Voting Members and sent invitations. The Subcommittee now consists of 21 Voting Members, with excellent ethnic, gender and geographic diversity (see Appendix), as well as expertise across a range of topics and fields that will be necessary for defining the remaining unnamed Cambrian stages.

The ISCS organised a Cambrian session at the 4th International Congress on Stratigraphy (Strati 2023) in Lille, France, in July 2023. Six talks and three posters were presented, including two talks on trilobites and biostratigraphy in Cambrian Series 2 of Spain, a poster on the SPICE event, and a talk on biodiversity across space and time in the Cambrian. A brief subcommittee meeting was held in the evening of 12<sup>th</sup> July, unfortunately with very few attendants.

The ISCS has set up a multipurpose communication platform using MS Teams, which is being used for online meetings and file sharing. In early November 2023, the Executive and other Voting Members met during two online sessions to discuss current issues and future strategies (see also Sections 9 and 10 below). Key among these matters was the status and membership of the Working Groups for Cambrian Stages 2, 3, 4 and 10. It was decided that the Working Groups for Stages 2, 3 and 4 should have new Chairs and memberships be rebuilt for each one. Former ISCS Chair, Prof. Per Ahlberg, reported on the status of Cambrian Stage 10, noting that much work has already been done and the current Voting Members should continue on with deciding which marker—that is, either the FAD of *Lotagnostus americanus* or the FAD of *Eoconodontus notchpeakensis* (just below the onset of the HERB/TOCE isotope excursion)—best defines the base. Thus, it was agreed that an active Stage 10 Working Group is not required at this point in time. The Subcommittee will continue to work closely with Prof. Ahlberg on evaluating the existing Cambrian Stage 10 proposals and assessing current research in this area in order to move forward with a definition of this important boundary.

**6. SUMMARY OF EXPENDITURE IN 2023**

Since this has been an exceptional year due to the rebuilding of the Subcommittee, there has been very minimal expenditure of the available funds. Former ICS Chair, Prof. Per Ahlberg, used some of the existing funds to attend the Strati 2023 meeting in Lille where he organized a Cambrian session and ran a subcommittee meeting.

|                               |            |
|-------------------------------|------------|
| Opening balance               | \$ 7660.00 |
| 2023 expenditure              | \$ 1760.00 |
| To be carried forward to 2024 | \$ 5900.00 |

**7. SUMMARY OF INCOME IN 2023**

|                           |            |
|---------------------------|------------|
| Carried forward from 2022 | \$ 7660.00 |
| ICS Allocation            | \$ 0000.00 |
| TOTAL 2023 income         | \$ 7660.00 |

**8. BUDGET REQUESTS FROM ICS IN 2024**

Since it has been an exceptional year and there were no planned activities while the subcommittee was being rebuilt, a considerable amount of money is left from 2023, and the budget request for 2024 is therefore modest (USD 2500). We plan to hold a Cambrian session and a subcommittee annual meeting at an international conference, probably at the GSA Annual Meeting in Anaheim, California (22–25 Sep. 2024). These requested funds will go towards these activities.

The money carried forward from 2023 will be saved for a field conference in the near future, most likely relating to visiting the best candidate GSSP for Cambrian Stage 10. At this field meeting, we will have the opportunity to examine and discuss stratigraphic issues surrounding Stage 10 and the remaining undefined stages.

|                                       |            |
|---------------------------------------|------------|
| PLANNED EXPENDITURES FOR 2024         |            |
| Annual meeting in Anaheim, California | \$ 2500.00 |
| TOTAL 2024 PLANNED EXPENSES           | \$ 2500.00 |
| ICS 2024 BUDGET REQUEST               | \$ 2500.00 |

**9. OBJECTIVES AND WORK PLAN FOR NEXT YEAR (2024)**

The Cambrian Subcommittee will continue work toward defining GSSPs for its remaining provisional stages. The key objectives are as follows:

- Decide on how to define Stage 10, then begin discussions on candidate GSSP sites, with the aim of naming and ratifying this stage over the next 12–18 months
- Re-establish the Working Groups for Stages 2, 3 and 4, including new Chairs, and commence discussions on how to best define these stages
- Continue examining issues surrounding the definition of the basal Cambrian GSSP
- Update and enhance the Cambrian Subcommittee website

## **10. KEY OBJECTIVES AND WORK PLAN FOR THE NEXT FOUR YEARS (2024–2027)**

The principal objective of the Subcommittee is to recognize and scrutinize the possibilities for horizons and GSSP stratotypes for the remaining undefined stages, which are provisionally identified as Stages 2, 3, 4, and 10. The ISCS has developed a prioritized plan for formalizing definition of the remaining undefined stages and their GSSPs. The plan is as follows:

- Provisional Stage 10 is expected to be defined next, and a decision on a GSSP will likely be made in late 2024 or 2025
- Following a decision on Stage 10, provisional Stages 2, 3, and 4 are expected to be defined in fairly rapid succession. A decision on the preferred GSSP horizon of any one of these three stages will restrict choices for the remaining two stages, so the ISCS is approaching work toward definition of the three stages as closely linked
- A longer-term objective is to re-examine the basal Cambrian GSSP (Terreneuvian Series, Fortunian Stage). Imprecision in correlating the lower boundary of the Cambrian System has been encountered on all palaeocontinents, and the ISCS is now engaged in seeking a practical solution to remedy the problem, in collaboration with the Ediacaran Subcommittee

## APPENDIX

### *Subcommission executive officers (late 2022–2027)*

*Chair:* John Paterson, Palaeoscience Research Centre, School of Environmental & Rural Science, University of New England, Armidale NSW 2351, Australia; Tel. +61 2 6773 2101; [jpater20@une.edu.au](mailto:jpater20@une.edu.au)

*Vice-Chair:* Jessica ‘JC’ Creveling, College of Earth, Ocean and Atmospheric Sciences, Oregon State University, 101 SW 26<sup>th</sup> Street, Corvallis, Oregon, USA 97331; Tel. +1 541 737 2112; [jessica.creveling@oregonstate.edu](mailto:jessica.creveling@oregonstate.edu)

*Secretary:* Marissa Betts, Palaeoscience Research Centre & Litholab (LLUNE), School of Environmental & Rural Science, University of New England, Armidale NSW 2351, Australia; Tel. +61 2 6773 1714; [mbetts7@une.edu.au](mailto:mbetts7@une.edu.au)

### *List of Voting Members (including officers) for 2023–2027*

1. Kristin Bergmann, MIT, USA; [kdberg@mit.edu](mailto:kdberg@mit.edu)
2. Marissa Betts, University of New England, Australia; [mbetts7@une.edu.au](mailto:mbetts7@une.edu.au)
3. Graham Budd, Uppsala University, Sweden; [graham.budd@pal.uu.se](mailto:graham.budd@pal.uu.se)
4. Sébastien Clausen, Université de Lille, France; [sebastien.clausen@univ-lille.fr](mailto:sebastien.clausen@univ-lille.fr)
5. Jessica ‘JC’ Creveling, Oregon State University, USA; [jessica.creveling@oregonstate.edu](mailto:jessica.creveling@oregonstate.edu)
6. Nigel Hughes, University of California, Riverside, USA; [hughesnc@ucr.edu](mailto:hughesnc@ucr.edu)
7. Sarah Jacquet, University of Missouri, USA; [jacquets@missouri.edu](mailto:jacquets@missouri.edu)
8. Sören Jensen, Universidad de Extremadura, Spain; [soren@unex.es](mailto:soren@unex.es)
9. Artem Kouchinsky, Swedish Museum of Natural History, Stockholm, Sweden; [artem.kouchinsky@gmail.com](mailto:artem.kouchinsky@gmail.com)
10. Gabriela Mángano, University of Saskatchewan, Saskatoon, Canada; [gabriela.mangano@usask.ca](mailto:gabriela.mangano@usask.ca)
11. Silvia Menéndez, Museo Geominero, Instituto Geológico y Minero, Spain; [s.menendez@igme.es](mailto:s.menendez@igme.es)
12. Arne Nielsen, University of Copenhagen, Denmark; [arnet@ign.ku.dk](mailto:arnet@ign.ku.dk)
13. Tae-Yoon Park, Korea Polar Research Institute, Incheon, South Korea; [typark@kopri.re.kr](mailto:typark@kopri.re.kr)
14. John Paterson, University of New England, Australia; [jpater20@une.edu.au](mailto:jpater20@une.edu.au)
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16. Eric Sperling, Stanford University, USA; [esper@stanford.edu](mailto:esper@stanford.edu)
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21. Zhiliang Zhang, Nanjing Institute of Geology and Palaeontology, China; [zhiliang.zhang@nigpas.ac.cn](mailto:zhiliang.zhang@nigpas.ac.cn)

### *List of Working (Task) Groups and their officers*

This list will be updated in 2024 when the Working Groups have been re-established.

1. WG on Stage 10 GSSP, chaired by Per Ahlberg, Department of Geology, Sölvegatan 12, SE-223 62 Lund, Sweden; Tel. +46 46 2227870, +4679 532 92 09 (mobile); [per.ahlberg@geol.lu.se](mailto:per.ahlberg@geol.lu.se)
2. WG on Stage 4 GSSP, chaired by James B. Jago, School of Natural and Built Environments, University of South Australia, Mawson Lakes, SA, 5095, Australia; [Jim.Jago@unisa.edu.au](mailto:Jim.Jago@unisa.edu.au)



3. WG on Stage 3 GSSP, chaired by Xingliang Zhang, Shaanxi Key Laboratory of Early Life and Environment, State Key Laboratory of Continental Dynamics, and Department of Geology, Northwest University, Xian 710069, China; [xzhang69@nwu.edu.cn](mailto:xzhang69@nwu.edu.cn)
4. WG on Stage 2 GSSP, chaired by Michael Steiner, Institut für Geologische Wissenschaften, FU Berlin, Malteserstraße 74-100, Haus D, 12249 Berlin, Germany; Tel. +49 30 838 70272; [michael.steiner@FU-Berlin.de](mailto:michael.steiner@FU-Berlin.de)
5. Cambrian GSSP, chaired by Zhu Maoyan, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 39 East Beijing Road, Nanjing, 210008, China); Tel. 0086-25-83282159; [myzhu@nigpas.ac.cn](mailto:myzhu@nigpas.ac.cn)



**International Commission on Stratigraphy**  
**Subcommission on Ediacaran Stratigraphy**  
**ANNUAL REPORT 2023**

**1. TITLE OF CONSTITUENT BODY**

**Subcommission on Ediacaran Stratigraphy**

*Submitted by:*

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Dr. Lucas Veríssimo Warren, Secretary, (Assistant Professor, Department of Applied Geology, São Paulo State University, Rua Quirino de Andrade 215, Sao Paulo, 01049-010, Brazil; [lucas.warren@unesp.br](mailto:lucas.warren@unesp.br))

**2. OVERALL OBJECTIVES, AND FIT WITHIN IUGS SCIENCE POLICY**

**Mission statement:** The Subcommission is the primary body for facilitation of international communication and scientific cooperation in Ediacaran stratigraphy, defined in the broad sense of multidisciplinary activities directed towards better understanding of the evolution of the Earth and life during the Ediacaran Period (circa 635 – 541 Ma). Its first priority is the unambiguous definition, by means of agreed GSSPs, of a hierarchy of chronostratigraphic units that provide the framework for global correlation.

**Goals:** The main goals of this Subcommission are: **(a)** to search for criteria useful in the subdivision and correlation of Ediacaran strata; **(b)** to define the basal boundaries of Ediacaran epochs (series) and ages (stages) through the establishment of global stratotype sections and points (GSSP's); and **(c)** to facilitate international collaboration in research on Ediacaran stratigraphy and Earth history through subcommission sponsored field trips, workshops, and meetings. In addition, the Subcommission is committed to further communication with a wider public through grassroots initiatives to conserve important Neoproterozoic geological sites, to support International Geoscience Program projects, and to encourage the wider dissemination of research findings on the internet or in popular science publications.

**Fit within IUGS Science Policy:** The objectives of the Subcommission relate to three main aspects of IUGS policy: **(a)** the development of an internationally agreed scale of chronostratigraphic units, fully defined by GSSPs where appropriate (Series and Stages), and related to a hierarchy of units (Standard Zones, Subzones etc.) to maximize relative time resolution within the Ediacaran Period; **(b)** the establishment of frameworks and systems to encourage international collaboration in understanding the evolution of the Earth during the late Neoproterozoic interval, in particular, cooperating with the **Cryogenian Subcommission (Graham Shields-Zhou, chair)** and the **Cambrian Subcommission (Per Ahlberg, chair)** to subdivide the late Precambrian to Early Cambrian transition; and **(c)** working towards an

international policy concerning conservation of geologically and paleontologically important sites such as GSSPs and important fossil localities. These relate to, *inter alia*, the IUGS Geosites Program.

### **3. ORGANIZATION – Interfaces with other international project**

Members of the Ediacaran Subcommittee are lead investigators and officers in a number of related international projects:

- ICDP GRIND-ECT (*Geological Research through Integrated Neoproterozoic Drilling: Ediacaran-Cambrian Transition*; <https://www.icdp-online.org/projects/world/global-coverage/grind-ect/details/>) led by Anthony R. Prave (Univ. of St. Andrews), Kristin Bergmann (MIT), Simone Antonia Kasemann (Univ. of Bremen), Francis A. MacDonald (UC Santa Barbara), Catherine Victoria Rose (Univ. of St. Andrews), Garneth Shamaila (Geological Survey Of Namibia), Ricardo Ivan Ferreira Da Trindade (Universidade De Sao Paulo), and Maoyan Zhu (Chinese Academy Of Sciences)
- Interactions with ICS Subcommittee on Cambrian Stratigraphy and ICS Subcommittee on Cryogenian Stratigraphy: Several members (**S. Xiao, M. Zhu, C. Zhou, M. Laflamme**, and others) are also active members of the ICS Subcommittee on Cambrian Stratigraphy and/or ICS Subcommittee on Cryogenian Stratigraphy.

#### **3a. Current Officers for 2020-2024:**

Chair: Marc Laflamme (University of Toronto Mississauga)  
Vice-Chair: James D. Schiffbauer (University of Missouri)  
Secretary: Lucas Warren (Universidade de Sao Paulo)

### **4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS**

none.

### **5. CHIEF ACCOMPLISHMENTS AND PRODUCTS IN 2020 (bullet point each significant achievement, limited to three maximum)**

*Due to the impact of the COVID19 Pandemic, many of our expected accomplishments were postponed to 2022. Our leadership transition took longer than expected, and the disruptions to activities as mundane as opening a bank account significantly affected our progress. Online/virtual teaching has also strained our members.*

- The Subcommittee will finally undertake its fieldtrip to Brazil in November 2023 (literally leaving tomorrow! I wish I had a few extra weeks to file the report so I could comment on its success). All logistical work is completed, and the costs were \$2100 USD per person (\$3062 CDN). It has now become a joint Ediacaran/Cryogenian trip, with voting members from both SC joining.
- Website continues to grow: As part of the Executive transition, we wished to transfer the website to new ownership. We also solicited our colleague Dr. Tara Selly to act as web-developer. <http://ediacaran.stratigraphy.org/>
- The construction of a database of known late-Ediacaran sections has been put on hold as we reevaluate the likely geochemical and geobiological tools used to define the boundaries. We will have a new survey of our voting members in January 2024, leading to a submission to Episodes once complete (similar to Xiao et al., 2016).

- A special issue of the Journal of Paleontology with the executive members (Laflamme, Schiffbauer, Warren, Selly) and voting member (Liu) as guest editors is finally complete. All eight manuscripts have successfully gone through the peer review process.
- We held a SC meeting in conjunction with GSA2023 in Pittsburg USA. We had several voting members including Marc Laflamme, Jim Schiffbauer, Guy Narbonne, Shuhai Xiao, Jay Kaufman, Luis Buatois and Tara Selly in attendance, in addition to a large group of potential corresponding members as it was held in conjunction with an Ediacaran “meet and greet” event organized by voting member Mary Droser (not in attendance) and her students.

**6. SUMMARY OF EXPENDITURE IN 2022:**

EXPENDITURES - The Subcommittee field workshop to examine terminal Ediacaran successions in Brazil scheduled for Nov. 19-27, 2023. The Ediacaran Subcommittee covered the costs of Prof. Shuhai Xiao to attend as he did not have the funding to cover the costs, and his presence was considered essential by the executive. There is an anticipated \$800-900 USD (1,235 CDN) additional costs to be covered by the subcommittee to cover the costs of the field trip leaders gas and supplies for their vehicles (expected to be about 2500km). This has not been charged to the SC yet.

**7. SUMMARY OF INCOME IN 2021:**

INCOME (note in CDN dollars)

|   |                         |
|---|-------------------------|
| Forwarded from 2022   | <b>CDN\$ 10,992.08*</b> |
| Field trip costs for Shuhai Xiao (could not attend otherwise) | <b>CDN\$ -3,062.69</b>  |
| Bank returns  | <b>CDN\$ 17.67</b>      |
| Total   | <b>CDN\$ 7947.06</b>    |
| Forwarding 2023   | <b>CDN\$ 7947.06*</b>   |

**8. BUDGET REQUESTED FROM ICS IN 2023**

Based on the low number of requests to cover field trip costs, we have a healthy budget for our new year and do not require additional funding.

PROJECTED EXPENSES

|                                   |                   |
|-----------------------------------|-------------------|
| Brazil field workshop sponsorship | CDN\$ 1235        |
| Website                           | CDN\$ 150         |
| <b>Total</b>                      | <b>CDN\$ 1358</b> |

PROJECTED INCOME:

|                        |                      |
|------------------------|----------------------|
| Carried over from 2021 | <b>CDN\$ 7947.06</b> |
| <b>BUDGET REQUEST</b>  | <b>CDN\$ 0</b>       |

**9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR (bullet point each key achievement anticipated, limited to three maximum)**

1. Field workshop to examine Ediacaran successions in Brazil. This trip will run in November 2023 (Previously 2020). Focus will be on the Corumba and Bambui groups in Brazil. The Corumba and Bambui groups contain *Cloudina* and other tubular fossils that are being considered as key biostratigraphic criteria to define the terminal Ediacaran stage (TES), and thus they are highly relevant to the missions of the Subcommission. The field workshop will be organized and led by Subcommission Secretary Lucas Warren and his colleagues in Brazil. The field guide is attached (**Appendix**).
2. Developing and managing a special issue (most likely in *Episodes*) that brings our membership up to speed on the progress made over the past 5 years (since Xiao et al., 2016. Towards an Ediacaran time scale: problems, protocols, and prospects. *Episodes*, 39(4), pp.540-555). This special issue will also summarize regional Ediacaran stratigraphy and potential criteria for the definition of the terminal Ediacaran stage (TES). Each manuscript will be formatted identically and designed as a facts-only short format where all proposed defining characters of the Series and Stages are identified and compared across sections. Importantly, recent recalibration and dating of the global Shuram negative excursion (Rooney et al., 2020, Calibrating the coevolution of Ediacaran life and environment. *Proceedings of the National Academy of Sciences*. 2020 Jul 21;117(29):16824-30) may finally provide a strong correlative character for the base of the Series and Stage. We believe we are close to a final vote and wish to have all the facts in one place before voting. With the change in leadership, we also require a change in our subcommittees. These committees will be tasked with setting realistic boundaries within both proposed Series. This work is ongoing from last report.
3. Construction of a database of all known end-Ediacaran sections worldwide. This includes fact-finding searches concerning the geology, geochemistry, and paleontology of each section. This is currently underway and continues as new data arises and will be instrumental to the “white paper” listed above. This task was listed last year but we had residual difficulties at organizing the members following covid. Our most recent meeting at GSA represents the first one since 2020, and was viewed as a “relaunch” by the executive. The past few years have been particularly difficult for members of the executive, especially in terms of being able to attend conference due to the high costs of these events. We hope to be able to have more in person events and meetings in 2024.
4. Holding a vote for new/renewed executives and voting members for 2025-2028

**9a. Potential funding sources external to IUGS:**

None at the moment. We will be engaging in fundraising in the upcoming year.

**10. OBJECTIVES AND WORK PLAN FOR NEXT 4 YEAR (2020–2024)**

- Subcommission annual newsletter will be distributed in January 2024. Secretary Dr. Lucas Warren will be leading the effort to compile and edit the annual newsletter.

- A vote will be called to decide what criterion or criteria will be the most useful in dividing the Ediacaran System into series and stages (particularly the second and terminal stages of the Ediacaran System). Our goal is to finalize the discussion on TES by 2024 (previously 2020).
- Developing and managing a special issue (most likely in *Episodes*) that brings our membership up to speed on the progress made over the past 5 years (since Xiao et al., 2016. Towards an Ediacaran time scale: problems, protocols, and prospects. *Episodes*, 39(4), pp.540-555). This special issue will also summarize regional Ediacaran stratigraphy and potential criteria for the definition of the terminal Ediacaran stage (TES). Each manuscript will be formatted identically and designed as a facts-only short format where all proposed defining characters of the Series and Stages are identified and compared across sections. Importantly, recent recalibration and dating of the global Shuram negative excursion (Rooney et al., 2020, Calibrating the coevolution of Ediacaran life and environment. *Proceedings of the National Academy of Sciences*. 2020 Jul 21;117(29):16824-30) may finally provide a strong correlative character for the base of the Series and Stage. We believe we are close to a final vote and wish to have all the facts in one place before voting. With the change in leadership, we also require a change in our subcommittees. These committees will be tasked with setting realistic boundaries within both proposed Series. This work is ongoing from last report.
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- Holding a vote for new/renewed executives and voting members for 2025-2028

## APPENDICES

### **Nominated Officers for 2020-2024:**

The Subcommittee is organized by an Executive consisting of Chairman, Vice-Chairman, and Secretary, who are all Voting Members of the Subcommittee. These officers were nominated by the Executive of the predecessor Neoproterozoic Subcommittee and appointed by ICS executives in August 2012. In 2015, they were re-elected by Subcommittee voting members to serve a second term in 2016-2020. In 2020, we elected a new Executive as follows:

Dr. Marc Laflamme, Chairman, (Associate Professor, Department of Chemical and Physical Sciences, University of Toronto Mississauga, 3359 Mississauga Road, Mississauga, ON L5L 1C6, Canada; [marc.laflamme@utoronto.ca](mailto:marc.laflamme@utoronto.ca))

Dr. James D. Schiffbauer, Vice Chairman, (Associate Professor, Department of Geological Sciences and Director, X-ray Microanalysis Core, University of Missouri, 101 Geological Sciences Building, University of Missouri, Columbia MO 65211, USA; [schiffbauerj@missouri.edu](mailto:schiffbauerj@missouri.edu))

Dr. Lucas Veríssimo Warren, Secretary, (Assistant Professor, Department of Applied Geology, São Paulo State University, Rua Quirino de Andrade 215, Sao Paulo, 01049-010, Brazil; [lucas.warren@unesp.br](mailto:lucas.warren@unesp.br))

### List of Voting Members

There are currently 19 voting members and over 30 corresponding members. The Voting Members were specifically selected for their international reputations, recognized expertise in an area of geoscience relevant to the subcommission, and their willingness to take an active role in the Subcommission's activities. In October 2016, five new voting members were nominated and voted by the incumbent voting members, and were approved by the Executives to replace five incumbent voting members.

