INTERNATIONAL WORKSHOP FOR A CLIMATIC, BIOTIC, AND TECTONIC, POLE-TO-POLE CORING TRANSECT OF TRIASSIC-JURASSIC PANGEA

The ICDP and US NSF funded International Workshop for a Climatic, Biotic, and Tectonic, Pole-to-Pole Coring Transect of Triassic-Jurassic Pangea was held on June 5-9, 1999 at Acadia University, Wolfville Nova Scotia, the purpose of which was to define the science goals of this global scientific coring program. Fifty six scientists from thirteen countries participated in this workshop, the results of which are planned to be published by ICDP.

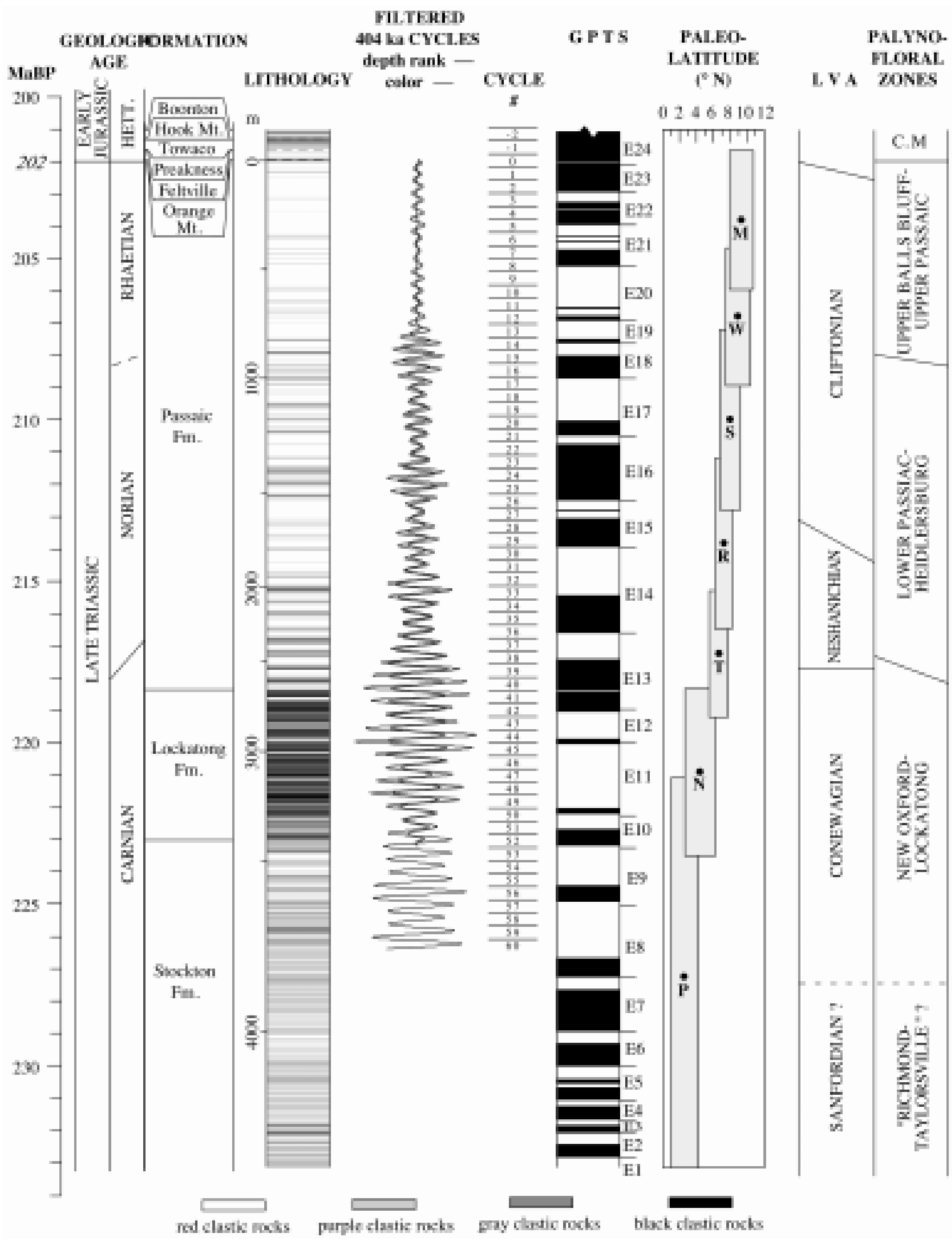

Figure 1: Time scale for the Late Triassic based on the NBCP cores. Adapted from Olsen and Kent (1999).

