



Edies

International Commission on Stratigraphy
Subcommission on Ediacaran Stratigraphy

Newsletter of the
Subcommission on
Ediacaran Stratigraphy
Number 3, February, 2015

Edies Newsletter #3, February 2015

Remarks from the Chair

By Shuhai Xiao

Marc Laflamme, Dima Grazhdankin, and myself would like to share with you the third newsletter of the Subcommission. Once again, I would like to thank you for your contributions and give Marc Laflamme a round of applause for his editorial effort.

In 2014, the Subcommission sponsored and members of the Subcommission organized three major field workshops. In January 2014, Mukund Sharma led a field workshop to examine the Neoproterozoic Marwar Supergroup in Rajasthan, India (see a report at the end of the newsletter). In June 2014, Chuanming Zhou, myself, and our Chinese colleagues led a field workshop to examine the Cryogenian and Ediacaran successions in South China and organized a symposium in Wuhan (see a report at the end of the newsletter). In September 2014, Javier Álvaro and his colleagues led a field trip to examine Ediacaran and Cambrian successions in Ouarzazate, Morocco. In addition, several symposia focusing on Ediacaran stratigraphy and paleobiology have been organized at GSA, NAPC, and IPC.

In December 2014, we as a community suffered a tremendous loss: Professor Martin Brasier died in a road accident at the age of 67 (see a dedication prepared by Rachel Wood in this newsletter). Martin was a voting member of the Subcommission. He made numerous important contributions that continue to guide our current and future research in Ediacaran stratigraphy and paleobiology. He was also a key player in defining the Ediacaran-Cambrian boundary, without which there would be no Ediacaran Period. He will be truly missed.

We have set high goals for 2015. We have established two working groups to focus on the

Second and Terminal Ediacaran Stages. These working groups are chaired by Chuanming Zhou and Guy Narbonne, respectively (see their messages in this newsletter). I hope that, with coordinated and focused efforts, we will be able to make real progress toward the eventual definition of the Second and Terminal Ediacaran Stages. I encourage you to contact Chuanming and Guy if you have any ideas about field workshops that would help defining the Second and Terminal Ediacaran Stages.

In July 2015, the Second International Congress on Stratigraphy (STRATI 2015) will be held in Graz, Austria. The Ediacaran, Cryogenian, and Precambrian subcommissions will sponsor a joint symposium “Precambrian Stratigraphy and Earth System History” at STRATI 2015. We hope to see many of you in Graz.

Notes from the Secretary

By Marc Laflamme

Welcome to our third yearly newsletter. 2015 looks to be an exciting year for Ediacaran research, including a recently accepted Pardee Keynote Symposium P3: “*Earth-Life Systems at the Dawn of Animals*” at the 2015 Geological Society of America Annual Meeting in Baltimore, MD, organized by corresponding members James D. Schiffbauer, Simon A.F. Darroch, and myself. Talks will include several active members of the subcommission. Confirmed speakers include **Luis Buatois, Nicholas Butterfield, Jean Bernard Caron, Sean Carroll, Douglas Erwin, David Evans, Ganqing Jiang, Andrew Knoll, Gordon Love, Shan'an Peters, Kevin Peterson, Rachel Wood, and Shuhai Xiao.**

Our subcommission was also very active in publishing exciting new results in top-tier journals (see references below). Please continue to let us know of any important

contributions to our discipline, and check out the field trip reports at the end of the newsletter.

Dedication to the life and times of Professor Martin Brasier (April 12th, 1947 – December 16th, 2014).



John Lindsay, Simon Conway Morris and Martin Brasier
– by Rachel Wood

Martin Brasier, Emeritus Professor of Palaeobiology at the University of Oxford, died in a road accident near Oxford at the age of 67. He will be remembered for his innovative palaeobiology, particularly on the early biosphere and the Cambrian Explosion, his many contributions to international geology, and an ability to entertain with a wickedly dry wit.

Martin's career was driven by a deep passion to understand the Earth's record and stretched from the Archean to the Recent. He was primarily concerned with the interaction of life with the Earth System: a true geobiologist. After a classic geological training at Chelsea College, London, he undertook a PhD on the ecology of modern benthic foraminifera and associated communities in the Caribbean. From this he developed ideas on microfossil morphospace and the evolution of photosymbioses: interests which never left him. His interest in the fossil record developed during a year spent as ship's scientist aboard the naval survey ship *Fawn* in the Caribbean in 1970. 'From this,' he recalled, 'I could see that it is the analysis of interconnections between and within systems that

may provide a valuable key for decoding the early history of life.' In early 2014, Martin's lifelong contributions to the geological sciences were formally recognized by the award of the prestigious Lyell Medal from the Geological Society of London.

When lecturing later at the Universities of Reading and Hull, he became interested in the ecological interactions in Lower Cambrian archaeocyath reefs, which led by the late 1970s to an interest in the Cambrian Radiation. Martin relocated from Hull to Oxford in 1988. Here he helped to establish a dedicated palaeobiology research laboratory and from then he became interested in how new high-resolution geochemical techniques could be applied to Ediacaran and Cambrian fossils and their sedimentological context. He was a keen advocate of the importance of detailed field observation and painstaking petrographic interrogation. It was during this time that Martin took a leading role in the International Geological Correlation Programme (IGCP), specifically the formal definition of the Cambrian and Ediacaran time periods through use of stratotype sections. He also organized several international field meetings including the epic expedition in 1993 to Outer Mongolia: 5 weeks of mutton, fermented mare's milk, and camaraderie never to be forgotten.

During the next 15 years Martin helped to reinvent study of the earliest biosphere, pioneering a new, critical approach to the assessment of the biogenicity of Earth's most ancient life. In particular he constructed elegant arguments to refute the presence of organic structures in the 3.460 Ma Apex Chert. He also initiated high-resolution digital scanning of the assemblages at Charnwood Forest, made major contributions to the fractal nature of the Ediacaran biota, and brought to life the complex biotas that inhabited the lacustrine environments of the Precambrian of Scotland.

Martin was a prolific writer, not only of journal publications, but also a large number of books. Martin established a course on Micropalaeontology in Hull in 1980s and from this came his first

textbook, 'Microfossils'. The second edition (co-authored with Howard Armstrong) remains a core textbook used by students of micropalaeontology around the world. In 1981 he was co-editor (with John Neale) of a book on Microfossils from Recent and Fossil Shelf Seas. He also wrote two fascinating books for the popular science market, 'Secret Chambers' and 'Darwin's Lost World: The Hidden History of Animal Life', published in 2009 as part of the Charles Darwin centenary celebrations.