Voting members serving 2020-2024:

| Name                           | Email  | Institution  |
|--------------------------------|--|--|
| Buatois, Luis                  | <a href="mailto:luis.buatois@usask.ca">luis.buatois@usask.ca</a>   | University of Saskatchewan   |
| Chuanming, Zhou                | <a href="mailto:cmzhou@nigpas.ac.cn">cmzhou@nigpas.ac.cn</a>   | Chinese Academy of Sciences  |
| Droser, Mary                   | <a href="mailto:droser@ucr.edu">droser@ucr.edu</a>   | University of California Riverside                                 |
| Grazhdankin, Dimitry           | <a href="mailto:dima.grazhdankin@gmail.com">dima.grazhdankin@gmail.com</a>   | A.A. Trofimuk Institute of Petroleum Geology and Geophysics SB RAS |
| Kaufman, Alan Jay              | <a href="mailto:kaufman@umd.edu">kaufman@umd.edu</a>   | University of Maryland   |
| Laflamme, Marc                 | <a href="mailto:marc.laflamme@utoronto.ca">marc.laflamme@utoronto.ca</a>   | University of Toronto  |
| Liu, Alex                      | <a href="mailto:agscl2@cam.ac.uk">agscl2@cam.ac.uk</a>   | University of Cambridge  |
| Moczydlowska-Vidal, Malgorzata | <a href="mailto:malgo.vidal@pal.uu.se">malgo.vidal@pal.uu.se</a>   | Uppsala University   |
| Mukund, Sharma                 | <a href="mailto:mukund_sharma@bsip.res.in">mukund_sharma@bsip.res.in</a>   | Birbal Sahni Institute of Palaeosciences                           |
| Narbonne, Guy                  | <a href="mailto:narbonne@geol.queensu.ca">narbonne@geol.queensu.ca</a>   | Queens University  |
| Pengju, Liu                    | <a href="mailto:pengjul@sina.com">pengjul@sina.com</a> ;<br><a href="mailto:pengju@cags.ac.cn">pengju@cags.ac.cn</a>         | Chinese Academy of Geological Sciences                             |
| Pruss, Sara                    | <a href="mailto:spruss@smith.edu">spruss@smith.edu</a>   | Smith College  |
| Schiffbauer, James             | <a href="mailto:schiffbauerj@missouri.edu">schiffbauerj@missouri.edu</a>   | University of Missouri   |
| Selly, Tara                    | <a href="mailto:sellyt@missouri.edu">sellyt@missouri.edu</a>   | University of Missouri   |
| Strauss, Justin                | <a href="mailto:Justin.V.Strauss@dartmouth.edu">Justin.V.Strauss@dartmouth.edu</a>   | Dartmouth College  |
| Tostevin, Rosalie              | <a href="mailto:rosalie.tostevin@uct.ac.za">rosalie.tostevin@uct.ac.za</a>   | University of Cape Town  |
| Warren, Lucas                  | <a href="mailto:lucas.warren@unesp.br">lucas.warren@unesp.br</a>   | São Paulo State University   |
| Wood, Rachel                   | <a href="mailto:rachel.wood@ed.ac.uk">rachel.wood@ed.ac.uk</a>   | The University of Edinburgh  |
| Xiao, Shuhai                   | <a href="mailto:xiao@vt.edu">xiao@vt.edu</a>   | Virginia Tech  |
| Yuan, Xunlai                   | <a href="mailto:xlyuan@nigpas.ac.cn">xlyuan@nigpas.ac.cn</a>   | Nanjing Institute of Geology and Paleontology                      |
| Zhu, Maoyan                    | <a href="mailto:zhumaoyan@gmail.com">zhumaoyan@gmail.com</a> ;<br><a href="mailto:myzhu@nigpas.ac.cn">myzhu@nigpas.ac.cn</a> | Nanjing Institute of Geology and Paleontology                      |

**Working group leaders and corresponding members** – note that these working group leaders and corresponding members will be reevaluated this year given the difficult progress since covid.

- SES (Second Ediacaran Stage) working group: chaired by Chuanming Zhou (Chair) to focus on the Second Stage of the Ediacaran System.
- TES (Terminal Ediacaran Stage) working group: led by Guy Narbonne (Chair) and Malgorzata Moczydlowska-Vidal (secretary) to focus on the Terminal Stage of the Ediacaran System.
- UESr (Upper Ediacaran Series) working group: led by Alan Jay Kaufman (Chair) and James D. Schiffbauer (co-Chair) and to focus on the Upper Ediacaran Series.
- Task Group to investigate the Ediacaran-Cambrian boundary, led by voting member Dr. Maoyan Zhu.

Corresponding Members (a partial list; membership continues to grow)

- |                               |                                     |
|-------------------------------|-------------------------------------|
| • Antcliffe Jonathan          | University of Lausanne, Switzerland |
| • Boggiani, Paulo César       | São Paulo, Brazil                   |
| • Butterfield, Nicholas       | Cambridge, UK                       |
| • do Carmo, Dermval           | University of Brasilia, Brazil      |
| • Chen, Xiaohong              | Wuhan                               |
| • Chumakov, Nikolay           | Moscow, Russia                      |
| • Dermeval Aparecido Do Carmo | Brazil                              |
| • Erwin, Douglas              | Smithsonian NMNH, USA               |
| • Dunn, Frankie               | Oxford University, UK               |
| • Erdtmann, Bernd-D.          | Germany                             |
| • Evans, David A.D.           | Yale University, USA                |
| • Fedonkin, Mikhail           | Moscow, Russia                      |
| • Frimmel, Hartwig            | Wuerzburg, Germany                  |
| • Gaucher, Claudio            | Montevideo, Uruguay                 |
| • Hoffmann, Karl-Heinz        | Windhoek, Namibia                   |
| • Hofmann, Mandy              | Germany                             |
| • Jenkins, Richard            | Adelaide, Australia                 |
| • Kenchington, Charlotte      | Oxford University, UK               |
| • Knoll, Andrew H.            | Harvard University, USA             |
| • Kochnev, Boris              | Novosibirsk, Russia                 |
| • Leme, Juliana de M.         | University of San Paolo, Brazil     |
| • Linnemann, Ulf              | Dresden, Germany                    |
| • Melezhik, Victor            | Norway                              |
| • Nagovitsin, Konstantin      | Novosibirsk, Russia                 |
| • Patricia Vickers-Rich       | Monash University, Australia        |
| • Pokrovskii, Boris G.        | Russia                              |
| • Rainbird, Robert            | Ottawa, Canada                      |
| • Semikhatov, Mikhail A.      | Moscow Russia                       |
| • Sergeev, Volodya            | Russia                              |
| • Smith, Emily                | USA                                 |
| • Sun, Weiguo                 | Nanjing, China                      |
| • Van Kranendonk, Martin      | University of New South Wales       |
| • Walde, Detef                | Universidade de Brasília            |



- Walter, Malcolm
- Wang, Xiaofeng

Sydney, Australia

Wuhan

Attachments:

1. 2023 Joint International Subcommittee on Ediacaran and Cryogenian Stratigraphy Field Trip to Brazil. See attached PDF.



# **Joint International Subcommittee on Ediacaran and Cryogenian Stratigraphy Field Trip to Brazil**

**Nov 20-26, 2023**



**Sete Lagoas Formation in Janelão Cave, Pearuaçu National Park, Montalvânia, Brazil**

**Organization - Lucas Warren (UNESP) and Fabrício Caxito (UFMG)**

## THE GEOLOGY OF THE BAMBUÍ GROUP IN ITS SOUTHERN AND NORTHERN AREAS

**Ediacaran Unit:** Bambuí Group (Minas Gerais State, Brazil), including Cryogenian glacials and related features of the Jequitai Formation

**Number of participants:** Máx. 25

**Date:** Nov 20-26, 2023 (7 days)

**Responsible institutions:** São Paulo State University (UNESP) and Minas Gerais Federal University (UFMG)

**Organizers:** Lucas Warren (UNESP) and Fabrício Caxito (UFMG)





## **Brazilian Field Trip 2023**

### **Our trip will include:**

- Hotels and accommodations;
- 7 dinners/7 lunches + non-alcoholic drinks available throughout the period of field activities;
- Transfer by chartered bus throughout the trip;
- Field guides and all support material;
- Entrance to all national parks;
- Logistic assistance 24 hours a day;
- 1 touristic guide 24hr.

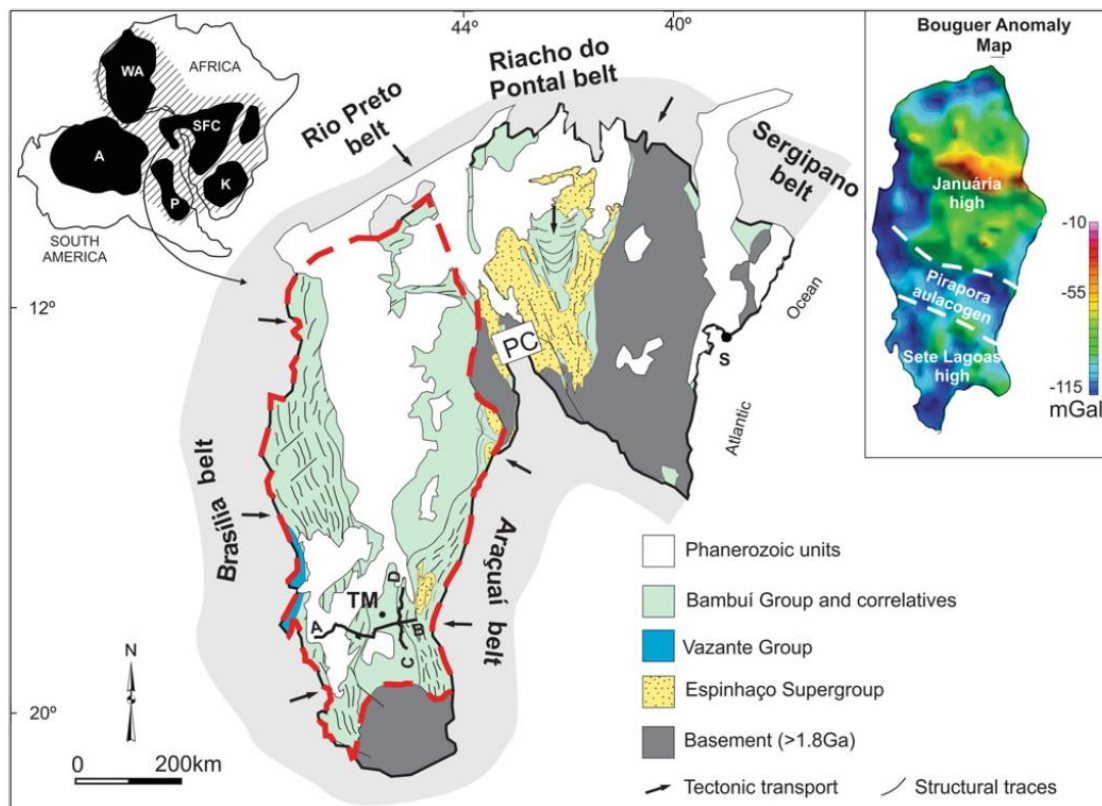
### **Basic itinerary:**

- 11/19** - Arrival in Belo Horizonte International Airport (BSB) (sleep in Belo Horizonte, MG - Hotel Bourbon Afonso Pena);
- 11/20** - Activities around Belo Horizonte (sleep in Belo Horizonte, MG - Hotel Bourbon Afonso Pena);
- 11/21** - Activities on the highway and nearby outcrops between Belo Horizonte and Montes Claros (sleep in Montes Claros, MG - Hotel Intercity);
- 11/22** - Activities on the highway and nearby outcrops between Montes Claros, Jequitai and Januária (sleep in Januária, MG - Hotel Viva Maria);
- 11/23** - Activities in Januária (sleep in Januária, MG - Hotel Viva Maria);
- 11/24** - Activities in Januária (sleep in Januária, MG - Hotel Viva Maria);
- 11/25** - Visit to Peruaçu National Park + Closing party (sleep in Januária, MG - Hotel Viva Maria);
- 11/26** - Return to Belo Horizonte (sleep in Belo Horizonte, MG - Hotel Bourbon Afonso Pena);
- 11/27** - Return flights to countries of origin.

## GEOLOGICAL CONTEXT

### Stratigraphic framework

The Bambuí Group (Fig. 1) is a late Neoproterozoic/Cambrian mixed carbonate-siliciclastic sedimentary cover which outcrops over 350,000km<sup>2</sup> over the Archean/Proterozoic São Francisco Craton in east central Brazil (Caxito et al., 2012; Reis et al., 2017 and references therein). The Bambuí Group developed concomitantly to the main Brasiliano/Pan-African orogenic fold-and-thrust belts that surrounded the São Francisco Craton (Brasília, Araçuaí/Ribeira and Rio Preto belts) during the amalgamation of western Gondwana, and the sedimentary rocks that comprise this group are deformed at the basin borders due to craton-verging tectonic loading related to development of these orogenic fronts, while at basin center the rocks are essentially horizontally-layered.



**Figure 1** – Distribution of Neoproterozoic/Cambrian covers in the São Francisco Craton, including a Bouguer anomaly map showing basement highs and lows. The location of A-B and C-D seismic sections of Figure 4 is shown. From Reis et al. (2017).



The classic lithostratigraphy of the Bambuí Group (**Fig. 2**, Dardenne, 1978) comprises six major units, from base to top:

- (1) **Jequitaí Formation**, ca. 100 m maximum thickness, comprising diamictites, sandstones and fine-grained siliciclastics, containing remarkable late Neoproterozoic glacial-related deposits (e.g. Caxito et al., 2012; Cukrov et al., 2005; Karfunkel and Hoppe, 1988; Kuchenbecker et al., 2013; Reis and Suss, 2016; Uhlein et al., 1999), locally sitting atop striated pavements (Isotta et al., 1969). No direct age constraints are available for the Jequitaí Formation glacials; younger detrital zircon populations define a maximum depositional age at ca. 880 Ma (Rodrigues, 2008).
- (2) **Sete Lagoas Formation**, ca. 400 m maximum thickness, containing various types of limestones with stromatolites toward the top and subordinated mudstones. Geological mapping conducted by the Brazilian Geological Survey in the type locality of the Sete Lagoas Formation, in the southern portion of the São Francisco basin (Sete Lagoas high), suggested to separate it into two distinct carbonate-rich units: the lower Pedro Leopoldo and the upper Lagoa Santa members.

The lower Pedro Leopoldo Member covers the glacial deposits or onlaps the crystalline basement and comprises a typical early Ediacaran cap carbonate succession (Alvarenga et al., 2014; Caxito et al., 2021, 2012; Hippertt et al., 2019; Okubo et al., 2018; Uhlein et al., 2019). At the base, a meter-thick patchy cap dolostone unit shows decreasing-upwards  $\delta^{13}\text{C}$  from -3.2‰ down to -6.5‰ and associated  $\delta^{18}\text{O}$  at -5‰ (all values reported as compared to VPDB; Alvarenga et al., 2014; Caxito et al., 2012). The cap dolostone is succeeded by up to a couple hundred meters-thick limestone containing pseudomorphs of calcite after original aragonite crystal fans with negative  $\delta^{13}\text{C}$  (Kuchenbecker et al., 2016b; Okubo et al., 2018; Perrella Júnior et al., 2017; Vieira et al., 2015). Phosphorite deposits (Drummond et al., 2015), apatitic cements (Okubo et al., 2018) and centimetric barite layers with a characteristic  $\Delta^{17}\text{O}$  anomaly (Crockford et al., 2018), probably caused by perturbations in the ozone layer due to excess  $\text{CO}_2$  accumulated during the Marinoan glaciation, are locally recognized. Cr isotope and geochemical data (negative Ce anomalies, low Th/U ratios, Mo and U contents, and Fe speciation data) suggest pulsed oxygenation of the post-glacial ocean due to meltwater contribution (Caxito et al., 2018; Hippertt et al., 2019).

Babinski et al. (2007) obtained a Pb-Pb whole-rock isochron array of  $740 \pm 20$  Ma on carbonates containing aragonite fan pseudomorphs at the Samba Quarry, and thus suggested a mid-Cryogenian (post-Sturtian glaciation) age for the Pedro Leopoldo cap carbonate (Vieira et al., 2007). Alternatively, Caxito et al. (2012) and Alvarenga et al. (2014) pointed out that the Pedro Leopoldo cap carbonate bears a set of litho- and chemostratigraphic features that are very similar to post-Marinoan (early Ediacaran) cap carbonates worldwide, such as a basal, meter-thick pale cap dolostone with decreasing-upwards  $\delta^{13}\text{C}$  values,  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios above 0.7074, including a sharp peak to around 0.7080 in the basal layers (Caetano-Filho et al., 2019; Caxito et al., 2021; Guacaneme et al., 2021; Paula-Santos et al., 2017), and barite layers with a characteristic  $\Delta^{17}\text{O}$  anomaly (Crockford et al., 2018), among other typical features of basal Ediacaran cap carbonates (Halverson et al., 2010; Knoll et al., 2004; Shields, 2005). Further, Caxito et al. (2021) provided new direct age constraints for the aragonite fan pseudomorphs of the Samba Quarry, through LA-ICPMS U-Pb dating of the calcite-after-aragonite fans. Two samples from the base and top of the quarry, respectively, yielded U-Pb lower intercept dates of  $615.4 \pm 5.9$  Ma (SMB1 – crystal-fans + matrix),  $608.1 \pm 5.1$  Ma (SMB2A – crystal-fans) and  $607.2 \pm 6.2$  Ma (SMB2B – matrix) and a mean in-situ  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio of  $0.707224 \pm 0.000006$ .

Although some workers suggested that the top of the Pedro Leopoldo carbonate member is marked by an erosional unconformity, recognized in both seismic and locally isotopic breaks (Martins and Lemos, 2007; Zalán and Romeiro-Silva, 2007), no convincing field evidence other than dissolution features, tepees, mud cracks, dolomitization and other facies changes, as well as subtle variations in regional dip have yet been described, so it is safer to assume this interval as a depositional hiatus or condensed section (Caxito et al., 2021). Above lies the couple hundred meters-thick Lagoa Santa Member, comprising a second crystal-fan-bearing limestone level superimposed by laminar and columnar stromatolites and thrombolites with  $\delta^{13}\text{C}_{\text{at}}$  ca. 0‰. This intermediate succession contains some putative trace fossils and sparse, loosely packed *Cloudina* sp. shells and *Corumbella weneri* fragments (Warren et al., 2014). The  $\delta^{13}\text{C}$  values rise quickly upwards to  $> +10\%$ , reaching extreme values of ca.  $+16\%$  (Caetano-Filho et al., 2021; Cui et al., 2020; Uhlein et al., 2019) and the macrofossil content virtually disappears. These  $\delta^{13}\text{C}$  values are anomalously high when compared to Ediacaran global seawater curves (Caxito et al., 2021; Cui et al., 2020; Uhlein et al., 2019) and persist upsection for around 350 m, spanning through the

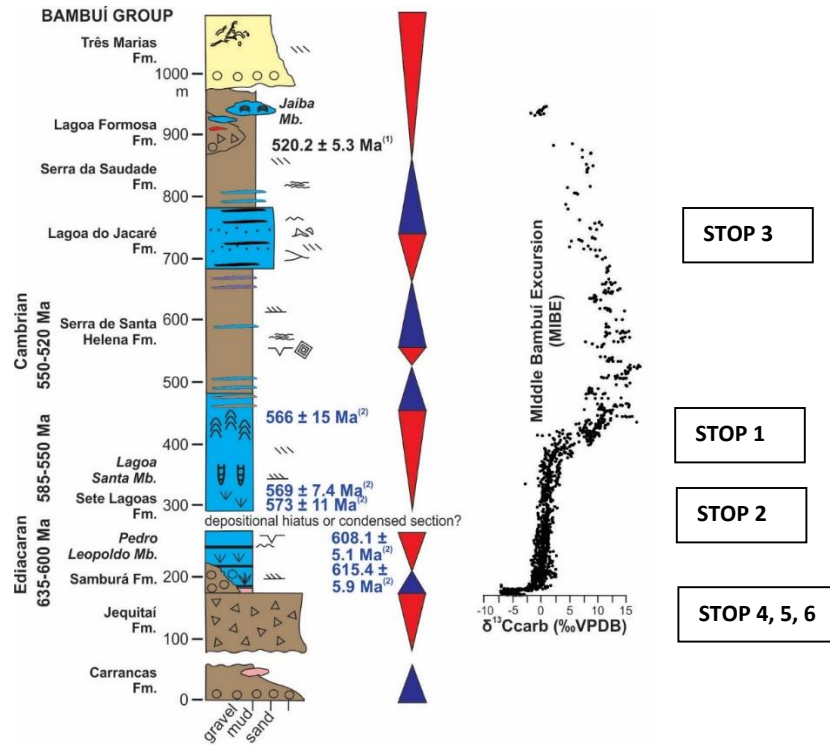
siltstone-dominated Serra de Santa Helena Formation and dark storm-related limestone of the Lagoa do Jacaré Formation, defining the Middle Bambuí Excursion (MIBE; Uhlein et al., 2019). The youngest concordant (within 5%) detrital zircons recovered from the Lagoa Santa member yielded a weighted mean  $^{206}\text{Pb}/^{238}\text{U}$  age of  $571 \pm 3$  Ma ( $n = 6$ ), interpreted as a maximum depositional age for this unit (Caxito et al., 2021, calculated after data from (Paula-Santos and Babinski, 2018; Paula-Santos et al., 2015; Rodrigues, 2008).

Crystal-fan-bearing limestones of the Lagoa Santa Member at the Tatiana Quarry yielded lower intercept U–Pb dates of  $573.0 \pm 11$  Ma (TATIA – crystal-fans;  $^{87}\text{Sr}/^{86}\text{Sr}$  of  $0.707525 \pm 0.000007$ ) and  $569.4 \pm 7.4$  Ma (TATIB – matrix;  $^{87}\text{Sr}/^{86}\text{Sr}$  of  $0.708058 \pm 0.000017$ ). The same samples yielded a  $576 \pm 36$  Ma stepwise Pb leaching isochron. The topmost dark stromatolitic carbonates of the Lagoa Santa Member at the Road Police Station near Sete Lagoas bear very positive  $\delta^{13}\text{C} > 10\text{‰}$  corresponding to the MIBE and yielded a  $566 \pm 15$  Ma U–Pb date, with in-situ  $^{87}\text{Sr}/^{86}\text{Sr} = 0.707270 \pm 0.000012$  for the stromatolite columns and  $0.708140 \pm 0.000029$  for the dark micrite matrix (all data from Caxito et al., 2021).

- (3) **Serra de Santa Helena Formation**, containing up to 200 m thick siltstones and mudstones, with local carbonate lenses. This unit represents a transgression over the whole basin, marking a maximum flooding surface.
- (4) **Lagoa do Jacaré Formation**, with up to ca. 100 m thick of dark oolitic to muddy limestones, containing tempestite (Dantas et al., 2022) and tidal-influenced deposits (Moura et al., 2022). The bed geometry is lenticular, with carbonate patches formed in shallow lagoons during a regional regression.
- (5) **Serra da Saudade Formation**, containing up to 200 m thick of green siltstones, shales and sandstones. Economically important potassium and phosphorite deposits are contained in this unit, especially within the greenish siltstones commonly known as “verdetes” (Lima, 2011; Moreira et al., 2020). LA-ICPMS U–Pb zircon dating of a tuff layer interleaved in this unit provides a direct age constraint at  $520.2 \pm 5.3$  Ma (Moreira et al., 2020), thus spanning the Cambrian Series 2.
- (6) **Três Marias Formation**, containing arkoses, sandstones, conglomerates and shales, deposited over an erosional unconformity at the top of the Serra




























da Saudade Formation. This unit represents the final infilling of the basin. Trace fossils interpreted as *Treptichnus pedum* confirm a Cambrian age for the topmost Bambuí Group (Sanchez et al., 2021), as well as youngest detrital zircons at ca. 527 Ma (Tavares et al., 2020).



(1) U-Pb zircon age from tuff, Moreira et al. (2020)  
(2) U-Pb LA-ICPMS calcite ages, Caxito et al. (2021)

(7)

| key   |                       |  <i>Treptichnus pedum</i>              |  transgressive-regressive interval |
|---|-----------------------|---|---|
|  | sineresis cracks      |  <i>Cloudina</i> and <i>Corumbella</i> |  black shale                       |
|  | MISS                  |  microbial laminites                   |  limestone                         |
|  | hummocky cross-strat. |  stromatolites                         |  dolostone                         |
|  | salt casts            |  ooids                                 |  jaspillite                        |
|  | mudcracks             |  phosphorite                           |  fine-grained clastics             |
|  | symmetric ripples     |  aragonite crystal fans                |  sandstone                         |
|  | tabular cross-beds    |  barite layers                         |  conglomerate                      |
|  | cross-lamination      |   |  diamictite                        |

(8)

**Figure 2** – Simplified stratigraphic column and compilation of carbon isotopic data for the Bambuí Group (for sources see Caxito et al., 2021).

