Geology and Diagenesis of Belridge Diatomite and Brown Shale, San Joaquin Valley, California

The late Miocene to Pliocene argillaceous and siliceous shales of the upper Monterey Formation (the Brown Shale and overlying Belridge Diatomite) represent laterally continuous deposits of nearshore, diatom-rich muds and open marine, argillaceous, diatom-bearing muds on a developing shelf and growing anticline which flanked the San Joaquin basin. These units are laterally equivalent to submarine fan and turbidite sedimentary rocks deposited into the basin from the west, south, and east.

The lithology of the Brown Shale and Belridge Diatomite is controlled by original composition and subsequent burial diagenesis. The muds underwent diagenetic alteration with the development of silica phases in the sequence: (1) unaltered diatom frustules (biogenic amorphous silica or opal-A); (2) diagenetic amorphous silica (opal-A); and (3) diagenetic crystalline silica (opal-CT). In the oil field, the Belridge Diatomite grades downward from a massive or faintly laminated siliceous mudstone with diatom frustules and opal-A', to a laminated and massive siliceous mudstone with opal-A' and some well-preserved diatoms. The Brown Shale grades from a massive or laminated siliceous mudstone with opal-A' and some diatoms to a well-laminated argillaceous, diatom-bearing mudstone with opal-A' and some opal-CT. There is no distinct break in lithology between the Belridge Diatomite and Brown Shale reservoirs, but recrystallization and detrital clay increase downward across the boundary.

Porosity in the best diatomite is about 62%, and permeability is about 1 md.

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Lower Pleistocene Quiet-Water Lacustrine Ooliths from Koobi Fora Tuff, East Lake Turkana, North Kenya

Complex, asymmetric ooliths occur within a thin (5 to 50 cm) carbonate deposit exposed along the northeastern margin of Lake Turkana, an alkaline lake located south of the Kenya-Ethiopia border. The limestone is part of a lower Pleistocene sequence of tuffaceous lake margin sediments (the Koobi Fora tuff) and outcrops over an area of 45 sq km. It is the only laterally extensive, oolitic unit within the 300-m section of Pliocene-Holocene lacustrine and fluvial sediments in the basin. Structurally, the limestone consists of multiple, well-cemented layers, the tops of which in some places exhibit desiccation cracks. Texturally, it ranges from oosparite to biosparite. The unit is composed predominantly of complex ooliths (2 to 80%), biogenic grains (0 to 10%), micritic, low-Mg calcite cement (0 to 15%), and blocky/sparry low-Mg calcite cements (15 to 90%). The ooliths average 0.8 mm in diameter and consist of nuclei that are unevenly coated by as many as 15 incomplete, overlapping, fan-shaped rims of radial-fibrous, low-Mg calcite. Both texture and mineralogy appear to be primary. Within a single oolith, every "fan" shows an orientation of fibrous crystals which is unique with respect to adjacent "fans." Each fan-like lamina thus represents a different episode of calcite accretion.

The ooliths formed on a coastal plain inundated by proto-Lake Turkana during a relatively high stand of lake level. Calcite precipitated only on the up-sides of stationary nuclei, however grains remained at the sediment surface long enough to be moved repeatedly by high energy waves and acquire composite cortices. The occurrence of asymmetric ooids indicates that agitation may play a minor role in oolitic deposition. In quiet water settings, nuclei availability, presence and concentration of organic matter and/or microorganism activity may be the major factors controlling ooid growth and morphology.

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Biostratigraphy of Discocyclinid-Bearing Beds, Eocene Llajas Formation, Southwestern Santa Susana Mountains, California

Tests of the discocyclinid foraminifer *Pseudophragmina clarki* occur in several 50-cm thick beds that are widely dispersed within alternating laminated and bioturbated sandstone of the Llajas Formation. At the 575-m thick type section, this sandstone makes up the interval from 100 to 370 m above the base of the formation.

Most of the beds consist of laminated to bioturbated, calcareous, very fine to fine quartzarenite; many are channel deposits, within which tests are concentrated in small pods. *Turritella andersoni lawsoni* may or may not occur with the discocyclinids, but if present it is the only megafossil. Associated foraminifers, listed in decreasing abundance, include *Robulus, Nodosaria, Cibicides, Operculina, Asterigerina,* and *Quinqueloculina.* Most of the genera are extant and are found today in tropical to subtropical shallow marine waters.

The fragile tests of *Pseudophragmina clarki* are mostly complete, unabraded, and 1.5 to 7 mm in diameter. Associated fossils also show no obvious signs of abrasion but they must have been transported because they occur in what are interpreted to be channels. Absence of significant abrasion and fragmentation is suggestive of minimal transport. *P. clarki* and associated fossils, therefore, constitute transported assemblages which are in the same environment in which they lived. The paleontologic evidence of a shallow marine environment is in keeping with the presence of the fossil beds within alternating laminated and bioturbated sequences. Modern examples of such sequences are found predominantly in inner shelf environments.

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Mesozoic and Cenozoic Base Maps

Sixteen maps are presented illustrating the relative positions of the continents from the Early Triassic to the Recent. The spreading history of the Atlantic and Indian Oceans is based on the plate tectonic models of Sclater et al; Norton and Sclater; and Phillips and Tapscott. The age of the oceanfloor has been plotted using Sclater's data-base of worldwide linear magnetic anomalies.

Mesozoic and Cenozoic paleomagnetic data were compiled and selected for reliability. Pole positions obtained from samples that were insufficiently demagnetized, that were from unstable tectonic areas, or that did not exhibit a primary remanence, were rejected. A global apparent polar wander path (African coordinates) was constructed using these selected paleomagnetic determinations. The position of the magnetic pole for each plate tectonic reassembly was estimated by interpolating along this polar wander path.

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