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Style is generally that of U.S. Geological Survey publications. (See USGS *Suggestions to Authors*, 7th ed., 1991, or recent issues of *Oregon Geology*.) Bibliography should be limited to references cited. Authors are responsible for the accuracy of the bibliographic references. Include names of reviewers in the acknowledgments.

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

Cover photo

Historical example of Oregon stock certificate issued by the Comer Mines Company in 1912. Through 1913, President E.D. Brigham and Secretary-Treasurer M.M. Wasley, who had come from Chicago to do business in Portland, had succeeded in finding investors for about 75 percent of their capital stock of $1.5 million. Four years later, the company went out of business. Photo from Oregon Historical Society negative number ORHI 90670, manuscript 2220.

In the article beginning on page 114, Bob Whelan discusses how to evaluate mineral ventures before investing in them. ☐

Time's up!

As you read this, you may realize that the delivery of this issue of *Oregon Geology* also marks the deadline for the mystery photo contest of the previous issue. Announcing the winner of the contest will have to wait until yet another issue of our magazine. However, we can now at least satisfy your curiosity and tell you briefly what the picture showed: The area is in the Cascade Range, just south of the southernmost end of the Three Sisters Wilderness, in the Irish Mountain 7½-minute quadrangle. We shall tell you more about it in the next issue. —*ed*

Time's almost up!

This issue of *Oregon Geology* is the last one to show the current subscription rates and prices. **Effective October 1, 1994**, the price for a single issue of *Oregon Geology* will be $3, the subscription price for six issues (one year) will be $10, and the subscription price for 18 issues (three years) will be $22. We hope for your understanding and will do our best to continue bringing you Oregon's geology in the manner to which you have become accustomed.

You still have a chance to renew at the old prices. Remember that your renewal will go into effect only after your current subscription expires—there is no overlap and no loss. Use the renewal form on the back cover **now** and let us have your renewal at the old price—**by October 1**! —*ed*

Governing Board adopts civil penalty rules for mining violators

In a major step toward stricter control of health and safety or environmental risks posed by mining, the Governing Board of the Oregon Department of Geology and Mineral Industries (DOGAMI), including Chair Ronald Culbertson of Myrtle Creek, John Stephens of Portland, and Jacqueline Haggerty-Foster of Weston Mountain, adopted civil penalty rules for violations related to all mining operations other than chemical-process mining (which is covered by existing rules).

On the basis of this decision made at the Board's meeting on July 11, 1994, in Portland, DOGAMI may issue a Notice of Civil Penalty whenever mining operators do not respond to notices of violation or if the violation poses an immediate threat to the public or the environment. The new rules establish four classes of civil penalties DOGAMI may impose. Fines range from maximally $1,000 per day to $10,000 per day. ☐

DOGAMI drilling in Salem to collect earthquake hazard data

The Oregon Department of Geology and Mineral Industries (DOGAMI) is starting a drilling program in the Salem area to collect data that can be used to define the geology of the area and determine how sediments and bedrock will respond to seismic waves. Those data will help to develop hazard maps that show which areas are most likely to suffer damage when an earthquake occurs.

Two holes will be drilled. The first hole will be located in Bush's Pasture Park and is expected to reach a depth of about 150 ft. The second hole will be about 60 ft deep and will be drilled west of Salem at what used to be Eola County Park in the Eola Hills.

The drilling project is funded by the Oregon State Lottery and DOGAMI and is part of DOGAMI's relative hazard mapping program currently focused on urban areas in the Willamette Valley and along the coast. Information from this drilling project will be made available to the public by the end of 1995. ☐

The Bornite breccia pipe, Marion County, Oregon

by Barton G. Stone, Kinross Copper, P.O. Box 409, Mill City, Oregon 97360

ABSTRACT

The Bornite breccia pipe (called Cedar Creek breccia pipe in earlier literature) is a Miocene-age tourmaline-copper sulfide breccia associated with a diorite/quartz diorite intrusion in the Western Cascades, 48 mi east of Salem, Oregon. Kinross, current property owner, has successfully completed an Environmental Impact Statement, with the USDA Forest Service (USFS) Record of Decision approving construction of a 1,000-ton per day (tpd) underground copper mine on a reserve of 2.2 million tons of 2.53 percent copper, 0.57 ounces per ton (opt) silver, and 0.021 opt gold. This paper presents geologic information developed since the geochemical discovery by AMOCO in 1976.

INTRODUCTION

The Bornite breccia pipe (called Cedar Creek pipe in earlier literature) is a vertically oriented cylinder of tourmaline-copper sulfide mineralization associated with granodioritic intrusions emplaced into Sardine Formation andesites of Miocene age. The deposit is located at 2,200 ft elevation in a portion of the Western Cascades at lat 44°50′N. and long 122°15′E. Kinross Copper, current owner of the property, has identified a mining reserve of 2.2 million tons at 2.53 percent copper, 0.57 opt silver, and 0.021 opt gold. The deposit is notably deficient in pyrite, unlike many similar tourmaline-bearing breccia pipes in the Western Cascades. The primary sulfides are bornite and chalcopyrite, which constitute 99 percent of the sulfides. Trace amounts of sphalerite, wittichenite, molybdenite, and galena have been noted in mineralogical studies. The purpose of this paper is to summarize geologic studies and observations made during the period 1975 to 1993.

EXPLORATION HISTORY

The North Santiam mining district (Figure 1), in which the Bornite pipe is located, attracted mining attention in the 1890s, but most of the production was intermittent between 1915 and the 1930s. The total production was very small, amounting to $10,554 over the 50 years between 1880 and 1930 (Callaghan and Buddington, 1938). This production was only one percent of the total production of the seven Cascade districts described in Callaghan and Buddington (1938). Their work drew attention to the close relationship of the mining camps to small dioritic intrusions and the zonal nature of metals in camps like the North Santiam, where a central zone of chalcopyrite veins (Figure 2) was surrounded by a zone of more complex veins, according to J.E. Allen, Portland State University (personal communication, 1992). Allen was the geologic field assistant on the Callaghan-Buddington investigation.

The porphyry copper boom of the early 1970s brought the district to the attention of AMOCO Minerals: The company had done a literature search that indicated some favorable geologic features in the district. As a followup, AMOCO then conducted a reconnaissance mapping project and staked the claims over the Bornite pipe as part of that project. An initial pass noted a number of tourmaline-bearing breccia pipes and dioritic intrusions with pyritic haloes in the next valley to the northeast of the Bornite pipe but overlapping into the Cedar Creek valley (Stan Dodd, personal communication, 1991). Claim staking, followed by geochemical and geophysical surveys in 1975 and 1976 (Figures 3 and 4), led to the identification of eight soil samples that were anomalously high in copper. Followup magnetic studies showed a low in the vicinity of the high-copper soils (Figure 5). This discovery, coupled with rock chip geochemistry, gave AMOCO personnel a drilling

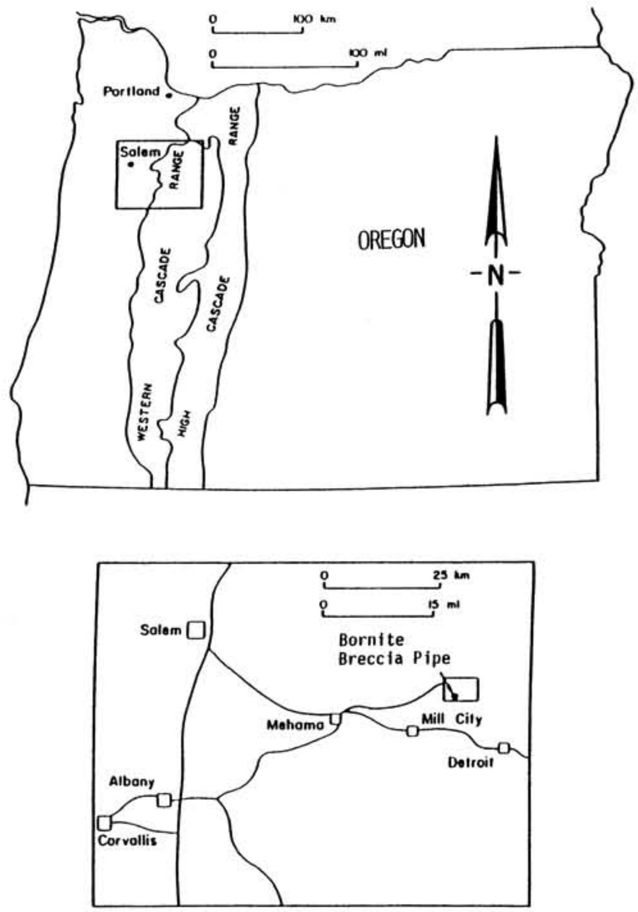

Figure 1. Index map of the North Santiam district and location of the Bornite breccia pipe. Figures 1–11 from Stone (1992).

target. Diamond core hole CC 1 was drilled at a −45° angle but lacked mineralization to explain the geochemistry or the magnetic signature. The drill mast was turned vertically and at 325.7 ft intersected a coarse-grained quartz-chlorite-tourmaline-sulfide breccia that averaged 92 ft of 6.89 percent copper (J. Matlock, unpublished data, 1991). Drilling continued until 1979, but AMOCO quickly realized it did not have a major porphyry discovery but a small high-grade breccia pipe. From 1980 to 1988, AMOCO performed limited drill programs to satisfy the annual claim assessment requirements. Through 1988, AMOCO Minerals (and its successor, Cyprus Minerals) drilled a total of 17,865 ft in 20 core holes and one conventional rotary hole (Figure 6).

Kinross, under its earlier name Plexus, Inc., acquired control of the breccia pipe in a trade agreement with Cyprus Minerals in 1989 and renamed it the Bornite pipe because of the abundance of that copper sulfide mineral. Since then, the company has drilled an additional 16,419 ft of core in 25 angle holes to confirm the geometry and grade estimates (Figure 7). Plexus conducted additional geophysical studies, using a number of contractors to develop a breccia pipe model signature for continued exploration in the district (Figure 8). In July 1991, Kinross filed a Plan of Operations with the USDA Forest Service to initiate an Environmental Impact Study (EIS). In April 1993, the USFS published the Final EIS and Record of

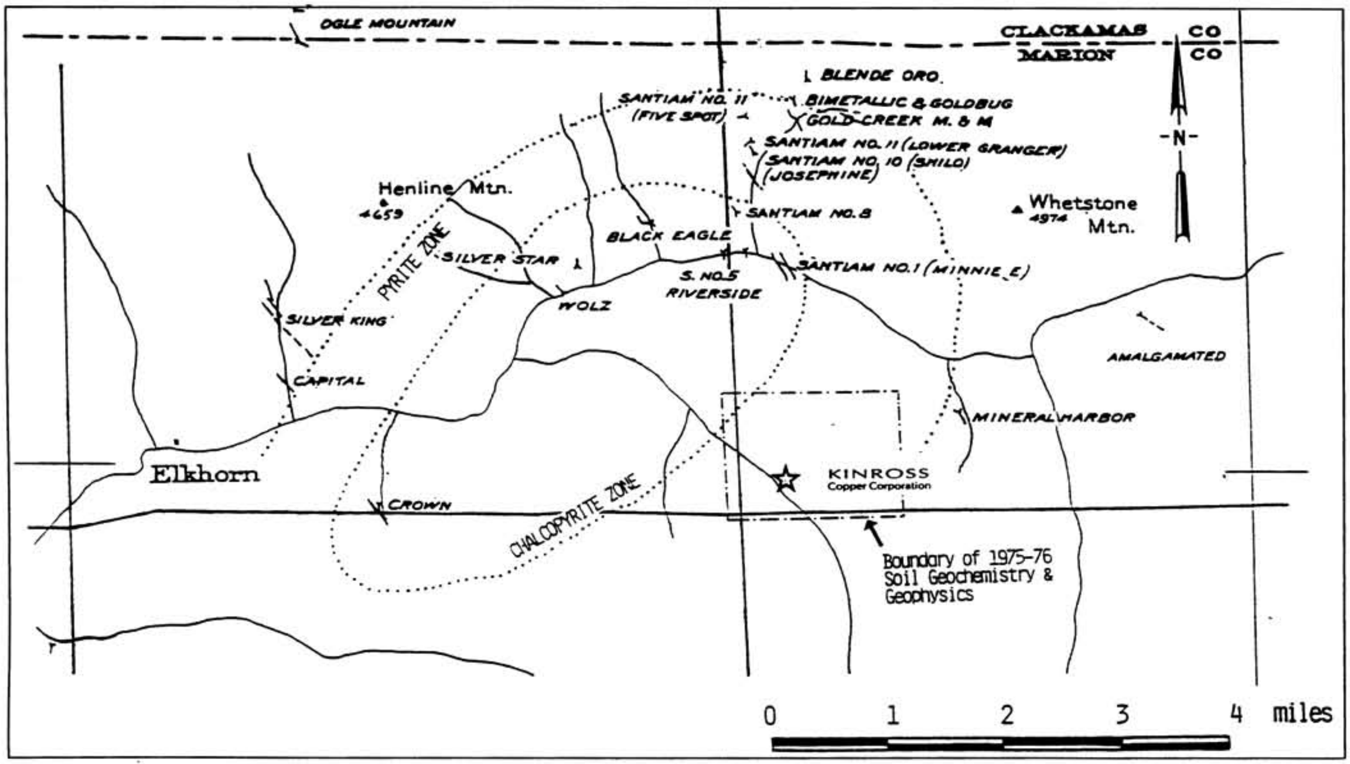

Figure 2. Sketch map of the North Santiam district in 1930–1931, showing location of mining camps and metal zones. After Callaghan and Buddington (1938).