RATIONALE

The Late Triassic and Early Jurassic was a critical time in Earth history, representing one of the end members of Earth system states. The continents were united in the supercontinent of Pangea, with recent proxy data indicating the highest CO2 levels since the early Paleozoic. Although, all major groups of living terrestrial vertebrates evolved during the early Mesozoic, the Triassic-Jurassic boundary marked a mass extinction, perhaps of greater magnitude than that at the the Cretaceous-Tertiary transition. Either coincident with the Triassic-Jurassic mass-extinction or shortly thereafter, began what may have been the largest igneous event in Earth history - the 6000 km diameter Central Atlantic Magmatic Province (CAMP) event, which may also mark the initiation of the earliest Atlantic Ocean sea-floor. Fortunately, the extension leading up to the break up of Pangea resulted in the formation of the largest known rift province and associated basins, the result of which is a spectacular sedimentary and igneous record of Triassic-Jurassic tectonic, climatic, and biotic events with the interval being represented virtually in many basins on all continents.

A high-resolution record of one of these basins, the Newark rift basin of New York, New Jersey, and Pennsylvania, USA, has already been recovered in nearly its entirety in 6700 m of core by the US National Science Foundation- funded Newark Basin Coring Project (NBCP) (Figure 1). Analysis of this record produced the longest continuous record of astronomical climate forcing in the World, which in turn led to the development of an astronomically tuned geomagnetic polarity time scale for the Late Triassic and earliest Jurassic spanning roughly 31 million years (Olsen et al., 1996; Kent et al., 1995; Olsen and Kent, 1996, 1999a; Kent and Olsen, 1999). Subsequent studies have shown that this time scale can be used for high-resolution correlation to other areas, hundreds to thousands of kilometers distant (e.g. Kent and Olsen, 1997; Olsen and Kent, 1999b; Kent and Clemennson). The NBCP and related work demonstrates that it is possible to obtain records equivalent in quality to those from the Neogene, but at a spatial and temporal scale hitherto unavailable. This fine-scale temporal framework should allow exploration of major events and processes at unprecedented precision and scale.

It is within this exciting new context that the ICDP and US NSF funded workshop was held to develop a prioritized plan to core specific targets along a largely pole to pole transect of Triassic-Early Jurassic Pangea. It is only with continuous core that the the extremely large magnitude global events and processes cane be examined at appropriate (large and small) levels of temporal and spatial resolution.

SCIENTIFIC THEMES

The meeting was structured around three basic science themes: 1) climate, astronomical forcing, and chaos; 2) Pangean break-up; and 3) biotic change in a Hot-House world.

1) The climate, astronomical forcing, and chaos theme involves the development of a global high resolution (~20 ky) spatio-temporal matrix to examine how astronomical forcing plays out over latitude in continental and marine environments. Although efforts are underway to finally obtain comparable climatic records from the Quaternary and rest of the Neogene by others, it is essential to obtain comparably detailed records from more ancient times to understand the long term behavior of the climate system, its forcings, and its age-independent aspects. In addition, the climatic transect for Triassic-Jurassic Pangea can be obtained for longer time periods and at more modest expense than for virtually any other geologic period, including the Neogene.

Integral to this goal of understanding astronomical forcing over latitude, is the exciting realization that it provides a matrix for exploring the long-term behavior of the planets. The million year-scale cycles of eccentricity expressed as modulations of climatic precession already documented from Triassic-Jurassic tropical regions (Olsen and Kent, 1999a), has allowed calibration of part of the chaotic behavior of the planets outlined by Laskar (1990) (Figure 2). However, a fuller understanding and tests of these observations require equally detailed records from other latitudes, especially where obliquity is prominent (e. g. high latitudes). Records in which obliquity is prominent are also needed to refine the Triassic-Jurassic general precessional “constant”, needed to constrain the evolution of the Earth-Moon system as well as certain as yet poorly constrained geophysical parameters of the Earth. The development of this high-resolution spatio-temporal matrix will result in general methodologies for producing insolation curves for time periods far distant from the 20 my limit imposed by the chaotic behavior of the planets.

2) The Pangean break-up theme focuses on the evolution of the rift system itself and the initiation of oceanic crust production and drift. The high-resolution time scale now available for the Late Triassic and Early Jurassic allows a quantitative understanding of continental extension and ultimate rupture, both at the basin and trans-continental scales. Recent efforts by Contreras et al. (1997) indicate that it is possible to derive the large scale behavior of rift-basins (e.g. The Newark basin) from first-order fault growth models. However, understanding of the linkages between basins and the time- and geography-dependent aspects of continental rifting will require additional high resolution records from different rifts within the same and different rift systems.

