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COVER PHOTO

Siskiyou Divide on the California-Oregon border; looking east from Jackson Gap. Field trip guide beginning on next page discusses the geology of this metamorphic terrane.

SMAC reports on year's activities

The purposes of the State Map Advisory Committee (SMAC) are to (1) recognize and pursue mapping goals for the State of Oregon; (2) promote coordination of programs, policies, and resources of the various agencies that make maps; and (3) bring the benefits of mapping more effectively to the people of Oregon. Through coordinated planning, SMAC also works to (1) effectively utilize all mapping resources, (2) improve mapping services to the State, and (3) minimize unnecessary duplication of effort.

Because of the inadequate topographic map coverage for the State of Oregon, SMAC during 1979 placed top priority on completion of the 7½-minute topographic map base. Plan development and communications involved SMAC, the U.S. Geological Survey, the Office of the Governor, and the Congressional Delegation. An eight-year plan for completion of the State's 7½-minute topographic map base has been developed.

At SMAC's meeting held December 14, 1979, in Salem, State agencies identified topographic mapping priorities in groups and quantities consistent with the eight-year plan, the logistic requirements of regional mapping, and the priorities of Federal agencies. These priorities are overlain with Federal input in developing mapping strategies for the State.

Other major SMAC activities during 1979 included (1) presentation of mapping functions and services of the U.S. Geological Survey; (2) participation in the pilot computerized map index project for the NCIC of the U.S. Geological Survey; (3) brief examination of SLAR imagery with emphasis on its application and limitations; (4) progress toward the completion of a brochure of map products available to the public from the many agencies in the State; (5) participation in a peripheral manner in the ongoing evaluation of the possible benefits of computer hardware and software as they relate to the map needs of Oregon (primary responsibility for this function resides in the Executive Department); and (6) representation of the State of Oregon on a regional and national basis for the development of a topographic map program for Oregon. □

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Geologic field trip guide through the north-central Klamath Mountains

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INTRODUCTION

This field trip guide summarizes geologic relations in the north-central Klamath Mountains of northern California and adjacent Oregon (Figure 1). The geology of the area is notable for the great diversity in metamorphic and plutonic rock types and for the structural complexities of the various lithologic units. In preparing the field trip guide, we have drawn from the geology described in several publications by Hotz (1967; 1971a, b; 1979) and in a number of unpublished doctoral dissertations (Pratt, 1964; Medaris, 1966; Barrows, 1969) and masters' theses (Engelhardt, 1966; Heinrich, 1966; Donato, 1975; Ferns, 1979). The field trip guide also includes results of unpublished mapping and field studies by the University of Oregon Geology Summer Field Camp in the southern parts of the Talent and Ashland quadrangles in Oregon.

Two important and obvious geologic features observed in traversing the area of this field trip guide are (1) progressively metamorphosed western Paleozoic and Triassic belt rocks which range in grade from greenschist to amphibolite facies, and (2) greenschist-facies Condrey Mountain Schist which also contains glaucophane-crossite and stilpnomelane. The progressively metamorphosed sequence, with grade increasing structurally downward, is sharply juxtaposed with and separated from the underlying glaucophanitic greenschist-facies rocks. The rocks of the western Paleozoic and Triassic belt and the Condrey Mountain Schist have overlapping radiometric ages.

This field trip guide was prepared for the 76th Annual Meeting of the Cordilleran Section of the Geological Society of America, which will be held in March, 1980, in Corvallis, Oregon.

SALIENT FEATURES OF THE REGIONAL GEOLOGIC SETTING

Rock units and their ages

In the northern and approximately central parts of the area of this field trip guide (Figure 1), rocks of the western Paleozoic and Triassic belt are sharply juxtaposed with the Condrey Mountain Schist along a folded thrust fault. Evidence obtained from mapping along the Klamath River at the contact of the Paleozoic and Triassic belt with the western Jurassic belt Galice Formation suggests that Galice rocks served as the protolith for the Condrey Mountain Schist (Klein, 1977). However, this interpretation is presently incompatible with the presumed age of the Galice Formation and the metamorphic ages obtained for the Condrey Mountain Schist (Lanphere and others, 1968; Suppe and Armstrong, 1972).

Granitoid rocks of dominantly Late Jurassic age abundantly intrude the western Paleozoic and Triassic belt rocks but are rather scarce in the Condrey Mountain Schist. Hotz (1971a) reports potassium-argon mineral ages ranging from 146 to 160 m.y. obtained from biotite and hornblende separates from the plutons of the field trip guide area. The plutonic rocks range in composition from diorite through quartz monzonite, but quartz diorite is most plentiful.

Serpentinized peridotite occurs in sheet-like bodies tectonically interleaved and folded together mostly with amphibolite-facies metamorphosed western Paleozoic and Triassic belt rocks. Pyroxenite and gabbro occur usually as smaller bodies within or closely associated with serpentinized peridotite. However, it is not clear in all cases how the gabbro and pyroxenite are related. In some places, both are metamorphosed and have mineral assemblages consistent with those of their host peridotite.

Metamorphism

The grade of metamorphism in the Paleozoic and Triassic belt rocks generally increases toward the contact with the underlying Condrey Mountain Schist. For example, in traversing westward from Interstate 5 on California State Highway 96 along the Klamath River, the grade of metamorphism in Paleozoic and Triassic belt rocks changes from feebly metamorphosed greenschist-facies metabasalt with relict volcanic textures to thoroughly recrystallized, medium-grade amphibolite-facies schists and gneisses. The metamorphic grade increases toward the contact with the underlying Condrey Mountain Schist, and upon crossing that boundary there is a sharp reversal in grade to glaucophanitic greenschist facies. As Donato and others point out in an article to be printed later this year in *Oregon Geology*, the presumption is that glaucophane and crossite ($\pm$ stilpnomelane) are distributed more abundantly in the structurally lower levels of the Condrey Mountain Schist. The mineral assemblage suggests a higher pressure, lower temperature metamorphism for these schists. The overlap in metamorphic ages of the western Paleozoic and Triassic belt schists and gneisses and the Condrey Mountain Schist (Lanphere and others, 1968; Suppe and Armstrong, 1972; Kays and others, 1977) and the distribution of metamorphic facies in these terranes suggest that structural juxtaposition was accompanied by recrystallization in both terranes.

Structure

Detailed mapping by Hotz (1967), Ferns (1979), and Kays (unpublished) indicates that western Paleozoic and Triassic belt rocks are cut by thrust faults. The thrust planes are marked in the most obvious cases by the occurrence of ultramafic rocks. The thrust faults appear to represent zones of movement associated with emplacement of nappes or sheets of Paleozoic and Triassic rocks. An early and apparently primary foliation in the nappes is axial planar to large recumbent folds that are roughly concordant with the thrust planes. Detailed mapping in the Wrangle Gap-Red Mountain area (Ferns, 1979, and unpublished) and adjoining areas indicates that the thrust faults, the recumbent folds of nappes, and the metamorphosed assemblages in the western Paleozoic and Triassic belt rocks and Condrey Mountain Schist were all subsequently folded (Figures 2, 3, and 4).