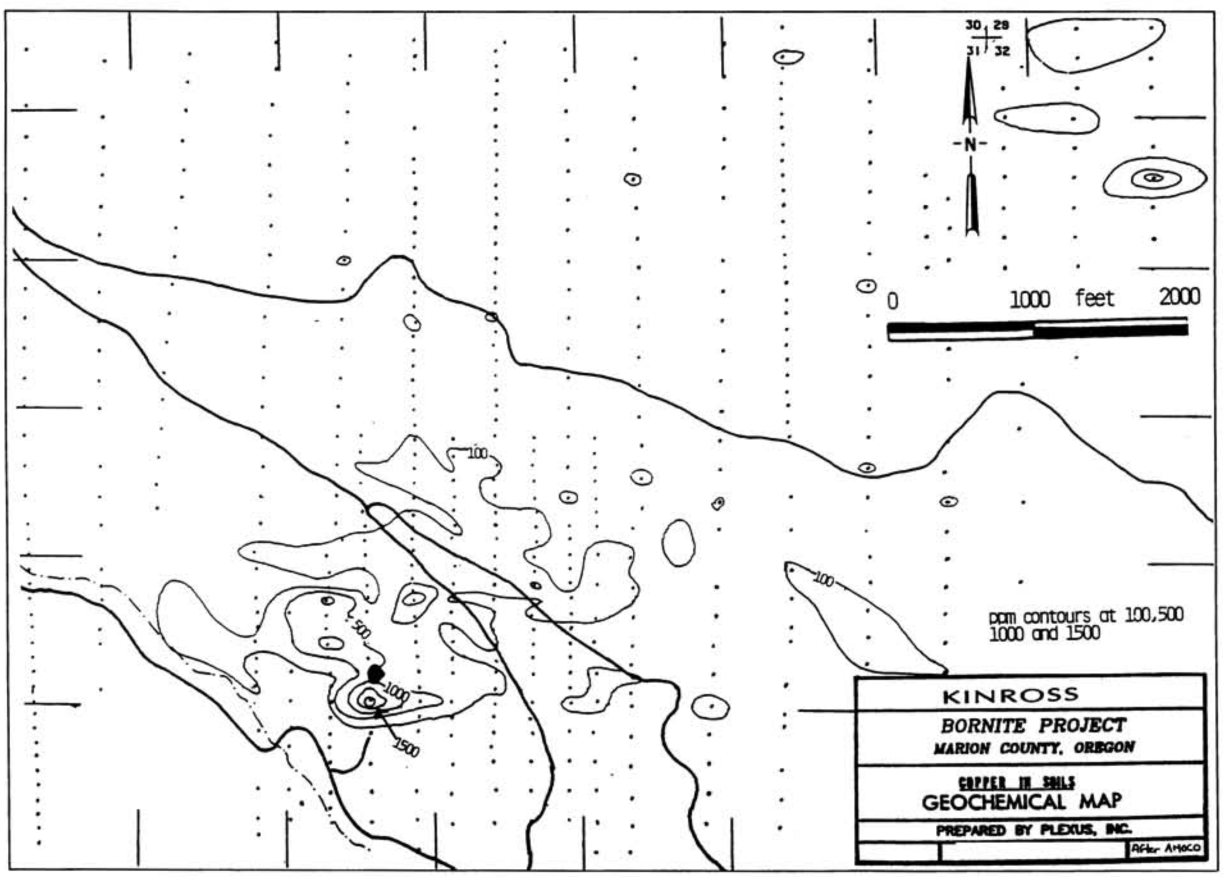

Figure 3. Geochemical survey map showing copper in soils at Bornite project. Contour lines outline 100, 500, 1,000, and 1,500 parts per million (ppm) copper. Heavy lines are roads; dotted lines mark survey grid.

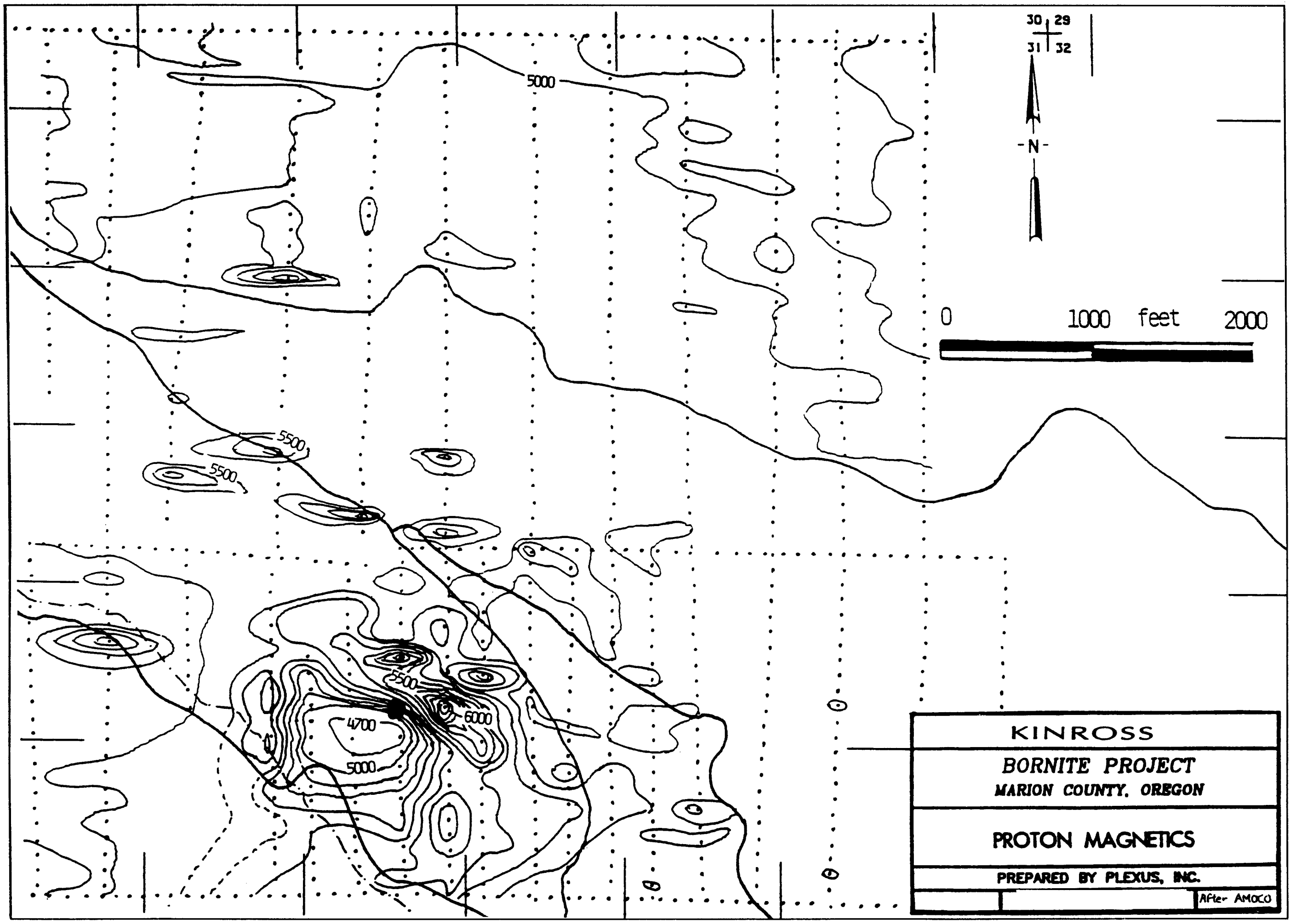

Figure 4. Magnetic survey map of Bornite project, showing gamma contour lines at contour intervals of 100 gammas. For absolute values, 50,000 gammas are to be added to each map value. Dotted lines mark survey grid.

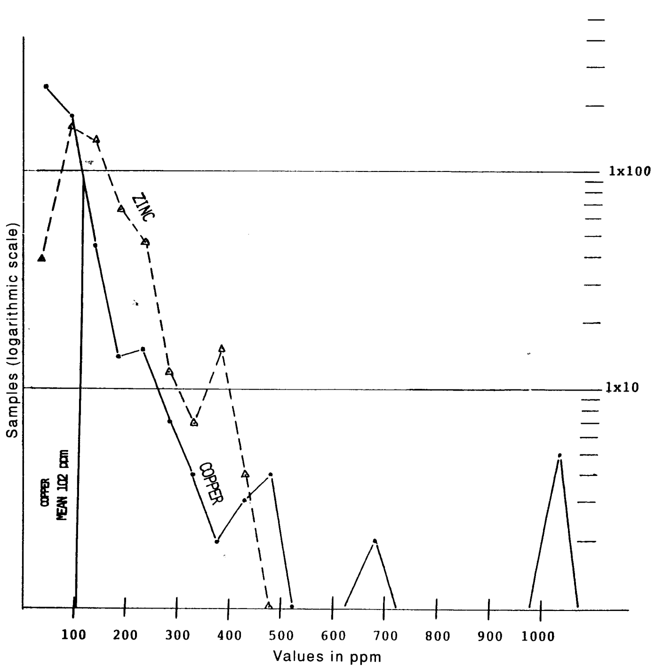

Figure 5. Bornite project copper and zinc soil geochemistry, showing ppm versus number of samples (on logarithmic scale).

Decision to allow the development of a 1,000-tpd underground copper mining operation. Kinross is currently awaiting the final permit from the National Pollution Discharge Elimination System (NPDES) and a decision by the State of Oregon on the use of water.

REGIONAL GEOLOGY

The sketch map in Figure 9 shows the geology of the North Santiam area. Cummings and others (1989) conducted extensive work in the volcanic stratigraphy of the North Santiam mining district. The volcanic stratigraphy is characterized by its complexity in both the horizontal and vertical dimensions. Two stratigraphic sequences have been recognized in the vicinity of the Bornite pipe. The lower sequence has been assigned to the Sardine Formation (Thayer, 1937; Peck and others, 1964) and occurs from the bottom of stream valleys to an elevation of approximately 3,950 ft. The upper sequence overlies the lower sequence across an erosional unconformity. The upper sequence is at least 1,300 ft thick and underlies the ridge crests of the area. This upper sequence includes the Elk Lake formation (McBirney and others, 1974), and the High Creek ignimbrite (Dyhrman, 1975; Hammond and others, 1980). This sequence was deposited on a moderate relief surface eroded into the Sardine Formation.

The Sardine Formation includes andesite flows, andesite lapilli, lithic tuffs, sparse sediments, and intrusions. All lithologies have had some degree of superimposed alteration, which often obscures primary igneous textures. In the eastern part of the North Santiam district, Sardine Formation stratigraphy was divided into Unit A and

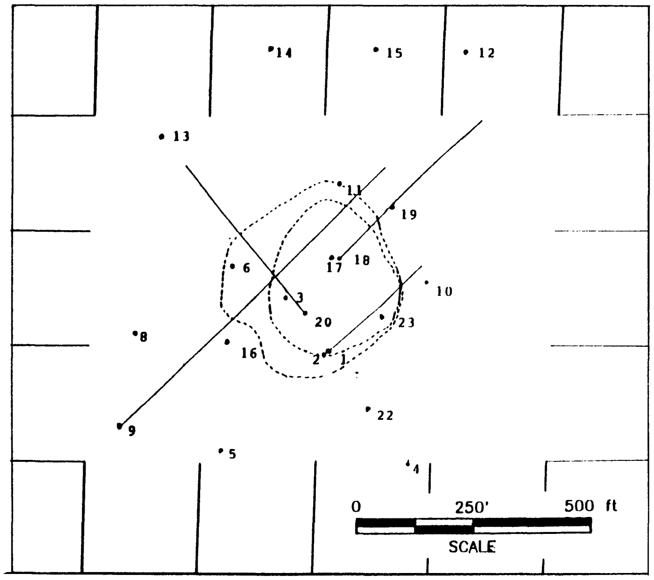

Figure 6. Drilling performed by AMOCO during 1976–1988 at the Bornite pipe, showing locations of 20 core holes and one rotary hole. Not all holes are located within the limits of this map area.

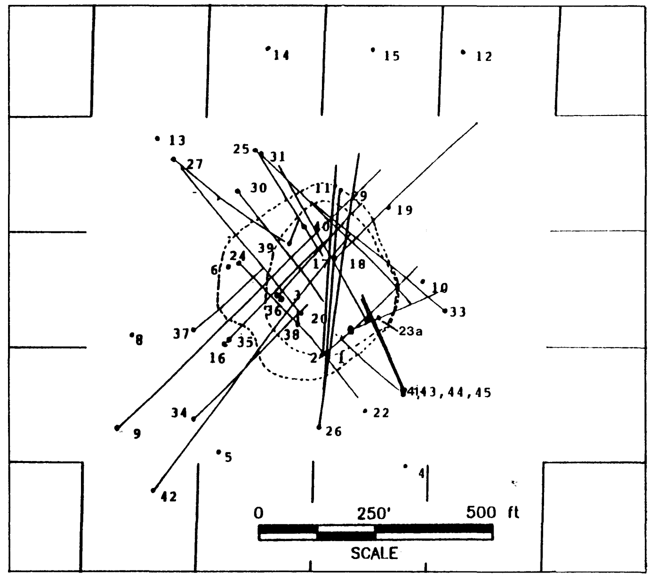

Figure 7. Kinross (formerly Plexus) drilling during 1989–1992, superimposed on Figure 6. Not all holes are located within the limits of this map area. Note general confirmation of earlier findings.

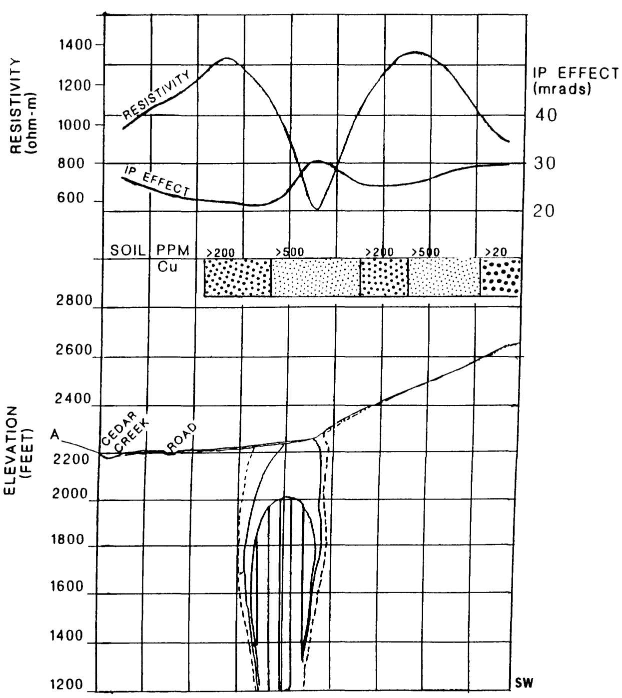

Figure 8. Signatures of induced-polarization (IP) effect and resistivity measurements over the Bornite breccia pipe (top) in relation to soil sample data (below) and the underlying cross section of the same breccia pipe.

Unit B by Pollock (1985). The two units were distinguished by their relative proportions of fragmental rocks and flows. Unit A, the lower unit, consists of andesitic tuffs and tuff breccias, with individual cooling units ranging from 35 to 150 ft in thickness; and Unit B consists of porphyritic andesite flows interbedded with lapilli tuffs. Along Cedar Creek in the vicinity of the Bornite pipe, Unit B is approximately 1,800 ft thick.

INTRUSIVE ROCKS

Two major intrusive rock types have been described in the North Santiam district (Olson, 1978). The first consists of fine-grained dike rocks ranging in composition from basalt to rhyodacite and probably correlative with the Sardine Formation. The second, younger type of intrusions consist of coarser-grained dioritic rocks. These rocks have been subdivided into three main types: (1) Microdiorite; (2) medium- to coarse-grained diorite (Ruth diorite); and (3) a composite intrusive unit (Hewlit granodiorite) consisting of medium- to coarse-grained tonalite, granodiorite, and quartz monzonite.

