



**International Commission on Stratigraphy
Subcommission on Ediacaran and Cryogenian
Stratigraphy**

ANNUAL REPORT 2006

1. TITLE OF CONSTITUENT BODY

Subcommission on Ediacaran and Cryogenian Stratigraphy

Submitted by:

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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 and late Neoproterozoic stratigraphy, defined in the broad sense of multidisciplinary activities directed towards better understanding of the evolution of the Earth during the Ediacaran Period and more generally during the late Neoproterozoic (circa 800 – 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

These fall into three main areas:

- (a) The definition of basal boundary stratotypes (GSSPs) and the refinement of standard chronostratigraphic scales, through the establishment of multidisciplinary Working Groups;
- (b) International coordination of and collaboration in research on late Neoproterozoic environments, through the establishment of thematic Working Groups, for example on Neoproterozoic glaciations.
- (c) International coordination of efforts to establish consensus global stratigraphic calibration schemes for the late Neoproterozoic using alternative methods of stratigraphy, such as chemostratigraphy.

In addition, the Subcommission exists to further communication with a wider public through grassroots initiatives to conserve important Ediacaran geological sites, to support International Geoscience Programme (IGCP) projects, and to encourage the wider dissemination of research findings on the world wide web 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 (Stages), and related to a hierarchy of units (Standard Zones, Subzones etc.) to maximize relative time resolution within the Ediacaran period;
- (2) Proceed with a program of workshops and symposia to select criteria, boundary stratotype section, and GSSP for a “Cryogenian” period and system, immediately below the Ediacaran;
- (3) 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 Subcommission** (W. Bleeker, chair) to subdivide the Precambrian. The Ediacaran and Cryogenian Subcommission will concentrate on the Neoproterozoic, while the Precambrian Subcommission will work on Archean and older Eras of the Proterozoic. Both subcommissions will seek to establish “natural” or rock-based boundaries that will enable global correlation.
- (4) Working towards an international policy concerning conservation of geologically and paleontologically important sites such as GSSPs. This relates to, *inter alia*, the IUGS Geosites Programme.

3. ORGANIZATION

Officers for 2004-2008:

| | |
|-------------|-------------------------------|
| Chair: | Dr. James Gehling, Australia |
| Vice-Chair: | Dr. Shuhai Xiao, USA |
| Secretary: | Dr. Graham Shields, Australia |

The Subcommission is organized by an Executive consisting of Chairman, Vice-Chairman and Secretary, who are all Voting Members of the Subcommission. These officers were nominated and elected by voting members of the now terminated Terminal Proterozoic Subcommission during late 2003. There are currently 37 other Voting Members, making 40 voting members in total (see appendix); there are currently 15 additional corresponding members. The Voting Members have been specifically selected for their international reputations and recognised expertise in an area of geoscience relevant to the subcommission. Four voting members are required to be officers of the Cambrian and Precambrian Subcommissions. All responded promptly to their nominations by email; ease of contact and promptness of response are prerequisites of being voting members on this subcommission.

Two thematic working groups have been established to assess candidates for 1) subdivision of the Ediacaran Period and 2) definition and subdivision of the Cryogenian Period, respectively. These two groups fit neatly within the auspices of existing IGCP project groups (IGCP 493, 512)

4. INTERFACES WITH OTHER INTERNATIONAL PROJECTS

Members of the Neoproterozoic (Ediacaran and Cryogenian) Subcommission are lead investigators and officers in a number of international projects, normally in an individual capacity but sometimes facilitated by contacts through activities related to the Subcommission:

IGCP 478 (*Neoproterozoic-early Paleozoic events in SW Gondwana*) led by voting members **Claudio Gaucher, Hartwig Frimmel and Paulo Boggiani**;

IGCP 493 (*The Rise and Fall of the Vendian biota*) led by voting member **Mikhail Fedonkin** (Paleontological Institute, Moscow), Pat Vickers-Rich (Monash Uni.) and Ediacaran Subcommission chairman **James Gehling**;

IGCP 497 (*The Rheic Ocean: its origin, evolution and correlatives*) led by voting member **Ulf Linnemann**.

