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U.S. GEOLOGICAL SURVEY CIRCULAR 976

The Conterminous United States Mineral Appraisal Program: Background Information to Accompany Folio of Geologic, Geochemical, Geophysical, and Mineral Resource Maps of the Medford 1° by 2° Quadrangle, Oregon and California

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Abstract

The Medford 1° by 2° quadrangle in southern Oregon and northern California was studied by an interdisciplinary research team to appraise its mineral resources. The appraisal is based on geological, geochemical, and geophysical field and laboratory investigations, the results of which are published as a folio of maps, figures, and tables, with accompanying discussions. This circular provides background information on the investigations and integrates the information presented in the folio. The bibliography lists selected references to the geology, geochemistry, geophysics, and mineral deposits of the Medford 1° by 2° quadrangle.

INTRODUCTION

This circular, as well as a separately published folio of maps, is part of a series of U.S. Geological Survey reports that give information about the mineral-resource potential of the conterminous United States. Both this circular and the folio maps were compiled under the Conterminous United States Mineral Assessment Program (CUSMAP). CUSMAP is intended to provide regional mineral appraisal information both to assist in the formulation of a long-range national minerals policy and to assist Federal, State, and local governments in their land-use planning. The products of CUSMAP are also intended to increase geological, geochemical, and geophysical knowledge of the conterminous United States. Thus, the program provides a regional geologic and mineral-resource framework for mineral exploration and for specific studies such as the mineral appraisal of wilderness areas.

Location and geography

The Medford 1° by 2° quadrangle, the subject of this folio, covers approximately 19,000 km^2 in southern Oregon and northern California. Less than 2 percent of the quadrangle lies within California. The quadrangle lies between lat 42° and 43° N. and long 122° and 124° W. (fig. 1). Most of the quadrangle lies within the Klamath Mountains and Cascade Range physiographic provinces. A small part in the northwest corner of the quadrangle is in the Coast Range province, and a strip along the eastern border lies within the Basin and Range province. Overall the quadrangle is mountainous with rugged relief. Elevations range from about 150 m to nearly 2,800 m, but mostly are between 900 m and 1,600 m. The climate is mild and precipitation is heavy, especially during winter storms; as a result, slopes are thickly covered with trees and underbrush.

The major river in the quadrangle is the Rogue which, along with its tributaries such as the Illinois and Applegate, drains more than two-thirds of the quadrangle. Small areas are drained by the Middle Fork Coquille, South Fork Umpqua, and Klamath Rivers in the northwest, north-central, and eastern parts of the quadrangle, respectively. The main stem of each of these last three rivers makes a short loop into the quadrangle. Crater Lake and part of upper Klamath Lake lie within the quadrangle. Smaller lakes are common in the Cascade Range; man-made reservoirs are common throughout the quadrangle.

The Medford quadrangle is served by an extensive road network. Interstate 5 runs generally from southeast to northwest across the quadrangle, and serves all major towns. Other federal, state, and county roads generally follow major streams. The Forest Service, Bureau of Land Management, and private wood-products companies maintain extensive networks of hard-surfaced and graveled roads throughout forested areas. Away from roads, however, movement cross country is painfully slow and outcrops few. Major towns are Medford, Grants Pass, Ashland, Cave Junction, and Canyonville.

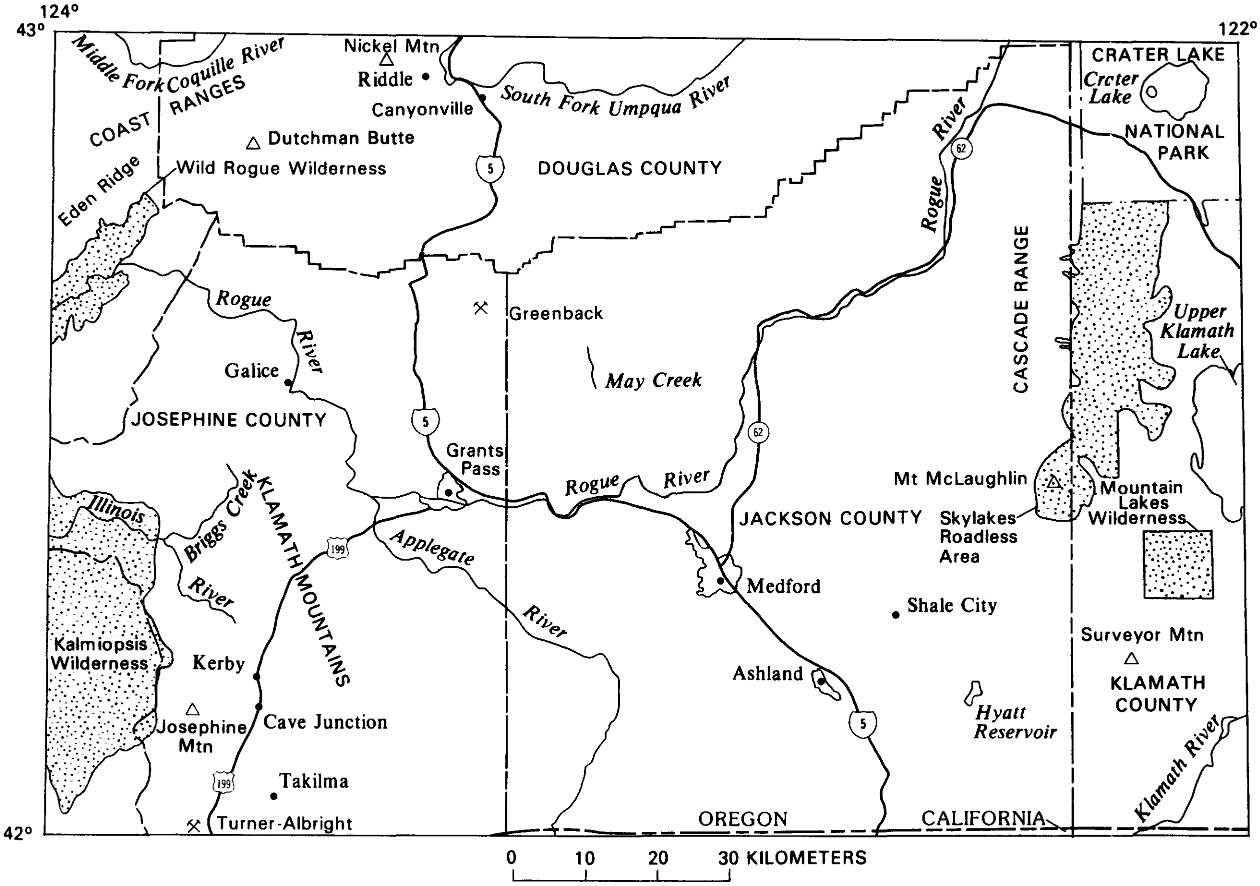

Figure 1. Medford 1° by 2° quadrangle.

Previous work

Prior to 1900 few systematic geologic studies were made in the area of the Medford 1° by 2° quadrangle. J. S. Diller was the first to undertake comprehensive studies in this heavily wooded and poorly exposed area. His early works described the topographic development of the area (Diller, 1902), the geology and petrology of Crater Lake (Diller and Patton, 1902), and the mineral resources of a large portion of the western part of the quadrangle (Diller and Kay, 1908, 1909; Diller, 1914). A later publication described the geology and mineral deposits of the 30-minute Riddle quadrangle in the northwestern part of the quadrangle (Diller and Kay, 1924). These reports were followed by the studies of Frances G. Wells and colleagues who systematically examined much of the Klamath Mountains during the late 1930's, 1940's, and early 1950's and published on the geology and mineral deposits of the 30-minute Grants Pass quadrangle (Wells, 1940), the 30-minute Kerby quadrangle (Wells, Hotz, and Cater, 1949), the 15-minute Galice quadrangle (Wells and Walker, 1953), and the 30-minute Medford quadrangle (Wells, 1956).

Early interest in the Cascade Range part of the quadrangle concentrated on the geologic history of Crater Lake and its precursor, Mount Mazama. In 1942, Howell Williams published his classic monograph on Mount Mazama, which included an often overlooked geologic reconnaissance along the crest of the range south to Mount Shasta (Willams, 1942).

In the early part of this century, the Oregon Bureau of Mines and Geology (now the Oregon Department of Geology and Mineral Industries) began a comprehensive program of describing and cataloging geology and development information about individual mines and prospects. The data were published in series of reports that covered the entire state or individual counties (Winchell, 1914; Butler and Mitchell, 1916; Parks and Swartley, 1916; Oregon Department of Geology and Mineral Industries, 1940; 1942; and 1943). This program continues to the present with the publication of a series of compilations concerning specific ore-deposit types (chromite, Ramp, 1961; mercury, Brooks, 1963; gold and silver, Brooks and Ramp, 1968; nickel, Ramp, 1978), as well as revised county reports (Douglas County, Ramp, 1972; central Jackson County, Beaulieu and

Hughes, 1977; Josephine County, Ramp and Peterson, 1979).

