THE GEOLOGY OF PART OF THE EAGLE CAP WILDERNESS AREA, NORTHEASTERN OREGON

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Recently the western coast of North America has been shown to consist of a number of fault-bounded, stratigraphically distinct, allochthonous or suspect terranes (Coney et al., 1989; Hillhouse et al., 1981). The present study attempts to describe and analyze in detail the geology of a small area located in northeastern Oregon, which may be part of an accreted island arc terrane. The field area (Figure 1) comprises deformed Triassic strata and abundant dikes.

Two sedimentary formations of Upper Triassic to Lower Jurassic age are exposed in the field area and are locally subdivided for the purpose of this study (Figure 2). Divisions are based on carbonate and argillite content and contacts are gradational. Both formations have been regionally metamorphosed and tremolite commonly occurs in argillaceous sediments.

The oldest exposed sedimentary formation is the Martin Bridge Limestone which is divided into two units based on argillite content. The lower unit consists of light-grey to white, nearly pure limestone with minor detrital quartz. Bedding is obscured by tectonic banding and carbonate grains, which range in size from < 1-3mm in diameter, are elongate parallel to banding. The lower contact of this unit in the field area is a fault contact; only a minimum thickness of 20m could be obtained. The upper Martin Bridge unit is a bluish-grey, thinly bedded, fine-grained limestone in which silty beds are common. No preferred orientation of grains is apparent in either handsample or thin section. This unit is approximately 20-25m.

The Hurwal Formation conformably overlies the Martin Bridge Limestone in gradational contact and has been divided into three units. The lower unit, 43-50m thick, is well bedded, tan and dark grey, with limestone and silt occurring in roughly equal proportions. Graded cycles 4-7cm thick are common, as are fossil bivalves. The middle unit comprises 58m of thin to medium bedded siltstone with common thin beds of limestone. Sedimentary structures include parallel laminations and cross-bedding which are commonly distorted by soft-sediment deformation. The upper Hurwal unit is rusty-weathering argillite; limy beds are uncommon. Bed thickness is generally 3-8cm but individual beds are as much as 20cm thick. Soft-sediment deformation, cross-bedding, climbing ripples, rip-up clasts, and parallel laminations are the dominant sedimentary features. The upper contact is nowhere observed in the field area. A minimum thickness of 50m was measured.

The sedimentary formations are marine in origin. The Martin Bridge Limestone is most recently interpreted as an island carbonate platform containing local reefs (Stanley and Senowbari-Daryan, 1986). While no reefs were observed in the field area, fossils were common. The Hurwal sediments were probably deposited by turbidity currents on a steep, unstable slope in deeper water than the carbonates were deposited in. This interpretation is supported by the common sequence of cross-beds over parallel laminations in the upper Hurwal which probably represents the B and C portions of the Bouma cycle. Additionally, rip-up clasts and soft sediment deformation indicate periods of rapid deposition such as is associated with turbidity currents.

The field area is characterized by regional shortening accommodated by thrust faults, folds, and cleavage (Figure 2). The dominant foliation in the field area is spaced cleavage. It is most prominantly developed in the upper Martin Bridge unit and in the lower and middle Hurwal units. Plotted on a stereonet, cleavage measurements show relatively little scatter with the average orientation being approximately N40E;35SE. Foliation in the lower Martin Bridge unit is penetrative, resulting from parallel alignment of elongate grains.

Stereonet plots of folded bedding indicate that major folds are generally non-cylindrical. Fold geometry is complicated by the ductile behavior of the carbonate units, particularly the lower Martin Bridge where it overlies a thrust fault. This unit forms folds of various shapes and sizes with widely scattered orientations. Dikes intruding this unit are folded and boudinaged parallel to foliation within the limestone. This boudinage suggests that there was significant flow along foliation as the fault propagated. Both the degree of boudinage and the degree of parallelism of dikes to banding increase with increasing proximity to the fault. With increasing argillite content, units behave less ductily. The folds exhibited by the Hurwal units are broad and open. Minor and parasitic folds