The diorites and quartz diorites in the vicinity of the Bornite pipe are thought to be correlative with the Hewlit granodiorite, exposures of which have been dated by K-Ar methods at 13.4±0.9 Ma (Power and others, 1981). In the Ruth Mine area, 3.5 mi east-northeast of the Bornite pipe, sulfide deposition occurred at depths exceeding 2,830 ft (900 m) (Pollock, 1985).

Four miles to the southwest of the Bornite pipe, a 5-km (3-mi)-wide zone of dikes extends northwest from the Detroit stock through Rocky Top (Curless, 1991). Intrusive rocks within the adjacent Sardine Creek and Rocky Top areas have mineralogical, textural, and chemical features similar to the spatially and temporally related Detroit stock. The Detroit stock, 7 mi south of the Bornite pipe, is of intermediate composition, having at least five stages of intrusion into volcanic rocks at least as young as early Miocene age (Curless, 1991). Curless' work on the plutonic rocks in the Rocky Top and Detroit Dam area suggests that plutonic hornblende granodiorites were emplaced at a minimum depth of approximately 1,000 m (3,300 ft), whereas the older quartz diorites were emplaced at shallower levels (Curless, 1991). Walker and Duncan (1989) report a whole-rock K-Ar age of 9.94±0.18 Ma for a sample from the Detroit stock. A sample of hydrothermal sericite in the Bornite pipe yielded a K-Ar age of 10.1±0.4 Ma (Winters, 1985), which suggests synchronous emplacement with the Detroit stock to the south.

BORNITE PIPE GEOLOGY

The geometry of the pipe is that of a mineralized ring of copper sulfides (60 percent chalcopyrite, 39 percent bornite; Winters, 1985) up to 450 ft in diameter and 1,200 ft vertically (Figures 10 and 11). Minable widths of the ring approach 30 ft on average. This 30-ft

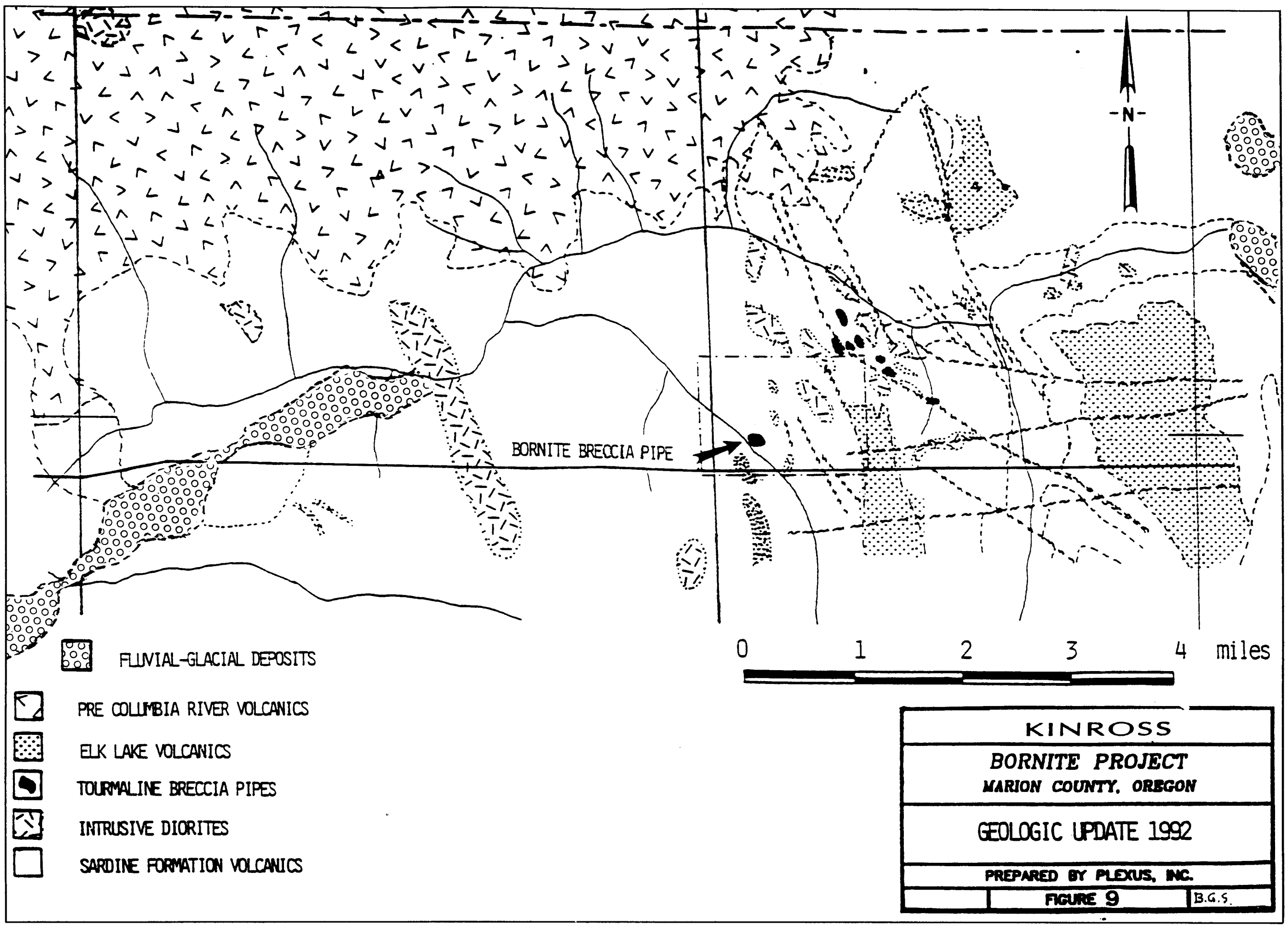

Figure 9. Geologic sketch map of Bornite project area (marked by dot-dash rectangle). Straight dashed lines mark contacts; lines of wiggly dashes indicate faults.

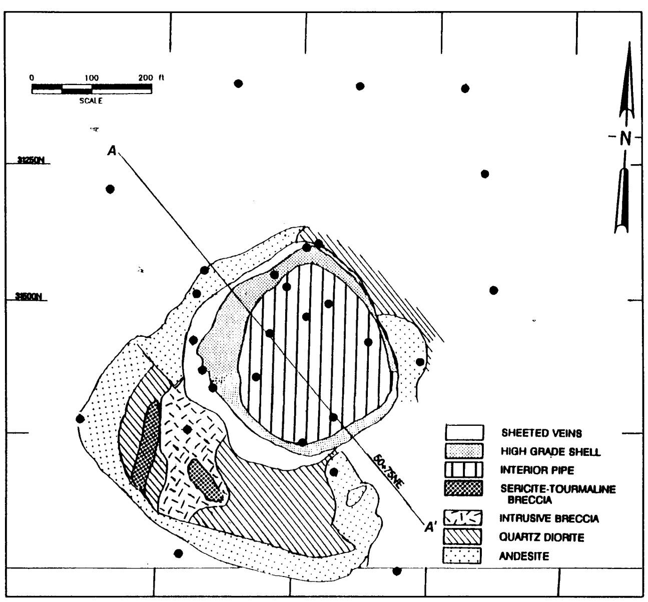

Figure 10. Geologic elevation-level plan of the Bornite breccia pipe at an elevation of 1,800 ft. Dots mark drill-hole piercing points. Line A–A′ indicates orientation of cross section shown in Figure 11.

annular body of quartz-sericite-tourmaline-sulfide surrounds a low-grade to unmineralized diorite to quartz diorite core. The outer edge of the ring has the highest metal values.

Although earlier work suggested formation of the deposit by an intrusive diorite moving towards the surface and creating a strongly brecciated margin that was subsequently mineralized, more recent work suggests that large portions of the core diorite are as brecciated as the sulfide ring, and the only difference is the lack of copper-sulfide mineralization in the core of the brecciated zone.

Several textural types of breccia occur within the Bornite pipe. The most distinctive is a lath breccia where the long dimension of a fragment exceeds the narrow dimension by at least 4:1. The appearance is similar to a shingle breccia in sedimentary rocks and has been called shingle breccia by other igneous-breccia workers (Sillitoe, 1985). Similar textures have been described associated with tourmaline breccia pipes and granodiorite intrusions in the area of Stoney Creek, 1.5 mi northeast of the Bornite pipe (Cummings and others, 1989). Arrangement of the rectangular clasts ranges from parallel to random irregular. Identical breccias may or may not contain copper mineralization. Some of the lath fragments were mineralized with quartz veins prior to being incorporated in the lath breccia, as veins within breccia clasts are truncated at the edge of the fragment (drill hole CC-43). Frequently the parallel orientation of laths gives the appearance of closely jointed rock which has been slightly swelled, and chlorite/sericite/tourmaline fills the joints as a network of veinlets. A long intercept through the diorite may have dozens of discrete lath breccia zones with identical

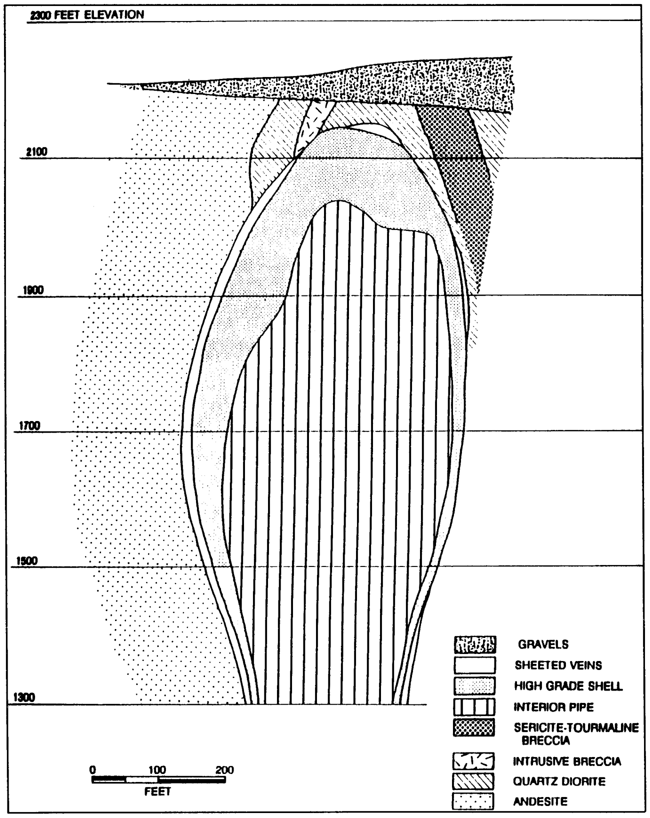

Figure 11. Geologic cross section of the Bornite breccia pipe along line shown in Figure 10 as A–A′.

massive diorite on either side. The lithology of the lath clasts is the same as the unbrecciated diorite on either side.

A second type of breccia is the large-fragment breccia that is clast supported with fragments up to 6 in. long. Matrix material is predominantly crystalline quartz with lesser amounts of tourmaline, sulfide, sericite, and apatite. Quartz in these zones has vug cavities with euhedral quartz and apatite crystals up to 1 in. in diameter. A better description of this would be a vein breccia with the quartz and related crystalline minerals separating the fragments.

Numerous geologists have examined the core over the past 16 years. The mineralized rock is essentially a brecciated diorite with varying amounts of quartz, chlorite, sericite, tourmaline, bornite, and chalcopyrite. Consequently, all sorts of lithologic names have been assigned to what are actually, at the hand-specimen level, variable degrees of alteration.

ALTERATION

Propylitic alteration is ubiquitous in the Cedar Creek valley and in all outcrops surrounding the Bornite pipe. It is weakly pervasive but increases near intrusions, faults, fractures, and vein systems. The alteration assemblage is characterized by a secondary mineral assemblage of epidote ± chlorite ± quartz ± sericite ± calcite ± albite ± hematite ± magnetite ± pyrite, that is not destructive of original textures. Hand specimens show various shades of pistachio and olive green, dependent on the relative amounts of epidote and chlorite. Generally, calcite and epidote replace the plagioclase, while chlorite, calcite, and epidote replace primary mafic minerals. Veinlets containing quartz, calcite, and epidote are common in the propylitically altered rocks. Within the Bornite pipe, calcite veinlets appear to be the final mineralizing event.

In my porphyry copper experience in the western United States, potassic alteration is most commonly associated with strong silicification and is characterized by the conversion of minerals to secondary sericite, potassium feldspar, and biotite. The lack of biotite and potassium feldspar at Bornite and the difficultly of separating the sericite associated with phyllic alteration from what is often associated elsewhere in porphyry copper systems with potassic alteration have caused us to assign the sericite to the phyllic alteration zone. Massive crystalline clusters of bright silver sericite up to 0.10 in. in cross-sections of individual plates are common in the Bornite deposit. Unlike the Black Jack pipe owned by Kinross in the Washougal mining district of Washington, the Bornite pipe lacks obvious potassium feldspar or biotite minerals.

Phyllic alteration is associated with silicification and tourmalinization throughout the Bornite pipe—as texturally destructive sericite replacement of fragments, selvages on veins, and broad haloes on small faults and fractures. In drill core it is ubiquitous as bleached texture-destructive alteration haloes, which, in the diorite, grade outward into the argillic zone where swelling clays preferentially replace plagioclase phenocrysts.

Silification is most commonly defined by the development of crystalline quartz veins with crystal-lined vugs and cavities. Individual quartz crystals up to 1 in. in diameter have been observed in some of these vugs and veins. Similar-size apatite crystals have been observed in the same locations. Multiple periods of quartz mineralization are observed in the cross-cutting relationships found in drill core. At 393.5 ft in drill hole CC-43, a 0.4-in. quartz veinlet with molybdenite centerline and traces of chalcopyrite and bornite is cut perpendicularly by a 0.04-in. chalcopyrite veinlet that contains chalcopyrite only in the portions cutting the diorite. In drill hole CC-45 at 306 ft, a steep 0.08-in. quartz-chlorite-sericite veinlet with bornite centerline cuts and offsets a 0.04-in. quartz vein with bornite centerline. Selvage wall-rock bleaching appears to be mostly associated with the narrower, later veinlet. In drill hole CC-42 at 299 ft., a 0.4-in. vuggy quartz vein is cut by a 0.04-in. chalcopyrite veinlet that is in turn cut by a 0.08-in. carbonate-quartz veinlet. At 201 ft in drill hole CC-43, a 0.20-in. gray quartz veinlet crosscuts a 0.25-in. quartz-chlorite-tourmaline-chalcopyrite veinlet. Quartz veining occurred prior to some of the brecciation, as evidenced by diorite fragments within breccia that contained two ages of quartz veins prior to brecciation (drill hole CC-43 at 477 ft).