Martin was a very novel thinker: often a maverick with a tangential view that was always thought-provoking and stimulating. He was also a polymath – his field sketches had great artistic flair and within his College of St. Edmunds he was for a time responsible for their fine collection of paintings. At his retirement celebration in Oxford in September 2014 we were not only treated to a display of some of his Roman and other ancient seals (his collection extended to Celtic coins amongst many others), but also his honky-tonk piano playing lit by a giant candelabra, a viewing of a first edition of Robert Hooke's 'Micrographia', and ridiculously delicious wine (all 4 courses of it).

Martin often coincided family holidays with geological fieldwork, and his love of geology was clearly infectious. He collaborated with his son Alex, a lecturer in Geology at the University of Aberdeen, on Precambrian calcretes. He is survived by his wife Cecilia, his sons Matthew and Alex, daughter Zoe, two grandchildren, and will be missed by all his many former students and colleagues.

- Rachel Wood, Edinburgh, February 2015

Subcommission Annual Report (submitted to ICS on November 10, 2014)

Submitted by: Dr. Shuhai Xiao, Chairman
Department of Geosciences, Virginia Tech,
Blacksburg, VA 24061, USA
Tel. 540-231-1366, Fax. 540-231-3386
Email: xiao@vt.edu

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 – 542 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);
- (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 four main aspects of IUGS policy:

- (1) 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;
- (2) 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 **Precambrian Subcommittee (M. Van Kranendonk, chair)** and **Cryogenian Subcommittee (Graham Shields-Zhou, chair)** to subdivide the late Precambrian.
- (3) 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.

3a. CHIEF ACCOMPLISHMENTS AND PRODUCTS IN 2014

- The second annual newsletter of the Subcommittee was disseminated in February 2014. See attached.
- The Subcommittee established two working groups to focus on the second stage and the terminal stage of the Ediacaran System. These working groups are chaired by Dr. Chuanming Zhou (Ediacaran stage 2) and Dr. Guy Narbonne (Ediacaran terminal stage).
- The Subcommittee sponsored the 2014 International Field Workshop on the Marwar Supergroup, Rajasthan, western India, which was held on 20th-28th January 2014. This field trip examined Ediacaran and Cambrian successions in Rajasthan. Corresponding member Mukund Sharma was the organizer of this field workshop, Chair-person Shuhai Xiao and several corresponding members (e.g., Ulf Linnemann and Mukund Sharma) participated in this field workshop. A report has been published in *Episodes*. See attached.
- The Subcommittee sponsored and organized the 2014 Subcommittee field workshop “*International Symposium and Field Workshop on Ediacaran and Cryogenian Stratigraphy*” in South China (June 11-22, 2014). Nearly 60 scientists from Australia, Brazil, China, Germany, Mongolia, Russia, UK, and USA participated in this field workshop. Chair-person Shuhai Xiao, Vice-Chair Dmitry Grazhdankin, nine other voting members (James Gehling, Ganqing Jiang, Alan J. Kaufman, Guy Narbonne, Graham Shields-Zhou, Chongyu Yin, Xunlai Yuan, Chuanming Zhou, Maoyan Zhu), and six corresponding member (Carlos Alvarenga, Douglas Erwin, Alex Liu, Pengju Liu, Konstantin Nagovitsin, Linzhi Gao) participated in this field trip. In addition, several voting and corresponding members of the Cryogenian Subcommittee (Carlos Alvarenga, Linzhi Gao, Alan J. Kaufman, Graham Shields-Zhou, Shuhai Xiao, Qirui Zhang, Chuanming Zhou, Maoyan Zhu) participated in this field workshop. A symposium was also organized as part of the field workshop, and there were 31 oral presentations and 20 poster presentations at the symposium. A report has been published in *Episodes*. See attached.
- The Subcommittee co-sponsored and voting member Jose-Javier Alvaro organized a field workshop on the Ediacaran-Cambrian stratigraphy of Morocco (September 15-24, 2014; Ouarzazate, Morocco). A special volume entitled “*Geological Evolution of the Ediacaran and Cambrian in the High Atlas and Anti-Atlas Ranges, Morocco*” was published in the October 2014 issue of

“*Journal of African Earth Sciences*”. Voting members Jose-Javier Alvaro and Chuanming Zhou participated in this field workshop.

- Corresponding member James D. Schiffbauer and Chair-person Shuhai Xiao assembled a *Journal of Paleontology* special issue on the Ediacaran-Cambrian transition (*Journal of Paleontology*, 2014, vol. 88, no. 2).
- Secretary Marc Laflamme and corresponding members James D. Schiffbauer and Simon A.F. Darroch organized a short course on exceptional preservation—“*Reading and Writing the Fossil Record: Preservation Pathways to Exceptional Fossilization*”—at the 2014 Geological Society of America annual meeting. This short course included several papers associated with the Ediacaran/Cambrian transition.
- Voting members Jim Gehling and Guy Narbonne organized a symposium entitled “*Neoproterozoic palaeobiology: preservation, palaeobiology, environments and phylogeny*” at the 4th International Paleontological Congress (September 28 - October 3, 2014; Mendoza, Argentina).
- Secretary Marc Laflamme organized a symposium entitled “*Ediacaran Environments and Ecosystems*” at the 10th North American Paleontological Convention (February 15-18, 2014; Gainesville, Florida). Several voting and corresponding members (Martin Brasier, Mary Droser, James Gehling, Marc Laflamme, Alex Liu, Guy Narbonne, Shuhai Xiao, Xunlai Yuan, Chuanming Zhou) co-authored abstracts or presented talks at this symposium.
- The Ediacaran, Cryogenian, and Precambrian subcommissions have submitted a joint proposal for a symposium entitled “Precambrian Stratigraphy and Earth System History” at the STRATI 2015

meeting (19-23 July 2015, Graz, Austria). The proposal has been accepted.

4a. OBJECTIVES AND WORK PLAN FOR 2015

- Subcommission annual newsletter will be distributed in February 2015. Secretary Dr. Marc Laflamme will be leading the effort to compile and edit the annual newsletter.
- Continue maintaining and updating Subcommission webpage (<http://www.paleo.geos.vt.edu/Ediacaran/>).
- The Ediacaran, Cryogenian, and Precambrian subcommissions will sponsor and organize a joint symposium entitled “Precambrian Stratigraphy and Earth System History” at the STRATI 2015 meeting (19-23 July 2015, Graz, Austria).
- Formalize the membership of the two workgroups. Currently, Dr. Chuanming Zhou and Dr. Guy Narbonne are putting together the two working groups to focus on the second stage and the terminal stage of the Ediacaran System.
- 2014 was a busy year, with multiple field workshops and symposia in India, China, Morocco, Argentina, and the USA. In 2015, the Subcommission will likely organize and sponsor two or three field workshops, each focusing on the second stage and the terminal stage of the Ediacaran System. Proposals for field workshops will be solicited immediately after the membership of the two working groups is finalized.
- Activities planned for 2015 will focus on the criteria to define the second and terminal stages of the Ediacaran Systems, and will be guided by consensus from previous discussion (particularly the 2014 Subcommission meeting in Wuhan), which is summarized below.
 - There is very clear consensus that stable carbon isotopes, acritarchs, and Ediacara fossils are the most practical correlation tools. Ediacaran glaciations and oxidation events may be useful. There is

very little support for stromatolites or the Acraman impact events as interregional correlation tools.