IGCP 512 (*Neoproterozoic Ice ages*) led by subcommission secretary **Graham Shields** and voting member **Emmanuelle Arnaud** and boasts most subcommission voting members on its mailing list.

5. CHIEF ACCOMPLISHMENTS AND PRODUCTS IN 2005 and 2006

An IGCP 493 meeting entitled: *The elusive Ediacarans — where did they come from and where did they go?* was organized by Prof. Terufumi Ohno and Prof. Patricia Vickers-Rich, in Japan at Kyoto University Museum from 30-31 January, 2006.

In conjunction with the 2nd International Palaeontological Congress held in China from June 17-24, 2006, Chinese voting members Zhu Maoyan, Yin Chongyu and Shuhai Xiao and a team of colleagues and their students organized a *Neoproterozoic field workshop* from June 6-16, to study the Cryogenian and Ediacaran successions of south China. The 32 participants in the pre-Congress field trip included nine voting members from six countries as well as 11 PhD candidates working on Neoproterozoic-Cambrian projects. In transit between field sites, participants gave in-bus presentations on the principal Neoproterozoic stratigraphy of the countries they represented and their research projects.

At the 2nd International Palaeontological Congress held on the Beijing University campus, (June 17-21), the Ediacaran and Cryogenian (Neoproterozoic) Subcommission organized a very-well attended symposium and poster session on *Neoproterozoic Palaeontology and Geobiology*, that extended over two days. Papers and posters at the symposium included nine by voting members from seven countries. The strength of this meeting was the active participation by the best known palaeontologists, sedimentologists, geochemists and geochronologists active on Neoproterozoic projects. The symposium was followed by a working meeting of the subcommission to plan trips for 2007 and 2008 to investigate candidate sections for a Cryogenian GSSP and subdivision of the Ediacaran (*see Appendix 2*). The meeting asked for expressions of interest in organizing field workshops to investigate candidate sections for a Cryogenian GSSP and Ediacaran subdivision. Vibuti Rai has offered to organize an Indian field workshop in 2007. Paul Hofmann and Charlie Hoffmann have offered to organize a Namibian field workshop in 2008.

The *Australian Centre for Astrobiology* (Macquarie University, Sydney, New South Wales) headed by Malcolm Walter (former Vice-Chair of the Terminal Proterozoic Subcomm.) organized an *Acraman Workshop* in South Australia from August 4-9. The 20 participants gave papers and participated in field study of the Acraman eject layer. The Acraman horizon lies in the middle of the Ediacaran succession in the Flinders Ranges of South Australia, 1.5 km stratigraphically above the Ediacaran GSSP. The group is planning a project to drill the melt rock in the Acraman impact crater preserved in Mesoproterozoic volcanics to the west on Eyre Peninsula. The aim is to obtain an absolute age for the event which is loosely timed at 580 Ma and could form a lower limit to the first large organic walled microfossils in the Ediacaran.

A meeting entitled “*Snowball Earth 2006 appraisal conference*” was held at the Centro Stefano Franscini, Ascona, Switzerland, July 16-21, 2006. This conference was organised by Dr James Etienne, Prof. Philip Allen and Dr Andrea Cozzi (Switzerland) and was cosponsored by IGCP 512. The conference brought together many of the world’s experts in Neoproterozoic Earth System Science and represented the 2nd meeting of the thematic working group on Neoproterozoic ice ages. Discussions related to the subcommission are given in *Appendix 3*.

The Australian Broadcasting Commission (ABC) weekly science program, *Catalyst*, broadcast a feature on the Ediacaran GSSP and Ediacara fossils of the Flinders Ranges, South Australia, on 9 November 2006.

39 papers have been published so far in 2006 on paleontology, sedimentology, chemo- and litho-stratigraphy of the late Neoproterozoic (*see Appendix 6*).