In some places within the area covered by this field trip guide, especially to the east of the Condrey Mountain Schist, the western Paleozoic and Triassic belt rocks and serpentinized peridotites form a mélange. Mapping indicates that the mélange was subsequently folded, thus forming an unusual assemblage of broken, but

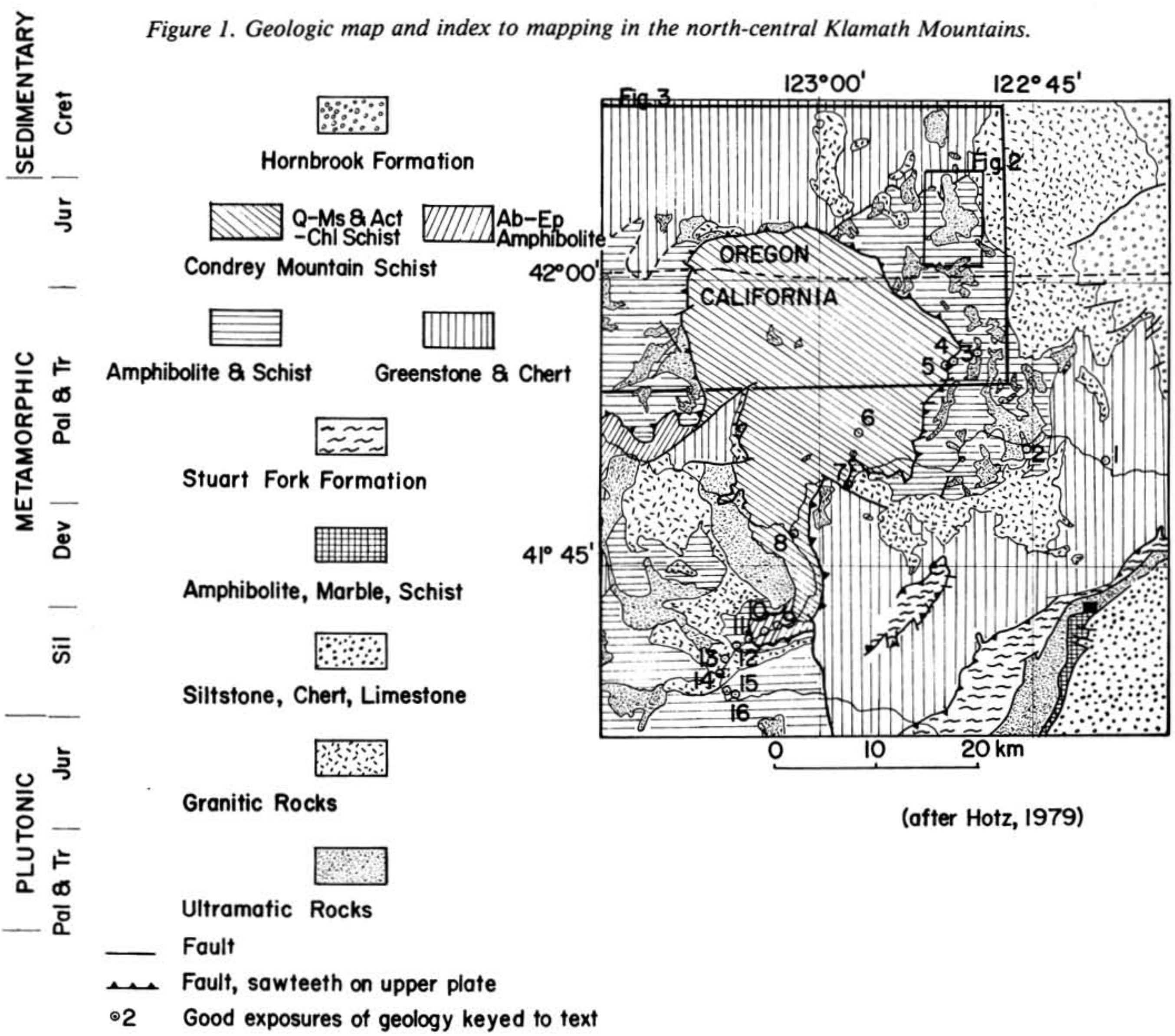


Figure 1. Geologic map and index to mapping in the north-central Klamath Mountains.

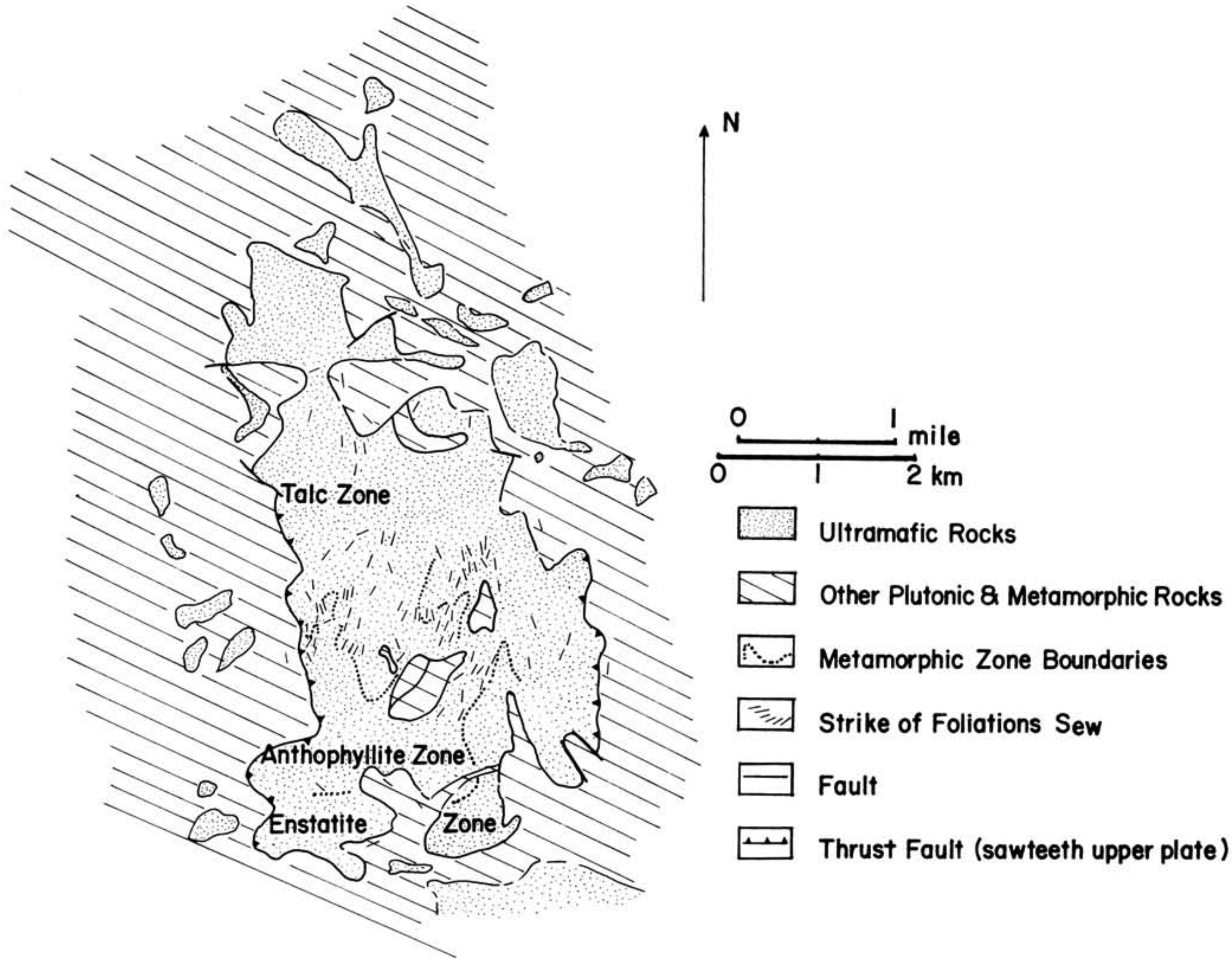


Figure 2. Folded nature of metamorphic isograds in the Wrangle Gap-Red Mountain ultramafic body (after Ferns, 1979).

coherently folded, and metamorphosed rocks. Since the same folds affect both the mélange and the parts that are not fragmented, the mélange must be related to early deformation that was apparently associated with nappe emplacement.

A regional compilation map (centerfold) of the northern part of the area of the field trip guide shows that the higher grade metamorphosed western Paleozoic and Triassic belt rocks and associated serpentinized ultramafic rocks end abruptly just to the north of the Oregon-California line. We interpret the boundary between higher grade and more feebly metamorphosed rocks as marking the northern termination of the napped sequence of Paleozoic and Triassic rocks. The boundary was affected at a later time by normal faulting.

We therefore interpret the axial planar foliation (S_{ew} in Figure 3), roughly coincident with the thrust planes that floor the nappes, as having evolved during or as a consequence of thrust movement. The dominant north-south-trending folds that affect all the pre-Tertiary rock units evolved through later east-west compression and crustal shortening that have in some places nearly obliterated the evidence for the early thrust movement. We term the axial planes of the later folds "S_{ns}" (Figure 3). Thus, the early recumbent folds were subsequently folded about axes that now trend approximately north-south. The last folding also affected the Condrey Mountain Schist. Donato and others will address the problem of the structure of these rocks in their upcoming *Oregon Geology* article. Relations between axial planes of folds, axial planar foliations, and later deformation are summarized in the sketches of Figure 3.

