

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

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♦ INTRODUCTION

Fossil Butte National Monument contains within its boundaries a significant portion of 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 (Oriol 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 paleogeography, 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 will 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, 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 isograd, facies, mineral distribution, isotope variation, etc.) produced by plotting of sedimentary structure, facies, mineralogic, unit thickness, total organic carbon, isotopic (oxygen), and other related data. Paleontologic data will be included where available or easily observed in hand sample (primarily ostracods, gastropods, trace fossils and plant remains).

♦ METHODS

Field methods have included the measurement of nearly 100 stratigraphic sections selected whenever possible at approximately 1-2 km intervals along exposed outcrops of canyons and valleys. The sampling covered the majority of the Fossil Butte Member of the Green River Formation, involving an area of nearly 1000 sq. km. Poor outcrops, covered section, or erosion (lack of outcrop) prevented sampling in some areas.

The same stratigraphically equivalent sedimentary units (Figure 1) were sampled from each stratigraphic section. Samples consisted of hand size rock samples that were labeled, including vertical orientation indicated with an up-arrow. Sample locations were plotted on topographic maps and air photos. Thickness of each unit as well as intervals between units was measured with a jacob staff.

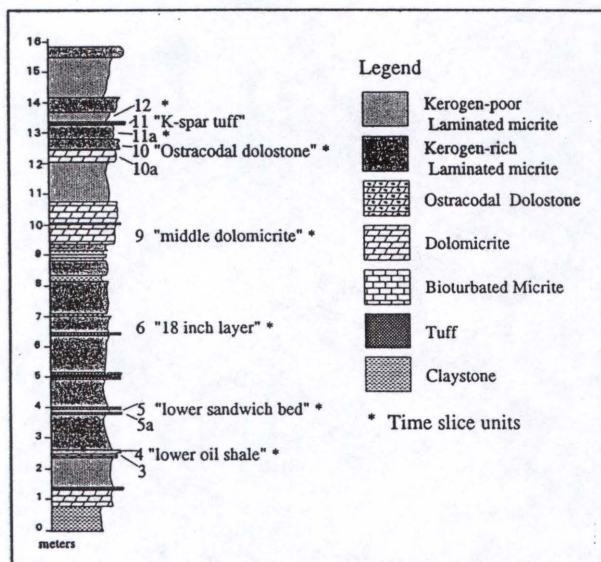


Figure 1. Stratigraphic section of the Green River Formation showing units sampled during this study.

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 is being performed on each sample. Data obtained is being entered into computer graphics programs and plotted out as a series of paleogeographic maps showing unit thickness variations, mineralogic variations, laminae frequency variations, etc.

♦ PRELIMINARY RESULTS

Figure 2 illustrates that preliminary paleogeographic maps that are being constructed. Fossil Butte National Monument is located somewhat north of the deepest portion of fossil lake. Preservation of fossil fish follow the depth trends, with the best preserved fishes found in the deepest portions of the lake. However fossil fish are still fairly well preserved in lake margin localities, and include more abundant sting-rays and other species. The map provides other important clues about Fossil Lake during unit 5 time. Note that lake depths are not great, generally around 11-13 m nearer the center. This is comparable with modern Salton Sea which has maximum depths of 15 m and is of comparable size (and contains abundant fish). The depth is calculated from 4 m maximum delta foreset sequences near the inflow area in the southeast corner of the basin. The delta foresets indicate the lake depth at site of deposition. Lake depths at any location are calculated by: multiplying the distance from known delta foreset sites by interpreted lake bottom gradients and then adding the estimated depth at the site of delta deposition (4 m maximum). Bottom gradients were probably less than .40 m per km (established from work of Bradley (1929, 1964; Surdam and Wolfbauer 1975; and Lundell and Surdam 1975). In other words, 16 km times .4 m plus 4 m would equal 10.4 m depth. One could add a meter for water depth above the delta topset beds. The bottom profile is interpreted from the unit 5 isopach map (unit thickness map), where one assumes that the thickness of the unit is related to lake depth based on work of Buchheim (in press). Deeper regions of the lake being more distant from the margins and source areas received less sediment deposition. Higher total organic carbon contents are also expected in the deeper zones due to lower oxygen levels and temperatures. Although not plotted on this map yet, total organic carbon contents of unit 5 follow in a general way these depth trends. Note that the paleogeographic map shows a relatively "steeper" bottom profile on the east side of the lake basin (as indicated by isopach lines), while the west side of the lake exhibits a much lower profile. Preliminary studies have indicated that the lake extended as a shallow shelf a significant distance to the west, perhaps as much as 30 km beyond the map border.