Topical studies on selected mining districts and ore deposit types were conducted by members of the U.S. Geological Survey and others; significant among these were the studies by Shenon (1933a, b, c) and Lowell (1942) on copper and gold; Hotz (1971b) on gold; Wells, Page, and James (1940) on chromite; Hundhausen (1952) on copper-nickel, Pecora and Hobbs (1942) and Cumberlidge and Chace (1968) on nickel, and Derkey (1981) and Koski (1981) on massive sulfide deposits. Most of the preceding studies concentrated on the Paleozoic and Mesozoic rocks in the western part of the quadrangle. Only Callagahan and Buddington (1938) examined the mineral resources of the Cascade Range.

Recent studies in the western part of the quadrangle have focused on bedrock geology and its relationship to current plate tectonic models. A few theses and areal geology reports also discussed other aspects of the geology of the Medford 1° by 2° quadrangle and these were consulted as part of this study. Work by Harper (1980a, b), Jorgenson (1970), Coleman and others (1976), Garcia (1976a, b), and Irwin (1977, 1979) were particularly useful in our interpretation of the geology as well as the reports by Jones (1960), Jones and Imlay (1973), Lovell (1969), Kays (1970), Elliott (1971), Thoms (1975), Dick (1976), Loney and Himmelberg (1976), Miles (1977), Vail (1977), Donato and others (1980), Harper (1980b), Gray (1982), and Nilsen (1984).

Recent studies within the Cascade Range have concentrated on glacial and volcanic geology. Among these are glacial geology along the crest, especially in the Mountain Lakes Wilderness (Carver, 1972); a reinterpretation of the history of Mount Mazama (Bacon, 1983a); the history of Mount McLoughlin (Maynard, 1974); aerial geology and geochemistry of the Hyatt Reservoir and Surveyor Mountain 15-minute quadrangles (Naslund, 1977); and tectonic rotation of the volcanic rocks of the Western Cascade Range (Magill and Cox, 1980).

Present Study

The maps and interpretations included in the CUSMAP folio of the Medford 1° by 2° quadrangle are products of numerous multidisciplinary studies, most of them conducted between 1974-1980. The study originated as a land-resource analysis project that sought to combine modern geologic mapping with reinterpretation of existing maps to relate mineral resources, regional structure, and tectonostratigraphic units with plate tectonic models; the project was incorporated in the CUSMAP program in 1976. The earlier investigations in the Klamath Mountains, principally those by Frances G. Wells and colleagues, were the starting point and foundation for compiling the geologic map of the Medford 1° by 2° quadrangle. We used many of their original field notes and maps for reinterpretation and compilation during the CUSMAP study. We retreived ore samples collected during earlier studies for examination and geochemical analysis; many were from mines no longer active or accessible. In many areas new reconnaissance geologic mapping was done at a scale of 1:62,500. Outcrops were examined along rivers, creeks, ridges, and side slopes, but especially along the extensive network of logging roads that has developed since the early investigations.

The program was integrated with studies of wilderness areas in the Klamath Mountains (Page, Gray, and others, 1981; Gray and others, 1982) and the Cascades (Smith 1983; Smith and Benham, 1983b). Helicopters were used in support of some fieldwork in the wilderness areas and adjacent areas.

The Oregon Department of Geology and Mineral Industries, in particular Len Ramp and Norm Peterson of the Grants Pass office, cooperated with members of the CUSMAP project in many stages of geologic investigations.

The results of the Medford 1° by 2° quadrangle CUSMAP program are presented in an open-file map and a series of Geological Survey Miscellaneous Field Studies Maps (table 1). Other maps and reports related to the program are indicated by an asterisk in the bibliography at the end of this report. Mineral-resources data have been entered into a computer file in the U.S. Geological Survey's Mineral-Resources Data System (MRDS); information about MRDS may be obtained from the Regional MRDS Representative at the U.S. Geological Survey, 12201 Sunrise Valley Drive, Reston, VA 22092 or at the U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025.

GEOLOGIC MAP
(OFR 82-955)

The geologic map of the Medford 1° by 2° quadrangle is compiled from a combination of new reconnaissance geologic mapping and reinterpretation and compilation of previous mapping. Selected areas shown in this 1:250,000 scale compilation (Smith and others, 1982) were also published as detailed maps at 1:62,500 scale or larger (see Page and others, 1977; Page and others, 1978; Johnson and Page, 1979; Gray, 1980a; Blair and others, 1981; Gray and others, 1981; Page, Gray, and others, 1981; Page, Moring, and others 1981; Smith, 1983).

The geology of the Medford 1° by 2° quadrangle is complex, varied, and, unfortunately, throughout much of the quadrangle, poorly exposed. The western two-thirds of the quadrangle is composed of complexly faulted and metamorphosed late Paleozoic and early Mesozoic

Table 1.—Contents of the Medford 1° by 2° CUSMAP folio
[MF, U.S. Geological Survey Miscellaneous Field Studies Map; OF, Open-File Report]

OF 82-955	Geologic map, by James G. Smith, Norman J Page, Maureen G. Johnson, Barry C. Moring, and Floyd Gray
MF 1383-B	Aeromagnetic data and interpretation, by Richard J. Blakely
MF 1383-C	Mineral resource assessment maps, by Donald A. Singer, Norman J Page, James G. Smith, and Maureen G. Johnson
MF 1383-D	Characteristics of lode gold, by Norman J Page, Maureen G. Johnson, and Jocelyn A. Peterson
MF 1383-E	Granitic rocks, by Norman J Page, Richard J. Blakely, and Jerome J. Cannon
MF 1383-F	Mineral deposits and mineral exploration, by Roscoe M. Smith and Jocelyn A. Peterson
MF 1383-G	Abundance and distribution of copper in stream-sediment samples, by Charles L. Whittington, David J. Grimes, and Reinhard W. Leinz
MF 1383-H	Abundance and distribution of silver in stream-sediment samples, by Charles L. Whittington, David J. Grimes, and Reinhard W. Leinz
MF 1383-I	Abundance and distribution of chromium in stream-sediment samples, by Charles L. Whittington, David J. Grimes, and Reinhard W. Leinz
MF 1383-J	Abundance and distribution of arsenic in stream-sediment samples, by Charles L. Whittington, Reinhard W. Leinz, and David J. Grimes
MF 1383-K	Abundance and distribution of mercury in rock samples, by Charles L. Whittington, Reinhard W. Leinz, and David J. Grimes
MF 1383-L	Isostatic residual gravity, by Richard J. Blakely and Lisa Senior

island-arc volcanic rocks and oceanic ophiolitic and ultramafic sequences intruded by later Mesozoic granitic plutons. After partial unroofing, the metamorphic and plutonic rocks were covered unconformably by Late Cretaceous and Paleogene sequences of marine and nonmarine sandstone and shale. The eastern one-third of the quadrangle is composed of two groups of volcanic and volcaniclastic rocks, which together make up the Cascade volcanic arc. The older Oligocene and Miocene group is composed dominantly of volcaniclastic strata and is called the volcanic rocks of the Western Cascade Range. The younger Pliocene to Holocene group is composed mostly of constructional volcanic edifices and is called the volcanic rocks of the High Cascade Range.

The geologic and structural pattern of the western two-thirds of the quadrangle is one of tectonically juxtaposed terranes that have widely different lithologies and preamalgamation geologic histories. The terranes consist of (1) low-grade metavolcanic and metasedimentary sequences with island-arc affinities, (2) broken and dismembered mafic and ultramafic sequences with ophiolitic affinities, (3) unmetamorphosed graywacke-shale sequences that are interpreted to have originated as deep-sea fans, (4) true tectonic melanges such as those of the Takilma and Dutchman Butte areas, (5) a tectonic window of muscovite and chlorite schist (the Condrey Mountain Schist), (6) high-grade micaceous schists and amphibolite (the May Creek Formation, and (7) amphibolite (the amphibolite of Briggs Creek of Coleman and others, 1976).

These terranes are separated by northeast-trending structural zones that define the tectonic grain of this part of the quadrangle. Most of these zones are shallowly to steeply east-dipping thrust faults that are commonly marked by dismembered ophiolite sequences. In general, thrust-bounded terranes are successively younger to the west. However, within each block stratigraphic sequences are generally young in the opposite direction to the east. In a general way from east to west, the metavolcanic and metasedimentary rocks of the Applegate Group are thrust westward over similar volcanic and sedimentary island arc sequences of Jurassic age. These rocks are in turn thrust westward over the shales and graywackes of the Dothan Formation of Late Jurassic and Early Cretaceous age. Each terrane is composed of numerous fault slices that contain coherent, distinctive stratigraphic sequences of metavolcanic and metasedimentary rocks. This distinctiveness allowed us to reconstruct the stratigraphy of the Paleozoic, Triassic, and Jurassic rocks. Previously, most rocks in the quadrangle were assigned to either the Applegate Group or the Rogue or Galice Formations. However, the new mapping has made it possible to distinguish lithologically distinct sequences in each terrane with the resultant reassignment of some of these rocks to herein-designated (new) rock-units.