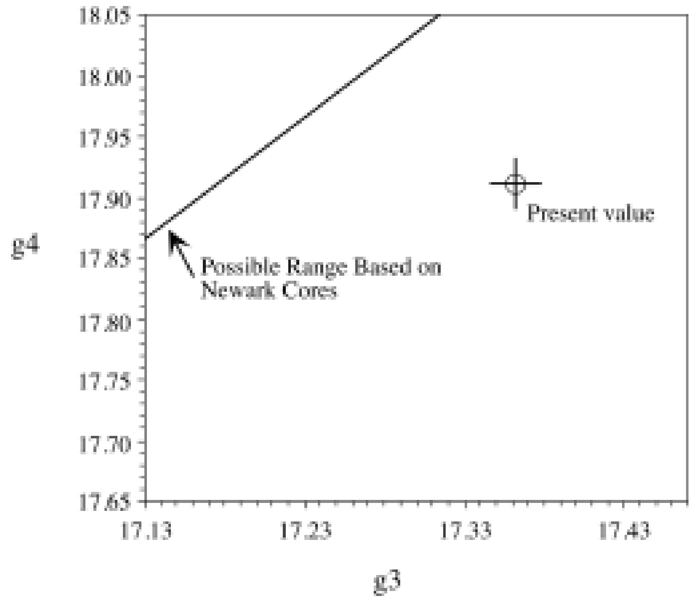

Figure 2: Range of possible g3 and g4 values based on the Newark cores andlimited by the size of the chaotic zone as defined by Laskar (1990) for the last 200 million years and possible range of those values that satify the data from the NBCP cores (from Olsen and Kent, 1999a)

Especially notable is the realization that the CAMP igneous event (Figure 3) was of gigantic proportions but of very short duration (Marzoli et al., 1999; Olsen, 1999b). It is plausible that the CAMP Large Igneous Province (LIP) was related to the development of the extensive suite of seaward-dipping reflectors (SDRs) bordering the south-central Atlantic (Oh et al, 1995; Talwani et al. 1995). Because this may very well be the largest continental LIP known and it appears temporally associated with the Triassic-Jurassic mass-extinction, it is critical to understand the links between these entities, and this requires deep sampling of the seaward-dipping reflectors themselves and the related rifts. Obviously, the relation between the CAMP, the seaward-dipping reflectors, and rifting is integral to the understanding of the fundamental processes of plate-motion, and the deep Earth.

3) The biotic change in a Hot-House world theme deals with biological patterns at three scales: global biogeographic patterns characteristic of the

Hot-House world; Triassic-Jurassic evolution; and the Triassic-Jurassic mass extinction. According to Zeigler et al. (1993) Hot-House Pangea may have been characterized by a unique phytogeography with extraordinarily limited equatorial humid zones. High resolution climate and phytographic data is needed over a wide swath of geography to allow tests of the efficacy of global climate models under appropriately constrained boundary conditions, at appropriate temporal and spatial scales.

Mammals, lizards, turtles, frogs, salamanders, dinosaurs and pterosaurs evolved during the Triassic. All but pterosaurs survived both the Triassic-Jurassic and Cretaceous-Tertiary mass extinctions (dinosaurs in the form of birds). Understanding the chronology, tempo, and mode of their evolution, as well as that of their contemporaries, is of obvious intrinsic interest, and sheds light on the origin of major groups. Critically needed are high-resolution records to provide chronologies for the diverse biotic assemblages that have been discovered to date, as well new material from particular critical episodes of biotic change such as the Triassic-Jurassic boundary.

There is now growing evidence that the Triassic-Jurassic mass extinction was of very large magnitude and very abrupt. The cause is as yet unknown as is the temporal scale outside the Newark basin. However, very recent work by McElwaine et al. (1999) on sections from Greenland and Sweden shows that the extinction appears to have been associated with an abrupt CO2 increase. Such an increase of CO2 could have resulted from massive outgassing associated with the CAMP flood basalts or even an asteroid impact. In any case, the temporal and geographic framework for the boundary and its relationship to the CAMP event require the high-resolution sampling that a pole-to-pole coring transect would uniquely provide.

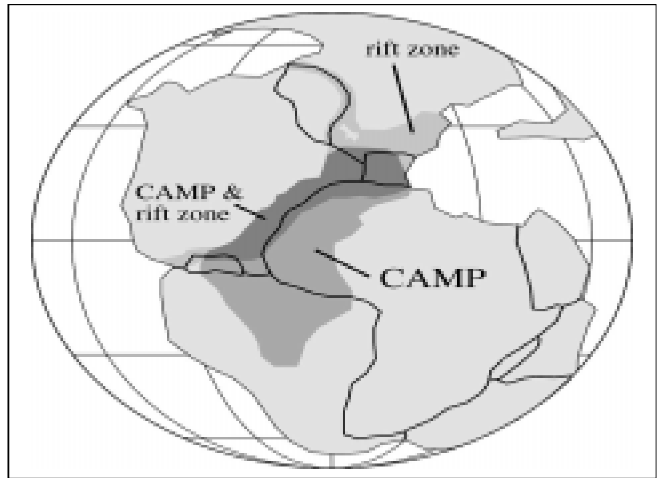

Figure 3: Dimensions of the CAMP igneous event at 202 Ma. From Olsen (1999).

