

IGCP PROJECT (2010-2015) Updated 7 April 2011

PROJECT: Of Identity, Facies and Time, the Ediacaran (Vendian) Puzzle

A successor to:

IGCP 493. The Rise and Fall of the Vendian Biota (Ediacaran Period)

<http://www.earth.monash.edu.au/PreCsite/index.html>

1. Topics

(i) **1.4** Global Change and Life Evolution

(iii) IGCP493 and this successor project have and will continue to develop a number of outreach programs to communicate research results to students at all levels (Primary, Secondary, Tertiary) and the general public through popular publications, exhibitions, stamp issues, public lectures and developing curriculum in both developed and developing countries). This will be one of the foci in this project as well.

This project also addresses one of the topics of particular interest to IGCP – Global Change and the Evolution of Life: Evidence from the Fossil Record

2. Short title of project

Of Identity, Facies and Time – the Ediacaran (Vendian) Puzzle

3. Full title of project

Of Identity, Facies and Time – the Ediacaran (Vendian) Puzzle: *Factors Controlling the Observed Diversity and Reality of the Relationships of the Earliest Metazoans*

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5. Scale of Project

Global

6. Brief Outline of Project (Resume)

This project is particularly interested in the precise timing of Proterozoic events, the effects that the changing environments of the time, climates, global ocean and atmospheric chemistry and palaeogeography had on the development and diversification of animals, culminating in the spectacular Ediacaran/Vendian faunas. These biotas are best represented along the Winter Coast of the White Sea in Russia, the Flinders Range of South Australia, the deserts of southern Namibia and the coastal outcrops of Newfoundland, but other less biodiverse faunas may provide significant input regarding the origin and demise of this unique metazoan assemblage. And furthermore, working out what controls the makeup of these globally distributed assemblages, facies or evolutionary stage, with its biostratigraphic implications, is a central issue to this proposal.

This project aims to extend the work begun by IGCP493 (2003-2009) in attempting to locate additional material from areas with a sparse Ediacaran biotic record (South America, Middle East, Siberia, Mongolia), but with marked palaeobiogeographic interest; to closely compare those settings (using sedimentology and detailed basin analysis, carbon and oxygen isotope input, palaeogeography) settings of where some of the most abundant Ediacaran biotas have been collected. This project will allow the proposers and associates to increase significantly the data base (and stimulate further discussion and joint research) of some of those less biodiverse, yet specimen abundant, assemblages, such as those in Namibia, as well as classic sites in the Ukraine, Siberia, and the Urals, and microsites in Mongolia, China, the White Sea, Australia. The project will attempt to push further back in time and examine older assemblages, such as those in the Bangamall Basin of Western Australia and new material from Tasmania, where some of the oldest probable records of multicellular organisms have been reported. And, we hope to access slightly younger sequences that themselves predate the oldest metazoan producing sediments in a hunt for the ancestors of the Ediacarans. Beyond that some younger sediments, such as the Kangaroo Island Cambrian locales and others globally will be searched for the offspring and latest survivors of the Ediacarans in a quest to work out what happened to this diverse and enigmatic fauna that was successful for more than 40 million years at least.

In doing so, we wish to bring together researchers across many disciplines to examine and gain experience with the Ediacaran assemblages worldwide, to involve students and non-scientists, artists, documentary makers, etc. in the hope of markedly increasing the amount of material from some of the lesser known locales, refining the dating of all of these locales, and popularizing the research results to a broader audience. By understanding the sequence and rate of occurrence of such biotic events during the Neoproterozoic and their drivers, wisdom concerning our future predictions of climate and habitability of the Earth will also be an outcome.

