# PALEO-HISTORICAL FLUCTUATIONS IN PALEOGEOGRAPHY, DEPOSITIONAL ENVIRONMENT, AND CHEMISTRY OF EOCENE FOSSIL LAKE

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## ♦ INTRODUCTION

Fossil Butte National Monument contains within its boundaries a significant portion the world's best preserved and most complete ancient lake deposit, known in the scientific literature as the Fossil Butte and Angelo Members of the Green River Formation (Oriel and Tracy 1970). Fossil Lake, the Eocene depository of these members of the Green River Formation, occupied a north-south trending structural basin within the Wyoming Thrust Belt known as Fossil Basin. Within Fossil Basin one can follow individual time horizons or rock units from lake center to margin with relative ease and great accuracy. Those rock units have faithfully recorded lake center to lake margin differences in lake depth, turbidity, salinity, alkalinity, temperature, and faunal elements. Areal changes in thickness and lithology (rock type) can be measured and mapped revealing details of lake shape, geography, and regional differences in lake depth and chemistry. Details concerning location and size of fluvial inlets and deltas, variations in lake bottom gradient and sediment type, and how these relate to flora and fauna can be discerned. An understanding of these aspects of the ancient lake system are essential if paleontologists are to put together a complete picture of the lake's fish fauna, which is the focal point of the monument. A variety of basin analysis maps derived from data collected in the field and laboratory will be used to make paleoenvironmental and paleogeographical interpretations of Fossil Lake through time.

## ♦ OBJECTIVES

The primary objective of this research is to determine the paleogeograpy, depositional environment, chemistry and paleoclimate of Eocene Fossil Lake and to document how these aspects fluctuated through time. The result will be a series of about seven "time slice" maps portraying the widely differing characters of Fossil Lake throughout it's history. The aerial maps would show (when and where possible) lake margin boundaries, location of major inflow rivers, deltas, lake bottom gradient, variations in lake chemistry (salinity and alkalinity), variations of lake depth, location of subaqueous turbidity flow channels, sediment or facies distributions, Eh or oxygen conditions of the bottom sediment and water column, proximity and probable location of volcanic vents near the lake, and distribution of bottom dwelling bioturbators. These maps will be interpretive maps based on numerous data maps (isolith and isogrid, facies, mineral distribution, isotope variation, etc.) produced by plotting of sedimentary structure, facies, petrographic, mineralogic, unit thickness, total organic carbon, isotopic (oxygen), and other related data. Paleontologic data will be included where available or easily observed in hand samples (primarily ostracods, gastropods, trace fossils and plant remains).

## ♦ METHODS

During the 1991 field season 33 stratigraphic sections of the Fossil Butte Member of the Green River Formation were measured and sampled (Figure 1). Ten sedimentary units were sampled (generally fist sized samples) as indicated in Figure 2. Sections were located at approximately one km intervals along outcrops of the Fossil Butte Member where possible. Poor outcrops, covered section, or erosion (lack of outcrop) prevented sampling in some areas. Samples consisted of hand size rock samples that were labeled, including vertical orientation indicated with an arrow. Sample locations were plotted on topographic maps and air photos. Thickness of section was also measured between sample intervals.

A total of 330 samples were collected. In the laboratory each rock sample was slabbed with a rock saw, polished, acid etched and stained, to allow detailed sedimentological analysis. X-ray diffraction, thin-sectioning, and isotope analysis will be completed before the beginning of the 1992 field season.

Data obtained will be entered into a computer graphics program and plotted out as a series of paleogeographic maps showing unit thickness variations, mineralogic variations, laminae frequency variations, etc.

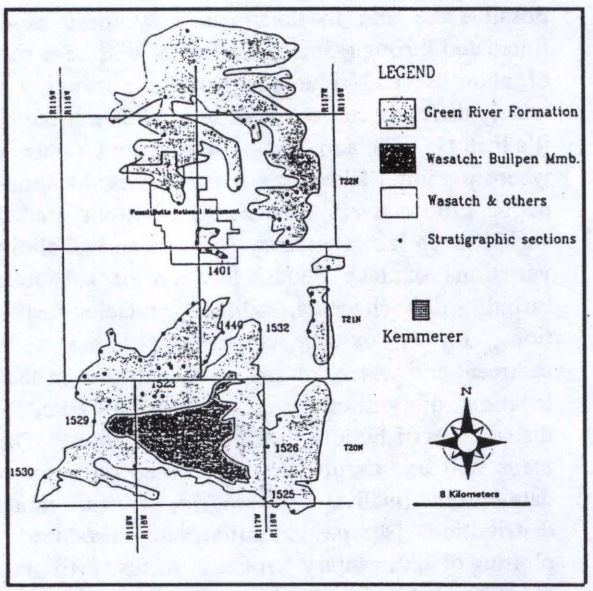


Figure 1. Location of measured stratigraphic sections within the Green River Formation of Fossil Basin.