ROCK UNITS AND THEIR METAMORPHISM

The rock units briefly described in the following summary are presented in observed structural sequence

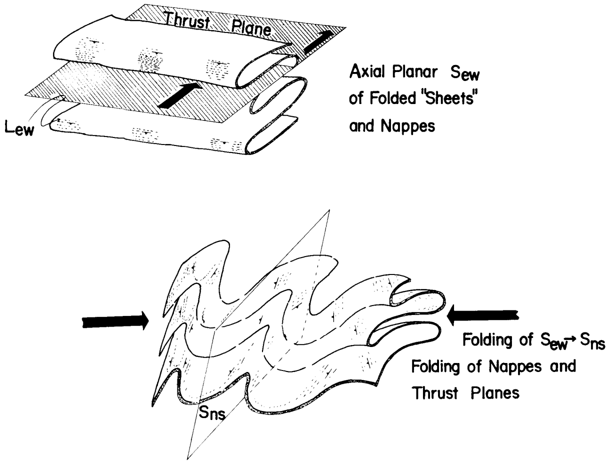


Figure 3. Presumed sequence of folding in western Paleozoic and Triassic belt rocks in the Wrangle Gap-Red Mountain area.

from lowest to highest. The stratigraphic relations between these rock units are poorly understood. Some of the correlations between metamorphosed units are tentative, but, it is hoped, "reasonable guesses." For more details than can be provided here, the reader is referred to the excellent summary by Hotz (1979) on the regional character of metamorphism in the north-central Klamath Mountains.

Condrey Mountain Schist

Since Donato and others will discuss the characteristics of these rocks at some length in their upcoming article, we restrict the following discussion to a brief summation of the salient features of the Condrey Mountain Schist. These rocks are thoroughly recrystallized schists of two main kinds (Hotz, 1979): (1) black to dark-grey graphitic quartz-mica schists, and (2) green actinolite-chlorite schists with glaucophane and stilpnomelane as important additional minerals that occur abundantly in certain zones within this rock unit. The very well-developed metamorphic fabric is the result of at least two episodes of folding and recrystallization. Hotz reports two main assemblages in the quartz-mica "blackschists": (1a) quartz-muscovite-albite-chlorite-graphite, and (1b) quartz-albite-muscovite-epidote-chlorite. There are three important assemblages in the actinolite-chlorite "greenschists": (2a) quartz-albite-actinolite-chlorite-epidote, (2b) albite-actinolite-chlorite-epidote-quartz-muscovite, and (2c) glaucophane-epidote-quartz-albite-chlorite-sphene.

Barrows (1969) has mapped interlayered "greenschist" and "blackschist" units exposed along the lower reaches of the Scott River near its confluence with the Klamath River. Hotz (1971b) correlates these units with the Condrey Mountain Schist. Both units have conformable quartz veins that are locally auriferous; quartz veins are especially abundant in graphitic micaceous schists. Barrows shows that the interlayered sequence of rocks grades upward into epidote-amphibolite-facies schists and gneisses along the Scott River between McGuffy Creek and Townsend Gulch. Barrows also indicates that the albite-epidote-blue-green-hornblende-bearing schists may grade upward to regionally metamorphosed amphibolite-facies plagioclose-hornblende ± garnet ± clinopyroxene schists and gneisses between Tompkins Creek and George Allen Gulch along the Scott River.

Amphibolite-facies Paleozoic and Triassic rocks

Rocks of this grade are widespread in a zone surrounding the Condrey Mountain Schist, as shown by Hotz (1979, Fig. 1, p. 3; 1971b, Plate 1). In the Condrey Mountain, Talent, Ruch, and Seiad Valley 15-minute quadrangles, amphibolites occur as foliated hornblende-plagioclase (An_{25-35})-sphene-(opaques) gneisses that are clinopyroxene bearing in places. Massive or unfoliated amphibolites also occur and consist of plagioclase (An_{25-35})-sphene-apatite-opaques. Metasedimentary rocks are interlayered and folded together with the amphibolites. The metasedimentary rocks are phyllites or schists and consist of quartz-biotite-sodic plagioclase ± muscovite ± garnet ± chlorite (after biotite). Graphitic quartz-rich schists are rather widespread and also contain minor biotite, tremolite, and, in some places, pyrite. Tourmaline-bearing quartzites are important members of the metasedimentary sequence.

In the Wrangle Gap-Red Mountain area, the metabasalts have amphibolite-facies mineral assemblages and show the same general patterns of metamorphic zonation as do the adjacent ultramafic rocks. Unfortunately, there are no clearly diagnostic mineral assemblages in the mafic rocks. However, some estimate of temperature-pressure conditions can be made from coexisting mineral phases in the metasedimentary rocks. The assemblages are (1) calcite-diopside-quartz in the marbles, (2) clinozoisite-quartz-hornblende-plagioclase-opaques in the graphitic cherts, and (3) garnet-biotite-potassium feldspar-muscovite-sillimanite in the micaceous quartzites. A rough petrogenetic grid based on experimentally determined reaction equilibria (approximately the same as those observed) is considered in a later section along with other equilibria recognized in the ultramafic rocks. The grid serves to bracket conditions of peak metamorphism in the amphibolite-facies rocks.

Greenschist-facies Paleozoic and Triassic rocks

Predominantly basic and spilitic metavolcanic rocks occur interlayered with siliceous metasedimentary rocks at higher structural levels in the area covered by this field trip guide. These rocks apparently grade downward into higher grade amphibolite-facies rocks, as previously described. However, there are complexities caused by the thrust faults and "Schuppen-like" or mélange sequence, and the interpretation assumes that a uniform thermal gradient existed through these disturbed zones of rocks.

The least metamorphosed rocks have relict volcanic textures and structures including pillows, rubbly scoriaceous zones, muddy inter-pillow material, and "vesicularity" developed through weathering of amygdaloidal calcite fillings within pillows. Usually the thin, glassy pillow selvages show a higher degree of recrystallization. As Hotz (1979) indicates, these low-grade rocks have no apparent metamorphic fabrics but do contain albite, chlorite, veinlets of carbonate, and local prehnite. Well-formed relict phenocrysts of clinopyroxenes occur in some places. More completely recrystallized metavolcanic rocks also contain actinolite, biotite, clinozoisite-epidote, and sphene, in addition to those minerals already mentioned. These metavolcanic rocks are frequently referred to as greenstone.

The metasedimentary rocks interlayered with the low-grade metavolcanic rocks are dark-gray to black argillite, recrystallized chert, and rare lenticular beds of marble. At lowest grade, assemblages in argillaceous rocks consist of quartz-muscovite-organic matter with chlorite and local albite and actinolite; at higher grade, biotite replaces chlorite (Hotz, 1979). Calcite is locally abundant in the slaty or argillaceous rocks.

Metamorphosed ultramafic rocks

In the area covered by this field trip guide, ultramafic rocks are mostly serpentinized and occur as conformable, folded sheets, their mineralogy consistent with that of the surrounding metamorphosed rocks. Evans (1977) has shown that the mineralogy of such peridotites as these may be diagnostic of metamorphic grade for rock compositions in the system CaO-MgO-SiO_2 and closely approaching initial compositions in the $CaMgSi_2O_6$ (diopside)-Mg_2SiO_4 (forsterite)-$Mg_2Si_2O_6$ (enstatite) triangle (Figure 4). Frequently, too, the ultramafic rocks are tectonically interleaved or folded together with amphibolite-facies rocks, and there is a tendency for the surrounding rocks to become higher grade with proximity to the ultramafic sheets.

