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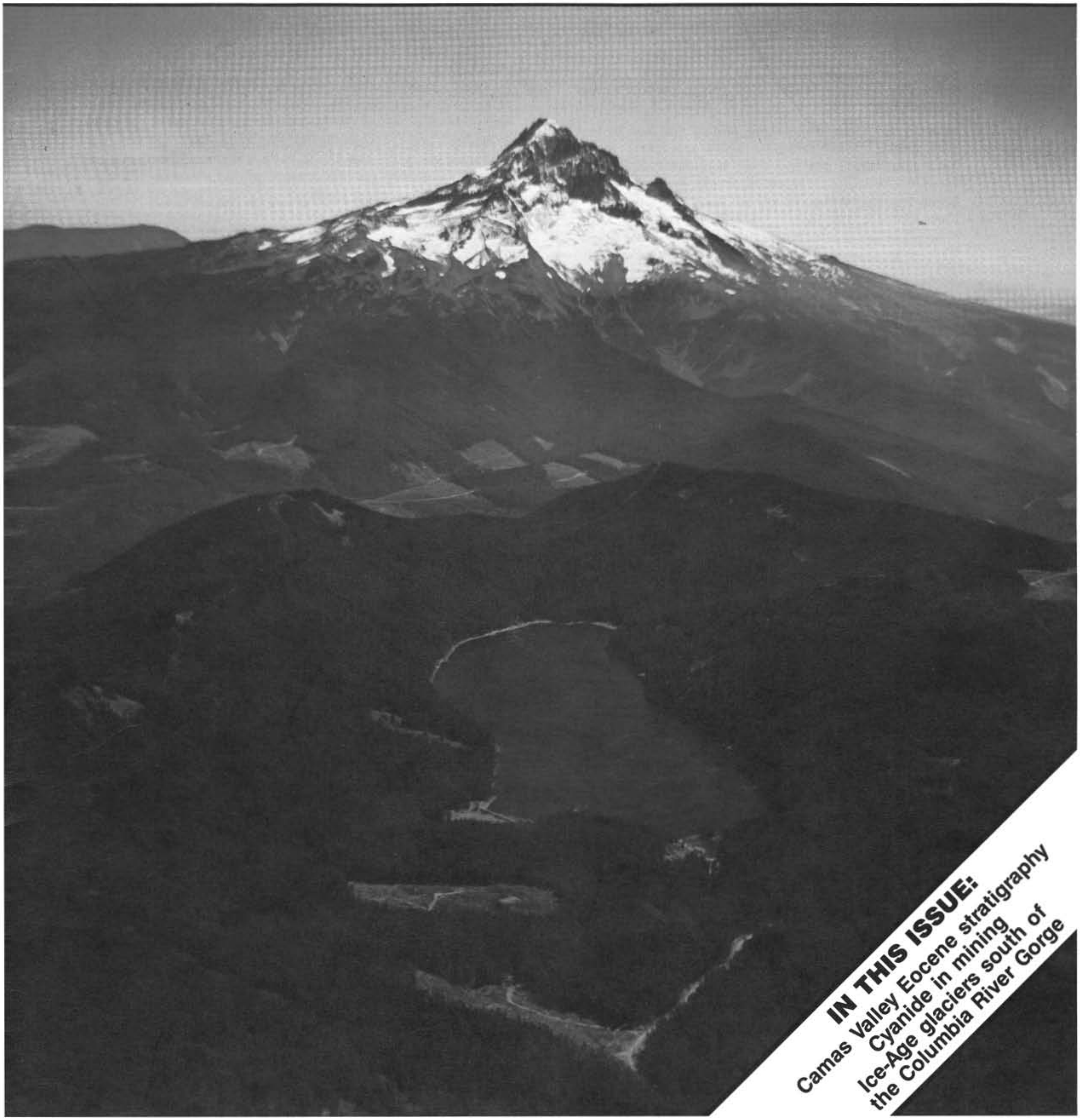

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The style to be followed is generally that of U.S. Geological Survey publications (see the USGS manual *Suggestions to Authors*, 6th ed., 1978). The bibliography should be limited to "References Cited." Authors are responsible for the accuracy of the bibligraphic references. Names of reviewers should be included in the "Acknowledgments."

Authors will receive 20 complimentary copies of the issue containing their contribution. Manuscripts, news, notices, and meeting announcements should be sent to Beverly F. Vogt, Publications Manager, at the Portland office of DOGAMI.

COVER PHOTO

Bull Run Lake, in the Bull Run watershed, major water supply for the City of Portland, is located northwest of Mount Hood in Clackamas County. It is one of the geomorphic features of the area that were at least partially formed by glaciers covering the mountain during the Pleistocene (Ice Age). Article beginning on page 12 discusses evidence of past glaciers and lakes south of the Columbia River Gorge.

OIL AND GAS NEWS

ARCO finishes 1988 drilling program at Mist

ARCO has completed a successful drilling program at Mist Gas Field, Columbia County. Of the twelve wells drilled to the productive Clark and Wilson sandstone during 1988, seven were completed as producers and five were dry holes. The successful gas wells are the CFI 34-1-55, CFW 12-15-64, CC 12-19-65, CC 24-9-64, CC 42-8-54, CC 44-27-65, and the LF 32-20-65R-RD1. The dry holes are the Benson 14-7-64, CFI 23-16-64, Johnston 44-19-65, LF 24-8-75 and RD1, and the Sterling 12-24-66 and RD1. No rates for the completed gas producers have been released.

Of particular significance is the fact that the locations of several of the gas producers extend the productive area of the Mist Gas Field. The CFW 12-15-64 and CC 24-9-64 are the easternmost gas wells in the field, and extend production 4 mi to the east of any previous producing gas wells. The CC 12-19-65 is the westernmost well in the field, extending gas production to within a quarter of a mile of the border to Clatsop County.

Clatsop County wildcat wells permitted

ARCO has received permits to drill in Clatsop County, about 12 mi northwest of Mist Gas Field. The permits are for the OR 13-33-86 and OR 21-33-86 wells located in T. 8 N., R. 6 W., and the wells are proposed for a 6,000-ft total depth. Wells drilled previously in this general area have had gas shows, but so far none have been completed as producers.

NWPA schedules field symposium

The Northwest Petroleum Association will hold its 1989 annual spring field symposium in Spokane, Washington, May 18-19, 1989. The symposium will concentrate on the geology of the Columbia River Basin, Washington. For details, contact Phil Brogan (503-382-0560), or Barbara Portwood (503-287-2762), or write the NWPA, P.O. Box 6679, Portland, OR 97228-6679.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
418	ARCO OR 21-33-86 36-007-00020	NW¼ sec. 33 T. 8 N., R. 6 W. Clatsop County	Location; 6,000.
419	ARCO OR 13-33-86 36-007-00021	SW¼ sec. 33 T. 8 N., R. 6 W. Clatsop County	Location; 6,000.

CONTENTS

Eocene unconformities in the Camas Valley quadrangle, Oregon

by Ewart M. Baldwin, Department of Geological Sciences, University of Oregon, Eugene, Oregon 97403, and Rauno K. Perttu, CMA, Inc., 2816 Upper Applegate Road, Jacksonville, Oregon 97530

The Oregon Department of Geology and Mineral Industries is initiating a jointly funded, cooperative investigation of the natural-gas potential of the southern Coast Range. Recognition of appropriate stratigraphic interpretations and depositional models for various parts of the study area constitutes a critical dimension of the investigation. The publication of this interpretation of the Eocene stratigraphy of the Camas Valley quadrangle is a valuable contribution to this effort. *—Editor*

ABSTRACT

Near the end of the early Eocene, a thick section of Paleocene and lower Eocene oceanic basalt of the lower Roseburg Formation and a thick section of flyschlike sandstone and siltstone of the upper Roseburg Formation were shoved against the southern Oregon continental mass. During emplacement, the lower Tertiary section moved in what now is seen as an eastward direction along the Canyonville fault zone relative to the Klamath Mesozoic rocks to the south. Clockwise rotation must be considered in reconstructing original motions.

Accompanying uplift and erosion of the deformed Roseburg and Mesozoic rocks was the unconformable deposition of a blanket of conglomeratic rock from the denuded Klamath terrane upon truncated Roseburg strata. Deposition of this unit, the Bushnell Rock Member of the Lookingglass Formation, which is notably thicker nearer to the Klamath mass and which thins noticeably north of the Canyonville fault zone, was followed by deposition of the thinner sandstone and siltstone of the Tenmile Member, which, in turn, was followed by deposition of the coarser, offlapping Olalla Creek Member. Mild deformation followed as the Lookingglass Formation was eroded from the top of the Porter Creek anticline, and then the onlapping seas deposited the basal sandstone of the White Tail Ridge Member of the Flournoy Formation, which trends southward through Camas Mountain and around the south end of Camas Valley. The thinner bedded siltstone of the Camas Valley Member of the Flournoy Formation underlies the broader portions of Flournoy and Camas Valleys.

The Tyee Formation, a massively bedded, thick sandstone unit, was deposited in the center of the Coast Range following regional warping and rests on all the older Tertiary units. The Tyee Formation is the oldest Tertiary unit to cover the Canyonville fault zone without noticeable offset.

The Paleogene section may be separated into mappable units by unconformities caused by recurring periods of deformation.

INTRODUCTION

The Eocene stratigraphy of the Camas Valley quadrangle (Figure 1) and nearby parts of Oregon was initially described by Diller (1898). Baldwin (1974) subdivided Diller's Umpqua Formation into the Roseburg, Lookingglass, and Flournoy Formations and mapped their regional distribution. The Tyee Formation remained the same as described by Diller, but younger formations to the north were described and named the Elkton Siltstone and the Bateman Formation. Nearly all of the formations formerly in the Umpqua Formation have been divided by Baldwin into members, many of them named for features within the Camas Valley quadrangle. Detailed mapping of these members by Baldwin was critical to determining the structural relationships and boundaries of the geologic formations in the region. The map in this paper (Figure 2) is the first published map showing the areal extent and distribution of the individual members.

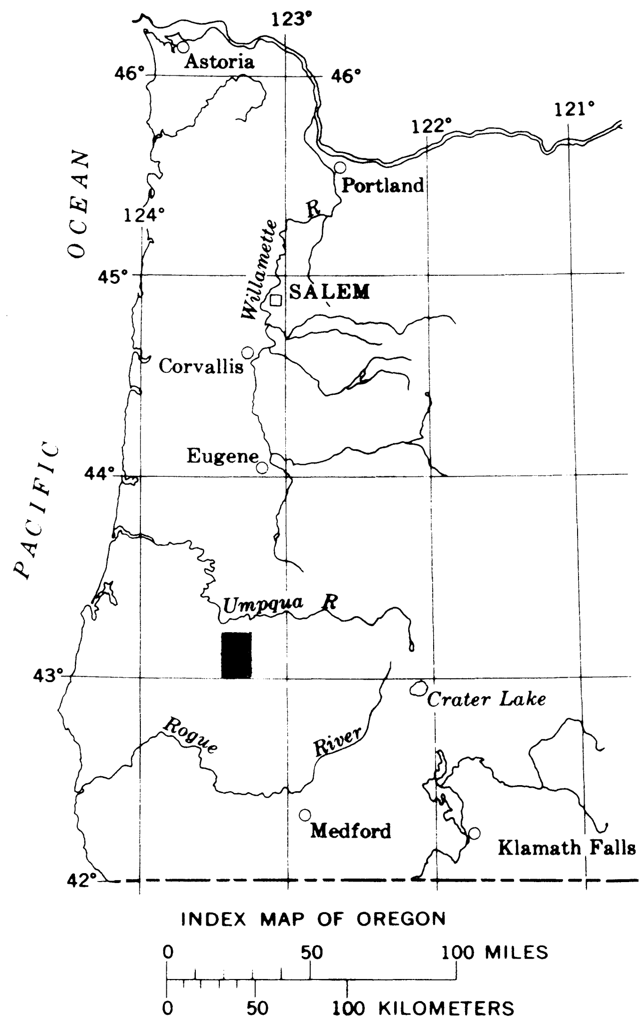

Figure 1. Location of Camas Valley quadrangle, Oregon.