Tourmalinization is ubiquitous and displays numerous characteristics in its occurrence. Most commonly, it is in the form of jet-black radial clusters associated with the highest temperature quartz veins. Very commonly, the quartz vein selvages consist of tourmaline altering to a greenish chlorite (drill hole CC-42). Another common occurrence is in the form of large black clots several inches across in the middle of medium-grained diorite, as if they were large xenoliths. Frequently, the bornite and chalcopyrite appear to be preferentially concentrated within the tourmaline clots. Sericite frequently appears to replace the fibrous tourmaline needles, and in places it may be pseudomorphous in the rosette sites. The strong radiating acicular habit of the tourmaline is acquired by its replacement minerals hematite and sericite (drill hole CC-42 at 930 ft). In the clotted form, the tourmaline aggregates form up to 10 percent of the rock mass (drill hole CC-45). Often, the physical appearance of the clots is that of oil drops or paint splatter on the core surface. Tourmalinization without associated sulfide minerals is quite common, even outside the breccia pipe limits, which may indicate more than one period of tourmalinization.

FLUID INCLUSION STUDIES

Microthermometric measurements of 90 samples from eight drill holes were taken by Winters (1985), who distinguished four types of inclusions based on different phase assemblages (Figure 12):

- Type I: Vapor and liquid;
- Type II: Vapor, liquid, and halite (NaCl);
- Type III: Vapor, liquid, NaCl, and sylvite (KCl);
- Type IV: Vapor, liquid, NaCl, KCl, and one or more other solid phases.

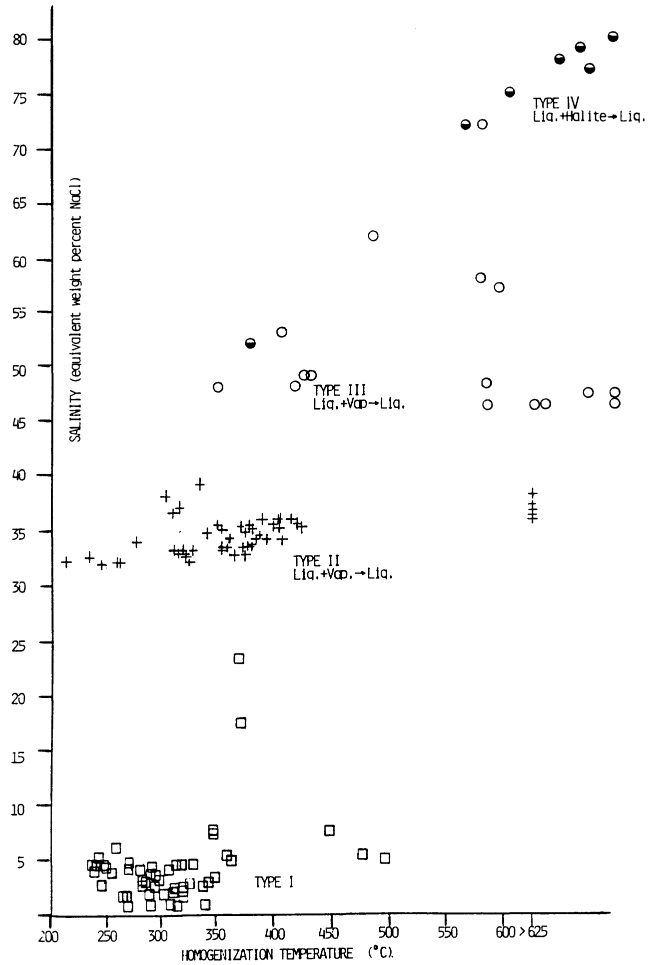

Figure 12. Fluid inclusion data on Bornite breccia pipe, plot of homogenization temperature (°C) versus salinity (equivalent weight percent NaCl). Data from Winters (1985). Inclusion types: Type I = open squares; Type II = crosses; Type III = open circles; Type IV = partially filled circles.

Tentative identification of two of the unknown solid phases were gypsum and anhydrite. Results of the homogenization studies showed the following (summarized in Table 1):

Type I inclusions

A total of 85 measurements in quartz inclusions and 28 in apatite indicated a temperature range of 150° to 300°C for apatite and 225° to 500°C for quartz. No relationship to depth could be determined from homogenization temperatures or salinities.

Type II inclusions

A total of 72 Type II inclusions were examined. All homogenized to liquid by vapor disappearance, with the majority between 300°C and 425°C. Salinity ranged from 31 to 39 equivalent weight percent NaCl. No correlations between homogenization temperature, salinity, and depth were found.

Type III inclusions

A total of 31 Type III inclusions were observed. Seven homogenized by halite disappearance, the remainder by vapor disappearance. Homogenization temperatures ranged from approximately 325°C to >625°C. Total salinities of Type III inclusions are 45 to 80 percent but do not appear to be related to depth.

Type IV inclusions

Measurements were made on 45 Type IV inclusions. Homogenization temperatures ranged from 375°C to 525°C. Heating was continued to 625°C to observe the behavior of anhydrite. No correlation was found between homogenization temperature, salinity, and depth.

Table 1. *Summary of the results of fluid inclusion studies*

Type	Temperature (°C)	Composition (equivalent weight percent NaCl)	Pressure (bars)
I	225–500	0–23	220–800
II	212– +625	31– +65	20–875
III	327– +625	45–80	50–175
IV	384–529	n.d.	n.d.

The results of fluid inclusion study suggest three generations of inclusions indicative of three different hydrothermal events (Winters, 1985). Core logging and thin section studies support multiple phases of mineralization (Summers, 1991). Summers' work showed homogenization temperatures of 224° to 300°C for Type I inclusions with salinities of 1.2 to 5.1 weight percent NaCl equivalent associated with sulfide-bearing veins. Type III inclusions homogenized at >490°C, the upper limit of Summers' microthermometry equipment, and were associated with quartz-tourmaline veins. Minimum pressure of formation was estimated at >300 bars.

SULFUR ISOTOPE STUDIES

The four naturally occurring isotopes of sulfur fractionate in response to physical and chemical processes acting upon them. The most abundant of the isotopes are ^{32}S and ^{34}S. Compositions are given by conventional per mill (parts per thousand) notation with respect to ^{34}S in the meteorite standard: positive values represent enrichments of ^{34}S in per mill, and negative values represent depletions of ^{34}S in per mill, relative to the standard. In hydrothermal systems, these fractionations are preserved as small differences between the isotopic compositions of coexisting sulfide minerals and large differences between coexisting sulfate and sulfide minerals (Summers, 1991). Summers' work looking at sulfides from a variety of Cascade breccias did not include any isotope samples specifically from the Bornite breccia pipe, but Cyrus Field of Oregon State University has documented the values shown in Table 2 below from the Bornite pipe (personal communication, 1994):

Table 2. *Bornite pipe sulfur isotope data by Cyrus Fields (unpublished data, 1994)*

Drill hole	At depth (ft)	Description	$\delta^{34}S$ percent
CC-3	520	Chalcopyrite veinlet; bornite in veinlet	+4.19 +5.03
CC-3	500	Chalcopyrite in breccia; bornite in breccia	+1.65 +4.77
CC-2	796	Chalcopyrite in breccia; bornite in breccia	+4.58 +3.94
CC-17	1,600	Chalcopyrite	+4.85
CC-2	362	Bornite in breccia	+3.81
CC-2	382	Chalcopyrite in breccia bornite in breccia	+4.10 +3.90

These values are consistent with a magmatic sulfur source in hydrothermal fluids dominated by a reduced sulfur species (S^{2-}, HS^-, H_2S).

STRUCTURE

The geology of the Bornite pipe is obscured by a glacial-colluvial cover of coarse sandy gravel up to 140 ft thick. Drill site excavations on the north side have exposed the top portion of the tourmaline-sulfide breccia. The field evidence indicates a fine-grained, clay-rich till layer approximately 6 in. thick immediately on top of fresh sulfides. Oxidation of the sulfides extended only 2 in. below the till, indicative of a relatively impermeable barrier to downward migrating meteoric water.

Mapping of joint patterns at the outcrop and in the Cedar Creek river channel on the south side show that the dominant orientation of joints is N. 20°–30° W. The district photo-linear pattern for the area shows the predominant orientation of N. 40°–50° W. (Venkatakrishnan and others, 1980) (Figure 13). Small gouge and brecciated structural zones occur throughout all core holes but are minor in quantity, as is reflected by high recovery and high RQD values for all holes.[1] The orientation of these minor structures may be expected to mirror surface patterns of structures, but final details must await development of the deposit. Projection of ore contact boundaries and grade over hundreds of feet with validity checks by subsequent drilling suggests that structural offsets within the breccia pipe are minor.

[1] *Recovery and rock quality designation (RQD) measure quality and structure of rock. In simplified terms, recovery is the percentage of core length recovered from the total length of a drill run; RQD is the percentage of core consisting of pieces 4 in. or longer in such a run.*

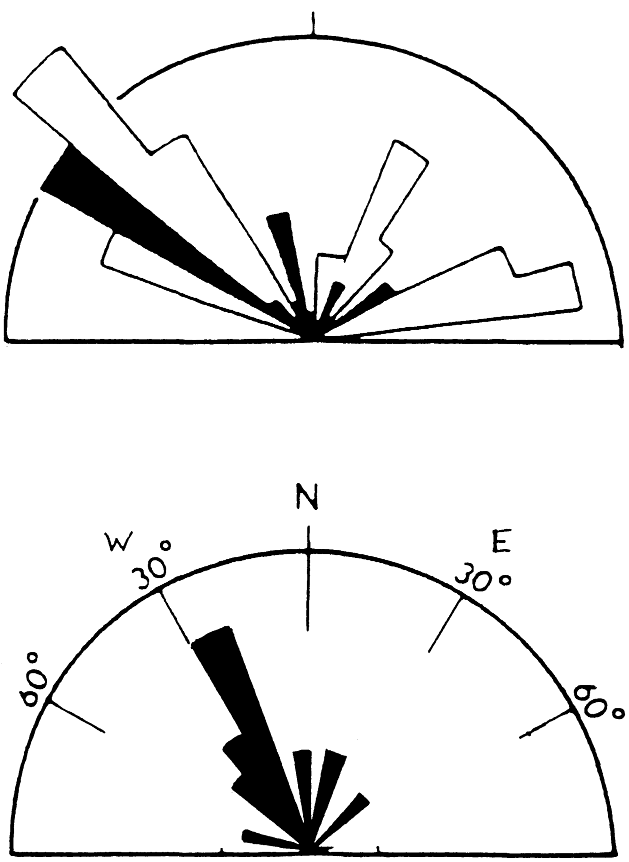

Figure 13. Rose diagrams showing photolinear patterns. Top: Frequency of linears between Detroit Lake and Whetstone Mountain after Venkatakrishnan and others (1980). High-altitude U-2 infrared linears shown as open radials; side-looking radar (SLAR) radials are darkened. Bottom: Joint frequency of Bornite breccia pipe and adjacent Cedar Creek areas.

GEOCHEMISTRY

The discovery of the Bornite breccia pipe was the result of the application of soil geochemistry prospecting technology in 1976, which identified B-horizon copper values exceeding 20 times background. The pipe has an obvious copper signature as well as a less developed molybdenum signature in soils. Construction of monitoring wells in 1991 by Kinross has led to the analysis of water in both bedrock and colluvium on a quarterly basis. The boron content of the bedrock water is the only element that shows a spatial relationship to the breccia pipe. Wells closest to the pipe have the highest boron values (in range of 0.1 ppm B).

Hundreds of assays on core provide ranges to trace element geochemistry as shown in Table 3.

Table 3. *Trace element geochemistry of the Bornite breccia pipe*

Element	General range (ppm)	Maximum value (ppm)
Lead (Pb)	50–150	2,000
Zinc (Zn)	150–500	14,500
Molybdenum (Mo)	20–100	8,000
Bismuth (Bi)	50–200	2,600
Arsenic (As)	15–250	2,600
Antimony (Sb)	1–20	450
Mercury (Hg)	<10–20	3

The sulfide composition of the breccia pipe consists of 60 percent chalcopyrite and 39 percent bornite (Winters, 1985), while the remaining sulfides total 1 percent. Tetrahedrite is the arsenic/antimony sulfosalt found in some vugs and cavities in the copper zone. Gold and silver occur as electrum grains in bornite with dimensions up to 0.08 in. across (Plexus, unpublished data, 1989). Sphalerite and galena appear to be associated with later stage carbonate mineralization and not the copper sulfide mineralization (Summers, 1991).

WHOLE ROCK CHEMISTRY

Twenty samples were sent for whole rock analysis by Bondar-Clegg at the company's Toronto lithology laboratory, where borate fusion and induction coupled plasma (ICP) methods were used (Table 4). The high copper content of many of the mineralized breccia samples caused total values of major oxides and loss on ignition (LOI) to be substantially lower than 100 percent. Three samples represent the quartz diorite intrusion, four samples the host andesite, and the remaining 13 samples the mineralized breccia. Overall mineralization effects suggest a decrease in CaO, Na_2O, and SiO_2 compared to the host andesite and intrusive diorite, but an increase in Fe_2O_3, MgO, K_2O, MnO, and copper, the economically most important. Table 5 presents the statistics for the economic metals copper, silver, and gold in the assay record of all drillholes in the Bornite pipe.

CONCLUSION

Petrographic, textural, fluid inclusion homogenization, and geochemical studies indicate that the Bornite breccia pipe was the locus of multistage mineralization leading to the economic concentration of copper sulfides. The time span involved in the events of the hydrothermal alteration is as yet unknown, as is the mechanism of formation of a cylinder of sulfide mineralization. The author's experience with chalcopyrite-magnetite concentration at the cúpola of a quartz monzonite porphyry intrusion in the Yerington pit (Lyon County, Nevada) suggests a possible similar mode of formation wherein the rising diorite created a fracture zone of cylindrical proportions above an intrusive cupola. The fracture zone became the depositional site for volatiles including copper emanating from the cooling magma.