Fig 3.1 Harper plott of Fe2O3

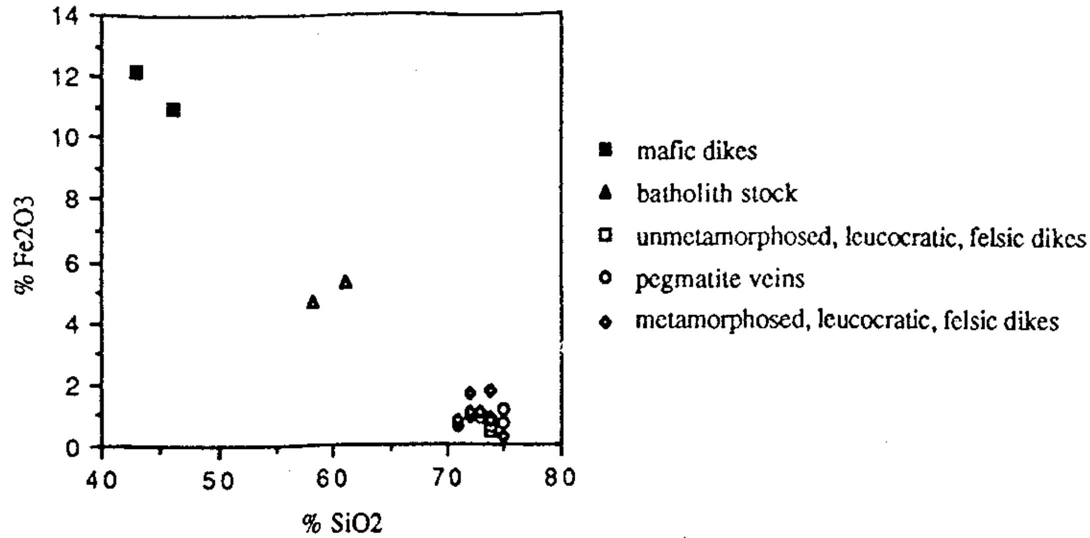
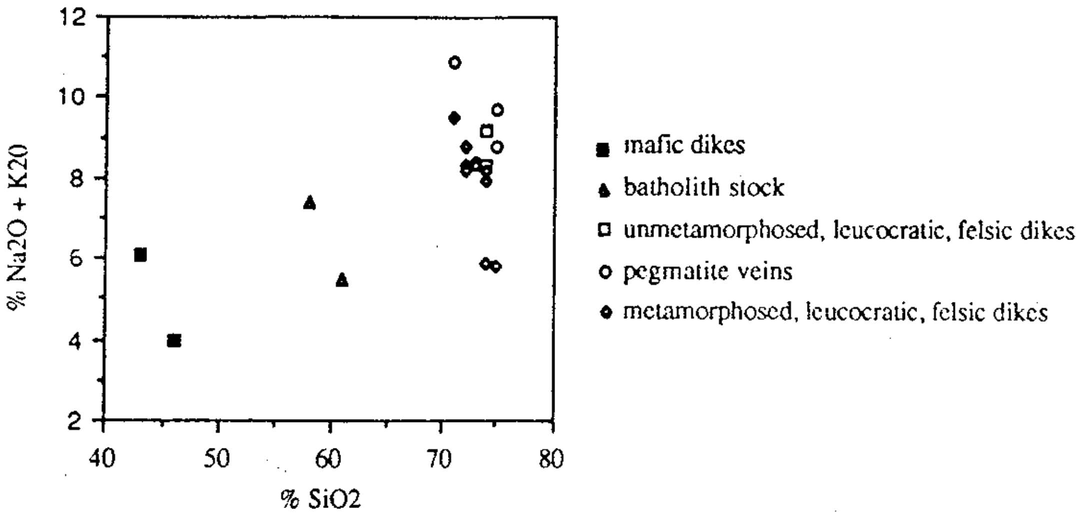


Fig 3.2 Harper plot of Na20 + K20



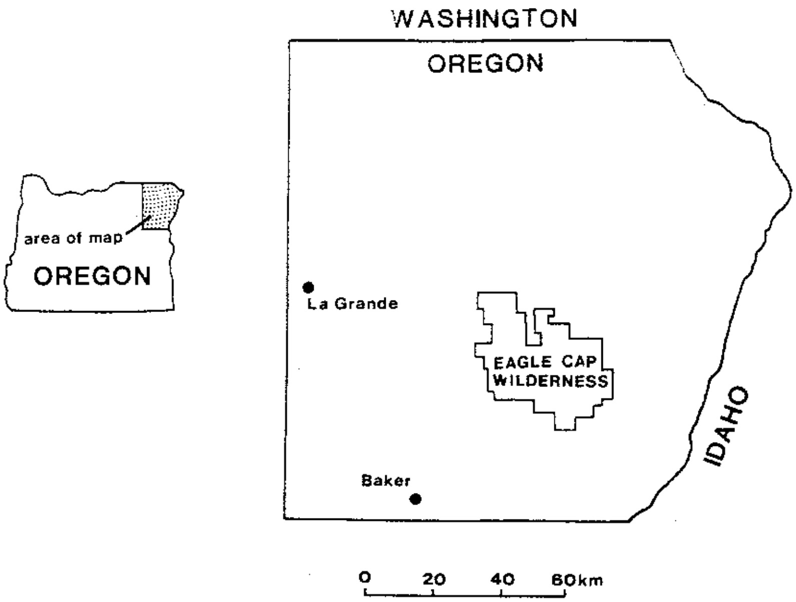


Figure 1. Northeastern Oregon, showing location of the Eagle Cap Wilderness Area (after Weiss et al., 1976).