Baldwin's study of the Camas Valley quadrangle (Figure 1) began with supervision of graduate studies by N.V. Peterson (1957), who mapped the southeast third of the quadrangle. Baldwin later conducted geologic mapping in the central part of the Oregon Coast Range for the U.S. Geological Survey (USGS), under the supervision of P.D. Snavely, Jr., and extended this mapping into the Camas

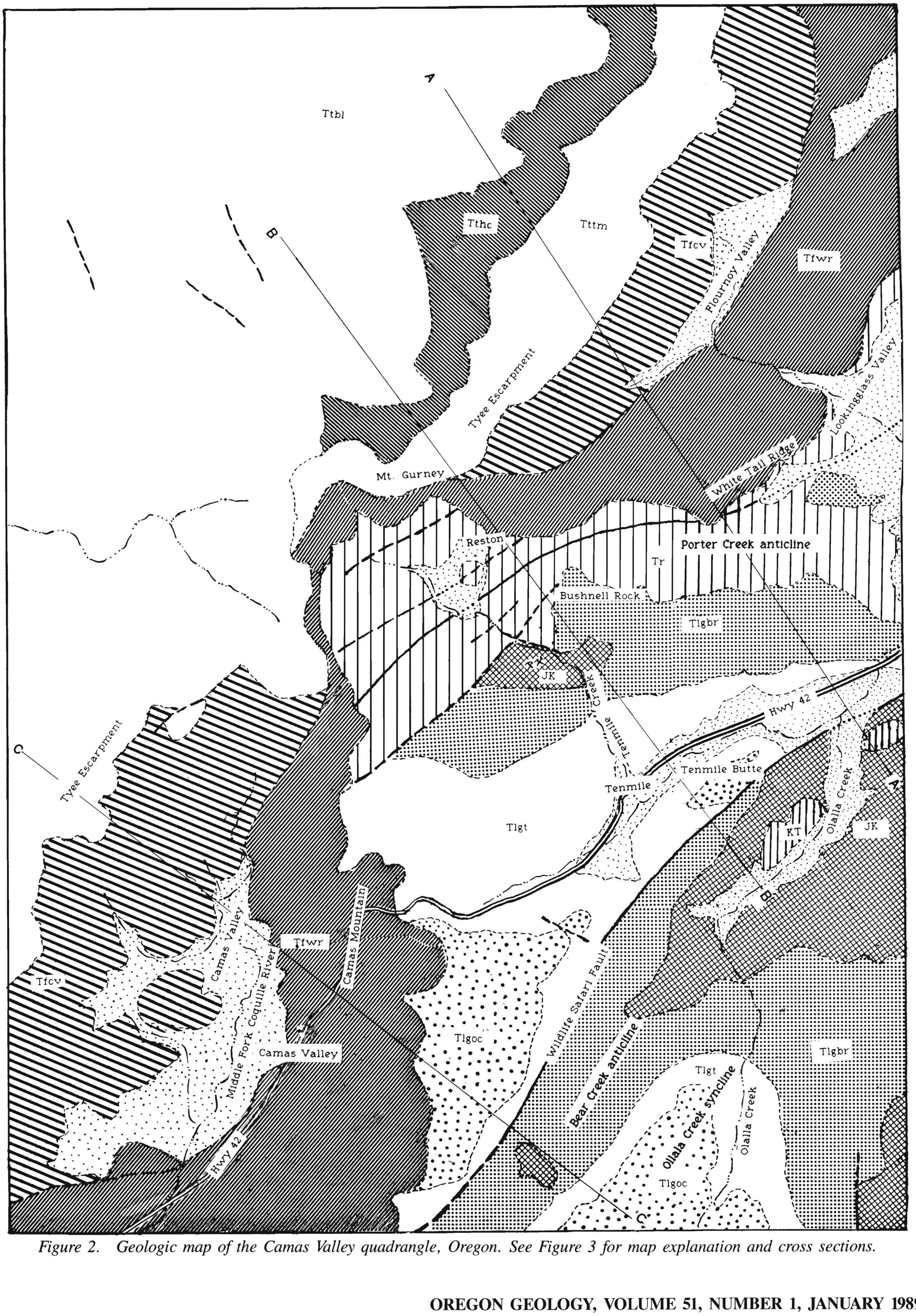

Figure 2. Geologic map of the Camas Valley quadrangle, Oregon. See Figure 3 for map explanation and cross sections.

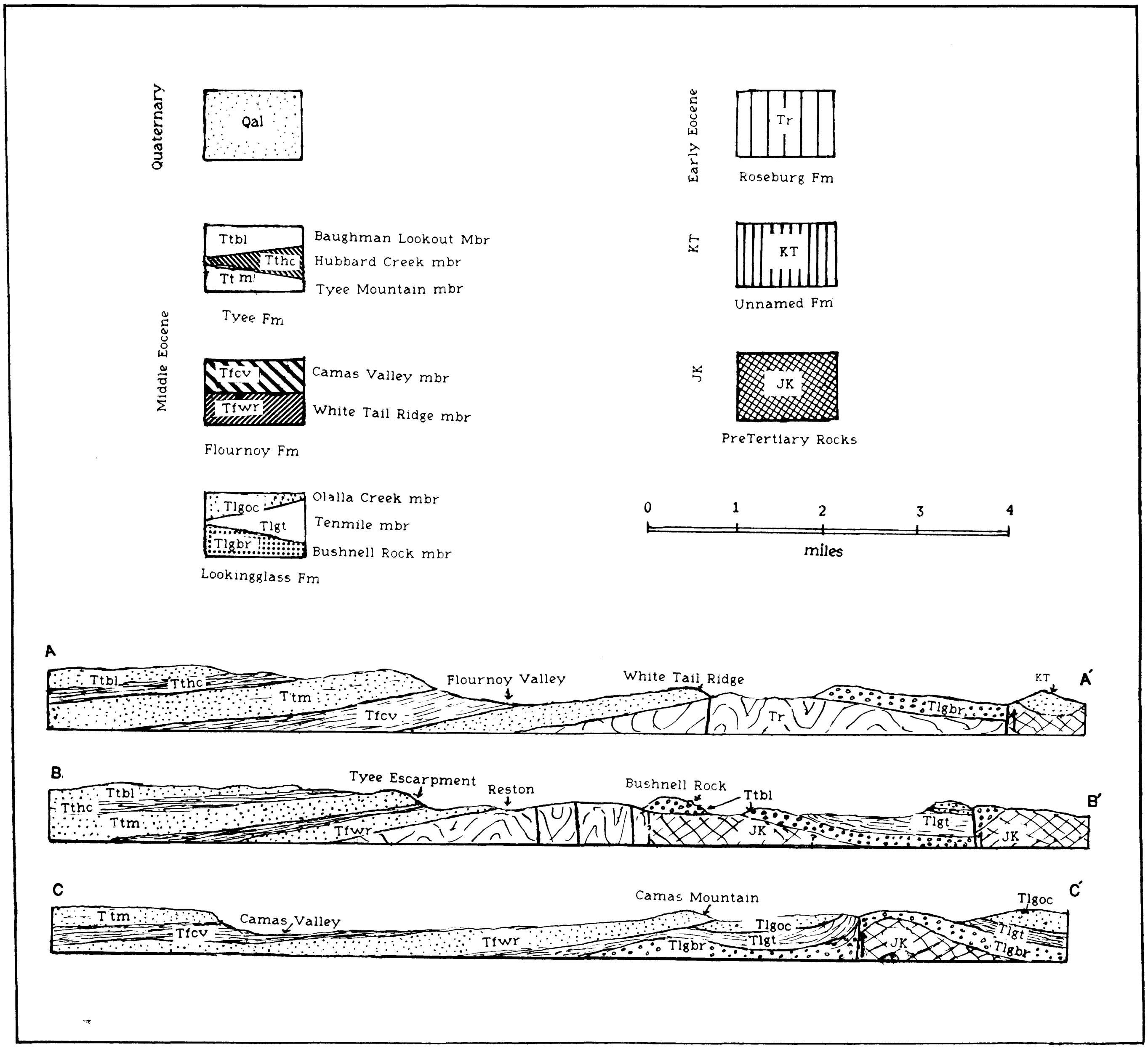

Figure 3. Cross sections and explanation of map symbols for geologic map of the Camas Valley quadrangle (Figure 2).

Valley and Tyee quadrangles in the mid-1960's. When the study of the oil and gas potential of this region was discontinued by the USGS, mapping was sponsored by the Oregon Department of Geology and Mineral Industries (DOGAMI) under H.M. Dole and R.E. Corcoran.

The Camas Valley quadrangle (Figures 2, 3, and 4) is situated near the northern boundary of the Klamath Mountains, which are believed to be an accumulation of accreted miniplates of pre-Tertiary age (Blake and others, 1985). Although there are local complications, Mesozoic rocks in the Camas Valley quadrangle are generally separated from the Tertiary section to the north by the Canyonville fault zone (Perttu, 1976; Baldwin and Perttu, 1980). The Wildlife Safari fault is a northeast-trending branch of the Canyonville fault zone.

STRATIGRAPHY

No attempt is made herein to subdivide the Mesozoic rocks in the Camas Valley quadrangle. The Mesozoic units have been discussed by Blake and others (1985). Most of the pre-Tertiary rocks are restricted to the southern end of the quadrangle south of the Wildlife Safari fault. A thick Eocene section occurs north of the fault. One formation of intermediate and as yet undetermined age, sometimes called the "Hoover Hill beds," occurs south of the Wildlife Safari fault and overlies Mesozoic units. We refer to this formation as the "unnamed formation."

Unnamed formation

Peterson (1957) described beds of uncertain age that crop out in Hoover Hill and Olalla Creek and in a hill just northeast of the Umpqua River bridge east of Winston. Rock of this formation is massively bedded, light-gray, arkosic, coarse- to medium-grained sandstone. The formation is poorly bedded, with only minor siltstone interbeds. Peterson noted that the unnamed unit had an unconformable relationship with the underlying Mesozoic rocks and suggested that it was Late Cretaceous in age, possibly the same age as the Chico (Hornbrook) Formation. We have not found the unnamed formation and the Roseburg Formation in contact anywhere. Furthermore, the base of the Roseburg Formation is not exposed, because the Roseburg basalt is probably an emplaced seamount or island-arc terrane, so the age relationships of the Roseburg Formation and the unnamed formation are difficult to determine. The unnamed unit is resting on Klamath Mountains terrane and therefore had a different provenance than the Roseburg sediments. It also would not have been subjected to subduction zone jamming and rebound as was the Roseburg Formation (Perttu, 1976). Consequently, even if it were an age equivalent of the Roseburg units, it would appear quite different. Baldwin believes the formation to be of Late Cretaceous or Paleocene age but has found no fossil evidence to confirm this age.

Roseburg Formation

The Roseburg Formation (Baldwin, 1974) is made up of a thick basal sequence of pillow basalt flows and breccia with minor sandstone interbeds, overlain by a thick section of tuffaceous sedimentary rock. The basalt appears to be thickest in excellent exposures along the North Fork of the Umpqua River from a point about 2 mi west of Glide nearly to Roseburg. The Roseburg Formation also crops out along U.S. Highway I-5 for approximately 35 mi from Scott Valley near Yoncalla to a point south of Roseburg.

In the Camas Valley quadrangle, the formation is mostly well-bedded sandstone and siltstone, which intertongues with lesser amounts of pillow basalt flows. Basalt of the Roseburg Formation is present in the valley of Porter Creek and southwest of Bushnell Rock. The basalt could with considerable effort be mapped as a separate formation and potentially be correlated with the Siletz River Volcanics in the central Coast Range of Oregon and the Crescent Formation in Washington.

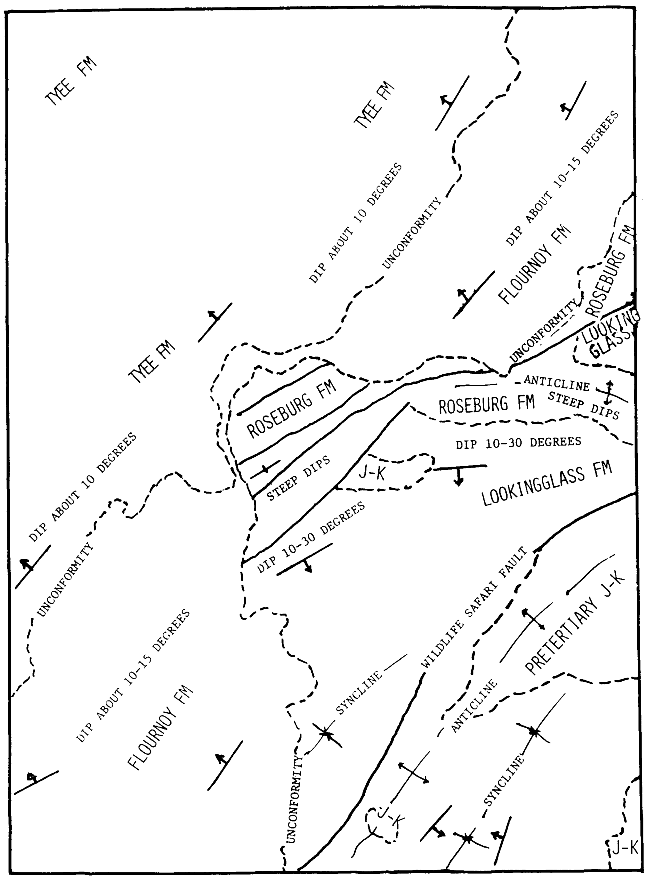

Figure 4. Sketch map showing structural relationships of the formations in the Camas Valley quadrangle.