Table 4. *Whole-rock analyses of samples from the Bornite breccia pipe, by Bondar-Clegg Laboratories*

HOLE NO	SAMPLE	FOOTAGE	ROCK TYPES	Elements SiO_2 Pct	TiO_2 Pct	Al_2O_3 Pct	Fe_2O_3 Pct	MnO Pct	MgO Pct	BaO Pct	CaO Pct	Na_2O Pct	K_2O Pct	LOI Pct	Elements Cr_2O_3 Pct	P_2O_5 Pct	Total Pct	S Tot Pct	Pb Ppm	Cd Ppm	Hg Ppm	As Ppm	Cu Ppm
CC-17	18752	484	Quartz Diorite	63.91	0.55	14.98	4.73	0.47	2.60	0.077	3.80	2.66	1.28	4.99	0.02	<0.03	100.07	0.11	473	3.5	0.132	1.2	1874
CC-17	18753	888	Mineralized Breccia	68.47	0.44	12.10	5.05	0.26	2.36	0.057	2.77	0.66	2.16	4.41	0.03	0.27	99.04	0.03	69	1.7	0.107	0.7	148
CC-17	18754	1727	Quartz Diorite	64.02	0.39	13.92	4.56	0.39	1.72	0.045	3.89	0.16	3.25	5.48	0.02	<0.03	97.84	0.17	114	0.3	0.084	2.2	1473
CC-18	18802	238	Andesite	65.68	0.58	14.80	5.65	0.06	2.14	0.033	4.07	3.06	1.06	1.85	0.02	<0.03	99.00	0.18	14	<0.2	0.118	1.8	1603
CC-18	18803	294	Quartz Diorite	66.15	0.51	14.41	3.51	0.18	1.94	0.025	3.37	2.87	0.89	4.68	0.03	0.12	98.68	0.04	7	<0.2	0.070	0.6	433
CC-18	18804	24	Mineralized Breccia	69.29	0.60	10.39	7.71	0.20	1.50	0.047	0.70	0.07	2.64	5.76	0.04	<0.03	98.95	2.10	32	0.3	0.104	50.0	24500
CC-18	18805	106	Mineralized Breccia	59.07	0.69	11.62	10.88	0.51	1.78	0.031	0.83	0.05	2.73	7.59	0.04	<0.03	95.82	3.20	52	3.8	0.123	877.7	34100
CC-28	19626	178	Mineralized Breccia	59.12	0.69	16.14	6.63	0.21	1.76	0.074	0.50	0.08	4.67	6.06	0.02	<0.03	95.95	0.75	70	<0.2	0.011	7.2	15934
CC-28	19627	243	Mineralized Breccia	63.50	0.89	13.73	6.79	0.17	2.05	0.054	0.47	0.09	3.73	6.31	0.03	<0.03	97.81	0.76	16	<0.2	0.019	23.2	8114
CC-30	17048	263	Andesite	65.22	0.58	14.83	5.11	0.15	1.22	0.070	1.50	0.13	4.07	4.95	0.03	<0.03	97.86	1.50	23	0.3	0.068	8.7	17932
CC-30	17049	321	Mineralized Breccia	68.28	0.48	11.24	6.24	1.10	1.59	0.052	0.50	0.07	3.03	4.63	0.03	<0.03	96.24	2.27	54	2.4	0.099	3.4	37600
CC-30	17050	564	Mineralized Breccia	55.40	1.01	12.65	8.74	0.80	5.24	0.055	3.45	0.12	1.99	7.14	0.03	<0.03	96.63	0.41	139	0.4	0.072	1.4	8941
CC-32	16887	613	Mineralized Breccia	39.57	0.95	13.15	24.47	0.88	5.18	0.014	1.46	0.04	0.78	6.58	<0.01	<0.03	93.07	4.86	46	1.2	0.031	27.0	48800
CC-32	16888	636	Mineralized Breccia	42.16	0.92	15.73	13.30	0.83	5.91	0.044	5.52	0.04	2.22	6.51	0.02	<0.03	93.20	2.87	6920	68.8	0.054	5.7	35700
CC-42	16760	307	Andesite	54.27	0.92	23.37	2.34	0.04	1.40	0.029	4.65	6.61	1.47	3.62	0.01	<0.03	98.73	0.13	4	<0.2	0.088	5.0	2013
CC-42	16761	674	Andesite	68.00	0.42	14.03	2.95	0.17	1.39	0.029	3.35	2.59	1.97	4.49	0.02	<0.03	99.41	0.15	4	<0.2	0.113	1.6	1905
CC-42	16762	705	Mineralized Breccia	55.94	0.70	14.25	7.34	0.29	4.00	0.044	3.03	0.61	2.69	7.02	0.03	<0.03	95.94	1.00	53	1.9	0.085	1.6	21600
CC-42	16763	742	Mineralized Breccia	49.47	0.53	11.48	14.34	0.73	5.12	0.029	3.85	0.04	1.36	10.44	0.03	<0.03	97.42	1.69	302	3.3	0.097	6.8	17187
CC-44	16920	335	Mineralized Breccia	32.27	0.50	18.43	19.20	0.57	4.95	0.092	0.92	0.03	2.18	18.21	0.02	<0.03	97.37	1.40	75	2.5	0.011	8.6	19780
CC-44	16921	393	Mineralized Breccia	71.74	0.57	14.42	3.54	0.08	1.48	0.064	0.46	0.24	2.83	3.59	0.03	0.23	99.27	0.04	13	<0.2	0.068	4.5	327

Table 5. *Bornite summary assay values. Copper values in percent, silver and gold values in ounces per ton*

	ALL ASSAYS			HIGH GRADE SHELL		
	COPPER	SILVER	GOLD	COPPER	SILVER	GOLD
Number of Assays Determined	2760	2724	2708	264	264	264
Number of Assay Values Trace	2665	2335	652	264	264	264
Maximum	23.48	5.43	0.3780	23.48	5.43	0.2280
Minimum	0.00	0.00	0.0000	0.26	0.030	0.0000
Range	23.48	5.43	0.3780	23.22	5.40	0.2280
Total	1732.01	432.043	11.0090	940.23	187.93	6.6540
Mean	0.6275	0.1586	0.0041	3.5615	0.7119	0.0252
Variance	2.042	0.1347	0.3595 E-03	8.945	0.6474	0.001995
Standard Deviation	1.429	0.3670	0.1896 E-01	2.991	0.8046	0.04467
Geometric Mean	0.1955	0.0607	0.0071	2.6904	0.3848	0.0135

	SHEETED VEIN			INTERIOR PIPE		
	COPPER	SILVER	GOLD	COPPER	SILVER	GOLD
Number of Assays Determined	113	113	113	768	751	751
Number of Assay Values Trace	113	112	91	751	714	219
Maximum	9.00	2.380	0.0950	7.830	2.200	0.2720
Minimum	0.19	0.000	0.0000	0.000	0.000	0.0000
Range	8.81	2.380	0.0950	7.83	2.200	0.2720
Total	124.12	39.77	1.1860	394.35	137.851	1.9660
Mean	1.0984	0.3519	0.0105	0.5135	0.1836	0.0026
Variance	0.8977	0.1321	0.0001999	0.4965	0.07375	0.0001605
Standard Deviation	0.9475	0.3634	0.01414	0.7046	0.2716	0.01267
Geometric Mean	0.9109	0.2356	0.0092	0.2413	0.1008	0.0046

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The author would like to thank specific individuals whose background and experience in the district have contributed significantly to the current knowledge about the Bornite breccia pipe. Jim Matlock collared the discovery hole, drill hole CC-2, in 1976, and his recollections of the experience and methodology leading to the discovery were very helpful. Jim Garmoe was a personal mentor early in this author's career and was responsible for the Kinross (Plexus at the time) view that the deposit was a volcanic breccia pipe similar to Los Pilares in Mexico—a deposit on which he had done extensive work years ago. Greg Gosson and Stan Dodd were Plexus geologists who established much of the framework from which

current ore reserve estimates and geologic models have been built. Cyrus Field and his students at Oregon State University have contributed geologic input into the economic geology of the Bornite pipe. Cy Field's personal enthusiasm has been a constant encouragement. Michael Cummings and his students at Portland State University have contributed much to unraveling the complex volcanic geology of the Western Cascades and the area immediately to the east of the Bornite pipe. Mike Cumming's discussions on the deposit have helped in the science and public-relations issues we have dealt with over the past few years. My thanks also go to Frank Hladky of the Oregon Department of Geology and Mineral Industries for encouraging the publication of our scientific work and, once again, Mike Cummings and Cy Field for reviewing this paper.

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No Name Caves in southwestern Oregon are now under BLM care

by Kathleen Murphy, Oregon Department of Geology and Mineral Industries, Grants Pass field office, with photos by John Dutcher, U.S. Bureau of Land Management, Medford, Oregon

The U.S. Bureau of Land Management (BLM) recently traded 41 acres of timber land to Brazier Forest Industries in exchange for 758 acres of Brazier property in southwestern Oregon, thus acquiring several caves that BLM plans to make accessible and enjoyable for the general public. Most noteworthy among these caves are the two caves this author visited, No Name Cave and Lake Cave (often together called the No Name Caves), of which No Name Cave is considered the second longest limestone cave in Oregon—after Oregon Cave in the Oregon Caves National Monument.

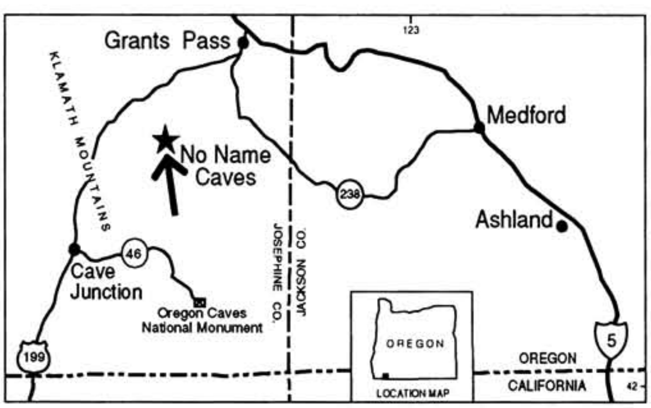

Figure 1. Location of No Name Caves (arrow).

The caves have been known for some time but were accessible without control and have suffered from vandalism and illegal garbage dumping. BLM will include the caves in its ecosystem management plans to protect the uniqueness of the caves and possibly existing bat colonies or other wildlife in them, while making the area available for public enjoyment. Long-range plans may include a picnic area, signs with maps, a day-use parking area, a lookout tower, trails to the caves, and perhaps guided tours. Natural Resource Specialist John Dutcher of the BLM Medford office was kind enough to offer himself as guide for a tour of the caves.

Located in the mountains near Grants Pass (Figure 1), the caves are nestled in the forest, with beautiful meadows nearby. Geologically, much of this part of southwestern Oregon is made up of mainly sedimentary rocks that are known as the Applegate Formation and contain extensive lenses (an area totaling 4,000–5,000 acres) of limestone. Erosion of the limestone has produced the many caves in this area and the wonders inside them.

The two caves are on a south-facing slope (Figure 2). The upper (No Name) cave contains a well-decorated series of large chambers; the lower (Lake) cave is quite a bit smaller, somewhat barren of formations, and subject to flooding. Total distance between the two cave entrances is about 750 ft. The year-round temperature inside the caves is about 40°F, not affected by any wind. Colors seen in the caves are red, white, black, chocolate brown, and orange. Although

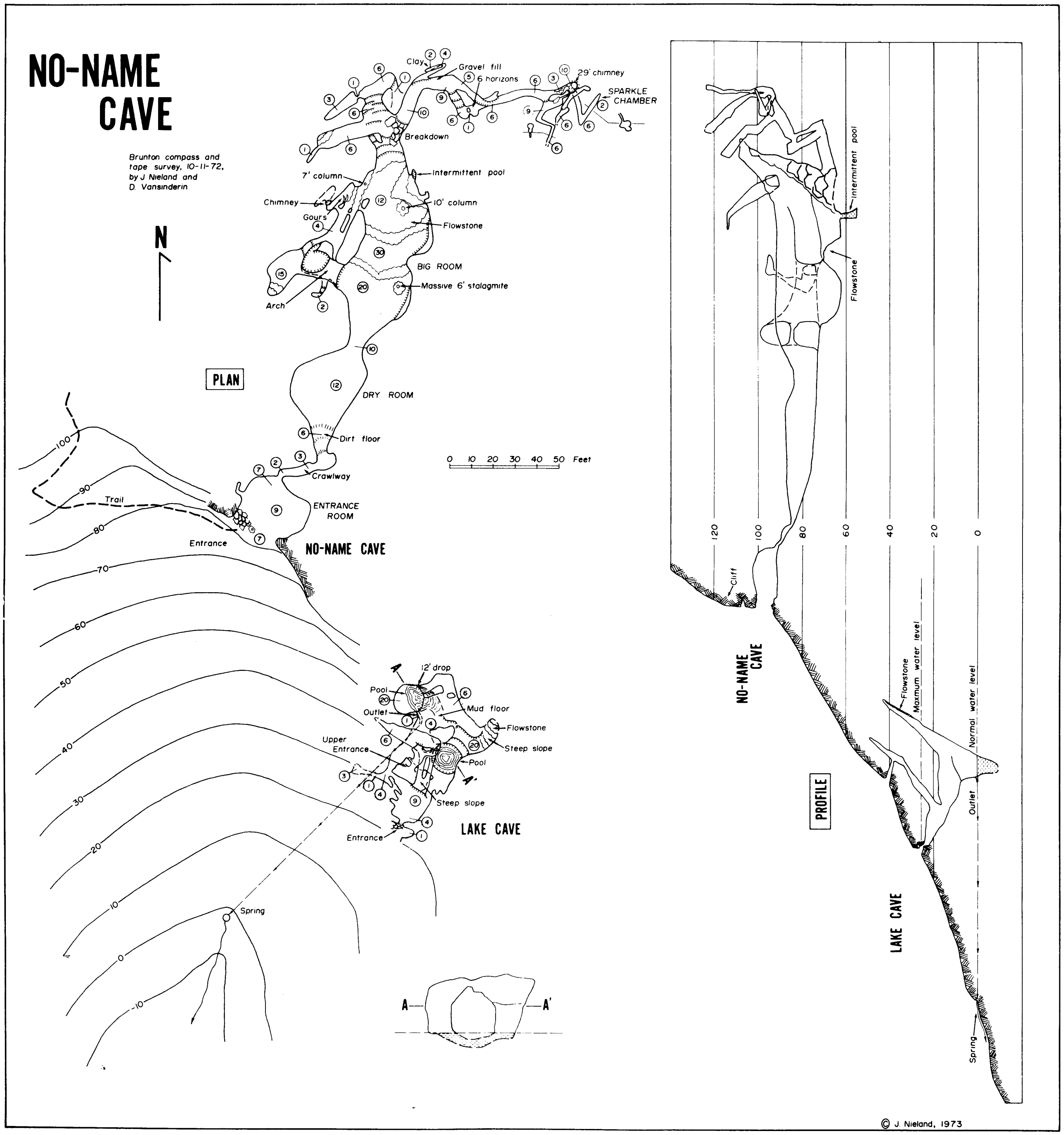

Figure 2. Maps of No Name Caves in plan view and profile, drawn by J. Nieland. Reproduced, with permission, from "Caves of Oregon," Bulletin 4 of the Oregon Speleological Survey, copyright 1975 by Charlie and Jo Larson, Vancouver, Washington. Originally prepared for use by the Audio-Visual Aids Committee of the National Speleological Society. Circled numbers of plan view are ceiling heights in feet.

we did not see much water, we could hear dripping. We did not see any animals in the caves. It was sad to see that quite a bit of vandalism has damaged the caves, and we saw one large trash bag full of litter being carried out.