7. Estimated duration of

5 years

8. Full description of project

8.1. Aims and Background

For background reference IGCP493 (www.geosci.monash.edu.au/precsite)

- ⌘ Further detailed examination of each of the major Ediacaran successions (Yangzte, Avalon, White Sea, Nama) to tease out whether they represent evolutionary, geographic or facies controlled assemblages or combinations of these factors. Finely detailed sedimentology, basin analysis, geochemistic, radiometric dating and biostratigraphic analysis of microfossils – all to be pursued.
- ⌘ Develop a more detailed biostratigraphy for the Ediacaran Period, emphasizing micropalaeontology. One example will be a specific study to biostratigraphically tie the newly discovered Mongolian silica-based microfossil assemblages with other Ediacaran (Vendian) assemblages, how does the Russian acritarch succession relate to the Australian? Etc.
- ⌘ Search for the ancestors and survivors – for origins of the Ediacarans and their offspring using both palaeontology and molecular biology approaches, with an attempt to further integrate data from both of these disciplines. Molecular biology has presented evidence for bilaterians evolving in the Ediacaran and sponge-grade organisms in the late Cryogenian. A comparison molecular evidence with newly discovered mega- and microfossils is needed.
- ⌘ Determine what are the true affinities of many of the Ediacarans (Vendians) – what is Yorgia, Dickinsonia, etc. and how did they live their lives – some clues exist but further field data and analyses are needed.
- ⌘ Establish a better understanding of the drivers for the rise and fall of the Ediacaran (Vendian) biotas

8.2 Significance

“To solve the puzzle of Ediacaran fossils, paleontologists have to become more perceptive to unorthodox thinking. They also need to broaden their field searches to seek fossil in such sediments as black shales, cherts, and bituminous limestones. These unconventional preservational windows may offer novel perspectives on Ediacarans. In addition, future analyses should focus on the evolutionary patterns and processes of the rise and demise of the Ediacaran biota.” Shuhai Xiao, *Science*, 21 March 2008 (1618-1619).

Xiao points to how much more detail about environment, ocean chemistry, climate and in addition to us, precise timing of events, are needed before the “puzzle” of the Ediacarans is more fully constructed. The rise of animals on Earth is a fundamental issue that needs decidedly more study before we have a true grip on working out just how this happened and when. This proposed project attempts to add more of that detailed information and analysis.

8.3 Present state of activities in the field of the proposed project

Studies of Precambrian biotas have been a hot topic in scientific journals over the past decades, and the concept of the first animals on Earth is popular with the general public. The scientific literature is vast, and as part of IGCP493, the base upon which this proposal is built, two publications resulted which summarize in detail the state of research and the resulting vast literature.

Fedonkin, M. A., Gehling, J. G., Grey, K., Narbonne, G. M. & Vickers-Rich, P., 2007. *The Rise of Animals. Evolution and Diversification of the Kingdom Animalia*, Johns Hopkins University Press, 328 pp. (with a 35 page Atlas detailing available knowledge of all taxa of Ediacarans known to date, and with an extensive bibliography).

Vickers-Rich, P. & Komarower, P., 2007. *The Rise and Fall of the Ediacaran Biota*. Geological Society of London, Special Contribution 286, 456 pp. (a collection of research papers resulting from two international conferences organized under the auspices of IGCP493 in Prato, Italy along with the International Geological Congress and another in Kyoto, Japan).

Trusler, P., Vickers-Rich, P. & Rich, T. H., 2010. *The Artist and the Scientists. Bringing Prehistory to Life*. Cambridge University Press, Cambridge.

In addition to those, and other publications which resulted from IGCP493, the website can be accessed to demonstrate the awareness of the proposers to this research field (www.geosci.monash.edu.au/precsite).

Exemplary papers indicative of the state of activities in this field and relate directly to themes that will be pursued in this project include:

Bamforth, E. L., Narbonne, G. M. & Anderson, M. M., 2008. Growth and ecology of a multi-branched Ediacaran rangeomorph from the Mistaken Point Assemblage, Newfoundland. *Journal of Paleontology*, 82 (4): 763-77.

Canfield, D. E. et al., 2008. Ferruginous conditions dominated later Neoproterozoic deep-water chemistry. *Science*, 321: 949-952.