6. CHIEF PROBLEMS ENCOUNTERED IN 2006

- The problem of the apparent diachroneity of Neoproterozoic diamictites judging from recent U-Pb dates.
- Determining criteria for a Cyogenian GSSP, which might utilize a chemostratigraphic anomaly in conjunction with microflora and event stratigraphy.
- Mismatch of timing of the onset and extinction of large ornate, organic walled microfossils in the Ediacaran that suggests problems for determining series boundaries.
- Previously proposed Ediacara biota fossil associations, representing a potential time sequence, are showing evidence of being more a product of environmental differences between and within fossil assemblages. However, a series boundary may well be determined using the end of the Gaskiers glaciation as a series boundary, since it appears to represent the base of the oldest known fossils of the Ediacara biota. There is now geochemical evidence for a rise in marine oxygen levels to a level that could sustain metazoans.
- Polarization of researchers on the potential of stable isotope patterns as a means for intercontinental correlation.

7. SUMMARY OF EXPENDITURES IN 2006 (ANTICIPATED THROUGH MARCH 2007):

INCOME

| | |
|----------------------------|-----------------|
| Carried forward from 2005_ | US\$200 |
| ICS | <u>US\$1950</u> |
| TOTAL | US\$2195 |

EXPENDITURE FROM 2006 BUDGET

| | |
|---|----------------|
| Travel support for Indian voting member to 2 nd IPC and Field Workshop | US\$700 |
| Field expenses for J. Gehling on Acraman Workshop, Aug 4-10, 2006 | US\$430 |
| Field expenses for two Chinese voting members visiting Ediacaran GSSP and succession in Flinders Ranges South Australia Aug 19-21, 2006 | <u>US\$580</u> |
| TOTAL | US\$1710 |

To be carried forward to 2007 US\$485

8. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR (2007):

(a) Newsletter:

A circular is currently being prepared for end 2006 to inform all corresponding members of:

- subcommission meeting in India during November 2007 to focus on the Neoproterozoic as a whole (V. Rai).

- related meeting in Australia (IGCP 512) during June 2007 to focus on Ediacaran subdivision (M. Corkeron).
- call for preliminary proposals for stratigraphic subdivision of the Neoproterozoic
- vote on possible criteria to subdivide the Neoproterozoic.

(b) Preparation of GSSP proposals:

Working groups will explore the potential of preliminary proposals and subdivision criteria and discuss them within wider spheres: IGCP 493 (and IGCP 478) in the case of Ediacaran Subdivision and IGCP 512 in the case of the Cryogenian subdivision and definition.

(c) Voting:

Towards the end of 2007, voting members will be asked to vote on preliminary proposals for criteria used to subdivide the Ediacaran and define the base of the Cryogenian.

10. BUDGET AND ICS COMPONENT FOR 2006

We anticipate that **\$5000** will be needed to support voting members who wish to participate in the planned field excursion to the Neoproterozoic and Neoproterozoic of India (*see Appendix 4*)

Potential funding sources outside IUGS

National IGCP committees and project groups for IGCP projects 478, 493 and 512.

The Neoproterozoic (Ediacaran and Cryogenian) Subcommission does not receive financial support from outside IUGS-ICS, except for office support (computer, access to internet services, telephone, etc.) from the host institutions of the Executive. Most members are supported by national research grants, normally won competitively. Specific activities, such as meetings and some Working Groups, sometimes receive small grants to Convenors and Organizers from various sources, such as host institutions and national and regional authorities of the country where the meeting is being held.

11. REVIEW CHIEF ACCOMPLISHMENTS OVER PAST FIVE YEARS (2001-2005)

2003: In September 2003, a 3rd ballot of the Terminal Proterozoic Subcommission resulted in 85% of the votes in favor of a **GSSP for the Terminal Proterozoic Period** at the base of the Nuccaleena Formation *cap dolostone*, immediately above the Elatina glaciogenic diamictite in the Enorama Creek Section, Flinders Ranges, South Australia. The name “**Ediacaran**” received 79% of the votes cast. As a result the Subcommission submitted a proposal to the full International Commission on Stratigraphy (ICS) in December 2003.

2004: On February 16th, 2004, the ICS voted 14:1 in favor (with one abstention) on the GSSP and name for the “Ediacaran System”. The results were submitted to IUGS, which ratified the GSSP and name for the Ediacaran System and Period on March 19th (IUGS E-Bulletin, March 2004).

IGCP 493 “Rise and Fall of the Vendian Biota” ran a post IGC workshop on Neoproterozoic Paleobiology in Prato Italy on August 30-31. The resulting papers will be published in a special edition of the Journal of the Geological Society, London in 2007.