SCIENCE FOCUS AREAS

A main result of the workshop was the delineation of six geographic areas in which coring could best address the principle scientific themes. At the present time, the areas known in enough knowledge to proceed fall into three conjugate margin transects and three additional areas of interest. These are: 1) Low latitude conjugate margin transect; 2) Mid-latitude conjugate margin transect; 3) High latitude conjugate margin transect; 4) Colorado Plateau; 5) Sicily; and 6) Siberia.

The low latitude conjugate margin transect would focus on coring targets related to the Pangean break-up theme, specifically the relationship between the CAMP event, the seaward dipping reflectors, and the Triassic-Jurassic boundary. Off- and onshore southeastern United States is the main area of interest for coring from the shallowest areas the seaward-dipping reflectors could be sampled on the continental shelf, to onshore where lavas connected to the SDRs overlie or are interbedded with rift basin sedimentary strata (e.g. South Georgia Rift). The conjugate margin of Mauritania, Senegal, and Mali can provide critical data on the CAMP rocks on the surface and in the subsurface.

The mid-latitude transect comprises the Nova-Scotian and Newfoundland margin and its conjugate Moroccan-Iberian counterpart. This transect straddles the boundary between volcanic and non-volcanic margins. Coring was identified as needed specifically in the Fundy basin of Nova Scotia, which is the largest of the logistically accessible basin to provide a climatic record dominated by precession, but with some obliquity forcing, address biotic change at the Triassic Jurassic boundary, and provide a chronology of tectonic events related to the volcanic and non volcanic margin boundary. Complimentary record, but less thick is available in Morocco and Iberia.

The high latitude conjugate transect is principally Greenland and northern Europe. Existing data shows that Greenland has a climatic record that has obliquity forcing recorded (Clemmensen, et al., 1998), and hence cores from Greenland and the complimentary Germanic basin are critical to understanding the climatic effects of astronomical forcing in the Hot-House higher latitudes and planetary behavior, as well as constraining the Triassic-Jurassic boundary in the same regions. A Triassic Germanic basin coring project is already underway (Bachmann, pers. comm.). The workshop stressed and validated the critical role of magnetostratigraphy in that project.

In addition to these three conjugate margin transects, the workshop focused on three other areas. First, while not a rifting area, the Colorado Plateau comprises a classic Triassic-Jurassic sequence in which many of the richest faunal assemblages from that period have been recovered. However, the relationship between the stratigraphy of the Colorado Plateau and the rifting area remains very controversial, as does the existence of the so called “J1-Cusp” and the amount of rotation of the Plateau itself, which historically have strongly influenced paleolatitudinal estimates of virtually all of Pangea. The workshop concluded that a core or cores through the Triassic Jurassic sequence on the Plateau as well as off the Plateau would resolve these issues. Second, marine sections in Sicily, particularly Monte Triona and Pizzo Mondelo should provide ideal places for coring to resolve marine/continental correlations as well as provide a marine record of orbitally forced climate overlapping in time with that of the continents. Third, polar areas in the Triassic Jurassic specifically Siberia, have continental basins (with abundant coal) in which cores should allow examination of polar climate during Hot-House times.

The workshop concluded that high-latitude Southern Hemisphere (e.g. Karoo, Argentina) and polar (Australia, Antarctica) targets are desirable but that further work was needed to identify specific target areas.

ACTION ITEMS

The workshop concluded with the recommendation for five specific short-term action items: 1) Propose to NSF/ICDP to core East-Greenland; 2) Produce a letter of intent to ODP for coring the seaward dipping reflectors and landward targets; 3) Produce a letter of intent to ODP/ICDP/NSF for coring the Fundy basin of Nova Scotia; 4) Produce a proposal to NSF to core the Colorado Plateau; and 5) Forge linkages to other programs, (e.g. German Consortium, MARGINS, RIDGE).

A www site for viewing a description of the meeting and its field trips as well as the draft report of this meeting is at: *http://www.ldeo.columbia.edu/~polsen/nbcp/pangeaworkshop.html*

Steering Committee: P. E. Olsen, D. V. Kent, R. Raeside, M. Withjack, G. McHone, F. Surlyk, K. Burke

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