- Grazhdankin, D. V. et al., 2008. Carbonate-hosted Avalon-type fossils in Arctic Siberia. *Geology*, 36 (10): 803-806.
- Hoffman, P. F., 2009. Pan-glacial-a third state in the climate system. *Geology Today*, 25 (2): 107-114.
- Knoll, A. H. et al., 2006. The Ediacaran Period: a new addition to the geologic time scale. *Lethaia*, 39: 13-30.
- Kumar, G & Maithy, P. K., 2008. The Ediacaran Period: It's lower and upper boundaries in India. *The Palaeobotanist*, 37 (2008): 33-52.
- Laflamme, M & Narbonne, G. M., 2008. Competition in a Precambrian world: palaeoecology of Ediacaran fronds. *Geology Today*, 24 (5): 182-187.
- Lin, J-P et al., 2006. A parvancorina-like arthropod from the Cambrian of South China. *Historical Biology*, 18 (1): 33-45.
- McFadden, K. A. et al., 2008. Pulsed oxidation and biological evolution in the Ediacaran Doushantuo Formation. *PNAS*, 105 (9): 3197-3202.
- McNamara, K.J., 2008. Earth and life: Origins of Phanerozoic diversity. *Australian Journal of Earth Sciences*, 85: 1023-1036.
- Narbonne, G., 2005. The Ediacara Biota: Neoproterozoic origin of Animals and their Ecosystems. *Annual Review of Earth and Planetary Sciences*, 33: 421-442.
- Shu, D-G et al., 2006. Lower Cambrian vendobionts from China and early diploblast evolution. *Science*, 312 (5774): 731-734.
- Swalla, B. J. & Smith, A. B., 2008. Deciphering deuterostome phylogeny: molecular, morphological and palaeontological perspectives. *Philosophical Transactions of the Royal Society, B*, doi:10.1098/rstb.2007.2246 (published online).
- Valentine, J. W., 2004. *On the Origin of Phyla*. University of Chicago Press.

8.4 Workplan

Year 1. (2010) Australia, India, Newfoundland

- ☞ Participate in the **field conference** Precambrian Life, Time and Environment: Evolving Concepts and Modern Analogues offered by IGCP512 from 2-9 Feb 2010 in the Lesser Himalayas with the purpose to visit the more important metazoan-bearing sections on the Indian subcontinent.

- ☞ **Fieldtrip** with colleagues in this new proposal to significant Australian locales (Flinders Ranges, South Australia) and production of revised **field guide** to these areas examining sedimentology (with emphasis on facies associations), biostratigraphy, taphonomy.
- ☞ **Filming** in Flinders Ranges and Kangaroo Island for a **documentary** that was initiated by IGCP493 with **David Attenborough** and Atlantic Productions in the UK based on *The Rise of Animals. Evolution and Diversification of the Kingdom Animalia*, which was written by participants in IGCP493. This is to be a two part documentary that will highlight the outcomes of this and the IGCP493/587 projects.
- ☞ Field conference in Newfoundland to focus on the issues of facies vs evolutionary controls on Ediacaran assemblages, June-July.
- ☞ Meet with local community groups to plan how **public outreach centers**, educational material could be prepared concerning the Precambrian sequence in the Flinders Ranges of South Australia and the Aus region of southern Namibia, where a small museum has been emplace and a heritage listing is underway for one of the farms in this region rich in Ediacaran fossils.
- ☞ Revise and update **website** which was engineered for predecessor project IGCP493 (<http://www.geosci.monash.edu.au/precsite>)
- ☞ **Begin revision** of *The Rise of Animals. Evolution and Diversification of the Kingdom Animalia* with Johns Hopkins University Press. This book was published in late 2007 with the idea of stimulating discussion and re-examining the taxonomy and phylogenetic relationships of the Ediacaran metazoans. A significant collection of new research papers and correspondence/conversations with colleagues has already been resulted, as hoped, and these and others collected up to this date are to be incorporated into the revision.
- ☞ **Complete a popular large format book** on Science and Art (*The Artist and the Scientists. Bringing Prehistory to Life*) that highlights the palaeo-reconstruction art carried out by artist Peter Trusler, a significant part of which has featured Neoproterozoic metazoans – work with Narbonne, Gehling, Vickers-Rich, Fedonkin and others. The book is being published by Cambridge University Press and will accompany an **exhibition** featuring the original art and due to be on show in Singapore (the Singapore Science Centre) and Taiwan (the National Museum of Natural Sciences in Taichung) during 2010 and travel globally thereafter.
- ☞ **Launch traveling exhibition** called *Wildlife of Gondwana* which includes a section on the Ediacarans, particularly those collected from Gondwana (Australia, Namibia, South America) at the South Australian Museum in late 2009-early 2010

and continue to add new specimens that result from field efforts, develop further educational kits that are up to date with new information gained during duration of this new IGCP Project. A public lecture (the Sprigg lecture will accompany this exhibition. This exhibition will travel from Adelaide, South Australia to Singapore Science Centre in mid 2010 and then to the Northern Territory Museum and Art Gallery in Darwin in late 2010. It popularizes the research and also generates funding for both research and education.

