U21B-04 0935h INVITED

Tectonics and Glaciation in the Neoproterozoic

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This presentation addresses the links between tectonics and glaciation in the Neoproterozoic. The global context of glaciation at that time is the massive reorganisation of the planet's land and ocean systems resulting from the break up and dispersal of the supercontinent Rodinia. Commencing about 750 Ma and lasting for at least 150 million years, global rifting was the overriding control on sedimentary basin formation, basin fill stratigraphies, and it is argued, glaciation. An initial phase of rifting began after 750 Ma along the paleo-Pacific margin of Laurentia with a later phase at about 600 Ma along its paleo-Atlantic Iapetan margin. It cannot be simply coincidental that these two rift phases are directly linked to episodes of glaciation; the first phase that of the Sturtian and equivalent Rapitan glacials, the second that of the Marinoan and Vendian glacial deposits. Precise dating of these glacial intervals has not yet been achieved but they occur within thick rift-related tectonostratigraphic successions. These consist for the most part of thick submarine slope and fan deposits reflecting rift basin formation and influxes of large volumes of clastic sediment, including large volumes of detrital carbonate debris, from uplifted rift shoulders. Successions are dominated by turbidites, olistostromes and debris flow facies (diamictites); some, where uplift or latitude were appropriate, are glacially-influenced but many are not. Deposits record a fully functioning hydrological cycle. Tectonically generated topography in the form of uplifted rift flanks may have been a key control on the growth of regional ice centers suggesting a diachronous climatic response to uplift as rifting progressed in a zipper-like fashion around the margins of Laurentia.

U22A CC: 517 A Tuesday 1030h

Extreme Environments of the Precambrian Earth II

Presiding: **G S Jenkins,** Howard University**; C Poulsen,** University of Michigan

U22A-01 1030h

Extreme carbonate super-saturation of the ocean and Neoproterozoic ice ages

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In the modern ocean, reduction in carbonate deposition on the continental shelves can be compensated for by the increased preservation in deep sea sediments of biogenic carbonate originating from planktic calcifiers living in the open ocean. The result is that ocean carbonate chemistry is strongly buffered and the carbon-climate system relatively stable. However, before the advent of metazoan biomineralization in the Cambrian and proliferation of calcareous plankton during the Mesozoic, carbonate deposition would have been largely restricted to shallow water photic environments. Such a system is highly susceptible to positive feedback between sea level fall, reduced shallow water carbonate deposition, increased carbonate saturation of the ocean, atmospheric CO_2 draw-down, and ice-sheet growth. This is consistent with the occurrence of ice ages of near-global extent during the Neoproterozoic. Both the widespread occurrence and observed thickness of cap' (dolostone) carbonate deposited during postglacial transgression are explicit predictions of this hypothesis. The enigmatic cap facies thus record the rapid removal of accumulated alkalinity from an ocean that has reached an extreme degree of carbonate super-saturation by the end of the glacial period.

URL: http://tracer.env.uea.ac.uk/e114/publications.html

U22A-02 1045h

Weathering History During Extreme Climate Conditions in Neoproterozoic Time: a Clay Mineral Study on the Nanhuan-Sinian Succession (South China)

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The Nanhuan-Sinian sedimentary rocks on the Yangtze Platform in South China represent a glacial succession of Neoproterozoic age. The succession of paleolow-latitude is assumed to be correlative to the global glacial "snowball Earth" event. This estimation is on the one hand based on sparse age determinations and on the other hand on in the simalarities of its consecutive occurence of tillites and warm-water carbonates similar to successions on other continents. One of the postulates of the snowball Earth hypothesis is that during glaciation chemical weathering on the continents was shut down and was followed by intense silicate weathering in the aftermath of the glaciation. Furthermore, as a result of the nearly complete ice-cover oceanic bottom waters allegedly became anoxic. Clay minerals are being produced among other things by weathering of silicate minerals. We evaluated the degree of chemical weathering by combining major and trace element analyses (incl. REE), XRD and TEM to recontruct the weathering history during the Nanhuan-Sinian time. Lithological records together with the application of geochemical weathering proxies indicate an inter- or at least intraglacial stage for the Nanhuan-Sinian succession. The values of paleoredox indices do not show anoxic bottom water conditions during the Nanhuan glaciation. Our results allow two possible implications: (i) The snowball Earth scenario did not occur exactly as postulated and needs to consider climate variability and long-term ocean-atmosphere interaction, or (ii) the Nanhuan glaciation evolved independently from the global glaciations considered by the snowball Earth hypothesis.