2005: Interpretive signs and a marker or “golden spike” were dedicated by the South Australian Premier at the Ediacaran GSSP on April 16 at the Ediacaran GSSP site in the Flinders ranges National Park.

Australia Post released an Ediacaran Postage Stamp series in conjunction with the dedication of the Ediacaran GSSP site in South Australia in April 2005.

The Neoproterozoic (Ediacaran and Cryogenian) Subcommittee and IGCP 493 sponsored and ran a symposium (Ediacaran paleobiology: paleontological, molecular, embryological, and ecological constraints) at the NAPC meeting in Halifax Nova Scotia (June 19-26, 2005) and a 5-day pre-conference excursion to the Ediacaran succession of SE Newfoundland.

The first meeting of IGCP 512 (Cryogenian) was held at a "Conference on Sedimentary Processes and Products" in Aberystwyth, Wales from 23-27 August, 2005, followed by a field excursion to Cryogenian and Ediacaran strata of SW Scotland.

Members of the Neoproterozoic (Ediacaran and Cryogenian) Subcommittee participated in a *Time Scale Workshop* held by the Precambrian Subcommittee in conjunction with a final "Supercontinents and Earth Evolution Symposium" organized by the Tectonics Special Research Centre at University of Western Australia/Curtin University, September 26-30, 2005.

See review of 2006 activities.

12. OBJECTIVES AND WORK PLAN FOR NEXT 4 YEARS (2006-2009)

The Neoproterozoic (Ediacaran and Cryogenian) Subcommittee aims to encourage research that will facilitate correlation and subdivision of the late Neoproterozoic (circa 800 – 542 Ma) by the time of the next IGC in 2008. In particular, field excursions and symposia will be designed to encourage international cooperation and collaboration that will lead to GSSP's for the base of the "Cryogenian", and subdivision of the Ediacaran. Suggestions for appropriate successions that would facilitate placement of GSSP's will determine the precise location of future meetings and excursions but some preliminary ideas are outlined below for the years 2006-2008.

2007

- Call for submission of full proposals for Ediacaran subdivision.
- Vote on preliminary proposals for Cryogenian Period GSSP.
- Call for submission of full proposals for Cryogenian Period GSSP.
- A field workshop in India, organized by Vibuti Rai, to visit both the Himalayan and Vindhyan basins for Ediacaran, Neo, Meso and Palaeoproterozoic parts of the sequence (see Appendix 4)
- A field workshop is planned to review the Sturtian and Marinoan diamictites and claims for younger diamictites in the Neoproterozoic successions of the northern Flinders Ranges and Kimberley Ranges for June 2007) (*see Appendix 5*).

2008

- Vote on Cryogenian GSSP.
- Vote on Ediacaran Period subdivision into two or more epochs.
- Paul Hoffman and Charlie Hoffmann to lead a field workshop to study the Cryogenian successions of northern Namibia (June-July, 2008).

APPENDIX 1

NEOPROTEROZOIC (EDIACARAN AND CRYOGENIAN) SUBCOMMISSION Voting Members 2004-2008

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APPENDIX 2

Newsletter: Subcommission meeting and call for submissions distributed September 19th 2006

Neoproterozoic Subcommission meeting, June 25th, Beijing, China

A recent meeting of the ICS Neoproterozoic Subcommission took place at 17:00 on June 25th, 2006 within the auspices of the International Palaeontological Congress (IPC) in Beijing, China. All officers (J. Gehling, S. Xiao and G. Shields) and a total of 12 voting members (M. Fedonkin, S. Jensen, V. Melezhik, S. Peng, V. Rai, W., Sun, C. Yin, L. Yin, M. Zhu) were present. About the same number of observers were also present (S. Bengtson, P. Hoffman, K.-H. Hoffmann, M.M. Mus, K. Peterson, C. Zhou and other unnamed observers).