The complex intertonguing of the Roseburg sedimentary rocks and the top of the basalt makes mapping of the basalt-sediment boundary difficult. Baldwin therefore prefers to retain the units in one formation and considers the basalt the lower member of the formation. If the basalt and sedimentary units of the Roseburg Formation are divided into two formations, then Perttu believes that a second division within the Roseburg sedimentary units would also be appropriate but difficult to make. He believes that the Roseburg sedimentary units must have an underlying, although at least partially age-equivalent, lower member that was deposited in association with the marine basalt volcanic centers and an overlying member that represents continent-derived lower slope and trench flysch that was deposited at the time of emplacement of the Roseburg volcanic piles. At the time of emplacement of the Roseburg volcanic piles and associated sediments into the subduction zone, continent-derived flysch would have partially buried the impinging Roseburg units. Perttu feels that some of the upper Roseburg sediments below the Bushnell Rock Member of the Lookingglass Formation represent such onlap units. These units would be very similar in appearance to the underlying Roseburg flysch but should show a very different provenance.

Bukry and Snavely (1988) cite K-Ar dates of 62.1-59.2 million years for five samples of oceanic tholeiitic basalt collected from rock the writers assign to the lower part of the Roseburg Formation. They also found a coccolith assemblage that, like the basalts, ranges from Paleocene into the early Eocene.

Miles (1977) examined the planktonic Foraminifera of the Roseburg, Lookingglass, and Flournoy Formations. He found that the Foraminifera of the Roseburg and Lookingglass Formations are indistinguishable. He assigned the units to the P7 and P8 zones of the "standard" tropical zonation. He found none that he could definitely assign to the Paleocene. It is possible that the foraminiferal and coccolith zonations are not quite the same.

The Roseburg beds were steeply folded and faulted during the latter stages of continental accretion when the Roseburg Formation moved eastward relative to the Klamath terrane. This deformation probably accompanied emplacement of the Roseburg Formation volcanics and associated sediments against the North American continent during possible jamming and subsequent westward jumping of an Eocene subduction zone.

Faults and folds of the Roseburg Formation trend N. 50°-80° E. (Baldwin, 1964; Perttu and Benson, 1980). This trend may represent a later clockwise rotation of structures that originally paralleled the continental margin. When the movement along the Canyonville fault zone before rotation is considered, the implied original direction of impingement of the Roseburg Formation against the continent was at an angle of approximately N. 10° E.

Lookingglass Formation

The Lookingglass Formation (Baldwin, 1974) was named for exposures of the formation along Lookingglass Creek in Lookingglass Valley. The formation has been divided into the lower conglomeratic Bushnell Rock Member, the middle Tenmile Member, and the upper Olalla Creek Member. The Lookingglass Formation may represent sediments that were deposited immediately after the collision of the Roseburg block with the subduction zone.

The Bushnell Rock Member is a massive conglomerate nearly 800 ft thick that rests on both steeply dipping Roseburg strata and pre-Tertiary rocks along Tenmile Creek (Figure 2). The conglomerate rests directly on the eroded surface of the Klamath terrane south of the Wildlife Safari fault. Movement along the fault appears to have been right-lateral through Roseburg time. Perttu suggests that movement along the Canyonville fault system, of which the Wildlife Safari fault is a strand, is more than 40 km. Immediately after jamming of the subduction zone, right-lateral movement on the Canyonville fault system would have ended, and rebounding of the inactivated subduction zone would have occurred. This rebounding, which was initially accompanied by continued compressive deformation, resulted in rapid erosion, generating the Bushnell Rock conglomerates. The conglomerate thins rapidly to the north. The entire Lookingglass Formation does not crop out north of a line drawn from Coos Bay to Sutherlin. Flournoy beds surround Roseburg basalt outcrops in the Coos Bay and Drain quadrangles without the presence of the intervening Lookingglass clastic wedge.

The Tenmile Member is composed of nearly 5,000 ft of thinly bedded sandstone and siltstone beds in the valley of Tenmile Creek. Microfossils from this member have been dated by Miles (1977) as early Eocene.

The Olalla Creek Member is dominantly conglomerate and is similar to the Bushnell Rock Member. It also represents rapid erosion of the Klamath Mountains terrane following renewal of uplift along the south side of the Canyonville fault zone. This uplift may have been associated with the formation of a new wedge of underthrust sediments below the new continental margin along the new subduction zone to the west and development of new drainage systems across the newly accreted terrane. The Olalla Creek Member is thickest in the Olalla Creek syncline, which was active during deposition of the member. A small patch of the member also caps Tenmile Butte. Some of the beds are red, perhaps indicating oxidation on subaerial fan surfaces.

Flournoy Formation

The Flournoy Formation (Figure 5) is named for outcrops of the formation's basal sandstone in White Tail Ridge and siltstone in Flournoy Valley. The White Tail Ridge Member sandstone thins around the western end of the Porter Creek anticline and extends to Camas Mountain; then the beds curve westward around the south end of Camas Valley, forming a gentle dip slope under the valley. The sandstone is not as well graded in Camas Valley as it is farther to the north and west in the Coast Range. The beds in White Tail Ridge were deposited in shallower water near the shore.

The upper thinly bedded sandstone and siltstone of the Flournoy Formation crop out in the Flournoy and Camas Valleys. This unit was named the Camas Valley Member for exposures in Camas Valley and up the side of the nearby Tyee escarpment. Baldwin (1974) correlated the Sacchi Beach Beds and the Lorane Siltstone with the Camas Valley Member of the Flournoy Formation. Microfossils in the Camas Valley Member are middle Eocene (Ulatisian) in age (Miles, 1977).

Tyee Formation

The Tyee Formation was named first when Diller (1898) called it "Tyee sandstone." Although no type section was designated, the name was taken from Tyee Mountain, which is located north of Coles Valley. The Umpqua River enters a canyon it has carved into the sandstone beds of the Tyee Formation. Details concerning the lithology and mode of deposition of the formation are discussed by Chan and Dott (1983) and by Heller and Ryberg (1983). Baldwin divided the Tyee Formation along its eastern margin into the Tyee Mountain Member, the Hubbard Creek Member, and the Baughman Lookout Member. The lower and upper members are composed of thickly bedded sandstone with thin layers of siltstone. Pebbles are remarkably scarce. The Tyee Mountain Member sandstone, which is 2,500 ft thick in Tyee Mountain, can be traced southward along the Tyee escarpment, where it disconformably overlies the Camas Valley Member of the Flournoy Formation. South of Mount Gurney, the beds appear to thin and pinch out against the Porter Creek anticline. This relationship may imply that the anticline was a positive area still undergoing some compression at the time of Tyee deposition.

The Hubbard Creek Member, which consists of about 400 ft of thinly bedded sandstone and siltstone beds, crops out along Hubbard Creek in the Tyee quadrangle to the north. This member pinches out south of Mount Gurney.

The Baughman Lookout Member of the Tyee Formation forms much of the southern Coast Range. It continues southward into the Bone Mountain and Eden Ridge quadrangles. Like the Tyee Mountain Member, the Baughman Lookout Member is massively bedded and approximately 2,500 ft thick. This member may interfinger with the Elkton Siltstone to the north. The Tyee Formation appears to be disconformable on older units in the Camas Valley quadrangle. On the western edge of the Coast Range syncline, the Camas Valley silty beds were eroded, leaving the basal Tyee sandstone resting on the White Tail Ridge Member sandstone of the Flournoy Formation. The two formations are very similar in appearance. In other locations, such as along the uppermost portion of the North Fork of the Coquille River and just west of Sitkum, the Tyee Formation rests on the Camas Valley siltstone. The contact is relatively easy to determine in these areas. The Tyee Formation overlaps all older Eocene units in the southern Coast Range and thus demonstrates its unconformable relationship with these older units. The Tyee Formation is the oldest Eocene formation to bridge the Canyonville fault zone without noticeable offset. Fossils as well as stratigraphic position indicate a middle Eocene age for the Tyee Formation. The formation appears to represent a major delta system that developed from the (now) southeast and unconformably overlapped the older formations and structures of the continental shelf and slope. The Tyee Formation is locally nonmarine in its southern exposures, where it contains coal seams, and becomes progressively deeper water marine to the north.

Figure 5. Flournoy Valley from Mount Gurney.

Younger Eocene formations

No younger Eocene formations crop out in the Camas Valley quadrangle. The upper part of the Tyee Formation interfingers with the Elkton Siltstone in the Elkton quadrangle, and it is in turn overlain in the southern part of the Elkton quadrangle by shallow water to nonmarine coal-bearing, deltaic beds of the Bateman Formation (Baldwin, 1961). To the west, the Coos Bay syncline contains 6,000 ft of deltaic, coal-bearing strata of the Coaledo Formation. This formation rests unconformably on the Roseburg, Lookingglass, and Flournoy Formations. The Coaledo Formation is nowhere in contact with the Tyee, Elkton, or Bateman Formations. Beds called Elkton by some writers at and south of Cape Arago are considered by Baldwin to be upper Flournoy siltstone. The Bastendorff and Tunnel Point Formations of latest Eocene age rest with apparent conformity upon the Coaledo Formation. The Coaledo Formation probably represents a deltaic system that was independent of the Tyee system. It is spatially associated with the Coos Bay syncline, which was actively deforming during Coaledo time, and appears to have periodically continued downwarping to the present. The downwarping may have been associated with lateral faulting, which may have shifted the Coaledo block northward relative to the other formations to the east.

DISCUSSION OF STRATIGRAPHIC USAGE

The International Subcommission on Stratigraphic Classification (ISSC) has discussed stratigraphic units such as the Roseburg, Lookingglass, and Flournoy Formations that are unconformity bounded (ISSC, 1987). The magnitude and extent of the unconformity help define the terminology. Although the term "sequence" has been used for such units, the term has not been used consistently. The subcommission proposed the name "synthem" to replace "sequence."

Baldwin's three subdivisions of Diller's Umpqua Formation are unconformity bounded throughout all of the southern Coast Range. The post-Roseburg unconformity represents erosion that accompanied severe folding and thrusting that occurred during final emplacement of the Roseburg Formation against the continental coastline. Baldwin and Lent (1972) proposed that the Colebrooke Schist in the northern Klamath Range was emplaced at the same time as the Roseburg Formation was deformed. That part of the Klamath terrane that crops out along Tenmile Creek south of Bushnell Rock may have been thrust to its present position at the same time. Baldwin believes that the pre-Tertiary units along Tenmile Creek may have come from a position south of the Canyonville fault zone.

If the terminology proposed by the ISSC is adopted, then the Roseburg, Lookingglass, and Flournoy Formations might qualify as synthems. The Lookingglass "synthem" could be divided into the Bushnell Rock, Tenmile, and Olalla Creek "Formations." If there were minor unconformities separating them, which we have not found, they would be "subsynthems." The ISSC says (ISSC, 1987, p. 234):

> "Unconformity-bounded units should not be used when they are not necessary, and only those that serve a useful purpose should be recognized. Unconformity-bounded units should be established only where and when they can fulfill a need that other kinds of stratigraphic units cannot meet, where they can contribute to the understanding of the stratigraphy and geologic history of an area..."

We do not intend to formally change the terminology of the Eocene units in the southern Oregon Coast Range. Nevertheless, the importance of the regional unconformities in deciphering the history and stratigraphy of the area should not be overlooked.

The Roseburg, Lookingglass, and Flournoy Formations are subdivisions of Diller's Umpqua Formation. Some have referred to these formations as the "Umpqua Group." From a historical standpoint, this may be appropriate. The definition of a group is "the lithologic unit next higher in rank than a formation." Groups are defined to express the natural relationships of associated formations. It is possible that such profound unconformities within the "Umpqua Group" would make the use of the word inappropriate. However, if the Roseburg, Lookingglass, and Flournoy Formations may be questionably of group rank, there should be little doubt that they can no longer be lumped together as the Umpqua Formation. Molenaar (1985), however, rejected the Roseburg, Lookingglass, and Flournoy as formations and proposed that the Umpqua Formation of Diller be used. A formation is a lithological mappable unit. The three formations, formerly parts of Diller's Umpqua Formation, are such mappable—and mapped—units and should stand on their own merits. Distinguishing these formations from each other is important to understanding the tectonic development of southwestern Oregon. To do less is to obscure the geology.

ROTATION OF THE EOCENE UNITS

Simpson and Cox (1977) and other authors have shown that western Oregon has undergone 50°-70° clockwise rotation in an area from the Klamath Mountains to a point north of Newport in the Coast Range. If the Coast Range rotated as a block, the location of the axis of rotation is unclear. This complex problem has been studied by Wells and Heller (1988). Although no clear answer is known, they ascribe rotation to a combination of movement of the colliding plates and stretching of the Great Basin. As noted in this article, the interpreted rotation must be factored into statements of location and paleogeography at various points in time. The place of the reconstruction implied here in interpretations of Eocene plate tectonics is touched on but is not the subject of this paper.

ACKNOWLEDGMENTS

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Cyanide in mining

by Allen H. Throop, Mined Land Reclamation Program, Oregon Department of Geology and Mineral Industries, 1534 Queen Avenue SE, Albany, Oregon 97321

A new application of old technology combined with favorable prices has revolutionized the gold mining industry. The effects of the revolution are now being felt in Oregon. New applications of cyanide technology are allowing profitable mining of lower grades of ore.

