Reconstruction of a Late Cretaceous-Paleocene river system - Geometry of an Early Tertiary nonconformity in the Elkhorn Mountains, northeastern Oregon

Gabriel Cisneros
Department of Geosciences, University of Arizona, Tucson, AZ 85721
Faculty Sponsor: George H. Davis, University of Arizona

MINI ABSTRACT

A significant unconformity in the Blue Mountains of northeastern Oregon separates Permian and Triassic metasedimentary rocks intruded by Late Jurassic to Early Cretaceous plutons below from Early Tertiary sedimentary rocks above. The eroded surface of the crystalline rocks below the nonconformity displays paleo-potholes and other dramatic evidence of fluvial erosion. The basal sediments above the unconformity contain an impressive cobble-boulder conglomerate up to 4 m thick as well as sedimentary structures and textures indicating that the area was host to a vigorous high-gradient river system proximal to a rapidly eroding highland. Reconstructing the nature of this river system required mapping the unconformity, constructing a structural contour map at the top of the crystalline "basement", and palinspastically restoring the original configuration. Results of this analysis indicate that the major streams were contained within valleys that were incised deeply (over 1000") into the Late Cretaceous landscape. These valleys, which presently trend N20W, have been rotated approximately between 15° to 60° clockwise since their formation based on paleomagnetic data from the basement units and the overlying Tertiary volcanic rocks. Thus the original flow direction was approximately to the west-northwest.

INTRODUCTION

During the summer of 1998, undergraduates from various colleges participated in a Keck Geology Consortium entitled, "Oregon-The Elkhorn Mountains". The leader was Dr. Kevin Pogue of Whitman College and the goal was to map the 7.5 minute Crawfish Lake quadrangle in the Elkhorn Mountains of northeastern Oregon. The mapped area contained an assortment of rock types. The oldest rocks in the area are Permian and Triassic metasedimentary rocks known as Elkhorn Ridge Argillite. These intensely deformed and folded rocks consist mainly of chert, siliceous argillite, and dark-colored argillite. The Elkhorn Ridge Argillite is intruded by the Bald Mountain batholith. The Bald Mountain batholith is Late Jurassic-Early Cretaceous in age and consists of eight distinct rock types that range from norite to quartz monzonite (Taubeneck, 1995). In some areas, these two "basement" rock units are overlain by Eocene to Oligocene basalt flows, silicic flows, andesitic tuff, and volcaniclastic rocks. The focus of this paper is a relatively thin and discontinuous sedimentary layer that locally intervenes between the basement Tertiary volcanics.

PALEOCENE-LATE CRETACEOUS CONGLOMERATE

A thin layer of Late Cretaceous-Paleocene conglomerate crops out locally throughout the Crawfish Lake and surrounding quadrangles. Taubeneck (1955) was the first to mention this unit. This conglomerate varies from a few centimeters to several meters thick, and consists of sub- to well-rounded, pebble- to boulder-sized clasts of chert, metagabbro, and quartzite. Clasts of serpentine, porphyritic dike rocks, and tonalite are also present. Most of the pebbles, cobbles, and boulders are well-rounded with obvious percussion marks. Taubeneck (1955) noted that many of the cobbles are rotten (easily crumbled when struck with a hammer), implying that they experienced a long interval of exposure prior to Tertiary volcanism. Similar sedimentary layers have been described by Wilkinson and Oles (1968) in the Mitchell quadrangle approximately 95 miles to the southwest, and the two may be related.

