Green River laminites: Does the playa-lake model really invalidate the stratified-lake model?

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Abstract

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The playa-lake model is untenable for the typical fish-bearing, kerogen-rich microlaminated sediments. These laminites were probably deposited in a large ectogenic meromictic lake—a chemically stratified lake that formed when increased fresh-water inflow "drowned" a saline playa complex.

First Page Preview

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ABSTRACT

Proponents of the playa-lake model have proposed deposition of most of the Green River Formation microlaminated carbonates (including oil shales) in lakes that were not perennially stratified (meromictic). However, there is a variety of evidence favoring a meromictic depositional environment: (1) close similarity of much of the lamination to varves in modern meromictic lakes, (2) evidence that hydrologic events favoring development of meromixis (chemical stratification) occurred prior to deposition of major accumulations of oil shale, (3) mutually exclusive distribution of fossil nekton (especially fish) and normal lacustrine benthos (including mollusks), and (4) analogy with a Quaternary playa that became a meromictic lake following increased inflow.

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INTRODUCTION

A paper by Surdam and Stanley (1979) is one of a series of works, mostly by Surdam and various co-workers, which propose that deposition of most of the Green River Formation occurred in a playa-lake complex. Its proponents feel that this model invalidates the "classic" meromictic (perennially stratified) lake model evolved in several papers by Bradley (1929, 1963; Bradley and Eugster, 1969). Some convincing evidence— stromatolites, oolites, ripples, flat-pebble conglomerates—has been offered, demonstrating that much of the formation was deposited in a playa complex, in environments such as shallow, ephemeral, unstratified ponds or emergent flats (for example, Lundell and Surdam, 1975). However, controversy continues to surround the most-studied rocks of the Green River, the oil shales (actually microlaminated, kerogen- and fish-bearing carbonates). In essence, the playa-lake model proposes deposition of these sediments in a shallow, unstratified or intermittently stratified lake surrounded by extensive salt flats and attributes their lamination to aperiodic, intermittent phenomena such as algal-mat growth and storm events. The meromictic model envisions deposition in a large perennial meromictic lake and interprets much of the lamination as a series of varves produced by regular seasonal variations in physical-chemical or biogenic carbonate precipitation.

Desborough (1978) has argued effectively against the playa model, basing his reasoning on evidence from chemical petrology and mineralogy. I propose here that the playa model interpretation of oil shales is also vulnerable in terms of other kinds of evidence, on which its proponents have placed great emphasis: facies relationships, sedimentary structures, paleoecology, and analogy with younger closed basins. This paper is not meant to be a comprehensive discussion of the Green River Formation, but a critique intended to stimulate a closer look at Green River laminites. The basic theme is that the playa-lake model, as it relates to most of the microlaminated carbonates, is inadequate and that a meromictic model is better able to explain several diverse phenomena. This critique is an outgrowth of a paper (Boyer, 1981) describing a lacustrine sequence in North Dakota whose resemblance to the Green River Formation is obvious and striking; every lithology present in this sequence—tuffaceous sandstone, greenish zeolitic mudstone, chalcedonic chert, a possible paleosol, dolomite with obvious current-formed structures, and laminated limestone with superbly preserved fish—also appears in the Green River Formation. My interpretation concentrated on the laminites, which I regard as sediments of an ectogenic meromictic lake—a type of chemically stratified lake that often forms when some extrabasinal event (usually climatic change) increases fresh-water inflow, enlarging a pre-existing saline lake (see Fig. 1). The ectogenic-meromictic model may have wide applications in interpreting sedimentary sequences of closed basins. Extrapolation of the model to the Green River Formation seems especially promising in view of the similarity of its laminites to the North Dakota ones.

FACIES RELATIONSHIPS

The facies relationships described by Surdam and Stanley (1980) suggest that an ectogenic-meromictic model is appropriate for much of the Green River oil shale. They stated that oil shale of the Laney Member was deposited after Lake Gosiute expanded and deepened as a result of "spillover" of drainage from other basins to the north. Their interpretation seems tantalizingly incomplete. The sequence of events they reconstructed—evaporative buildup of salts in a closed basin, followed by increased inflow, forming an open lake—is almost a "recipe" for generating an ectogenic meromictic water body. Yet Surdam and Stanley shrank

Index Terms/Descriptors

carbonate rocks | Cenozoic | environment | Eocene | Green River Formation | lacustrine environment | laminations | laminite | lithofacies | oil shale | organic residues | paleoecology | Paleogene | paleolimnology | planar bedding structures | sedimentary petrology | sedimentary rocks | sedimentary structures | sedimentation | Tertiary | United States | Western U.S.

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