For over 100 years, metallurgists have used cyanide to dissolve and recover gold and silver from some ores by leaching. About 15 years ago, the U.S. Bureau of Mines designed a recovery method combining the efficiency of cyanide leaching with modern large-scale, open-pit mining techniques. Nevada, California, Idaho, and Washington are among the states where, in recent years, gold mining has increased dramatically because of these contemporary methods. Oregon should soon join them.

THE PROCESS

Heap leaching gold from ore is, in a general way, similar to the geologic processes that concentrated native copper in the huge Arizona deposits that initially drew miners to that state. In those copper deposits, acidic waters dissolved copper from low-grade deposits and then, as conditions changed, redeposited and concentrated the copper into economically recoverable orebodies. In a typical heap leaching process, a weak solution of cyanide dissolves low-grade gold and then redeposits the gold on activated carbon from which the now more concentrated gold can be economically recovered.

Because each deposit is unique, the nature of the ore and, consequently, the details of mining and processing vary from site to site. For example, although only gold is mentioned in this article, the cyanide heap leaching process also recovers silver.

A typical sequence used in heap leaching is as follows:

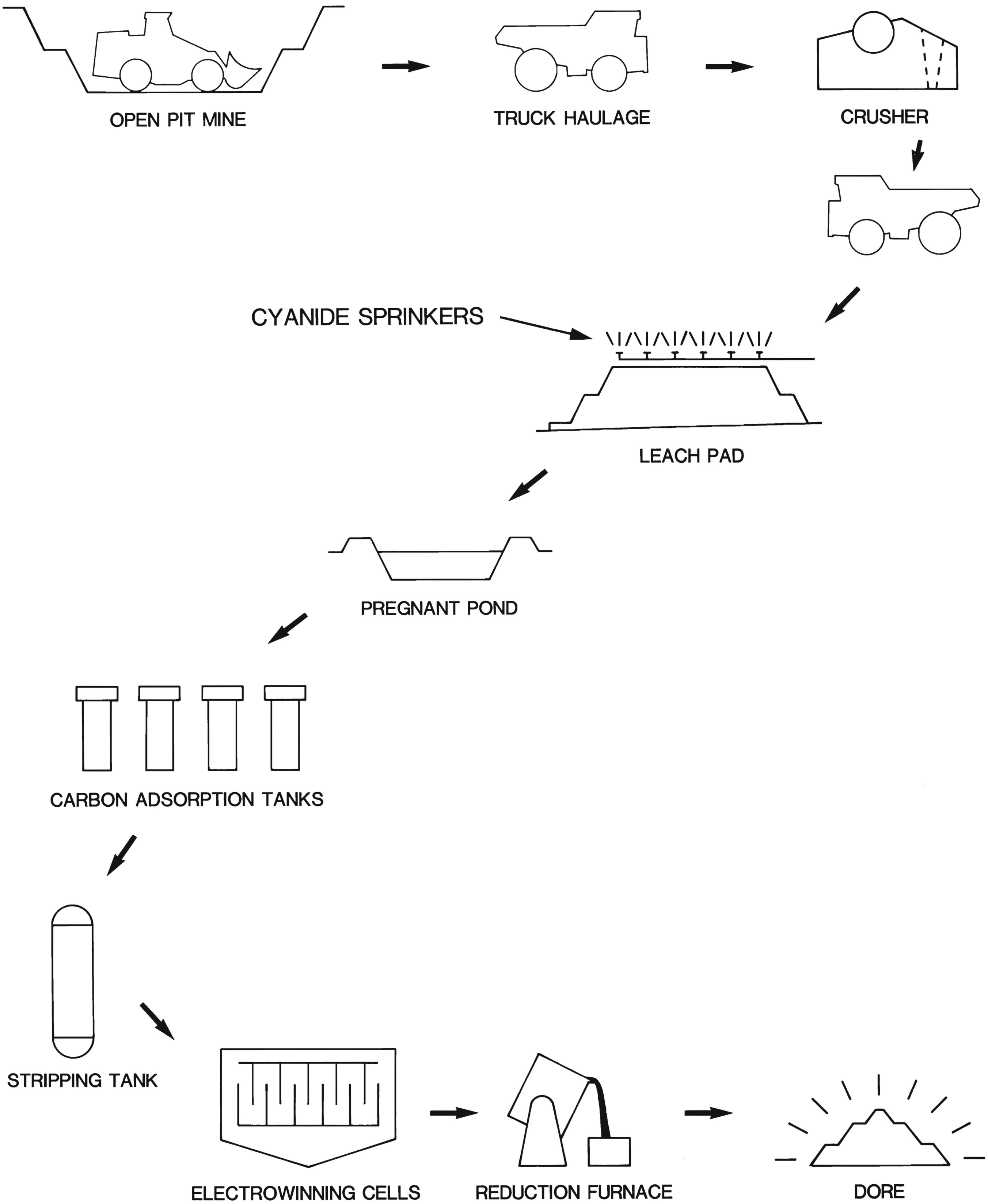
Ore is drilled and blasted from an open pit. A ton of ore may contain less than 0.05 oz of gold. Recovering this gold might be compared to finding the fragments of a pulverized rice grain in a rock the size of a refrigerator.

After blasting, large front-end loaders dump the ore into trucks that carry it to the processing site. The ore is next crushed into pieces that are three-quarters of an inch or less in diameter. After crushing, trucks or conveyors heap the crushed rock in piles 50 ft or deeper on large, specially built pads that can cover many acres.

Once the heaps are built on the pad, plastic pipes with sprinklers are laid on top of the ore. A weak cyanide solution is then sprayed over the heaps. It trickles through the ore and dissolves the microscopic gold particles. After reaching the bottom of the heap, the gold-bearing solution collects in pipes. Because it contains gold, miners refer to the liquid as the "pregnant" solution. From the heaps, the pregnant solution flows to the pregnant pond, where it is held to await further processing.

At a constant rate, pumps move the pregnant solution from the pond to a series of columns filled with carbon. The gold in the pregnant solution is quickly adsorbed onto the carbon. Once the metal is stripped from the liquid, the now barren solution is sent to a second holding pond, the barren pond. The solution is treated to have the correct alkalinity and the proper cyanide content restored and is then pumped back to the leach pad to start the cycle over again.

Aerial view of gold mine and processing facilities of Atlas Gold Mining, Inc., in Eureka, Nevada. 1=open-pit mine; 2=waste dumps; 3=crusher and mill; 4=administration, laboratory, and maintenance buildings; 5=heap leaching pad; 6=carbon columns; 7=pregnant pond; 8=barren pond; 9=fresh-water pond. Photo courtesy of Atlas Gold Mining, Inc.



Simplified heap leach flow chart, showing the main steps from mined ore to refined gold. At the end of the process, the "dore" that is poured into bars is 90 percent pure gold.

Base preparation of heap leach pad. On a slightly inclined surface, an impermeable plastic sheet (darker in color) is covered with a highly permeable synthetic material (lighter color). The permeable sheet and the perforated pipes serve to drain off the leaching solution after it has moved from the top to the bottom of the ore pile and become "pregnant." Under the impermeable sheet and not visible in the picture, a leak detection system is installed.

The carbon is removed from the columns, when it has adsorbed as much gold as possible. A stronger cyanide solution redissolves the precious metal, which is then precipitated onto steel wool. The steel wool/gold mixture is melted in a furnace, and iron and other impurities go into slag that is separated from the gold. The "dore" that is finally poured from the furnace into bars is now 90 percent pure gold. Final refining takes place away from the mine site. After mining, hauling, milling, and leaching the ore, the mining company will receive less than $20 for the gold in each ton of ore.

GOLD MINING IN OREGON

During the last 20 years, most of Oregon's gold production has been from placer deposits in Baker, Malheur, Grant, Josephine, and Douglas Counties. Such deposits consist of coarse gold particles mixed in gravels. Since gold is much denser (heavier) than gravel, processing the ore through a trommel and sluice box works well to separate the precious metal from the gravel, and cyanide is not generally used in placer mining. Gravity methods are cheaper, and gold nuggets sold for jewelry bring prices higher than the price for refined gold.

Cyanide solution being applied on heap leach pad at Atlas Mine. Photo courtesy of Atlas Gold Mining, Inc.

Heap leach pad in production. Only the section in background is currently being sprinkled with cyanide solution.

However, the cyanide leaching technology has encouraged geologists to look at areas where they might find large deposits of low-grade and very fine gold. Only recently have exploration companies focused their attention on Oregon.

Several deposits have been found and are now undergoing advanced exploration and feasibility studies. Galactic Services and Wavecrest are working at Quartz Mountain in Lake County. Atlas Precious Metals is working in Malheur County. Many other exploration projects are active in central and eastern Oregon.

One deposit in Grant County has now been developed to the point where GSR Goldsearch Resources (US), Inc., a subsidiary of a Canadian company and the company that will operate the Grant County mine, has received all the necessary permits for a mining operation. The permitted operation is known as the Prairie Diggings Mine.

Example of carbon columns used to remove gold from pregnant solution.

WHAT IS CYANIDE?

Chemically, the word "cyanide" refers to several compounds of carbon and nitrogen which are often combined with other elements. For the leaching process, the U.S. mining industry starts with solid sodium cyanide (NaCN) and mixes it in a highly alkaline solution (pH of 10.5 or greater) before spraying it on the leach pad. The alkalinity must be kept high to prevent a breakdown of the solution and loss of the cyanide into the atmosphere as a gas.

To humans, fish, and other animals, cyanide is very toxic. Eating a piece of sodium cyanide equal to half a rice grain can be fatal

(Continued on page 20, ***Cyanide****)*

Ice-Age glaciers and lakes south of the Columbia River Gorge

by John Eliot Allen, Emeritus Professor of Geology, Portland State University, Portland, Oregon 97207-0751

ABSTRACT

Geomorphic analysis of the 600 mi² lying between the Columbia and Sandy-Zigzag Rivers, based on 26 topographic maps with scales varying from 1:125,000 to 1:24,000, has determined that a minimum of 60 mi² or 10 percent of the total area was covered by ice during the Pleistocene by two large glaciers, one in the valleys of the Sandy and Zigzag Rivers and one in the valley of the West Fork Hood River, and 52 small glaciers that chiseled the upper north and east slopes of the volcanic upland above elevations of 3,000 ft. Small tarns and morainal lakes occupy 14 of the cirques.

INTRODUCTION

Fourteen years ago, I published an article (Allen, 1975), that described, largely from a geomorphic or landform study of 12 topographic maps, the extent and characteristics of the Ice Age glaciers that covered 337 mi² of the Wallowa Mountains in northeastern Oregon. That study involved the recognition of 13 kinds of landforms produced by mountain glaciers, eight of them erosional in origin (matterhorn, arete, col, cirque, tarn lake, bastion, U-shaped valley, and hanging valley) and five depositional in origin (terminal, lateral, and recessional moraine; morainal lake; and glacial outwash plain).

I have been interested in the area lying between the Columbia River Gorge and the Sandy and Zigzag Rivers ever since I traversed most of its ridges in 1931, while contributing to one of its first reconnaissance geologic maps (Allen, 1932). Logging of these upland surfaces had been completed a few years earlier and had bared much of the topography. Now, however, decades of new growth have subdued and mantled the glacial features.

For several years, I have been plotting these features on older 15- and 30-minute quadrangle maps that were made in the field by skilled cartographers using plane table methods, their knowledge of geomorphology—and some artistic license. Since 1975, more than 20 new 7½-minute quadrangles of the area between the Sandy and Zigzag Rivers and the Columbia River Gorge have been released. I had hoped that the new maps, which were made with more sophisticated techniques and are more accurate than the older maps, would also be more helpful in the geomorphic study of the area's glaciation. But I soon realized that the older, more interpretative maps were more useful for this purpose. For that reason, a 1907 base map is used in this paper to illustrate the glaciation.

In this analysis, three of the 13 landforms listed as criteria of glaciation evidence for the Wallowas—arete, bastion, and matterhorn—were discarded as inappropriate for the area around the Gorge. I have also added three criteria: The landform is at an elevation above 3,000 ft, it is on an east or northeast slope, and it is one of a group of at least three similar nearby landforms located in similar topographic positions. In order to be included on the map presented in this paper, a glacial landform had to display at least four of the 13 distinguishing features.

It is important to note that the map shows the absolute minimum area covered by ice during the Ice Age. It may well have amounted to twice the 60 mi² suggested.

GEOLOGIC SETTING

North and west of Mount Hood, the pre-Ice Age plateau consisted of numerous, mostly Pliocene (2- to 5- million year [m.y.]-old) coalescing and overlapping shield volcanoes lying along and south of a line between Larch Mountain on the west and Mount Defiance on the east.

Relatively undissected areas surround many of these volcanoes (Larch, Palmer, Talapus, Eagle, Big Bend, Aschoff, Green Point, Hiyu, Lost Lake, and Defiance) and also occur at Latourelle Prairie and Benson Plateau.

