STRUCTURAL ANALYSIS OF AN EXOTIC TERRANE WALLOWA MOUNTAINS, NORTHEASTERN OREGON

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The Wallowa Mountains of northeastern Oregon are an erosional window through the Miocene Columbia River Plateau Basalts (CRB) to the Mesozoic geology which underlies them. These mountains are composed of a series of late Permian-early Jurassic volcanic and sedimentary rocks and Cretaceous plutonic rocks (Ross, 1938; Smith and others, 1941). Lithologic, paleontological and geochemical data have determined that these rocks formed in an oceanic, not continental environment, and have been accreted to North America tectonically (Whalen, 1988; Strayer and others, 1989). The area is geologically appealing because of its distinctive location in the otherwise complete coverage of the CRBs - and the insight that it gives into the accreted margin of western North America in terms of structural history and terrane correlations. Purposes of this study are: 1) to attempt to define the structure of a small, highly deformed area within the Wallowa Mountains, 2) to determine what created the tectonic framework in which these rocks were deformed, and 3) to examine the arguments regarding whether the terrane exposed in the Wallowas can be correlated with other terranes of the western Cordillera that are better exposed in Canada.

The rocks in the area of this study were part of the late Triassic Martin Bridge Limestone and Jurassic Hurwal Formation. These sediments overlie the volcanics of the Seven Devils Group, though the conformity of this contact has been disputed by several authors (Mirkin, 1986) - which correlates with the Lower Sedimentary Series in the southern Wallowas, the Clover Creek Greenstone in the northern Wallowas, and the Doyle Creek Formation in the Snake River Canyon area of the Idaho-Oregon border (Jones and others, 1977; Mirkin, 1986). This sequence of volcanics is overlain by the shallow and deep water sediments of the Martin Bridge and Hurwal Formations and the entire assemblage suggests an island-arc depositional environment.

The facies changes suggest increasing water depth in the basin as the sediments grade from the shallow water Martin Bridge Limestone upward into the finer deep water Hurwal clastics. It was suggested, based on similarities in lithology and fauna, that the rocks of the Wallowa Mountains represent a southern extension of Wrangellia. Wrangellia is a suspect terrane that contains a Permo-Triassic volcanic series and an upper Triassic shallow-deep water sedimentary assemblage (Jones and others, 1977). However, this correlation was tentatively made and based on an incomplete study. Later work suggests that while the two terranes may be coeval and may have formed at similar paleolatitudes, they may not be correlative due to differences in the geochemistry of the volcanic units. The volcanics of the Wallowa terrane are calc-alkaline and formed in an island arc tectonic setting. However, the metabasalts of Wrangellia - the Karmutsen Formation of the Nikolai Greenstone - are tholeitic in nature (Sarewitz, 1983). That these two sets of volcanics formed in different tectonic settings makes it difficult to correlate Wrangellia and the Wallowas as one terrane.

The study area covered approximately three square kilometers (figure 1a), and combined with adjoining study areas the project covered approximately 10 km^2. In the study area the Martin Bridge Limestones and the argyllites of the Hurwal Formation have been intruded by the Cretaceous Wallowa batholith (Armstrong and others, 1977), the contact with which defines the northern boundary of the study area.

In the field, the rocks appeared highly deformed. The Martin Bridge Limestone was a grey-blue marble with 2-3 mm grain size. Some outcrops contained intermediate composition igneous dikes which had been highly deformed. Where possible fold axes were measured from these outcrops. Other structural features such as bedding, foliation and lineation were not apparent in the Martin Bridge Limestone due to extreme deformation.

The Hurwal Formation ranged from a brown-black hornfelsic argyllite to a 1-10 cm banded unit with sandy interbeds. These interbeds contained numerous primary sedimentary structures such as ripple beds, cross beds and graded beds. These structures were used as facing indicators. Within the field area, the Martin Bridge Limestone and the Hurwal Formation are tectonically interleaved (figure 1b). Small slices of the Martin Bridge are thrust over the Hurwal. These thrust sheets were then folded into a NE/SW trending NW vergent overturned tight anticline (figure 2). The Hurwal contained a penetrative foliation, which was especially well developed in the nose of this anticline (figure 3). Due to the more micaceous nature of the Hurwal, foliation was more prominent in the Hurwal than the Martin Bridge Limestone, and generally had an orientation of N10E/20E. This orientation is compatible with the axial plane of the overturned fold.