The classical stratigraphic subdivision proposed by Dardenne (1978) was progressively refined over the years. Thus, other stratigraphic units are progressively being formally included in the Bambuí Group, such as the Samburá (conglomerates, sandstones and pelites) and the Lagoa Formosa (diamictite, sandstone, siltstone,

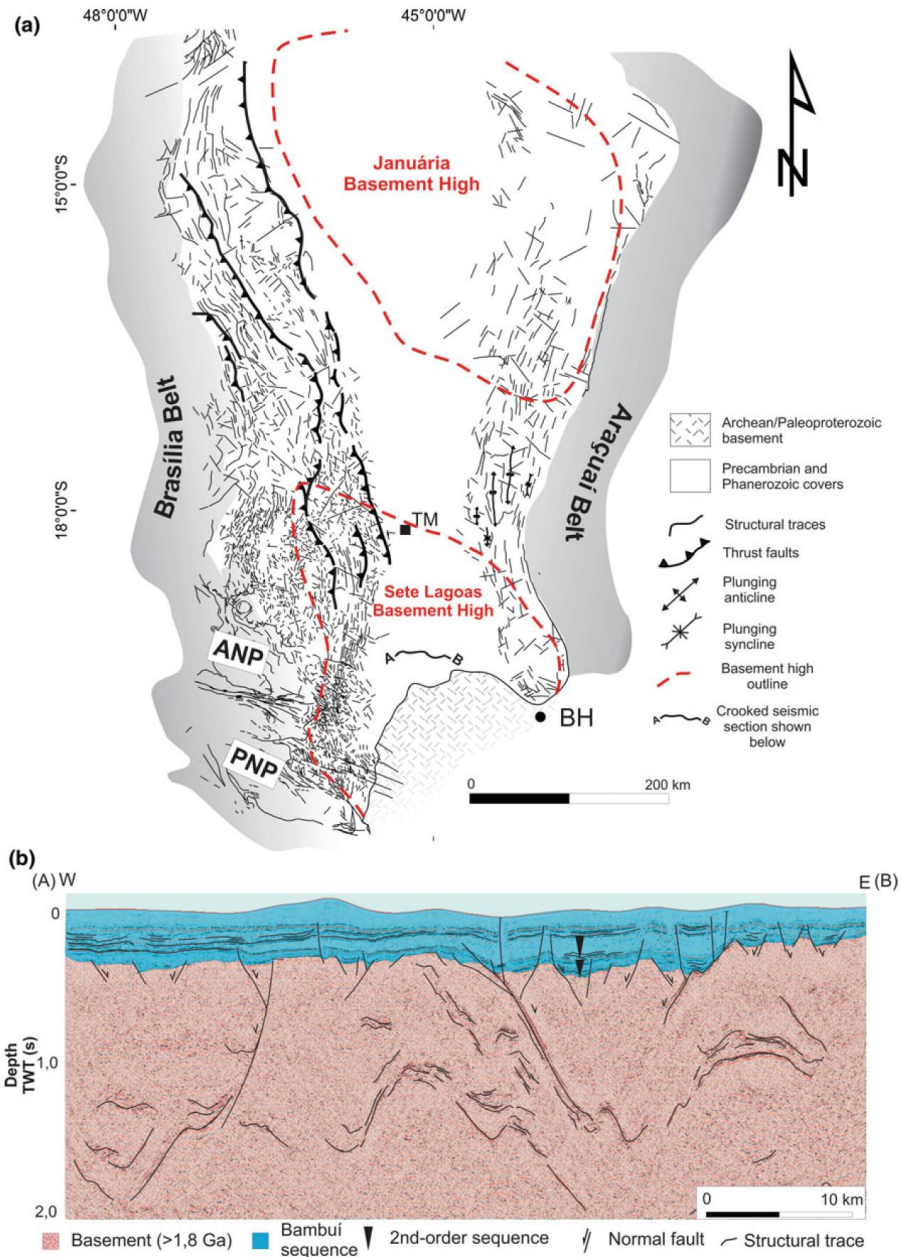


and lenses of limestone and jaspilite) formations (Castro and Dardenne, 1995, 2000; Uhlein et al., 2013, 2017). These successions are exposed in the western part of the São Francisco basin and have been interpreted as conglomerate-rich wedges related to the development of the Brasília Orogen to the west (Uhlein et al., 2017). The Jaíba Formation (Uhlein et al., 2021) and the Gorutuba Formation (Kuchenbecker et al., 2016a), on the other hand, are exposed exclusively in the upper part of the Bambuí Group in the eastern São Francisco basin. The Jaíba Formation encompasses a ca. 40m-thick limestone unit atop fine-grained siliciclastics of the Serra da Saudade Formation and overlain by coarse-grained deposits of the Três Marias Formation in the Jaíba Range, while the Gorutuba Formation includes a succession of continental to shallow marine breccias, conglomerates, sandstones and pelites in the uppermost Bambuí Group.

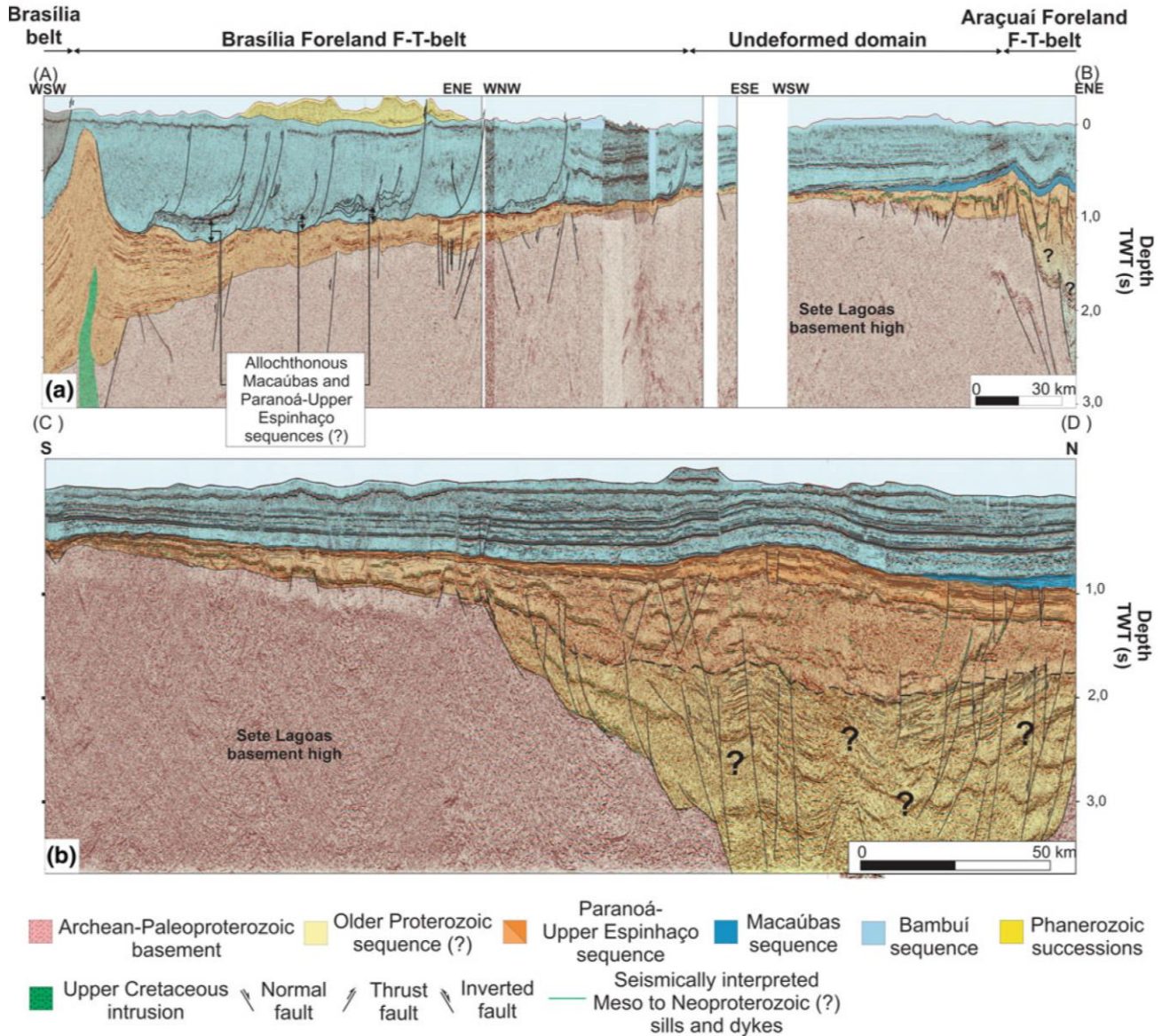
### **Tectonic, environmental and biological evolution**

The stratigraphic, sedimentological, isotopic and biological record of the Bambuí Group is intimately linked with evolution of the orogenic regions that surrounded the São Francisco paleocontinent during the Ediacaran/Cambrian assembly of western Gondwana (**Fig. 3**, Caxito et al., 2021). In this context, the São Francisco basin transitioned from an open marine setting in the aftermath of the Marinoan glaciation to a fully restricted basin in the late Ediacaran.

At ca. 635-600 Ma, closure of the Goiás-Pharusian ocean and loading of the Brasília Orogen thrust fronts over the western margin of the São Francisco paleoplate generated a foreland system (**Fig. 4**), with sedimentary partitioning of the basin into two major depocenters: (i) a foredeep mostly filled with fine- to coarse-grained siliciclastics and (ii) a forebulge filled with mixed carbonate-siliciclastics, in the western and eastern portions of the São Francisco basin, respectively. Carbon and strontium isotopes in the Pedro Leopoldo Member mirror the global early Ediacaran curve, due to continued seawater connection through the Adamastor ocean (**Fig.5**). Ce anomalies, Cr isotopes, Mo and U enrichments, Fe speciation and trace elements in sedimentary pyrite (Caxito et al., 2021, 2018; Hippertt et al., 2019; Lima et al., 2023; Paula-Santos et al., 2020) supports transient oxygenated conditions for the surficial post-glacial waters. This, however, seems to have been a temporary and patchy oxygenation pulse, perhaps triggered by glacial meltwater input to the basin (Caxito et al., 2018).



**Figure 3** – A. Simplified tectonic map of the southern São Francisco basin highlighting the Neoproterozoic Brasília and Araçuaí foreland fold-and-thrust belts, respectively on the west and on the east. The map also shows the relationship between these belts and the main basement structures. B. Crooked seismic section showing the extensional reactivation of Archean compressional structures during the deposition of the lower Bambuí sequence on the Sete Lagoas basement high. Depth is shown in two-way travel time (TWT). From Reis et al. (2017)



**Figure 4** - Crooked composite seismic sections across the southern São Francisco basin showing: a the distribution of the main stratigraphic units of the São Francisco basin, and the expression of the Neoproterozoic Brasília and Araçuaí foreland fold-thrust belts; and b the Pirapora aulacogen, partially inverted in the influence area of the Araçuaí foreland f-t-belt. The rift and sag 2nd-order sequences of the Paranoá-Upper Espinhaço sequence are represented in white and dark orange, respectively. On both illustrations, the depth is shown in two-way travel time (TWT). From Reis et al. (2017). Location of the sections in Figure 1.

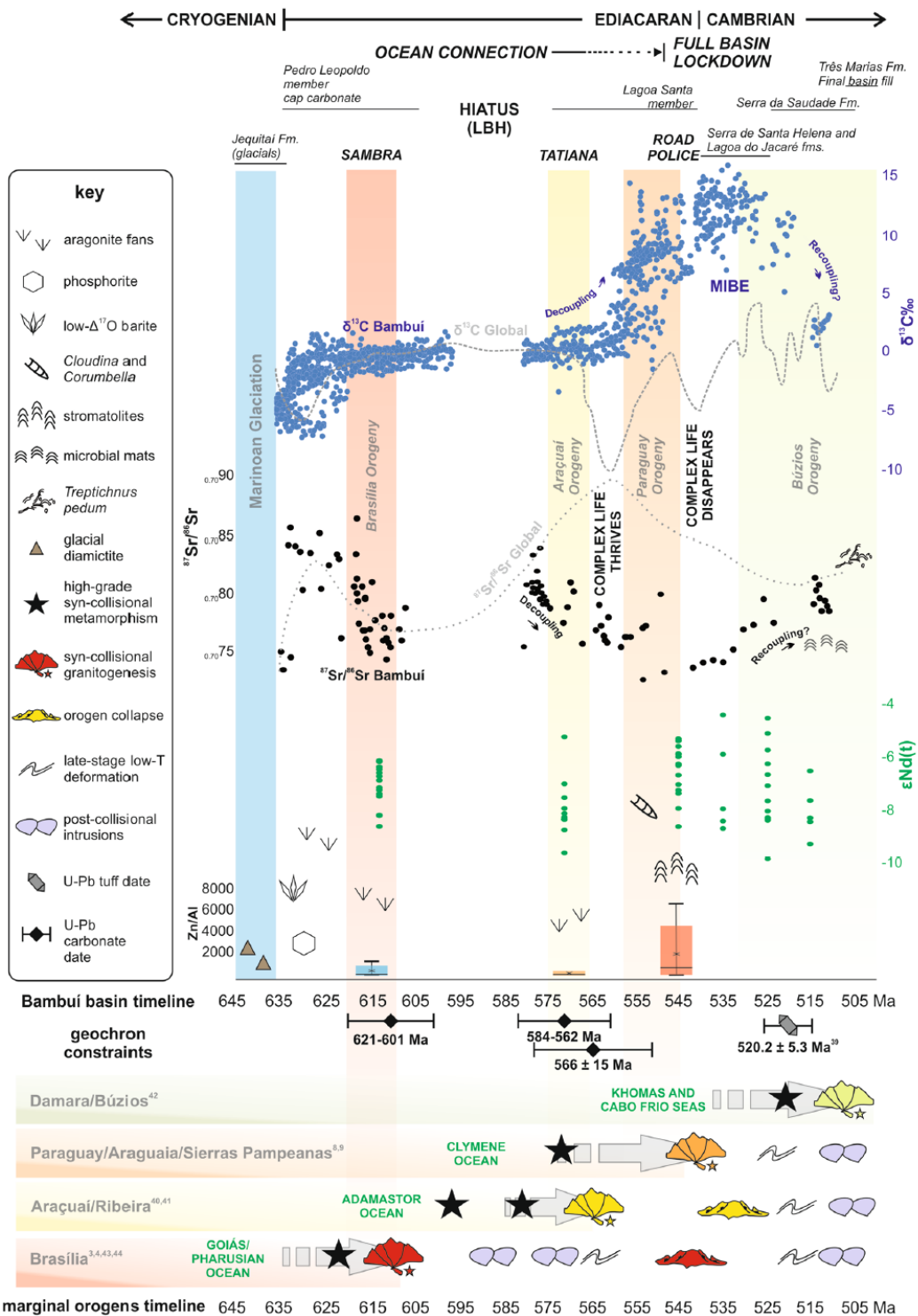


Nevertheless, it led to an important input of sulfate and phosphate to the basin, with formation of phosphorites (Drummond et al., 2015) and authigenic phosphate cements encrusting crystal fans (Okubo et al., 2018). Ca isotope systematics (Silva-Tamayo et al., 2010), as well as the sharp  $^{87}\text{Sr}/^{86}\text{Sr}$  peak from ca. 0.7074 to ca. 0.7080, support enhanced weathering of source areas during deposition of the cap carbonate.

Uplift of the Araçuaí-Ribeira Orogen at ca. 585-530 Ma caused renewed flexure of the eastern border of the São Francisco paleocontinent (**Fig. 4**), generating new accommodation space and deposition of the Lagoa Santa Member. At that time, the São Francisco basin was still connected to the Ediacaran global ocean, recording  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios of ca. 0.7080 and  $\delta^{13}\text{C}$  around 0‰. Late-Ediacaran biomineralizing metazoans such as *Cloudina sp.* briefly thrived. Upsection, however, the remainder of the Bambuí Group is largely devoid of late Ediacaran/Cambrian macrofossils.

The development of typical Ediacaran-Cambrian ecosystems was probably hampered by the progressive restriction of the basin by the encircling orogenic belts. Collision of the Amazonian paleocontinent (**Figs. 5 and 6**) and consequent closure of the Clymene ocean to the west caused renewed uplift of the Brasília Orogen at 540-520 Ma, completely restricting the São Francisco basin from all sides. These processes were ultimately responsible for the unique Middle Bambuí Excursion (MIBE, Uhlein et al., 2019; **Figs. 1 and 5**) of  $\delta^{13}\text{C} > 10\text{‰}$ . The  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios became decoupled from the global curve, recording anomalously low values of circa 0.7072, probably due to the erosion of juvenile terranes and/or of ancient carbonate platforms uplifted in the surrounding orogenic belts (Caetano-Filho et al., 2021; Caxito et al., 2021; Cui et al., 2020; Guacaneme et al., 2021; Paula-Santos et al., 2017; Uhlein et al., 2019).

In this scenario, progressive restriction due to tectonic confinement and uncontrolled delivery of nutrient-rich waters might have fueled biomass production that was efficiently re-mineralized through methanogenesis (Caetano-Filho et al., 2021; Uhlein et al., 2019). Limestone that record the MIBE present a covariation of paired  $\delta^{13}\text{C}_{\text{carb}}$ -  $\delta^{13}\text{C}_{\text{org}}$  data, high  $\delta^{34}\text{S}_{\text{pyrite}}$  and low carbonate-associated sulfate (CAS) (Caetano-Filho et al., 2021; Cui et al., 2020; Okubo et al., 2022). A sulfate poor, water-column methanogenesis environment was recently proposed (Caetano-Filho et al., 2021; Cui et al., 2020; Okubo et al., 2022), in which  $^{13}\text{C}$ -depleted methane is released from sediments and water without being oxidized. Thus, seawater DIC record anomalously positive  $\delta^{13}\text{C}$  signals from methanogenic  $^{13}\text{C}$ -enriched  $\text{CO}_2$ . This scenario is only achieved after a drastic reduction of the dissolved oxygen pool through aerobic respiration and consumption of other oxidants.



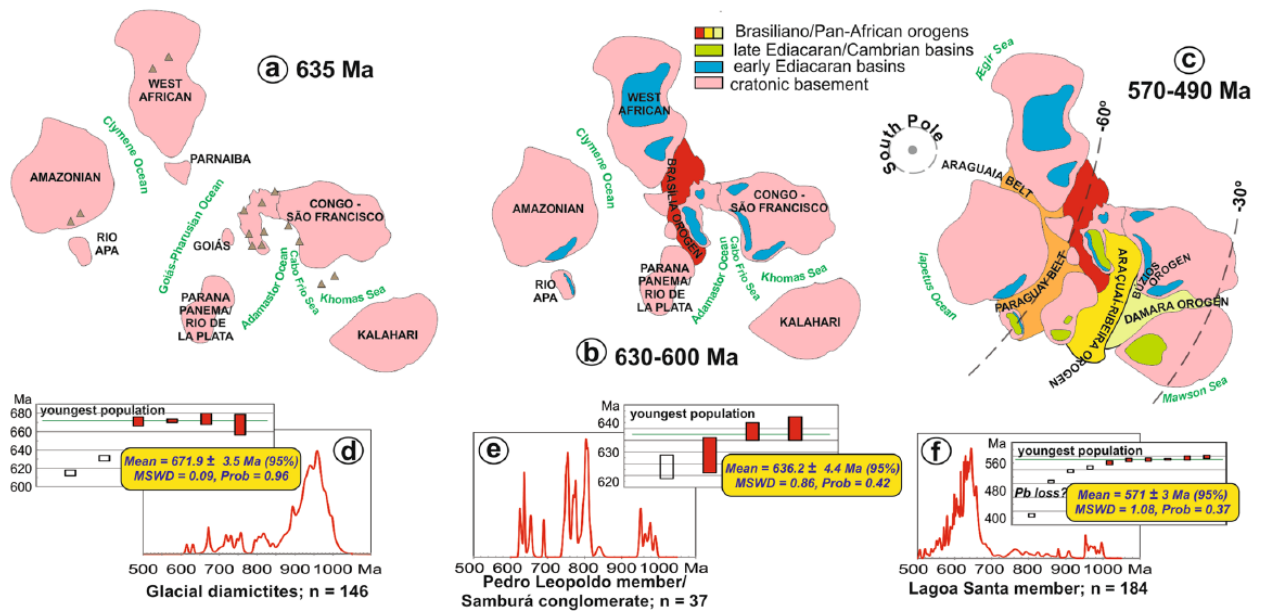
**Figure 5** - Timeline showing the integrated evolution of mountain belts and the Bambuí Group at the core of western Gondwana. From Caxito et al. (2021).



Alternative factors might have contributed to the MIBE, such as a change in total carbon input from the weathering of older carbonate rocks with high  $\delta^{13}\text{C}$  (Paula-Santos et al., 2017; Uhlein et al., 2019) and a third authigenic carbonate sink (Cui et al., 2020), but are unlikely to have acted alone in maintaining a  $^{13}\text{C}$ -enriched DIC throughout the basin. A significant shallowing of the redoxcline and increasing of anoxic incursions into proximal settings during the MIBE is thus interpreted. Anaerobic degradation of organic matter (through methanogenesis and dissimilatory Fe reduction) likely resulted in a degree of P recycling back to the water column, thus fueling productivity to probably very high levels, provided P did not get trapped in ferrous iron minerals. The absence of oxygen, eutrophication effects and a probable methane-rich water made the environment extremely eco-stressful and hampered complex life forms and the establishment of a typical Ediacaran–Cambrian style trophic chain (Hippertt et al., 2019; Caxito et al., 2021).

While progressive basin restriction disconnected the Bambuí waters from the global sea and thus isolated it from the prevailing biotic and abiotic conditions, preventing the rise of typical late Ediacaran/early Cambrian macrofaunal biota, some distinct microbial benthic assemblages might still have thrived, as indicated by localized stromatolites and recently described MISS structures (Okubo et al., 2023). Microbial mats of the Jaíba Formation, above the Serra da Saudade Formation, yielded  $\delta^{13}\text{C}$  around + 3‰ and  $^{87}\text{Sr}/^{86}\text{Sr}$  of ca. 0.708052 (Uhleim et al., 2021), similar to the early Cambrian seawater curve, which might suggest a recoupling with global oceanic waters and the return to normal biogeochemical conditions at the topmost Bambuí Group after the intensively restricted period of the MIBE (Caxito et al., 2021). Finally, putative ichnofossils such as *Treptichnus pedum* in the Três Marias Formation (Sanchez et al., 2021), uppermost unit of the Bambuí Group, signals the return to paleoenvironmental conditions that were not completely toxic to complex animal forms.

The integrated tectono-sedimentary evolution of Bambuí Group is summarized in **Figures 5 and 6**.



**Figure 6** - Integrated evolution of Ediacaran–Cambrian orogens and basins in western Gondwana. In (A–C) schematic models of evolution of western Gondwana during the late Ediacaran–early Cambrian. In (D–F) literature-compiled Neoproterozoic detrital zircon  $^{206}\text{Pb}/^{238}\text{U}$  age spectra for the Bambuí basin during each of the stages depicted in (a–c) respectively. From Caxito et al. (2021).





## THE SOUTHERN OUTCROP AREA OF THE NEOPROTEROZOIC BAMBUÍ GROUP IN MINAS GERAIS STATE, BRAZIL (SETE LAGOAS BASEMENT HIGH AND JEQUITAÍ AREA)

### OBJECTIVES

The first part of the field will take participants to look at the Cryogenian to Ediacaran successions at the southern border of the São Francisco Craton, with undeformed sections in the vicinities of Belo Horizonte city (MG, Brazil) and in the northern cratonic domain (Januária town, MG, Brazil). The Ediacaran carbonate succession starts with a cap-carbonate overlying glacial diamictite of the Jequitaí Formation (late Cryogenian), or directly overlying Paleo/Mesoproterozoic rocks of the crystalline basement. The first part of this field trip will be focused in regional aspects of the stratigraphy and sedimentological from the Jequitaí Formation and Bambuí Group.

### PLANNED ITINERARY

**Guides:** Lucas Warren (UNESP) and Fabrício Caxito (UFMG).

#### Day 1: Geological Survey of Brazil Drill core facility at Caeté

- We will drive ca. 60 km from Belo Horizonte to the city of Caeté, where the Geological Survey of Brazil has a facility that holds drill cores obtained by the company since the 1980's. There, we will be able to investigate drill cores of the São Francisco basin that intercepts both pre-glacial units (mainly sandstones with interleaved black shales), glacial diamictites of the Jequitaí Formation (probably end-Cryogenian), the basal Ediacaran cap carbonate succession of the basal Sete Lagoas Formation, including ex-aragonite fans and other sedimentary structures, and the late Ediacaran mudstone-dominated Serra de Santa Helena and limestone-dominated Lagoa do Jacaré Formation. The drill cores in question span drastic variations in  $\delta^{13}\text{C}$ , iron speciation and other proxies, and record important paleoenvironmental shifts in the Bambuí Group during the Cryogenian/Ediacaran transition and into the Ediacaran.