Four items were discussed:

1. The suggestion was made and supported that a compilation of possible basal Cryogenian defining criteria be made and circulated to the subcommission. Experts need to be contacted by the officers of the subcommission for their input:
 - Geochronological data. Suggestion from Kevin Peterson that we contact EarthTime in order to facilitate new age dates from key sections. Presently a database is being compiled and updated by Breandan MacGhabhann.
 - Isotopic data. Currently being compiled by Galen Halverson with his and other data compiled on IGCP 512 website.
 - Vase-shaped microfossils. A compilation of global distribution needs to be made. S. Porter, A.H. Knoll and M.M. Mus are experienced in this field.
 - Glacial strata. This is being done as part of a book effort by IGCP 512 although it was agreed to be unlikely that glacial strata themselves will be used as part of the definition.
 - Molar-tooth structure. A global compilation is being compiled by Graham Shields and should be available online soon.
 - Calcified microbes. Global compilation unavailable.
 - Stromatolites. Global compilation unavailable.
 - Acritarchs. Global compilation unavailable.

It was suggested in this context that the subcommission propose a provisional GSSP by the IGC 2008 in Norway based on proposed criteria before banging in the Golden Spike at a later date.

2. Regarding possible subdivision of the Ediacaran Period, several possible criteria were discussed:
 - Potential of acritarchs through this interval needs to be examined as they hold great potential (M. Fedonkin).
 - Disappearance of Large Spiny Acritarchs may be globally correlative event.
 - FAD of Ediacaran-type soft-bodied fossils.
 - Shuram/Wonoka negative $\delta^{13}\text{C}$ excursion appears to be globally correlative.
 - Gaskiers glaciation is not known yet to be globally correlative phenomenon

Same approach as for Cryogenian definition could be attempted.

3. Concrete proposals for future fieldtrips are required:
 - Lesser Himalaya 2007 (details to be announced by V. Rai)
 - Namibia 2008 (P. Hoffman, K.-H. Hoffmann) – *see Appendix 4 below*
 - Australia (considered highly desirable by those present but so far no offers to organize such a trip – likely to be very popular) – *see Appendix 5 below*
4. Call for PDFs of hard-to-find literature to be put on the web (P. Hoffman):
 - This idea was also well received and two websites are currently available for this: www.IGCP512.com and www.SnowballEarth.org

APPENDIX 3

Discussion document from the Ascona conference circulated on September 19th, 2006

The Tonian-Cryogenian transition – an open discussion at Snowball Earth 2006, July 21st, Ascona, Switzerland

The **Cryogenian** Period (**c.750-635 Ma**), once it is formally defined in the rock record, will likely represent the most globally coherent time slice so far defined in the geological record. Its obvious metaphorical qualities have the potential to reach far beyond the normal sphere of academic research into the wider domain of schools and the general public. The name is already widely used and there seems to be no will within the geological community to challenge its status in the official geological time scale. The question of its definition and global correlation are stated goals of the International Subcommittee on Neoproterozoic Stratigraphy.

What defines the Cryogenian Period and what preceded it were the topics of discussion in the second of two open forum discussion sessions at the recent Snowball Earth 2006 conference in Ascona, Switzerland in July 2006, moderated by Graham Shields. It followed similar discussions at the IGCP 512 meeting in Aberystwyth, UK in August, 2005 and followed the Neoproterozoic Subcommittee meeting in Beijing, China in June, 2006 (see below). The discussion centred on the nature of the Earth System in the run-up to glaciation. The audience pointed out that the **end of the preceding Tonian Period** was characterized by:

1. Widespread continental rifting, possibly caused by a mantle plume event, between 850 Ma and 750 Ma, and leading to the break-up of the supercontinent 'Rodinia'. Some rifting events are marked by low-latitude flood basalts that would have been more susceptible to chemical weathering.
2. Start of a major rise in seawater $^{87}\text{Sr}/^{86}\text{Sr}$ from approximately 850 Ma. Values rose from 0.7055 to 0.7067 or higher by the onset of glaciation. After the c.635Ma deglaciation, ocean $^{87}\text{Sr}/^{86}\text{Sr}$ continues rising to 0.7092 by 500Ma.
3. Generally high seawater $\delta^{13}\text{C}$ values and first major negative $\delta^{13}\text{C}$ excursion of the Neoproterozoic: the "Bitter Springs" anomaly, which occurred when seawater $^{87}\text{Sr}/^{86}\text{Sr}$ had reached 0.7063.
4. Low continental relief, possibly due to the long existence of the supercontinent 'Rodinia'; widespread development of shallow, stromatolite seas and massive deposition of evaporite minerals across Australia, in particular, c.850 Ma.