- ☛ **Continued Discussion concerning Initial visit to Iran** under the auspices and invitation of the Geological Survey of Iran to plan a longer term field program investigating possible Ediacaran sites near Kushk.

Year 2. (2011). South America, Namibia India, Saudi Arabia, Siberia, Italy

- ☛ **Reconnaissance trip** to the Puncoviscana Formation in Argentina with Drs. Guillermo and Gilberto Acenolaza (Universidad de Tucuman, Argentina) and to late Neoproterozoic rocks in Rio Negro Province, Argentina.
- ☛ Continue traveling the *Wildlife of Gondwana Exhibition* to the Australia and continue negotiations for Middle East (U.A.E) and South Africa.
- ☛ Begin traveling *The Artist and the Scientist Exhibition*, with negotiations underway in South Africa and Europe (launch expected in Prato, Italy)
- ☛ Continue revision of a **highly illustrated popular book** (*The Rise of Animals. Evolution and Diversification of the Kingdom Animalia*) on the origin and early evolution of life and the first animals, emphasizing the Ediacaran assemblages, within a setting of changing environments, climate and continental arrangements. This book won the 2007-2009 Victorian Premier's Award for Science Writing and was short listed for the Queensland Premier's Award for 2008. It is both popular but also contains a comprehensive Atlas of all Ediacaran metazoan taxa which will be thoroughly updated in this revision.

Updating this Atlas with input from research globally will be a significant contribution to the field at the end of this project.

- ☛ **Description and publication** of new material that results from investigative work in Russia (White Sea, Urals, Siberia), Australia, Newfoundland, China and Namibia.
- ☛ Continue work on the **Cambrian Burgess Shale-like fossil quarry** on Kangaroo Island, South Australian Museum (Emu Bay).
- ☛ Develop **undergraduate course** that deals with Precambrian biostratigraphy, global events, palaeoecology and the development of complex life to be taught

both at Monash University in Australia and use as a shortcourse, emphasizing the events and biota of the Ediacaran/Vendian time period which can be taught elsewhere. Topic already incorporated in to School of Earth Science curriculum as part of ESC2032/ESC3232 undergraduate courses.

- ④ **Field conference** on the late Neoproterozoic of Rajasthan co-hosted by Monash University and the Biribal Institute of Palaeobotany, Lucknow. (January 2011)
- ④ Continue to generate **student projects** related to topics covered by this project at the various institutions involved in this project.
- ④ Detailed **photography of locales and stratigraphic logging of Nama Group** sequences in southern Namibia to aid in reconstructing detail of palaeoenvironmental setting of fossil material Production of a field guide to be used by undergraduate students from Namibian and South African universities when on site. Small field conference planned for May 2011.
- ④ **Field conference and symposium** in Siberia (Novosibirsk).

Year 3. (2012) Australia, South America, England

- ④ **Symposium** on the Ediacaran of South America, University of Tucuman, Argentina.
Special topic at this conference will be the current state of systematic of Ediacaran body and trace fossils. The Puncoviscana Group will provide an excellent backdrop with its wealth of trace fossils across a sequence of late Neoproterozoic into early Phanerozoic terrances.
- ④ **Field conference** to Puncoviscana Group in the high Andes of northwestern Argentina and possibly another to Corumbura region of western Brasil.
- ④ **International Geological Congress Field Excursion** to the Ediacaran successions of the Flinders Ranges National Park and the National Heritage-Listed fossil excavation site at Nilpena in South Australia.
- ④ Many of the programs regarding **student engagement** and short course offerings will continue as above.
- ④ Traveling of *The Artist and the Scientists* and *Wildlife of Gondwana* will continue for public engagement and educational materials around these two exhibitions will be continually enhanced

Year 4. (2013) Namibia and Southern Africa, etc.

- ☛ **Symposium and field conference** in Namibia to discuss and refine understanding of the African Ediacaran sequence. Symposium volume to be prepared from papers presented at this conference.
- ☛ Many of the programs regarding **student engagement** and short course offerings will continue as above.