U22A-03 1100h

Biogeochemical susceptibility of Proterozoic oceans to extreme isotopic events

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It has been suggested that Proterozoic oceans contained an unusually concentrated pool of dissolved and suspended organic carbon [1]. This high concentration is traced to its accumulation in the water column, prior to the evolutionary innovations that caused organic matter to sink. Oxidation of a small part of this large reservoir can create a large isotopic signal in the smaller inorganic pool, thereby explaining the large Neoproterozoic fluctuations in the isotopic composition of carbonate. Here we construct a simple continuous model to analyze the mechanisms by which such an organic-rich ocean can be created and investigate its stability with respect to oceanic circulation and evolutionary changes. Our model describes the biological, geochemical, and physical interactions of oceanic organic carbon, dissolved oxygen, and dissolved nutrients as a function of depth. It is formulated as coupled advection-reaction-diffusion equations. We first verify that, in the presence of sinking organic matter, the model simulates modern depth profiles of oxygen, carbon, and nutrients such as phosphorus. We then explore the consequences of producing neutrally-buoyant organic matter. As expected, this case results in lower levels of oxygen at depth. We analyze the dynamic stability of this state, with particular emphasis on the effects of instability on the isotopic composition of carbonate. 1. Rothman D.H., Hayes J.M., Summons R.E. (2003) Dynamics of the Neoproterozoic carbon cycle. Proc. Nat. Acad. Sci., USA 100: 8124 - 8129.

U22A-04 1115h

High methane abundance throughout Precambrian.

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Decreased solar luminosity (Gough, 1981) and multiple lines of geologic evidence in favor of a "liquid" ocean in the Archean set a puzzle known as "Faint Young Sun" paradox. For several decades, elevated atmospheric CO2 levels were considered to be the most self-consistent solution for the warm Archean climate (Walker et al., 1977; Kasting et al., 1993). However, to offset a 25% decreased solar luminosity (at 3.5 Gyr ago) and keep the mean global surface temperature at 288K, CO2 should have been at a steady-state concentration of about 0.3 bars. At such high levels CO2 would condense (Mellon, 1996) in the Earth's polar regions (as it does on Mars today) and no longer could be considered as the only "stabilizer" of the Archean climate. Lack of siderite in paleosols (Rye et al., 1995) and lack of glaciations in Archean/Proterozoic also does not support large CO2 concentrations and pure CO2 greenhouse in the Precambrian. Climate simulations (Pavlov et al., 2000) show that 100-1000 ppm of methane would be sufficient to maintain warm climate under decreased solar luminosity without invoking huge CO2 levels. Therefore, the key question is how to maintain such high CH4 levels. In the anoxic Archean environment (Pavlov & Kasting, 2002), the lifetime of methane molecule would be long 10000 years. Previous photochemical calculations show that to maintain the "steady-state" 1000 ppm of CH4, the methane flux into Archean atmosphere should have been close to the present day biogenic methane flux (Pavlov et al., 2001) which is debatable. However, previous calculations assumed a high ("diffusion-limited") rate of hydrogen loss to space. If atmosphere was anoxic, hydrogen should have been lost at much (5-100 times) slower rate (Tian et al., 2003). Here we demonstrate that 100-1000 ppm could be maintained with much smaller methane flux in the hydrogen-rich Archean atmosphere. In the oxygenated Proterozoic atmosphere the lifetime of methane becomes much shorter. However, the biogenic flux from the oxygen/sulfate-poor Proterozoic ocean could have been even higher than the present total biogenic flux. The methane abundance in the oxygenated atmosphere is a non-linear function of methane source because methane molecules destroy their major sink - OH radicals (Prather, 1996). We showed (Pavlov et al., 2003) that 100 ppm of methane in Proterozoic could be maintained with only 7-10 times increased present biogenic flux. We conclude that methane was abundant throughout Archean and Proterozoic and most likely was responsible for lack of glaciations in the Precambrian.