Drillhole cores PSB13 and PSB14 (**Fig. 7**) will be under display for our excursion purposes. Their approximate location within the basin, including two other

drill cores that will not be available for this excursion, along with a regional seismic section (**Fig. 8**, ANP – National Petroleum Agency of Brazil, Dantas et al., 2022).

Drillhole core PSB13 is from a basement through over the Januária high, and intercepts ca. 250 meters of carbonatic rocks of the Sete Lagoas Formation, predominantly micritic limestones including various black shale intercalations. At its base, a level of mud/siltstone containing sparse dropstones transitions downwards to glacial diamictite, which in turn covers pre-Bambuí siliciclastic strata of unknown age (Espinhaço Supergroup).

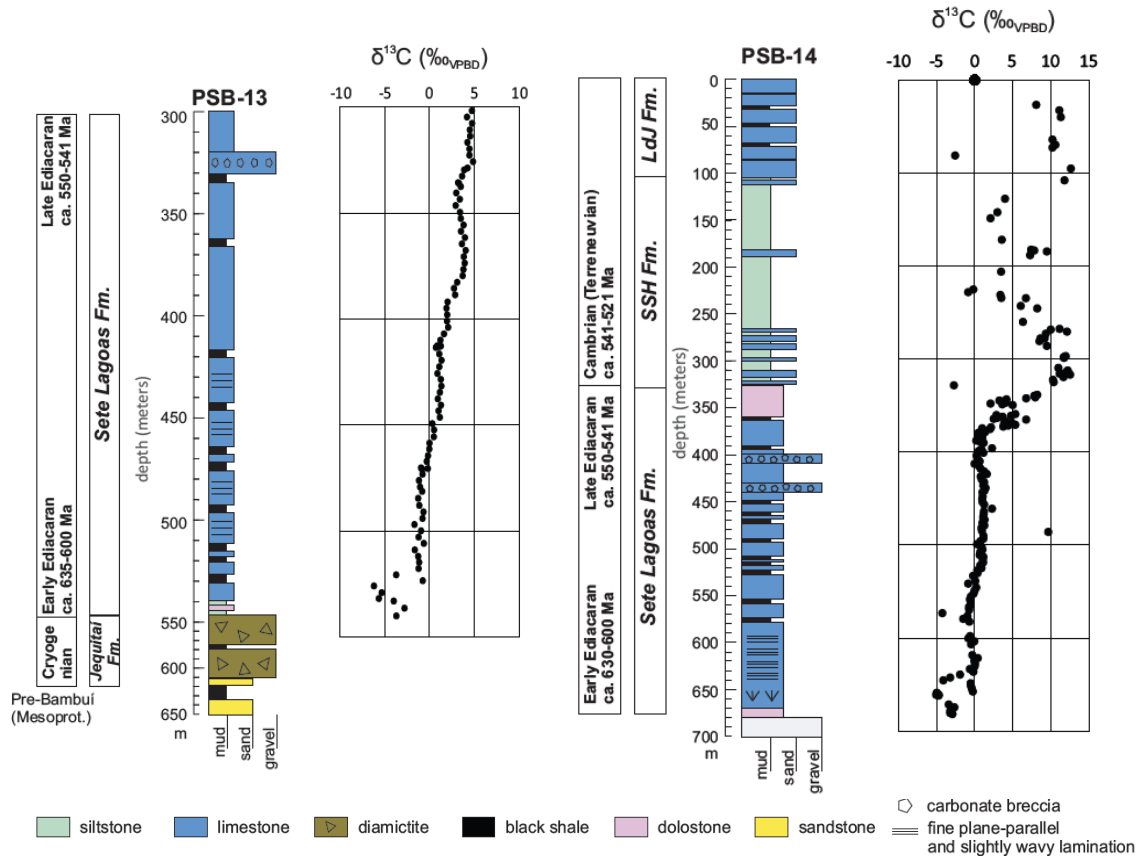
Drillhole core PSB14 is from a deeper portion of the basin and intercepts both the Sete Lagoas, Serra de Santa Helena and Lagoa do Jacaré formations. At its base, a ca. 10 m-thick whitish dolostone onlaps crystalline basement of the São Francisco Craton. The cap dolostone is covered by micritic limestone containing calcite-after-aragonite crystal fans at ca. 657 meters, which transitions to a reddish limestone and then limestone with sparse black shale intercalations. Close to the contact with the Serra de Santa Helena Formation mudstones, some brecciated levels occur, and a second level containing calcite-after aragonite pseudomorphs is observed, at ca. 350 meters. Thus, distinct calcite-after-aragonite fan levels occur in the basal carbonates of the Bambuí Group, separated by ca. 300 meters of limestone-dominated packages. The mudstone-dominated Serra de Santa Helena Fm. is then capped by black coarse-grained limestones of the Lagoa do Jacaré Fm., with frequent black shale intercalations.

The characteristic basal Ediacaran (post-Marinoan) U-shaped  $\delta^{13}\text{C}$  curve is present in both drill cores (**Figs. 8 and 9**). Upsection, the PSB14 core records the MIBE excursion, with  $\delta^{13}\text{C}$  values reaching up to ca. +14 per mil.



**Figure 7** - Some features of the Brazilian Geological Survey São Francisco basin drill cores: glacial diamictite in contact with cap carbonate; ex-aragonite fans; black shale interbedded within the cap carbonate succession.





**Figure 9** – Schematic stratigraphic and chemostratigraphic plots for drill cores PSB13 and PSB14. From Caxito et al. (2021, GSA Meeting Abstract), incorporating  $\delta^{13}\text{C}$  data from Uhlein et al. (2019) and Baptista (2020). SSH = Serra de Santa Helena; LdJ = Lagoa do Jacaré.

- Travel to the city of Belo Horizonte. Accommodation and dinner.

## Day 2: The complete Bambuí Group section (Part 1)

- Drive from Belo Horizonte to Montes Claros (~435 km), with stops along the BR-040 road near the town of Sete Lagoas;
- **Stop 1** – Black columnar stromatolites of the topmost Sete Lagoas Formation at the Road Police station (lat -19.474521°, long -44.291777°), spanning the MIBE interval ( $\delta^{13}\text{C} > 10$  per mil).

The columnar stromatolites occur in a roadcut at the Road Police station of Sete Lagoas, and represent the topmost carbonates of the Sete Lagoas Formation in this area. Siliciclastic mudstones of the Serra de Santa Helena Formation cover the outcrop at the northern end. They mark the moment of maximum flooding in the basin, with a major transgression and deeper water fine-grained sediments covering the stromatolites and temporarily shutting down the carbonate factory. Samples from this outcrop yielded a  $566 \pm 15$  Ma U–Pb LA-ICPMS date, with in-situ  $^{87}\text{Sr}/^{86}\text{Sr} = 0.707270 \pm 0.000012$  for the stromatolite columns and  $0.708140 \pm 0.000029$  for the dark micrite matrix (**Fig. 13h**; Caxito et al., 2021).



**Figure 10** - Black columnar stromatolites of the uppermost Sete Lagoas Formation at Road Police station.

- **Stop 2** – Ex-aragonite fans of the Sete Lagoas Formation in either the Samba (lat  $-19.426763^\circ\text{S}$ , long  $-44.378674^\circ$ ) or Tatiana quarries (lat  $-19.439487^\circ$ , long  $-44.303027^\circ$ ), depending on access liberation.

In the Sete Lagoas basement high near Belo Horizonte, the thin basal cap dolostone is absent. Here, the Sete Lagoas Formation either sits atop

paraconglomerate and rhythmite of the Carrancas Formation (Uhlein et al., 2016), generally with a sharp contact, or directly above crystalline basement, onlapping Archean gneisses and granites.

As discussed for the drill cores, multiple levels containing calcite-after-aragonite crystal fans occur in both the Pedro Leopoldo and Lagoa Santa members of the Sete Lagoas Formation, separated by over 300 m of carbonate-rich packages. Thus, not every calcite-after-aragonite crystal fan level is directly related to the post-glacial succession. In effect, near Sete Lagoas, two distinct quarries contain limestone with abundant calcite-after-aragonite crystal fans: The Samba Quarry of the Pedro Leopoldo Member and the Tatiana Quarry of the Lagoa Santa Member (Babinski et al., 2007; Hoppe et al., 2002; Peryt et al., 1990; Vieira et al., 2015). While the  $\delta^{13}\text{C}$  profile of the Samba Quarry is identical to profiles of the laminated limestones that overlie the basal cap dolostone in other parts of the São Francisco basin, with negative  $\delta^{13}\text{C}$  around -5‰ at the base (Babinski et al., 2007; Kaufman et al., 2001; Vieira et al., 2007),  $\delta^{13}\text{C}$  values in the Tatiana quarry are mostly constant around 0 per mil.

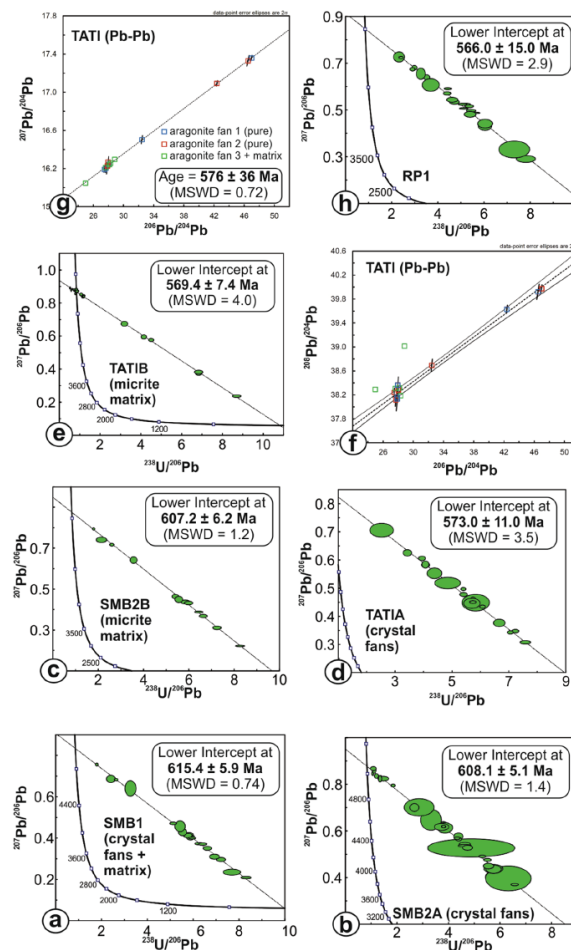
Samples from the Samba Quarry yielded U–Pb LA-ICPMS lower intercept dates (**Fig. 13a, b and c**) of  $615.4 \pm 5.9$  Ma. (SMB1 – crystal-fans + matrix),  $608.1 \pm 5.1$  Ma (SMB2A – crystal-fans) and  $607.2 \pm 6.2$  Ma (SMB2B – matrix) and a mean in-situ  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio of  $0.707224 \pm 0.000006$  (Caxito et al., 2021). The crystal-fan-bearing limestone of the Lagoa Santa Member at the Tatiana Quarry yielded lower intercept U–Pb LA-ICPMS (**Fig. 13d and e**) dates of  $573.0 \pm 11$  Ma (TATIA – crystal-fans;  $^{87}\text{Sr}/^{86}\text{Sr}$  of  $0.707525 \pm 0.000007$ ) and  $569.4 \pm 7.4$  Ma (TATIB – matrix;  $^{87}\text{Sr}/^{86}\text{Sr}$  of  $0.708058 \pm 0.000017$ ). The same samples yielded a  $576 \pm 36$  Ma stepwise Pb leaching isochron (**Fig. 13f and g**; Caxito et al., 2021).



**Figure 11** - Ex-aragonite fans of the Sete Lagoas Formation (Pedro Leopoldo Member) at Samba Quarry.



**Figure 12** – 3-D view of ex-aragonite fans of the Sete Lagoas Formation (Lagoa Santa Member) at Tatiana Quarry.



**Figure 13** – U-Pb LA-ICPMS and Pb-Pb whole rock data for the outcrops visited at stops 1 and 2. From Caxito et al. (2021).

- **Stop 3** – Storm-dominated black limestone of the Lagoa do Jacaré Formation at the GMD Quarry (lat -19.251488°, long -44.389765°).

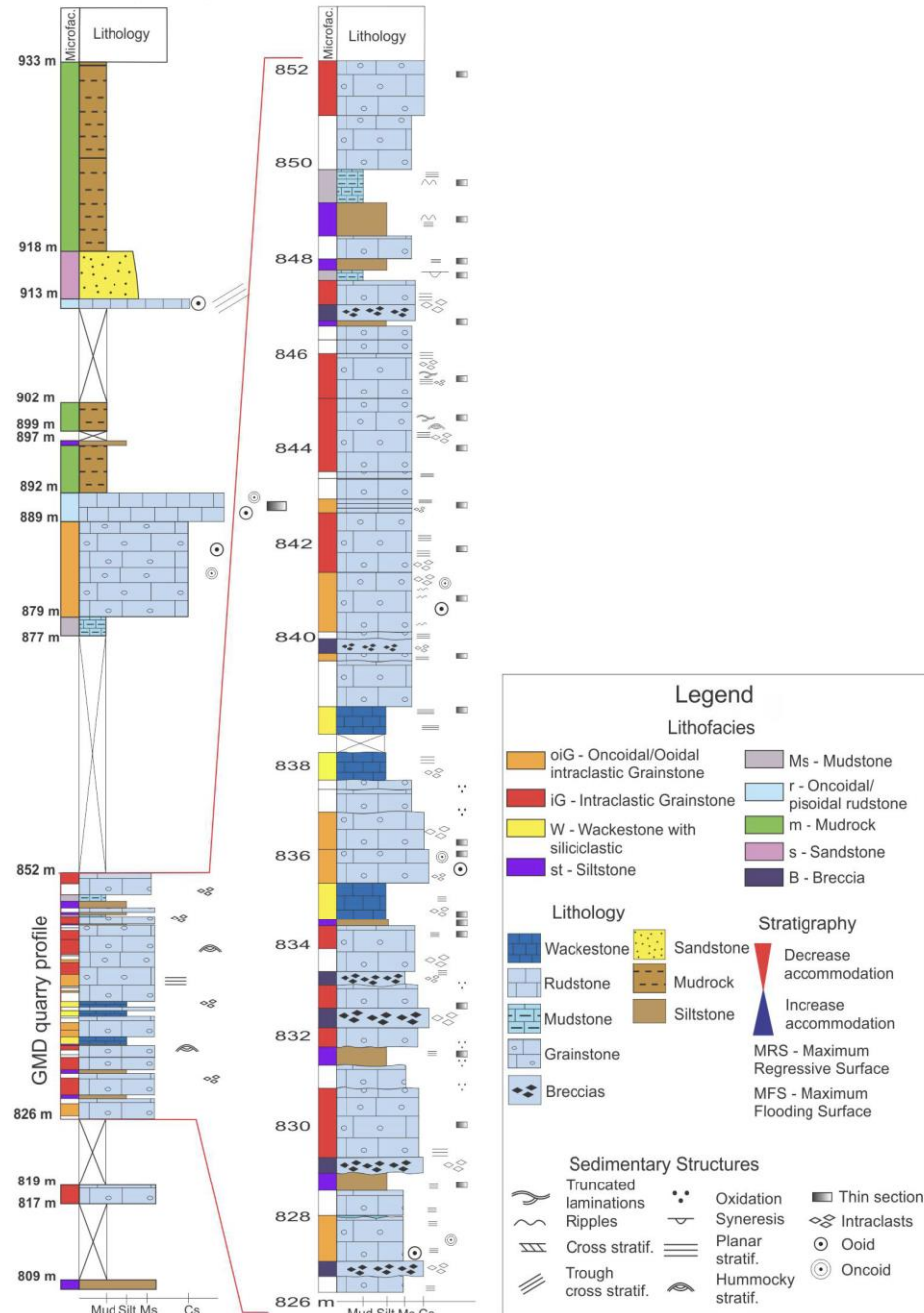
This quarry has been studied in detail by Freitas et al. (2021) and Dantas et al. (2022). The authors describe nine lithofacies showing distal tempestites grading upwards to a shallower, oncoidal/ooidal carbonate marine environment, then to basinal shales. This succession comprises a low-order transgressive hemicycle, recording the transition from a storm-influenced carbonate ramp to a siliciclastic-dominated platform. Chemostratigraphic data yielded  $\delta^{13}\text{C}$  values ranging between +11.11‰ and +13.94‰, within the MIBE interval.



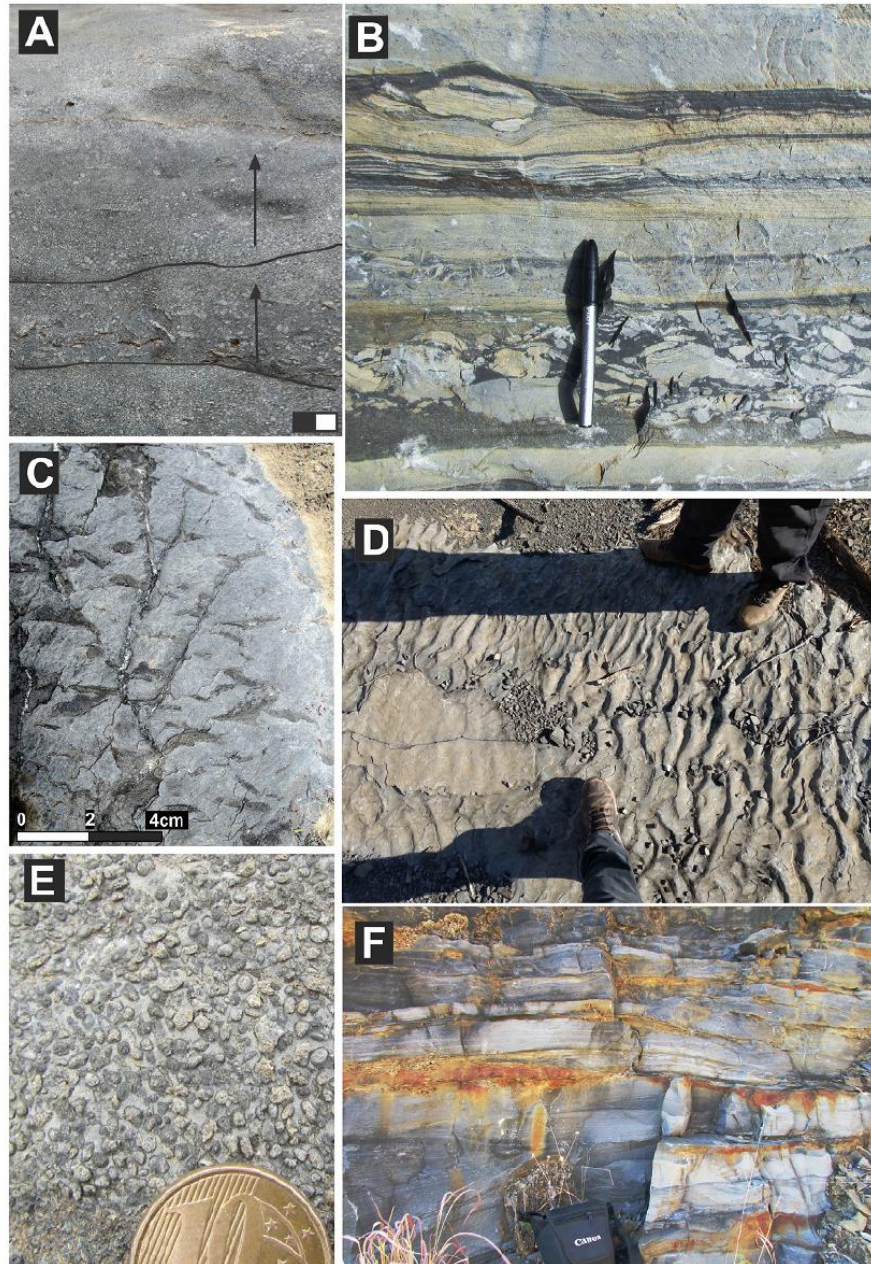
**Figure 14** - Lagoa do Jacaré Formation at GMD Quarry.



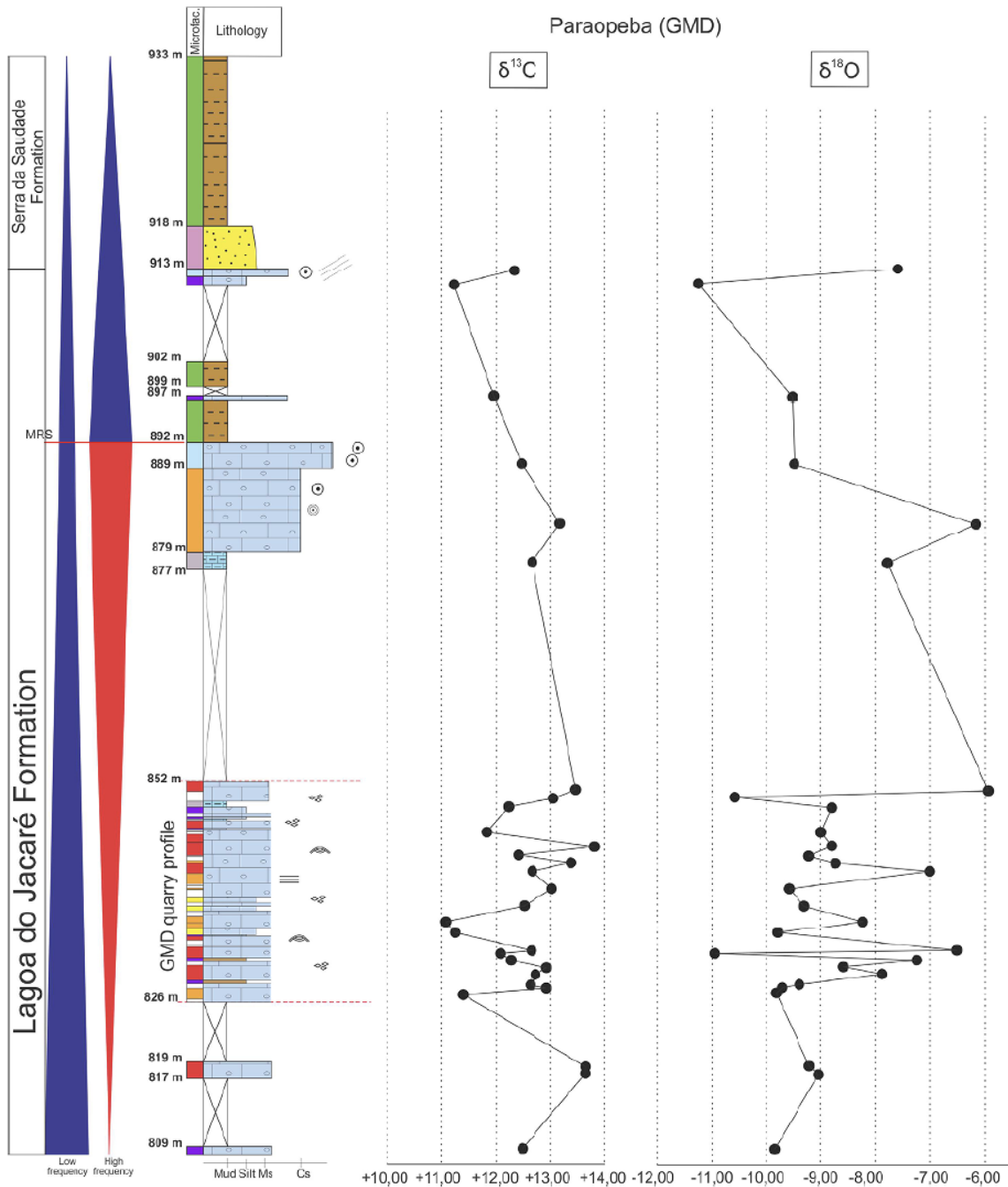
COMPLETE VERTICAL PROFILE



**Figure 15** - Columnar sections of the GMD quarry and its surroundings presenting the main sedimentary structures, lithologies and lithofacies interpreted. From Dantas et al. (2022).