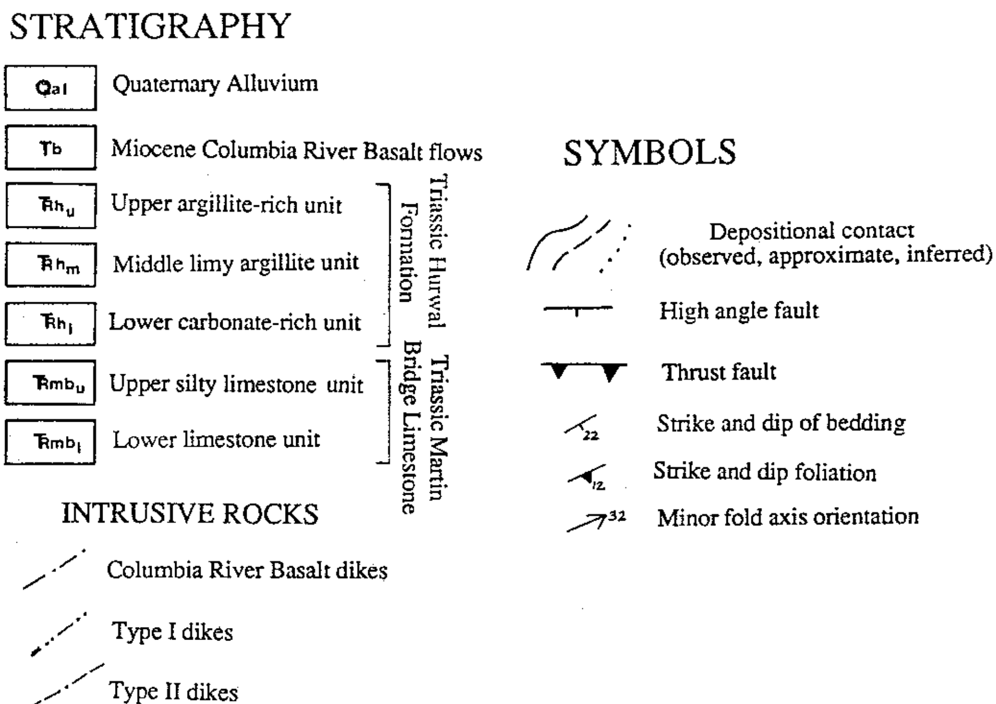


Figure 2a. Key to geologic map.