5. Widespread carbonate precipitation in shallow marine environments: high stromatolite diversity; global acme in molar-tooth structure (early calcite cements) worldwide; large ooids; first appearance of calcified cyanobacterial sheaths.
6. Biological diversification of eukaryotes, such as acanthomorphic acritarchs, organic walled megafossils (Chuarina-Tawuia assemblage) and enigmatic forms of apparently pelagic, single-celled eukaryotes, such as vase-shaped microfossils (VSM's). These last fossils have been interpreted to be possible testate amoebae and may even have been lightly mineralised. Although the Tonian-Cryogenian transition marks a change from simple, long-ranging taxa to more complex taxa, it was acknowledged that Cryogenian assemblages are depauperate. The change to short-lived complex taxa is renewed after 635 Ma.

In essence the Tonian-Cryogenian transition is marked by the onset of phenomena that are set to become characteristic of later Neoproterozoic and early Cambrian time: continental rifting and volcanism; negative $\delta^{13}\text{C}$ excursions; high $\delta^{13}\text{C}$ values. Several aspects seem then to 'take a back seat' during the Cryogenian Period but are renewed after 635Ma, e.g. rising seawater $^{87}\text{Sr}/^{86}\text{Sr}$, diverse, short-lived acritarch assemblages and possibly biomineralisation. Some innovations do not reappear until the Precambrian-Cambrian boundary, e.g. calcimicrobes.

APPENDIX 4

Provisional arrangements for 2006 subcommission meeting proposed by V. Rai during Nov. 2006

Field excursion planned for the Lesser Himalayan Neoproterozoic successions and Central Indian Vindhyan Basin, India organized by Vibhuti Rai (University of Lucknow, India). Likely duration 14 days. Likely timing **November 15th to 28th, 2007**. Likely costs: US \$800-\$1400 per person depending on partial versus complete participation. The Himalayan trip can accommodate about 30 participants but the Vindhyan part only 20 due to logistics. A two-day conference will also be part of this trip during which there will be presentations and discussions on geological evidence for the relationship between biological evolution and climate during the Precambrian – this will be cosponsored by the Neoproterozoic Subcommission.

The participants would be assembling at **Dehradun**, the capital of Uttaranchal, a city well connected by Air and Train from **Delhi**. The first part of the trip ends at **Lucknow** from where participants can fly or travel by train to **Delhi, Kolkata, Agra** etc. The second part of the Field Meeting ends at **Khajuraho** which is rather ill connected. Participants can fly to **Delhi** or **Varanasi** from **Khajuraho** or travel by Bus/ Taxi/ Car to **Lucknow** from where they can travel to anywhere in India. The costs include expenses related to lodging, boarding, train/bus/taxi travel and field guide-book etc. Travel up to **Dehradun** and Travel from **Lucknow/ Khajuraho** would be at the participants cost). Itinerary below:

- DAY- 1 Arrival at **Dehradun** and Introductory Get-together
- DAY- 2 **Dehradun** to **Rishikesh** and Back – Evaluation of Varanger Glacials and Cap carbonates (the Blaini Formation)
- DAY – 3 **Dehradun** to **Kauriyala** and back – Evaluation of Varanger to Toyonian Succession (Blaini to Tal Formation)
- DAY – 4 **Dehradun** to **Mussoorie** and **Dhanaulti** and back – Complete succession of Ediacaran age (Krol and Tal Formations)
- DAY – 5 **Dehradun** to **Solan** (Himachal Pradesh)– On the way, exposures of Varanger and Ediacaran successions would be evaluated. Stay in **Solan**.
- DAY -6 **Solan** to **Simla** – Evaluation of different levels of Varanger glacials, type area of Blaini Formation and older Cryogenian deposits, Return to **Chandigarh**. Departing from Chandigarh to **Lucknow** by TRAIN in late evening.
- DAY – 7 Arrival early morning at **Lucknow**. Inauguration and Technical Sessions of Conference on Precambrian Life, Events & Basins
- DAY – 8 Technical Sessions of the Conference till Afternoon. Departure by Evening TRAIN to **Chopon**.