The general consistency between mineral assemblages and structures of the ultramafic rocks is well illustrated in the Wrangle Gap-Red Mountain area. Here, Ferns (1979) has shown that several equilibria among minerals of the ultramafic rocks define (1) a talc zone in which olivine and tremolite may also be present, (2) a zone characterized by anthophyllite and tremolite whose formation may be dependent on instability of the assemblage talc + olivine, and (3) an enstatite zone in which enstatite interrupts anthophyllite-olivine stability (Figures 2 and 4). Antigorite or some other variety of serpentine mineral and diopside are also commonly present. The equilibria defining temperature-pressure conditions for the Wrangle Gap-Red Mountain ultramafic body are summarized below and in Figure 4:

$$\text{Antigorite} = 18\ \text{forsterite} + 4\ \text{talc} + 27\ H_2O \quad (1)$$

$$9\ \text{talc} + 4\ \text{forsterite} = 5\ \text{anthophyllite} + H_2O \quad (2)$$

$$\text{Talc} + \text{forsterite} = 5\ \text{enstatite} + H_2O \quad (3)$$

$$\text{Anthophyllite} + \text{forsterite} = 9\ \text{enstatite} + H_2O \quad (4)$$

$$5\ \text{chrysotile} = 6\ \text{forsterite} + \text{talc} + 9\ H_2O \quad (5)$$

$$2\ \text{diopside} + \text{talc} = \text{tremolite} \quad (6)$$

$$\text{Tremolite} + \text{forsterite} = 2\ \text{diopside} + 5\ \text{enstatite} + H_2O \quad (7)$$

$$\text{Clinochlore} = \text{forsterite} + \text{spinel} + 2\ \text{enstatite} + 4\ H_2O \quad (8)$$

Since there are presently no compositional data on mineral phases at Wrangle Gap-Red Mountain, temperature-pressure estimates are based on pure mineral phase equilibria. We also assume $P_{H_2O} = P_{total}$ and that P_{CO_2} was low or insignificant, which seems a reasonable assumption in that carbonate phases are absent in the serpentinized peridotite. Note then that the occurrence of chlorite and tremolite in all three zones indicates that recrystallization conditions must lie within the tremolite + olivine stability field. This field is bounded by the reaction curves for equilibria (6) and (7) and is roughly correlative with amphibolite-facies metamorphism. The olivine + anthophyllite assemblage places further restrictions on the temperature-pressure conditions at Wrangle Gap-Red Mountain. Experimentally determined curves for (2) and (4) will bracket these conditions if $P_{H_2O} = P_{total}$.

The serpentinized peridotite has certain characteristics which suggest a serpentinite protolith was subsequently metamorphosed. Thus, mapped isograds in peridotite reflect regional changes in temperature-pressure conditions during metamorphism. Since space does not permit a detailed presentation of all evidence for prograde recrystallization of a serpentinite protolith, the important characteristics are summarized below (after Ferns, 1979):

(1) There is a consistent, zonal pattern in the way in which enstatite, talc, and anthophyllite are distributed in the peridotite (Figure 2).

(2) Large, elongate anthophyllite crystals occur in radiating clusters, a texture consistent with metamorphic recrystallization of serpentinized peridotite (Moore and Qvale, 1977).

(3) The harzburgites are uniformly low in CaO and Al_2O_3, characteristics which Evans (1977) suggests reflect serpentinized parents.

(4) The calc-silicate zones which have developed along the borders of tectonic gneiss blocks within the ultramafic body have mineral assemblages which indicate amphibolite-facies metamorphism (reaction 11, Figure 5). These rocks are apparently metamorphosed rodingites which form initially only under low temperatures of serpentinization (Coleman, 1967).

(5) Both olivine and enstatite are generally free of opaque inclusions. Recrystallization temperatures and pressures for the Wrangle Gap-Red Mountain prograde metamorphism can be estimated from the combined petrogenetic grids for assemblages recognized in the ultramafic and associated metasedimentary rocks and metarodingites (Figure 5). Bracketing by equilibrium in the ultramafic and associated metamorphosed rocks gives the range 570 to 720°C and 2.8 to 5.2 kb.

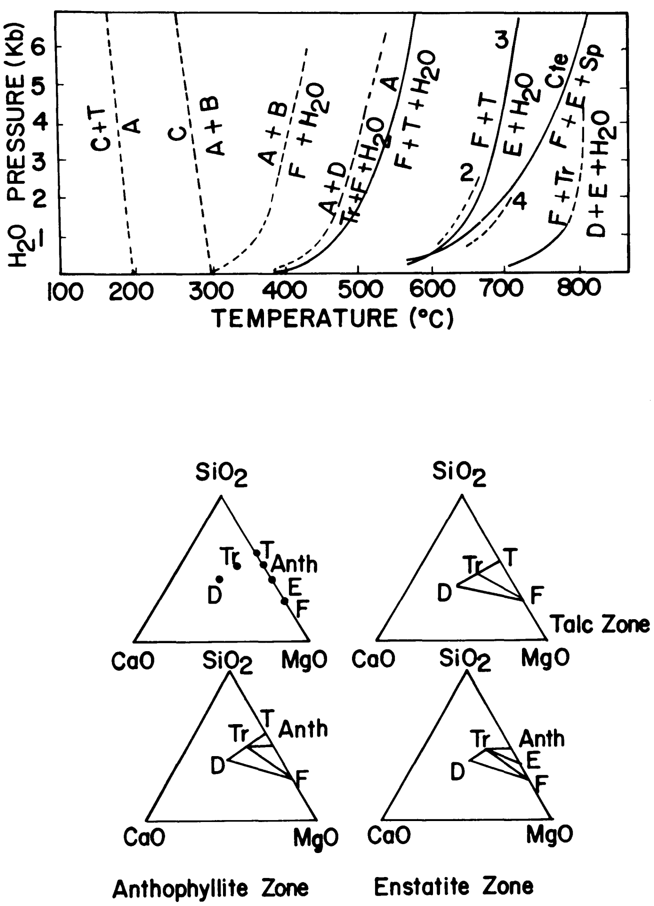


Figure 4. Metamorphic equilibria defining conditions of peak metamorphism in the ultramafic rocks. Ultramafic mineral assemblages in the system CaO-MgO-SiO_2. Abbreviations used are as follows: Clinochlore (C), antigorite (A), brucite (B), talc (T), forsterite (F), diopside (D), tremolite (Tr), enstatite (E), chlorite (Cte), and spinel (Sp).

PLUTONIC ROCK UNITS

Hotz (1971a) has studied and described the petrographic features and chemical compositions of plutons in the Klamath Mountains and reported their ages. We therefore provide only a brief summary of the major varieties of plutonic rock types and some of their outstanding features. For more information than can be included here, the reader is referred to the article by Hotz.

Gabbro-pyroxenite

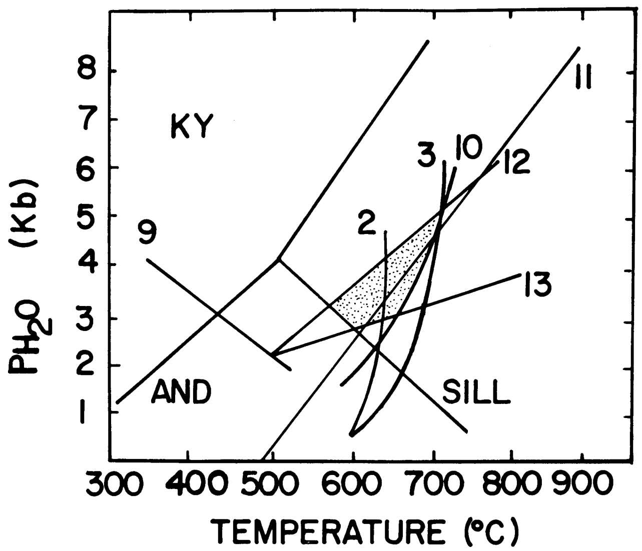
Small bodies of calcium-rich ultramafic rocks in the compositional range clinopyroxenite-wehrlite-pyroxene gabbro are generally associated with larger bodies of serpentinized peridotite. Only a few bodies have an areal distribution of more than 1 km². Where they occur in peridotite, the bodies frequently have tectonized, sheared boundaries. The bodies may be strongly banded with alternating layers of clinopyroxene or tremolite and partially serpentinized olivine-rich layers.