**Figure 16** - Main lithofacies and their sedimentary structures in the GMD quarry, from Dantas et al. (2022). (A) Detail of oncolitic/ooidal intraclastic grainstone with erosive contacts and graded beds. (B) Non-oriented, normally graded breccias grading up to fine to medium grainstones and siltstones. (C) Syneresis cracks in wackestone. (D) Current ripples in fine to medium grainstone. (E) Detail of oncolitic-pisoidal rudstone. (F) Coarse grainstone with hummocky cross-stratification.



**Figure 17** - Interpreted composite vertical profile of the GMD quarry and surroundings in Paraopeba area. From Dantas et al. (2022)

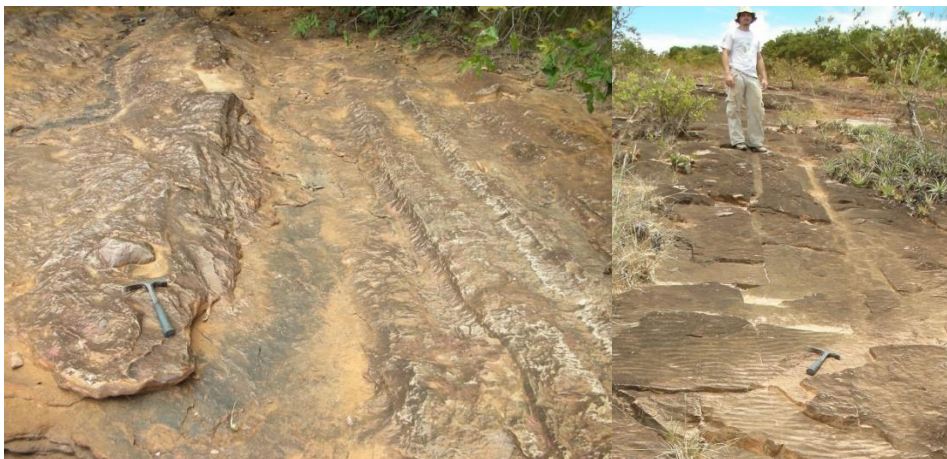
- Accommodation and dinner in the city of Montes Claros.

### Day 3: The complete Bambuí Group section (Part 2)

- Drive from Montes Claros to Jequitaiá (~100 km) and to Januária (~250 km) with stops along the BR-365 and BR-135 roads;
- **Stop 4** – Soft-sediment striated pavement over unconsolidated Cryogenian sand-rich rocks (lat -17.297222°, long -44.390839°).

On the northeastern flank of the Água Fria range, 10 km southeast of Jequitaiá, Isotta et al. (1969) described beautifully preserved striated pavements in quartzites underlying a diamictite of the Jequitaiá Formation. East-west trending striae vary from fine, V-shaped thin scratches to U-shaped grooves up to 20 cm wide x 5 cm deep, bearing crescent-shaped cracks that consistently indicate a roughly eastward ice flow direction. Individual grooves reach up to 18 meters in length with no widening or shallowing at the ends.

Although Isotta et al. (1969) originally interpreted the striae to be formed over an indurated quartzite pavement, Rocha-Campos et al. (1996) re-interpreted the glacial abrasion marks as having been formed over a soft-sediment substratum, in the fluctuating grounding zone of a marine ice sheet, based on evidence that includes internal striae in the U-shaped groove walls that are covered by slumped plow ridges, clasts partially embedded in the basement quartzites, and striae and ripple marks occupying the same bedding plane. These observations imply that the underlying sandstones were still unlithified during glaciation, and hence belong to the basal Jequitaiá Formation and not to the Mesoproterozoic Espinhaço Supergroup, as conventionally interpreted.



**Figure 18** - Striated pavement at Serra da Água Fria, near Jequitaiá (Isotta et al., 1969). U-shaped groove walls covered by slumped plow ridges, clasts partially

embedded in the basement quartzite, and striae and ripple marks occupying the same bedding plane. These observations imply that the underlying sandstone were still unlithified during glaciation, and hence belong to the basal Jeiquitaí Formation and not to the Mesoproterozoic Espinhaço Supergroup (Caxito et al., 2012).

- **Stop 5** – Jeiquitaí Formation diamictite, with striated clasts and other features (lat -17.196072°, long -44.436085°).

The Jeiquitaí Formation diamictites were originally interpreted as continental tillites resting directly above the grooved and striated pavement (Gravenor and Monteiro, 1983; Karfunkel et al., 2002; Karfunkel and Hoppe, 1988). However, (Cukrov et al., 2005; Uhlein et al., 2011, 1999) noted the scarcity of outwash facies deposits around Jeiquitaí, and interpreted the stratified diamictites as glacio-marine deposits. In the observed roadcut, a mudstone that comprises the diamictite matrix predominates at the base of the outcrop, being superseded by mudstone with sparse outsized clasts, then by a clast-poor diamictite and finally by a clast-rich diamictite at the top of the section. Clasts include a multitude of carbonatic rocks, granite, gneiss, quartzite, and many other rock types with varying size and shape. Locally, triangular shapes and striated clasts can be observed.



**Figure 19** - Striated clast within the Jeiquitaí Formation end-Cryogenian diamictite.

- **Stop 6** - Jequitáí Formation diamictite with esker channels filled by sand (lat -17.055464°, long -44.330191°).

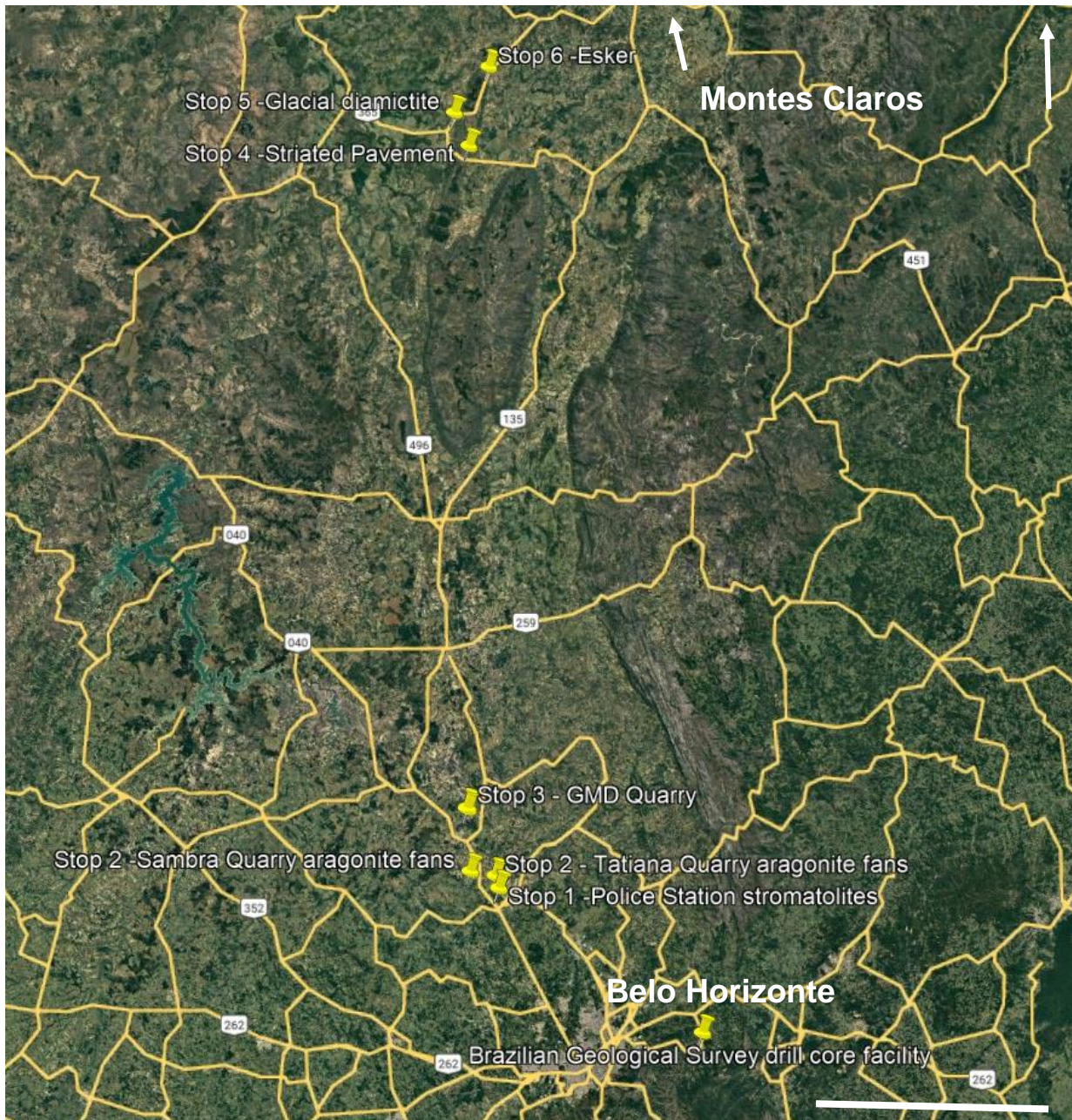
Major sandstone lenses within the diamictites were previously interpreted as eskers (Karfunkel and Hoppe, 1988), as ice-thrust features (Gravenor and Monteiro, 1983) or as submarine channel fills. The pinch-and-swell structures observed in some of those lenses make the former interpretation of channels formed by meltwater cutting through soft diamicton preferable. We will observe one of the most prominent of those features, a fish-shaped lens some meters thick in a BR-365 roadcut between Jequitáí and Montes Claros.



**Figure 20** - Fish-shaped sandstone channel within the glacial diamictite of the Jequitáí Formation, interpreted as a paleoesker.

- Accommodation and dinner in the town of Januária.

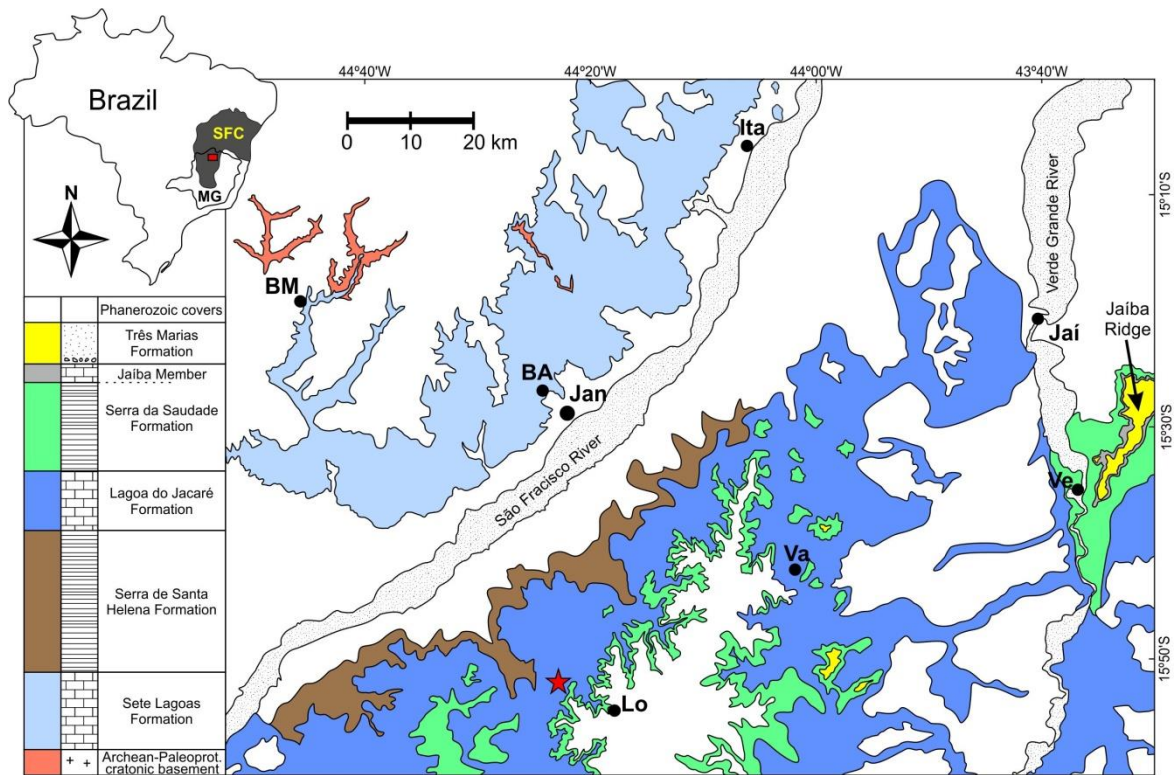
## THE SOUTHERN OUTCROP AREA OF THE NEOPROTEROZOIC BAMBUÍ GROUP IN MINAS GERAIS STATE, BRAZIL - ROAD MAP



Scale bar = 100km

## THE NORTHERN OUTCROP AREA OF THE NEOPROTEROZOIC BAMBUÍ GROUP IN MINAS GERAIS STATE, BRAZIL (JANUÁRIA BASEMENT HIGH)

### Geologic aspects of the Bambuí Group in Januária area (Northern Minas Gerais State, Brazil)



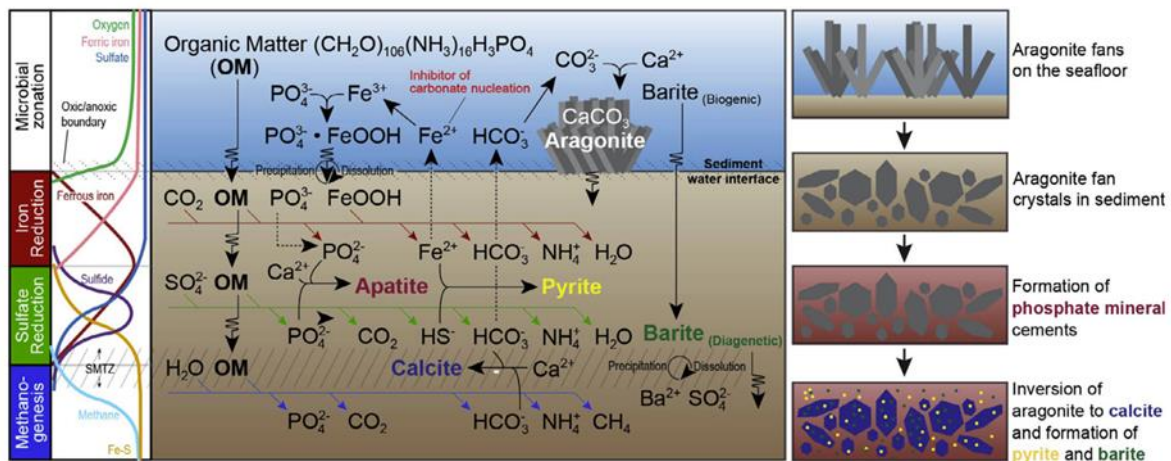
**Figure 21** – The Bambuí group in the Januária area. Figure from Uhlein et al., 2019.

In the Januária vicinities, the lowermost Bambuí Group is composed of the Sete Lagoas Formation that corresponds to the post-glacial, early Ediacaran deposits of pink dolostone and limestone that bear characteristics of a post-Marinoan cap carbonate interval such as: (1) a basal pink cap dolostone with negative  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values that decrease up section (Caxito et al., 2012); (2) an overlying transgressive carbonate interval with aragonite pseudomorphs and locally barite fans.

From detailed petrography using SEM and WDS elemental maps, Okubo et al. (2018) identified a sedimentary model for aragonite crystal fan formation and



phosphogenesis in the cap carbonate interval (Figure 9). Just like aragonite pseudomorphs, barite fans are ubiquitous in the first meters of the Sete Lagoas Formation in the Januária area. Crockford et al. (2017) analyzed the cm-thick barite layers for triple oxygen and sulfur isotopes and identified a strong negative  $\Delta^{17}\text{O}$  anomaly down to  $-1.05\text{‰}$ . The authors suggest a global character for this geochemical signal used to cross-correlate Marinoan post-glacial cap carbonates around the world (with examples in China, Mauritania, Canada, Australia and now, Norway and Brazil). Recently, this interpretation came into dispute with data of fluid inclusions from Okubo et al (2020) and the suggestion of a hydrothermal origin for these minerals.



**Figure 22** – Aragonite crystal fan formation and phosphogenesis in the lower Sete Lagoas Formation at the Januária area (Okubo et al., 2018).

Above the typical cap carbonate interval the middle Sete Lagoas Formation is constrained to the terminal Ediacaran due to *Cloudina*-bearing levels and rare *Corumbella* fragments identified on thrombolites and grainstones in Januária and Montalvânia areas, Minas Gerais State, Brazil (Warren et al., 2014; Uhlein et al., 2019), along with detrital zircons as young as ca. 560 Ma (Paula-Santos et al., 2015). This suggest a cryptic discordance between the post-Marinoan cap carbonate and the overlying succession containing *Cloudina* remnants and Ediacaran detrital zircons and in this area, although field evidence is still lacking to confirm such time gap.

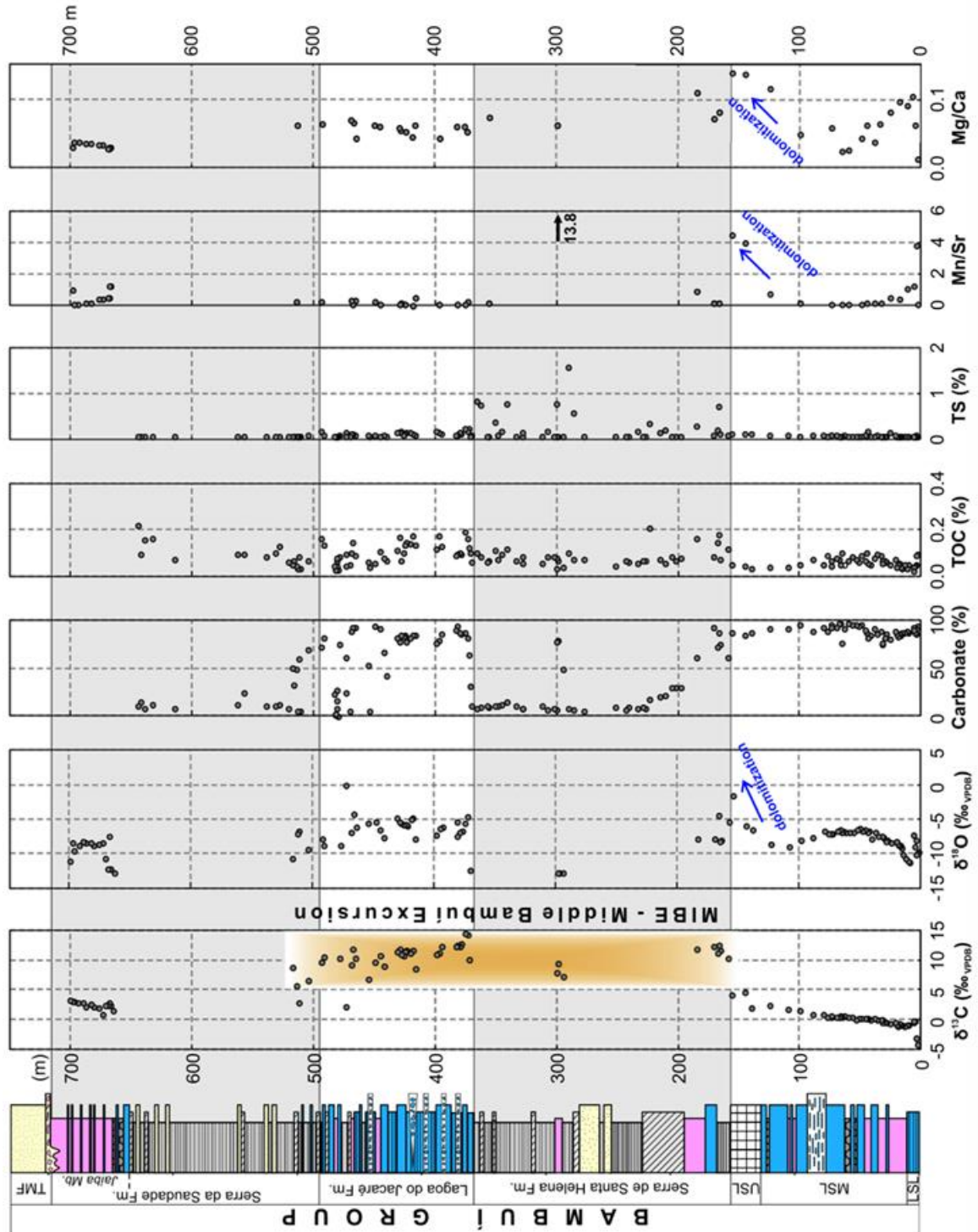
Above, the Serra de Santa Helena, Lagoa do Jacaré and Serra da Saudade formations are all terminal Ediacaran to Cambrian in age (Moreira et al., 2020) and make up a siliciclastic-carbonate mixed deposition. Carbonates from the Serra de Santa Helena and Lagoa do Jacaré formations yield a significant positive  $\delta^{13}\text{C}$



excursion dubbed MIBE (Middle Bamuí Excursion – Uhlein et al., 2019), that can reach values as high as +15‰ and maintain a plateau of heavy carbon isotopes around +10‰ until the base of the Serra da Saudade Formation (~300 m-thick of high  $\delta^{13}\text{C}$  values, Figure 10). The MIBE interval possesses low TOC, Mn/Sr and Mg/Ca ratios. It also shows invariant  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios around 0.7075, something unusual for terminal Ediacaran carbonates and which is tentatively explained by a phase of water mass restriction (Paula-Santos et al., 2017; Uhlein et al., 2017, 2019).

The Serra da Saudade Formation bears greenish, glauconite-rich siltstone, phosphatic rhythmite and limestone especially in the west-central basin, where a tuff bed was recently dated by U-Pb method at ca. 520 Ma (Moreira et al., 2020). This new data define that the upper Bamuí is Cambrian in age and that the Ediacaran-Cambrian boundary must be positioned somewhere between the middle Sete Lagoas Formation (*Cloudina*-bearing beds) and the upper Serra da Saudade Formation (Cambrian tuff). In the Januária area, the Serra da Saudade Formation holds shale, sandstone, grainstone and microbialites and is partially eroded by Cretaceous sandstone (Uhleim et al., 2019).

Finally, the Bamuí Group culminates in cross-bedded sandstone and shale of the Cambrian Três Marias Formation that represent a progradation of fluvial to shallow-marine deposits over the former marine succession (Uhleim et al., 2019).



**Figure 23** – Chemostratigraphic data of the Bambuí Group in the Januária area (Uhlein et al., 2019).

## OBJECTIVES

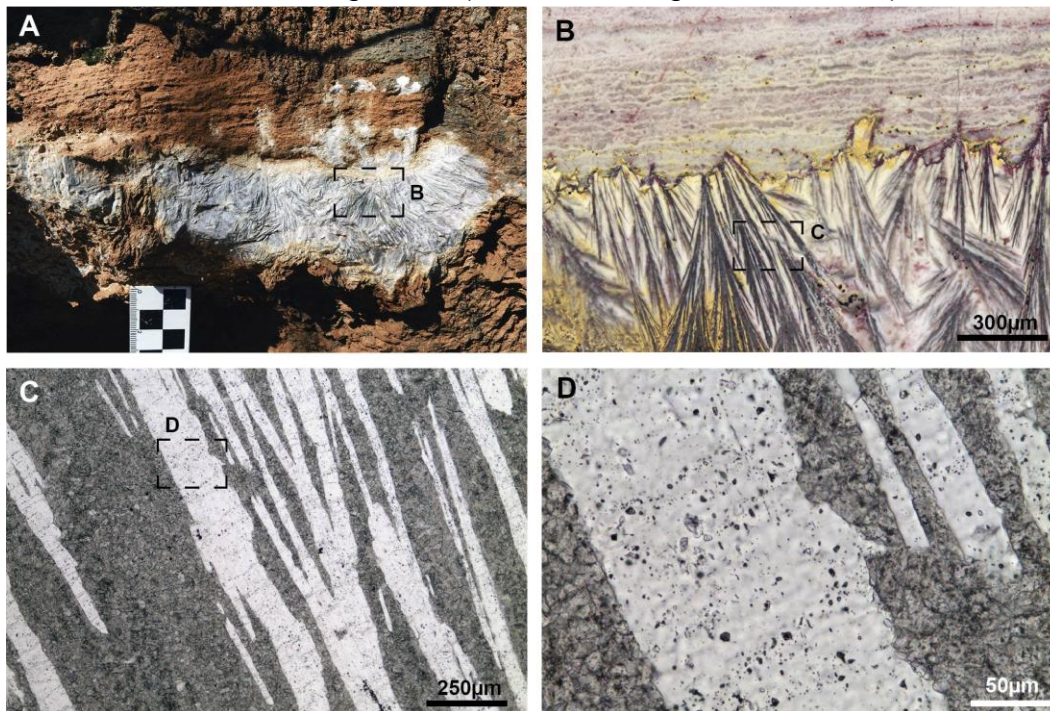
Visit the Bambuí Group in northern Brazil (central São Francisco craton) including cap carbonate outcrops, microbialites and *Cloudina*-bearing expositions.