DEPOSITIONAL ENVIRONMENT OF THE CONGLOMERATE

French Diggings, (UTM 4976 N, 395 E), and Camp Carson, (UTM 4987 N, 398 E), are abandoned hydraulic mine sites containing an exposed "basement" unit with sedimentary rocks above. Figure 1 illustrates the sedimentary rocks at Camp Carson. Based on the stratigraphy presented in Figure 1, one can infer that the Camp Carson site is situated within a major paleo-river channel. It is evident that the conglomerate unit was deposited by a vigorous river system with a high gradient. It is also evident that the shale layer was deposited within a temporary lagoon environment. Abundant plant debris is apparent in the shale as carbonized impressions of leaves, and possible tiny conifer stems and silicified ferns (Jack Wolfe, Owen Davis, personal communication). Taubeneck (1955) suggests that the fossilized ferns could be *Tempskya,* a giant fern apparently restricted to late Cretaceous in western America. It is also clear that the conglomerate layer capping the shale was deposited by a flowing river system. Given the stratigraphy and sedimentary structures, one can infer a paleoenvironment containing a huge meandering river system flowing to the northwest. A temporary lagoon environment was either produced by fluctuating water levels or deposited as the paleoriver meandered. A contour map of the basement surface was constructed in order to define this paleoriver system.

STRUCTURE CONTOUR MAP

In order to analyze the geometry of this river system, the nonconformity was mapped within the studied field area. Knowing that the "basement" rocks were Permian to Early Cretaceous in age and that the volcanics present within our area were as Eocene in age, the Late Cretaceous - Early Tertiary surface could be defined by mapping out the contact between the two. Once this was accomplished a structure contour map could be constructed by plotting points of the contact between basement rocks and Tertiary volcanics within the Crawfish Lake, Limber Jim, Mt. Ireland, and Granite quadrangles. The points were formatted in a text only format and contours were computed and plotted using McGridzo, a contouring program (Fig. 2). The resulting map illustrates the topography of the present-day surface of the basement rocks in the studied quadrangles. Pre-Eocene faults are visible on the map and indicate areas that have undergone displacement. Cross-sections were produced in order to retrodeform the area and complete a palinspastic contour map that illustrates the true surface of the basement rocks during the Late Cretaceous-Paleocene (Fig. 3). This map depicts the restored basement surface and river channels can be clearly seen. In figure 3, both French Diggings and Camp Carson sites appear situated within a river channel.

INITIATION OF THE PALEORIVER SYSTEM

From the Late Cretaceous to the Oligocene, the locus of arc magnetism gradually shifted from the area OF the Idaho Batholith to near the present site of the Cascade (Lipman, 1992). It can inferred that during the Late Cretaceous, a volcanic arc existed in northeastern Oregon. Thus, regional uplift was invoked as an isostatic response to crustal thickening associated with voluminous granitic plutonism. Wilkinson and Oles (1968) and Taubeneck (1955) had earlier postulated the existence of this regional uplift. Also, using Reeside's (1944) isopach maps, Guilluly (1949) estimated that 6 km of rock was eroded from the surface of northeast Oregon, depositing thick Cretaceous sediments on the west coast. If this interpretation is correct, there was substantial uplift during the Middle Cretaceous in northeastern Oregon and adjacent Idaho. This uplift created large high-gradient rivers that eventually unroofed part of the Bald Mountain and Idaho Batholiths. The coarse fluvial deposits like those of French Diggings record the unroofing of the Cretaceous plutons as they were isostatically rising. The chert and quartzite clasts in the conglomerate were derived from the country rocks that hosted these plutons.

TECTONIC ROTATION

Paleomagnetic studies on rocks of the Oregon Coast range and the Blue Mountains of northeastern Oregon have concluded that Oregon experienced tectonic rotation during both pre-Tertiary and post-Tertiary times (Cox and Magill, 1977; Simpson and Cox, 1977; Wilson and Cox, 1980). Jurassic plutons of the Blue Mountains record approximately $60° \pm 10°$ of clockwise rotation. Beck et al. (1978), based this on paleomagnetic readings from andesitic flows just west of the Blue Mountains. They determined that $15° \pm 22°$ of post-Eocene clockwise rotation affected the Blue Mountains region. These flows are assumed to be associated with the andesite flows within the Limber Jim, and Crawfish Lake quadrangles. Using these measurements, it appears that the present northwest flow direction of the paleodrainage system has been rotated clockwise from its Late Cretaceous-Paleocene flow direction, which was westward.