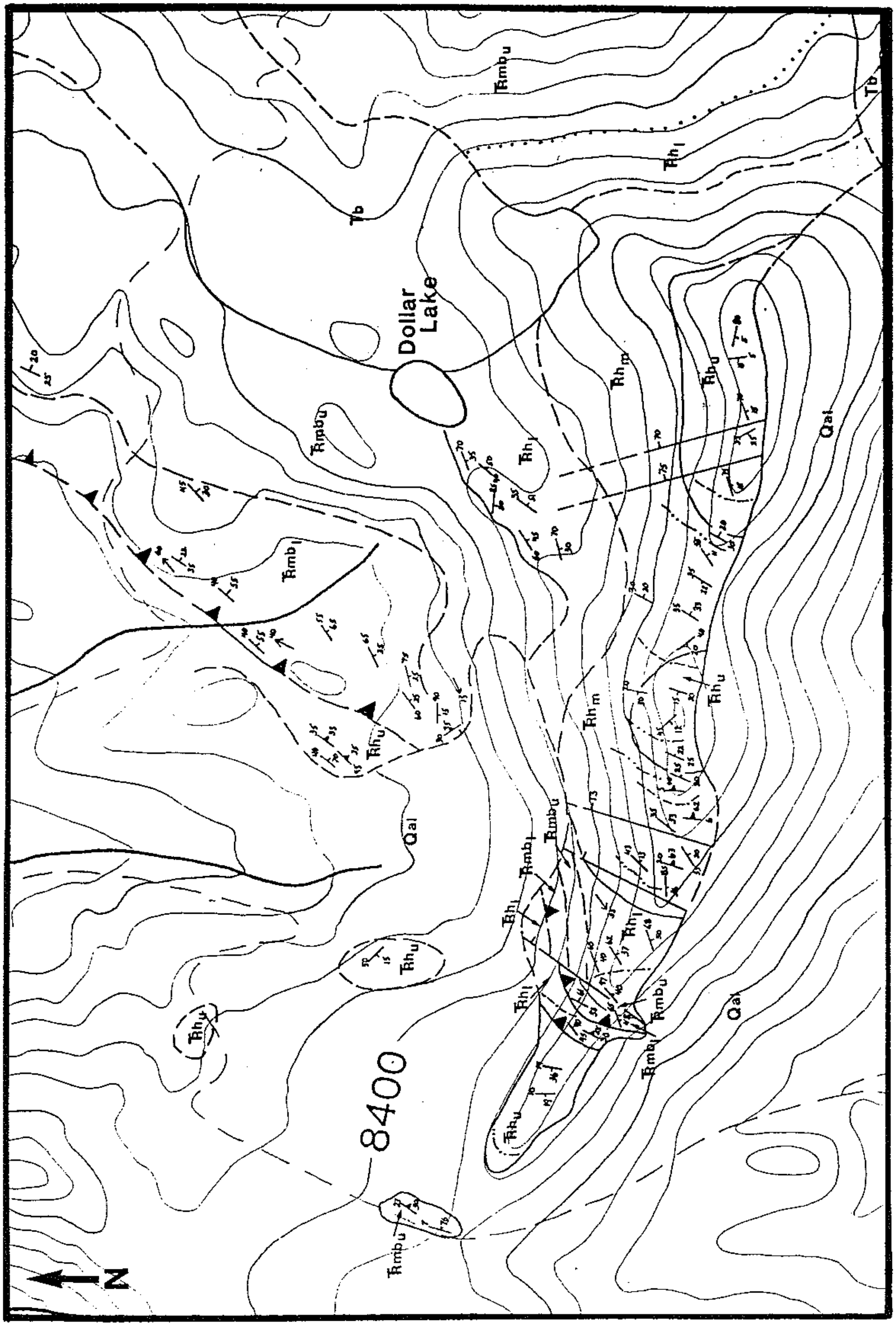


Figure 2b. Geologic map of field area. Scale 1cm = 100m.

are predominantly westward vergent. Several high-angle faults with minimal offset (<20m) are apparent at the steepest parts of major folds and may have occurred when plastic limits of deformation were exceeded.

Westward transport is indicated along the major thrust fault in the field area. Locally, this fault appears to be a bedding plane fault which was displaced along the ductile lower Martin Bridge unit. The near-surface geometry of the fault can be traced along the face of a cliff and locally, its dip is clearly shallow. Sub-surface geometry is uncertain.

Numerous dikes crop out in the field area and samples of representative types were collected for petrographic and geochemical analysis. Thin section analysis reveals that all samples were metamorphosed under amphibolite grade conditions. Conditions of metamorphism are difficult to constrain precisely for amphibolites, but several features provide some clues. First, the olive-brown pleochroism of hornblende suggests moderate temperatures and relatively low pressures; at high temperatures hornblende is deep brown and at high pressures it is tinted blue. Additionally, the typomorphic texture of ragged, fibrous hornblende grain boundaries is typical of low grade amphibolite conditions; at higher grades grain boundaries become smooth and straight (Spry, 1969). Finally, the presence of epidote in the igneous samples, and the presence of tremolite in the argillaceous sediments (as noted in the field) further constrain metamorphism to low-grade amphibloite conditions; at higher grades, epidote is lost and diopside replaces tremolite.

Protolith compositions are also difficult to determine petrographically given the "garbage-can" mineralogy of hornblende which commonly comprises up to 30% or more of the samples. Mineralogy and textures are variable among the samples but two distinct petrographic and geochemical types are evident. In Type I, hornblende is abundant and together with altered plagioclase, comprises the bulk of the rock. Additional minerals include pyroxene, biotite, epidote, and quartz in minor quantities. A representative XRF analysis for this type is as follows:

SiO_2 50%	K_2O 1%
MgO 15%	CaO 10%
Al_2O_3 11%	TiO_2 0.6%
P_2O_5 0.07%	MnO 0.2%
Na_2O 1%	Fe_2O_3 9%

Because high proportions of hornblende in metamorphosed igneous bodies is suggestive of a mafic parent rock (Spry, 1969), the abundance of hornblende in Type I dikes along with the low silica content, suggests a basaltic protolith.