## PLANNED ITINERARY

**Guides:** Lucas Warren (UNESP) and Fabrício Caxito (UFMG)

### Day 4: Sete Lagoas Formation – Riacho da Cruz and Sapé sections.

- **Stop 7** - Riacho da Cruz section [UTM-E0568556/S8307779]: Paleoproterozoic basement rocks below post-Marinoan cap dolostone interval with void-filling barite (lower Sete Lagoas Formation);

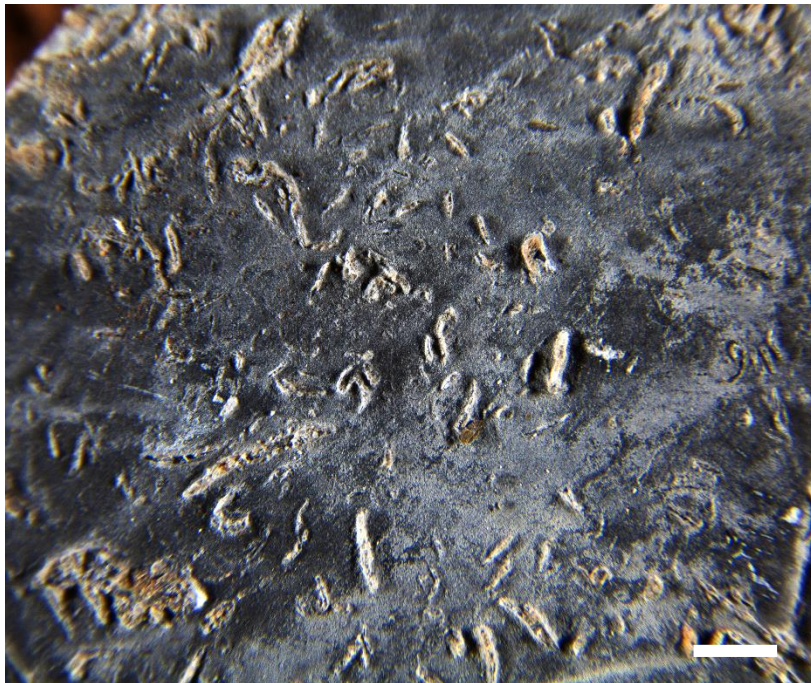


**Figure 24** - Mesoscopic and microscopic features of the barite layer. A) Void-filling barite in the outcrop, commonly forming rosettes, growing inward from both the top and bottom of the vug. B) Dolomitic matrix (top) and radiating bladed barite crystals (bottom). C) Secondary (?) fluid inclusion trails perpendicular to growth direction of barite crystals. Plane polarized light microscopy (PPL). D) Enlarged view of (C), showing trails of intergranular and intragranular secondary (?) fluid inclusions perpendicular to the growth direction of barite crystals. (Okubo et al., 2020).

- **Stop 8** - Sapé section [UTM-E0563157/S8313286]: Laminated microbialites, thrombolites, grainstone, *chert* and *Cloudina* bearing carbonates from the middle Sete Lagoas Formation;



**Figure 25** – Laminated microbialites and thrombolites (Sapé Section).

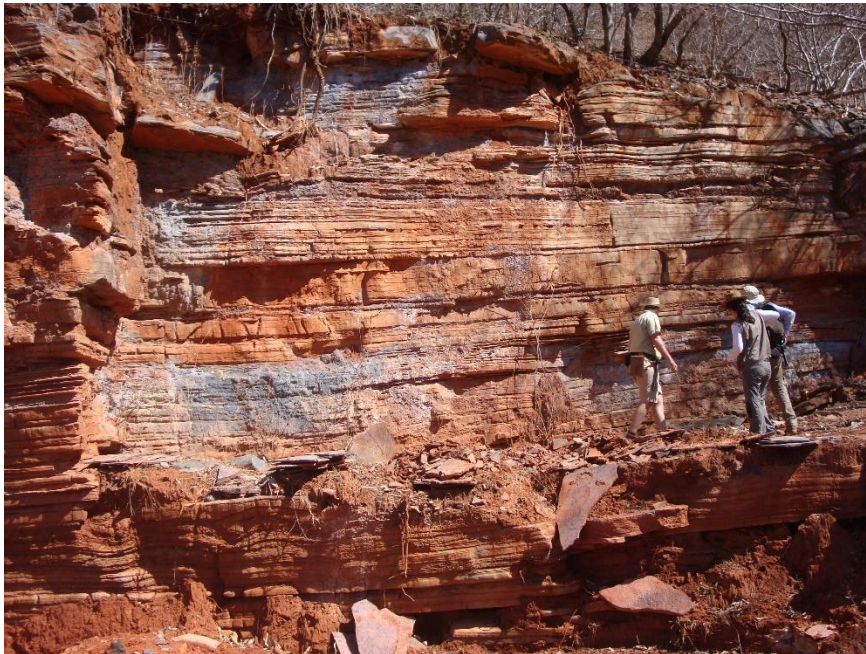


**Figure 26** – Poorly-preserved *Cloudina* fragments in mudstone facies. Scale bar is 1cm length.

- **Stop 9** - Barreiro quarry [UTM-E0560936/S8290370]: Very well exposed carbonate facies deposited in shallow platform context. Distinct types of microbialites, *Cloudina* bearing rocks and rip-up breccias (middle Sete Lagoas Formation);



**Figure 27** – View of the Barreiro section in the vicinities of the Januária town.

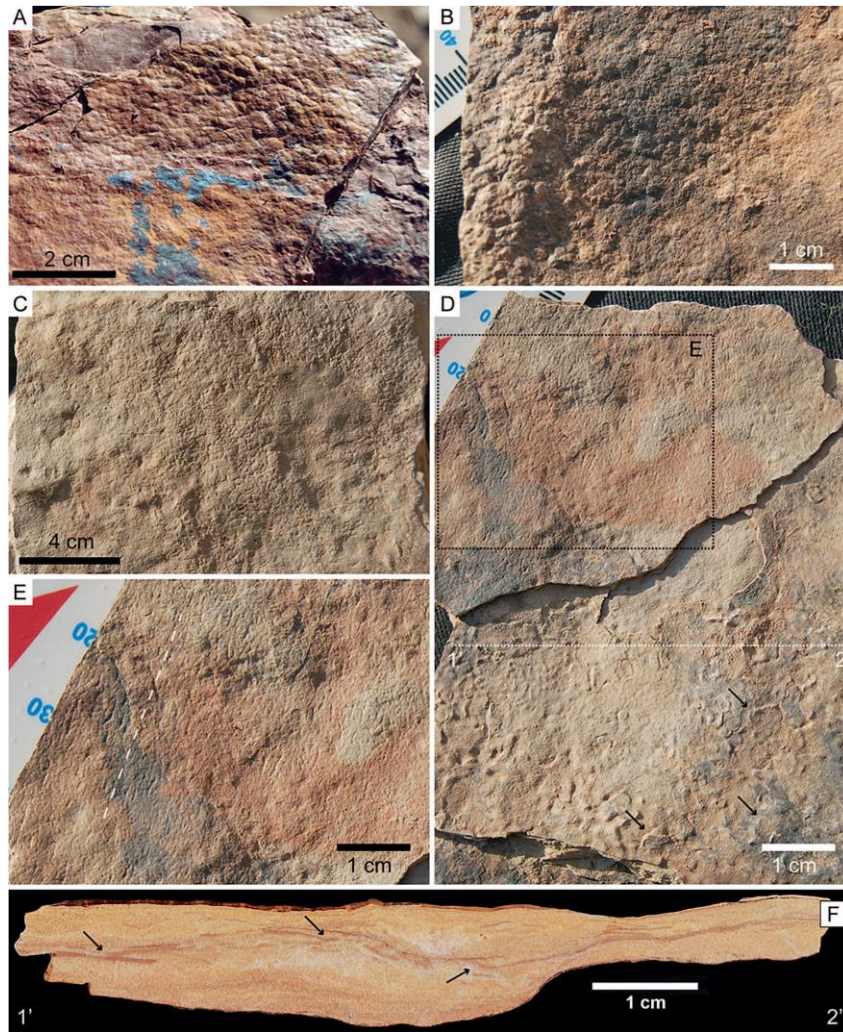


**Figure 28** – Rippled fine-grained grainstone interbedded with microbial facies in the Barreiro Section.

- Dinner in Januária and free time for leisure.

**Day 5: Serra de Santa Helena, Lagoa do Jacaré and Serra da Saudade formations in Januária-Lontra section (5 selected outcrops along the BR-135 road).**

- **Stop 10** - Sandstone and shale with MISS, mudcracks and small (< 1 cm) supposed trace fossils of the Serra de Santa Helena Formation (UTM E0565471/S8262548);



**Figure 29** - Wrinkles in siliciclastic facies of the Serra de Santa Helena Formation. A–C) ‘Elephant-skin’ texture in siltstone (A) and fine-grained sandstone (B, C). D) Millimetric ridges and grooves preserved in fine-grained sandstone at the Lontra section. Float but probably top bedding surface view. E) Detail of D showing *Arumberia*-like structure. F) Cross-section of D (10–20) showing disrupted laminae (black arrows) of fine-grained sediment overlain by sandstone. (Okubo et al., 2023).

- **Stop 11** - Black limestone reworked by waves and currents of the Lagoa do Jacaré Formation (UTM E0565611/S8261344);



**Figure 30** – Outcrop of the Lagoa do Jacaré Fm. in the Lontras Section.



**Figure 31** – Fine-grained rippled packstone interbedded with black laminated mudstone with syneresis cracks (white arrow).



- **Stop 12** - Rudstone, grainstone and mudstone of the Lagoa do Jacaré Formation (UTM E0566252/S8259169);
- **Stop 13** - Peritidal microbialites and grainstone from the Lagoa do Jacaré Formation (UTM E0570873/S8251026);



**Figure 32** – Plan view of syneresis cracks in black laminated mudstone of the Lagoa do Jacaré Fm.

- **Stop 14** - Siliciclastic-carbonate mixed shelf of the Serra da Saudade Formation (UTM E0572793/S8249276E);
- Visit to a local "alambique" and tasting one of the most appreciated cachaças (sugar cane spirit) in Brazil. Alambiques are places where handmade cachaça is produced using traditional methods that date back hundreds of years ago.



**Figure 33** – Very happy geologist between cachaça barrels in the vicinities of Januária town.

- Dinner in Januária and free time for leisure.

#### **Day 6: Caves, limestone and party**

- **Stop 15** - Visit to Peruaçu National Park (UTM E582123/S8324281). Light trail along one of the largest caves in the world, the “Janelões Cave”, entirely developed in microbialites and peritidal carbonates from the Sete Lagoas Formation. Observations of beautiful outcrops and cave paintings by Paleo-Indians that inhabited the region thousands of years ago;



**Figure 34** – View from the skylight inside the cave of Janelão.

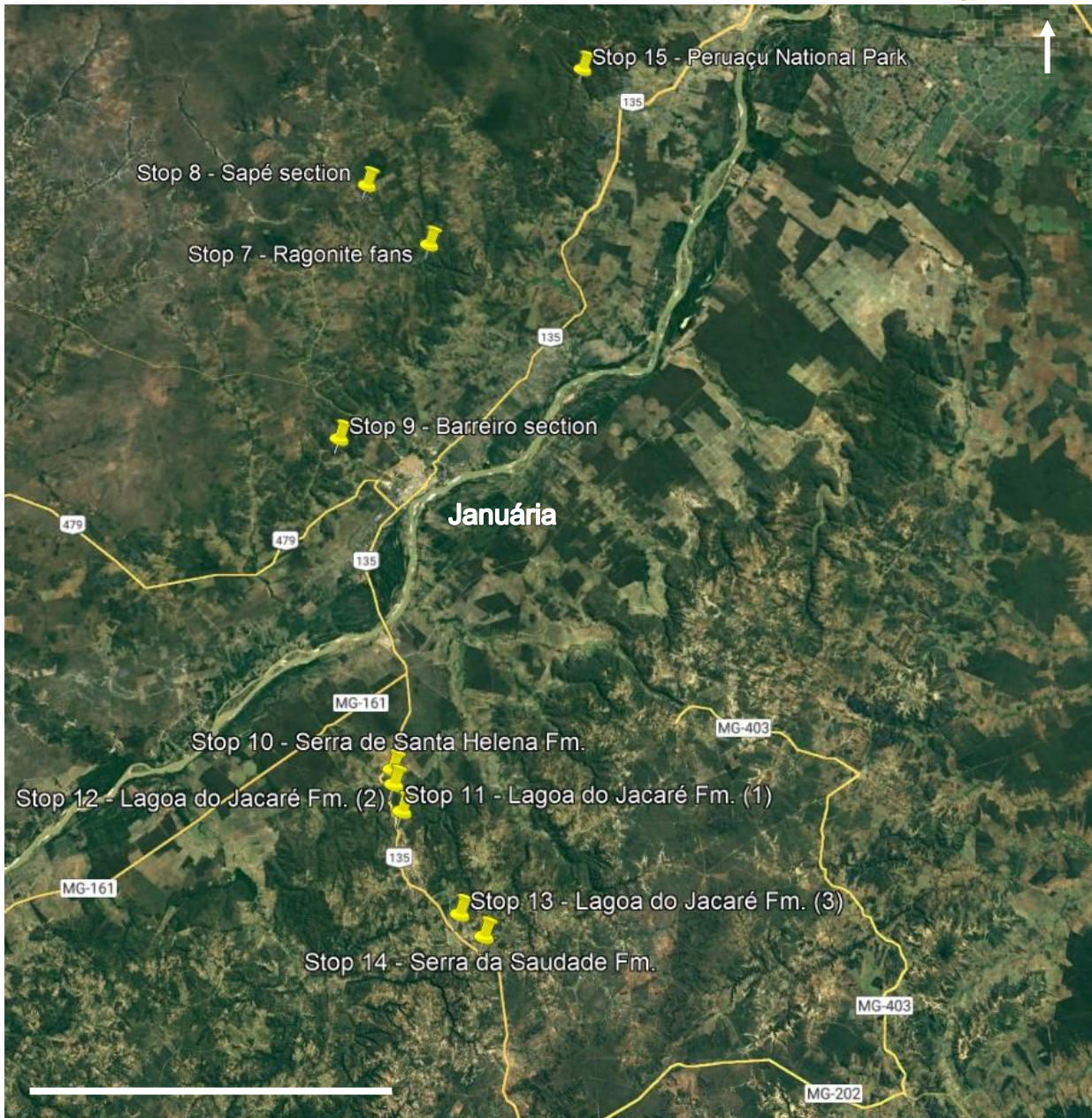


**Figure 35** – A calm river inside the Janelão cave.

- Closing party in Januária – Brazilian typical barbecue.

**Day 7: Return to Belo Horizonte, MG (~588 Km)**

**THE NORTHERN OUTCROP AREA OF THE NEOPROTEROZOIC BAMBUÍ GROUP IN MINAS GERAIS STATE, BRAZIL - ROAD MAP**



Scale bar = 30km

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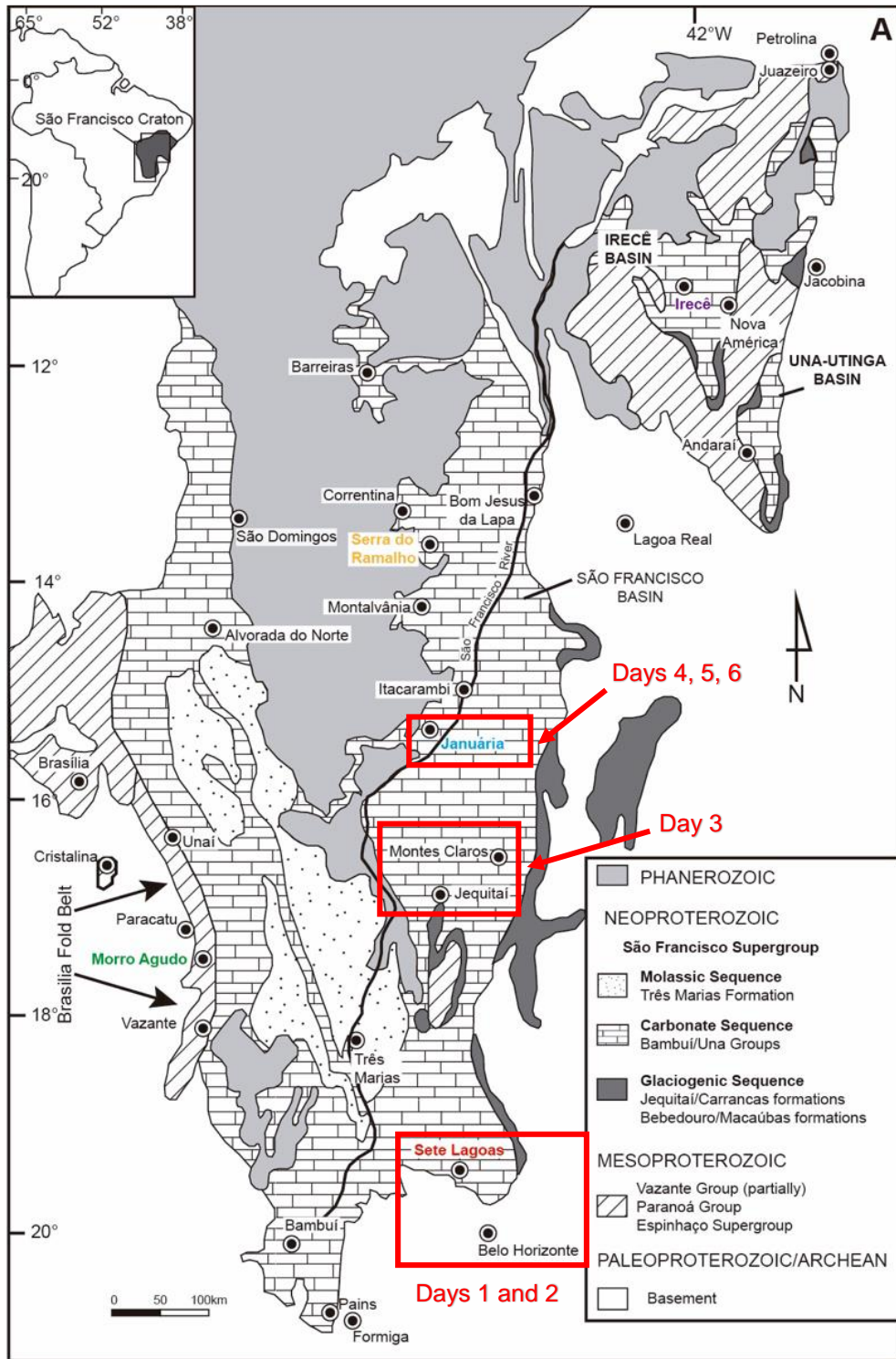
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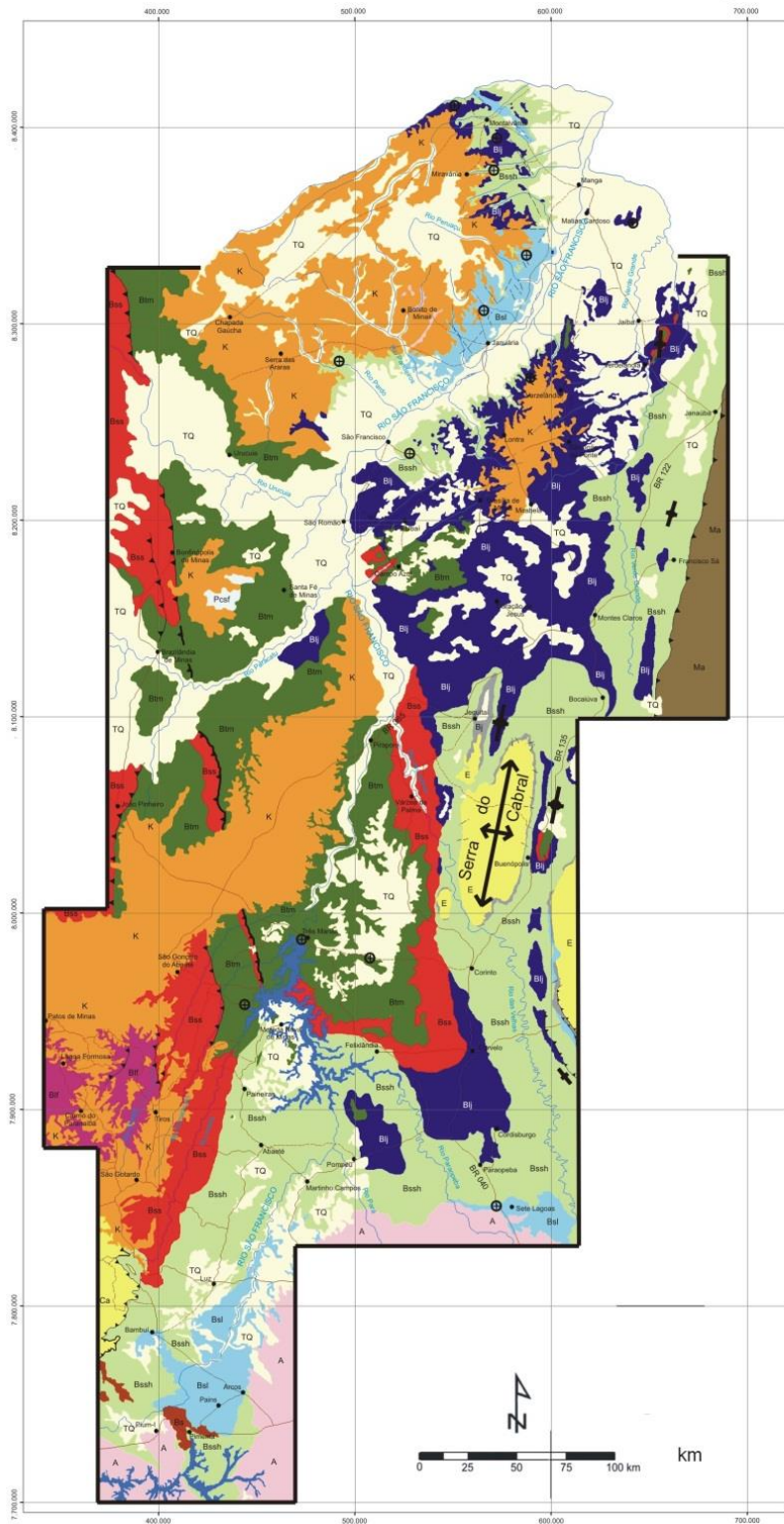


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## SIMPLIFIED GEOLOGIC MAP OF THE STUDY AREA



# GEOLOGICAL MAP OF THE BAMBUÍ GROUP IN MINAS GERAIS STATE

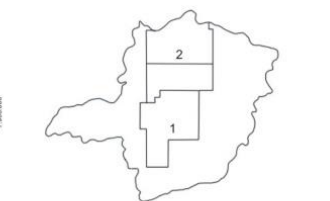


|   |   |   |
|---|---|---|
| FAIBERZOICO   | CENOZOICO   | Terciário - Quaternário - Cretáceo, Paleoceno, Eoceno, Oligoceno, Mioceno e Plioceno                    |
|   | MESOZOICO   | Grupo Araxós, Itambé, Serra da Corda - Araxós, Araxós subalterno, Congonhas, Araxós e Rochas vulcânicas |
|   | PRÉ-CAMBRIANO   | Grupo Santa Fé - Cambriano, Araxós e Itambé   |
| PROTEROZOICO  | <b>GRUPO BAMBUÍ</b>   |   |
|   | Setor Ocidental      Setor Oriental   |   |
|   | Formação Três Marias - Gálvez, arenitos e calcários cinza e verde-escuro                                      |   |
|   | Formação Serra da Saudade - Fósforos, argilas e siltes verdes, calcários subarenosos                          |   |
|   | Unidade Lagoa Formosa - Argilas, siltes, arenitos, calcários e argilitos                                      | Formação Lagoa do Barão - Calcários, siltes, argilitos e argilitos                                      |
|   | Formação Serra de Santa Helena - Siltes cinza a amarelados e tabofofo   |   |
|   | Unidade Santa Helena - Arenitos amarelados, siltes, argilas e argilitos (incluindo a unidade de Santa Helena) | Formação São Leopoldo - Calcários, siltes e argilitos   |
|   | Formação Ingaí - Fósforos, calcários e argilitos  |   |
|   | Grupo Marabá - Arenitos, calcários, quartzitos, xistos  |   |
|   | Paleo / Mesoproterozoico  |   |
| Grupo Canastra - Supergrupos Espinhaço - Quartzitos, xistos, gneiss |   |   |
| ARQUEANO  | Arquariano Indígena - TTG (granitos) e migmatitos tipo "graniteiro" (Serra, SFR)                              |   |

| CONVENÇÕES CARTOGRAFICAS  | SÍMBOLOS ESTRUTURAIS    |
|---------------------------|-------------------------|
| • Cidade                  | ⊖ Acamamento Horizontal |
| — Rodovia Pavimentada     | — Falha                 |
| — Rodovia não Pavimentada | ▲ Falha de Empurrão     |
| — Curso D'água            | + Anticlinal            |
|                           | ⊕ Sinclinal             |

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Escala de Trabalho: 1:1.000.000  
Sistema de Coordenadas:  
South American 1969 UTM Zona 23 S  
Maio / 2007



Localização aproximada do mapa no Estado de Minas Gerais. Os números indicam mapas-base da compilação (fontes de consulta):

- 1 - Lima, O. N. B. 2005. Grupo Bambuí: estratigrafia regional no alto do São Francisco e geologia dos depósitos fosfáticos da Serra da Saudade - MG. Dissertação de Mestrado, UFMG, 142 pg.
- 2 - Martinez, M. I. 2007. Estratigrafia e tectônica do Grupo Bambuí no norte do Estado de Minas Gerais. Dissertação de Mestrado, UFMG, 122 pg.