The present Columbia River Gorge was cut during the last 3 m.y. (M.H. Beeson, personal communication, 1987), and the upland surface was deeply dissected by the Bull Run, Sandy, and Hood Rivers and their tributaries, as well as by Herman, Eagle, Tanner, and other lesser creeks that drain to the Columbia. This dissection also cut away much of several other volcanic peaks (Nesmith, Tanner, Chinidere, and Indian).

GLACIERS

During the last 2 m.y. (Pleistocene), the upper sides of many of the higher peaks, ridges, and plateau remnants in the 600-mi² area were carved by at least 52 small glaciers that, except for glaciers in the valleys of Sandy River, Zigzag River, and the West Fork Hood River, rarely extended down below 3,000 ft in elevation.

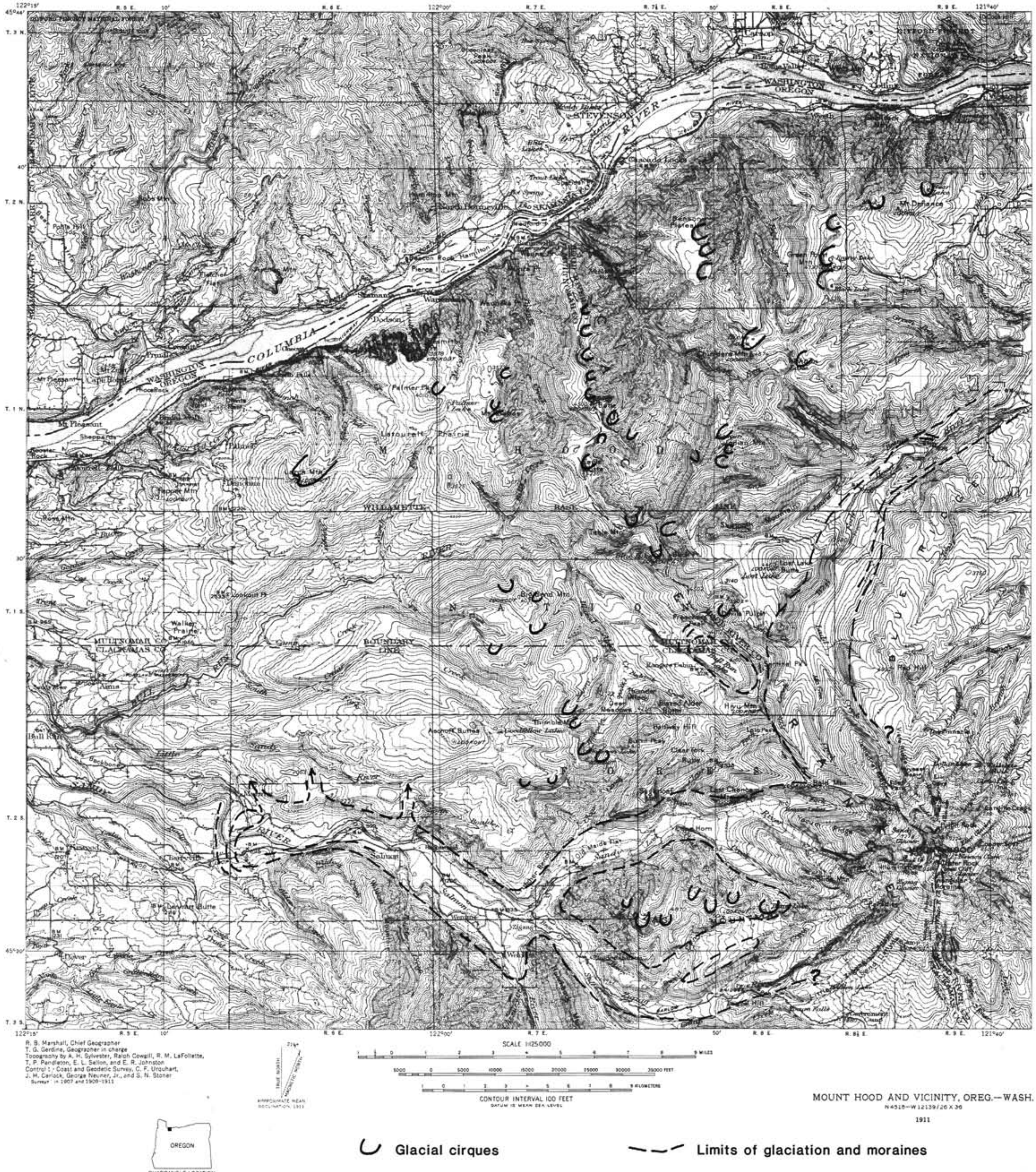
Fifteen thousand years ago, glaciers on Mount Hood were probably much different and certainly were much larger than today. Three of the west-side glaciers (now Zigzag, Reid, and Sandy Glaciers) then joined and extended 20 mi down the Sandy River valley and may have even extended northwest of Marmot toward the Little Sandy River to a point only 6 mi east of the present-day town of Sandy. This Sandy River glacier produced by far the largest number of landforms, and, along with its Zigzag River tributary, covered more than 35 mi² of those valleys below the slopes of Mount Hood. The glacier filled its valley with ice to a depth of at least 1,000 ft near its western end, since outwash overflowed north into the Little Sandy River valley through three saddles in the ridge between Marmot and Brightwood. The glacier both widened and deepened the valley, steepened its walls, and left terminal and recessional moraines that now occupy the center of the northward bend of the river at Alder Creek. A south-side lateral moraine forms the lower parts of the hills south of Highway 26 for 4 mi west of Brightwood, and hummocky ground moraine may be seen near Cherryville.

It is probable that most of the features described here were results of the last Vashon or Pinedale glaciation (Crandell, 1965), which culminated 15,000 years ago. Many earlier and possibly just as extensive advances of ice occurred during the 2 m.y. of the Pleistocene, but field work will be required to prove their presence and extent.

Although today only the Glisan and Ladd Glaciers contribute to the West Fork Hood River, its valley once contained a large glacier that covered more than 15 mi². The glacier came down the valley to near the outwash plain that is now Dee Flat, and terminal, recessional, and lateral moraines can be inferred from the topography along the West Fork. If the upper part of this glacier was more than 1,000 ft thick, it would have spilled over the col north of Hiyu Mountain into the headwaters of the Bull Run River to scour out the Bull Run Lake basin.

Evidence of the Ice Age extent of the glaciers originating on the other three sides of Mount Hood has been largely covered by volcanic debris from explosive eruptions (pyroclastic flows) and lahars (mudflows) during the last 10,000 years.

The largest of the 52 smaller glaciers was on the northeast side



Map showing glaciation of the area between the Columbia River Gorge and the Sandy and Zigzag Rivers. The base map used is a 1907 U.S. Geological Survey map, which is rather interpretative and shows some of the glacial features more clearly than newer maps of the area.

of Larch Mountain and once covered more than a square mile. Most of the rest of the glaciers formerly covered areas of half to a quarter of a square mile or less. The headwalls of their cirques or glacial amphitheaters were usually less than 700 ft high. If the average area is about a third of a square mile, these small glaciers covered a total of 17 mi^2.

LAKES

Eighteen, or 35 percent, of these cirques still contain remnants of small tarns or morainal lakes. The east side of "County Line Ridge," between Eagle and Tanner Creeks, has 10 cirques in the 9 mi between Table Mountain and Wauna Point south of Bonneville Dam, and four of them contained lakes in the 1907 map used for this study. Five cirques around Mount Defiance contain lakes. Four of the seven cirques on the north side of Zigzag Mountain contain lakes.

The glacial origin of Wahtum, Lost, and Bull Run Lakes has been questioned. Although called a glacial lake in the *Atlas of Oregon Lakes* (Johnson and others, 1985), Wahtum Lake, with a depth of 184 ft, could be a diatreme or phreatic (steam) volcanic explosion crater. Lost Lake probably lies within a glaciated valley, but the lake was formed by a lava dam from Lost Lake volcano.

According to Beaulieu (1974), Bull Run Lake basin was partially formed by a lava flow. However, the valley is U-shaped, the head of the lake is cirquelike, and there is morainal material on top of the lava at the northwest end of the lake.

These and the 14 other small lakes contain spores and pollen in the sediment on their floors. Probably many more of the 52 cirque basins once contained lakes that now have changed to swamp or meadow.

Hansen (1946, 1947) was the first in Oregon to use the priceless scientific pollen record entombed in Oregon lakes and swamps to determine the different kinds of plants that occupied the area and the sequences of climatic changes that have occurred during the last 10,000 years. The investigation of the pollen record from Battleground Lake, north of Vancouver, Washington (Barnosky, 1985), which is the latest of these studies that have added much to our knowledge of the postglacial period, is a good model for future pollen studies in the Cascades.

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Rock eaters at work

The involvement of biological agents in the decomposition of rocks has attracted increased attention in recent years, particularly in the area of preserving historic structures. Scientists have found that, until now, the role of microorganisms in the deterioration of stone and similar building materials has been largely underestimated.

Wilhelm Irsch reports in *Die Zeit* (Overseas edition, no. 38) on findings of scientists in Germany, where the Federal Government supports investigations by such groups as the geomicrobiology research team at the University of Oldenburg. Here, geologists, biologists, chemists, and physicists are collaborating in studies of the effects of the numerous organisms that attack buildings. These tiny "rock eaters" include lichens, algae, fungi, molds, and bacteria. Thus, for instance, fungi closely related to those growing in marmalade jars have been found occurring widely on rocks; even wastewater organisms have been discovered on rocks.

The same rapid processes of decomposition that affect organic substances, for instance, the spoiling of fresh food or the rotting of animal cadavers, are applicable in the biologic deterioration of minerals. The "rock eaters" attack not only stone and concrete but also glass, metals, sheet rock, paints, and wall paper.

These organisms may attack building materials directly or indirectly, for instance, through acids or salts that they produce and that migrate and concentrate in the stone or concrete; they may spread the same substances through the atmosphere, through ground water, or through rain or condensation moisture that migrates within the building materials. Such substances include nitric, sulfuric, and carbonic acids as well as organic acids. It was found that considerable effects on stone were produced not only by nitric oxides from automobile emissions but also by nitric oxides produced by bacteria that "eat" ammonium and ammonia compounds and whose origin is still a mystery. In addition, there are mechanical destructive effects, such as biological blasting and splitting through growth processes or the formation of gases and indirect effects through influences on many chemical processes that occur in the building material even without the presence of the "little wreckers."

Because of the minute size of microorganisms, it is hard to imagine the size of the problem these colonizers represent. For example, the Cologne Cathedral contains approximately five million stones. Microorganisms populate these stones to a depth of 5 cm from the surface, at an average density of at least 100,000 bacteria per cm^3. That means that the fantastic number of approximately ten quadrillion (10^{16}) microorganisms live on—and eat from—the Cathedral. The speed of their reproduction and their metabolic activity are beyond description.

To the microscope view of the scientist, the microflora of building-material surfaces assumes the dimensions of a tropical rain forest, and large cities appear as so many "lands of milk and honey" for microbes.

Modern cities, it seems, are particularly fertile areas for rock-eating microbes. During a study of the process of colonization, it was found that the microflora of rocks brought into the city as building materials increased a hundredfold within six months, from 20,000 per gram of rock material to two million.

For sources of energy, microbes use the sun as well as chemical energy from inorganic compounds or from organic ones such as coal, oil, methane, wood, protein, or paper. The microbes' "menu" ranges from carbon, nitrogen, sulfur, oxygen, and hydrogen to phosphorus and various salts. Gradually, through the feasting of the microbes, building materials not only lose substance but also change their chemical composition.

So far, protective substances used to preserve building materials were not aimed at controlling such processes. Thus, there exists a considerable need to catch up in the study of microbial "rock eaters."

—*Klaus Neuendorf*

Collecting rocks

Modified from a U.S. Geological Survey pamphlet, "Collecting Rocks," by Rachel M. Barker

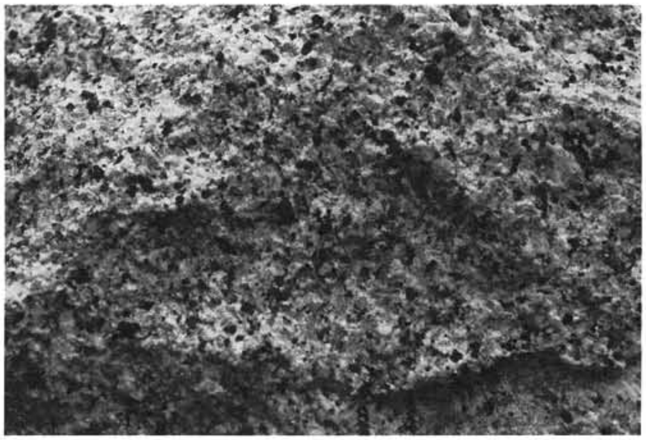
THE EARTH'S STORY IN ROCKS

Rocks are the very substance of the Earth. They are composed of the same elementary particles as all other matter in the universe, but the particles are so arranged in rocks that the aggregate masses are very extensive. Individual rock bodies commonly occupy hundreds or thousands of cubic miles of the Earth's volume. Even so, they differ greatly from place to place because of the many different rock-forming processes.