When plotted on an equal area stereonet, the orientations of bedding planes and fold axes confirm this structural interpretation. This plot indicates an asymmetrical overturned fold trending NE/SW, with a larger SE away from the contact. The narrow wollastonite zone indicates fairly low thermal conductivity and limited SiO_2 metasomatism, which in turn suggests a relatively dry batholith. This may also explain the lack of metasomatic zonation. Finally, igneous hornblende and biotite in the batholith have reacted to pyroxene immediately adjacent to the wollastonite zone. This implies a significant degree of CO_2 diffusion into the batholith, rather than out of it, again supporting the hypothesis of a dry igneous body.

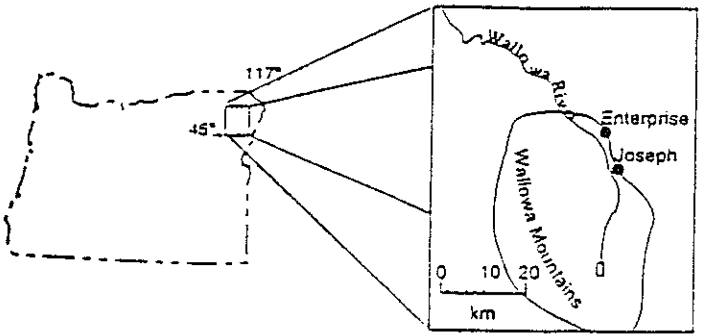

Figure 1a): Index map showing location of Wallowa Mountains and study area (after Green, 1960).

LEGEND

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☐ Kw: Wallowa Batholith
☐ Trh: Hurwal Formation
☐ Trmb: Martin Bridge Limestone

Trend and Plunge of overturned anticline:

contour interval 80 ft

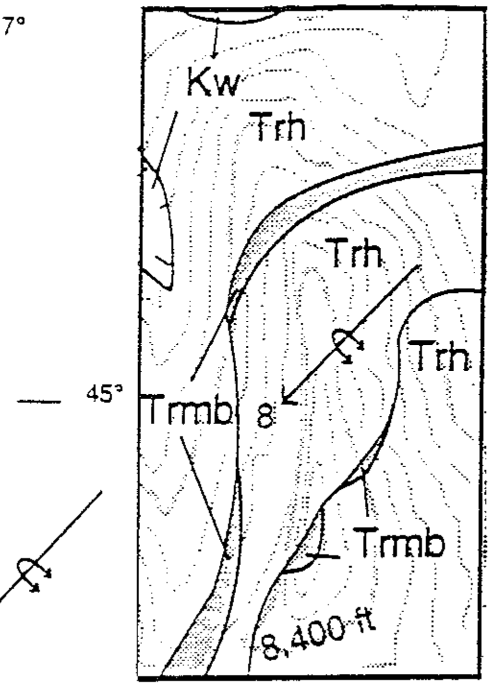


Figure 1b): Geologic map of study area showing interleaving of Martin Bridge Limestone and Hurwal Formation. The Wallowa batholity appears on the north and west boundaries.