To enter No Name Cave (Figure 3), you must crawl about 50 ft through a 3-ft-diameter tunnel that slopes downward. You end up in a large chamber, where it is possible to stand up. I was struck by the utter quietness and the still air. Once inside the cave, we did not see any sources of light except where we had come in, which led us to believe that only this one entrance exists. We traveled approximately 220 ft back into the large cave and went into several chambers, which required a moderate amount of climbing and squeezing through narrow openings. At first, I found it very hard to overcome my fear of entering underground confined places, but once I was inside and found everything so different and beautiful and fascinating, I found it just as easy to lose and forget that fear.

Figure 3. Entrance to No Name Cave.

Figure 5. Closeup of formations such as shown in Figure 4.

Being in a cave is like being in a different world, with colorful, unfamiliar forms everywhere around. Specific names have been given to many of these forms created by the movement of mineral-laden water: We saw "flowstone," a coating on the floor or the walls that consists of a sheet of calcium carbonate deposited by slowly flowing water. As it accumulates, it assumes forms that closely resemble masses of ice or large, impressive cascades in stone. "Rimstone pools" are basins with a rim built up of calcite precipitated from slowly overflowing water. "Bacon-rind drapery" is a type of "dripstone" (Figure 4) that projects from the cave wall and ceiling in thin, translucent sheets, sometimes with parallel colored bands. In some places, several rows of such draperies were hanging from the ceiling, and they looked like huge tobacco leaves lined up (Figure 5). "Soda straws" are hollow, tubular "stalactites" (mineral forms like icicles hanging from the ceiling). "Stalagmites" are conical mineral deposits growing upward from the floor through the action of the dripping water. One of these was so huge that it reminded me of Jaba the Hut, a character in *Star Wars*.

The cave also contained columns (Figure 6), which are formed by the union of a stalactite with its complementary stalagmite. One such column was 30 ft high and 2 ft in diameter. We encountered white gypsum as a crust on the rock surface. "Grape" formations in the caves are clusters of smooth, nodular, microcrystalline calcite; each cluster has a lumpy surface, resembling a bunch of grapes. We also saw "scallops" that consist of mosaics of small, shallow, intersecting hollows formed on the surface of soluble rock by turbulent dissolution (i.e., uneven dissolution caused by moving water). These hollows are steeper on the upstream side; the smaller ones were formed by faster flowing water. "Pendants," closely spaced groups of solutional remnants, were hanging from the ceiling.

Lake Cave (Figure) was easier to enter, and we were able to walk in. Almost as soon as we had entered, we came to a hole that went down about 40 ft into a chamber apparently about 20 ft across. We were not equipped with climbing gear, so we did not venture down but began to look around. Because it was slippery, we had to step carefully so as not to fall down the deep hole. We climbed up on a ledge and saw small openings too difficult to enter. This cave was not as colorful and did not have as many interesting formations as the large No Name Cave.

Visiting caves is a beautiful experience but also a dangerous one if you do it unprepared. Some tips for going into caves:

- Never go into a cave alone, and always stay with your group.
- Never go without letting someone know where you are going and when and where you expect to return.
- Step carefully and cautiously, and be prepared to get very dirty.
- Take plenty of lights (my flashlight went out after two hours). Carry three separate light sources, all with fresh batteries.
- Wear a hat; knee pads are helpful when you crawl; gloves can protect your hands from sharp rocks; and hiking boots give sure footing on slippery surfaces.
- For the No Name Caves, make sure you have current information about access. Some trails may lead you to private land and locked gates.

For information about the No Name Caves contact John Dutcher, U.S. Bureau of Land Management, 3040 Biddle Road, Medford, OR 97504, phone (503) 770-2277. □

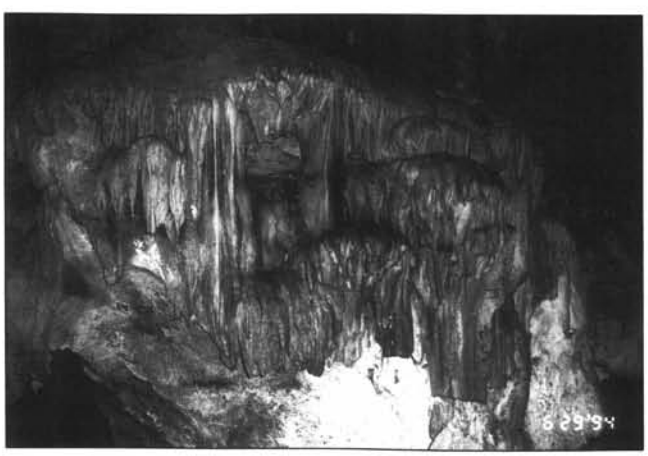

Figure 4. Dripstone with draperylike features.

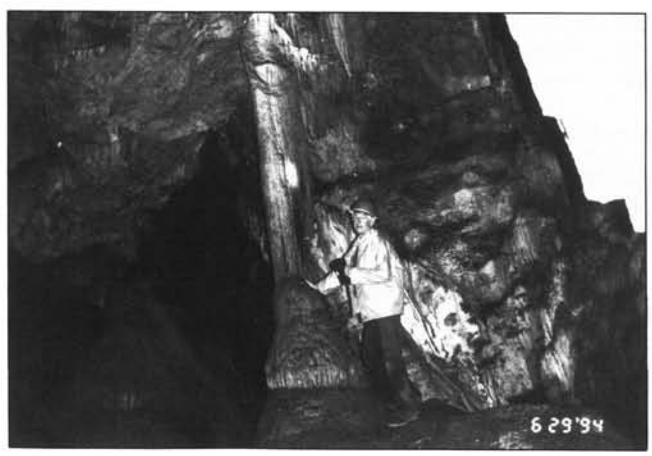

Figure 6. Column formed when stalactite and stalagmite meet.

Loma Prieta damage largely attributed to enhanced ground shaking[1]

by Thomas L. Holzer, U.S. Geological Survey, 345 Middlefield Road, MS 977, Menlo Park, California 94025-3591

INTRODUCTION

Earthquake hazards are commonly treated independently by Earth scientists, yet when a large earthquake occurs, property losses are seldom totaled separately for each earthquake hazard. Four years after the 1989 Loma Prieta earthquake rolled through northern California, a quantitative answer to the following question is not yet available: How much damage was caused by ground shaking, liquefaction, landslides, tectonic ground rupture, or tsunami?

Although the consequences of one earthquake do not necessarily follow for others, an answer to this question will help guide public policy and set research priorities. The cost effectiveness of earthquake hazard mitigation can be improved when the relative significance of earthquake hazards is known, because it enables public agencies to concentrate mitigation efforts on the most portentous hazards.

An answer also encourages cost-effective, problem-focused research by providing a rational basis for allocating research dollars. This is particularly timely because congressional reauthorization of the National Earthquake Hazards Reduction Program is currently under debate. A congressionally mandated review of the program criticized its lack of coordinated programmatic strategic planning, which would direct its resources into efforts that are priority-ranked and problem-focused. The program review also emphasized a need for greater incentives to implement earthquake risk reduction measures. Identifying the relative importance of earthquake hazards helps set priorities for both problem-focused research and implementation.

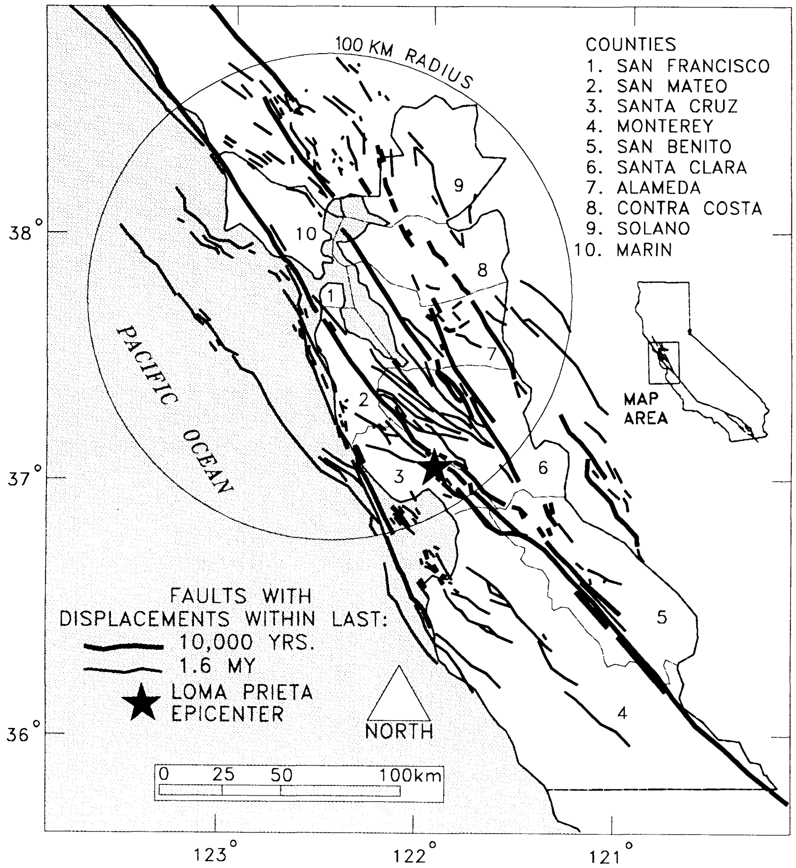

Figure 1. Map of counties that suffered property damage from the Loma Prieta earthquake and faults that offset Holocene and Quaternary sediments. The 100-km (62-mi) circle encompasses the region in which magnitude 7 earthquakes might cause significant damage to parts of the San Francisco city and county that are prone to enhanced ground shaking.

THE 1989 LOMA PRIETA EARTHQUAKE

The moment magnitude 6.9 Loma Prieta earthquake, which hit at 5:04 p.m. PDT on October 17, 1989, was the largest earthquake to shake the San Francisco and Monterey Bay areas since the great San Francisco earthquake of 1906 (Figure 1).

Ground shaking from the earthquake was felt over an area of more than 1,000,000 km^2, and damaging ground motions were observed at epicentral distances of approximately 100 km along selected azimuths (Plafker and Galloway, 1989). Damaging liquefaction and landsliding were triggered at similar epicentral distances. Large ground cracks—not related to shallow downslope movements—occurred in the epicentral region and damaged houses, roads, and underground utilities. In addition, a small but nondamaging tsunami was observed at Moss Landing on Monterey Bay.

The earthquake caused 63 fatalities and 3,757 injuries (McNutt, 1990). At least 12,000 people were displaced from their homes. Physical losses included damage to 23,408 private homes and the destruction of 1,018. In addition, 3,530 commercial buildings were damaged, and 366 were destroyed. Three bridges suffered collapses of one or more spans, and major port and airport facilities experienced significant damage. Electrical service was interrupted to approximately 1.4 million customers, and normal gas service was interrupted to 150,000 customers, about 90 percent of whom turned off their gas supply after the earthquake.

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COST OF THE EARTHQUAKE

The California State Office of Emergency Services (OES) estimated that the losses associated with direct property damage and disrupted transportation, communications, and utilities totaled $5.9 billion (Table 1). These approximated losses were compiled from surveys by local and county governments, state agencies, and the Red Cross. The OES figure is the only systematically compiled estimate of total damage caused by the Loma Prieta earthquake. Approximately $4 billion of the damage was to private homes and commercial and public buildings, and $1.8 billion was to transportation facilities and utilities (McNutt, 1990). Approximately $100 million in damage was unclassified.

A precise and independent loss compilation is beyond the scope of this study and is not attempted here. Such a compilation is difficult because not all damage was reported and because post-earthquake repairs commonly are not just restorations to pre-earthquake conditions but include structural upgrades if not outright replacement. A minimum estimate that provides some confidence in the OES estimate can be made by summing federal, state, and private insurance expenditures (Table 2). Expenditures compiled in the table probably underestimate the total cost of Loma Prieta because nonreimbursed losses were omitted. For example, residential losses are not included

Table 1. *Loma Prieta earthquake losses by county*

County	Distance from earthquake (km)	Total damages (million $)
Alameda	48–100	1,472
Contra Costa	74–118	25
Marin	100–168	2
Monterey	19–203	118
San Benito	27–139	102
San Francisco	85–108	2,759
San Mateo	30–90	294
Santa Clara	7–60	728
Santa Cruz	0–41	433
Solano	107–165	4
	Total	5,936

if they were not covered by insurance; only about 32 percent of homeowners purchase earthquake insurance in the area affected by Loma Prieta (Roth and others, 1992).

LOSSES CAUSED BY EARTHQUAKE HAZARDS

To estimate the loss from each earthquake hazard during Loma Prieta, I compiled property losses that were directly attributable to liquefaction, landslides, ground ruptures, and tsunamis and then assumed that the remaining damage—the difference between the total OES loss estimate (Table 1) and the aggregate loss for these hazards—was caused directly by ground shaking. Losses caused directly by ground shaking were then subdivided into those caused by either normally attenuated or enhanced—that is, higher than expected—ground shaking.

To subdivide direct shaking losses, I used a threshold distance from the earthquake at which ground shaking typically associated with a magnitude 6.9 earthquake would not be expected to cause significant damage even to structures with low seismic resistance. I then compared the distance of each county from the earthquake (Table 1) to this distance. For counties that spanned the threshold distance, I assigned all of the loss in the county to normally attenuated ground shaking. The small size of most counties made it easy to subdivide the shaking losses (Figure 1).

This method for assigning losses to specific hazards provides only crude results, but it is adequate for establishing the thesis of this study. It works for the Loma Prieta earthquake because the losses and their uncertainties—from permanent ground deformation were modest, as were indirect losses, such as those due to fire. It also circumvents two onerous tasks: sorting through tens of thousands of claims and building permits and trying to distinguish between repairs and upgrades, and estimating the characteristics of ground shaking at each damage site.

A threshold distance of 26 miles was used to distinguish between damage caused by normally attenuated and enhanced ground shaking. This corresponds to the distance at which ground-motion attenuation relationships for a magnitude (M) 6.9 earthquake (Boore and others, 1993) predict that peak ground acceleration on firm ground would have decayed to a non-damaging level of 0.10 g. This distance is consistent with correlations of size of area shaken at modified Mercalli intensity 7, the intensity at which damage to poorly built structures is considerable, with earthquake magnitude. Such correlations yield an equivalent radius of 31 miles for M=6.9 (Hanks and Johnston, 1992).

D.K. Keefer, D.J. Ponti, and I—the editors of U.S. Geological Survey Loma Prieta earthquake Professional Paper chapters on permanent ground deformation—compiled the estimates of losses caused by landslides, ground rupture, and liquefaction (Table 3). We did this primarily by contacting engineers and public officials responsible for repair activities at sites with damage. The total loss from these causes is probably accurate to within 50 percent.