- We should focus on successions with mixed lithologies, geochronological constraints, and chemostratigraphic and biostratigraphic potential.
- In order to make progress, we should start working on the stage boundaries. The two priorities identified at the 2014 Subcommittee meeting in Wuhan are the second and terminal stages of the Ediacaran System. Stable carbon isotopes, acanthomorphic acritarchs, biomineralizing animal fossils, and Ediacara fossils should be investigated for their significance in stratigraphic correlation.
- Another focus in 2015 will be series boundary or boundaries of the Ediacaran System. The Ediacaran System can be divided two or more Series. Although the Series boundary should be unambiguously defined, at the present it is perhaps unrealistic to use the FAD or LAD of an Ediacaran species (with possible exception of *Cloudina hartmannae*) for global correlation. Thus, we should aim at characterizing the Series using a combination of bio- and chemostratigraphic features (e.g., one or two Series in the lower Ediacaran System characterized by Ediacaran acanthomorphs; one or two Series in the upper Ediacaran System characterized by macroscopic Ediacara fossils and skeletal fossils; alternatively, three Series each characterized with a carbon isotope cycle).
- The broad congruency between evolutionary and physical events in the Ediacaran Period is encouraging, but the uncertainties about each individual criterion demand that we should adopt a holistic approach (i.e., using multiple

criteria in order to maximize the usefulness of the GSSP).

4b Specific GSSP Focus for 2015

- Following the establishment of the two working groups to focus on the second and terminal stages of the Ediacaran System, at least two field workshops will be organized to discuss and examine the criteria to be used to define and correlate these two stages.
- The Subcommittee will discuss and determine whether the Ediacaran System should be divided into two or three series.

5. SUMMARY OF EXPENDITURES IN 2013:

INCOME

Forwarded from 2013	US\$ 891
ICS	US\$ 4000
<u>Total</u>	<u>US\$ 4891</u>

EXPENDITURES

Office and administrative supplies	US\$ 450
Software and website maintenance	US\$ 502
Marwar workshop sponsorship	US\$ 500
Indian and China workshop sponsorship & participation costs	US\$ 2700
<u>Total</u>	<u>US\$ 4152</u>

To be carried forward to 2015	US\$ 739
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6. BUDGET REQUESTS AND ICS COMPONENT FOR 2015

In 2014, with the help of ICS and several funding agencies (Chinese Academy of Sciences, Chinese State Key Laboratory of Paleobiology and Stratigraphy, National Natural Science Foundation of China), we were able to financially sponsor the Marwar workshop, to offer registration discount to all student participants in the China workshop, and to offer assistance to five keynote speakers at the China workshop.

In 2015, the Subcommittee plans two to three field workshops in 2015. Likely field sites

include Ediacaran successions in South Australia, Oman, and possibly Russia. These field workshops will be located in remote areas and will involve significant efforts and financial assistance to prepare. Although we will continue to apply for financial assistance through multiple funding agencies of the host countries, we anticipate that the amount of grants will be smaller than was awarded in 2014. In addition, the Subcommittee will sponsor and organize a symposium entitled "Precambrian Stratigraphy and Earth System History" at the STRATI 2015 meeting (19-23 July 2015, Graz, Austria). A business meeting will be held at STRATI 2015. Thus, we request \$6,211 from ICS to these field workshops in 2015.

PROJECTED EXPENSES

Office & website expenses	US\$ 350
Field workshop preparation	US\$ 3000
STRATI 2015 travel	US\$ 2000
Graduate students support	US\$ 2400
<u>Total</u>	<u>US\$ 7750</u>

PROJECTED INCOME:

Carried over from 2014	US\$ 739
<u>Total</u>	<u>US\$ 739</u>

BUDGET REQUESTS US \$7011

7a. Current Officers and Voting Members

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. There are currently 16 other Voting Members, making a total of 19 voting members. There are currently over 30 additional corresponding members. The Voting Members

have been specifically selected for their international reputations, recognized expertise in an area of geoscience relevant to the subcommittee, and their willingness to take an active role in the subcommittee's activities.

Officers

- **Chair:** Shuhai Xiao (Department of Geosciences, Virginia Tech, Blacksburg, VA 24061, USA; xiao@vt.edu)
- **Vice Chair:** Dima Grazhdankin (Institute of Petroleum Geology and Geophysics, Koptyug Avenue 3, Novosibirsk 630090, Russia; dima.grazhdankin@googlegmail.com)
- **Secretary:** Marc Laflamme (Department of Chemical and Physical Sciences, University of Toronto Mississauga, 3359 Mississauga Road, Mississauga, ON L5L 1C6, Canada; marc.laflamme@utoronto.ca)

Voting members

- Alvaro, Jose-Javier
- Brasier, Martin D.
- Christie-Blick, Nicholas
- Gehling, James G.
- Grazhdankin, Dmitri V.
- Grey, Kathleen
- Jensen, Sören
- Jiang, Ganqing
- Kaufman, Alan Jay
- Laflamme, Marc
- Moczydlowska-Vidal, Malgorzata
- Narbonne, Guy M.
- Rai, Vibhuti
- Shields-Zhou, Graham A.
- Xiao, Shuhai
- Yin, Chongyu
- Yuan, Xunlai
- Zhou, Chuanming
- Zhu, Maoyan

Corresponding Members

- Antcliffe, Jonathan
- Boggiani, Paulo César
- Butterfield, Nicholas
- Chen, Xiaohong
- Chumakov, Nikolay
- Erwin, Douglas
- Bernd-D. Erdtmann
- Evans, David A.D.
- Fedonkin, Mikhail
- Frimmel, Hartwig
- Gaucher, Claudio
- Hoffmann, Karl-Heinz
- Hofmann, Mandy
- Jenkins, Richard
- Khomentovsky, Vsevolod
- Knoll, Andrew H.
- Kochnev, Boris
- Linnemann, Ulf
- Liu, Alex
- Liu, Pengju
- Melezhik, Victor
- Nagovitsin, Konstantin
- Pokrovskii, Boris G.
- Rainbird, Robert
- Schiffbauer, James D.
- Semikhatov, Mikhail A.
- Sergeev Volodya
- Sharma, Mukund
- Sperling, Erik
- Van Kranendonk, Martin
- Vickers-Rich, Patricia
- Volodya, Sergeev
- Walter, Malcolm
- Walde, Detlef
- Wang, Xiaofeng
- Weiguo, Sun

And the list is growing ...