- DAY -9 Halt at **Renukut**. Fieldwork in and around Son Valley in the Lower Vindhyan successions (Palaeoproterozoic).
- DAY -10 Departure for **Rewa** by BUS/ CAR, Fieldwork on the way in Lower and Upper Vindhyan successions (Palaeoproterozoic and Mesoproterozoic Successions).
- DAY – 11 Halt at **Rewa**. Visit to **Chorhat** (Dolf Seilacher’s Locality) in Lower Vindhyan successions, Travel to **Maihar**.
- DAY -12 Halt at **Maihar**. Visit to Lower Vindhyan Successions.
- DAY – 13 Travel to **Khajuraho**. On the way, evaluation of lower part of Upper Vindhyan successions, Diamondiferous Kimberlite pipes and Rewa, Bhandar Formations. Halt at **Khajuraho**.
- DAY -14 Valedictory Function at **Khajuraho**. Departure by Air/ BUS/ Taxi/ Car to **Delhi/ Varanasi/ Lucknow**.

APPENDIX 5

Provisional arrangements for 2006 IGCP 512 meeting proposed by M. Corkeron during 2007

Field excursion planned for the Kimberley Ranges, NW Australia organized by Maree Corkeron (James Cook University, Australia). Likely duration 9-12 days. Likely timing 23 June to July 8th. Likely costs: AUS \$1600 per person. Itinerary below:

- Fly into Broome.
 - Day 1 and 2: Broome to Mount House Station to view striated pavements beneath Walsh Tillite and either Mount House type section, or cap carb overlying diamictite in anticline used for palaeomag analysis..
 - Day 3; Travels from Mount House to Louisa Downs via Windjana Gorge - Devonian reef.
 - Day 4-5; Possibly 2 days at Louisa Downs; view Landrigan Tillite cap, possibly diamictite; Striated pavements beneath Egan Formation, stromatolite reef of Tungusia julia; complete sections of Egan Formation; spectacular scenery.
 - Day 6; Louisa Downs to Bungle Bungle (Purnululu National Park). On way see Egan Fm type section.
 - Day 7 Day at Bungles; west of Bungles is Neoproterozoic succession (Fargoo Tillie, Frank River Sandstone, Moonlight Valley Tillite and cap carb). Can either walk through succession, or take shorter visit to cap carbonate and spend half day looking at the Bungle Bungles.
 - Day 8 Bungles to Kununurra or Keep River National Park via Texas Downs. Several hours stop at Texas Downs/Moonlight Valley; view Moonlight Valley type section; drive through Texas Downs across the Ord River and then through Spring Creek Station. This takes you up through the Antrim Plateau Volcanics. We could o/night at Keep River National Park instead of Kununurra.
 - 9) Kununurra to Darwin (no geological stops required - though of course there is lots to see!!)
- Fly out from either Kununurra or Darwin

Opportunity for a guided visit the Ediacaran GSSP will be provided either before or after the excursion.

APPENDIX 6

Neoproterozoic Publications for 2006 in Paleontology, Sedimentology, Isotope Geochemistry and Stratigraphy

1. Alene, M., Jenkin, G., Leng, M., and Darbyshire, F., 2006. The Tambien Group, Ethiopia: An early Cryogenian (ca. 800-735 Ma) Neoproterozoic sequence in the Arabian-Nubian Shield, Precambrian Research, 149, 79–89.
2. Allen, P. and Leather, J., 2006. Post-marinoan marine siliciclastic sedimentation: The Masirah Bay Formation, Neoproterozoic Huqf Supergroup of Oman, Precambrian Research, 144, 167–198.
3. Arnaud, E. and Eyles, C., 2006. Neoproterozoic environmental change recorded in the Port Askaig Formation, Scotland: climatic and tectonic controls on sedimentation, Sedimentary Geology, 283, 99–124.
4. Azmy, K., Kaufman, A., Misi, A., and deOliveira, T. F., 2006. Isotope stratigraphy of the Lapa Formation, Sao Francisco Basin, Brazil: Implications for Late Neoproterozoic glacial events in South America, Precambrian Research, 149, 231–248.