The gabbro bodies may be clinopyroxene bearing, but the pyroxenes are sometimes altered to hornblende. The contact relations of the gabbro bodies are in many places obscured by later deformation, but contacts appear to be intrusive into peridotite. Metamorphic fabrics are quite variable and range from well-developed gneissic fabrics to directional fabrics with only weak, mafic mineral preferred orientation.

Late Jurassic plutons

Granitoid plutonic rocks are plentiful as small stocks less than a mile in diameter but also occur with outcrop area of 150 km² or more, as in the case of the Ashland pluton. The larger plutons tend to be elongate with their long axes parallel to the north-south arcuate trend of the Klamath Mountains province. The plutons range in composition from diorite and gabbro to quartz monzonite, with quartz diorite (tonalite) being most widespread.

Donato (1975) has shown that a 75-km² portion of the Ashland pluton consists of all the above-mentioned rock types. The pluton has a strongly foliated western margin consisting, from west to east, of hornblende tonalite, hornblende granodiorite, and hornblende quartz monzonite. Further eastward, there is granular, unfoliated biotite granodiorite and biotite quartz monzonite. Large xenolithic blocks of hornblende diorite occur throughout the biotite-bearing quartz monzonite-



(2) $9T + 4F = 5Anth + H_2O$

(3) $T + F = E + H_2O$

(9) $Crd + Ms_{ss} = Bio + Als + Q + Ab_{ss} + H_2O$

(10) $Ms + Q = Sill + Ksp + H_2O$

(11) $Gr + Q = An + 2Wo$

(12) $Ms_{ss} + Ab_{ss} + Q = Ksp_{ss} + Als + H_2O$

(13) $Bio_{ss} + Ab_{ss} + Q + Als = Ksp_{ss} + Crd + H_2O$

Figure 5. Metamorphic equilibria defining conditions of peak metamorphism in Paleozoic and Triassic belt rocks. Stippled area represents possible temperature-pressure regime. Abbreviations used are the same as in Figure 4 and as follows: Anthophyllite (Anth), cordierite (Crd), muscovite (Ms), biotite (Bio), aluminum silicate (Als), quartz (Q), albite (Ab), sillimanite (Sill), K-feldspar (Ksp), grossular (Gr), anorthite (An), wollastonite (Wo), and solid solution subscript (ss).

granodiorite but are restricted to smaller disk-shaped schlieren in the more mafic, hornblende-bearing rock types of the western margin.

CONCLUSION

The increase in grade of metamorphism in the western Paleozoic and Triassic belt rocks toward structurally lower levels of the plate and the association there with abundant, tectonically interleaved sheets of ultramafic rocks are probably not fortuitous. We interpret the increase in grade and the association of rock types to be a normal "view" downward through deformed oceanic floor, culminating in a disrupted ophiolitic sequence. The increase in grade of metamorphism with proximity to the ultramafic rocks may reflect the oceanic geotherm near to the oceanic ridge in the western Paleozoic and Triassic belt crustal sequence.

Subduction of the western Jurassic belt rocks or thrusting of the western Paleozoic and Triassic belt rocks may have initiated in response to collapse of a Jurassic back-arc basin. The basin fronted the continental crustal section to the southeast and rested on an oceanic floor of western Paleozoic and Triassic belt rocks continuing below the continental margin. Early deformation-folding of the lower part of the oceanic sequence with disrupted-interleaved ultramafic rocks may have developed before decay of the oversteepened oceanic geotherm. Late folding of the juxtaposed sequence of western Paleozoic and Triassic belt rocks and the underlying Condrey Mountain Schist may have developed in response to Late Jurassic Pacific-North American Plate convergence.

ACKNOWLEDGMENTS

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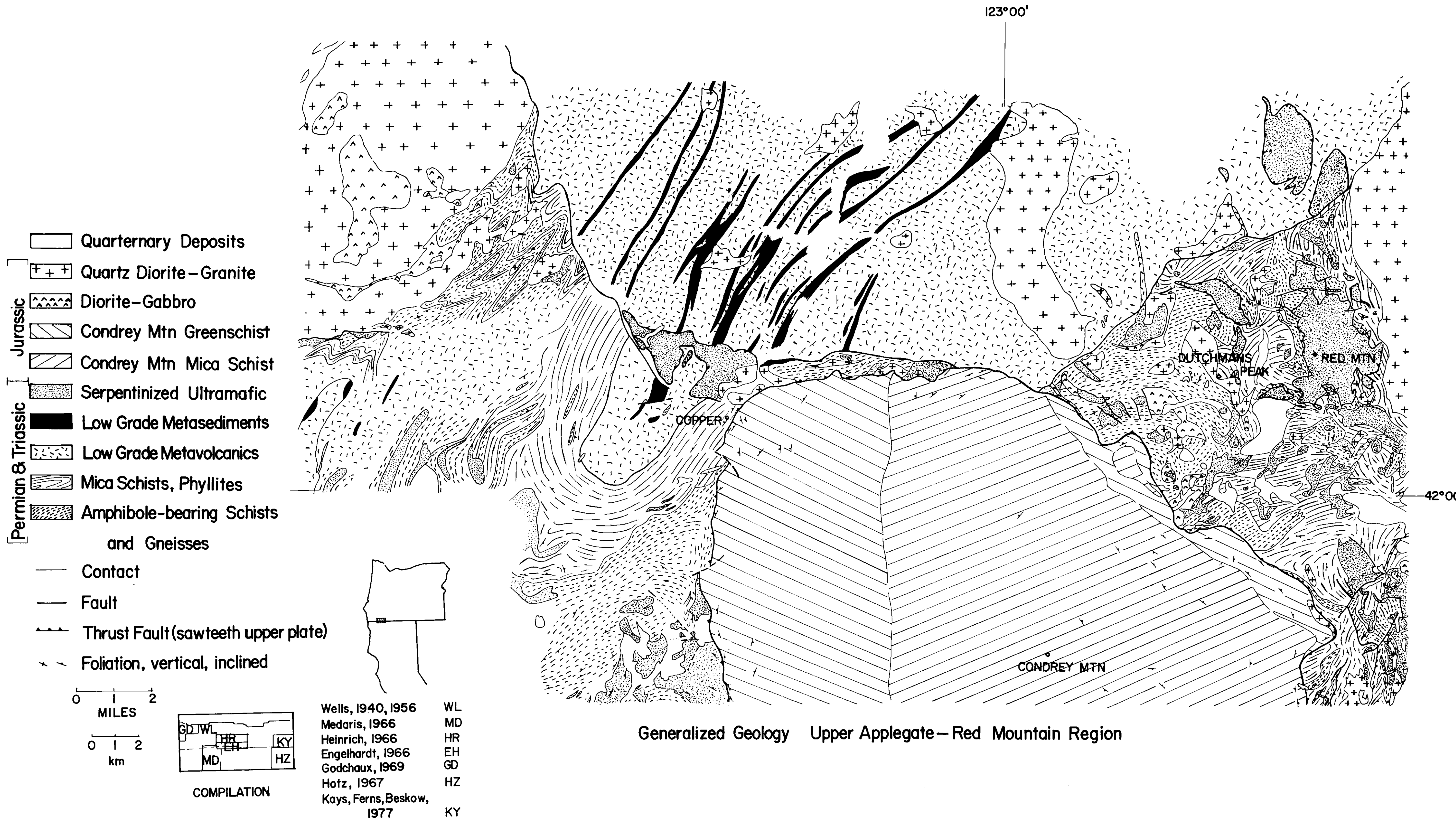

Geologic map compilation for the northernmost part of the field trip guide.

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ROAD LOG

(See Figure 1 for route and stops as indicated below.)

