



Edies

*International Commission on Stratigraphy
Subcommission on Ediacaran Stratigraphy*

Newsletter of the
Subcommission on
Ediacaran Stratigraphy

Number 2
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Opening Remarks from the Chair

By Shuhai Xiao

As we welcome the Year of Horse, I would like to take a moment to reflect on the past year. In 2013, the Subcommittee distributed its first newsletter, thanks to your contributions and to Marc Laflamme's editorial effort. In August 2013, Detlef Walde led a field workshop to examine the Neoproterozoic successions in the Paraguay Belt. Alex Liu is preparing a list of Ediacaran fossil sites in order to promote some of them as UNESCO world heritage sites (see <http://www.charmiaresearchgroup.com/index.html> as an example). Mukund Sharma and his team just completed an international field workshop on the Marwar Supergroup in Rajasthan, western India (see report below). Preparation for the 2014 field workshops in South China and Morocco is underway. The second circulars for both workshops will be distributed soon.

The Year of Horse will be a busy one. There will be several symposia focusing on Ediacaran paleobiology, stratigraphy, and environments at the 10th North American Paleontology Convention (February 15 - 18, 2014, Gainesville, Florida, USA) and the 4th International Paleontological Congress (September 28–October 3, 2014, Mendoza, Argentina). More importantly, there will be two field workshops sponsored by the Subcommittee: the Ediacaran-Cryogenian Joint Field Workshop in South China (preliminarily scheduled on 11–22 June, 2014), and the Ediacaran-Cambrian Joint Field Workshop in Morocco (15-24th September, 2014). We are hoping to have a good turnout for both workshops, particularly the South China workshop where we will discuss critical issues related to the subdivision of the Ediacaran Period.

I look forward to seeing you at these conferences and field workshops, and wish you a productive year in 2014!

Notes from the Secretary

By Marc Laflamme

Welcome to our second yearly newsletter. 2014 looks to be an exciting year for Ediacaran research, including special sessions at the North American Paleontological Convention on "Ediacaran Environments and Ecosystems", the International Paleontological Congress "Neoproterozoic Palaeobiology: Preservation, Palaeobiology, Environments and Phylogeny", and a special issue on the Ediacaran-Cambrian transition in the Journal of Paleontology. Our subcommittee was also very active in publishing exciting new results in top-tier journals (see references below). Please continue to keep us abreast of any important contributions to our discipline.

Subcommittee Annual Report (submitted to ICS on December 15, 2013)

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2. OVERALL OBJECTIVES, AND FIT WITHIN IUGS SCIENCE POLICY

Mission statement

The Subcommittee 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 Subcommittee 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 subcommittee sponsored field trips, workshops, and meetings;

In addition, the Subcommittee 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 Subcommittee 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**

Subcommission (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 2013

- Corresponding member Alexander Liu is preparing a list of Ediacaran fossil sites in order to promote some of them as UNESCO world heritage sites. One example of his compilation can be found at <http://www.charniaresearchgroup.com/index.html>.
- The first annual newsletter was disseminated in February 2013.
- An international field workshop, sponsored by the Subcommittee and entitled "The Neoproterozoic Paraguay Belt (Brazil): glaciation, iron-manganese formation and biota" was held at Campo Grande and Corumbá, Brazil, August 4-9, 2013. The workshop was organized by corresponding member Detlef Walde at Universidade de Brasília. Voting members (Alan J. Kaufman, Chuanming Zhou) and corresponding members (Paulo Boggiani, Claudio Gaucher, Patricia Rich) participated in the workshop.
- Corresponding member James D. Schiffbauer and Chair Shuhai Xiao organized a symposium on Ediacaran-Cambrian transition at the 2012 Geological Society of America annual meeting in Charlotte, North Carolina. Based on this symposium, a special issue of *Journal of Paleontology* edited by Schiffbauer and Xiao will be published in March 2014.
- Following the 2012 Subcommittee field trip in South China and in preparation for the 2014 Subcommittee field workshop in

Yichang (June 11-22, 2014), Subcommittee chair Shuhai Xiao, voting members (Chuanming Zhou and Xunlai Yuan), and corresponding member (Pengju Liu) carried out joint field excursion to examine outcrops and sections to be visited in 2014. Extensive discussion with members of the Cryogenian Subcommittee (Graham Shields-Zhou, Maoyan Zhu, and Linzhi Gao) resulted in a joint field workshop with the Cryogenian Subcommittee. Logistic arrangement has been made and the first circular has been sent out.