The simplicity of the westward thrusting described above is complicated by other periods of faulting. Before the westward thrusting took place, part of the Josephine ophiolite of Harper

(1980a and 1980b), in the southwestern part of the quadrangle, was thrust northward over the Jurassic rocks. After the westward thrusting, northeast-trending faults and rock sequences were broken and offset by northwest-trending, steeply dipping faults. In addition, a major eastward-trending strike-slip fault system cuts across the northern part of the quadrangle. Correlation of volcanic rocks near Canyonville with those to the west in the Wild Rogue Wilderness indicates considerable pre-Oligocene strike-slip movement. Offset of a prominent 35 m.y. old ash-flow tuff in the Roseburg 1^{o} by 2^{o} quadrangle indicates post-Oligocene rejuvenation but with dip-slip movement.

Jurassic and Early Cretaceous granitic plutons intruded older thrust-faulted rocks. The granitic plutons are discussed and analyzed in detail in another part of this folio (MF 1383-E).

By Late Cretaceous time the rocks of the western part of the quadrangle had been eroded to considerable depth, partially unroofing the plutons. The Klamath Mountains acted as a local source terrane for a thick sequence of shallow-water to deep-water conglomerates, sandstones, and shales. Today these homoclinally dipping beds are exposed adjacent to interstate highway I-5 from the California border to Medford. They extend eastward under younger rocks for an unknown distance.

During Eocene time, marine shallow- to deep-water sandstones were deposited in the northwestern part of the quadrangle. They are gently folded and are part of a sequence that extends to the northeast in the Oregon Coast Range. Near Medford and Ashland, poorly dated but approximately correlative nonmarine conglomerate and fluvial sandstone were deposited, the source of which was recycled Cretaceous sedimentary and basement rocks of the Klamath Mountains.

The geology of the eastern one-third of the Medford quadrangle is dominated by the volcanic and volcaniclastic rocks of the Cascade volcanic arc. Volcanism began in early Oligocene time as fans of volcaniclastic debris spread out over Eocene nonmarine sedimentary rocks in the south and pre-Tertiary basement rocks in the north. Volcanism continued, shifting its locus from place to place along the Cascade volcanic arc, until approximately 17 Ma. This older sequence is called the volcanic rocks of the Western Cascade Range. It forms a structurally simple but stratigraphically complex sequence of continental volcanic, volcaniclastic, and sedimentary rocks about 5,500 m thick. The rocks form an east-northeast-dipping homoclinal sequence with dips ranging from 30^{o} to 5^{o}. Folds, such as those mapped by Peck and others (1964) farther north, are absent.

A single, complete, unique stratigraphic section of these rocks does not exist. Instead, the volcanic rocks of the Western Cascade Range are composed of many overlapping and intertonguing volcanogenic and sedimentary units. Lithologic correlations, even of similar stratigraphic sequences, without corroborating K-Ar ages or detailed mapping cannot be trusted. Individual beds generally extend from a few kilometers to a few tens of kilometers. Rapid facies changes are common because as individual emplacement units traveled away from vents they thinned, changed depositional mode, and, therefore, field appearance. However, units from different, and commonly widely separated, volcanoes have identical compositions and modes of emplacement and look nearly identical.

For this study, conventional stratigraphic formations were neither mapped nor used to delineate rock units on the map because of the stratigraphic problems mentioned above. Rather, a dual division based on lithology and time was used. The rocks were divided into a few broad lithologic units that could be mapped in the field using reconnaissance methods. Further subdivision was based on age as determined by K-Ar methods and extended by mapping away from K-Ar sample sites. Breaks between units were chosen in part to represent the ages of Wells' (1956) formations as determined by K-Ar dating of samples from his type localities.

There is no documented volcanism within the Medford 1^{o} by 2^{o} quadrangle between 15 m.y. and about 7 m.y. ago. During that time the volcanic rocks of the Western Cascade Range were slightly uplifted, tilted eastward, and eroded. On this eroded landscape, carved into the volcanic rocks of the Western Cascade Range, renewed eruption, starting about 7 m.y. ago and continuing to the present day, built the constructional volcanic edifices of the volcanic rocks of the High Cascade Range.

The volcanic rocks of the High Cascade Range consist of spectacular andesite stratovolcanoes interspersed with less prominent basalt and basaltic andesite shield volcanoes, small generally monogenetic volcanoes of basalt, basaltic andesite, or andesite, extensive valley-filling flows, and cinder cones. Constructional volcanic landforms predominate, although stream erosion and glacial action have considerably modified the symmetrical shapes of older volcanoes. Unlike the volcanic rocks of the Western Cascade Range, even the oldest volcanoes in this group have not been tilted. The products of individual volcanoes piled up around vents, or in the case of the more fluid lavas, flowed downhill filling streams and low areas between adjacent volcanoes.

The volcanic rocks of the High Cascade Range in the quadrangle are from volcanoes that formed mostly 3.5-0.5 Ma, based on K-Ar ages and magnetic polarity measurments. More than three-fourths of the individually mapped volcanic units formed during this time.

AEROMAGNETIC MAP
(MF-1383-B)

Magnetic properties of certain rock types often produce explicit magnetic anomalies. For example, contacts between magnetic ophiolitic rocks and nonmagnetic sedimentary rocks cause abrupt aeromagnetic boundaries even though these contacts may be buried at depth below the topographic surface. Careful study of aeromagnetic data, therefore, can provide insights about the subsurface geology and the mineral-resource potential.

The aeromagnetic map (sheet 1 of MF 1383-B) was compiled from four published surveys by machine-contouring the digital representation of each survey and photographically splicing the resulting contour maps together. In addition, magnetic susceptibilities were determined for 163 samples from various rock types to aid interpretation of the magnetic data. The magnetic properties of major rock types in the Medford 1° by 2° quadrangle often produce distinctive patterns of magnetic anomalies. Eleven (magnetic) terranes with distinctive magnetic patterns were identified. For example, the volcanic rocks of the Cascade Range produced scattered, high-amplitude, short-wavelength anomalies whereas the ophiolite belts in the western part of the map area produced arcuate, linear anomalies. Less magnetic terranes, such as that underlain by the Dohan Formation, characteristically show subdued anomalies.

An interpretive map (sheet 2 of MF-1383-B) shows approximate boundaries of various rock units that have characteristic magnetic anomalies. These boundaries, supported in several cases by computer modeling experiments, allow the interpreter to extrapolate geologic information from known areas into covered or inaccessible regions.

MINERAL-RESOURCE ASSESSMENT MAPS
(MF-1383-C)

The mineral-resource assessment consists of two maps showing tracts of land delineated by the type of mineral deposit that may be present, and a text discussing the assessment, figures, and tables that contain supporting information and references. The text is organized by deposit type with a summary description of the characteristics of each deposit type followed by a discussion of the geology of the Medford quadrangle that guided tract delineation for that type, graphical grade and tonnage models or a contained metal model for each type, and, for a few deposit types, estimates of the number of undiscovered or unrecognized deposits.

The tracts were outlined on the basis of their known deposits and the potential for undiscovered deposits as inferred from occurrences in similar geologic settings elsewhere. For example, 12 tracts were delineated, based on mapped geology, as permissive for the occurrence of massive sulfide deposits in marine felsic to intermediate volcanic rocks. By integrating geologic, geochemical, and geophysical information, as well as information about the extent and adequacy of past exploration and present geologic knowledge, the authors subjectively estimated a 90 percent chance of at least one undiscovered deposit, a 50 percent chance of at least two or more deposits, and a 10 percent chance of four or more deposits in the quadrangle. The grade-tonnage model for this deposit type indicates that about 50 percent of the undiscovered deposits will be larger than 0.2 million metric tons and will contain copper, zinc, silver, gold, and some lead.

In the same manner, five tracts were delineated for massive sulfide deposits in mafic volcanic rocks (Cyprus-type deposits). In addition to the one known deposit of this type (Turner-Albright), an estimate was made of a 10 percent chance of two or more Cyprus-type deposits in the delineated tracts. Fifty percent of such deposits contain 1 million metric tons or more with copper, zinc, gold, and silver recoverable in many.

Widespread alteration identified and mapped during this program, as well as numerous geochemical anomalies detected, led to delineation of eight tracts for epithermal precious-metal deposits in the Western Cascades of the Medford quadrangle. Significant clustering of mercury, arsenic, tellurium, antimony, and other elements within the altered areas strongly suggest the presence of epithermal precious-metal mineralization. A contained metal model for the deposit type indicates that such deposits can have large amounts of gold and silver. An estimate was made of a 50 percent chance of two or more undiscovered deposits in the delineated tracts.