Apoio



FAPEMIG  
Fundação de Amparo à Pesquisa do Estado de Minas Gerais

(Caxito et al., 2007).



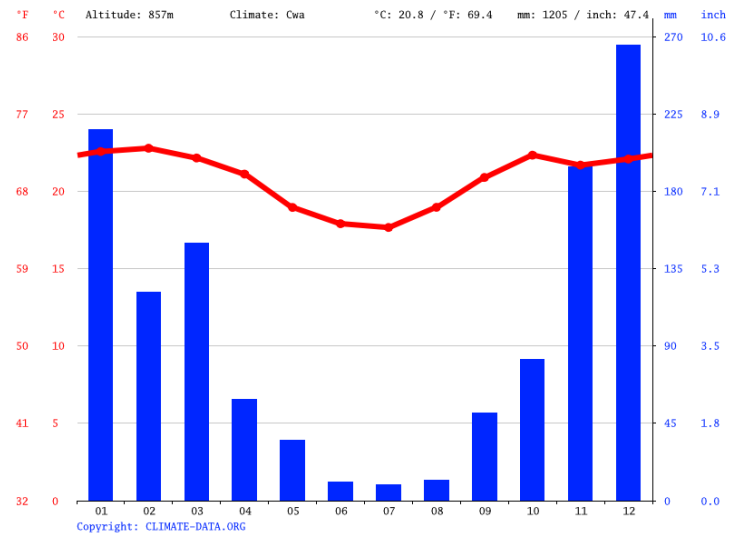
## USEFUL INFORMATIONS

- Brazilian code **+55**
- Citizens of the United States, Australia, Canada, Japan and China need a tourism visa to enter in Brazil;
- During our field activities, any health problem must be reported immediately to the guides so that appropriate measures can be taken;
- Brazilian are very warm and smiling people and love to make jokes. So, don't be afraid if a Brazilian say goodbye with a hug! In rural areas of the country (like the surroundings of Januária town), it is very common for people to invite you to visit their home and give gifts. So don't be alarmed if this happens;
- Avoid drinking tap water, even if it looks drinkable;
- Brazil is a tropical country so the heat in November can be quite high in the areas we will be visiting. Therefore, constant hydration and sunscreen are necessary for any outdoor activity;
- The urban areas that we will visit are relatively safe; however, Belo Horizonte is the capital of the state of Minas Gerais and has the same problems like a large city in the world. Basic care is advised, such as always leaving with a document (VISA) and avoiding remote locations or places far from the hotels where we will be staying;
- Avoid eating in street places like food-trucks or similar. In general, the food is healthy, but since we'll be traveling, it's always good to avoid problems;
- Food in Brazil can be very spicy. It is suggested to ask before eating something that might contain pepper.

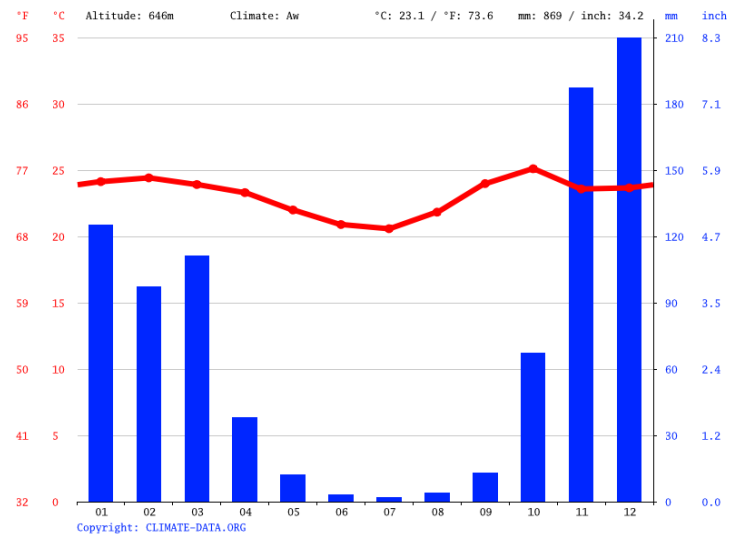
## Useful phone numbers

- Lucas Warren cel. phone – (11) 99199-5672
- Fabricio Caxito cel. phone – (31) 98852-9993
- Eddie (touristic guide) cel. phone. – (11) 97250-4549

- Military police – 190
- Fire Department – 193
- Federal Road Police - 198
- Emergency medical care – 192
- USA embassy – (61) 3312-7000
- China embassy – (61) 2195-8200
- Canada embassy – (61) 3424-5400



**Figure 36** – Belo Horizonte climatogram (year).



**Figure 37** – Montes Claros climatogram (year).



# International Commission on Stratigraphy Subcommission on Cryogenian Stratigraphy

ANNUAL REPORT 2023

## 1. TITLE OF CONSTITUENT BODY

### **Subcommission on Cryogenian Stratigraphy**

*Submitted by:*

Maoyan Zhu, Chair

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Carol Dehler, Vice-Chair

Department of Geology, Utah State University, USA; Carol.Dehler@usu.edu

Ying Zhou, Secretary

Department of Earth Sciences, University College London, UK; y-zhou@ucl.ac.uk

## 2. OVERALL OBJECTIVES, AND FIT WITHIN IUGS SCIENCE POLICY

### **Mission statement**

The Subcommission is the primary body for facilitation of international communication and scientific cooperation in Cryogenian stratigraphy directed at better understanding Earth system evolution during the Cryogenian Period (c.720 – c.635 Ma). Its priority is the unambiguous definition, by means of global stratotype section and points (GSSP), of a hierarchy of chronostratigraphic units that provide the framework for correlation of Cryogenian strata.

### **Goals**

The main goals of this Subcommission are:

- To establish for the first time a rock-based GSSP for the base of the Cryogenian that will also serve as the top of the underlying Tonian.
- To identify criteria useful in the subdivision and correlation of Cryogenian (and upper Tonian) strata.
- To define the basal boundaries of Cryogenian epochs (series) and ages (stages) through the establishment of GSSPs.
- To facilitate international collaboration in research on Cryogenian stratigraphy and Earth history through subcommission sponsored field trips, workshops, and meetings.

In addition, the Subcommission is committed to expanding communication to a wider public through grassroots initiatives to conserve important Neoproterozoic geological sites, to support International Geoscience Programme projects, and to encourage the wider dissemination of research findings on the internet, in popular science publications, and through public lectures.

### **Fit within IUGS Science Policy**

The objectives of the Subcommittee relate to three main aspects of IUGS policy:

- The development of an internationally agreed scale of chronostratigraphic units, fully defined by GSSPs where appropriate (Series and Stages), and related to a hierarchy of units (Standard Zones, Subzones etc.) to maximize relative time resolution within the Cryogenian Period;
- The establishment of frameworks and systems to encourage international collaboration in understanding the evolution of the Earth during the middle Neoproterozoic (*c.*850-*c.*635 *Ma*), in cooperation with the Precambrian and Ediacaran subcommissions.
- Working towards an international policy concerning conservation of geologically and paleontologically important sites such as GSSPs and important fossil localities. This relates to, *inter alia*, the IUGS Geosites Programme.

### **3. ORGANISATION - interface with other international projects / groups**

Members of the Cryogenian Subcommittee are lead investigators and officers in a number of related international projects, including:

- IGCP 648 (*Supercontinent Cycles and Global Dynamics*).
- ICDP project GRIND ECT (*Geological Research through Integrated Neoproterozoic Drilling (GRIND): The Ediacaran-Cambrian Transition (ECT)*).

#### **3a. Current Officers:**

- **Chair:** Maoyan Zhu, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, China
- **Vice-Chair:** Carol Dehler, Utah State University, USA
- **Secretary and webmaster:** Ying Zhou, University College London, UK

### **4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS**

None

### **5. CHIEF ACCOMPLISHMENTS IN 2023 (including any relevant publications arising from ICS working groups)**

- **Business meeting and a session in STRATI 2023, Lille (July):** resulted in updated version of criteria for Tonian/Cryogenian boundary and action plan for the joint Ediacaran and Cryogenian Subcommissions fieldtrip to Brazil.
- **Field excursion to Scotland (July):** 6 voting members and 6 corresponding members joined the fieldtrip which resulted in documents “field guide to the proposed Cryogenian boundary section” :

I.J. Fairchild, A.M. Spencer, N. Rees-Doherty, D. Webster et al. Chapter 7: Stratigraphy below the Port Askaig Formation (in preparation)

- **Field excursion to Central Brazil sponsored jointly with Ediacaran subcommission (November 20-26):** led by Lucas Warren and Fabricio Caxito, 5 voting members and 3 corresponding members of the Cryogenian subcommission joined. Visits to outcrops of possible Cryogenian/Ediacaran transition of the Bambui Group and discussions among members of two subcommission. Resulted in documents:

Lucas Warren and Fabricio Caxito, 2023, Field guide of Joint International Subcommission on Ediacaran and Cryogenian Stratigraphy Field Trip to Brazil.

- **A book by voting member Graham Shields on the Cryogenian was published:**

*Born of Ice and Fire -- How Glaciers and Volcanoes (with a Pinch of Salt) Drove Animal Evolution.* Yale University Press. 2023.

## 6. SUMMARY OF EXPENDITURE IN 2023

- The subcommission co-convened the Cryogenian session for STRATI at Lille and held a subcommission meeting during STRATI. Financial support of two voting members' participation to STRATI: £784 each, £1568 in total; ~1950 USD.
- A two-day international fieldtrip of 12 people to Scotland, looking at some sections with key transitional units after STRATI. Financial support to the fieldtrip including travel organisation, involving voting members and correspondent members, including early career researchers into the trip (financial support for 6 people): £3462 spending in total (~4305 USD).
- A joint inter fieldtrip to Brazil on Ediacaran and Cryogenian Stratigraphy in November. 4 people from Cryogenian subcommission will join. Financial support for this fieldtrip is: £1761.76 (USD 2180) + £1159.34 (USD 1441.6) + £500 (USD621.7)

Total spending in 2023 for subcommission is: **£ 8342.12**

## 7. SUMMARY OF INCOME IN 2023

**\$4500** from the IUGS, which was transferred from the treasurer (Durham University, UK) to Ying Zhou (Secretary of Cryogenian subcommission).

The fund was then transferred in GBP, **£3449.86.**

## 8. BUDGET REQUESTED FROM ICS IN 2024

The subcommission financially helped multiple fieldtrips and the STRATI, and they are the first and postponed trips since COVID19 outbreak. A big proportion of the fund granted by IUGS previously have been used for the mentioned trips. The fund can be carried forward will be £80



and USD. Existing funds will be used to support field trips planned for 2024. The subcommission plans to join the IUGS meeting during 2024 to early 2025 and have one major international fieldtrip around that time:

- A joint international fieldtrip on Ediacaran and Cryogenian Stratigraphy in Namibia, early June 2024.
- Supporting members to join the 37<sup>th</sup> International Geological Congress in Bosan, Republic of Korea and hold a subcommission meeting there, August 2024;
- A joint international fieldtrip on Ediacaran and Cryogenian Stratigraphy in South China, early September 2024.

Detailed plan please see the budget plan table and session 9. In total, for the field trip to South China and supporting members joining IGC, we will need  $3750+2000+3750+200 = \$9,700$ . The fund we can carry over is \$4,100, so we apply another \$5,600.

**Planned Expenditures and meetings for 2024: \$9700**

| Purpose of expenditure | Planned time | Sum (USD) | Items  | Expenditure (USD) |
|------------------------|--------------|-----------|--|-------------------|
| Namibia fieldtrip      | June, 2024   | 3750      | support (~\$1250 each) up to 3 voting members participants/core team's travel and accommodation of the fieldtrip     | 3750              |
| IGC, Bosan             | Aug, 2024    | 2000      | support (~\$1000 each) up to 2 participants/core team's travel and accommodation to attend the IGC congress in Bosan | 2000              |
| South China field trip | Sept, 2024   | 3750      | support (~\$1250 each) up to 3 voting members participants/core team's travel and accommodation of the fieldtrip     | 3750              |
| others                 |              | 200       | bank transfer fees   | 200               |

**9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR (2024):**

- Working on and voting for criteria to define **the base of the Cryogenian System** before March 2024. **A white paper to propose three-fold subdivision of the Cryogenian System** is planned to be submitted to ICS and published in *Episodes*.
- Field trip to Namibia **jointly sponsored by Cryogenian and Ediacaran subcommissions**, led by voting members Galen Halverson and Marc Laflamme, possibly during June, 2024. The ca. 10 days excursion will aim to examine classic Tonian-Ediacaran successions in northern Namibia, as well key sections in southern Namibia.
- **South China field trip jointly sponsored by Cryogenian and Ediacaran subcommissions**, led by voting members Maoyan Zhu and his colleagues. A 6 days field trip after 37<sup>th</sup> ICS to look at sections covers critical intervals during the Tonian, Cryogenian and Ediacaran periods in the western Hubei, South China.
- **Cryogenian Webinar Series.** During 2020 and 2021, the webinar series are proven to be a great way to introduce the up-to-date research of the Tonian/Cryogenian records worldwide, and offer good opportunities for discussion among researchers. Each time, we have up to 50 attenders. The subcommission decides to reactivate the webinar series during 2024, and aim to cover another 2 key Cryogenian groups. The webinar series will be organized by Ying Zhou.

**10. KEY OBJECTIVES AND WORK PLAN FOR THE PERIOD 2020-2024**

- Voting for criteria to define the base of the Cryogenian System (Early 2024)
- Call for proposals for basal Cryogenian GSSP candidates (later 2024).
- Voting and ratification of basal Cryogenian GSSP (2024).
- Establishment of working groups on Cryogenian subdivision (2024)
- Voting and ratification of Cryogenian series (2024-2025).
- Interface with other international projects / groups.
- Field trips planned: (1) Utavi, Namibia field trip, early to mid June, 2024 (organised by Galen Halverson and Marc Laflamme); (2) South China field trip, 2024 (organized by Maoyan Zhu); (2)Tonian Urals field trip, 2025 (organized by Anton Kuznetsov);

## **REFERENCES**

To be updated in the subcommission homepage: <http://cryogenian.stratigraphy.org/>

## APPENDIX I

The Subcommittee is organized by an Executive consisting of Chair, Vice-Chair and Secretary, who are all Voting Members of the Subcommittee. There are currently 18 other Voting Members, making a total of 21 voting members. There are also additional corresponding members ([cryogenian-subcommission@googlegroups.com](mailto:cryogenian-subcommission@googlegroups.com)).

### Current Officers

- 1) Chair: Maoyan Zhu, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, China; [myzhu@nigpas.ac.cn](mailto:myzhu@nigpas.ac.cn)
- 2) Vice-Chair: Carol Dehler, Department of Geology, Utah State University, USA; [Carol.Dehler@usu.edu](mailto:Carol.Dehler@usu.edu)
- 3) Secretary: Ying Zhou, Department of Earth Science, University College London, UK; [y-zhou@ucl.ac.uk](mailto:y-zhou@ucl.ac.uk)

### List of Voting Members

- 4) Fabricio Caxito, Federal University of Minas Gerais, Brazil. [facaxito@yahoo.com.br](mailto:facaxito@yahoo.com.br)
- 5) Ian Fairchild, School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK; [i.j.fairchild@bham.ac.uk](mailto:i.j.fairchild@bham.ac.uk)
- 6) Hartwig Frimmel, Institut für Geographie und Geologie, University of Würzburg, Am Hubland, 97074 Würzburg, Germany; [hartwig.frimmel@uni-wuerzburg.de](mailto:hartwig.frimmel@uni-wuerzburg.de)
- 7) Galen Halverson, Dept. of Earth & Planetary Sciences, McGill University, 3450 University Street, Montreal, Quebec, H3A 2A7 Canada; [galen.halverson@mcgill.ca](mailto:galen.halverson@mcgill.ca)
- 8) Karl-Heinz Hoffmann, Geological Survey, Private Bag 13297, Windhoek, Namibia; [mkh.hoffmann@iway.na](mailto:mkh.hoffmann@iway.na)
- 9) Anton Kuznetsov, Institute of Precambrian Geology and Geochronology, Russian Academy of Sciences (RAS), nab. Makarova, 2, St. Petersburg, 199034 Russia; [antonbor9@mail.ru](mailto:antonbor9@mail.ru)
- 10) Marc Laflamme, University of Toronto Mississauga, 3359 Mississauga Road, Mississauga, ON, L5L 1C6, Canada. [marc.laflamme@utoronto.ca](mailto:marc.laflamme@utoronto.ca)
- 11) Konstantin Nagovitsin, TIPGG, Russian Academy of Sciences, Novosibirsk, Russia; [nagovicinKE@ipgg.sbras.ru](mailto:nagovicinKE@ipgg.sbras.ru)
- 12) Susannah Porter, Department of Earth Science, University of California at Santa Barbara, CA 93106, USA; [porter@geol.ucsb.edu](mailto:porter@geol.ucsb.edu)
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- 14) Leigh Anne Riedman, University of California, Santa Barbara, USA; [lriedman@ucsb.edu](mailto:lriedman@ucsb.edu)
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- 18) Nicholas L. Swanson-Hysell, Earth and Planetary Science Department, University of California, Berkeley, California 94720, USA; [swanson-hysell@berkeley.edu](mailto:swanson-hysell@berkeley.edu)
- 19) Malcolm Wallace, School of Earth Sciences, University of Melbourne, Parkville Vic 3010, Australia; [mww@unimelb.edu.au](mailto:mww@unimelb.edu.au)
- 20) Shihong Zhang, State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China; [shzhang@cugb.edu.cn](mailto:shzhang@cugb.edu.cn)
- 21) Chuanming Zhou, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, No.39 East Beijing Road, Nanjing 210008, China; [cmzhou@nigpas.ac.cn](mailto:cmzhou@nigpas.ac.cn)

# **International Commission on Stratigraphy**

## **Subcommission on Pre-Cryogenian Stratigraphy**

### **Report 2023**

#### **1. Title of constituent body and name of reporter**

International Subcommission on Pre-Cryogenian Stratigraphy  
Respectfully submitted by Nora Noffke, Acting Chair

#### **2. Overall Objectives and fit within IUGS Science Policy**

The International Subcommission on Pre-Cryogenian Stratigraphy coordinates the study of selected stratigraphic sections worldwide that represent the Precambrian Earth ages before the Cryogenian. It organizes its presentation through the ICS website. The Subcommission's priority is to enable the international geoscience community to have stratigraphic information on the first  $\frac{3}{4}$  of the geological record.

#### **3. Organization**

The Subcommission includes eighteen members. The membership is representative of almost all continents (see appendix). All members conduct active research and education on Hadean, Archean and Proterozoic Earth history.

Current Officers for 2020-2024 period (together with any changes in personnel):

Chair: Martin Whitehouse

Vice-Chair(s): Nora Noffke (Acting Chair); Douglas Galante (Vice Chair)

Secretary: Evelyn Sanchez

Web person: ICS

#### **4. Interfaces with other international projects and/or extent of support other than IUGS**

A new collaboration is in place with the Geological Survey of Western Australia, Perth. The Geological Survey is of great help in finding Archean and Proterozoic rock successions for inspection. The Survey also is interested in establishing protection status for selected rock successions in the Pilbara region (Paleoarchean through Paleoproterozoic).

## 5. Chief accomplishments for 2023

- We have established the base of the Hadean.
- We have established the significant Hadean/Archean boundary.
- We are actively finalizing the establishment of a Lower/Upper Paleoproterozoic boundary. In this context we turn the “Eoarchean” into an informal name.
- Two manuscripts are submitted to Episodes with the lead by Jaana Halla and Humberto Reis.
- At the STRATI in Lille, France, and at the 6<sup>th</sup> International Symposium on Archean in Perth, the current work of the subcommission was discussed with the scientific community.
- We have submitted a proposal to establish a IUGS Geoheritage site in South Africa (Noffke, Smit and Nhleko)

## 6. Summary of expenditures in 2023

|                          |                  |
|--------------------------|------------------|
| Travel to STRATI, Lille: | \$ 2 x 371.59    |
| Hotel Lille:             | \$ 161.50        |
| Registration STRATI:     | \$ 415.78        |
| <b>Total spent:</b>      | <b>\$ 996.47</b> |

## 7. Summary of Income 2023

We gratefully have received for 2023 the amount of \$ 5250 from IUGS. Jaana Halla was able to cover her travels to Perth by own grant money, so no costs arose for the flight to Perth.

## 8. Budget requested from ICS for 2024

We request \$5,905 for representative members of our subcommission to attend the IAS conference in Aberdeen, UK. We also like to continue our field visits of Archean and Proterozoic rock successions in collaboration with the Geological Survey of West Australia.

|  |                          |
|--|--------------------------|
| Flight Australia                         | ca. \$ 3 400.00          |
| Flight UK                                | ca. \$ 1 000.00          |
| Registration IAS conference Aberdeen, UK | ca. \$ 625.00            |
| Logistics Perth and Aberdeen, UK         | ca. \$ 980.00            |
| Total budget estimate:                   | -----<br>ca. \$ 5 905.00 |

## 9. Work plan, anticipated results, milestones, and communications to be achieved in 2024

- We like to proceed with the ICS vote on the Archean subdivisions:
  - the Lower/Upper Paleoproterozoic (final proposal for vote by our subcommission in progress),
  - the Paleoproterozoic/Mesoproterozoic boundary (started)
  - the Mesoproterozoic/Neoproterozoic boundary.
- We just established a working group for the Mesoproterozoic.
- We like to establish the GSSA on Eo-/Paleoproterozoic rocks for example in the Buick Geoheritage Reserve, Western Australia, and in the Barberton Greenstone Belt, South Africa.
- We are exploring Meso- and Neo-Proterozoic rock successions in collaboration with the Geological Survey of Western Australia. For this, Noffke likes to discuss with Sara Martin and Heidi Allen, both Geological Survey Perth) in the field. We have received an invitation by the Survey and the trip is in preparation.
- We plan to present the results at the meeting of the IAS in Aberdeen, UK.
- There are 3 manuscripts that are being published in 2024:
  - A manuscript lead by Halla and Reis on the base of the Hadean (submitted to Episodes);
  - A manuscript on the Hadean/Archean boundary (finalized and submission to Episodes is in preparation);
  - A manuscript lead by Reis and Noffke on the Lower/Upper Paleoproterozoic boundary (in progress).