- Subcommittee chair organized a symposium “Critical Transition in the History of Life and Earth” at the GSA-GSC joint meeting in Chengdu, China, on June 17-19, 2013.
- The 2014 International Field Workshop on the Marwar Supergroup, Rajasthan, western India (will be held on 20th-28th January 2014) is underway. Corresponding member Mukund Sharma is the organizer of this field workshop, which is co-sponsored by the Subcommittee. This field trip will examine the Ediacaran and Cambrian successions, as well as numerous Ediacara fossils reported by Indian paleontologists.
- Voting members Jim Gehling and Guy Narbonne are organizing a symposium on “Neoproterozoic palaeobiology: preservation, palaeobiology, environments and phylogeny” at the 4th International Paleontological Congress (September 28 - October 3, 2014; Mendoza, Argentina)
- Voting member Jose-Javier Alvaro is organizing a field workshop on the Ediacaran-Cambrian stratigraphy of Morocco (September 15-24, 2014; Ouarzazate, Morocco). This field workshop is jointly sponsored by the Ediacaran and Cambrian Subcommittees.
- Secretary Marc Laflamme is putting together a symposium on “Ediacaran

Environments and Ecosystems” at the 10th North American Paleontological Convention (February 15-18, 2014; Gainesville, Florida). Abstracts have been accepted from several international voting and corresponding members.

4a. OBJECTIVES AND WORK PLAN FOR 2014

- Keep the Subcommittee webpage (www.paleo.geos.vt.edu/Ediacaran/) up to date.
- Several field workshops and symposia, with a strong focus on Ediacaran stratigraphy, will occur in 2014.
 - International Field Workshop on the Marwar Supergroup, Rajasthan, western India (20th-28th January 2014): First circular has been sent out; Organizer: Dr. Mukund Sharma (corresponding member);
 - Symposium “Ediacaran Environments and Ecosystems” at the 10th North American Paleontological Convention (15th-18th February 2014; Gainesville, Florida): <http://www.flmnh.ufl.edu/napc/>; Organizers: Lydia Tarhan and Marc Laflamme (secretary and voting member);
 - ICS Ediacaran-Cambrian Joint Field Workshop on Ediacaran-Cambrian Stratigraphy (15-24th September 2014, Ouarzazate, Morocco): First circular has been sent out; Organizer: Dr. J. Javier Alvaro (voting member);
 - ICS Ediacaran-Cryogenian Joint Field Workshop on Cryogenian-Ediacaran Stratigraphy (11-22nd June 2014, Yichang, China): First circular has been sent out; Organizers: Shuhai Xiao (Chair), Chuanming Zhou (voting member), Linzhi Gao, Pengju Liu, Chongyu Yin (voting member), Xunlai Yuan (voting member), Maoyan Zhu (voting Member),
 - Symposium “Neoproterozoic palaeobiology: preservation, palaeobiology, environments and

- phylogeny” at the 4th International Paleontological Congress (September 28 - October 3, 2014; Mendoza, Argentina): www.ipc4mendoza2014.org.ar organized by Jim Gehling and Guy Narbonne (both voting members)
- Participants in these field workshops and symposia will discuss the criteria and protocols for the subdivision of the Ediacaran Period, following guidelines resulting from a 2009 survey, which are 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.
 - We should proceed from Series to Stages, rather than from Stages to Series (as practiced in Phanerozoic stratigraphy). 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 2014

Following discussion at the China field workshop, a vote will be called to decide

- (1) What criteria will be the most useful in Ediacaran subdivision and correlation? The results from this vote will be used as a basis for subsequent decisions concerning System-level subdivisions.
- (2) Whether the Ediacaran System should be divided into two or three series.

5. SUMMARY OF EXPENDITURES IN 2013:

INCOME	
Forwarded from 2012	US\$ 458
ICS	US\$ 3,333
<u>Total</u>	<u>US\$ 3,791</u>
EXPENDITURES	
Travel expenses	US\$ 2,550
Office expenses	US\$ 350
<u>Total</u>	<u>US\$ 2,900</u>
To be carried forward to 2014	US\$ 891

6. BUDGET REQUESTS AND ICS COMPONENT FOR 2014

In 2014, there will be three field workshops sponsored by the Subcommittee. These field trips will be in South China, western India, and Morocco. Additional Subcommittee activities are planned at the IPC (Argentina), NAPC (Florida), and GSA (Vancouver) meetings. Of these, the South China field trip—Yangtze Gorges 2014—is critical for Ediacaran subdivision and eventually the establishment of series-level GSSPs of the Ediacaran System. The organization committee of the Yangtze

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Gorges 2014 field trip has already received several applications for financial assistance from graduate students, post-doctoral fellows, and young scientists. We anticipate multiple awards, equivalent to the full waiver of the \$1,200 registration fees for seven participants (total amount \$8,400). To meet this financial challenge, we have already submitted a proposal to the Chinese Academy of Sciences to request some modest financial assistance. We are also requesting **\$3,000** from the ICS NSF grant to support this field workshop, in addition to the regular budget request of **\$5,109**.