U22A-05 1130h

High obliquity simulations of Proterozoic climate conditions

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Results from GCM simulations using boundary conditions (solar forcing, landmass position) for the Proterozoic Era (Palaeoproterozoic, Mesoproterozoic, Neoproterozoic) are presented. The primary purpose of this presentation is to determine from model simulations when high obliquity conditions are consistent or inconsistent with the implied climatic conditions from geologic rock record. The results suggests that high obliquity is a viable solution for most of the Proterozoic Era with the exception of the extreme events at the end of the Neoproterozoic when glacial deposits may have existed in high latitudes (>40 degrees). However, the high latitude glacial deposits have the largest uncertainties. A number of studies have suggested that the proposed mechanisms for restoring obliquity to the present day values at the end of the Neoproterozoic are not viable. However, the overall agreement with the implied climate conditions during the Proterozoic Era makes it difficult to dismiss the High Obliquity Hypothesis.

U22A-06 1145h

Evidence for Microbial Activity in 3.5 Ga Pillow Basalts From the Barberton Greenstone Belt, South Africa

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We have discovered biosignatures in the formerly glassy rims of pillow lavas from the Mesoarchean Barberton Greenstone Belt (BGB) in South Africa. Over the last decade, bioalteration of basaltic glass in pillow lavas and volcaniclastic rocks has been well documented from in-situ oceanic crust and well-preserved Phanerozoic ophiolites. Much of the debate regarding the biogenicity of purported microfossils of early life centers on the interpretation of the host rocks' protoliths. To date, most protoliths have been interpreted to be of sedimentary origin. Some workers have proposed alternate origins for these substrates, including hydrothermal and even volcanic derivation, to cast doubt on their putative biogenicity. Hence studies documenting evidence for early life have proven to be controversial. Here we document evidence for microbial activity in 3.5 Ga subaqueous volcanic rocks that represent a new, unambiguous geological setting in the search for early life on Earth. The BGB magmatic sequence is dominated by mafic to ultramafic pillow lavas, sheet flows, and intrusions interpreted to represent 3480- to 3220-million-year-old oceanic crust and island arc assemblages. The BGB pillow lavas are exceptionally well-preserved and represent unequivocal evidence that these rocks were erupted in a subaqueous environment. The formerly glassy rims of the BGB pillow lavas contain micron-sized, microbially generated, tubular structures consisting of titanite. These structures are interpreted to have formed during microbial etching of the originally glassy pillow rims and were subsequently mineralized by titanite during greenschist facies seafloor hydrothermal alteration. Overlapping metamorphic and magmatic dates from the pillow lavas suggest this process occurred soon after eruption of the pillow lavas on the seafloor. X-ray mapping has revealed the presence of carbon along the margins of the tubular structures. Disseminated carbonates within the microbially altered BGB pillow rims have C-isotope values depleted by as much as -16 per mil, which is consistent with microbial oxidation of organic matter. In contrast, the crystalline pillow interiors exhibit C-isotope values bracketed between Archean marine carbonate (0 per mil) and mantle CO2 (-5 to -7 per mil). On the basis of the observed textural and geochemical signatures we propose that the glassy rims of the BGB pillow lavas hosted microbial life almost 3.5 billion years ago. Remnants of Archean oceanic crust may therefore be one of the most promising places to search for vestiges of early life on Earth.

U23A CC: 517 A Tuesday 1330h

The International Polar Year 2007-2008 I

Presiding: **M Albert,** Cold Regions Research and Engineering Laboratory**;** **P Johnson,** University of Ottawa

U23A-01 1330h

A New Phase of Exploration and Understanding: Planning for The International Polar Year - 2007/2008