5. Bottjer, D.J. and Clapham, M.E. 2006. Evolutionary paleoecology of Ediacaran benthic marine animals. In *Neoproterozoic Geobiology and Paleobiology*. Edited by S. Xiao and A.J. Kaufman, Springer, pp. 91-114.
6. Canfield, D.E., Poulton, S.W. and Narbonne, G.M., 2006. Late Neoproterozoic deep-ocean oxygenation and the rise of animal life. *Science*, 10.1126/science.1135013.
7. Corsetti, F. and Lorentz, N., 2006. On Neoproterozoic cap carbonates as chronostratigraphic markers, in S. Xiao and A. Kaufman (Eds.), *Neoproterozoic Geobiology and Paleobiology*, Springer, New York, vol. 27, 273–294.
8. De, C. 2006. Ediacara fossil assemblage in the upper Vindhyan of Central India and its significance. *Journal of Asian Earth Sciences* 27, 660-683.
9. Deynoux, M., Affaton, P., Trompette, R., and Villeneuve, M., 2006. Pan-African tectonic evolution and glacial events registered in Neoproterozoic to Cambrian cratonic and foreland basins of West Africa, *Journal of African Earth Sciences*, 46, 397–426.
10. Droser, M. L., Gehling, J.G. and Jensen, S.R. 2006. Assemblage palaeoecology of the Ediacara biota: The unabridged edition? *Palaeogeography, Palaeoclimatology, Palaeoecology* 232, 131-147.
11. Evans, D., 2006. Proterozoic low orbital obliquity and axial-dipolar geomagnetic field from evaporite paleolatitudes, *Nature*, 444, 51–55.
12. Fike, D.A., Grotzinger, J.P., Pratt, L.M. and Summons, R.E., 2006. Oxidation of the Ediacaran ocean. *Nature* 444, 744-747.
13. Font, E., Nédélec, A., Trindade, R., Macouin, M., and Charrière, A., 2006. Chemostratigraphy of the Neoproterozoic Mirassol d'Oeste cap dolostones (Mato Grosso, Brazil): An alternative model for Marinoan cap dolostone formation, *Earth and Planetary Science Letters*, 250, 89–103.
14. Frimmel, H., Tack, L., Basei, M., Nutman, A., and Bowen, A., 2006. Provenance and chemostratigraphy of the Neoproterozoic West Congolian Group in the Democratic Republic of Congo, *Journal of African Earth Sciences*, 46, 221–239.
15. Hagadorn, J.W., Xiao, S., Donoghue, P.C.J., Bengtson, S., Gostling, N.J., Pawlowska, M., Raff, E.C., Raff, R.A., Turner, F.R., Yin, C., Zhou, C., Yuan, X., McFeely, M.B., Stampanoni, M., and Neilson, K.H., 2006. Cellular and subcellular structure of Neoproterozoic embryos: *Science*, v. 314, p. 291–294.
16. Halverson, G., 2006. A Neoproterozoic Chronology, in S. Xiao and A. Kaufman (Eds.), *Neoproterozoic Geobiology and Paleobiology*, Springer, New York, vol. 27 of *Topics in Geobiology*, 231–271.
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21. Jiang, G., Kennedy, M., Christie-Blick, N., Wu, H., and Zhang, S., 2006. Stratigraphy, sedimentary structures, and textures of the Late Neoproterozoic Doushantuo cap carbonate in South China, *Journal of Sedimentary Research*, 76, 978–995.
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addition to the geologic time scale, *Lethaia*, 39, 13–30, 10.1080/00241160500409223.

28. Le Guerroué, E., Allen, P., and Cozzi, A., 2006. Chemostratigraphic and sedimentological framework of the largest negative carbon isotopic excursion in Earth history: The Neoproterozoic Shuram Formation (Nafun Group, Oman), *Precambrian Research*, 146, 68–92.
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36. Stern, R., Avigad, D., Miller, N., and Beyth, M., in press. Geological Society of Africa Presidential Review: Evidence for snowball Earth hypothesis in the Arabian-Nubian Shield and East African Orogen, *Journal of African Earth Sciences*.
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