Km	Mi	
0.0	0.0	Begin mileage, intersection of Interstate 5 and California Highway 96, which follows the Klamath River. On this part of the field trip we will observe an increase in metamorphic grade in Paleozoic and Triassic belt rocks. We begin here in feebly metamorphosed metavolcanic rocks with relict textures and poorly developed or nonexistent metamorphic fabrics. Apparently, the rocks are oceanic and include pillowed lavas, flow breccias, and interlayered cherts, cherty argillites, etc. We will proceed through low-grade greenschist-facies rocks, presumably rather high in the pile, through to amphibolite-facies schists and gneisses with good metamorphic fabrics toward the base of the sequence of Paleozoic and Triassic belt rocks. At the base, the amphibolite-facies schists and gneisses are in thrust contact with the underlying Condrey Mountain Schist.
3.5	2.2	Old highway to Yreka.
6.6	4.1	Ash Creek bridge.
10.4	6.5	Turnoff to Tree of Heaven Campground.
12.0	7.5	**Stop 1.** The Paleozoic and Triassic belt pillowed lava sequence begins here and continues for a short distance. The pillows are well formed and may have relict "pseudo-vesicles" owing to weathering of amygdaloidal fillings. Other relict features include well-formed augite phenocrysts.
14.1	8.8	Lime Gulch.
20.0	12.5	Empire Creek.
22.7	14.2	**Stop 2.** Beginning of roadcut with non-foliated, low-grade amphibolite-facies rocks, with relict porphyritic texture locally (Hotz, 1967). The amphibolites are tectonically interleaved with the surrounding ultramafic rocks.
27.8	17.4	Beaver Creek road; turn right.
29.0	18.1	Smith Mine road.
29.4	18.4	Outcrop, folded fine-grained biotite schist.
32.2	20.1	Outcrop, biotite schist and amphibolite gneiss, apparently interlayered. The schist is fine grained and has a good cleavage. The amphibolite is fine to medium grained and is composed of plagioclase and hornblende. The hornblende has a good pre-

Km	Mi	
		ferred elongation.
33.3	20.8	Outcrop of amphibolite; leave paved road.
35.4	22.1	Turnoff to Beaver Creek Campground. Stay on Beaver Creek road.
36.5	22.8	**Stop 3.** Good outcrop of locally garnetiferous, medium-grained quartz-biotite schist. Note intersection of Beaver Creek road with U.S. Forest Service (USFS) road to Wards Fork Gap and Deer Creek Camp. We will turn here and proceed along the Wards Fork road, ultimately to the contact of the Paleozoic-Triassic belt rocks with the Condrey Mountain Schist.
38.2	23.9	**Stop 4.** Good outcrop to view Paleozoic-Triassic belt amphibolite gneiss and biotite schist and their apparent interlayered nature.
40.2	25.1	Road intersection with USFS Road 47N40. Turn left (west). The contact between the Condrey Mountain Schist and Paleozoic-Triassic amphibolites and biotite schists (**Stop 5**) is on Road 47N40 half a mile from the intersection. Road 47N40 circles around the head of the gulch that is visible from the road intersection, and the contact is just on the other side of the gulch.
		Return to Highway 96 and start new mileage.
0.0	0.0	Intersection of Beaver Creek road and California Highway 96; turn right.
1.4	0.9	Klamath River Lodge on the right.
3.4	2.1	Exposures of ultramafic rocks on the right.
4.3	2.7	Klamath River Community Hall; golf course across the river.
6.7	4.2	Walker Bridge.
7.4	4.6	Road to Deer Camp; turn right. California Highway Maintenance Building is just on the left at the road intersection.
9.3	5.8	Road to Deer Creek on right. Continue on main road and observe the occurrence of recumbent folded, shallow-dipping Condrey Mountain Schist composed of graphitic quartz-mica schist (blackschist) and interlayers of actinolite-chlorite schist (greenschist).
13.1	8.2	Doggett Creek and road intersection. Continue uphill on USFS Road 46N52 and stay on this road until mile point 11.3. Pretty good exposures of Condrey Mountain Schist are just beyond the road intersection.
13.6	8.5	Note the blue-colored road rock composed of crushed Condrey Mountain greenschist-blueschist.
16.6	10.4	Road intersection; continue on USFS Road 46N52.
18.1	11.3	Road intersection; go right on gravel road. Condrey Mountain greenschist with blackschist interlayers is exposed here.
23.2	14.5	**Stop 6.** Blueschist quarry. At this locality (SW ¼ sec. 31, T. 47 N., R. 9 W., west of Kohl Creek), blueschist and greenschist are interlayered. Both rock types have good foliation that is crenulated or crinkle-folded. Foliation is apparently axial planar to early folds. Folding can be observed on the scale of a hand specimen. Note, too, that in some places there are two crenulations at nearly right angles. One crenulation is nearly parallel with axial planes of early folds, whereas the other is later and mostly with north-south orientation—the same as folding in the surrounding Paleozoic and Triassic belt rocks. The layered aspect of the glaucophane schists is emphasized by layers of epidote and white mica. The greenschists consist of fine-grained actinolite, chlorite, and muscovite; note that they have good cleavage nearly parallel with schistosity. Both rocks have quartz veins largely parallel with layering. The blueschists have lenses that are epidote-rich. Return to Highway 96.
		Start new mileage.
0.0	0.0	Intersection of road to blueschist quarry and Highway 96; turn right.
1.4	0.9	Oak Knoll Ranger Station (USFS).
1.6	1.0	Doggett Creek.
5.8	3.6	Kohl Creek. There are good exposures of Condrey Mountain blackschist with abundant quartz veining along this part of the road.
8.6	5.4	**Stop 7.** Good exposures of Paleozoic and Triassic belt schists and gneisses, apparently interlayered quartz-biotite schists and amphibolite gneisses, cut by metamorphosed mafic dikes.
9.3	5.8	Outcrop of leucocratic, medium-grained quartz monzonite intrusive rock, probably Jurassic in age, which cuts Paleozoic and Triassic sequence.
10.4	6.5	Bridge over the Klamath River. Old placer workings, used now for gravel.
12.3	7.7	Horse Creek store.
13.4	8.4	Extensive roadcut in Condrey Mountain greenschist opposite broad bend in the

Km	Mi	
		Klamath River.
16.3	10.2	Continue on Condrey Mountain greenschist—good exposures.
18.4	11.5	Blue Heron boat access.
19.8	12.4	Road intersection and confluence of Klamath and Scott Rivers. Begin new mileage.
0.0	0.0	Scott River road.
0.3	0.2	**Stop 8.** Extensive outcrop of Condrey Mountain Schist. Just opposite the bridge over the Scott River is rather "massive" greenschist with structure resembling pillow structure but with a fair schistosity. The rock is fine to medium grained and is composed of quartz, chlorite, albite, ± actinolite, ± pale pink garnet, and some scattered grains of bright-green mica (fuchsite?). Note that rocks locally have quartz veining conformable with schistosity but develop lenticular or "augen-like" appearance as schistosity improves. The rock grades along the outcrop to muscovite-richer schist with dark-brown to black chlorite and graphite. Note the recumbent folds with westerly-dipping axial planar foliation. The greenschist may also be feldspathic with fine, disseminated garnets rolled within their foliation planes; locally the feldspathic-micaceous greenschist is epidote-rich. The quartz veins are folded by "first" folds and in places are ptygmatic. Note, however, that the "first" folds are crenulated near the contact of the greenschist and blackschist (south end of outcrop). Some outstanding folds are obvious in the greenschist with amplitudes of 15 to 20 m and wavelengths possibly about one-third of the amplitude. In the area where good folds are exposed, there is an early schistosity nearly at right angles to the folded foliation planes. Note, too, the crenulation of foliation parallel with axial planes of these folds.
4.3	2.7	Intrusion of quartz-rich granodiorite into Condrey Mountain Schist. Exposures of the pluton start in Franklin Gulch. The foliation of the pluton is parallel to that of the surrounding feldspathic greenschist.
5.3	3.3	Confluence of Mill Creek and Scott River at Scott Bar. Gold mine across Scott River with gold apparently in quartz veins of interlayered blackschist-greenschist. As we progress southward along the Scott River for the next few miles, we pass through an apparently gradational sequence of greenschist facies-amphibolite facies rocks as mapped by Barrows (1969). The greenschists are correlated by Hotz (1971) with the Condrey Mountain Schist. However, Hotz interprets the amphibolite-facies rocks as belonging to the Paleozoic and Triassic belt sequence.
7.7	4.8	Exposure of quartz-chlorite-feldspar schist ± actinolite. The rock is somewhat fissile, but the schistosity is not well developed.
11.0	6.9	Good chlorite-actinolite schist with feldspar. The schist locally develops a gneissic fabric owing to alignment of actinolite. The rock is a bit coarser grained than previous exposures.
11.7	7.3	George Allen Gulch. We are now well into the unit with mineralogy of epidote-amphibolite facies which Barrows (1969) correlates with Condrey Mountain Schist of Hotz (1971b). The road is narrow here, and it is difficult to get to good exposures.
12.8	8.0	**Stop 9.** Sugarpine Gulch. Dark-green gneissic rock, fine- to medium-grained, with abundant amphibole (hornblende? or actinolite?) which occurs as elongate, acicular grains up to several millimeters long; note that plagioclase is also elongate and similar in size. There is crenulation of poorly developed schistosity (cleavage) and the hornblende-plagioclase lineation. Compare with earlier exposures of Condrey Mountain Schist.
14.4	9.0	**Stop 10.** McCarthy Creek. Very definite change in texture and fabric; the hornblende-plagioclase gneiss is coarser grained and has a strong, gneissic fabric.
16.5	10.3	**Stop 11.** Good medium- to coarse-grained amphibolite gneiss with local, strong segregation of hornblende in lenses and layers which alternate with plagioclase-rich layers. Barrows (1969) shows this rock as correlative with the Condrey Mountain Schist through progressive increase in grade of metamorphism. Note, too, that this amphibolite gneiss is locally garnetiferous with fine-grained garnets in the feldspathic layers. The layering here is textural and compositional, from 1 or 2 cm to 15 cm thick.
16.6	10.4	Gold Flat.
17.4	10.9	**Stop 12.** Tompkins Creek. Follow path to Tompkins Creek to gain access to outcrops along the Scott River, where there are excellent exposures of coarse-grained,