Property losses from each earthquake hazard are summarized in Table 3 both as dollar losses and percentages of the total loss. Ground shaking is clearly the primary cause of damage. Ninety-eight percent, $5.8 billion, of the property losses was directly from shaking. Table 3 also reveals that approximately 70 percent of the property losses from Loma Prieta were caused by enhanced ground shaking. Although locally devastating, only 2 percent, $131 million, of the property damage was attributed to liquefaction, landslides, and tectonic ground rupture.

Although this approach does not identify the specific causes of enhanced ground shaking during the Loma Prieta earthquake, many investigators have concluded that the primary cause was local amplification by Holocene clayey-silt deposits that were deposited in San Francisco Bay (Borcherdt and Glassmoyer, 1992). Other potential causes of elevated incoming bedrock motions included a critical reflection off the base of the crust (Sommerville and Yoshimura, 1990) and directivity (Campbell, 1991), a phenomenon by which amplitudes of seismic waves are higher in the direction of the rupture.

IMPLICATIONS

Ground shaking as the primary direct cause of earthquake damage has been assumed for years; the importance of enhanced ground shaking as a hazard, however, is not as widely appreciated. Thus the degree to which the significance of enhanced ground shaking can be projected from the Loma Prieta earthquake to future earthquakes elsewhere in the United States is a critical consideration, if this aspect of Loma Prieta is to have broad application.

Table 2. *Expenditures by government agencies and private insurance*

Agency	Expenditure (million $)
Federal Emergency Management Agency	643
Federal Highway Administration	774
Small Business Administration	582
Other federal agencies	286
CALTRANS	1,500
Other California state agencies	1,224
Private insurers	902
Total	5,911

Table 3. *Loma Prieta earthquake losses by earthquake hazard*

Earthquake hazard	Total damages (million $)	Loss (% of total)
Ground shaking		
Normally attenuated	1,635	28
Enhanced	4,170	70
Liquefaction	97	1.5
Landslides	30	0.5
Ground rupture	4	0
Tsunami	0	0
Total	5,936	100

Clearly, one must be cautious when drawing conclusions from a single earthquake, but two considerations suggest a basis for concern. First, many American cities were founded adjacent to water bodies, and hence their oldest facilities tend to be in areas underlain by geologically young floodplain, estuarine, and lacustrine sediment, all of which have potential for amplifying earthquake shaking. Thus, although the degree of hazard may vary among urban areas, the potential for enhanced shaking is present to some degree in many urban areas. Second, the next most damaging earthquake in North America in the 1980s was the 1985 Michoacan earthquake; although it was 217.5 miles from Mexico City, it caused approximately $4 billion in property loss there because of enhanced ground shaking (Anderson and others, 1986).

Research into enhanced ground shaking and its effects on manmade facilities as well as mapping of urban areas susceptible to enhanced shaking would improve any hazard mitigation effort, from insurance programs to mandatory construction requirements. Soil linearity—the extent to which soft-soil amplification factors can be extrapolated from low to high levels of shaking—remains a controversial subject. Some investigators even predict that ground shaking will be reduced in areas underlain by soft soils when large earthquakes occur nearby (Idriss, 1990). Despite the availability of several methods for mapping enhanced ground shaking, no specific method has been widely adopted and applied. To further compound the problem, even when ground shaking values are known, techniques for estimating building damage in earthquakes are approximate (Housner, 1989).

Susceptibility to enhanced ground shaking is relevant to setting priorities for mitigation through seismic zoning—classification of land based on its earthquake hazard potential. For example, following the Loma Prieta earthquake, California enacted legislation, the Seismic Hazard Mapping Act of 1990, which requires the state geologist to prepare maps of areas susceptible to earthquake hazards—strong ground shaking, liquefaction, and landslides. Mapping of potentially active tectonic ground rupture was already required by the Alquist-Priolo Special Studies Zone Act of 1972. Equal emphasis on earthquake hazards—ground shaking, liquefaction, landsliding, ground rupture, and tsunami—is not the lesson of Loma Prieta. The relative significance of earthquake hazards must first be assessed, because some may be more significant than others.

Potential for enhanced ground shaking also has implications for estimating the seismic risk to many existing and particularly older facilities that are underlain by soft soils in both the San Francisco Bay area and other urban areas. Many of these facilities, which have low seismic resistance, may be at significant risk from magnitude 7 earthquakes within a 62 mile radius, not just from local events.

For larger earthquakes, the radius becomes even larger, which requires earthquake potential to be assessed over broad areas around urban centers. This pertains not only to California, where many large earthquakes have occurred on seismogenic geologic structures well removed from California's primary seismogenic zone—the San Andreas fault—but to the remainder of the United States as well. The problem is illustrated for San Francisco in Figure 1, which reveals the large number of potential seismogenic faults exposed at the surface within 62 miles of the city.

As the 1994 Northridge, California, earthquake forcefully demonstrated, assessment of earthquake potential immediately within an urban area remains necessary. Seismic design of new facilities is largely driven by nearby seismogenic geologic structures, because they are believed to produce the largest ground motions. However, earthquake hazard reduction in urban areas must address all existing facilities, and the risk to older facilities is increased when the more distant seismogenic geologic structures are included. This is an important, albeit not a new, lesson from the Loma Prieta earthquake. By focusing only on nearby seismogenic geologic structures, the risk in urban areas due to enhanced ground shaking is underestimated.

CONCLUSIONS

Approximately 98 percent of the $5.9 billion in property damage from the 1989 Loma Prieta earthquake was caused directly by ground shaking; enhanced ground shaking was directly responsible for approximately two-thirds, $4.1 billion, of the total property loss. Permanent ground deformation accounted for only about 2 percent of the damage.

These observations indicate that we must understand local controls of shaking and enhancement, not just local sources of shaking. Earthquake hazard reduction efforts in the United States would benefit from improved understanding of phenomena that enhance ground shaking, including seismic wave amplification in soft soils at high levels of shaking; mapping areas susceptible to enhanced ground shaking; and delineating seismogenic geologic structures at greater distances from urban areas with soft-soil conditions.

ACKNOWLEDGMENTS

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A guide for evaluating mineral ventures — 1: Business issues

by Robert Whelan, Oregon Department of Geology and Mineral Industries, Portland, Oregon 97232-2162

INTRODUCTION

Mineral ventures can be very profitable, but they are also financially risky. Individuals should carefully evaluate mining and oil and gas deals before investing in them. While there are many successful ventures, there are also many failures and even some fraudulent schemes. Investors must do their homework.

This is the first of two articles giving you tips on how to investigate mineral ventures. In this article, we will look at business issues. It will help you decide whether a mineral project is an appropriate investment for you. It also points out some things to look out for and where to get help.

The second article, which will be published in a later edition of *Oregon Geology*, explains how you can physically evaluate a mineral deposit. This is a crucial step. It tells you if the property is worth risking your money. The article will also cover some of the legal steps needed before opening a mine or drilling a well. Mineral extraction is carefully regulated, so it is important that you understand the basic rules and laws.

Be aware that we cannot include everything you need to know. If you are thinking about investing, hire qualified scientific, legal, and financial advisors. Even if you have expertise in one of these areas, it is still worth getting a second opinion. A few hours of an expert's time should not cost much and can be well worth the cost.

See cover photo and cover photo caption. The Comer Mines Company apparently tried to revive the Present Need Mine near the confluence of Comer and Dixie Creeks northeast of John Day in Grant County. No mining activity was reported for the period during which the company was in existence.

BUSINESS ISSUES

Anytime people try to sell an investment to the public, they must offer a prospectus. A prospectus is a written report that discloses all of the important facts about an investment. For mineral projects, this includes geological data, cost estimates, a market analysis, and a discussion about competitors. A prospectus will also tell you about the qualifications and history of the company. It provides the same information about the venture's principals (officers, key employees, and major investors). After reading a prospectus, average investors will know what will be done with their money and what the risks are. That is why you should always carefully review a prospectus before sending in any money.

In Oregon, investments are registered with the state's Corporate Securities Section. It is a part of the Department of Consumer and Business Services. Any investment sold in Oregon must be registered with the state, even if the business is located somewhere else.

A few investments are exempt from the registration requirement, for example, businesses financed entirely within a family. Even in such a case, however, any business seeking investment dollars must make full and truthful disclosures, i.e., the investors must all be fully informed about the risks and plans for the business. Failure to provide such information opens the door to fraud charges.

If those who ask you to invest say that they do not have to file a prospectus, call the Corporate Securities Section in Salem at (503) 378-4387. The Corporate Securities people will direct you to the right person in state government who can tell you if an investment is exempt from the rules. If it is, ask the seller for a copy of the venture's business plan or any other written materials that show what your money will be used for and what the risks are.

If you invest, keep the prospectus, business plans, and other documents in a safe place. If it turns out that you were misled, these documents may serve as evidence in case you need to sue. If you can prove fraud, however, you still have major hurdles to overcome. Recovering your investment is often difficult and sometimes impossible. People who commit securities fraud may disappear after they have your money. At other times, they will spend the money and leave you with nothing to collect. That is why you should thoroughly investigate a venture **before** you hand over your money, not after.

Once you have the prospectus or business plan, verify all of the key statements. Factual information is the easiest to check, but many claims are opinions. Having a very optimistic opinion is, while misleading, not fraudulent behavior. You have to assess the realism of the prospectus and business plan. For that, you have to do research.

Read and understand the investment documents. Your attorney, accountant, and technical advisors can give you a good sense of the risks you are taking.

All mineral ventures are a gamble. The "Risk Factors" section of the prospectus outlines some of the dangers. Even good projects can fail for unforeseen reasons. You may lose all your money. Should your investment succeed, you may have trouble selling your interest in it. This is called illiquidity. It is a common problem especially for people who need to take their money out on short notice. For these reasons, never risk retirement funds, money set aside for important purchases, or cash you might need for living expenses. You should never invest more money than you can afford to lose.

MARKET FORECASTS

Crucial to any prospectus or business plan is its market forecast. Pay close attention to the forecast. It is the basis for all the revenue and profit projections.

A market forecast is an opinion. Those wanting you to invest in their venture will make their business look as good as possible. They may be too optimistic about the market. It is up to you to make sure the forecast is reasonable.

Assuming that mineral prices will rise faster than the rate of inflation is a common planning mistake. Over the long run, such price increases rarely happen. Competition keeps most metal and mineral prices lagging behind the inflation rate. Businesses are always looking for ways to produce more goods at lower cost. In mining, these productivity gains can average one percent a year. If that happens to the mineral you are producing, you should expect prices to lag one percent behind the annual inflation rate. Over several years, this gap can have a dramatic effect on your venture's profits.

Be suspicious of any prospectus or business plan based on sharply higher prices. Unless there is a clear economic reason for it, you should lower the forecast. Bear in mind that rising demand for a mineral is not necessarily an economic reason for expecting higher prices. Higher demand, in fact, often leads to lower prices, because it allows mines to operate at higher, more efficient rates. One simple test you can perform on a plan is to simply replace the high price forecast with current prices. What does this do to the project's profits?

Sometimes forecasting higher prices makes sense. Metal and energy markets are cyclical. There are times when prices are unreasonably high or low. Shortages can drive prices so high that even the least efficient mines make extraordinary profits. At times of poor demand and oversupply, the best-run mines can lose money. These are both temporary conditions. Economic forces eventually force prices to levels where industry profits are normal. This is called the long-run sustainable level. A good forecast uses it and then factors in the industry's productivity. Productivity changes directly influence the long-run price level.

Usually, productivity improves over time. Declining productivity, however, does occur. This happens when laws are passed that raise costs. If the impact is large and felt by many producers, productivity will fall. Competitive forces will cause prices to rise faster than inflation.

Is the basis for the price forecast correct? Too often, people use published prices to estimate revenues. It is common, however, for a project's realized price to be less than published figures. A small difference in quality can cause a big price variance. So can shipping costs. Make sure the quality and location of your project's output fits the commercial standard used for the published price.

The other side of the revenue equation is sales volume. If the mining venture produces an unusual mineral, market size becomes a limiting factor. This is also true for bulky, low-value products like crushed rock, clay, and sand. An accurate local market demand forecast is important in these cases. You can sell only so much material in a limited market before you start pushing prices down. Be sure that the market can comfortably absorb the new supply coming from your venture. If you are exploring for oil or natural gas, think about how you are going to send them out to markets.

PRODUCTION COSTS

A prospectus has cost estimates. If it is an exploration project, costs should be well defined. Any figures for ultimate production are speculative and should be viewed as such. Production cost estimates for known mineral deposits will be rooted in more solid assumptions. Check these assumptions for their realism.

You should compare projected costs with those of other similar properties. This can be difficult, but it is an important step. The U.S. Bureau of Mines is a good place to start. The Bureau has specialists in every mineral commodity. Its publications *Minerals Yearbook* and *Mineral Facts and Problems* both list the names of specialists and contain excellent market summaries on different minerals. You can find these books in most public libraries.These publications, however, are slated for termination due to federal budget cuts.

When comparing costs, consider the operating conditions. Is the mining method of your project inherently more or less expensive than that of its competitors? Are the mining or drilling conditions harder or easier? Does the geology make it expensive to extract the product from the ground? Are you in an area where roads, utilities, and labor are freely available? Does your property have special environmental risks?

Your objective in examining production-cost figures is to assure yourself of the venture's plausibility. If the prospectus or business plan contains low cost numbers, be ready to ask questions. Many mineral ventures fail because the owners underestimated their costs. The opposite also occurs. You could be given excessive cost estimates. In this case the promoter is hoping you are not going to check the figures. That way, the promoter can collect far more cash than is actually needed to fulfill the business obligation discussed in the prospectus. The promoter and other insiders can then take the remaining money for themselves.

SOURCES OF INDUSTRY INFORMATION

Many useful publications can be found in the library of the Department of Geology and Mineral Industries, which is open to the public. We also have publications and maps for sale through our Nature of Oregon Information Center. It is an excellent place to start your research. The center is on the first floor of the State Office Building in Portland. Some library resources and for-sale materials are also available at our field offices in Baker City and Grants Pass. See page 98 of this issue for addresses.

If your project involves coal, oil, natural gas, or geothermal energy, contact the U.S. Department of Energy for help. If it involves fertilizer minerals, such as phosphates, the U.S. Department of Agriculture has experts available. Their help, like that of the Bureau of Mines, is free.

Do not overlook annual reports, magazines, and newspaper articles. They often report costs. You can also learn about other issues affecting the industry. Ask your librarian for help in researching publications.

Most other data sources cost money. There are consultants who specialize in various minerals. You can get their names by contacting some of the larger producers. Depending on the size of your investment, it may be worth paying a consultant to spend a few hours reviewing the prospectus for you. A typical industry consultant charges $75 to $150 an hour.