The nickel-bearing laterite deposit at Nickel Mountain near Riddle was the most important producer of primary nickel in the U.S. since 1956. Numerous other nickel-bearing laterites in the Medford quadrangle are lower in grade and tonnage than laterite deposits that have produced or for which capital expenditures have been made for production.

Other metal-bearing mineral resources in the Medford quadrangle include placer gold, and small tonnage lode deposits containing chromite, antimony, mercury, nickel, molybdenum, manganese, or tungsten. Resources of coal at Eden Ridge and adjacent Squaw Ridge centered just to the west in the Coos Bay 1° by 2° quadrangle, oil shale at Shale City, limestone, sand, gravel, and rock suitable for various industrial and construction purposes exist in the quadrangle.

CHARACTERISTICS OF LODE GOLD
(MF-1383-D)

The relationships of about 500 lode gold occurrences, prospects, and mines that have been reported from the Medford 1° by 2° quadrangle are analyzed in map, graph, diagram, and table form with respect to pertinent geologic and economic characteristics. Significant features described include the geographic distribution of deposits and their relation to geologic and lithologic features, production information, mineralogy of the ore and gangue, gold-silver ratios, and speculations on possible genetic models for some types of deposits.

Geologic units not associated with precious metals in lode gold deposits and probably not related to the genesis of the deposits include the volcanic rocks of the High Cascade Range, the marine and nonmarine sedimentary rocks of Tertiary age, and the sedimentary rocks of Jurassic and Cretaceous age. Volcanic rocks of Jurassic age, rocks of dismembered ophiolite sequences of Jurassic age, and volcanic rocks of Paleozoic and Triassic age are host to, by far, the greatest number of lode gold deposits. Gold has been recovered from a variety of genetically different deposit types: (1) gossans and oxidized parts of volcanogenic massive sulfide deposits and as a by-product of copper mining of unoxidized ore, (2) gold-quartz-base-metal veins that are the feeders of plumbing systems for massive sulfide deposits and occur in metavolcanic and metasedimentary rocks, (3) gold-quartz veins unrelated to massive sulfide deposits which occur in a variety of host rocks, and (4) epithermal vein systems in the volcanic rocks of the Western Cascade Range. The bulk of the lode gold production came from six mines; the largest, the Greenback, had a production of 100,000 oz; 75 percent of the lode gold deposits produced less than 100 oz. The most common mineral assemblages are gold, gold-pyrite, and gold-pyrite-chalcopyrite-galena. Other moderately common minerals are arsenopyrite, sphalerite, and telluride minerals. Gold-silver ratios average about 3.6 and locally zonal patterns of this ratio appear to be associated with some of the plutons.

GRANITIC PLUTONS
(MF-1383-E)

The granitic plutons in the Medford 1° by 2° quadrangle are analyzed in map, graph, diagram, and table form with respect to pertinent geologic, geochemical, and geophysical characteristics. Signifcant features described include petrographic and modal data, age data, geochemical data for selected elements, magnetic susceptibility, magnetic expression in relation to outcrop patterns, and relation to a gravity high within the quadrangle.

Tonalite and quartz diorite are the most common phases within granitic plutons, but areas of dioritic, monzodioritic, quartz monzodioritic, granodioritic, monzonitic, quartz monzonitic and granitic composition also occur. Rock textures range from medium- to coarse-grained, hypidiomorphic, inequigranular to equigranular with local areas of porphyritic textures. Some plutons are composite and consist of distinct phases. The plutons range in age from 143 to 166 Ma based on isotopic dating and have contact aureoles that locally reach the pyroxene-hornfels facies. Magnetic anomalies over the plutons outline both the shape of the pluton and the distribution of magnetic minerals within it. Plutons in the quadrangle were divided into classes on the basis of their magnetic expression: plutons that produced magnetic anomalies that correspond closely with their mapped lateral extent, plutons with anomalies that are not associated with outcrops, and plutons that produce no anomalies. All of the highly magnetic plutons fell within a positive gravity anomaly whereas the weakly or nonmagnetic plutons were outside of it.

PROBABILITY OF MINERAL EXPLORATION
(MF-1383-F)

MF-1383-F consists of a computer tabulated list of 1,428 mines and prospects and four computer-plotted maps of commodities found in the Medford quadrangle. The maps are organized as follows:

Map 1.—Nonmetallic deposits and prospects including barite, building stone (granite), clay, coal, diatomite, feldspar, gems, gypsum, limestone, marble, olivine, petroleum, pumice, quartz, and talc.

Map 2.—Asbestos, chromite, and nickel deposits and prospects.

Map 3.—Metallic mineral deposits and prospects of antimony, copper, gold, iron, lead, manganese, mercury, molybdenum, silver, tungsten, and zinc.

Map 4.—Placer deposits and prospects of gold and platinum.

The list of properties was tabulated primarily from the U.S. Geological Survey Mineral Resource Data System (MRDS). The table summarizes information about location, name, workings, commodities, deposit size, host rock, production, reserves, and references for each property. Modified versions of these data are stored currently in the MRDS system; the MRDS record number is given in the table. Inquiries may be addressed to the Regional MRDS Representative at the U.S. Geological Survey, 12201 Sunrise Valley Drive, Reston, VA 22092 or at the U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025. Procedures for public access can be obtained through either of these representatives.

The probability of exploration for specific commodities is illustrated on maps 2 and 3. Each outlined area on the map is assigned one of four categories for probability of exploration: (1) frequent or continuous exploration in areas of favorable host rocks or known active or inactive deposits and prospects, (2) intermittent exploration in areas of favorable host rocks, but where known deposits or prospects are depleted or low grade, (3) possible exploration in areas of exposed favorable host rocks or host rocks concealed by younger rocks but few, if any, known deposits and prospects, and (4) unlikely exploration in areas of no favorable host rocks for the commodities presented on the map. Exploration potential for commodities shown on maps 1 and 4 are indicated in the marginal texts.

GEOCHEMICAL STUDIES MAPS
(MF-1383-G, H, I, J, and K)

The geochemical maps contain data that show the distribution and abundance of selected elements and delineate areas with anomalous concentrations of these elements.

Geochemical studies consisted of the collection and analysis of 3,146 rock, 1,529 stream-sediment, 1,529 oxide-residue, and 35 soil samples and the compilation and interpretation of the analytical data. Sample preparation and analysis was carried out in mobile laboratories at field camps or in U.S. Geological Survey laboratories in Denver, Colo. Rock samples were collected from all major rock types in the quadrangle. These included fresh unaltered rocks for determining normal trace elment populations, as well as rocks containing visible signs of mineralization or alteration. In preparation for analysis, rocks were crushed, split, and ground to approximately 0.1 mm in a pulverizer equipped with ceramic plates.

Stream-sediment sampling used a grid system in which the quadrangle was divided into sampling cells. As far as possible, a sample was collected in each cell in all areas containing bedrock exposures, generally at the most readily accessible site that was considered suitable. Preference was given to sampling small flowing streams with small drainage basins (5 km^2 or less), but dry drainages or larger streams were substituted where necessary. Where possible, the sample was collected in the most active part of the stream. Samples were air dried and sieved to minus 0.18 mm in stainless-steel sieves. Oxide residues were prepared from minus 0.18 mm stream sediments using an oxalic-acid leach (Alminas and Mosier, 1976). In this procedure, the sample is boiled with a solution of oxalic acid and filtered hot through a fast filter. The filtrate is evaporated to dryness, and the resulting material is ignited to an anhydrous residue by heating at 450 °C. The purpose of the procedure is to concentrate the soluble iron and manganese oxides from the sediment along with coprecipitated trace metals.

Soil samples were collected in several areas where stream-sediment samples contained anomalous concentrations of one or more elements. The soil samples were air dried and sieved to minus 0.18 mm in stainless-steel sieves prior to analysis.

All samples were analyzed for 18 or more elements by an emission spectrographic method. Oxide residues and selected rocks were analyzed for arsenic by colorimetry. Most rocks were analyzed for mercury by vapor detection techniques. Many rocks were analyzed for gold and tellurium by atomic absorption and for platinum-group metals by a fire-assay emission-spectrographic technique.

Geochemical data sets were merged and manipulated by computers located at the U.S. Geological Survey's Computer Centers in Denver, Colo., and Menlo Park, Calif. The combined data sets, containing multi-element analyses and locations of all samples, have been presented in open-file reports (Whittington, Grimes, and Peterson, 1983; Whittington, Leinz, and Speckman, 1983). Parts of the data have been used to produce the geochemical distribution and abundance plots incorporated into the geochemical maps. The elements shown on these maps were selected for their pertinence to the delineation of areas favorable for the occurrence of metalliferous mineral deposits.