Km	Mi	
		well-foliated, garnetiferous hornblende-plagioclase gneiss. Hotz (1971b) correlates this rock with higher grade parts of the Paleozoic and Triassic belt; Barrows (1969) shows the rock as correlative with, but a higher grade part of, the Condrey Mountain Schist. Note that the foliation in the gneiss is approximately parallel to axial planes of nearly recumbent folds. The foliation is amplified by quartz-feldspar-rich and hornblende-rich segregations. Intrusion into the amphibolite gneiss by the adjacent quartz diorite may be responsible for the coarse-grained, granular quartz-feldspar-rich segregations. The layers with hornblende-garnet porphyroblasts are also folded, and the garnets are as large as 1.5 cm in diameter. Garnet seems to concentrate in the hornblende-rich layers and is flattened parallel with lineation or gneissosity in the plane of foliation.
17.4	10.9	Crossing Tompkins Creek. Note that we are in a coarse-grained gneissic rock of plutonic origin and quartz-diorite composition, with hornblende as the dominant mafic silicate.
19.0	11.9	**Stop 13.** Walk back about 0.2 mi. Here we have a medium- to coarse-grained black or dark-green gneiss with hornblende and plagioclase. The gneissic fabric fades locally. Note the recumbently folded pegmatitic plagioclase + hornblende intrusive(?) rock. The rock here is apparently part of a larger plutonic complex with overall tonalitic composition; this rock is dioritic or gabbroic.
19.8	12.4	Middle Creek.
20.3	12.7	**Stop 14.** The host rock here is part of the same intrusive complex as the last stop but has large, rounded xenoliths of ultramafic rock. The xenoliths are composed of coarse-grained hornblende and clinopyroxene. The xenoliths occur in clusters in dioritic gneiss exposures all along the roadcut. The plutonic complex is apparently Jurassic in age.
22.1	13.8	Bridge Flat USFS Campground.
22.6	14.1	Kelsey Creek and bridge over Scott River. Now we are back into higher grade metamorphic parts of the Paleozoic and Triassic belt rocks of Hotz (1971b).
22.7	14.2	Kelsey Creek USFS Guard Station.
23.4	14.6	Spring Flat USFS Campground.
23.7	14.8	**Stop 15.** Interlayered medium-grained micaceous quartzite and biotite schist with some lenses of marble. The quartzite shows extreme plastic deformation and has fine-grained clusters of garnet. Note folding with foliation approximately parallel to axial planes of folds.
24.6	15.4	Big bend in the river. Medium- to coarse-grained plagioclase-hornblende gneiss and ultramafic rock composed of talc-antigorite and possibly anthophyllite and tremolite. The amphibolite is isoclinally folded.
25.9	16.2	**Stop 16.** Good roadcut. Note that a leucocratic, medium-grained granodiorite with gneissic fabric is intrusive into quartz-feldspar-biotite schist. The plutonic body has xenoliths of the surrounding biotite-rich schist. The xenoliths are lenticular and have a schistosity that is probably derived from the host Paleozoic and Triassic belt schists. Amphibolite gneiss is dominant at the opposite end of the roadcut, apparently interlayered with biotitic schists.
27.2	17.0	Turnoff to Indian Scotty Campground.
34.2	21.4	Paleozoic-Triassic belt amphibolite gneiss.
34.6	21.6	Crossing fault into low-grade Paleozoic and Triassic belt greenstone-chert association.
35.7	22.3	Exposures of low-grade Paleozoic and Triassic belt metasedimentary and volcanic rocks.

End of field trip. Continue on the Scott River road toward Fort Jones and to the intersection with California Highway 3. Turn left (northeast) and proceed through Fort Jones to Yreka and Interstate 5. □

Claim deadline passes: 29,400 filed with OSO

About 29,400 mining claims were filed with BLM's Oregon State Office before the October 22, 1979, deadline, according to Diane Livengood of the Records and Data Management Branch.

Filing was required for miners who located their claims on Federal land before October 21, 1976. Claims located since then must be filed with the BLM within 90 days.

Claims not filed with the BLM are voided by law.

—BLM News Clips □

Schlicker enters private practice

Herbert G. Schlicker, Engineering Geologist for the Oregon Department of Geology and Mineral Industries since 1955, left the Department on January 1, 1980, to open his own engineering geology firm, H.G. Schlicker and Associates, Banfield Plaza, Portland.

During his almost twenty-five years with the Department, Schlicker provided leadership in many new ways. Together with Lloyd Staples, University of Oregon, he was instrumental in bringing about the registration of geologists in Oregon. Schlicker, who is currently serving on the State of Oregon Board of Geologist Examiners, was first Chairman of that board. He also planned and conducted numerous geology and engineering geology studies for the Department, including the Department's first rock material resource assessment, *Gravel Resources in Relation to Urban Development in the Salem Area* (1961), and together with Robert Deacon, its first engineering geology study, *Engineering Geology of the Tualatin Valley Region, Oregon* (1967).

A native of Grangeville, Idaho, and graduate of Oregon State University, Schlicker came to the Department after working as a soils engineer with the Oregon Highway Department and as a geologist for a Louisiana oil company.

Since 1955, Schlicker was principal author, investigator, or compiler of 26 published studies and co-author of four. He also produced more than 100 unpublished reports and geologic studies for State and local governmental agencies and the U.S. Geological Survey. In addition, he provided engineering geology information to individuals, companies, and government bodies. He served as the Chairman of the Geology Section of the Oregon Academy of Science, Chairman of the Engineering Geologists of Oregon, and Chairman and Treasurer of the Oregon Section of the American Institute of Professional Geologists. He was a member of the Advisory Committee of the Association of Engineering Geologists and the Hazards Committee of the American Institute of Professional Geologists.

Schlicker's final report for the Department is the soon-to-be-published Bulletin 99, *Geology and Geologic Hazards of Northwestern Clackamas County, Oregon.* □

Herbert G. Schlicker

Geologists in eastern Oregon face awesome challenge

During the early Cenozoic, 50 to 15 m.y. ago, rotation of the Coast Range (Simpson and Cox, 1977; Beck and Burr, 1979) and probable concomitant rotation across Oregon of the Cascade Range volcanic arc (Hammond, 1979) from the Mesozoic continental margin to the east left many fault blocks of Mesozoic terranes, some possibly oil-bearing, in eastern Oregon. Subsequent extension during the late Cenozoic, 15 m.y. ago to the present, has caused recurrent volcanism and burial of most Mesozoic blocks. The positions of these blocks are problematical. Deep exploratory drilling through the volcanic cover could penetrate grabens filled with interbedded volcanic and volcaniclastic sedimentary rocks, eruptive centers along fault zones, as well as detached Mesozoic blocks lacking stratigraphical and structural continuity. Geologists face an awesome challenge in restoring the fault blocks, like putting together a jigsaw puzzle on a treadmill.