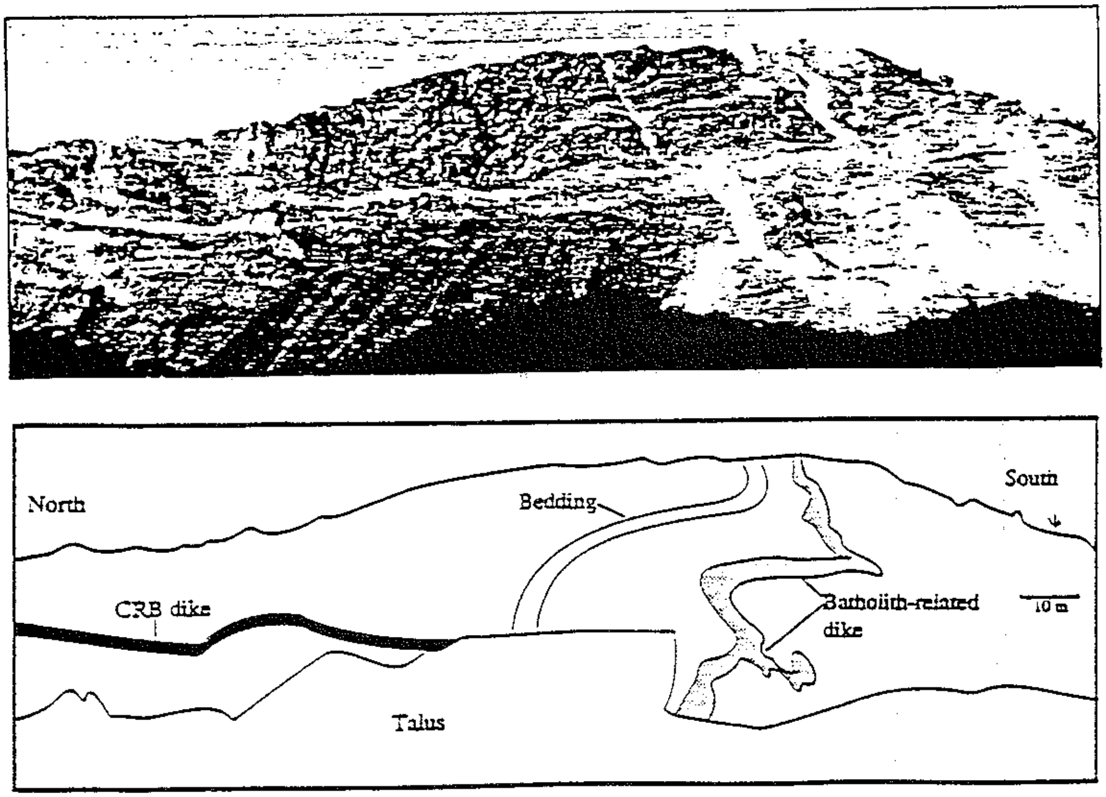


Figure 2: Digitized image and sketch of a prominent ridge of the Hurwal Formation. Note bedding which primary structures indicate is overturned. View is to the east.