GRAVITY MAP
(MF-1383-L)

Residual gravity anomalies manifest lateral density changes in the upper crust of the earth and provide subsurface geologic information in rocks that contrast in density with their neighbors. Published gravity measurements in the Medford 1° by 2° quadrangle were compiled and supplemented by 400 new measurements. Standard methods, including a correction for the effect of all terrain within 167 km of each station, were used to compute complete Bouguer anomaly values for each datum. In addition, a regional gravity field was calculated according to an isostatic model (Simpson and others, 1983) and was subtracted from each datum. The machine-contoured map of these residual anomalies (sheet 1 of MF 1383-L) provide subsurface geologic information. Ultramafic bodies within the less-dense Dothan Formation, for example, usually produce positive residual anomalies. A notable exception, however, is the Josephine Peridotite; it does not produce a large residual gravity anomaly and probably is a thin tectonic sheet.

SELECTED BIBLIOGRAPHY

The plus (+) indicates references cited in this report. Asterisk (*) indicates maps or reports of the Medford 1° by 2° quadrangle CUSMAP program other than MF 1383-B-L (table 1). Additional references to many mining properties are contained in a computer file (MRDS). MRDS is an acronym for the U.S. Geological Survey's Mineral Resource Data System, about which additional information may be obtained from the following address: U.S. Geological Survey, 920 National Center, 12201 Sunrise Valley Drive, Reston, VA 22092.

+Alminas, H. V., and Mosier, E. L., 1976, Oxalicacid leaching of rock, soil, and stream-sediment samples as an anomaly accentuation technique: U.S. Geological Survey Open-File Report 76-275, 25 p.

Appling, R. N., Jr., 1958, Manganese deposits of southwestern Oregon: U.S. Bureau of Mines Report of Investigations 5369, 56 p.

Bacon, C. R., 1981, Eruptive history of Mount Mazama [abs.]: International Association of Volcanology and Chemistry of the Earth's Interior, Symposium—Arc Volcanism, Tokyo, p. 22-23.

+_____1983a, Eruption history of Mount Mazama, Cascade Range, U.S.A.: Journal of Volcanology and Geothermal Research, v. 18, p. 57-115.

_____1983b, The precursory and climatic eruptions of Mount Mazama and collapse of Crater Lake caldera, Oregon [abs.]: Geological Society of America, Abstracts with Programs, v. 15, no. 5, p. 330.

Bacon, C. R., and Lanphere, M. A., 1983, K-Ar chronology of eruptions at Mount Mazama before the formation of Crater Lake Caldera [abs.]: Eos (American Geophysical Union, Transactions), v. 64, no. 45, p. 879.

Baldwin, E. M., 1974, Eocene stratigraphy of southwestern Oregon: Oregon Department of Geology and Mineral Industries Bulletin 83, 40 p.

Baldwin, E. M., Beaulieu, J. D., Ramp, Len, Gray, J. J., Newton, V. C., Jr., and Mason, R. S., 1973, Geology and mineral resources of Coos County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 80, 82 p.

*Barnard, J. B., Page, N. J, Blakely, R. J., Ziemianski, W. P., Banister, C. A., and Giusso, J. R., 1981, Map showing distribution of serpentine minerals, density, and magnetic susceptibility of rocks from the Kalmiopsis Wilderness, southwestern Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1240-B, scale 1:62,500.

+Beaulieu, J. D., and Hughes, P. W., 1977, Land use geology of central Jackson County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 94, 87 p.

Bird, M. L., 1977, Electron-microprobe analyses of chromite and olivine from alpine ultramafic complexes: U.S. Geological Survey Open-File Report 77-236, 66 p., 4 figs.

Black, G. L., Blackwell, D. D., and Steele, J. L., 1982, Heat flow of the Oregon Cascades, in Priest, G. R., and Vogt, B. F., Geology and geothermal resources of the Cascades, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report 0-82-7, Ch. 7, p. 152-168.

Blackwell, D. D., Bowen, R. G., Hull, D. A., Riccio, Joseph, and Steele, J. L., 1982, Heat flow, arc volcanism, and subduction in northern Oregon: Journal of Geophysical Research, v. 87, no. B10, p. 8735-8754.

Blackwell, D. D., Hull, D. A., Bowen, R. G., and Steele, J. L., 1978, Heat flow of Oregon: Oregon Department of Geology and Mineral Industries Special Paper 4, 42 p.

*Blair, W. N., 1978, Radiolarians from Mesozoic rocks in western Oregon [abs.], in Geological Survey Research 1978: U.S. Geological Survey Professional Paper 1100, p. 78.

*Blair, W. N., Wong, Albert, Moring, B. C, Barnard, J. B., Page, N. J, and Gray, Floyd, 1981, Reconnaissance geologic map of parts of the Gold Hill, Ruch, Medford, and Talent 15-minute quadrangles, southwestern Oregon: U.S. Geological Survey Open-File Map 81-1076, scale 1:62,500.

Blakely, R. J., Jachens, R. C., Simpson, R. W., and Couch, R. W., 1985, Tectonic setting of the southern Cascade Range as interpreted from its magnetic and gravity fields: Geological Society of America Bulletin, v. 96, no. 1, p. 43-48.

Blank, H. R., Jr., 1966, General features of the Bouguer gravity field in southwestern Oregon, in Geological Survey Research 1966: U.S. Geological Survey Professional Paper 550-C, p. C113-C119.

_____1968, Aeromagnetic and gravity surveys of Crater Lake region, Oregon, in Dole, H. M., ed., Andesite Conference Guidebook: Oregon Department of Geology and Mineral Industries Bulletin 62, p. 42-51.

Botto, R. I., and Morrison, G. H., 1976, Josephinite; a unique nickel-iron mineral: American Journal of Science, v. 276, no. 3, p. 241-274.

+Brooks, H. C., 1963, Quicksilver in Oregon: Oregon Department of Geology and Mineral

Industries Bulletin 55, 223 p.
+Brooks, H. C., and Ramp, Len, 1968, Gold and silver in Oregon: Oregon Department of Geology and Mineral Industries Bulletin 61, 337 p.
Burchfiel, B. C., and Davis, G. A., 1972, Structural framework and evolution of the southern part of the Cordilleran orogen, western United States: American Journal of Science, v. 272, p. 97-118.
+Butler, G. M., and Mitchell, G. J., 1916, Preliminary survey of the geology and mineral resources of Curry County, Oregon: Oregon Bureau of Mines, Mineral Resources of Oregon no. 2, 134 p.
Callaghan, Eugene, and Buddington, A. F., 1933, Some features of the volcanic sequence in the Cascade Range in Oregon: American Geophysical Union Transactions, v. 141, p. 243-249.
+_____1938, Metalliferous mineral deposits of the Cascade Range in Oregon: U.S. Geological Survey Bulletin 893, 141 p.
*Carlson, C. A., Page, N. J, and Carlson, R. A., (in press), Map showing the distribution of platinum-group elements and gold in rocks from the western half of the Medford and part of the adjacent Coos Bay $1^{\circ} \times 2^{\circ}$ quadrangles, southwestern Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF- , scale 1:250,000.
*Carlson, C. A., Page, N. J, Grimes, D. J., and Leinz, R. W., 1982, Map showing geochemical characteristics of rock samples from the Kalmiopsis Wilderness, southwestern Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1240-C, scale 1:62,500.
+Carver, G. A., 1972, Glacial geology of the Mountain Lakes Wilderness and adjacent parts of the Cascade Range, Oregon: Seattle, University of Washington, Ph. D. dissertation, 72 p.
Coleman, R. G., 1967, Low-temperature reaction zones and alpine ultramafic rocks of California, Oregon, and Washington: U.S. Geological Survey Bulletin 1247, 49 p.
_____1972, The Colebrooke Schist of southwestern Oregon and its relation to the tectonic evolution of the region: U.S. Geological Survey Bulletin 1339, 61 p.
+Coleman, R. G., Garcia, Michael, and Anglin, Camille, 1976, The amphibolite of Briggs Creek: a tectonic slice of metamorphosed oceanic crust in southwestern Oregon? [abs.]: Geological Society of America Abstracts with Programs, v. 8, no. 3, p. 363.
Couch, R. W., Gemperle, Michael, McLain, W. H., Connrad, G. G., 1981, Total-field aeromagnetic anomaly map, Cascade Mountain Range, southern Oregon: Oregon Department of Geology and Mineral Industries Map Series GMS 17, scale 1:250,000.
Couch, R. W., Pitts, G. S., Veen, C. A., and Gemperle, Michael, 1981, Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon: Oregon Department of Geology and Mineral Industries Map Series GMS 16, scale 1:250,000.
Crandell, D. R., 1965, The glacial history of western Washington and Oregon, in Wright, H. E., and Frey, D. G., eds., The Quaternary of the United States: Princeton, N.J., Princeton University Press, p. 341-354.
+Cumberlidge, J. T., and Chace, F. M., 1968, Geology of the Nickel Mountain mine, Riddle, Oregon, in Ore deposits of the United States, 1933-1967 (Graton-Sales Volume), v. 2: New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, p. 1650-1672.
+Derkey, R. E., 1981, The Silver Peak volcanogenic massive sulfide, northern Klamath Mountains, Oregon, in Silberman, M. L., Field, C. W., and Berry, A. L., eds., Proceedings of the symposium on mineral deposits of the Pacific Northwest: Geological Society of America, Cordilleran Section, Annual Meeting, Corvallis, Oreg., 1980: U.S. Geological Survey Open-File Report 81-355, p. 213-222.
+Dick, H. J. B., 1976, The origin and emplacement of the Josephine Peridotite of southwestern Oregon: New Haven, Conn., Yale University, Ph. D. dissertation, 445 p. (Dissertation Abstracts International, v. 37, no. 7, p. 3311B, 1977).
_____1977, Partial melting in the Josephine Peridotite; 1, The effect on mineral composition and its consequence for geobarometry and geothermometry: American Journal of Science, v. 277, no. 7, p. 801-832.
_____1977 Evidence of partial melting in the Josephine Peridotite [abs.], in Magma genesis 1977; Proceedings of the American Geophysical Union Chapman conference on partial melting in the Earth's upper mantle: Oregon Department of Geology and Mineral Industries Bulletin, no. 96, p. 59-62.
Dick, H. J. B., and Gillete, H., 1976, Josephinite specimens from the Earth's core?: Earth and Planetary Science Letters, v. 31, no. 2, p. 308-311.
Dickinson, W. R., and Vigrass, L. W., 1964, Pre-Cenozoic history of the Suplee-Izee district, Oregon: Implications for geosynclinal theory: Geological Society of America Bulletin, v. 75, p. 1037-1044.
+Diller, J. S., 1902, Topographic development of the Klamath Mountains: U.S. Geological Survey Bulletin 196, 69 p.
+_____1914, Mineral resources of southwestern Oregon: U.S. Geological Survey Bulletin 546,