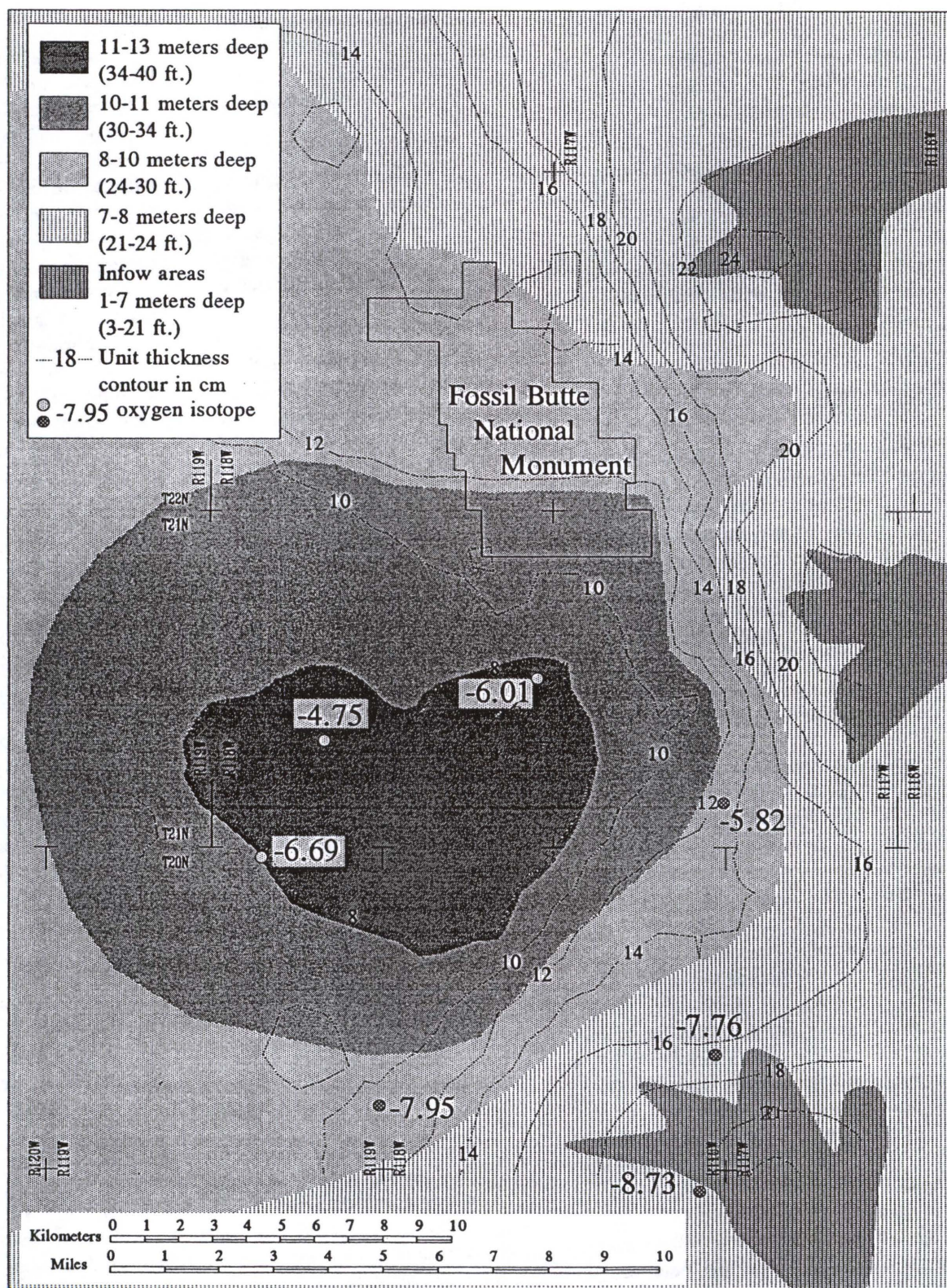


Figure 2. Paleogeography of Fossil Lake during Unit 5 time: includes lake depth, unit 5 thickness (contours), inflow dominated areas, and oxygen isotopes. See text for discussion.

Preliminary oxygen isotope data (note the larger numbers plotted on Figure 2) indicate fresher water conditions towards the margins of the lake. More negative numbers indicate fresher water conditions. Numbers less than -10 indicate very fresh waters while numbers more positive than -4 indicate saline waters (Janaway and Parnell Fig. 14 p. 104, 1989). This finding is consistent with data from calcite-dolomite ratios and associated tuff bed mineralogies that indicate a similar lake-ward trend from fresh to saline. This data will be included in the final paleogeographic maps.

Other significant findings to date, observed from the field and lab studies include the discovery of a river channel (a tongue of the Wasatch formation) that occurs between units 5 and 10 at location 1611 on the Hams Fork Plateau. This is an important discovery for a number of reasons. It documents the regression of Fossil Lake during this period of time and replacement of lake environment by fluvial flood plain and or mud-flat in this area. Detailed study of the cobbles in a channel associated with this tongue should also pin point the provenance (area of origin) of the rivers in this area that flowed into Fossil Lake. It is hypothesized that the eastern shoreline was a few kilometers east of this location, and a study of the cobbles in the channel deposit should verify or negate this hypothesis. Units 3 to 5 were also unique at this location, in that they contain beach and mud-flat sedimentary structures and an associated assemblage of gastropods. In general the entire formation takes on these characteristics in near-shore areas, however this is the first time that unit 3 to 5 have been traced directly into shore facies.

A significant discovery during the 1991 field season of a mass-mortality of fossil birds has spun off a detailed study of that deposit. A small quarry was opened that revealed thousands of extremely well preserved bird bones and a number of skulls.

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