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Continental Coring of the Newark Rift

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The entire Late Triassic record of the Newark continental rift of New Jersey, New York, and Pennsylvania will be drilled to recover about 7000 m of continuous core under the National Science Foundation's Continental Lithosphere Program. Unlike the relatively well-known postrift sedimentary succession of continental margins, there is hardly any continental rift sequence known in the detail necessary for quantitative tectonic or stratigraphic models. The Newark basin is one of the most accessible and most studied rifts in the world. While much has been learned over the 150 years of study by piecing together the record from discontinuous outcrops [*Manspeizer*, 1988; *Olsen et al.*, 1989], inevitable uncertainties in correlation and facies relationships have hampered the development of a comprehensive tectonic and stratigraphic history.

The Newark basin (Figures 1, 2) is one of a series of rifts that developed during the 60 m.y. (235–175 Ma) prior to the production of the earliest oceanic crust in the region along the North American-African suture. In eastern North America, these rifts formed along reactivated Paleozoic thrust faults that follow the grain of the Appalachian orogen; the exposed fill of these rifts is termed the Newark Supergroup [*Froelich and Robinson*, 1988] (Figure 1).

The Newark basin in cross section is a relatively simple, faulted, and partially folded half graben with a series of right-stepping relay boundary faults on its western edge (Figures 1, 2); in longitudinal section the basin is a synform. All of the basin fill is continental in origin and most is lacustrine. The oldest sediments are probably early Late Triassic in age (early Carnian 230 Ma), and the youngest are Early Jurassic in age (Sinemurian 199 Ma). The overall stratigraphic architecture (Figure 3) in the Triassic age part of the Newark basin is very similar to many rift basins of the world, and consists of three parts: a basal fluvial sequence (Stockton Formation), a middle "deep water" lacustrine sequence (Lockatong Formation), and an upper "shallow water" sequence (Passaic Formation). It is just this sort of common stratigraphic pattern that needs to be quantitatively modeled and physically explained. The sedimentary section of Early Jurassic age is also mostly lacustrine but its lower part is interbedded with thick thoeliitic lava flows (Figures 1–3).

A critical characteristic of the 26-m.y.-long lacustrine section of the Lockatong and Passaic formations is that it is primarily composed of a hierarchy of sedimentary cycles caused by the rise and fall of lake level, first identified in the Newark basin by Franklyn Van Houten. These sedimentary rhythms have been interpreted as reflecting climate cycles controlled by Milankovitch-type forcing (Figures 3, 4). Characteristic periods of the precession of the equinoxes (presently 19,000 and 23,000 years), cycles of the obliquity of the Earth's axis (presently 41,000 and 54,000 years), and cycles of the eccentricity of the Earth's orbit (95,000, 123,000, 413,000, and 2,035,000 years) have been identified in outcrops of sections of the Lockatong and Passaic formations (Figure 4) [*Olsen*, 1986]. These cycles are present over the entire lacustrine section, but general lack of continuous outcrop precludes detailed analysis, a problem addressed by the proposed coring.

The geomagnetic polarity time-scale is well known from analysis of marine magnetic anomalies back to about the middle Jurassic, the age of the oldest ocean floor. Prior to that time, geomagnetic polarity history must be determined from magnetostratigraphic studies of land sections; prerequisites include availability of continuous and well-dated sections with favorable magnetic properties. Paleomagnetic work in progress on outcrops and shallow cores in the Newark basin, in conjunction with the available cyclostratigraphy, demonstrate that the Newark Supergroup sediments satisfy these requirements [e.g., *Witte and Kent*, 1989]. Although the magnetizations are not simple and typically include a pervasive overprint related to a hydrothermal event in the late stages of basin development, a characteristic penecontemporaneous magnetization of normal and reversed polarity can be consistently isolated. Using distinctive Van Houten cycles as key lithostratigraphic marker beds to correlate between a half dozen sampling transects, we have been able to construct an internally consistent magnetostratigraphic framework for the Newark basin (Figure 3).