## 10. Key objectives and work plan for the next 4 years (2020 to 2024):

- We plan to finalize the subdivision of the Archean stratigraphy into Paleoproterozoic, Mesoproterozoic, and Neoproterozoic.
- We are starting on the Proterozoic subdivisions.
- We arrange for 5 working groups. These working groups shall be the basis for future subcommittees:
  - Working Group on Neoproterozoic Stratigraphy
  - Working Group on Mesoproterozoic Stratigraphy
  - Working Group on Paleoproterozoic Stratigraphy
  - 
  - Working Group on Neoproterozoic Stratigraphy
  - Working Group on Mesoproterozoic Stratigraphy
  - Working Group on Paleoproterozoic Stratigraphy
- We continue our fruitful collaboration with the Geological Survey of Western Australia regarding protection status for Paleoproterozoic to Neoproterozoic rock successions in the Pilbara.
- We continue with the publication of scientific papers and abstracts. There is one abstract planned for the IAS in Aberdeen. UK 2024.
- We think that with the start of the next 4-year period we may be able to shift to the Proterozoic stratigraphy.
- With respect to our membership, we will expand into the underrepresented Asia as well as Europe. Nine of our current members are female. We expect two additional members of early career status joining in 2024 (pending).

### Appendix – Member of the Pre-Cryogenian Subcommittee

| Member Name     | Institution   | Country      |
|-----------------|---|--------------|
| Axel Hofmann    | Department of Geology, University of Johannesburg   | South Africa |
| Barry Reno      | Northern Territory Geological Survey                | Australia    |
| Chris Fedo      | University of Tennessee                             | USA          |
| David Huston    | Geoscience Australia                                | Australia    |
| Donald Lowe     | Stanford University                                 | USA          |
| Douglas Galante | Brazilian Synchrotron Light Laboratory              | Brazil       |
| Evelyn Sanchez  | Universidade Federal dos Vales do Jequitin e Mucuri | Brazil       |



|                   |   |              |
|-------------------|---|--------------|
| Flavia Callefo    | Universidade Estadual de Campinas                             | Brazil       |
| Frances Westall   | CNRS Orleans Campus · Centre de Biophysique Moléculaire (CBM) | France       |
| Humberto Reis     | Universidade Federal de Ouro Preto                            | Brazil       |
| Jaana Halla       | Finnish Museum of Natural History                             | Finland      |
| Juha Köykkä       | Geological Survey of Finland                                  | Finland      |
| Linda Hinnov      | George Mason University                                       | USA          |
| Linda Kah         | University of Tennessee                                       | USA          |
| Mark van Zuilen   | Institut de Physique du Globe de Paris                        | France       |
| Martin Whitehouse | Swedish Museum of Natural History                             | Sweden       |
| Nicola McLoughlin | University of Cape Town                                       | South Africa |
| Andrey Czjaja     | University of Cincinnati                                      | USA          |
| Noah Nhekho       | Geological Survey and Mines Dept of Swaziland                 | Swaziland    |
| Nora Noffke       | Old Dominion University                                       | USA          |
| Peter Haines      | Geological Survey of Western Australia                        | Australia    |
| Simon Johnson     | Geological Survey of Western Australia                        | Australia    |
| Stan Awramik      | University of California                                      | USA          |
| Yogmaya Shukla    | Birbal Sahni Institute of Palaeobotany                        | Índia        |

## 1. TITLE OF CONSTITUENT BODY and NAME OF REPORTER

Subcommission on Stratigraphic Classification (ISSC)

Werner E. Piller, Chair; Jochen Erbacher, Secretary

22. 11. 2023

## 2. OVERALL OBJECTIVES AND FIT WITHIN IUGS SCIENCE POLICY

The Subcommission represents a core business for the International Commission on Stratigraphy, the primary body for creating, discussing, publishing and disseminating an internationally agreed-upon guide to stratigraphic terminology and classification. Its immediate priorities are to advertise new developments in stratigraphic methods, check that the procedures are carefully followed, monitor the application of the accepted rules, and encourage the teaching of basic stratigraphic principles and concepts to new generations of students and professionals. Its future goal is a revision of the International Stratigraphic Guide in order to keep it current but also open to new approaches.

## 3. ORGANISATION - interface with other international projects / groups

ISSC has always been directly or indirectly linked to big international projects such as deep-sea drilling and deep continental drilling as well as IGCP. It has close ties to national stratigraphic commissions, which increasingly look beyond the borders of the parent countries. This is especially true with the North American Commission on Stratigraphic Nomenclature ISSC encourages other national bodies to harmonize their codes with each other and the International Stratigraphic Guide.

### 3a. Current Officers for 2020-2024 period:

Chair: Werner E. Piller

Vice-Chairs: Brian Pratt and Richard Fluegeman

Secretary: Jochen Erbacher

Webpersons: Werner E. Piller, Georg Stegmüller

## 4. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS

Most ISSC activities are linked to various programs and projects, such as IGCP, IODP, ICDP and a variety of national projects. Out of these international programs and affiliated national projects ISSC activities are supported directly or indirectly.

## 5. CHIEF ACCOMPLISHMENTS IN 2023

- **BIOSTRATIGRAPHY:** After the workshop 2022 the organizers and editors (Piller, Erbacher) received the first manuscripts in autumn 2023 submitted to Newsletters on Stratigraphy which are currently under review.
- **CHRONOSTRATIGRAPHY:** The working group established end of 2020 (core: Marie-Pierre Aubry, Martin Head, Werner E. Piller) was discussing the topic and started to discuss some chapters in detail. The manuscript will be ready in 2024.

- **ISSC BUSINESS MEETING**  
A business meeting with an in-depth report by the chair was held during STRATI 2023 in Lille (France).
- **CONFERENCE PARTICIPATION** - ISSC co-organized the technical session (on-site presentations and posters) SSP2.1 “Integrated Stratigraphy - Reconstructing environmental change across the Earth System” at EGU 2022 in Vienna (oral: Thursday, 27 April, 8:30 – 12:25; posters on site: Thursday, 27 April, 14:00 – 15:45; posters virtual: Thursday, 27 April, 14:00 – 15:45).

#### 6. SUMMARY OF EXPENDITURE IN 2022:

Expenditures in 2023: USD 1,950.00

For participation and reporting of the chair at STRATI 2023 in Lille France.

#### 7. SUMMARY OF INCOME IN 2023:

\$ 0.00

#### 8. BUDGET REQUEST FROM ICS FOR 2024

ISSC chair will attend EGU 2024 in Vienna, IGS 2024 in Busan and GSA 2024, Seattle, USA. At EGU a session co-sponsored by ISSC will be held, IGC 2023 requires business meetings of ICCS and ICS, during GSA 2024 the chair will attend the annual meeting of NACSC.

Since Werner Piller is Professor emeritus no institutional financial support is available anymore and requests financial support for his attendance.

A number of meetings of the subcommission’s working groups are planned to be held around EGU in Vienna (see list of working groups below), IGC 2024 and GSA 2024 in order to proceed with the overview articles planned. The requested budget will be used to support the participation of officers, working group members and potential guests to these meetings.

#### PROJECTED EXPENSES

|  |                            |
|--|----------------------------|
| Participation in EGU 2024, Vienna                                | 650.- US\$                 |
| Travel expenses support for the IGC, Busan, South Korea          | 3500.- US\$                |
| Travel expenses editorial work for Biostratigraphy volume NOS    | 1200.- US\$                |
| Travel expenses for workshop on Chronostratigraphy (3-5 persons) | 2500.- US\$                |
| <b>TOTAL estimated expenditure</b>                               | <b><u>7,850.- US\$</u></b> |

#### 9. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR (2024):

- For the chapter Biostratigraphy some of the manuscripts are already submitted and are currently under review. Nine manuscripts are expected in total which have to be reviewed

and edited. Publication of the special volume in Newsletters on Stratigraphy is expected in late fall 2024.

- For the chapter Chronostratigraphy several meetings and workshops are planned. The manuscript should be ready in fall 2024.
- The chapters altogether represent the base for the new version of the International Stratigraphic Guide which will also be outlined during 2024.

Potential funding sources external to IUGS

The Subcommittee does not envisage being able, as an organization, to obtain significant funding from outside IUGS/ICS sources. Some financial support could be obtained by individual members from their host institutions and/or their personal research funds. There is, however, a considerable amount of in-kind funds supporting the activities of all ISSC members, such as covering of travel costs to our workshops etc.

#### 10. KEY OBJECTIVES AND WORK PLAN FOR THE PERIOD 2020-2024

- Publication of the chapters biostratigraphy and chronostratigraphy in Newsletters on Stratigraphy  
The two chapters represent the finalization of a series of papers printed in Newsletters on Stratigraphy.
- New and updated version of the International Stratigraphic Guide  
The final goal of ISSC is to update, upgrade and implement the International Stratigraphic Guide (Hedberg, 1976 [1<sup>st</sup> edition]; Salvador, 1994 [2<sup>nd</sup> edition]; Murphy and Salvador, 1999 [abridged edition] modified by Murphy et al., 2022). The ISG is a most important official document with a large distribution, which requires revisiting because of the fundamental advances of stratigraphy in the last 30 years.
- ISSC will take the initiative to suggest special sessions and symposia at conferences that advance stratigraphic principles, in collaboration with other ICS subcommissions.
- ISSC will continue to participate in GSSP discussions with ICS subcommissions.
- ISSC continues to interface with national stratigraphic commissions although only in an advisory capacity.

#### APPENDIX

Nominated officers

Chair: Werner E. Piller, [werner.piller@uni-graz.at](mailto:werner.piller@uni-graz.at), Institute for Earth Sciences (Geology and Palaeontology), University of Graz, Heinrichstrasse 26, 8010 Graz, Austria, Phone: +43 316 380 5582

Vice-Chair: Brian R. Pratt, [brian.pratt@usask.ca](mailto:brian.pratt@usask.ca), Department of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5E2, Canada, Phone: +1-306-966-5725.

Vice-Chair: Richard H. Fluegeman, [rfluegem@bsu.edu](mailto:rfluegem@bsu.edu), Department of Geological Sciences, Ball State University, 4130 West University Ave., Muncie, Indiana 47304, USA, Phone: (765)285-8267

Secretary: Jochen Erbacher, [erbacher@bgr.de](mailto:erbacher@bgr.de) – Stratigraphy and Collections, Federal Institute for Geosciences and Natural Resources, Stilleweg 2, 30655 Hannover, Phone: +49-511 643-2795

#### List of further Voting Members

- Aubry Marie Pierre, Rutgers University, New Jersey, USA; [aubry@rci.rutgers.edu](mailto:aubry@rci.rutgers.edu), Department of Earth & Planetary Sciences, Rutgers, The State University of New Jersey, Wright-Rieman Laboratories, 610 Taylor Road., Piscataway, NJ 08854-8066
- Catuneanu Octavian, Alberta, Canada; [octavian.catuneanu@ualberta.ca](mailto:octavian.catuneanu@ualberta.ca), Faculty of Science, 1-001 CCIS, University of Alberta, Edmonton, Alberta, Canada T6G 2E9
- Easton Mike, Sudbury, Canada; [mike.easton@ndm.gov.on.ca](mailto:mike.easton@ndm.gov.on.ca), Ontario Geological Survey, Ministry of Northern Development and Mines, Sudbury, Ontario, Canada P3E 6B5
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#### List of Working group leaders and corresponding members

##### Biostratigraphy WG

Chairs: Jochen Erbacher, Germany and Werner E. Piller, Austria

Jörg Pross, Germany

Claudia Agnini, Italy

Maria Rose Petrizzo, Italy

Carlo Coradini, Italy

Petr Storch, Czech Republic

Dieter Korn, Germany

##### Chronostratigraphy WG

Chair: Marie-Pierre Aubry, USA  
Martin Head, Canada  
Werner E. Piller, Austria  
Brian McGowran, Australia

List of corresponding members

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**INTERNATIONAL SUBCOMMISSION ON TIMESCALE CALIBRATION (ISTC)  
ANNUAL REPORT FOR 2023**

**1. International Subcommittee on Timescale Calibration (ISTC)**

REPORTING

Brad Cramer – Chair

Mark Schmitz – Vice-Chair

Anne-Christine DaSilva – Secretary

**2. Overall Objectives and Fit within IUGS Science Policy**

In response to a growing movement of geoscientists who increasingly work at the intersection of time and stratigraphy, and in an effort to provide a platform for promoting integration between the traditionally stratigraphic communities of the ICS with the radioisotopic communities that historically have not been a central component of the ICS enterprise, we have created a new International Subcommittee on Timescale Calibration (ISTC). The objective of this subcommittee is not to ‘certify’ or ‘approve’ any particular numerical calibration of the International Chronostratigraphic Chart, but rather, to provide advice and counsel to existing ICS Subcommittees on geochronological issues, to delineate best practices and the role of inter-laboratory calibrations to chronostratigraphic and timescale problems, and to provide a venue for increasing collaboration between chronostratigraphic and geochronologic research.

**3. Organization – Interface with other international project / groups**

This subcommittee became officially operational in 2020. The website is nearly completed and will include an interactive database of all radioisotopic dates utilized during the creation of the GTS2020 timescale. This will be a primary interface for the DDE to access the calibration data utilized in construction of the GTS2020. The preliminary website is completed and the interactive database is nearly complete and will go live in early 2024.

**3a. Current Officers and Nominated Officers for 2020-2024 period**

Chair: Bradley D. Cramer – University of Iowa

Vice Chair: Mark Schmitz – Boise State University

Secretary: Anne-Christine DaSilva - Université de Liège

Webperson: Bradley D. Cramer – University of Iowa

**4. Extent of National/Regional/Global Support from Sources other than IUGS**

There has, as yet, been no additional support from sources other than IUGS.

**5. Chief Accomplishments in 2023**

The discussion with the other subcommittee chairs at the STRATI2023 meeting regarding the plans for the future of the Geologic Time Scale book volumes. All chairs agreed that this should be pursued and should be considered by the ISTC as a potential objective of the subcommittee. Initial conversations with the executive committee of the ISTC, in addition to initial conversations with publishers has begun and will continue into 2024. A decision on the concrete plans for the next iteration of a GTS volume will be made in 2024.

**6. Summary of Expenditures in 2023**

There were no expenditures in 2023.

## **7. Summary of Income in 2023**

There was no income in 2023.

## **8. Budget Requested from ICS in 2024**

We are not requesting funds from ICS in 2024.

## **9. Work Plan, Critical Milestones, Anticipated Results & Communications to be Achieved Next Year**

- Session to be organized at the GSA National Meeting in 2024.
- Holding the first ISTC digital subcommission meeting to be held online in 2024.
- Making a concrete plan and securing a publisher for the next iteration of the GTS.

## **10. Key Objectives and Work Plan for the Period 2020-2024**

- Create the full subcommission with both voting members and corresponding members. We have completed the list of voting members and are now in the process of filling out the list of corresponding members.
- Organizing the first subcommission meeting to physically bring the ISTC together for the first time
- Organizing a major position volume to be focused on current best practices in timescale calibration as well as where we see the future of timescale calibration. This is to be a printed volume following on from the first subcommission meeting.
- Integrate the ISTC with other international as well as national and regional organizations. For example EARTHTIME, EARTHTIME EU, EARTHTIME China, Geochronology Division of the GSA, SEPM, The Paleontological Association, The Paleontological Society, etc.

## **APPENDIX**

The current officers and voting membership has been completed. We are now in the process of completing the list of corresponding members.

## ***International Subcommission on Timescale Calibration***

Voting Members and Executive Committee 2020

### **Executive Committee**

Chair: Brad Cramer – University of Iowa, USA (Integrated Stratigraphy)  
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Vice Chair: Mark Schmitz – Boise State University, USA (U-Pb)  
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Secretary: Anne-Christine da Silva – Université de Liège, Belgium (Integrated Stratigraphy)  
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### **Voting Members**

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Contributions to ICS annual report – Graphics Officer (Cohen) and Web/Informatics Officer (Car)

- The ICS Chronostratigraphic Chart, which included newly ratified GSSPs and revised numerical ages, was kept actual on [www.stratigraphy.org](http://www.stratigraphy.org) (versions released: 2023/04, 2023/06, 2023/09), as was a changelog ([LINK](#)).
- The ICS website since 2020 also features digitally generated web chart representations, based on its Semantic Web representation, which was kept up to date to the 2020 chart.
- Ten out of Seventeen Subcommissions are operating their own websites within the new website system. The status of Subcommissions' website standardisations can be seen online ([LINK](#)).
- Most of the translated versions of the ICS chart have been updated to the 2023/10 version. The Catalan and Turkish translations were particularly renewed.
- The Graphic Officer attended business meetings and sessions at STRATI congress in Lille (France) in July 2023 (July). In the ICS business meeting it was decided that an upcoming chart will include cross-check of numeric ages against GTS-2020 and the upcoming GTS-2024 publication. We aim to have done this before the IGC in Busan Korea (2024) and communicate this on the chart and as part of a publication in Episodes.org, updating the aging Cohen et al. (2013) reference. The outline of this publication was discussed within the executive, and a draft exists with the graphic officer.
- The Informatics officer visited DDE facility in Suzhou China as part of IUGS meeting there in November 2023.

For the upcoming year, points of attention and plans of the officers are:

- Keeping the ICS website up to date with chart status and downloads, ICS activities and news items, ICS output, ICS subcommission activities and content, stratigraphic guide text and downloads, statutes and annual report archives, and so on.
- Further integrating the workflows that follow each IUGS ratification, ICS Executive and ICS subcommission chair approved requests to change chart content, namely
  - cross-check if with a new GSSP also the numeric age is wished to be amended
  - the updating of the chart PDF/JPEG (editing and exports from graphics software)
  - the updating of the chart in Semantic Web representation (pushing edits on GitHub)
  - the uploading of the chart on the websites (emailing and web-admin)
  - updating the interactive chart connection to the latest GitHub-stored version
- Release of updated translations of the ICS chart
- Improved digital representation (structuring and accessibility of the chart)
  - Continued data remodeling work on the Semantic Web representation of the Chart ([LINK](#)) to better represent stratigraphic and temporal typologies has commenced with a new Knowledge Graph of Chart and related information being built at [LINK](#). Co-authoring this remodeling with Nicholas Car is Steve Richard, one of the two main contributors of the Semantic Web form of the Chart.
- Episodes paper on developments on the ICS chart last 10 years, to succeed the 2013 paper (i.e. a paper at meta-level: formal administrative, distribution-technical, digital-era representation-diversity and diversity-of-usage oriented).

## Report

STRATI 2023

**4<sup>th</sup> International Congress on Stratigraphy  
July 11<sup>th</sup> – 13<sup>th</sup> 2023, Lille, France**



Following the 1<sup>st</sup> edition of STRATI in Lisbon (Portugal) in 2013, and additional editions organized in Graz (Austria) in 2015 and Milan (Italy) in 2019, the ICS accepted the proposal by the organizing team at Lille (France) as the venue to welcome the 4<sup>th</sup> International Congress on Stratigraphy: **STRATI 2023 Lille**.

With famous pioneers, such as Cuvier and Lamarck, France is considered the birthplace of palaeontology (the word '*paléontologie*' was created by Blainville in 1822), and French scientists were also the first to develop stratigraphical concepts, including d'Orbigny who introduced stages as subdivisions of strata with unique fossil assemblages. Many international geological series and stage names have been defined in France, such as the Jurassic System, named after the French-Swiss Jura Mountains, or the Givetian Stage (Devonian), named after Givet, a city in northern France. Many Mesozoic and Cenozoic standard stages derive from French localities: Hettangian, Sinemurian, Toarcian, Bajocian (Jurassic); Berriasian, Valanginian, Hauterivian, Barremian, Aptian, Albian, Cenomanian, Turonian, Coniacian, Santonian, and Campanian (Cretaceous); Lutetian (Paleogene), Aquitanian and Burdigalian (Neogene). Lille, in the northernmost part of France, close to the Belgian border, has a long tradition on stratigraphical studies in the Upper Palaeozoic, being close to the famous Devonian-Carboniferous type localities, but also to the Ypresian (Paleogene) type section in Belgium.

The palaeontology research team from the CNRS unit Evo-Eco-Paleo of Lille University (UMR 8198) organized a three-day indoor meeting at the campus of the Cité Scientifique at Villeneuve d'Ascq, from Tuesday, July 11<sup>th</sup> to Thursday, July 13<sup>th</sup> 2023. The indoor sessions were organized to take place in the new Congress Centre of Lille University 'Lilliad,' that displays lecture halls, but also numerous smaller rooms that were booked for smaller group meetings.



The new Lilliad buildings (Lille University Learning Center) on the Campus 'Cité Scientifique' at Villeneuve d'Ascq

Before the indoor meeting, two workshops were organized on Monday, July 10<sup>th</sup>, that were followed by the icebreaker party. T

The three days of indoor sessions included six plenary sessions with keynote talks and regular lectures. The following keynote talks were presented:

Laia Alegret (Zaragoza, Spain): Global events of the Paleogene  
Lucia Angioloni (Milano, Italy): Carboniferous-Permian environments and climate  
Steven Holland (Athens, GA, USA): Stratigraphic paleobiology  
Michael Joachimski (Erlangen, Germany): Chemostratigraphy  
Jacques Laskar (Paris, France): Astronomy and stratigraphy  
Christopher Scotese (Evanston, IL, USA): Phanerozoic geography and climate

All 17 subcommissions of the ICS organized scientific sessions, most of which being scheduled in parallel, with a maximum of four parallel sessions.

In addition, most subcommissions organized their business meetings, scheduled at the end of each day. In addition, the ICS also organized a business meeting as a lunch meeting at the first day of the scientific sessions (Tuesday, July 11<sup>th</sup>)

Several pre-and post-conference fieldtrips have been scheduled to take place before and after the indoor meeting.

Two one-day field trips let the participants to the classical coastal section of the Jurassic chalk cliffs of the Côte d'Opale (Monday, July 10<sup>th</sup>) and the type localities of the Tertiary of Flanders, Belgium (Friday, July 14<sup>th</sup>).

Three other excursions were scheduled to visit: (1) classical localities of the North of England and Scotland, including Hutton's unconformity at Siccar Point and the Pliensbachian GSSP (Jurassic) of the Yorkshire Coast (four days: July 6<sup>th</sup> to 9<sup>th</sup>), (2) the classical Devonian-Carboniferous of Belgium and France (Givetian, Frasnian, Famennian; Tournaisian, Visean) in the East of Lille (three days: July 14<sup>th</sup> to 16<sup>th</sup>), and (3) the classical Ordovician sections of Estonia, visited during a post-conference field-trip (four days: July 15<sup>th</sup> to 18<sup>th</sup>) organized together with the organizers of the 14<sup>th</sup> ISOS (Ordovician) congress, scheduled July 19-21<sup>st</sup> in Tallinn, Estonia).



Jurassic cliffs of the Cap Blanc Nez – Côte d'opale



Devonian type section of Givet, Meuse Valley

A major social activity was the conference dinner organized on the evening of Wednesday, July 12<sup>th</sup>, at the the Hermitage Gantois, an ancient hospice of the late 15<sup>th</sup> century.

STRATI2023 was well attended with 285 participants from over 40 countries.

The meeting was co-organized by the palaeontology team of the research unite UMR 8198 Evo-Eco-Paléo of the CNRS and Lille University, and the French Geological Society (*Société Géologique de France*). The meetings was sponsored by both the CNRS (INSU, INEE, MITI) and the University of Lille, and a few external sponsors (including Saudi Aramco). The sponsoring allowed the organizers to reduce or withdraw the registration costs of numerous young scientists (students) and participants from developing countries. In addition, travel grants were distributed, and several students and participants from developing countries were invited to the conference dinner.

The support from the ICS is greatly acknowledged. This support allowed to cover the travel and living expenses of a few participants from developing countries, including colleagues from Argentina, Morocco, Tunisia and Turkey.