What rocks are like at depths within the Earth is known only imperfectly from indirect measurements made by various techniques. Rocks near the surface, however, have been studied for many years, and their characteristics are well known. Studies of rocks have taught much about the structure, composition, and history of the Earth. In fact, the success of geologists in reconstructing the Earth's story by piecing together information from rocks is one of the wonders of science.

Geologists classify rocks in three great groups according to the major Earth processes that formed them. The three groups are **igneous rocks**, **sedimentary rocks**, and **metamorphic rocks**. Anyone who wishes to build a meaningful rock collection should become familiar with the characteristics and interrelationships of these great groups. To transform a random group of rock specimens into a true collection, application of the geologic principles on which rock classification is based is necessary.

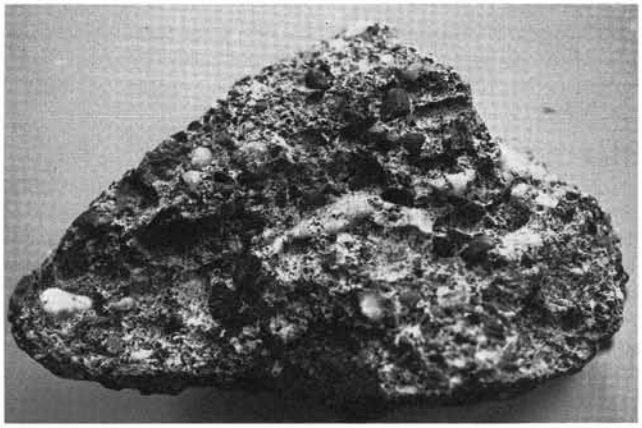
Igneous rocks are formed from molten material that has cooled and solidified. Molten rock material originates deep within the Earth and ascends to lesser depths or even, in volcanic eruptions, to the Earth's surface. When it cools slowly, usually at depths of thousands of feet, crystals separate from the molten liquid, and a coarse-grained rock results. When it cools rapidly, usually at or near the Earth's surface, the crystals are extremely small, and a fine-grained rock results. Separate bodies of molten rock material have, or acquire, unlike chemical compositions and solidify to different kinds of igneous rocks. Thus, a wide variety of rocks is formed by different cooling rates and chemical compositions. Dissimilar as they are, obsidian, granite, basalt, and andesite porphyry are all igneous rocks.



Coarse-grained igneous rock (granite).

Sedimentary rocks are formed at the surface of the Earth, either in water or on land. They are layered accumulations of sediments —fine to coarse fragments of rocks, minerals, precipitated chemical matter, or animal or plant materials. At no time during their formation are temperatures or pressures especially high, and their mineral constitutions and physical appearances reflect this fact. Ordinarily, sedimentary rocks become cemented together by minerals and chemicals or are held together by electrical attraction; some, however, remain loose and unconsolidated. The layers are normally parallel or nearly parallel to the Earth's surface; if they are at high angles to the surface or are twisted or broken, some kind of Earth movement has occurred since deposition.

Most people visualize more easily the formation of sedimentary rocks than that of igneous or metamorphic rocks, because the process occurs around us all the time. Sand and gravel layers on beaches or in river bars resemble sandstone and conglomerate. Mud flats need only to be compacted and dried to become shale. Scuba divers who have seen mud and shells settling on the floors of lagoons find it easy to understand the formation of sedimentary rock.



Sedimentary rock (conglomerate).

Sometimes, sedimentary and igneous rocks are subjected to pressures so intense or to heat so high that they are completely changed. They become metamorphic rocks, which form while deeply buried within the Earth's crust—usually during the long continued series of gigantic events that produce mountain systems. The process of metamorphism does not melt the rocks, but instead transforms them into denser, more compact, **foliated** rocks. (Foliated means the parallel arrangement of certain mineral grains that gives the rock a laminated appearance.) New minerals are created either by rearrangement of mineral components or by reactions with fluids that enter the rocks. Some kinds of metamorphic rocks—granite gneiss and biotite schist are two examples—are strongly banded or foliated. Other kinds, such as hornfels and quartzite, are massive. Stress or temperature can even change previously metamorphosed rocks into new types.

A peculiarity of metamorphic rocks is that, with increasing metamorphism, a related but unlike series of rocks is formed. Thus, in favorable localities, one can trace a formation from shale through slate to phyllite, to biotite-muscovite schist, and then to biotite gneiss—and know that all the rock types evolved from the same shale. Elsewhere, it may be impossible to tell which of two such dissimilar rocks as basalt and limy shale was the parent rock of hornblende schist.

Rock-forming and rock-destroying processes have been active for several billion years. Today, in the Guadalupe Mountains of western Texas, one can stand on limestone, a sedimentary rock, that was a coral reef in a tropical sea about 250 million years ago. In Vermont's Green Mountains one can see schist, a metamorphic rock, that was once mud in a shallow sea. Half Dome in Yosemite Valley, California, which now rises nearly 8,800 ft above sea level, is com-

Metamorphic rock (schist) with alternate bands of light and dark minerals (foliation).

posed of quartz monzonite, an igneous rock that was emplaced and solidified several thousand feet within the Earth. To realize that a simple collection of rocks can illustrate this tremendous sweep of Earth history is an inspiring thought.

STARTING A COLLECTION

A good rock collection consists of selected, representative specimens, properly labeled and attractively housed. It can be as large or as small as its owner wishes. An active collection constantly improves, as specimens are added or as poor specimens are replaced by better ones.

A rock collection might begin with stones picked up from the ground near one's home. These stones may have little value in the collection and can be replaced later by better specimens. Nevertheless, this first step is helpful in training the eye to see diagnostic features of rocks (features by which rocks can be differentiated). As one becomes more familiar with collecting methods and with geology, the collection will probably take one of two directions. One may try either to obtain representative specimens of igneous, sedimentary, and metamorphic rocks, or to collect all the related kinds of rocks from particular geologic provinces.

IDENTIFYING ROCKS

Many books about geology explain the identification and classification of rocks and describe the underlying geologic principles. Almost any recent general book on geology would help a rock collector.

Geologic maps, unsurpassed as collecting guides, are also excellent identification aids. They show the distribution and extent of particular rock types or groups of rock types. Depending on size and scale, the maps may cover large or small areas. Most have brief descriptions of the rock types. Some are issued as separate publications; others are included in book reports.

Most geologic maps are issued by public or private scientific agencies. The U.S. Geological Survey (USGS) booklet, *Geologic and Water-Supply Reports and Maps for Oregon*, provides a ready reference to USGS publications about Oregon. The free booklet may be obtained by writing to Western Distribution Branch, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225.

The Oregon Department of Geology and Mineral Industries (DOGAMI) has published numerous maps and books on the geology of Oregon (see list of available publications on pages 23 and 24 of this issue). DOGAMI has just released an updated version of an old favorite publication for rock and mineral collecting in Oregon, entitled *A Description of Some Oregon Rocks and Minerals* (see article on page 18 of this issue). This report describes the types of rocks and minerals found in Oregon and would be useful for rock collecting in this state. DOGAMI publications are sold in the Department's Portland, Baker, and Grants Pass offices (see addresses on page 2 of this issue) and are also available in many local libraries.

Comparing one's own specimens with those in a museum collection can help in identifying them. Most large rock collections are well labeled. Smaller rock collections abound in libraries, schools, public buildings, small museums, and private homes.

WHERE TO FIND ROCKS

Collections usually differ markedly depending on where the collector is able to search for rocks. In the great interior plains and lowlands of the United States, sedimentary rocks are exposed in wide variety. Igneous and metamorphic rocks are widespread in the mountains and piedmont areas of New England, the Appalachians, the Western Cordillera, and scattered interior hill lands; igneous rocks make up almost all the land of Hawaii. Along the Atlantic and Gulf Coastal Plains and locally elsewhere, loose and unconsolidated rocks are widespread; in northern areas, glaciers deposited many other unconsolidated rocks.

The best collecting sites are quarries, road cuts or natural cliffs, and outcrops. Open fields and level country are poor places to find rock exposures. Hills and steep slopes are better sites. Almost any exposure of rock provides some collecting opportunities, but fresh, unweathered outcrops or manmade excavations offer the best locations. Where feasible, it is a good plan to visit several exposures of the same rock to be sure a representative sample is selected.

COLLECTING EQUIPMENT

The beginning collector needs two pieces of somewhat specialized equipment—a geologist's hammer and a hand lens.

The hammer is used to dislodge fresh rock specimens and to trim them to display size. It can be purchased through hardware stores or scientific supply houses. The head of a geologist's hammer has one blunt hammering end. The other end of the most versatile and widely used style is a pick. This kind of hammer is aptly called a geologist's pick. Another popular style—the chisel type—has one chisel end; it is used mostly in bedded, soft sedimentary rocks and in collecting fossils.

The hand lens, sometimes called a pocket magnifier, is used to identify mineral grains. Hand lenses can be purchased in jewelry stores, optical shops, or scientific supply houses. Six-power to ten-power magnification is best. Optically uncorrected hand lenses are inexpensive and quite satisfactory, but the advanced collector will want an optically corrected lens.

Rock hammer and hand lens.

Other pieces of necessary equipment are neither unusual nor expensive: a knapsack to carry specimens, equipment, and food; paper sacks and wrapping paper in which to wrap individual specimens and a marking pen to mark them; a notebook for keeping field notes until more permanent records can be made; and a pocket knife, helpful in many ways, especially to test the hardness of mineral grains. *(Continued on page 22, **Rocks**)*

The severity of an earthquake

Interest in earthquakes in Oregon has been spurred recently by the hypothesis that the Juan de Fuca Plate may subduct beneath Oregon and Washington in a series of very large but infrequent earthquakes.

The National Earthquake Hazard Reduction Program has funded the Oregon Department of Geology and Mineral Industries (DOGAMI) for a five-year study aimed at predicting the local intensity of earthquakes in the Portland area, based on geology. Because it is important to understand the distinction between the magnitude of an earthquake and its intensity, we are reprinting the following discussion of earthquake intensity and magnitude from a U.S. Geological Survey pamphlet, *The Severity of an Earthquake.* Copies of this pamphlet may be obtained free from the Book and Open-File Reports Section, U.S. Geological Survey, Federal Center, Box 25425, Denver, CO 80225. Single free copies are also available at the Portland Office of DOGAMI (address on page 2 of this issue).

The severity of an earthquake can be expressed in terms of both **intensity** and **magnitude**. However, the two terms are quite different, and they are often confused by the public.

Intensity is based on the observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region depending on the location of the observer with respect to the earthquake epicenter.

Magnitude is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments that have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value.

Earthquakes are the result of forces (deep within the Earth's interior) that continuously affect the surface of the Earth. The energy from these forces is stored in a variety of ways within the rocks. When this energy is released suddenly, for example by shearing movements along faults in the crust of the Earth, an earthquake results. The area of the fault where the sudden rupture takes place is called the **focus** or **hypocenter** of the earthquake. The point on the Earth's surface directly above the focus is called the **epicenter** of the earthquake.

THE RICHTER MAGNITUDE SCALE

Seismic waves are the vibrations from earthquakes that travel through the Earth; they are recorded on instruments called seismographs. Seismographs record a zigzag trace that shows the varying amplitude of ground oscillations beneath the instrument. Sensitive seismographs, which greatly magnify these ground motions, can detect strong earthquakes from sources anywhere in the world. The time, location, and magnitude of an earthquake can be determined from the data recorded by seismograph stations.

The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included in the magnitude formula to compensate for the variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude of 5.3 might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

At first, the Richter Scale could be applied only to the records from instruments of identical manufacture. Now, instruments are carefully calibrated with respect to each other. Thus, magnitude can be computed from the record of any calibrated seismograph.

Earthquakes with magnitude of about 2.0 or less are usually called microearthquakes; they are not commonly felt by people and are generally recorded only on local seismographs. Events with magnitudes of about 4.5 or greater—there are several thousand such shocks annually—are strong enough to be recorded by sensitive seismographs all over the world. Great earthquakes, such as the 1906 Good Friday earthquake in Alaska, have magnitudes of 8.0 or higher. On the average, one earthquake of such size occurs somewhere in the world each year. Although the Richter Scale has no upper limit, the largest known shocks have had magnitudes in the 8.8 to 8.9 range. Recently another scale called the moment magnitude scale has been devised for more precise study of great earthquakes.

The Richter Scale is not used to express damage. An earthquake in a densely populated area that results in many deaths and considerable damage may have the same magnitude as a shock in a remote area that does nothing more than frighten the wildlife. Large-magnitude earthquakes that occur beneath the oceans may not even be felt by humans.

THE MODIFIED MERCALLI INTENSITY SCALE

The effect of an earthquake on the Earth's surface is called the intensity. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and, finally, total destruction. Although numerous intensity scales have been developed over the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the Modified Mercalli (MM) Intensity Scale. It was developed in 1931 by the American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead, it is an arbitrary ranking based on observed effects.