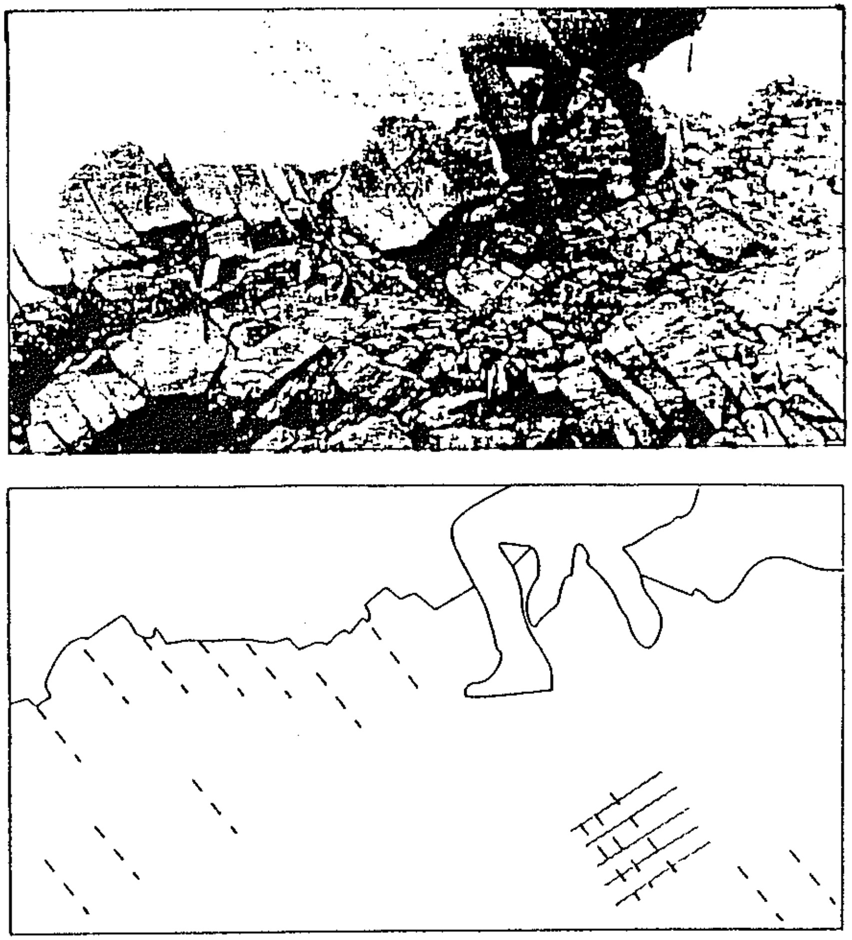
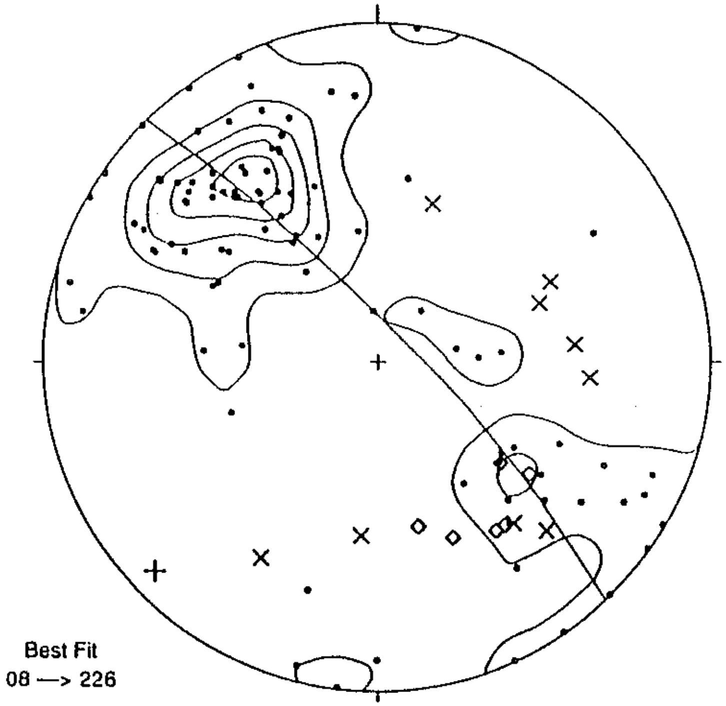


Figure 3: Digitized image and sketch of foliation and bedding in Hurwal Formation. Note penetrative foiation along which axial planar cleavage has formed. Also note the high angle between bedding and foliation which indicates that this is the nose of a fold. View is to the NE along strike of foliation.

Foliation:

Bedding:



Bedding: contoured at 1 3 5 7 9 times uniform

Figure 4: Equal area lower hemisphere projection of structural data. Poles to bedding are dots, fold axes are x's and lineations are diamonds. The best fit circle of poles to bedding is shown. The pole to this great circle trends 226 and plunges 08.

limb. The fold axes appear to be spread over in a NE/SW trend. The orientations of the lineations are approximately perpendicular to the fold axes (figure 4).

Thin sections were cut from twenty oriented samples. In order to observe possible kinematic indicators, they were cut perpendicular to foliation and parallel to lineation where apparent, and parallel to the regional trend of lineations where lineation was not visible in the sample. Samples were collected from the Martin Bridge and the Hurwal, as well as numerous igneous dikes ranging from fine-grained intermediate composition to coarse grained felsic dikes that are most likely related to the batholith. The thin sections of the Martin Bridge samples showed evidence of extensive post kinematic recrystallization of calcite. This recrystalliztion appears as equant-shaped grains with regular extinction and 120° grain boundaries. Because of the proximity to the batholith, structural data present in the older rocks may have been destroyed by post kinematic reheating during the intrusion of the batholith.

The asymmetry of the structure and the orientation of local lineations are compatible with top to the west tectonic transport. This is consistent with deformation resulting from the emplacement of the Wallowa terrane onto the western continental margin of North America along an east-facing subduction zone.