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—Paul E. Hammond, Department of Earth Sciences, Portland State University P.O. Box 751 Portland, Oregon 97207 □

Answers to frequently asked questions about gold mining

DOES GOLD OCCUR IN OREGON?

Lode and placer gold has been mined from many parts of the State. The southwestern and northeastern corners of the State have the highest production of both lode and placer gold. Minor output has come from the other corners of the State.

WHERE CAN I OBTAIN INFORMATION ABOUT PAST GOLD MINES AND MINING, INCLUDING MAPS?

The following can be purchased from the Portland, Grants Pass, and Baker offices of the Department of Geology and Mineral Industries:

(1) Mineral and Water Resources of Oregon (Bulletin 64), 1969 .... $2.00
(2) Oregon's Gold Placers (Misc. Paper 5), 14 p. .... .50
(3) Skin Diving for Gold in Oregon (The Ore Bin, April 1961), 8 p. .... .35
(4) Lest We Forget (The Ore Bin, Dec. 1976), 17 p. .... .35
(5) Special Gold Issue (The Ore Bin, April 1973), 16 p. .... .35
(6) Geology, Mineralization and Mining Field Guides for the Cascade Range (The Ore Bin, June 1977, Dec. 1977, May 1978, and June 1978). Price per issue..................... .35
(7) Recreational Gold Packet (includes items 2, 3, and 4 above, plus an 8½ × 11 mineral localities map and a list of Department publications) 1.00

Allow 1 month for delivery of publications ordered by mail. Payment must accompany orders less than $20. All sales are final. Foreign orders must be paid in U.S. dollars.

The following out-of-print reports can be read at most libraries, including the Department's:

(1) Gold and Silver in Oregon (Bulletin 61)
(2) Oregon Mineral Deposits Map and Key (Misc. Paper 2)

WHAT LANDS ARE OPEN FOR PROSPECTING AND MINING?

Land ownership for the surface and for mineral rights can be determined from the local County Assessor's maps. Patented mining claims are treated the same as any other privately owned land. Most U.S. Forest Service and U.S. Bureau of Land Management lands, shown on their published maps, are open for prospecting; however, much of the better lode and placer ground has already been staked.

HOW CAN I TELL IF AN AREA HAS BEEN STAKED?

All unpatented mining claims are recorded in the local County Courthouse and with the U.S. Bureau of Land Management, 729 N.E. Oregon Street (P.O. Box 2965), Portland, Oregon 97208 (telephone: 503 231-6283). The BLM records may be easier to work with than the county's.

SUPPOSE I FIND SOME GOLD, WHAT THEN?

The gold is yours to keep, give away, or sell. There is no limit to the amount. The U.S. Government no longer buys gold. Gold may be sold to individuals, jewelry manufacturers, or gold buyers. Best prices are received for good-sized nuggets or visible gold mineral specimens which have a collectors' value rather than a metal value. There is no fixed price for gold, with sales consummated between a willing buyer and a seller, at an agreed-upon price.

DO I NEED PERMISSION TO PROSPECT AND STAKE A MINING CLAIM ON PUBLIC LANDS?

On public lands that have not been withdrawn from mineral entry, Federal permission is not needed to prospect or stake a mining claim.

WHAT ARE THE RULES AND REGULATIONS FOR GOLD MINING?

The Department can supply a copy of the State Mining Code for 50¢, and the U.S. Bureau of Land Management has printed "Staking a Mining Claim on Federal Lands" for free distribution. For sale at most stationers are two forms which show how to stake either a lode or a placer claim. Each has a brief synopsis of the mining law. The forms are Form No. 830 (Notice of Vein or Lode Locations in Oregon) and Form No. 897 (Notice of Placer Location—Oregon). The forms are 20-30¢ each. If prospecting or mining is to go beyond the handtools stage, then the U.S. Forest Service and the U.S. Bureau of Land Management may require a notice of intent or a plan of operation, and the Oregon Department of Geology and Mineral Industries may require a surface mining permit, depending on the size of the proposed mining development.

Most gold panners and those with small dredges, however, are not interested in locating a mining claim and want only to do some recreational placer mining. No permits are required, and unless the miners unduly muddy the waters in a stream, there will be no problems. A report entitled "Recreational Mining Can Be Compatible with Other Resources," which gives the best

(See **Gold Mining,** *p. 38)*

Federal geothermal lease sale held in January

The U.S. Bureau of Land Management held a geothermal lease sale in Portland on January 8, 1980. Four energy companies—Anadarko Production Co., Hunt Oil Co., International Energy Corp., and Union Oil—were successful bidders on the parcels located in the Alvord, Breitenbush, Crump, and Klamath Falls Known Geothermal Resource Areas (KGRA's).

Sixty-two parcels were offered by the Federal government. Forty-nine parcels received no bids, and seven others were withdrawn.

Leases cover a 10-year period and give successful bidders a right to develop geothermal resources. Royalties begin when production is marketed.

Details on the bidding are as follows:

Parcel	Acreage	Area	Company	Amount ($)	Cost per acre ($)
13	2,280	Alvord	Anadarko	236,367.60	103.67
14	2,463	Alvord	Anadarko	90,605.33	36.78
33	1,029	Breitenbush	Union Oil	10,341.45	10.05
39	118	Klamath Falls	Intercontinental	917.53	7.78
50	2,371	Crump	Hunt Oil	4,833.35	2.04
51	2,344	Crump	Hunt Oil	4,828.58	2.06

—Data from USBLM Oregon State Office news release, January 14, 1980 □

Josephine County mineral study completed

The Oregon Department of Geology and Mineral Industries announces the completion of its investigation of the geology and metallic mineral deposits of Josephine County. Bulletin 100, entitled *Geology and Mineral Resources of Josephine County, Oregon*, by Len Ramp and Norman V. Peterson, presents the results of the investigation.

Bulletin 100 contains several multicolor geologic maps at various scales, a mine location map at a scale of 1:125,000 (one inch equals two miles), and a table that presents data from 470 mines. The accompanying 45-page text discusses the geology and geologic units of the County and evaluates the mineral-resource potential of the various units. It also contains pictures and accounts of some of the mineral exploration and mining that took place in Josephine County in the past.

Bulletin 100 may now be purchased for $9.00 from the Department's Portland and Grants Pass offices. Mailed orders should be addressed to the Oregon Department of Geology and Mineral Industries, 1069 State Office Building, Portland, Oregon 97201, or 312 S.E. "H" Street, Grants Pass, Oregon 97526. Payment must accompany orders under $20.00. □

(**Gold Mining**, *from p. 37)*

time to work in a stream, can be obtained from the Environmental Management Section of the State of Oregon Department of Fish and Wildlife (506 S.W. Mill Street, P.O. Box 3503, Portland, Oregon 97208—telephone: 229-5408).

Care must be taken not to trespass on valid mining claims or privately owned land. Good outdoor manners and a concern for the environment are essential.

WHERE CAN I GET MY SAMPLES ASSAYED FOR GOLD?

The Oregon Department of Geology and Mineral Industries has a complete assay service at its Portland headquarters. Samples of black sand concentrates, raw bank run sand and gravel, or ore specimens should weigh at least 1 pound for best results, and not over 5 pounds. An extra $3.00 fee is charged if the sample is over 5 pounds. The charge for assaying a sample for gold and silver is $10.00 for lode samples and $12.00 for placer samples (payment should accompany the samples). There is an additional sample preparation charge of $3.00 if the sample is wet and needs to be dried. If the sample is 3 inches or larger, a $3.00 fee is charged for crushing. There is no charge for identifying rocks and minerals unless special tests are required. Simple tests for gold are contained in "Oregon's Gold Placers," listed above.

Rocks and minerals also can be identified at the U.S. Bureau of Mines, 1450 Queen Street, S.W. (P.O. Box 70), Albany, Oregon 97321. □

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