PROJECTED EXPENSES

Office expenses	US\$ 400
Travel expenses	US\$ 4,200
Workshop sponsorship	US\$ 8,400
<u>Total</u>	<u>US\$ 13,000</u>

PROJECTED INCOME:

Carried over from 2013	US\$ 891
Requested: ICS NSF project to support the South China workshop	US\$ 3,000
Requested: Chinese Academy of Sciences grant	US\$ 4,000
<u>Total</u>	<u>US\$ 7,891</u>
BUDGET REQUESTS	US \$5109

7. 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 Grahdankin (Institute of Petroleum Geology and Geophysics, Koptyug Avenue 3, Novosibirsk 630090, Russia; dima.grahzdankin@googlemail.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.
- Grahdankin, 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
 - 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 ...

8. Contributions by our members: We have included a list of relevant 2013-2014 publications as submitted by our members.

Please continue to keep us abreast of your scientific contributions to our field.

Articles from 2013/early 2014:

- Babcock, L. E., S. Peng, M. Zhu, S. Xiao, and P. Ahlberg, in review. Proposed reassessment of the Cambrian GSSP. *Journal of Asian Earth Sciences*.
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- Guo, Q., Strauss, H., Zhu, M., Zhang, J., Yang, X., Lu, M., Zhao, F., 2013. High resolution organic carbon isotope stratigraphy from a slope to basinal setting on the Yangtze Platform, South China: Implications for the Ediacaran–Cambrian transition. *Precambrian Research*, 225: 209-217.
- Hall, M., Kaufman, A.J., Vickers-Rich, P., Ivantsov, A., Trusler, P., Linnemann, U., Hofmann, M., Elliott, D., Cui, H., Fedonkin, M., Hoffmann, K.H., Wilson, S.A., Schneider, G., Smith, J. 2013. Stratigraphy, palaeontology and geochemistry of the late Neoproterozoic Aar Member, southwest Namibia: Reflecting environmental controls on Ediacara fossil preservation during the terminal Proterozoic in African Gondwana. *Precambrian Research*, 238: 214–232.
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- Ling, H., Chen, X., Li, D., Wang, D., Shields-Zhou, G., Zhu, M., 2013. Cerium anomaly variations in Ediacaran-earliest Cambrian carbonates from the Yangtze Gorges area, South China: Implications for oxygenation of coeval shallow seawater. *Precambrian Research*, 225:110-127.

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- Special issue: Journal of Paleontology**
Ediacaran Cambrian Transitions, edited by
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- JOURNAL OF PALEONTOLOGY**
Volume 88 ▪ Number 2 ▪ March 2014
- Guy M. Narbonne, Marc Laflamme, Peter W. Trusler, Robert W. Dalrymple, and Carolyn Greentree.** Deep-water Ediacaran fossils from northwestern Canada: taphonomy, ecology, and evolution
- Malgorzata Moczydlowska, Frances Westall, and Frédéric Foucher.** Microstructure and biogeochemistry of the organically preserved Ediacaran metazoan Sabellidites
- Mike Meyer, David Elliott, James D. Schiffbauer, Michael Hall, Karl H. Hoffman, Gabi Schneider, Patricia Vickers-Rich, and Shuhai Xiao.** Taphonomy of the Ediacaran fossil *Pteridinium simplex* preserved three-dimensionally in mass flow deposits, Nama Group, Namibia
- Lucas V. Joel, Mary L. Droser, and James G. Gehling.** A new enigmatic, tubular organism from the Ediacara Member, Rawnsley Quartzite, South Australia
- Stephen M. Rowland and Margarita G. Rodriguez.** A multicellular alga with exceptional preservation from the Ediacaran of Nevada
- Dmitriy Grazhdankin.** Patterns of evolution of the Ediacaran soft-bodied biota
- James G. Gehling, Bruce N. Runnegar, and Mary L. Droser.** Scratch traces of large Ediacaran bilaterian animals
- Francis A. Macdonald, Sara B. Pruss, and Justin V. Strauss.** Trace fossils with spreiten from the late Ediacaran Nama Group, Namibia: complex feeding

patterns five million years before the Precambrian–Cambrian boundary

Calla Carbone and Guy M. Narbonne. When life got smart: the evolution of behavioral complexity through the Ediacaran and early Cambrian of northwestern Canada