147 p.
+Diller, J. S., and Kay, G. F., 1908, Mines of the Riddle quadrangle, Oregon: U.S. Geological Survey Bulletin 340-A, p. 134-152.
+____1909, Mineral resources of the Grants Pass quadrangle and bordering districts, Oregon: U.S. Geological Survey Bulletin 380-A, p. 48-79.
+______1924, Riddle quadrangle, Oregon: U.S. Geological Survey Geologic Atlas of the United States, no. 218, 8 p., 3 maps.
+Diller, J. S., and Patton, H. B., 1902, The geology and petrography of Crater Lake National Park: U.S. Geological Survey Professional Paper 3, 167 p.
Dole, H. M., ed., 1968, Andesite conference guidebook—International upper mantle project science report 16-s: Oregon Department of Geology and Mineral Industries Bulletin 62, 107 p.
+Donato, M. M., Coleman, R. G., and Kays, M. A., 1980, Geology of the Condrey Mountains schist, northern Klamath Mountains, California and Oregon: Oregon Geology, v. 42, no. 7, p. 125-129.
Dott, R. H., Jr., 1971, Geology of the southwestern Oregon coast west of the 124th Meridian: Oregon Department of Geology and Mineral Industries Bulletin 69, 63 p.
+Elliott, M. A., 1971, Stratigraphy and petrology of the Late Cretaceous rocks near Hilt and Hornbrook, Siskiyou County, California, and Jackson County, Oregon: Corvallis, Oregon State University, Ph. D. dissertation, 171 p.
Fieblekorn, R. B., Walker, G. W., MacLeod, N. S., McKee, E. H., and Smith, J. G., 1983, Index to K-Ar age determinations for the state of Oregon: Isochron/West, no. 37, p. 3-60.
+Garcia, M. O., 1976a, Rogue River Island arc complex, western Jurassic belt, Klamath Mountains, Oregon, [abs.]: Geological Society of America Abstract, v. 8, no. 3, p. 375.
+____1976b, Petrology of the Rogue River area, Klamath Mountains, Oregon: Problems in the identification of ancient volcanic arcs: Los Angeles, University of California, Ph. D. dissertation 185 p.
______1979, Petrology of the Rogue and Galice Formations, Klamath Mountains, Oregon: Identification of a Jurassic island arc sequence: Journal of Geology, v. 87, no. 1, p. 29-41.
*Gray, Floyd, 1980a, Geology of the igneous complex at Tincup Peak, Kalmiopsis Wilderness area, southwestern Oregon: U.S. Geological Survey Open-File Report 80-1243, 77 p., scale 1:12,000.
*___1980b, Lherzolitic and wehrlitic rock series at Tincup Peak, Klamath Mountains, southwestern Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 12, no. 3, p. 108.
+*_____1982, Geology of the igneous complex at Tincup Peak, Kalmiopsis Wilderness Area, southwestern Oregon: Amherst, University of Massachusetts, M.S. thesis, 135 p.
*Gray, Floyd, and McKee, E. H., 1981, New K-Ar dates from the Wild Rogue Wilderness, southwestern Oregon: Isochron/West, no. 32, p. 27-29.
*Gray, Floyd, and Miller, M. S., 1983, Wild Rogue Wilderness, Oregon, in Marsh, S. P., Kropschott, S. J., and Dickinson, R. G., Wilderness Mineral Potential: Assessment of mineral-resource potential in U.S. Forest Service Lands studied 1964-1984: U.S. Geological Survey Professional Paper 1300, v. 2, p. 914-916.
+*Gray, Floyd, Miller, M. S., Gaps, R. S., Peterson, J. A., Blakely, R. J., and Senior, Lisa, 1982, Mineral resource potential map of the Wild Rogue Wilderness, Coos and Curry Counties, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1381-D, scale 1:48,000.
*Gray, Floyd, and Peterson, J. A., 1982, Geochemical analyses of rock and stream-sediment samples from the Wild Rogue Wilderness Area, Coos, Curry, and Douglas Counties, Oregon: U.S. Geological Survey Open-File Report 82-186, scale 1:48,000, 24 p.
*Gray, Floyd, Ramp, Len, Moring, B. C., Douglas, Ian, Donahoe, J. L., 1981, Geologic map of the Wild Rogue Wilderness, Coos, Curry, and Douglas Counties, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1381-A, scale 1:48,000.
Hammond, P. E., 1983, Volcanic formations along the Klamath river near Copco Lake: California Geology, v. 36, no. 5, p. 99-109.
+Harper, G. D., 1980a, The Josephine ophiolite—remains of a Late Jurassic marginal basin in northwestern California: Geology, v. 8, no. 7, p. 333-337.
+____1980b, Structure and petrology of the Josephine Ophiolite and overlying metasedimentary rocks, northwestern California: Berkeley, University of California, Ph. D. dissertation, 281 p.
Hotz, P. E., 1971a, Plutonic rocks of the Klamath Mountains, California and Oregon: U.S. Geological Survey Professional Paper 684-B, 20 p.
+_____1971b, Geology of lode gold districts in the Klamath Mountains, California and Oregon: U.S. Geological Survey Bulletin 1290, 91 p.
+Hundhausen, R. J., 1952, Investigation of Shamrock copper-nickel mine, Jackson County, Oregon: U.S. Bureau of Mines Report of Investigations 4895, 12 p.
Imlay, R. W., Dole, H. M., Wells, F. G., and Peck, Dallas, 1959, Relations of certain Upper

Jurassic and Lower Cretaceous formations in southwestern Oregon: American Association of Petroleum Geologists Bulletin, v. 43, no. 12, p. 2770-2785.

Irwin, W. P., 1964, Late Mesozoic orogenies in the ultramafic belts of northwestern California and southwestern Oregon, in Geological Survey Research 1964: U.S. Geological Survey Professional Paper 501-C, p. C1-C9.

______1973, Sequential minimum ages of oceanic crust in accreted tectonic plates of Northern California and Southern Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 5, no. 1, p. 62-63.

+______1977, Ophiolitic terranes of California, Oregon, and Nevada, in Coleman, R. C., and Irwin, W. P., eds., North American Ophiolites: Oregon Department of Geology and Mineral Industries Bulletin 95, p. 75-92.

+______1979, Ophiolitic terranes of part of the western United States: Geological Society of America Map and Chart Series MC-33, p. 2-4, scale 1:2,500,000.

Irwin, W. P., and Galanas, S. P., Jr., 1976, Map showing limestone and selected fossil localities in the Klamath Mountains Province, California and Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-749, scale 1:500,000.

Irwin, W. P., Jones, D. L., and Kaplan, T. A., 1978, Radiolarians from pre-Nevadan rocks of the Klamath Mountains, California and Oregon, in Howell, D. G., and others, eds., Mesozoic paleogeography of the western United States: Pacific Coast Paleogeographical Symposium, no. 2, p. 303-310.

*Johnson, M. G., 1977, Mesozoic metavolcanic sequences in the northern Klamath Mountains, southwestern Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 9, no. 7, p. 1251-1252.

*______1980, Geochemical variations within an ancient island arc, southwestern Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 12, no. 3, p. 113.

*Johnson, M. G., and Page, N. J, 1979, Preliminary geologic map of the metavolcanic and associated rocks in parts of the Canyonville, Days Creek, and Glendale quadrangles, Oregon: U.S. Geological Survey Open-File Report 79-283, scale 1:62,500.