In Type II dikes, plagioclase and quartz are the dominant minerals. Opaques are generally abundant (3-5%) and biotite, muscovite, and epidote may all be present in minor amounts (1-3%). Representative XRF data indicates felsic compositions:

SiO_2 74%	K_2O 0.5%
MgO 0.3%	CaO 1%
Al_2O_3 16%	TiO_2 0.1%
P_2O_5 0.1%	MnO 0.2%
Na_2O 8%	Fe_2O_3 1.5%

Mineralogical and textural differences are somewhat gradational between the two types and may represent, to some degree, a suite of genetically related rocks. The fact that all of the sampled dikes exhibit signs of similar conditions of metamorphism constrains the timing of their emplacement to precede regional metamorphism. The dikes are possibly related to pre-accretionary island arc magmatism.

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Contact Metamorphic Effects of the Wallowa Batholith on the Hurwal Formation, Wallowa Mountains, Oregon.

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Introduction

The Upper Triassic to Lower Jurassic Hurwal Formation is part ot the Eagle Creek area of the southern Wallowa Mountains found in the Seven Devils terrane in Northeast Oregon. This region was deformed by Mesozoic tectonism that faulted and folded the terrane. Jurassic and Cretaceous intrusions of the Wallowa Batholith further metamorphosed the surrounding formations, recrystallizing the rocks and changing their mineralogy.

The Hurwal Formation consists of laminated carbonaceous beds and siltstones interbedded with shale and thin beds of limestone. Although a greater portion of this formation is badly weathered to a rusty color, graded bedding can still be seen in certain sections of the stratigraphic column. While there is no particular pattern to it, the Hurwal Formation tends to be more argillaceous and less silty higher in the stratigraphy. According to Vallier(1977) this is an indication of a deepening basin. For easier identification and convenience, I divided the formation into three sub-units:

1)Argillaceous Hurwal interbedded with limestone and/or marble
2)Shaley Hurwal, and
3)Limy Hurwal or siltstone

The three sub-units alternate throughout the stratigraphic column but follow no specific alternation pattern. The Hurwal conformably overlies the Martin Bridge Limestone, exhibiting a gradational contact between the two formations. The first argillaceous bed immediately above the top of the Martin Bridge beds was taken to be the base of the Hurwal Formation .

Following a field investigation, SEM/ EDS and petrographic studies of the obtained samples were carried out. By determining mineralogy and metamorphic textures from these rocks an estimate of the extent to which they were metamorphosed by the Wallowa Batholith could be made.

The batholith extends over miles of area and is in contact with various formations of the Seven Devils terrane. Although the actual batholith-Hurwal contact was rarely exposed in the area of study, batholith-related dikes cut through the Hurwal Formation. The contact aureole extends to approximately 30 from the Wallowa batholith. Except for small bands of coarser grained minerals near the contact, the Hurwal Formation appears relatively unmetamorphosed. The contact was probably faulted or covered by post-batholith deformation.

Mineralogy & Metamorphism

Minerals identified by petrographic analysis include, in order of abundance, quartz, pyroxene(diopside), magnetite, epidote, idocrase, zoisite / clinozoisite, chlorite, garnet, biotite, amphibole, sphene, albite, calcite, and muscovite. Table 1 shows the different samples/thin sections, their mineralogy and observed textures with estimated distance from the batholith contact. Although quartz and pyroxene are the most abundant minerals in all the studied samples, opaque mineral(s) were also present in most samples. From the SEM/ EDS analysis the presence of idocrase, pyroxene, amphibole, garnet, albite, quartz, and zoisite was confirmed. This technique also revealed the presence of muscovite, diopside, and magnetite in some Hurwal rocks. The presence of Ca-rich minerals is interesting as it might allude to a calsic precursor for the Hurwal Formation. The field relationship of the Hurwal with the Martin Bridge limestone could also be a factor worth investigating. However, that would be true if the occurrence was only at the gradational contact between the two formations, but the Ca-rich minerals occur throughout the sampled 500 meters of the Hurwal Formation. It is therefore very important to investigate some of the minerals that give Hurwal rocks their calsic component.

Vesuvianite (idocrase) is most common within 30 meters of the estimated contact with the batholith and occurs primarily as porphyroblasts. Together with diopside and/or grossularite, and with epidote, idocrase has been identified in medium grade rocks (amphibolite facies) (Winkler, 1974). Idocrase can, however, also appear in low grade or greenschist facies in the folowing assemblages: idocrase + chlorite, idocrase + actinolite, and idocrase + epidote. As shown in Table 1, idocrase occurs more often with garnet and diopside than with chlorite and amphibole, pointing to amphibolite facies metamorphic grade. Table 1 also shows the co-occurrence of diopside, idocrase and grossularite in certain samples, a sign of compositional variation within a small area of the rocks.