7b List of Working (Task) Groups and their officers

The Ediacaran, Cryogenian, and Precambrian subcommissions have submitted a joint proposal for a symposium on “Precambrian Stratigraphy and Earth System History” at the STRATI 2015 meeting (19-23 July 2015, Graz, Austria).

Two working groups have been established to focus on the second and terminal stages of the Ediacaran System. A task Group to redefine the Ediacaran-Cambrian boundary is led by voting member Dr. Maoyan Zhu, with Dr. Shuhai Xiao as a member.

Terminal Ediacaran working group, by voting member and director of the working group, Guy M. Narbonne

At the South China meeting in June 2014, the Ediacaran Subcommission moved towards Ediacaran subdivision by establishing Working Groups to define the second and terminal stages of the Ediacaran System. I have been asked to chair the Terminal Ediacaran Stage Working Group.

The Terminal Ediacaran Stage Working Group will investigate criteria for defining the base of the final stage of the Ediacaran System, including the first appearance of Ediacaran shelly fossils such as *Cloudina* and *Namacalathus*, diagnostic Ediacara-type impression fossils, distinctive isotopic excursions such as the top of the Shuram anomaly or excursions between the Shuram and the Cambrian, and other diagnostic attributes of the terminal Ediacaran. Ideally, the base of the terminal Ediacaran will be defined at a point that can be recognized and correlated worldwide using multiple criteria. The Terminal Ediacaran Stage Working Group will investigate potential subdivision criteria and sections where these criteria are well displayed. The Working Group will also organize symposia and field workshops related

to the terminal Ediacaran Earth and life. After appropriate deliberations and votes, the Terminal Ediacaran Stage Working Group will recommend a candidate GSSP to be voted on by the entire Ediacaran Subcommittee.

Please send an email directly to me narbonne@queensu.ca to indicate your interest in being a member of the Working Group on the terminal Ediacaran Stage, or if you have any further questions concerning the Working Group.

Ediacaran Stage 2 working group, by voting member and director of the working group, Chuanming Zhou

At the South China meeting in June 2014, the Ediacaran Subcommittee proposed the establishment of the Ediacaran Stage 2 Working Group to focus on the Second stage of the Ediacaran System. Several possible criteria were discussed at the meeting, including the termination of basal Ediacaran cap carbonate, the first appearance of Ediacaran acanthomorphs, a carbon isotope shift, and combination of these.

I have been asked to chair the Ediacaran Stage 2 Working Group. I am writing to invite you to participate in the Ediacaran Stage 2 working group. If you have any ideas about field workshops and other activities for 2015, please let me know at cmzhou@nigpas.ac.cn.

Happy Chinese New Year!

7c Interfaces with other international project

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

- IGCP 587 (Of Identity, Facies and Time, the Ediacaran Puzzle: Factors Controlling the Observed Diversity and reality of the Relationships of the Earliest Metazoans) led by Mikhail Fedonkin (Paleontological Institute, Russian Academy of Sciences,

Moscow, Russia), Patricia Vickers-Rich (School of Geosciences, Monash University, Melbourne, Victoria), Jim Gehling (South Australian Museum, South Australia) and Guy Narbonne (Dept of Geology, Queens University, Kingston, Ontario, Canada).

8. Contributions by our members: We have included a list of relevant 2014 publications as submitted by our members. Please continue to keep us abreast of your scientific contributions to our field.

Articles from 2014/early 2015:

Álvaro, J.J. 2014. Foreword to the Special Issue “Geological Evolution of the Ediacaran and Cambrian in the High Atlas and Anti-Atlas Ranges, Morocco”. *Journal of African Earth Sciences* 98, 1-2.

Álvaro, J.J., Bauluz, B., Clausen, S., Devaere, L., Gil Imaz, A., Monceret, E. & Vizcaino, D. 2014. Stratigraphic review of the Cambrian-Lower Ordovician volcanosedimentary complexes from the northern Montagne Noire, France. *Stratigraphy* 11, 83-96.

Álvaro, J.J., Benziane, F., Thomas, R., Walsh, G.J. & Yazidi, A. 2014. Neoproterozoic-Cambrian stratigraphic framework of the Anti-Atlas and Ouzellagh promontory (High Atlas), Morocco. *Journal of African Earth Sciences* 98, 19-33.

Álvaro, J.J., Bellido, F., Gasquet, D., Pereira, F., Quesada, C. & Sánchez-García, T. 2014. Diachronism of late Neoproterozoic-Cambrian arc-rift transition of North Gondwana: a comparison of Morocco and the Iberian Ossa-Morena Zone. *Journal of African Earth Sciences* 98, 113-132.

Álvaro, J.J., Pouclet, A., Ezzouhairi, H., Soulaïmani, A., Bouougri, E., Gil Imaz, A. & Fekkak, A. 2014. Early Neoproterozoic rift-related magmatism in the Anti-Atlas