+Jones, D. L., 1960, Lower Cretaceous (Albian) fossils from southwestern Oregon and their paleogeographic significance: Journal of Paleontology, v. 34, no. 1, p. 152-160.

+Jones, D. L., and Imlay, R. W., 1973, Structure of upper Jurassic and Lower Cretaceous rocks in the Riddle area, southwestern Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 5, no. 1 p. 64.

+Jorgenson, D. B., 1970, Petrology and origin of the Illinois River gabbro, a part of the Josephine peridotite-gabbro complex (Upper Jurassic), Klamath Mountains, southwestern Oregon: Santa Barbara, University of California, Ph. D. dissertation, 226 p.

+Kays, M. A., 1970, Mesozoic metamorphism, May Creek Schist belt, Klamath Mountains, Oregon: Geological Society of America Bulletin, v. 81, no. 9, p. 2743-2758.

Kays, M. A., and Bruemmer, J. L., 1964, Gravity field over zones of major tectonism, southwest Oregon: Ore Bin, v. 26, no. 3, p. 43-52.

+Koski, R. A., 1981, Volcanogenic massive sulfide deposits in ocean-crust and island-arc terranes, northwestern Klamath Mountains, Oregon and California, in Silberman, M. L., Field, C. W., and Berry, A. L., eds., Proceedings of the Symposium on Mineral Deposits of the Pacific Northwest, Geological Society of America Cordilleran Section Meeting, Corvallis Oregon, 1980: U.S. Geological Survey Open-File Report 81-355, p. 197-212.

Koski, R. A., and Derkey, R. E., 1981, Massive sulfide deposits in ocean-crust and island-arc terranes of southwestern Oregon: Oregon Geology, v. 43, no. 9, p. 119-125.

Leavell, D. N., 1979, The geology and distribution of Josephinite in the Josephine Peridotite, southwest Oregon [abs.]: Eos (American Geophysical Union, Transactions), v. 60, no. 46, p. 970.

Leavell, D. N., and Haggerty, S. E., 1978, Metallic mineralogy of serpentinites; implications for deep crustal magnetic anomalies [abs.]: Eos (American Geophysical Union, Transactions), v. 59, no. 4, p. 398.

Leaver, D. S., Mooney, W. D., and Kohler, W. M., 1984, A seismic refraction study of the Oregon Cascades: Journal of Geophysical Research, v. 89, no. 85 p. 3121-3134.

+Loney, R. A., and Himmelberg, G. R., 1976, Structure of the Vulcan Peak alpine-type peridotite, southwestern Oregon: Geological Society of America, v. 87, no. 2, p. 259-274.

+Lovell, J. P. B., 1969, Tyee Formation—undeformed turbidites and their lateral equivalents: Mineralogy and paleogeography: Geological Society of America Bulletin, v. 80, no. 1, p. 9-22.

+Lowell, W. R., 1942, The paragenesis of some gold and copper ores of southwestern Oregon: Economic Geology, v. 37, no. 7, p. 557-595.

+Magill, J. R., and Cox, Allan, 1980, Tectonic rotation of the Oregon Western Cascades: Oregon Department of Geology and Mineral Industries Special Paper 10, 67 p.

Mason, R. S., and Erwin, M. I., 1955, Coal resources of Oregon: U.S. Geological Survey Circular 362, 7 p.

+Maynard, L. C., 1974, Geology of Mount McLoughlin: Eugene, University of Oregon,

M.S. dissertation, 139 p.
Mehringer, P. J., Blinman, Eric, and Peterson, K. L., 1977, Pollen influx and volcanic ash: Science, v. 198, p. 257-261.
+Miles, G. A., 1977, Planktonic foraminifera of the lower Tertiary Roseburg, Lookingglass, and Flournoy Formations, southwestern Oregon: Eugene, University of Oregon, Ph. D. dissertation, 359 p.
*Moring, Barry, 1983, Reconnaissance surficial geologic map of the Medford 1^o by 2^o quadrangle, Oregon-California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1528, scale 1:125,000.
+Naslund, H. R., 1977, The geology of the Hyatt Reservoir and Surveyor Mountain quadrangles, Oregon: Eugene, University of Oregon, M.S. thesis, 126 p.
Newton, V. C., Jr., 1969, Oil shale, in Mineral and water resources of Oregon: Oregon Department of Geology and Mineral Industries Bulletin 64, p. 278-280.
+Nilsen, T. H., 1984, Tectonics and sedimentation of the upper Cretaceous Hornbrook Formation, Oregon and California: in Crouch, J. K., and Backman, S. B., eds., Tectonics and sedimentation along the California Margin: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 38, p. 101-118.
Noble, D. C., Drake, J. C., and Whallon, M. K., 1969, Some preliminary observations on compositional variations within the pumice- and scoria-flow deposits of Mount Mazama, in Dole, H. M., ed., Andesite conference guidebook: Oregon Department of Geology and Mineral Industries Bulletin 62, p. 157-164.
Noble, D. C., and Korringa, M. K., 1974, Strontium, rubidium, potassium, and calcium variations in Quaternary lavas, Crater Lake, Oregon, and their residual glasses: Geology, v. 2, no. 4, p. 187-190.
+Oregon Department of Geology and Mineral Industries, 1940, Oregon metal mines handbook (southwestern Oregon—Coos, Curry, and Douglas Counties): Oregon Department of Geology and Mineral Industries Bulletin 14-C, v. 1, 133 p.
+____1942, Oregon metal mines handbook (southwestern Oregon—Josephine County): Oregon Department of Geology and Mineral Industries Bulletin 14-C, v. 2, sec. 1, 229 p.
+____1943, Oregon metal mines handbook (southwestern Oregon—Jackson County): Oregon Department of Geology and Mineral Industries Bulletin 14-C, v. 2, sec. 2, 208 p.
____1952, Oregon metal mines handbook—Josephine County, 2nd ed.: Oregon Department of Geology and Mineral Industries Bulletin, no. 14-C, v. 2, sec. 1, 238 p.
____1953, The Nickel Mountain project: Ore Bin, v. 15, no. 10, p. 59-65.
____1954, Oregon's gold placers: Oregon Department of Geology and Mineral Industries Miscellaneous Paper, no. 5, 14 p.
____1969, Mineral and water resources of Oregon: Oregon Department of Geology and Mineral Industries Bulletin 64, published in cooperation with the U.S. Geological Survey, 278 p.
Oregon Department of Geology and Mineral Industries and National Oceanic and Atmospheric Administration, 1982, Geothermal resources of Oregon: Oregon Department of Geology and Mineral Industries map, scale 1:500,000.
*Page, N. J, Blair, W.N., Gray, Floyd, Cannon, J. K., Grimes, D. J., and Leinz, R. W., 1977, Preliminary reconnaissance geologic map of the Wimer quadrangle, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-848, scale 1:62,500.
+*Page, N. J, Carlson, R. R., Miller, M. S., Gray, Floyd, and Carlson, C. A., 1985, Maps showing geochemical characteristics of platinum-group elements and gold in rock samples from the Kalmiopsis Wilderness, southwestern Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1240-F, scale 1:62,500.
*Page, N. J, Gray, Floyd, Cannon, J. K., Foose, M. P., Lipin, Bruce, Moring B. C., Nicholson, S. W., Sawlan, M. G., Till, Alison, and Ziemianski, W. P., 1981, Geologic map of the Kalmiopsis Wilderness area, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1240-A, scale 1:62,500.
*Page, N. J, and Johnson, M. G., 1977, Chromite resources of the podiform chromite deposits and exploration for concealed chromite deposits in the Medford-Coos Bay quadrangles, southwestern Oregon: U.S. Geological Survey Open-File Report 77-656, 14 p.
*Page, N. J, Johnson, M. G., Haffty, Joseph, and Ramp, Len, 1975, Occurrence of platinum group metals in ultramafic rocks of the Medford-Coos Bay 2^o quadrangles, southwestern Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-694, scale 1:250,000.
*Page, N. J, Johnson, M. G., Moring, Barry, Gray, Floyd, and Cannon, J. K., 1978, Preliminary reconnaissance geologic map of the Glendale quadrangle, Oregon: U.S. Geological Survey Open-File Report OF-78-518, scale 1:62,500.
*Page, N. J, and Miller, M. S., 1983, Kalmiopsis Wilderness, Oregon, in Marsh, S. P., Kropschot, S. J., and Dickinson, R. G., Wilderness mineral potential: Assessment of mineral-resource potential in U.S. Forest Service Lands studied 1964-1984: U.S. Geological Survey Professional Paper 1300, p. 882-884.

*Page, N. J, Miller, M. S., Grimes, D. J., Leinz, R. W., Blakely, R. J., Lipin, B. R., Foose, M. P., and Gray, Floyd, 1982, Mineral resource potential map of the Kalmiopsis Wilderness, southwestern Oregon, with text by N. J Page and M. S. Miller: U.S. Geological Survey Miscellaneous Field Studies Map MF-1240-E, scale 1:62,500.