The Modified Mercalli Intensity value assigned to a specific site after an earthquake provides a measure of severity that is more meaningful to the nonscientist than the magnitude, because intensity refers to the effects actually experienced at that place. After the occurrence of a widely felt earthquake, the Geological Survey mails questionnaires to postmasters for distribution in the disturbed area, requesting information so that intensity values can be assigned. The results of this postal canvass and information furnished by other sources are used to assign an intensity value and to compile isoseismal maps that show the extent of various levels of intensity within the area where the earthquake was felt. The maximum observed intensity generally occurs near the epicenter.

The lower numbers of the intensity scale generally deal with the manner in which the earthquake is felt by people. The higher numbers of the scale are based on observed structural damage. Structural engineers usually contribute information for assigning intensity values of VIII or above.

The following is an abbreviated description of the 12 levels of Modified Mercalli intensity:

I. Not felt except by a very few, under especially favorable conditions.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.

IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.

VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.

VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings, with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.

XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Another measure of the relative strength of an earthquake is the size of the area over which the shaking is noticed. This measure has been particularly useful in estimating the relative severity of historic shocks that were not recorded by seismographs or did not occur in populated areas. The extent of the associated areas where effects were felt indicates that some comparatively large earthquakes have occurred in the past in places not considered by the general public to be regions of major earthquake activity. For example, the three shocks in 1811 and 1812 near New Madrid, Missouri, were each felt over the entire eastern United States. Because there were so few people in the area west of New Madrid, it is not known how far the shocks were felt in that direction. The 1886 earthquake at Charleston, South Carolina, was also felt over a region of about 2 million square miles, which includes most of the eastern United States. □

New geologic postcard available

A colorful postcard has been created in the Oregon Department of Geology and Mineral Industries and is now available for sale.

The card pictures color representations of the State Rock, the thunderegg, and a faceted specimen of the State Gemstone, the Oregon sunstone, along with some explanatory text. White print and color-photo inserts are set on a black background.

Price of the postcard is 50 cents. For ordering, see the Department's Portland address on page 2 of this issue. Orders under $50 require prepayment.

DOGAMI releases new publications

BREITENBUSH AREA REPORT

A new geologic report on studies of an area that includes the Austin and Breitenbush Hot Springs, both so-called Known Geothermal Resource Areas (KGRA) in the Cascade Range, presents a geologic cross section and geothermal model in greater detail than had been possible so far.

The Oregon Department of Geology and Mineral Industries (DOGAMI) has released *Geology and Geothermal Resources of the Breitenbush-Austin Hot Springs Area, Clackamas and Marion Counties, Oregon*, as DOGAMI Open-File Report O-88-5 (price $8.00). The report was edited by D.R. Sherrod of the U.S. Geological Survey (USGS) and contains contributions by Sherrod and five other scientists from the USGS, Washington State University, and Southern Methodist University.

The report summarizes several ongoing investigations, including geologic mapping, alteration studies, and the heat-flow results from cooperative and industrial drilling programs. The researchers were able to use, for the first time, previously confidential information from industry drilling.

The first five of six chapters present detailed treatments of geologic setting, stratigraphy, geochemistry, and alteration phenomena and analyze a substantial set of new data on thermal conductivity and heat flow. In the final chapter, all the contributions are combined into a geologic cross section showing topography, stratigraphy, structure, isotherms, heat flow, gravity, and hydrology.

The 91-page report is accompanied by a geologic map and cross section of the area around the geothermal drill hole CTGH-1, located about 14 km (8.7 mi) northeast of Breitenbush Hot Springs and 6 km (3.7 mi) northwest of Olallie Butte. This hole was rotary-drilled cooperatively by Thermal Power Company, Chevron Geothermal, and the U.S. Department of Energy in 1986 and yielded an essentially 100-percent core recovery down to its total depth of 161 m (528 ft).

REVISED GUIDE TO OREGON ROCKS AND MINERALS

Oregon's rocks and minerals are the subject of a newly revised version of an older publication by DOGAMI. *A Description of Some Oregon Rocks and Minerals*, released by the Department as Open-File Report O-88-6 (price $5.00) was first written by H.M. Dole and published in 1950, and a revised edition appeared in 1976. The new release is the second revision and was prepared by L.L. Brown of the U.S. Bureau of Mines in Albany, originally as a 4-H Leader Guide for the Oregon State University Extension Service.

The 59-page report begins with introductions into the definition, classification, and identification of minerals and rocks in general and then describes individual minerals and rocks. Minerals are grouped into metallic, nonmetallic, and rock-forming minerals; the basic division of rocks into three groups is further divided into such subgroups as extrusive-intrusive igneous rocks, consolidated-unconsolidated sedimentary rocks, and foliated-nonfoliated metamorphic rocks. Individual descriptions include references to the origin and pronunciation of names and to occurrences and economic uses in Oregon.

A bibliography for further reading and a glossary of technical terms used in the descriptions complete the report as a first introduction to the Oregon world of rocks and minerals and their economic significance.

NEW GEOLOGIC MAP FOR CASCADE HOT SPRINGS AREA

A new geologic map partially funded by the U.S. Department of Energy provides a detailed geologic description of the McKenzie Bridge 15-minute quadrangle in the Cascade Range.

Geologic Map of the McKenzie Bridge Quadrangle, Lane County, Oregon was prepared by G.R. Priest, G.L. Black, and N.M. Woller of DOGAMI and E.M. Taylor of Oregon State University. It was published in DOGAMI's Geological Map Series as Map GMS-48 (price $8.00).

The McKenzie Bridge quadrangle is located at the transition zone between the older Western Cascades and the younger High Cascades. This zone is also the location of some of the hottest known thermal springs in the Cascade Range. A major purpose of the study that culminated in the production of this map was to define the structure of the area in greater detail.

The report consists of two map sheets and a five-page text discussing the map data. The full-color geologic map at a scale of 1:62,500 (Plate 1) identifies 56 surficial, volcanic, and intrusive rock units and their structural relations and is accompanied by four cross sections. The second sheet (Plate 2) contains index and sample-location maps and three tables showing chemical analyses and radiometric ages of rock samples. The text discusses the structural geology, paleogeographic history, and mineral and geothermal resources of this complex geologic boundary.

FIRST DETAILED GEOLOGIC MAP FOR OWYHEE REGION

DOGAMI has released the first geologic map that describes in detail the geology and mineral potential of a part of the Owyhee region in Malheur County.

Geology and Mineral Resources Map of the Owyhee Ridge Quadrangle, Malheur County, Oregon was prepared by DOGAMI geologist M.L. Ferns with partial funding by the COGEOMAP program of the U.S. Geological Survey and has been published in DOGAMI's Geological Map Series as map GMS-53 (price $4.00). It is the first published result of an ongoing study of southeastern Oregon areas with a potential for mineral resources.

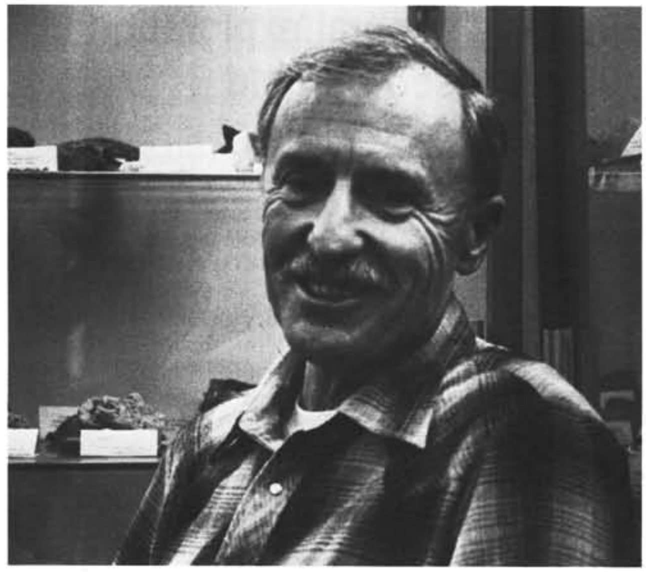
The Owyhee Ridge 7½-minute quadrangle covers approximately 48 mi^2 between Lake Owyhee State Park and Succor Creek in Malheur County. At a scale of 1:24,000, the new two-color map describes 20 mostly Tertiary rock units. Structure is described both on the map and in two cross sections. The approximately 28- by 40-in. map sheet also includes a discussion of mineral resources and tables showing whole-rock and trace-element analyses of rock samples.

All reports are now available at the Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 SW Fifth Avenue, Portland, Oregon 97201-5528. Orders under $50 require prepayment. □

Ramp retires

Len Ramp, 37-year veteran geologist with the Grants Pass Field Office of the Oregon Department of Geology and Mineral Industries, retired on January 1, 1989. Author or coauthor of numerous reports, bulletins, maps, and articles on the geology and mineral resources of the state, Ramp is probably most familiar to *Oregon Geology* readers for his work on Bulletin 61, *Gold and Silver in Oregon*; bulletins on chromite, on the Chetco drainage including the Kalmiopsis Wilderness and Big Craggies Botanical Areas, and on Douglas, Coos, Curry, and Josephine Counties; his investigations of nickel and talc; and geologic maps.

An avid runner, skier, climber, pilot, and river rafter, Ramp's physical skills and endurance are legendary in southwestern Oregon. He was born and raised on a ranch near Roseburg, was graduated from the University of Oregon, and has lived and worked in Grants Pass for many years. Consequently, he has studied and hiked or climbed over most of southwestern Oregon, and his extensive geologic knowledge of the area has been a valuable asset to miners and geologists looking for information. During his tenure with the Department, the theory of plate tectonics was developed, and Ramp had the opportunity of being one of the first geologists who were able to apply it to the complex geology of southwestern Oregon. During his retirement, he plans to pursue his numerous hobbies, enjoy the out-of-doors, catch up on projects around his home, and keep in touch with geology.



Len Ramp. Photo courtesy of Melissa Martin, Medford Mail Tribune

Ruthie Pavlat, secretary of the Grants Pass Field Office for 18 years, also retired on January 1, 1989. Born in Carbondale, Pennsylvania, Ruthie started life as a coal-miner's daughter but was raised in Binghamton, New York. Married for 45 years to a Navy pilot, Ruthie lived and worked "all over the country." She and her husband tried life in Maui after his retirement but eventually decided to settle permanently near Grants Pass, where they have lived since 1967. Ruthie's hobbies include playing the violin and organ, hiking, fishing and "loving animals," all of which she will continue to enjoy in retirement.

Ruthie Pavlat

Until further notice, the Grants Pass Field office will be open on a part-time basis, on Monday, Tuesday, and Wednesday mornings from 8:00 a.m. until noon. □

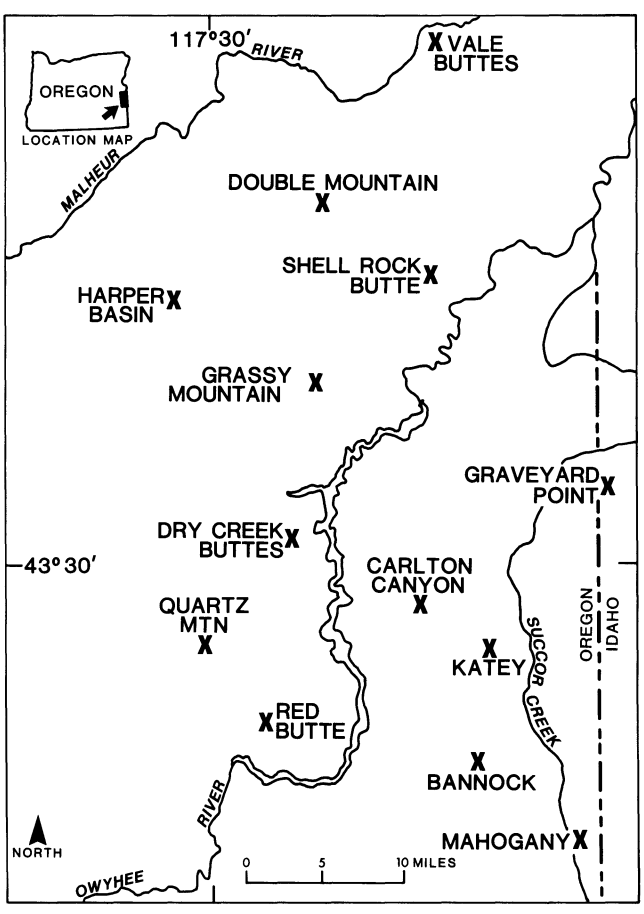
Oregon's mineral exploration in 1988 focused on gold

Precious metals were the main targets of exploration in Oregon during 1988, with focus on the frontier epithermal (hot-springs) districts of central and southeastern Oregon, as Mark L. Ferns, Oregon Department of Geology and Mineral Industries (DOGAMI) geologist, reported last month in a talk given at the Northwest Mining Association annual convention in Spokane, Washington.

Ferns summarized current exploration and mining activities in Oregon during 1988, commenting particularly on the new developments in the southeastern part of the State and presenting new interpretations of its geology and related precious-metal mineralization.