- margin of the West African Craton, Morocco. *Precambrian Research*.
- Babcock, L. E., S. Peng, M. Zhu, S. Xiao, and P. Ahlberg, Proposed reassessment of the Cambrian GSSP. *Journal of Asian Earth Sciences*, 98: 3-10.
- Boyle, R. A., Dahl, T.W., Dale, A.W., Shields-Zhou, G., Zhu, M., Brasier, M. D., Canfield, D. E., Lenton, T. M., 2014. Stabilization of the coupled oxygen and phosphorus cycles by the evolution of bioturbation. *Nature Geoscience*,
- Buatois, L.A., Narbonne, G.M., Mángano, M.G., Carmona, N.B., and Myrow, P., Ediacaran matground ecology persisted into the earliest Cambrian, *Nature Communications* 5, Article number: 3544, doi:10.1038/ncomms4544, p. 1-5.
- Broce, J., J. D. Schiffbauer, K. Sen Sharma, G. Wang, and S. Xiao, 2014, Possible animal embryos from the lower Cambrian (Stage 3) Shuijingtuo Formation, Hubei Province, South China. *Journal of Paleontology*, 88: 385-394.
- Cai, Y., Hua, H., Schiffbauer, J.D., Sun, B, and Yuan, X. (2014) Tube growth patterns and microbial mat-related lifestyles in the Ediacaran fossil *Cloudina*, Gaojiashan Lagerstätte, South China. *Gondwana Research* 25: 1008–1018.
- Carbone, C., and Narbonne, G.M., 2014, When life got smart: the evolution of behavioral complexity through the Ediacaran and early Cambrian of NW Canada. *Journal of Paleontology*, vol. 86: 309-330.
- Chen, L., S. Xiao, K. Pang, C. Zhou, and X. Yuan, 2014, Cell differentiation and germ-soma separation in Ediacaran animal embryo-like fossils. *Nature*, DOI: 10.1038/nature13766.
- Chen, Z., C. Zhou, S. Xiao, W. Wang, C. Guan, H. Hua, and X. Yuan, 2014, New Ediacara fossils preserved in marine limestone and their ecological implications. *Scientific Report*, 4: 4180 (DOI:10.1038/srep04180).
- Chengguo, Guan, Zhou Chuanming, Wang Wei, Wan Bin, Yuan Xunlai, Chen Zhe, 2014, Fluctuation of shelf basin redox conditions in the early Ediacaran: evidence from Lantian Formation black shales in South China. *Precambrian Research*, 245: 1-12
- Cortijo, I., Y. Cai, H. Hua, J. D. Schiffbauer, and S. Xiao, Life history and autecology of an Ediacaran index fossil: Development and dispersal of *Cloudina*. *Gondwana Research*, DOI: 10.1016/j.gr.2014.05.001.
- Cunningham, J.A., Donoghue, P.C.J., and Bengtson, S. 2014. Distinguishing biology from geology in soft-tissue preservation, p. 275–287. In Laflamme, M., Schiffbauer, J.D., and Darroch, S.A.F. (eds.), *Reading and Writing of the Fossil Record: Preservation Pathways to Exceptional Fossilization. The Paleontological Society Papers* 20
- Dong, Jin, Shihong Zhang, Ganqing Jiang, Haiyan Li, Rui Gao, 2013, Greigite from carbonate concretions of the Ediacaran Doushantuo Formation in South China and its environmental implications, *Precambrian Research*, 225: 77-85.
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Report of 2014 Marwar Field Workshop

Rajasthan, India, 20-28 January 2014



A number of Proterozoic sedimentary basins were formed in Peninsular India and they preserve rich records of the evolutionary and geological history of the Earth. One of these basins is the Marwar Basin in western Rajasthan. The Marwar Basin used to be regarded as a western extension of the Vindhyan Basin despite that the two are separated by the Delhi and Aravalli fold belts. As such, the sedimentary package in the Marwar Basin, the Marwar Supergroup, was thought to be equivalent to the Vindhyan Supergroup. However, recently acquired radiometric dates suggest that the Marwar Supergroup is distinctively younger than the Vindhyan Supergroup, and the two basins were independently developed although they shared some of their sedimentary source regions (Malone et al., 2008; McKenzie et al., 2011; Davis et al., 2014; Turner et al., 2014). In 2010, stimulated by paleontological discoveries from the Vindhyan Supergroup, Dr. S. Kumar (University of Lucknow) and Dr. M. Sharma (Birbal Sahni Institute of Palaeobotany)

organized an international field workshop to examine the Vindhyan Supergroup (Kumar and Sharma, 2012). Encouraged by the enormous success of the 2010 Vindhyan field workshop, Drs. M. Sharma and S. Pandey (Birbal Sahni Institute of Palaeobotany), organized a field workshop to examine the Marwar Supergroup during January 20-28, 2014 (Sharma et al., 2014). This field workshop was motivated by several recent reports of interesting fossils (Kumar et al., 2009; Prasad et al., 2010; Kumar and Ahmad, 2012; Kumar et al., 2012; Srivastava, 2012; Pandey et al., 2014; Srivastava, 2014), increasing interest of the petroleum industry in the hydrocarbon potential (Ghori et al., 2009; Craig et al., 2013), and ongoing debates on the depositional age and stratigraphic correlation of the Marwar Supergroup (Davis et al., 2014).

The field workshop drew 34 participants from Argentina, China, Germany, India, Oman, Spain, United Kingdom, and United States. It started with a short symposium on January 20 at the Department of Geology, Jai Narayan Vyas University in Jodhpur, Rajasthan, with several talks covering the regional geology, stratigraphy, palaeogeography, geochronology, and chemostratigraphy of the Marwar Supergroup and equivalent successions. This symposium provides an excellent primer for the ensuing outcrop discussion. It was very clear from the very beginning of the workshop that geochronological constraints, detailed sedimentological and stratigraphic data, and careful palaeontological analysis would be the focal points of field discussion.

On the first three days of field excursion (January 21-23), the group examined outcrops near Jodhpur, focusing on the contact between the Marwar Supergroup and the underlying

~770 Ma Malani Igneous Suite, sedimentary structures in the Sonia Sandstone of the Jodhpur Group, various macroscopic fossils in the Sonia Sandstone, bituminous limestone of the Gotan Formation, and the contact between the Pondlo Dolostone and the overlying Nagaur Group. The suite of sedimentary structures in the Sonia Sandstone beneath the magnificent Mehrangarh Fort incited intensive discussion on the sedimentary environments of the lower Jodhpur Group. There seems to be evidence suggesting that the lower Jodhpur Group, particularly the Pokaran Conglomerate and perhaps the lower Sonia Sandstone were deposited in fluvial systems, and much of the remaining Sonia Sandstone was deposited in foreshore and shoreface environments. The Sonia Sandstone preserves abundant microbially induced sedimentary structures and numerous enigmatic structures that have been interpreted as discoidal fossils and megaplant fossils; if correct, these could potentially offer new insights into the Neoproterozoic evolution of macroscopic life.

On January 24, the group traveled to Nagaur, and examined a pink limestone at the Gotan Limestone – Pondlo Dolostone transition, as well as a very nice section of a pyroclastic bed at the Sonia Sandstone – Girbhakar Sandstone transition in the Jodhpur Group. There was extensive discussion at the outcrop on the origin and potential implications of this pyroclastic bed. This pyroclastic bed could be dated and may provide a much needed age constraint on the depositional age of the Jodhpur Group. Several participants took samples for radiometric dating and palaeomagnetic analysis.

On the following day, the group examined several quarries near Dulmera to study the

abundant trace fossils preserved in the Nagaur Sandstone. Indian scientists have reported a diverse assemblage of trace fossils (including *Rusophycus*, *Cruziana*, *Monomorphichnus*, *Isopodichnus*, *Treptichnus pedum*, *Bergaueria*, among many others) from these quarries. These fossils unambiguously suggest that the Nagaur Sandstone must be no older than the lower Cambrian (Stage 2 of Terreneuvian). This is consistent with the youngest zircon (ca. 536 Ma) extracted from the Nagaur Sandstone as reported in previous studies (Malone et al., 2008; McKenzie et al., 2011; Turner et al., 2014). There was much discussion on the outcrop about the sedimentary environments of the Nagaur Sandstone and the need to carry out a careful analysis of the environmental distribution of trace fossils.