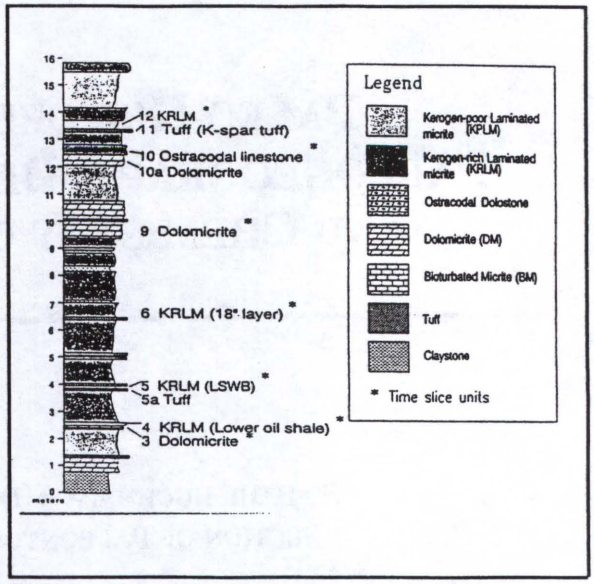


Figure 2. Stratigraphic section of the Green River Formation showing units sampled during this study.

## ♦ PRELIMINARY RESULTS AND INTERPRETATIONS

Although not enough data has been processed yet to construct detailed paleogeographic maps, field study and observations during lab analysis provide some insights into the paleogeography, paleoenvironments, geochemistry of Eocene Fossil Lake (refer to Figure 2). Unit 3 (refer to Figure 1), a dolomicrite, was found to grade laterally into calcimicrites nearer the margins of the basin, indicating fresher lake margins. The dolomicrite indicates hypersaline waters at the lake center, however the hypersalinity did not extend more than six kilometers outward from location 1401.

An abrupt expansion took place at the beginning of unit 4 (lower oil shale). This unit was found to be laminated, calcite dominated and kerogen-rich at all localities, indicating that Fossil Lake was at it's most expansive and freshest phase during deposition of this unit.

Unit 5a, a volcanic ash, shows alteration patterns that indicate a hypersaline lake at the basin center (about location 1440) as indicated by it's feldspar mineralogy. However the lake was increasingly fresh toward the margins, as indicated by

montmorillonite mineralogy.

Unit 5, can be easily identified by the presence of two red tuff beds marking it's base and top. The unit increases dramatically in thickness from about 8 cm at the basin center to over 28 cm at the basin margins. The laminae number increase from about 1000 to 1600 nearer the margins. Total organic carbon drops off from about 12% to less than 2% within eight kilometers of the basin center. Laminae thickness also follows this trend, increasing from .07 to .14 mm. Details of these trends will be plotted using a graphics program, and should reveal details about the lake's paleogeography. These data suggest that the precipitation of calcium carbonate was more dramatic at the lake margins. It is suspected that calcium-rich inflow waters mixed with the alkaline lake water resulting in higher rates of calcite deposition nearer the lake's margins.

Unit 6, famous for the abundance of fossil fishes, was apparently restricted to about a 150 $km^2$ area centered around location 1440. A centimeter thick pink tuff bed at it's base allows precise correlation of this unit. Total organic carbon drops off rapidly as it does in unit 5. The lake was restricted in size and occupied only less than half of it's normal basin. The calcite mineralogy of this unit is indicative of fresh waters.

Unit 9, a dolomicrite, is indicative of a highly regressed phase of Fossil Lake. The lake was hypersaline and all fish populations had either died or were driven to marginal fresh water lagoons or rivers.

Unit 10, represents a return to hypersaline conditions after a period of fresh lake expansion. The lake did, however cover over two-thirds of the lake basin, but probably was not more than several meters deep. Abundant ostracods at all locations, the presences of scour and fill structures, the restriction of laminated sediments to a 50 $km^2$ area centered around locality 1440 indicate shallow conditions.

Unit 11, the thickest volcanic ash (tuff) deposited in Fossil Lake, was found to be generally about 13 cm thick, but increased dramatically in the northwest part of the lake to over 25 cm, indicating a local volcanic source. Ripple and scour and fill structures within this unit provide evidence of shallow water conditions throughout the lake at this time. X ray mineralogy show that the tuff is composed of nearly 100% potassium feldspar, that suggests hypersalinity during it's deposition.

Unit 12 represents another expansion of Fossil Lake to it's second largest area, occupying about 350 $km^2$. It's calcite composition and well laminated structure provides evidence of a fresh lake, which seems contrary to the mineralogic evidence seen in Unit 11.

Data collected so far indicate a dynamic lake that occupied over 500 $km^2$ during it's most expansive phases and fluctuated from hypersaline to fresh. A closed hydrographic system and a nearly flat depositional basin allowed frequent regressions and expansions with only slight changes in lake level. Details of these events should become clear as more sample sites are studied, collected, and analyzed.

## ♦ LITERATURE CITED

Oriel, S.S. and J.I. Tracy, Jr. 1970. Uppermost Cretaceous and Tertiary stratigraphy of Fossil Basin, southwestern Wyoming: USGS Professional Paper 635, 53 p.