*Page, N. J, Moring, Barry, Gray, Floyd, Cannon, J. C., and Blair, W. N., 1981, Reconnaissance geologic map of the Selma quadrangle, Josephine County, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1349, scale 1:62,500.

+Parks, H. M., and Swartley, A. M., 1916, Handbook of the mining industry of Oregon: Oregon Bureau of Mines and Geology, Mineral Resources of Oregon, v. 2, no. 4, 306 p.

+Peck, D. L., Griggs, A. B., Schlicher, H. G., Wells, F. G., and Dole, H. M., 1964, Geology of the central and northern parts of the western Cascade Range, Oregon: U.S. Geological Survey Professional Paper 449, 56 p.

Peck, D. L., Imlay, R. W., and Popenoe, W. P., 1956, Upper Cretaceous rocks of parts of southwestern Oregon and northern California: American Association of Petroleum Geologists Bulletin, v. 40, no. 8, p. 1968-1984.

+Pecora, W. T., and Hobbs, S. W., 1942, Nickel deposit near Riddle, Douglas County, Oregon: U.S. Geological Survey Bulletin 931-E, p. 205-226.

Peterman, Z. E., Coleman, R. G., and Bunker, C. M., 1981, Provenance of Eocene graywackes of the Flournoy Formation near Agness, Oregon—A geochemical approach: Geology, v. 9, no. 2, p. 81-86.

*Peterson, J. A., and Gray, Floyd, 1982, Geochemical map and rock and stream-sediment data from the Wild Rogue Wilderness, Coos and Curry Counties, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1381-B, scale 1:48,000.

+Ramp, Len, 1961, Chromite in southwestern Oregon: Oregon Department of Geology and Mineral Industries Bulletin 52, 169 p.

+______1972, Geology and mineral resources of Douglas County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 75, 106 p.

______1975, Geology and mineral resources of the upper Chetco drainage area, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 88, 47 p.

+______1978, Investigations of nickel in Oregon: Oregon Department of Geology and Mineral Industries Miscellaneous Paper 20, 68 p.

Ramp, Len, and Brooks, H. C., 1969, Platinum group metals, in Mineral and water resources of Oregon: U.S. 90th Congress, 2d sess., Senate Committee Interior and Insular Affairs, Committee Print, p. 167-171.

*Ramp, Len, and Gray, Floyd, 1980, Sheeted dikes of the Wild Rogue Wilderness, Oregon: Oregon Geology, v. 42, no. 7, p. 119-124.

+Ramp, Len, and Peterson, N. V., 1979, Geology and mineral resources of Josephine County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 100, 45 p.

Riccio, J. F., 1982, Geothermal resources of Oregon: National Oceanic and Atmospheric Administration, scale 1:500,000.

+Shenon, P. J., 1933a, Geology and ore deposits of the Takilma-Waldo district, Oregon, including the Blue Creek district: U.S. Geological Survey Bulletin 846-B, p. 141-194.

+______1933b, Copper deposits in the Squaw Creek and Silver Peak districts and at the Almeda mine, southwestern Oregon, with notes on the Pennell and Farmer and Banfield prospects: U.S. Geological Survey Circular 2, 35 p.

+______1933c, Geology of the Robertson, Humdinger, and Robert E. gold mines, southwestern Oregon: U.S. Geological Survey Bulletin 830-B, p. 33-55.

+Simpson, R.W., Jachens, R. C., and Blakely, R. J. 1983, AIRYROOT A Fortran program for calculating the gravitational attraction of an Airy isostatic root out to 166.7 km: U.S. Geological Survey Open-File Report OF 83-883.

*Smith, J. G., 1977, K-Ar geochronology and stratigraphy of the Roxy, Wasson, and Heppsie Formation, southern Oregon [abs.]: Eos (American Geophysical Union, Transactions), v. 58, no. 12, p. 1247.

*______1979, Cenozoic volcanism in the Cascade Range, Medford 2° sheet, southern Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 11, no. 3, p. 128.

+*______1983, Geologic map of the Sky Lakes Roadless Area and Mountain Lakes Wilderness, Jackson and Klamath Counties, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1507A, scale 1:62,500.

*Smith, J. G., and Benham, J. R., 1983a, Sky Lakes Roadless Area and the Mountain Lakes Wilderness, Oregon, in Marsh, S. P., Kropschot, S. J., and Dickinson, R. G., Wilderness mineral potential: Assessment of mineral resource potential in U.S. Forest Service Lands studied in 1964-1984: U.S. Geological Survey Professional Paper 1300, p. 905-907.

+*______1983b, Mineral resource potential map of the Sky Lakes Roadless Area and Mountains Lakes Wilderness, Jackson and Klamath Counties, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1507B, scale 1:62,500.

*Smith, J. G., and Page, N. J, 1977, Preliminary reconnaissance geologic map of part of Jackson County, Oregon: U.S. Geological Survey Open-File Report 77-318, scale 1:250,000.

*Smith, J. G., Page, N. J, Johnson, M. G., Moring, B. C., and Gray, Floyd, 1982, Preliminary geologic map of the Medford 1° by 2° quadrangle, Oregon and California: U.S. Geological Survey Open-File Report 82-955, scale 1:250,000.

*Smith, J. G., Sawlan, M. S., and Katcher, A. C., 1980, An important lower Oligocene welded-tuff marker bed in the Western Cascade Range of southern Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 12, p. 153.

Taliaferro, N. L., 1942, Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geological Society of America Bulletin, v. 53, no. 1, p. 71-112.

+Thoms, R. E., 1975, Biostratigraphy of the Umpqua Group, southwestern Oregon, in Weaver, D. E., Harnaday, G. R., and Tiptin, Ann, eds., Paleogene Symposium and selected technical papers: American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, Society of Economic Geologists, Annual Meeting, Long Beach, Calif., p. 513-562.

+Vail, S. G., 1977, Geology and geochemistry of the Oregon Mountain area, southwestern Oregon and northern California: Corvallis, Oregon State University, Ph.D. dissertation, 183 p.

Vail, S. G., and Dasch, E. J., 1977, Jurassic ophiolitic rocks in the Klamath Mountains, southwest Oregon and implications for pre-Nevadan paleogeography [abs.]: Geological Society of America Abstracts with Programs, v. 9, no. 4, p. 519-520.

Wagner, H. C., Newton, V. C., Jr., 1969, Petroleum and natural gas, in Mineral and water resources of Oregon: Oregon Department of Geology and Mineral Industries Bulletin 64, p. 280-298.

+Wells, F. G., 1940, Preliminary geologic map of the Grants Pass quadrangle: Oregon Department of Geology and Mineral Industries, scale 1:96,000.

+_____ 1956, Geology of the Medford quadrangle, Oregon-California: U.S. Geological Survey Geologic Quadrangle Map GQ-89, scale 1:96,000.

_____ 1956, Preliminary geologic map of southwestern Oregon west of meridian 122° W. and south of parallel 43° N.: U.S. Geological Survey Mineral Investigations Field Studies Map MF-38, scale 1:250,000.

+Wells, F. G., Hotz, P. E., and Cater, F. W., 1949, Preliminary description of the geology of the Kerby quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 40, 23 p.

+Wells, F. G., Page, L. R., and James, H. L., 1940, Chromite deposits in the Sourdough area, Curry County, and Briggs Creek area, Josephine County, Oregon: U.S. Geological Survey Bulletin 922-P, p. 461-496.

Wells, F. G., and Peck, D. L., 1961, Geologic map of Oregon west of the 121st meridian: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-325, scale 1:500,000.

+Wells, F. G., and Walker, G. W., 1953, Geologic map of the Galice quadrangle, Oregon: U.S. Geological Survey Geologic Quadrangle Map GQ-25, scale 1:62,500.

+*Whittington, C. L., Grimes, D. J., and Peterson, J. A., 1983, Spectrographic and chemical analyses of rock and soil samples from the Medford 1° by 2° quadrangle, Oregon-California: U.S. Geological Survey Open-File Report 83-344, scale 1:250,000.

+*Whittington, C. L., Leinz, R. W., and Speckman, W. S., 1983, Analytical results of stream-sediment samples from the Medford 1° by 2° quadrangle, Oregon-California: U.S. Geological Survey Open-File Report 83-349, 142 p., scale 1:250,000.

Wilkinson, W. D., 1941, Reconnaissance geologic map of the Butte Falls quadrangle, Oregon: Oregon Department of Geology and Mineral Industries, scale 1:62,500.

+Williams, Howel, 1942, The geology of Crater Lake National park, Oregon, with a reconnaissance of the Cascade Range southward to Mount Shasta: Carnegie Institute of Washington Publication 540, 162 p.

+Winchell, A. N., 1914, Petrology and mineral resources of Jackson and Josephine Counties, Oregon: Oregon Bureau of Mines and Geology, Mineral Resources of Oregon, v. 1, no. 5, 265 p.

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