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Igneous Intrusions of Jewett and Aneroid Lakes Area, Wallawa Mountains, Oregon

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Introduction

The igneous intrusions described in this study, are located in a one-half square mile area roughly between the Jewett and Aneroid cirque lakes in the Eagle Cap Wilderness Area, Wallawa Mountains, Northeastern Oregon. Elevation in this area is 7600-8400 feet above sea level. The area of study is on the edge of the Cretaceous Wallawa Batholith, situated so as to include both a section of the batholith and its contact with metasedimentary Triassic and Jurassic rocks that are intruded by other igneous dikes. (See fig. 1.1.) Methods used are mapping igneous dike occurrence on topographic map base, sampling, field description, and lab analysis utilizing petrographic and ICP-AES (Inductively Coupled Plasma Atomic Emissions Spectrometry) chemical analysis techniques. Directors of this project are Dr. John Winter of Whitman College, Dr. Steven Weaver of Beloit College, and Dr. Peter Crowley of Amherst College. My specific project advisors are Dr. Frank Koucky of College of Wooster and Dr. Steven Weaver. The objectives of my study are: to describe all igneous intrusions in this area of batholith or prebatholith age, to interpret their relationships to each other, and to interpret their origin.

Field Methods

Mapping of igneous dikes and sedimentary contacts was conducted of the field area on foot. Strike measurements were taken of dikes, and intrusions were sketched on to a topographic map. Several representative samples were taken of each type of intrusion in the area. Sample locations and other locations important to the determination of age relationships, such as cross cutting relationships, were marked on the map. Photographs and notes were taken of cross-cutting relationships when possible and sketches as well as notes supplement observations.

Field Interpretation

The field interpretation is that there are six distinguishable types of igneous intrusions: 1) lineated, fine grained, mafic dikes 2) lineated, fine grained, leucocratic, felsic dikes 3) unmetamorphosed, batholith stock, main phase 4) unmetamorphosed, leucocratic, felsic dikes, tangential to the batholith stock 5) pegmatite veins, composed mostly of feldspar, and 6) a lineated, brown, more silicious dike, (determined later through thin section analysis not to be an igneous dike, but a silicified joint.)

In the order of age, from oldest to youngest, as determined from cross-cutting relationships they are: 1) fine grained, darker mafic dikes, 2) fine grained, leucocratic, felsic dikes, 3) batholith stock, main phase and batholith related dikes tangential to the batholith stock, 4) unmetamorphosed pegmatite veins within the batholith stock. The age relationship of the brown, more silicious (pseudo) intrusion with respect to the other intrusions is indeterminable. Columbia River Basalt Dikes also cut the area. These are mapped but not sampled because they have already been extensively studied and are without a doubt younger than all other igneous intrusions in the area (Reidel and Hooper, 1989). Previous studies in this area have not included prebatholith igneous dikes (Taubeneck, 1964). My interest in study lies in batholith and prebatholith intrusions.

Lab Analysis

Chemical analysis by method of ICP-AES (Inductively Coupled Plasma Atomic Emissions Spectrometry) has been carried out. Petrographic thin section analysis, because of fine grain size, has been supplemented with x-ray diffraction analysis and a normative mineralogy study. A discussion of the relationship of the normative mineralogy to the actual mineralogy will be presented at the 1991 Keck consortium. Data collected of normative mineralogy is listed in table 2.1 and of rock chemistry in table 2.2. Graphs 3.1 and 3.2 show representative plots of chemical data.

Chemical Data Interpretation

Harper plots of Fe_2O_3 and $Na_2O + K_2O$ are fairly representative examples of most of the chemical components harper plots, in that it presents a linear relationship between three groups: mafic, batholith, and leucocratic (meaning all others, including pegmatite veins). Both metamorphoseed and unmetamorphosed leucocratic, felsic dikes, as well as batholith pegmatites show a much closer relationship than previously expected. These are for the most part alike in terms of chemical composition. One difference between the metamorphosed and unmetamorphosed igneous intrusions is that the metamorphosed tend to be higher in sodium than potassium, and the unmetamorphosed higher in potassium than sodium.

Discussion

A close chemical affinity is observed in the dikes, batholith, and pegmatites. Since the batholith occurs in multiple stocks in this region, it is possible that the metamorphosed leucocratic, felsic dikes, could have been introduced by earlier batholith intrusions and metamorphosed by later intrusions of batholith stocks like the stock in my area. Intrusions of this region may show little variance.