Ten polarity magnetozones ranging from about 100 to 2000 m in thickness are identified in the Newark basin sequence. Bearing in mind that resolution has been limited by availability of outcrop, resulting in stratigraphic sampling gaps of up to 600 m, the Stockton and Lockatong formations are of reversed polarity, the Passaic Formation has mixed normal and reversed polarity and the earliest Jurassic age extrusive interval is uniformly of normal polarity (Figure 3). We have good stratigraphic coverage of the sediments interbedded with the basalts in the extrusive interval from work on the shallow Army Corps of Engineer cores; the new cores will allow comparable stratigraphic resolution in the Triassic strata with no sampling gaps. The resulting polarity stratigraphic sequence will be calibrated in time using the Milankovitch cyclostratigraphy.

The principal objective of this project is the recovery, with continuous core, the entire approximately 6-km-thick Late Triassic age section spanning the stratigraphic interval from the base of the Early Jurassic age basalt flows to metamorphic Paleozoic and Precambrian basement in New Jersey (Figure 1). What will be gained from the coring is a high-resolution chronostratigraphy of the Newark rift basin, which will include production of a detailed Milankovitch-type cyclostratigraphy at the 20,000-year level of resolution based on sediment fabrics and optical characteristics of the core, documentation of the biostratigraphy (palynology) of the cored interval, and production of a detailed magnetostratigraphy of the core. This detailed record will allow most of exposed portions of the basin to be correlated at the same scale of resolution, provide a basis for developing and testing quantitative models of rift basin evolution, and be the basis of a standard biostratigraphic, and geomagnetic reversal time scale for the Late Triassic.

The overall drilling plan is to commence coring in the lower part of the section in summer-fall 1990 and to complete coring by the end of 1991. To optimize competing cost and scientific considerations regarding depths of penetration, the gently dipping section will be cored in a series of 5-6 relatively shallow holes (nominally 1100 m) along two transects trending north-south in central New Jersey (Figure 2). The rationale for two transects is to avoid the stratigraphic and alteration complications caused by the Palisade sill, which in our present plans will not be cored (Figure 1). The first transect will be to the east of the Delaware River in the southern fault block and will cover the stratigraphic interval from the base of the Stockton Formation to the Perkasie Member of the lower Passaic Formation in three cores. The second transect will be in the New Brunswick to Bound Brook area and will cover the stratigraphic interval from the Perkasie member to the base of the Jurassic basalts (Figure 3) in three more cores. The correlation datum between the transects will be the lithologically distinctive Perkasie Member, which also is characterized by a geomagnetic polarity transition at its base.

Core diameter will be at least 2 inches (5 cm) and anticipated hole diameter will accommodate slim-hole logging tools, including a borehore televiewer (to assure core orientation), as well as a variety of standard techniques including natural gamma radioactivity, neutron density, and resistivity. Core orientation will primarily be by televiewer orientation of bedding planes and fractures matched to the core. The core will be split longitudinally with one half intended for archiving and the other half for sampling. Initial core

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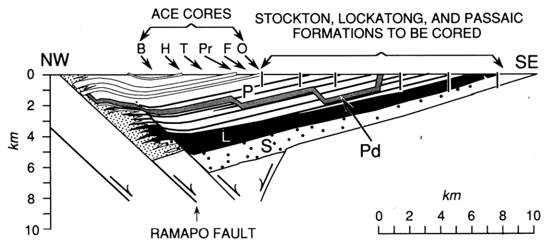

Fig. 2. Generalized cross section of Newark basin based on surface data in transect areas with position of core holes shown diagrammatically. Note that the Palisade Diabase (Pd) will be avoided in the core transect, and key lithostratigraphic marker beds (distinctive Van Houten cycles) will be used to correlate between holes. Symbols as for Figure 1.

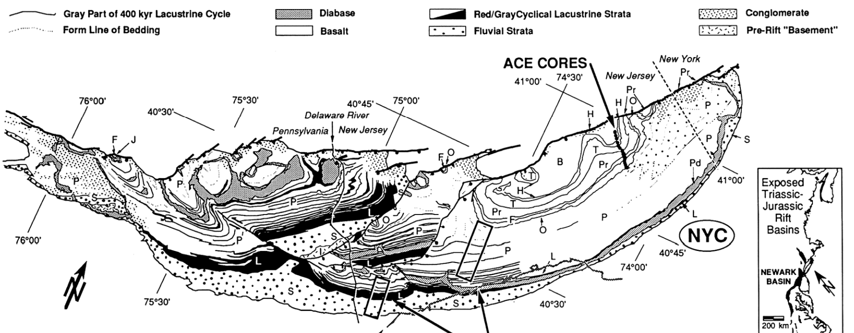

Fig. 1. Geological sketch map of the Newark basin and position of Newark basin within the Newark Supergroup. Core transect locations are indicated by boxed areas. NYC and PH represent the position of New York City and Philadelphia, respectively.