Another source is Dun and Bradstreet. They will send you a report on a company for $75. Reports contain the company's history and background, payment record, biographies of the principals, and reports on lawsuits, liens, and judgments. Sometimes these reports can be used to estimate competitor costs. The phone number for Dun and Bradstreet is (800) 362-2255. When you order a report, be sure to ask if it has the information you are most interested in.

CREDENTIALS CHECK

It is surprising how often people invest their money in projects without first checking the credentials of the principals. Sometimes they skip this step because the person soliciting money from them seems honest. Perhaps the solicitant is complimentary or gives an impressive story about the experience of the enterprise. While all this may reassure you, remember that deceitful people will try to appear honest.

It is up to you to check the backgrounds of the people who want you to invest in their mineral venture. Ask them questions about their past. Ask for their resumes. Do not be afraid of offending anyone. If they are experienced business people, they will expect you to check their backgrounds. If you do not, it could signal that you are a naive investor.

You can hire a private investigator to research individuals. The investigator will call schools and coworkers, conduct computer searches, and get personal credit reports. It typically costs from $100 to $500 for each person you have investigated. The cost varies depending on how much information you need and how complicated the search is. You can save money by supplying the investigator with the person's social security number and date of birth. Computer databases use these, so giving them to the investigator will save money and time.

You have to weigh the costs of doing background checks with the size of your investment. If a private investigator is too expensive, you can do your own research. It will take time, but it will cost you little or no money. The place to start is your library.

A good library has computer databases of newspaper and magazine articles. Bring with you a list of the names and work places of

Reverse side of Comer Mines Company stock certificate shown on front cover. Oregon Historical Society negative number 90671.

the people you are researching. Search the library's databases using these names and places.

Newspaper and magazine articles may give you insights as to whether the individuals actually held the positions they said they did. Pay close attention to stories about unethical business practices. If you find anything that concerns you, copy the article. The news stories often have names of people tied to the person you are investigating. Make a list of them. Don't forget to include the authors of the articles.

If you want to do a very thorough search of newspapers and magazines, try using Nexis. This company has the largest single database of newspaper and magazine articles in the country. The Mead Data Central's Nexis Express will do searches for you. The current charges are $2.50 a page and $6.00 a minute for search time. It is expensive, but very comprehensive. Unlike most literature searching systems, Nexis does a full text search. It will find any mention of the subject in articles rather than just searching for words in headlines and abstracts. The phone number for Nexis is (800) 843-6476. Other companies offering similar services include Dialog, Data Times, and CompuServe.

Use the library to get the phone numbers of schools and businesses cited by the principals. Add these to your list. Put down their graduation and employment dates. Ask the librarian for trade and professional association directories. Get the numbers of associations to which the principals belong.

Your next step is calling everyone on your list. Ask the people you call about the individuals you are investigating. For legal reasons, if there is a serious flaw in a person's background, people may be unwilling to say anything negative. Listen for positive comments. If you do not hear any, ask if the people would be eager to do business with this individual. Ask if they think the individual is highly qualified to be involved in a mineral venture such as the one you are being offered.

When you call a trade or professional association, ask how long the person you are investigating has been a member. Ask who else in the association has had dealings with the individual. Call that person. Bear in mind that in many cases all it takes to become an association member is to simply pay a fee.

Colleges and universities will verify degrees earned. If the person claims to have done research or a thesis, call the department he or she worked in and ask some questions.

The human resources departments of most companies will verify employment. They can tell you when the person worked there and what her or his title was. You can try to talk to the person who now holds that same position and ask about the individual you are investigating. Both schools and companies, however, avoid giving out detailed information, especially if it is negative.

If your investment is in an established company, check for legal problems. Start by contacting the state and federal courthouses where the company has its headquarters. Also, look for discussions of legal disputes in the company's Dun and Bradstreet report. Bear in mind, however, that a legal problem is not necessarily a sign of fraudulent or dishonest behavior.

If any of the principals are lawyers, call the American Bar Association at (312) 988-5319 or the Bar Association of the state where the principal is located. The ABA compiles public discipline records on lawyers. If you are dealing with a stock broker, call the National Association of Securities Dealers at (800) 289-9999 which also maintains disciplinary records. You can verify the history of many businesses by calling the Council of Better Business Bureaus, where records of complaints made against individuals and businesses are kept.

Oregon's Division of Finance and Corporate Securities will check its records on a person or business for you. It will tell you if it knows of any past problems. You should be aware, however, that a clean record is not proof that businesses or individuals are upright. It just means that there are no complaints or investigations filed on them. Still, the Finance and Corporate Securities people are a great help and their service is free.

Another agency offering free help is the state's Justice Department. Its Civil Enforcement Division has a Financial Fraud section. This section can tell you if a person or business has engaged in any dishonest financial practice. If you already have an investment in a business, but you suspect fraudulent accounting, you should call a Financial Fraud investigator at (503) 378-4732.

The state's ability to keep track of deceptive investment and financial schemes depends on public cooperation. If you feel that you were a victim of a fraudulent mineral venture, report it to the Division of Finance and Corporate Securities. Tell the Justice Department as well. People who engage in unethical business practices know that their victims are usually too embarrassed to report their losses to authorities. The state, however, needs your help to fight such criminal behavior.

If Oregon's records on a venture and its principals are clear, you may want to pursue it with other jurisdictions. If you know the principals worked in other states or Canada, call the fraud and securities departments in those places. Phone numbers of state agencies can be obtained from the North American Securities Administrators' Association by calling (202) 737-0900.

Can you prove that the principals own what they say they have? You can check some mineral claims and oil and natural gas leases with the government. If the property is privately held, there may not be any public documents. In these cases, you should ask for a copy of the agreement between the venture and the landholder. Visit the county assessor's office and verify real estate holdings. They can tell you who owns the property and whether any of the buildings are mortgaged. If the principals say they own equipment, check their Dun and Bradstreet report and make sure the equipment is not leased. The Department of Motor Vehicles can help you find out if the business owns its vehicles. All this will help you establish what the venture's assets are. Just because it is using assets you cannot be certain that it owns them. If the venture fails, you may recover money only from assets the venture owns outright.

RED FLAGS

Sometimes, mining and oil well ventures are fraudulent schemes, so you should watch for signs of deceptive business practices. Some of the more common "red flags" are outlined here. Their presence does not necessarily mean a project is bad, but it should make you ask tough questions.

Does the project involve an esoteric mineral or process? Some schemes feature these because that makes it hard for investors to evaluate the projects. With few outside sources of technical advice, investors tend to depend on the principals for information. This makes it easy for the principals to mislead investors. Even if the project is legitimate, having esoteric features makes it inherently more risky.

If you have trouble researching a mineral or process through the public library, call us at the Department of Geology and Mineral Industries. We can help you. In addition, we usually can give you names of other experts to contact.

Does the prospectus or business plan make a grossly exaggerated claim? For example, one recent project said that a new extraction process would produce over a trillion dollars' worth of gold. Even if it were possible to extract a trillion dollars' worth of gold, it would not be possible to sell it without collapsing the gold market. The entire world market for gold is only about $15 billion a year. In another case, someone had a scheme to extract gold through wells. Anyone knowledgeable about gold mining knows this cannot be done. Investors often fall prey to such extraordinary claims. It happens because they do not use experienced people at such places as the Department of Geology or the U.S. Bureau of Mines.

Does the project rely on the success of a new production technique? Experience shows us that these ventures are extremely risky. Some dishonest schemes pull investors in with exciting stories of a revolutionary technology that will make millions of dollars. If you are faced with such a project make sure the process truly is new and that the venture has the rights to use it. Ask for patent numbers. The U.S. Patent Office will send you copies of patents for $3 a piece. A patent shows its inventor's name. Do your research before investing. Get opinions from knowledgeable people. Consider what they tell you, ask questions, and weigh all the advice before making an investment decision.

Are you being asked to invest over the phone? Often this is a sign of a "boiler room" operation. Boiler rooms are teams of high-pressure salespeople who make unsolicited calls. They are illegal. If someone unexpectedly calls you, do not give any personal information such as date of birth, social security number, or credit card data. If you think it is a boiler room, call the Division of Finance and Corporate Securities or the Financial Fraud Section of the Department of Justice.

Are you being pressured to make a quick decision by people telling you they need your commitment or else you will lose your chance to get in? Fly-by-night schemes use this tactic. They want you to make a rush decision so you do not thoroughly research the deal and back out. They also may be in a hurry to collect money from unwary investors and leave the state. A legitimate business person offering a risky investment wants you to make a careful and informed decision. That way, if the venture does not work out, you cannot go back and claim that you were pressured or deceived.

Are the principals unwilling to give you accurate personal information about themselves? Without it, you cannot authenticate their credit worthiness, experience, and personal reputation. Just as you expect a bank to ask you personal questions when you apply for a mortgage, honest business people expect the same scrutiny from potential investors.

Are you certain the amount of money you are putting into a venture is proportional to your share of the ownership? Some promoters will sell more than 100 percent of a project. While this is illegal, it is also hard to prove.

Another scheme, which has occurred in a few oil well projects, is overestimating exploration costs. The promoters will sell interests in a real oil exploration well. The well might cost $100,000 to drill, but the promoters tell you it should cost $300,000. They then collect $300,000 from investors, drill the well for $100,000 and pocket the remaining $200,000, perhaps as a consulting fee or salary. Sometimes, they may avoid prosecution by fleeing the state. A savvy investor might avoid this by getting expert opinions from industry consultants on whether or not the promoter's cost estimate is fair.

Is there an affinity linking the investors and principals? In some cases, this can be a red flag. An affinity is a common characteristic which ties people together. Examples include a group of war veterans, members of a church, people with common political beliefs, or senior citizens. In several cases in Oregon, dishonest individuals have victimized people by claiming to share a similar background. This is called affinity fraud.

Criminals know that if they sell to one member of a group, it is far easier to sell to others in the group than to outsiders. Compared to strangers, we are simply more likely to believe friends we share interests with and have known for years. This saves the principals both time and marketing expense. That is why groups are so susceptible to fraud. Once it gets a foothold, a fraudulent investment can quickly penetrate an affinity group.

If someone soliciting an investment uses an affiliation as a way to convince you of the validity of a mineral venture, step back and look it over objectively. Try and separate the merits of the venture from other feelings you may have about your group or its individuals.

SUMMARY

Mineral ventures are financially risky. It is up to you to check them out carefully before investing. Be particularly wary of dishonest schemes. Below is a summary of some of the more important actions you should take:

- Get the prospectus and other documents showing where your money will go and what the risks are.
- Ask experts and professionals for their opinions.
- Double-check all material facts by doing research at the library and making phone calls.
- Call the Corporate Securities and Financial Fraud Divisions of state governments in places where the principals had businesses.
- Check the credit and business histories of the venture and its principals.
- Verify any claims of ownership of leases, mineral deposits, or technologies.
- Make sure that the venture has obtained the appropriate permits from government agencies so it can engage in exploration, mining, or drilling.
- Check records of mineral claims, leases, property holdings, and agreements with landholders.

ACKNOWLEDGMENTS

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DOGAMI PUBLICATIONS

Released August 1, 1994:

Digital data and selected texts from *Low-temperature geothermal database for Oregon*, by Gerald L. Black. Released as Open-File Report O–94–9 (one 3½-in. high-density diskette). Price $12.

The inventory of geothermal sites lists 2,193 geothermal wells and springs, more than doubling the number of known geothermal resources in the state over the previous inventory done in 1982. It is part of the nationwide Low-Temperature Geothermal Resource and Technology Transfer Program funded by the U.S. Department of Energy, Geothermal Division, and administered in Oregon by the GeoHeat Center at the Oregon Institute of Technology.

The new geothermal database was produced with the Excel program on the DOS platform. It is divided into three files, one for all the counties of Oregon except the area around Klamath Falls, the second for the Klamath Falls area, and the third for chemical data of all those sites for which such data are available.

Under the title **Low-temperature geothermal database for Oregon**, single paper copies of Black's report have been placed on library open file in the libraries of DOGAMI's offices in Baker City, Grants Pass, and Portland as Open-File Report O–94–8. This paper version contains the databases, the report text with a slightly extended appendix, and five location maps. Availability is restricted to examination in the library. Photocopies can be obtained at cost.

Released August 4, 1994:

Geology and mineral resources map of the Limber Jim Creek quadrangle, Union County, Oregon, by Mark L. Ferns and William H. Taubeneck. Released as map GMS-82. Price $5.

The map covers part of the headwaters of the Grande Ronde River in the southwestern corner of Union County, about 20 mi southwest of La Grande, including a historic mining district and critical salmon spawning habitat. Today, some known deposits of gold and silver still remain, but the general attention is focused on environmental concerns such as landslides and water pollution caused partly by previous mining and road construction. In the most notable case, federal and state agencies are cooperating now under the Oregon Watershed Health Program to reclaim and stabilize the abandoned Camp Carson mine site.

The new map depicts the geology in greater detail than any previous map, including faults and mining sites and prospects. It is accompanied by tables with analytic data and a text discussing rock units, geologic history, mineral resources, and landslides.

Released August 26:

Geology and mineral resources map of the Tumalo Dam quadrangle, Deschutes County, Oregon, by E.M. Taylor and M.L. Ferns. Released as map GMS-81. Price $6.

GMS-81 describes the geology of an area northwest of the city of Bend that is important particularly for the city's water supply. The map identifies twelve rock units, all products of the volcanism that created this region between seven million years and 20,000 years ago, before the glaciers of the last ice age covered and eroded it. It is accompanied by geologic cross sections; brief discussions of the Tumalo fault zone and its earthquake hazard potential, the geologic history, and the mineral and water resources; and tables with analytic data from rock samples.

Geologic map of the Kenyon Mountain quadrangle, Douglas and Coos Counties, Oregon, by G.L. Black. Released as GMS-83. Price $6.

Geologic map of the Mount Gurney quadrangle, Douglas and Coos Counties, Oregon, by T.J. Wiley, G.R. Priest, and G.L. Black. Released as GMS-85. Price $6.

These two quadrangles are situated adjacent to each other about 20 mi west of Roseburg and straddle the border between the two counties. In addition to rock units, both maps show geologic cross sections as well as details of faulting and of landslide deposits.

Mapping of these two quadrangles in the southern Coast Range represents part of DOGAMI's studies of the geology of the Tyee sedimentary basin as well as the wider area around the city of Roseburg. These studies have brought about a considerable amount of new information, which has given geologists a much better understanding of the stratigraphy of the region.

The new maps are all at a scale of 1:24,000 and are produced in two colors—a brown topographic base overlain by black geologic information. They are the results of larger mapping projects in which DOGAMI cooperates with the U.S. Geological Survey in the National Geologic Mapping Program, with other federal, state, and county agencies, and with private industry.

To order publications, see ordering information on the back cover of this issue, or contact the field offices listed on page 98. □

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