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Planning is underway for an International Polar Year in 2007-2008. (IPY 2007/8) which will be a significant research opportunity to further our understanding of polar regions and polar processes. The International Polar Year has the potential to capture the public's imagination and convey the crucial role that the polar regions play in global systems. IPY 2007/8 will be an international programme of coordinated, interdisciplinary, scientific research in the Earth's polar regions to explore new frontiers, to increase our ability to detect changes at the Earth's poles and to deepen our understanding of polar processes and their global linkages. A crucial component of the IPY 2007/8 will be to attract and develop the next generation of polar scientists, engineers and leaders and to capture the interest of the public and decision-makers. The vision is for many nations to work together to gain holistic insights into planetary processes, targeted at exploring and increasing our understanding of the poles and their role in the global system. The concept of an International Polar Year 2007/8 has been endorsed and advanced by a broad range of global and polar research groups both internationally and nationally. To date 18 nations have formed national committees who are coordinating IPY activities nationally. The International Council for Science (ICSU) formed an International Polar Year Planning Group (IPY-PG) to stimulate, encourage and organize a debate on the International Polar Year 2007/8, formulate a set of objectives and develop a high level Science Plan. The Planning Group has sought input from the international science community and to date has received 138 ideas from over 22 nations. This input from the international community covers both poles, global processes and a diverse spectrum of disciplines. To date the input from the science community has identified key questions and proposed projects within the three major themes proposed by the ICSU IPY Planning Group: Exploration of New Frontiers, Understanding Change at the Poles and Decoding Polar Processes. Within the "Exploration" theme, three major concepts advanced by the community are genomic studies of the polar ecosystems, probing the polar deeps and sub-ice environments and studying the influence of the Earth's interior on polar processes. Within the theme of "Change at the Poles" the three major concepts advanced include climate connections and instabilities, solar forcing of the polar atmospheres and polar ecosystems response to change. Within the theme of "Decoding Polar Processes" three major concepts advanced include global forces on Peoples of the North, polar influences on people of the globe and contaminants at the poles. These ideas have been integrated into an outline of the proposed science questions and projects for the International Polar Year to be presented to the science community between April and September of 2004 for debate, discussion and review.

U23A-02 1430h

Dawn of a New Era of Polar Science: Efforts of the U.S. National Committee for the International Polar Year

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The polar regions, fascinating regions that capture the imaginations of people everywhere, hold the keys to our changing world. Plans are underway toward International Polar Year (IPY) 2007-2008. The vision for IPY 2007-2008 is that it will be the dawn of a new era in polar science, kicked off with an intense, internationally coordinated campaign of activities. IPY 2007-2008 will address research in both polar regions that involve the strong linkages to the rest of the globe. It will be multi- and interdisciplinary in scope and truly international in participation. It will educate and excite the public, and help produce the next generation of engineers, scientists, and leaders. Formed in the summer of 2003, the U.S. National Committee for the IPY has initiated conversations at meetings large and small, held internet discussions, and has listened to ideas voiced by the research community. Suggestions brought forward from individuals and communities to the U.S. National Committee were insightful and wide-ranging, and they all fit under broad umbrellas of understanding change in the polar regions, and exploring new frontiers. Change has occurred in the past and is occurring now, including changing environment, changing modes of communication, and changing human-environment dynamics. Intellectual curiosity drives the ideas voiced for exploration, ranging from investigation of life forms and their adaptability, facilitated by new genomics techniques, to geophysical investigations using new autonomous tools. The U.S. National Committee has worked to serve as a facilitator between the scientific community and our national agencies, helping to nurture ideas and partnerships that can lead to new international endeavors that will make the International Polar Year 2007-2008 the dawn of a new era of polar science.

URL: http://www.us-ipy.org

U23A-03 1445h

The electronic Geophysical Year (eGY) 2007-2008

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An Electronic Geophysical Year (eGY) is planned for 2007/08 as a 50-year sequel to the highly successful International Geophysical Year. The central objective is to bring the management of geoscientific information worldwide into the 21st century through an e-Science approach and the development of virtual observatories. The challenge in 1957-58 was to acquire and make available to the world community the observational data required to build a comprehensive understanding of the Earth and its processes. That challenge remains and is yet more pressing because of the growing demands we place on our natural resources and environment. Our observational data gathering capabilities have expanded enormously during the past 50 years, particularly through space-based observations. For example, the US National Virtual Observatory will be adding 500 TB of astronomical data per year from 2004. This proliferation of data requires a modern, distributed approach to data management and dissemination. To meet this challenge, we have at our disposal the power of the Internet and grid computing infrastructures for data sharing, processing, and visualization. The eGY concept arose within the International Union of Geodesy and Geophysics, with support from the Scientific Committee on Solar-Terrestrial Physics, the International Union of Geological Sciences, and the Society of Exploration Geophysicists, as a means of providing an international focus for e-Science and