The announcement by Atlas Corporation of a significant gold discovery at Grassy Mountain, Malheur County, highlighted a summer of extensive exploration. Intense exploration drilling and sampling programs targeted the Vale-Weiser epithermal district in extreme eastern Oregon.

Ongoing mapping projects conducted by geologists from DOGAMI, Portland State University, Washington State University, and the U.S. Geological Survey are resulting in a better understanding of the geologic processes that have generated hot-spring-type gold systems in this area where the northern part of the Basin and Range Province in Oregon intersects with the western part of the Snake River Plain.



Location map of prospects for epithermal gold in southeastern Oregon.

To date, two broad ages of mineralization have been recognized: (1) Early mid-Miocene systems related to caldera formation and Basin and Range extensional environments, exemplified by the Grassy Mountain, Red Butte, Mahogany, Quartz Mountain, and Katey prospects; and (2) younger, late Miocene to early Pliocene systems related to the development of the western Snake River Plain, exemplified by the Vale Buttes, Birch Creek, Shell Rock Butte, and Double Mountain prospects.

The combination of extensional tectonic regimes, areally high heat flow, and favorable host rocks such as arkosic sediments and rhyolite flows and domes make the Vale-Weiser district an especially promising exploration target for epithermal gold systems. □

(Cyanide, continued from page 11)

to humans; much lower amounts can be fatal to trout. The Oregon Department of Geology and Mineral Industries (DOGAMI) and the Department of Environmental Quality (DEQ) administer regulations that are intended to ensure that cyanide stays within the processing area and does not escape into the ground water or surface water. Working in favor of the environment is the short-lived nature of cyanide. Sunlight, oxygen, or a pH below 8 all lead to the breakdown of cyanide. In addition, cyanide will combine with any iron, other metals, or organic matter that it encounters if it is spilled. Finally, if minute quantities of cyanide do get into animals or humans, the cyanide breaks down quickly. It does not accumulate in the body the way lead, for example, does.

The mention of cyanide tends to get a quick, emotional response from people who are not too well informed about it. Miners familiar with its use know that cyanide is a highly toxic chemical that is generally short-lived in the natural environment and that does a very efficient job of dissolving gold and silver. For an analogy, think of the gasoline in your gas tank. It is toxic and flammable. However, when used properly, it allows you to move around the state quickly and efficiently with very little thought about what would happen if you drank the gasoline.

To carry the analogy further, we don't think about drinking gasoline or cyanide but we do think about both escaping into ground water or into streams. The U.S. Environmental Protection Agency (EPA) and Oregon's DEQ are addressing the serious problem of leaking underground gasoline storage tanks and have developed response programs for surface gasoline spills. New gasoline storage facilities will be designed and built so that leaks and spills are avoided. Likewise DOGAMI and DEQ are working jointly to anticipate and prevent problems of cyanide leaks or spills.

Through existing reclamation laws supplemented by 1987 legislation, DOGAMI has the responsibility of ensuring that mines and leach pads are properly detoxified and reclaimed. The 1987 legislation requires miners to post a bond of between $25,000 and $500,000 for removal, detoxification, or cleanup of cyanide at each major facility. DEQ's authority applies to all industrial processes that can affect the environment. The two agencies are working closely to protect the environment, to give miners clear guidance about what is and what is not permissible, and to ensure that adequately prepared permit applications will be reviewed and the permits granted within a reasonable period of time.

Within the next two years, large-scale gold mining using cyanide leaching technology will probably begin in Oregon. To geologists, the low-grade deposits offer new targets for exploration. To state residents, the mines offer increased employment in parts of the state that have chronic high-unemployment problems. Combined with that is the possibility of large developments in areas that now are almost inaccessible. To the regulatory agencies, the use of cyanide offers a challenge to develop adequate controls that protect the environment while not being overly restrictive to the mining companies. □

Forum on the Geology of Industrial Minerals to meet in Portland

The Oregon Department of Geology and Mineral Industries (DOGAMI) will host the 25th Forum on the Geology of Industrial Minerals in Portland during the week of May 1-6, 1989. The Forum is a conference devoted to the geology, exploration, and production of industrial minerals and typically is attended by 100 to 200 delegates from private industry, government, and academic institutions.

The theme of the 25th Forum will be the industrial minerals of the Pacific Northwest. Papers presented during two days of technical sessions will include summaries of the industrial mineral production and potential of Oregon, Washington, Idaho, and British Columbia as well as discussions of bentonite, calcium carbonate, diatomite, emery, garnet, olivine, perlite, phosphate, pumice, talc, zeolites, and methods of industrial mineral analysis. A half-day field trip will visit local producers and processors, and a 3½-day trip will visit occurrences and producers in eastern and central Oregon.

Further details and registration information are available from Ron Geitgey at the DOGAMI Portland office (see page 2 for address and phone). □

Symposium on Southern Midcontinent announced

The Oklahoma Geological Survey (OGS) is sponsoring a symposium/workshop dealing with all aspects of Late Cambrian-Ordovician geology of the Southern Midcontinent, to be held in Norman, Oklahoma, October 18-19, 1989.

The symposium/workshop will consist of about 18 papers presented orally and about 20 informal poster presentations. The proceedings will be published by the OGS about eight months after the meeting.

Topics to be covered include sedimentology, diagenesis, petroleum occurrence and exploration, other mineral resources, geologic history, and other subjects important to understanding the geology of Late Cambrian and Ordovician rocks of the region. The area of interest includes all of Oklahoma, northern Texas, the Texas Panhandle, northeastern New Mexico, southeastern Colorado, southern Kansas, southwestern Missouri, and western Arkansas.

All persons who have been doing exploration in the Southern Midcontinent or studies on any of the above-mentioned topics and have an interesting paper to present are invited to submit a preliminary title by March 1, 1989, and an abstract by June 1, 1989. For publication, manuscripts are expected to be completed and submitted by October 1989, at the time of the symposium/workshop.

For further information and submittal of papers, contact Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, Norman, OK 73019 (phone 405/325-3031).

—Oklahoma Geological Survey news release

Oregon Ocean Resources Management Task Force meets

The 1987 Oregon Ocean Resources Management Act established a state-level program to plan for coordinated, comprehensive management of ocean uses and resources off the coast of Oregon. The Act strives to balance existing resources and traditional uses of the ocean with new uses by requiring a plan to be written by 1990.

Demands on the ocean for food, energy, minerals, waste disposal, navigation, and recreation increases the potential for conflict between new and traditional uses of the ocean. At present, there are many State and Federal programs for ocean resources management, but there is no comprehensive management structure. The plan developed under the Act will emphasize management over State waters (the first 3 mi from shore) but will consider sound management in Federal waters (from 3 mi to 200 mi offshore) as well.

The law requires an ocean plan and establishes an overall program for ocean management. A Task Force was established consisting of State and local government representatives, interest-group representatives, and members of the public at large. An Interim Report was prepared in 1988, and the Final Plan is due in July 1990. The Interim Plan is available from the Department of Land Conservation and Development in Portland.

Public involvement has included eight public workshops in the fall of 1988 as well as several Task Force meetings during the year. The next Task Force meeting will be held January 26 and 27 in Charleston, Oregon. Additional public input will be gathered on the Draft Plan at five workshops in October 1989.

The Ocean Resources Management Program publishes a newsletter called *Oregon Ocean.* For a copy of the newsletter or other additional information, contact Eldon Hout, Oregon Department of Land Conservation and Development, Portland, phone (503) 227-6068. □

Earthquake hazards workshop announced

The Oregon Department of Geology and Mineral Industries (DOGAMI) announces a workshop on earthquake hazards in the area between Portland and the Puget Sound. The workshop will take place March 26-29, 1989, at the Portland Marriott Hotel. It is the second workshop in a five-year series that is part of the Puget Sound/Portland project of the National Earthquake Hazard Reduction Program (NEHRP). The goal of the workshop is to facilitate the spread of technical hazard information and to develop hazard reduction policy.

The Pacific Northwest has become the number-one research target for the NEHRP due to concern over the potential for great earthquakes on the Cascadia subduction zone. The workshop will also focus attention on the hazards of smaller, more "conventional" earthquakes. The program will include

- a technical session on aspects of earthquake sources and effects in the Pacific Northwest;
- a tutorial session on basic earthquake hazard science for attendees without a technical background;
- a session aimed at presenting a scientific consensus of the current hazard status;
- a session devoted to examples of how the technical hazard information can be turned into hazard reduction policy; and
- a field trip to the Oregon coast to examine evidence for great subduction earthquakes.

The program will be cosponsored by the U.S. Geological Survey, the Federal Emergency Management Agency, the Oregon Emergency Management Division, DOGAMI, and the Washington Department of Natural Resources. Representatives from all of these agencies along with geoscientists, engineers, emergency and land use planners, educators, policy makers, and representatives of the insurance and finance industries from Oregon, Washington, California, and British Columbia will be invited to attend. Although attendance at the workshop is by invitation, interested individuals may contact Ian Madin at the Portland office of DOGAMI to be included on the invitation list. □

NWMA elects new president

The Northwest Mining Association (NWMA) has chosen a Denver mineral expert to lead its members in 1989. Ta M. Li, vice president and general manager for Behre Dolbear-Riverside, Inc., was elected president of the NWMA on November 29, 1988, by the organization's board of trustees. He succeeds Bill Booth of Hecla Mining Company, Coeur d'Alene, Idaho.

Other officers elected or reelected were Mark Anderson, general manager of ASAMERA, Wenatchee, Washington, first vice president; David A. Holmes, exploration manager for Meridian Minerals Co., Englewood, Colorado, second vice president; Karl W. Mote, executive director of the NWMA of Spokane, Washington, vice president; John L. Neff, a Spokane attorney, secretary; and David M. Menard, vice president of Washington Trust Bank in Spokane, treasurer.

Ta M. Li, NWMA President

The NWMA was organized in 1895 in Spokane, to support the mineral industry in the Northwest. With headquarters still in Spokane, the Association now has 2,200 members throughout North America, representing all aspects of the mineral industry.

—NWMA news release

*(**Rocks**, continued from page 16)*

On some collecting trips, additional equipment is desirable. Sledge hammers can be used to break especially durable ledges. Cold chisels often make it possible to loosen specimens. Dilute hydrochloric acid assists in identifying limestone and dolomite. A long list could be made of such equipment; the collector must decide for each expedition which tools are really worth the weight.

HOUSING AND ENLARGING A COLLECTION

The practical problems of cataloging and storing a collection are ones that every collector must consider. If desired, housing arrangements can be very simple, because rocks are durable and do not require special treatment. Cigar boxes and corrugated cardboard boxes are often used. Ordinary egg cartons can be used if the specimens are rather small. Shallow wall cases for rock collections are available commercially.

It is important to have a careful system of permanent labeling, so that specimens do not get mixed. Many people paint a small oblong of white laquer on a corner of each specimen and paint a black number on the white oblong. A notebook is used to enter the number, rock name, collector's name, date collected, description of collection site, geologic formation, geologic age, and other pertinent data. If rocks are kept on separate trays, a small card containing some data is usually placed in the tray.

Extra specimens are sometimes used for trading with other collectors. Few people have the opportunity to obtain all varieties of rock types, and exchanging can fill gaps in a collection. Collectors interested in trading are usually located by word of mouth. Local rock and mineral clubs and individual collectors are numerous throughout the United States.

It may be necessary to buy some specimens, but this should be done selectively because good specimens are expensive.

HINTS FOR ROCK COLLECTORS

1. Label specimens as they are collected. Identification can wait until later, but the place where the rocks were found should be recorded at once. Many collections have become confused because the collector did not do this.

2. Trim rocks in the collection to a common size. Specimens about 3 by 4 by 2 in. are large enough to show rock features well. Other display sizes are 2 by 3 by 1 in. or 3 by 3 by 2 in.

3. Ask for permission to collect rocks on private property. The owners will appreciate this courtesy on your part.

4. Be careful when collecting rocks. Work with another person, if possible, and carry a first aid kit. Wear protective clothing—safety glasses, hard-toed shoes, hard hat, and gloves—when dislodging, breaking up, or trimming specimens. Avoid overhanging rock and the edges of steep natural or quarried walls.

5. Do not collect rocks in national parks and monuments or in state parks, where it is illegal to do so. Similar rocks commonly crop out on land nearby and can be collected there.

6. Look for unusual rocks in large buildings or in cemeteries. Dimension stone blocks and monument stone are often transported long distances from where they are quarried. Polished stone sometimes looks different from unpolished rock. This provides good identification practice.

7. Join a mineral club or subscribe to a mineral magazine. They occasionally discuss rocks. □

U.S. POSTAL SERVICE STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION

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Beverly F. Vogt Publications Manager

AVAILABLE DEPARTMENT PUBLICATIONS

GEOLOGICAL MAP SERIES

	Price	No. copies	Amount
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GMS-5. Geologic map, Powers 15-minute quadrangle, Coos and Curry Counties. 1971	3.00		
GMS-6. Preliminary report on geology of part of Snake River canyon. 1974	6.50		
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