On January 26, the group moved camp to Sam west of Jaisalmer, stopping near Pokaran to examine the Pokaran Conglomerate at the base of the Jodhpur Group. The Pokaran Conglomerate has been variously interpreted as fluvial or glacial deposits. The participants discussed these alternative interpretations and concluded on the basis of sedimentary structures and stratigraphic relationships that the Pokaran Conglomerate is likely fluvial deposits. Evidence advanced for glacial striations could be alternatively of tectonic and/or eolian origins.

On the return trip back to Jodhpur on the last day of field excursion, the group visited the beautiful Patwa Haweli in the Golden City Jaisalmer and examined additional outcrops of the Malani Igneous Suite and the Sonia Sandstone. The Patwa Haweli gave the participants an opportunity to appreciate the rich historical and architectural heritage of Rajasthan. Upon return to Jodhpur, the group

had a valedictory function where scientific problems of the Marwar Supergroup were also discussed. Most participants felt that there is an imperative need to further constrain the depositional age of the Marwar Supergroup. At the present, the Marwar Supergroup is loosely constrained by the ~770 Ma Malani Igneous Suite and lower Cambrian trace fossils in the Nagaur Sandstone. The pyroclastic bed at the transition between the Sonia Sandstone and the Girbhakar Sandstone could potentially provide a much needed age constraint, and carbon and strontium isotope analysis of the Bilara Group could facilitate a chemostratigraphic correlation with other dated Neoproterozoic successions. It has also been suggested that xenotime overgrowth could provide potential age constraints on the Jodhpur Group. One of the challenges in the geological study of Marwar Supergroup is the poor exposure of the stratigraphic succession. Thus, it was strongly suggested that the scientific community should work closely with the petroleum industry that have drilled in the Marwar Basin.

Overall, this was an excellent field workshop. Trip leader Mukund Sharma and his team (Santosh K. Pandey, V. K. Singh, Arif Husain Ansari, A. S. Rathore, Shamim Ahmed, and Bandana Dimri) did an outstanding job in arranging the logistics. The participants represent a wide range of research fields, including stratigraphy, sedimentology, palaeontology, palaeomagnetism, geochronology, tectonics, basin analysis, geophysics, and exploration geology. All participants had learned something important about the geology of the Marwar Supergroup. The field workshop was organized by the Society of Earth Scientists (Lucknow) and supported by the Birbal Sahni Institute of

Palaeobotany, Indian Council of Scientific and Industrial Research, Department of Atomic Research, New Delhi, International Subcommission on Ediacaran Stratigraphy, International Subcommission on Cambrian Stratigraphy, International Geological Correlation Program 587, the Jai Narayan Vyas University (Jodhpur), and Ramgad Minerals & Mining Limited (Hospet).

Shuhai Xiao

Department of Geosciences, Virginia Polytechnic and State University, Blacksburg, VA 24061, USA

Mukund Sharma

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226007, India



Group picture at a Dulmera quarry in front of the Nagaur Sandstone. From left to right: Daniel G. Poire, Dilip Saha, quarry owner, Zhenbing She, Ulf Linnemann, Uday Bhan, Bivin George, Veeru Kant Singh, Jamie Stewart, Irene Gomez, Pranjal Saikia, Satish C. Tripathi, Ramson Asher, Bandana Dimri, Mukund Sharma, Surendra Kumar, Anand P. Singh, Rajni Tewari, Joseph G. Meert, Shuhai Xiao, Arjun Singh Rathor, Pitambar Pati, Shamim Ahmad, Balram Bhadu, Rajesh Awasthi (Assistant), Arif H. Ansari, Madan Kumar (Driver), Stuart D. Burley (photograph by Santosh Kumar Pandey).

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Report of 2014 China Workshop

11–22 June 2014, Hubei, Hunan, Guizhou, and Guangxi Provinces, South China



The Neoproterozoic Era (1000–542 million years ago) is emerging as one of the focuses in Earth system history studies. It is a geological interval of dramatic climatic change and important evolutionary innovations. The early Neoproterozoic is characterized by the final assembly and subsequent disassembly of the Rodinia supercontinent (Hoffman, 1991), associated with extensive continental rifting events. Global glaciations of unusual magnitude occurred in the Cryogenian Period (Kirschvink, 1992; Hoffman et al., 1998; Hoffman and Schrag, 2002; Jiang et al., 2003). The subsequent Ediacaran Period (Knoll et al., 2004, 2006) witnessed the radiation of various

eukaryotes, including animals (Gehling, 1991; Xiao et al., 1998; Bottjer and Clapham, 2006; Jensen et al., 2006; Liu et al., 2010; Erwin et al., 2011; Chen et al., 2013; Carbone and Narbonne, 2014), macroalgae (Xiao et al., 2002; Yuan et al., 2011), a unique assembly of acanthomorphic acritarchs (Zhang et al., 1998; Grey, 2005; Liu et al., 2014; Xiao et al., 2014), and classical Ediacara organisms (Narbonne, 2005; Fedonkin et al., 2007; Xiao and Laflamme, 2009; Liu et al., 2012; Gehling and Droser, 2013; Chen et al., 2014; Grazhdankin, 2014; Narbonne et al., 2014). There is increasing evidence suggesting that these evolutionary events may have been coupled with the progressive oxygenation and ventilation of the global oceans (Lenton et al., 2014; Lyons et al., 2014).

These exciting developments demand more rigorous stratigraphic subdivision and correlation of Neoproterozoic strata, particularly the Ediacaran and Cryogenian systems. To cultivate healthy discussion among Neoproterozoic workers, coordinated international efforts have been made to provide a platform for information exchange. These include the Subcommittee on Ediacaran Stratigraphy, Subcommittee on Cryogenian Stratigraphy, IGCP Project 512 (Neoproterozoic Ice Ages), IGCP 587 "Of Identity, Facies and Time: the Ediacaran (Vendian) Puzzle", among many others. In response to a 2012 survey carried out by the Subcommittee on Neoproterozoic Subcommittee, an international field workshop was organized to examine Ediacaran and Cryogenian stratigraphy in South China.