CONCLUSIONS

As the locus of arc magnetism progressively shifted from the Idaho to the Cascades region, a sufficient amount of uplift occured in northeastern Oregon. This uplift was responsible for initiating the paleodrainage system and creating the pertinent unconformity. Throughout the Late Cretaceous and Paleocene, these rivers meandered across most of northeastern Oregon, rapidly eroding the surface and transporting the sediment to the west coast. Fig. 3 illustrates a captured moment of this paleoriver during its last stages. Both French Diggings and Camp Carson sites provide sufficient evidence of a major river. Via retro-deformation and retro-rotation, paleocurrent indicators point to the west.

METHODS

Software. Adobe Photo Shop, Canvas, and McGridzo are the applications that were used to complete the structure contour maps and stratigraphic column.

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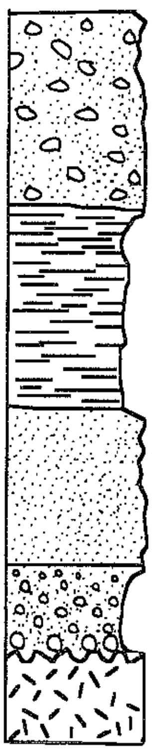
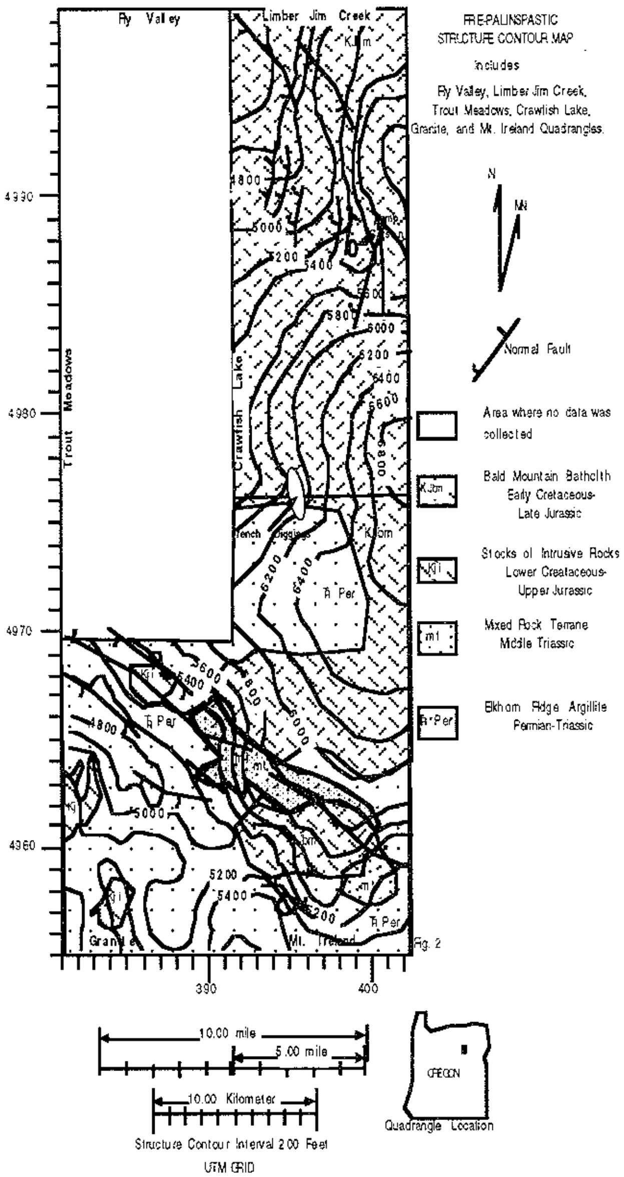
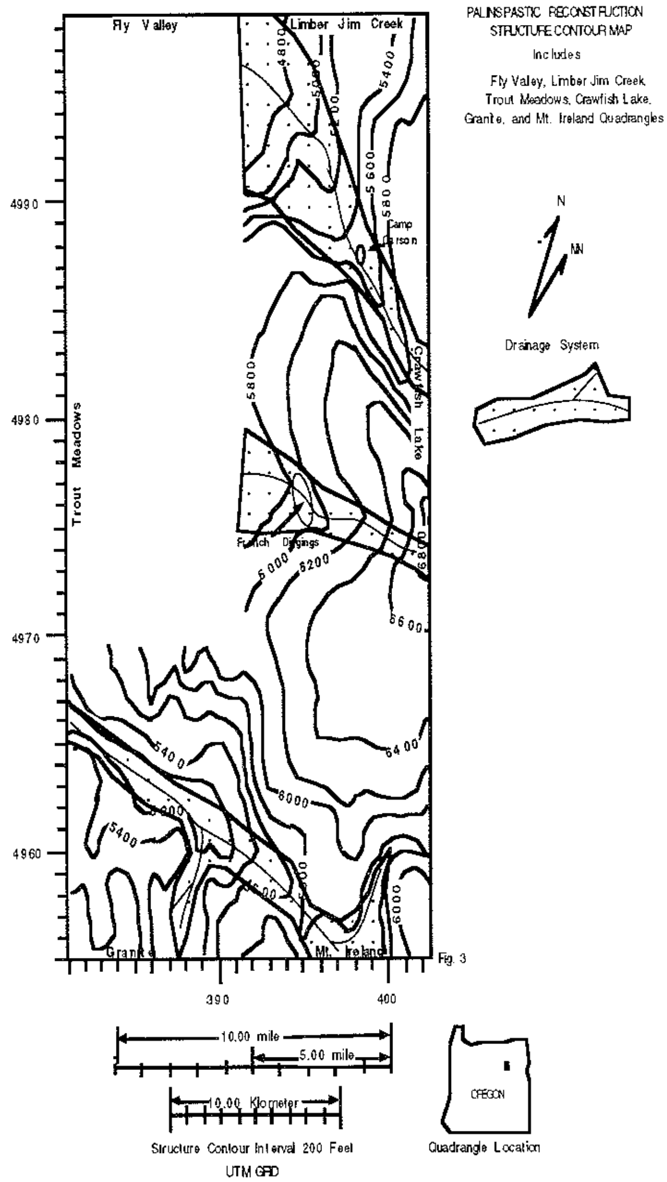