Takafumi Mochizuki, Tatsuo Oji, Yuanlong Zhao, Jin Peng, Xinglian Yang, and Sersmaa Gonchigdorj. Diachronous increase in early Cambrian ichnofossil size and benthic faunal activity in different climatic regions

Xinglian Yang, Yuanlong Zhao, Weiyi Wu, Zongyuan Sun, Haolin Zheng, and Yajie Zhu. Affinities and taphonomy of a Cambrian discoid from Guizhou, South China

John L. Moore, Susannah M. Porter, and Guoxiang Li. Two unusual small shelly fossils from the lower Cambrian of southeastern Shaanxi Province, China

Guoxiang Li, Zhifei Zhang, Hong Hua, and Huining Yang. Occurrence of the enigmatic bivalved fossil *Apistoconcha* in the lower Cambrian of southeast Shaanxi, North China Platform

Fangchen Zhao, Shixue Hu, Han Zeng, and Maoyan Zhu. A new helmetiid arthropod from the early Cambrian Chengjiang Lagerstätte, southwest China

Xiaoya Ma, Richard J. Aldridge, David J. Siveter, Derek J. Siveter, Xianguang Hou, and Gregory D. Edgecombe. A new exceptionally preserved Cambrian priapulid from the Chengjiang Lagerstätte

Jesse Broce, James D. Schiffbauer, Kriti Sen Sharma, Ge Wang, Shuhai Xiao. Possible animal embryos from the lower Cambrian (Stage 3) Shuijingtu Formation, Hubei Province, South China

Tae-Yoon Park, Ji-Hoon Kihm, Imseong Kang, and Duck K. Choi. Ontogeny of a new species of the Cambrian Series 3 (middle Cambrian) trilobite genus *Liostracina* Monke, 1903 from North

China and the taxonomic position of the superfamily Trinucleoidea

Steven T. Loduca and Anthony Kramer. Graptolites from the Wheeler and Marjum formations (Cambrian, Series 3) of Utah

Year in review: 2013

By Martin Brasier and Marc Laflamme

Should you wish to inform the subcommission of any progress over the past year, please do not hesitate to contact Marc Laflamme (marc.laflamme@utoronto.ca).

University of Oxford: In March 2013, we held a celebration at Leicester University for the seven decades of geological contribution made by Trevor Ford, including the palaeontology of Charnwood Forest and *Charnia*. In the same month, we held an international Lyell meeting on the Cambrian Explosion, at the Geological Society, London, at which there was much discussion concerning the nature of the Ediacaran-Cambrian transition and the position of the Ediacaran-Cambrian boundary. A strong defense was offered for the basal Cambrian stratotype in Newfoundland by Duncan McIlroy, and by Martin Brasier. Through the summer, Martin Brasier worked with the Bradgate Trust and Natural England on a survey of approaches for improving the protection of the fossil beds in Bradgate Park, after the site suffered further vandalism. Preliminary action has now been taking in the form of signs, legal warnings, and ropes. In July, Luke Parry submitted his MEdSc thesis on the Ediacaran of Corumba, Brazil (under Martin Brasier, with Paulo Boggiani, Thomas Fairchild and Juliana Leme), for which he won a Palaeontological Association Prize. During July to September, the Oxford Group of Jack

Matthews and Tom Hearing, plus Alex Liu, continued their mapping and geochronology work in the Mistaken Point Ecological Reserve and at sites on the Bonavista Peninsula. In October, Renee Hoekzema began her work (as a theoretical mathematician) on modeling the growth and evolution of rangeomorphs and on testing the relationship with dickinsoniomorphs. Also in October, Martin Brasier travelled to Brazil to present a lecture on new fossil finds and new geochronology of the Ediacaran of Brazil, at the 23rd Palaeontological Congress of Brazil in Gramado. Jonathan Antcliff has also returned to Oxford for his research into Ediacaran and Cambrian taphonomy, being based at the Oxford Natural History Museum.

University of Toronto: In May-June, Secretary Marc Laflamme collaborated with corresponding members Douglas Erwin and Erik Sperling to investigate Ediacaran sections in southern Namibia. This research was funded through the generous support of the National Geographic Society and the NASA Astrobiology Institute (MIT Node).

List of Working (Task) Groups and their officers

Task Group to redefine the Ediacaran-Cambrian boundary, led by voting member Dr. Maoyan Zhu, with Dr. Shuhai Xiao as a member;

A new Working (Task) Group focusing on the subdivision of the Ediacaran System will be formed after initial discussion at the South China workshop in June 2014.

Interfaces with other international projects:

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), Patricia Vickers-Rich (Monash University), Jim Gehling (South Australian Museum) and Guy Narbonne (Queens University).

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).

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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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