The choice of South China as a focus of this field trip is also motivated by the many contributions of Chinese scientists to our

understanding of Neoproterozoic stratigraphy and paleontology, as well as the opportunity to observe Neoproterozoic successions at many localities across the Yangtze Craton, from shallow-water inner shelf facies to deep-water basal facies (Fig. 1). Two and possibly three discrete glaciation events are recorded in Cryogenian successions in South China (Zhou et al., 2004; Zhang et al., 2011). The cap carbonate atop the terminal Cryogenian glacial deposit in South China is one of the best studied cap carbonates (Jiang et al., 2003; Jiang et al., 2006; Zhou et al., 2010; Bristow et al., 2011). Ediacaran successions in South China contain exceptionally preserved micro- and macrofossils, as well as abundant trace fossils, that have the potential to illuminate the early evolutionary history of animals and other multicellular eukaryotes (Xiao et al., 1998; Xiao et al., 2002; Yuan et al., 2011; Chen et al., 2013; Chen et al., 2014; Liu et al., 2014; Meyer et al., 2014; Xiao et al., 2014). In addition, Ediacaran successions in South China are characterized by mixed carbonates, phosphorites, and shales, providing opportunities for integrated chemostratigraphic and biostratigraphic investigation (Kaufman and Knoll, 1995; Zhou and Xiao, 2007; Zhou et al., 2007; Zhu et al., 2007; McFadden et al., 2008; McFadden et al., 2009; Yin et al., 2009; Xiao et al., 2012; Liu et al., 2013; Zhu et al., 2013). Finally, available radiometric dates from South China provide broad geochronological constraints and calibration of Neoproterozoic stratigraphy (Zhou et al., 2004; Condon et al., 2005; Zhang et al., 2008a; Zhang et al., 2008b; Gao et al., 2013). The new data will undoubtedly play a central role in the stratigraphic correlation of Ediacaran and Cryogenian strata.

The workshop starts with a 4-day field excursion (11–15 June 2014) to examine the Ediacaran and Cryogenian successions deposited in inner shelf facies in the Yangtze Gorges area of Hubei Province, focusing on the 750–720 Ma Liantuo Formation sandstone, the terminal Cryogenian Nantuo Formation diamictite (654–635 Ma), Ediacaran Doushantuo and Dengying formations (635–541 Ma), and the Ediacaran–Cambrian boundary in the Yanjiahe Formation. Participants debated on the depositional environment of the Liantuo Formation, whether the Liantuo Formation is part of the Tonian or Cryogenian System, the correlation of the Nantuo Formation and other Cryogenian diamictites in South China and beyond, the origin of extremely negative carbonate carbon isotopic values in the Doushantuo cap carbonate, sequence stratigraphy of the Doushantuo Formation, significance of carbon isotope chemostratigraphy and acritarch biostratigraphy in the subdivision and correlation of the Ediacaran System, as well as how to integrate biostratigraphic data (e.g., small shelly fossils, acritarchs, and trace fossils) and chemostratigraphic data (e.g., carbon and strontium isotopes) to correlate the Ediacaran–Cambrian boundary between carbonate and siliciclastic facies. The field excursion also highlighted recent progress on Ediacaran biostratigraphy based on acanthomorphic acritarchs from the Doushantuo Formation (Liu et al., 2014) and new discovery of classical Ediacara fossils including *Pteridinium*, *Rangaea*, *Charniodiscus*, and *Hiemalora* from the Dengying Formation (Chen et al., 2014).

The Yangtze Gorges field excursion was followed by a three-day symposium in Wuhan (16–18 June 2014), held together with the 3rd

International Conference of Geobiology. The symposium included 31 oral presentations and 20 poster presentations. In addition, the 3rd International Conference of Geobiology had a symposium with 10 oral presentations focusing on Precambrian geobiology. On June 18, participants had an opportunity to examine microfossils (e.g., acanthomorphic acritarchs, embryo-like microfossils, and tubular microfossils) from the Doushantuo Formation, macrofossils from the Lantian Formation, and Ediacara fossils from the Dengying Formation. Several participants also shared published and unpublished material from the Ediacaran Ura Formation in Siberia and the Biskopås Formation in southern Norway. During the symposium, eleven voting members and six corresponding members of the Ediacaran Subcommittee held a meeting to discuss strategies to divide the Ediacaran System, and made several recommendations that will be communicated to the Subcommittee at a later time.

After the Wuhan symposium, the group flew to Guiyang and started the final segment of the workshop to examine Ediacaran and Cryogenian successions deposited in slope and basal facies in eastern Guizhou, western Hunan, and northern Guangxi provinces. The Ediacaran successions in slope and basal facies are dominated by fine-grained siliciclastic sediments, including black shales and silicified mudstones. The Cryogenian System here is more complete than in the Yangtze Gorges area, including at least two discrete glacial diamictites. In addition to the Nantuo Formation diamictite, another glacial diamictite in the Chang'an Formation diamictite also occurs in slope and basal facies. Likely an equivalent to the Sturtian

glaciation in Australia or the Rapitan glaciation in North America, the Chang'an Formation diamictite is overlain by iron stone and sandstone of the Fulu Formation, black shale and rhodochrosite of the Datangpo Formation, and then the diamictite of the Nantuo Formation, which in places can reach over 1000 m in thickness. Although outcrops are spotty, this segment of the field workshop gave the participants an opportunity to appreciate the facies variation of Ediacaran and Ediacaran successions in South China and to debate on the source of silica in the silicified mudstone of the Ediacaran successions. Relevant to the Cryogenian Subcommittee, the field excursion included a stop to examine the continuous transition from siltstone of the Gongdong Formation (possibly pre-Cryogenian) to dropstone-bearing siltstone of the Cryogenian Chang'an Formation. At the end of the field excursion, voting and corresponding members of the Cryogenian Subcommittee held a meeting to discuss the criteria for the definition of the Cryogenian System and plans for future work.

Together, the three segments of the field workshop gave the participants an overview of Ediacaran/Cryogenian stratigraphy of South China and opportunities to discuss various topics related to the subdivision and correlation of the Ediacaran and Cryogenian systems. There were a total of 64 geologists who participated in all or part of the three segments (Fig. 2). The field workshop was sponsored by International Commission on Stratigraphy, State Key Laboratory of Palaeobiology and Stratigraphy and Key Laboratory of Economic Stratigraphy and Palaeogeography (Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences), Institute of

Geology (Chinese Academy of Geological Sciences), China University of Geosciences (Wuhan), National Natural Science Foundation of China, U.S. National Science Foundation, Subcommission on Ediacaran Stratigraphy, Subcommission on Cryogenian Stratigraphy, All-China Stratigraphic Commission, IGCP 587, and Virginia Tech Department of Geosciences. The organization committee consisted of Shuhai Xiao (chair), Linzhi Gao, Ganqing Jiang, Pengju Liu, Dan Wang Shucheng Xie, Chongyu Yin, Xunlai Yuan, Chuanming Zhou, and Maoyan Zhu.