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storage and handling will be at Lamont-Doherty Geological Observatory in Palisades, New York.

The Newark basin coring project should be viewed as an opportunity for additional scientific investigations, and we would be happy to provide information and guidance for requests for support for projects based on these core material, logs, as well as the holes. The cores and logs, of course, will be available indefinitely to the scientific community; however, because of monetary and safety considerations, the holes themselves must either be sealed shortly after logging, or responsibility for their closure must be accepted by the interested party. A few obvious associated projects might include coring of the Palisade sill, organic-inorganic geochemistry, sedimentary petrology, and clay mineralogy of the cores and sedimentary cycles, geophysical logging tool calibration, installation of down-hole seismometers, production and analysis of seismic profiles along core hole transects, groundwater studies, and magnetic mineralogy.

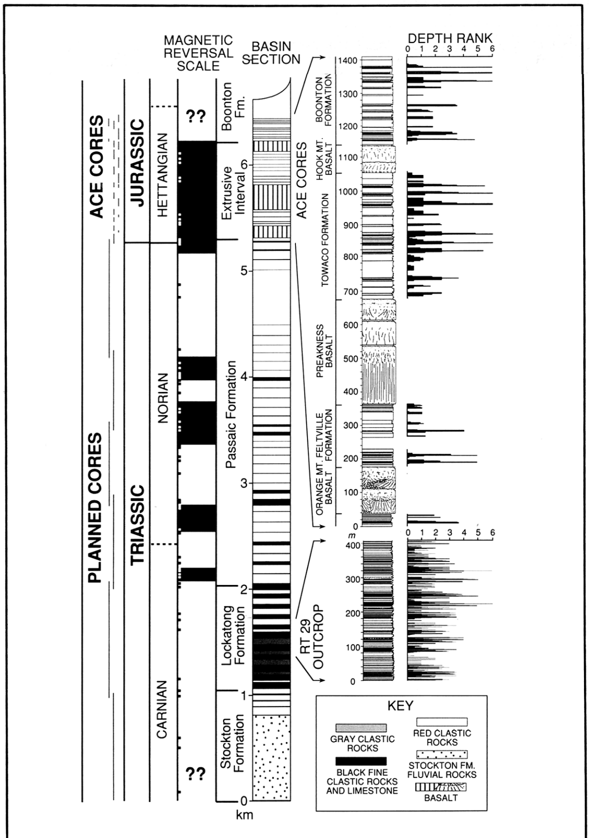

Fig. 3. Newark basin stratigraphy and magnetic reversal sequence showing details of cyclical lacustrine deposition based on cores from the Army Corps of Engineers (ACE) and surface outcrops. Depth rank is a proxy of lake depth based on sediment fabric that correlates with organic carbon content and fossil preservation (see Figure 4). Route 29 section described by *Olsen* [1986]. Black/open bars in the magnetic reversal scale represent normally/reversed magnetized zones and the ticks represent sampling sites of surface outcrops and the ACE cores, projected to common stratigraphic base using key lithostratigraphic marker beds.

An informal evening session is scheduled for May 29 at the Convention Center, 7:30-9 P.M., room 305, during the AGU Spring Meeting in Baltimore, Md. Interested persons should contact Paul Olsen or Dennis Kent at 914-359-2900. A workshop on the core project was presented at the Northeast Section meeting of the Geological Society of America held May 5-7 in Syracuse, N.Y.

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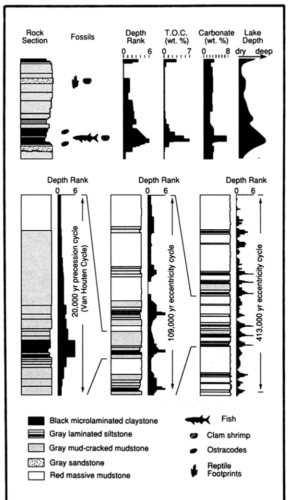

Fig. 4. Sedimentary cycles caused by Milankovitch-type climate changes. *Top,* single lake sequence (Van Houten cycle) showing changes in depth rank and associated variation in chemistry and fossil content. *Bottom,* compound cycles made up of increasing hierarchies of Van Houten cycles.