Year 5. (2014) Italy, etc.

- ☛ **Conference** to summarize results new project in Prato, Italy at the Monash University Campus, which will bring together both the micro and macro palaeontological community as well as other geoscientists and molecular biologists to provide the state of the science summary. Symposium volume of papers will be produced.
- ☛ Many of the programs regarding **student engagement and short course offerings** will continue as above.

8.4 Results expected

- ☛ A refined micropalaeontological biostratigraphy for the Ediacaran Period
- ☛ Most important outcome is to ensure that researchers from all countries with even a nascent Ediacaran interest and/or discoveries are able to visit sections and examine each others' fossils firsthand – both macro and microfossils. This will permit a common international language for the taxonomy, description and interpretation of these fossils. It will significantly enhance international collaborations on this important time period in early evolution of animals.
- ☛ Better defined biogeographic provinces typical of the Ediacaran
- ☛ Develop better understanding of whether the four subdivisions currently being considered (Yangtze [630-580], Avalon [580-560], White Sea [560-550], Nama [550-540]) are real or are overprinted in some or all by the palaeoenvironment
- ☛ Have a better understanding of the detailed anatomy of several of the Ediacaran taxa and thus more in depth interpretation of their ecology and phylogenetic relationships and a better understanding of the relationships of certain body fossils and trace fossils.
- ☛ Revision of the detailed Atlas first presented in *The Rise of Animals* to summarize the current state of taxonomy of Ediacarans.

- ☛ Several outreach modes – website, exhibitions, educational materials – will communicate the research results to a general public. Finalize the documentary on the First Animals with David Attenborough and Atlantic Productions/BBC by filling out the record with Russia and Namibia and incorporating the reconstructions of Peter Trusler.
- ☛ Hope to have set aside or have significant progress a heritage listing for Farm Aar in Namibia, which has one of the best records, if not the best, for Africa and about the youngest occurrence of diverse Ediacaran assemblages.
- ☛ Further integration of the palaeontology, developmental biology and the molecular information with regard to the timing of origin of metazoans
- ☛ Perhaps, if lucky, both older and younger occurrences of the Ediacarans as a result of investigation of unusual sedimentary settings (representing past environmental conditions) not yet explored in detail

8.6 Participation

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Note: this new group that joined IGCP587 in 2011 has the following goals: We will keep you aware about our activities, and vice versa, we look forward to read the news from other corners of the world on the web of the Project. Just briefly to repeat, our goals should be:

1, the study of possible ancestors of ediacarans in the Middle and partly also Early Cambrian, mostly not mentioned yet in the literature;

2, the study of flysch facies in the central Bohemia, attributable to the Vendian stage with some reservation by microfossils. No traces fossils, no finds of fauna; nevertheless, a Vendian flysch could be compared with the then life-hosting facies and settings;

3, interpretation of the already Publisher data from sandstone facies with Vendian microfossils and weak bioturbation, overlain by the Cambrian sandstones on the southeastern part of the Czech Republic - affinity to the Polish region; no finds of Ediacaran fauna; but a reconstruct-able life habitat for the Vendian life.

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8.7 Location of major field activities

Newfoundland, Flinders Ranges and Kangaroo Island of South Australia, White Sea Coast and Siberia in Russia, possibly the Ukraine, Namibia, several locales in China, Saudi Arabia, , Argentina, India and likely Iran.

8.8 Location of major laboratory research (assured co-operation of laboratories)

Monash University, Melbourne, Australia (providing synchrotron access); Senckenberg Naturhistorische Sammlungen Dresden, Museum für Mineralogie & Geologie (providing radiometric dating), Dresden, Germany; Paleontological Institute, Russian Academy of Sciences, Moscow; South Australian Museum, Adelaide, Australia; Department of Geology, Queens

University, Kingston, Canada; Geology Department, University of Tucuman, Tucuman, Argentina; Geological Survey of Namibia, Windhoek, Namibia; Geological Survey of Western Australia, Perth.

8.9 Budget

A request for \$10,000 per annum is requested.

8.10 Curricula Vitae of Proposer(s)

Attached

9. Letter of endorsement of IGCP/IUGS National

Attached

10. Signature