Figure 1


PRE-PALINSPASTIC
STRUCTURE CONTOUR MAP
Includes
Fly Valley, Limber Jim Creek,
Trout Meadows, Crawfish Lake,
Granite, and Mt. Ireland Quadrangles.
N
MN
Normal Fault
Area where no data was collected
KJbm Bald Mountain Batholith Early Cretaceous-Late Jurassic
KJi Stocks of Intrusive Rocks Lower Createaceous-Upper Jurassic
mt Mixed Rock Terrane Middle Triassic
TrPer Elkhorn Ridge Argillite Permian-Triassic
Fly Valley
Limber Jim Creek
Trout Meadows
Crawfish Lake
French Diggings
Granite
Mt. Ireland
4990
4980
4970
4960
390
400
10.00 mile
5.00 mile
10.00 Kilometer
Structure Contour Interval 200 Feet
UTM GRID
OREGON
Quadrangle Location
Fig. 2


PALINSPASTIC RECONSTRUCTION
STRUCTURE CONTOUR MAP
Includes
Fly Valley, Limber Jim Creek,
Trout Meadows, Crawfish Lake,
Granite, and Mt. Ireland Quadrangles
N
MN
Drainage System
Fly Valley
Limber Jim Creek
Trout Meadows
Crawfish Lake
Camp Carson
French Diggings
Granite
Mt. Ireland
4990
4980
4970
4960
390
400
10.00 mile
5.00 mile
10.00 Kilometer
Structure Contour Interval 200 Feet
UTM GRID
OREGON
Quadrangle Location
Fig. 3