Shuhai Xiao

*Department of Geosciences
Virginia Polytechnic and State
University, Blacksburg, VA 24061, USA*

Chuanming Zhou, Maoyan Zhu

*Nanjing Institute of Geol. and Palaeontology
Chinese Academy of Sciences
Nanjing 210008, China*

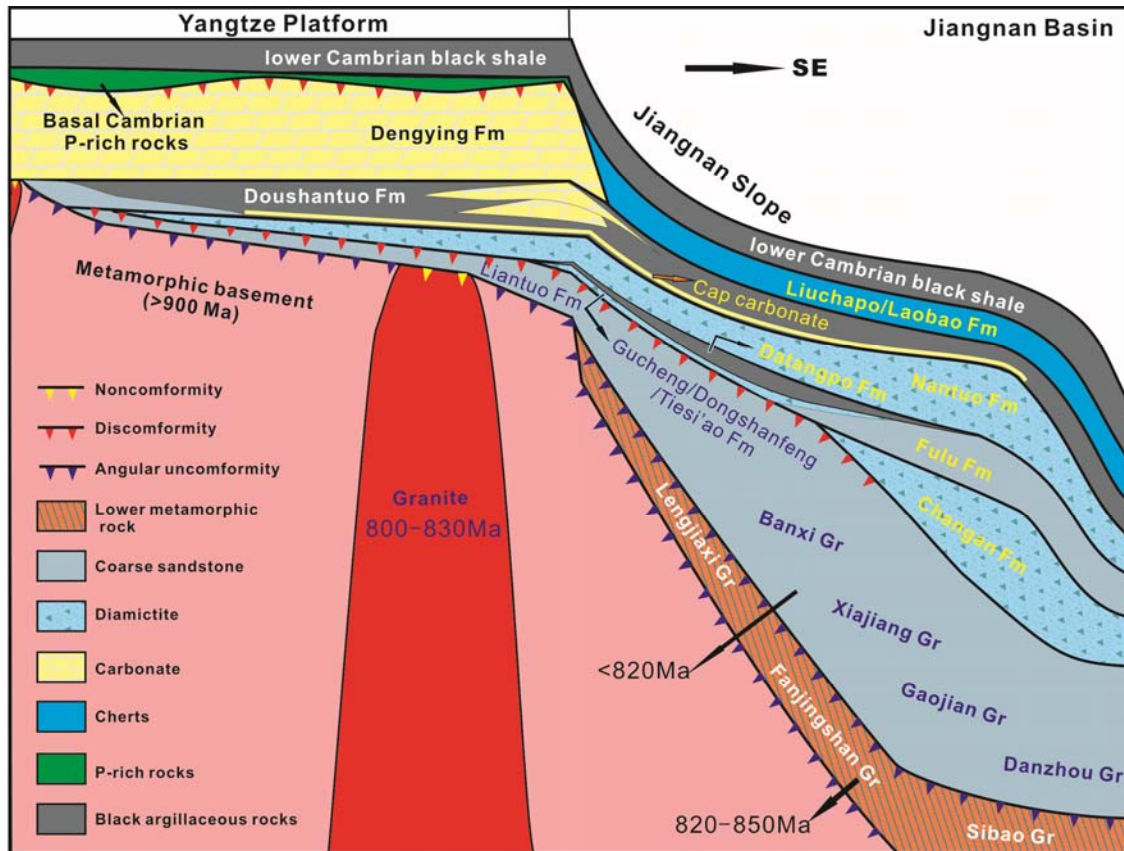
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A conceptual model of the Cryogenian-Ediacaran stratigraphic relationship across the Yangtze platform, from shallow water shelf facies (left) to deep water slope and basinal facies (right). Diagram prepared by Maoyan Zhu.

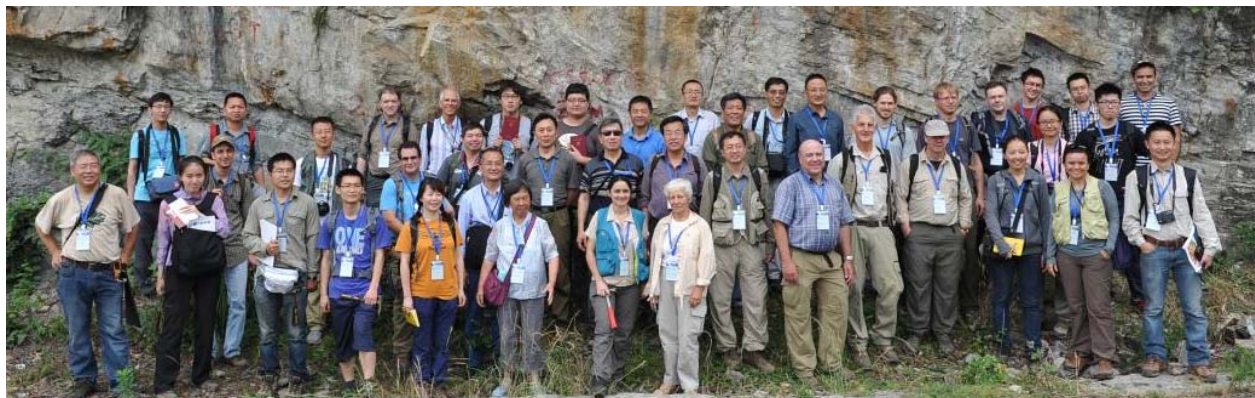


Fig. 2. Group picture of participants in the first segment of the field workshop, in front of the Doushantuo cap carbonate at the Jiulongwan section in the Yangtze Gorges area. From left to right: Maoyan Zhu, Chengguo Guan, Qing Ouyang, Jan-Peter Duda, Ke Pang, Xiang Chen, Huan Cui, Lei Chen, Graham Shields-Zhou, Alan J. Kaufman, Ying Zhou, Carlos Alvarenga, Daizhao Chen, Qirui Zhang, Wei Wei, Weilin Deng, Pengju Liu, Wei Guangyi, Chongyu Yin, Milene Figueiredo, Xunlai Yuan, Jinnan Tong, Edi Mendes Guimarães, Xinqiang Wang, Shuhai Xiao, Linzhi Gao, Ganqing Jiang, Guy Narbonne, Chuanming Zhou, James Gehling, Peter Adamson, Douglas Erwin, Dmitry Grazhdankin, Konstantin Nagovitsin, Uyanga Bold, Alex Liu, Frances Liu, Lucieth Vieira, Zhou Wang, Zerui Liu, Dermeval Do Carmo, Zhenbing She. Not present: Soo-Yeun Ahn, Zhe Chen, Inara Gehling, Lanyun Miao, Dan Wang, Jinlong Wang. Photograph by Zhe Chen.