The Ore Bin

The ORE BIN
Volume 37, No. 6

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland, Oregon - 97201
Telephone: [503] - 229-5580

FIELD OFFICES

2033 First Street, Baker 97814
521 N. E. "E" Street, Grants Pass 97526

Subscription Rate
1 year - $2.00; 3 years - $5.00
Available back issues - $.25 each

Second class postage paid at Portland, Oregon

State of Oregon
Department of Geology
and Mineral Industries
1069 State Office Bldg.
Portland Oregon 97201

The ORE BIN
Volume 37, No. 6
June 1975

"GLENDONITES" FROM OREGON AND WASHINGTON

Sam Boggs, Jr.
Head, Department of Geology, University of Oregon

Stone balls thought by some local residents to be Indian relics are common in the gray, Tertiary mudstones of various parts of northwestern Oregon and western Washington. These objects were first described to me as having either a square hole or a square core through their center, and were postulated to be weights that Indians from some ancient tribe used to hold their fishing nets to the stream bottom. I later had an opportunity to examine some of these "relics" and found that they were actually a rather unusual type of calcium carbonate concretion. An elongate, prismatic core or nucleus extends completely through each concretion, and the (broken) ends of this nucleus are visible on the surface of the concretion as rhombic-shaped scars. The nucleus is partially dissolved in a few specimens, leaving the so-called square holes.

The nuclei are the most interesting characteristic of the concretions and are the focus of this study. Although these nuclei have a prismatic or crystalline shape, their granular interior composed of small crystals of calcite clearly indicates that they are pseudomorphic after some original mineral no longer present.

The first published description of the pseudomorphs appears to be that of J. D. Dana (1849), who describes several prisms collected from the Astoria area. Dana also describes similar prisms found near Glendon in New South Wales, Australia and states that "The Glendon prisms differ in nothing (from the Astoria prisms) except in having a smoother exterior...." David and others (1905) named the New South Wales prisms glendonite, after the town of Glendon.

The Oregon and Washington prisms appear very similar to the Glendon prisms, though some differences do exist, and are referred to in this paper as "glendonites."

A detailed petrographic, X-ray, chemical, and isotopic analysis of several "glendonite" prisms was reported by Boggs (1972). The present paper offers a more generalized description of the important characteristics of the "glendonites" and provides a discussion of the probable origin of the prisms and concretions.

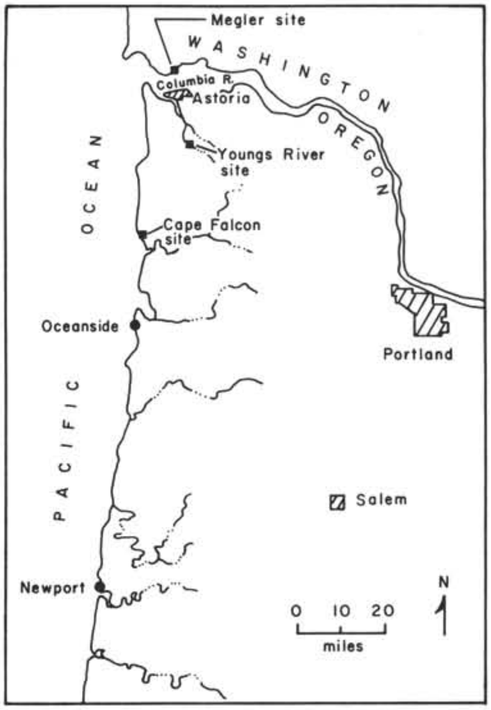

Figure 1. Index map of northwestern Oregon and southwestern Washington showing location of "glendonite" sites.

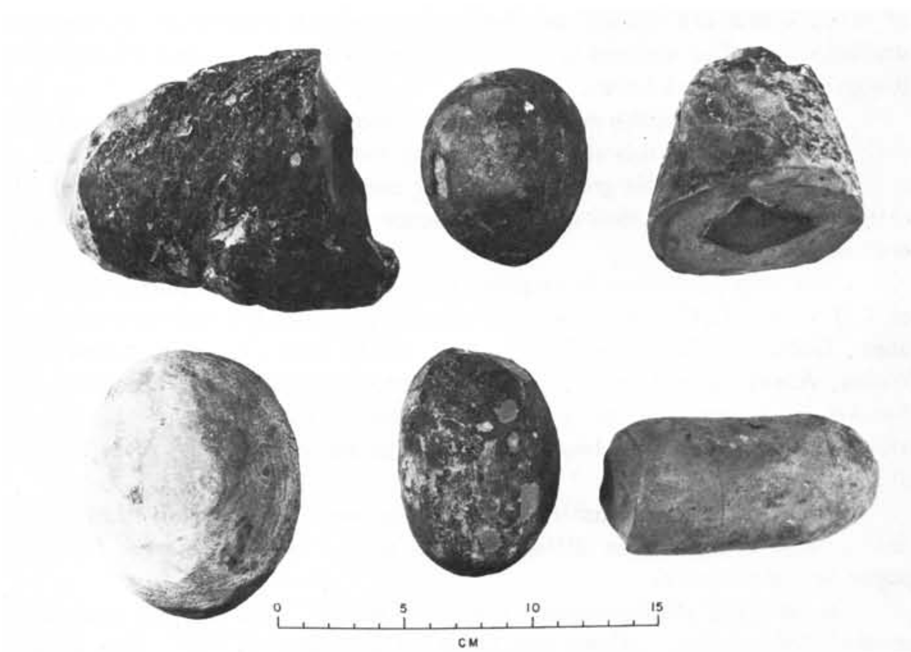

Figure 2. Typical "glendonite" concretions. Note variation in shape of concretions and rhombic cross-sectional shape of "glendonite" nuclei.

Most of the prisms and concretions described in this report were collected from an area on Youngs River a few miles south of Astoria, Oregon (Figure 1). They were first brought to my attention by Douglas Nelson of Astoria. The concretions occur in dark gray, silty mudstones of the Astoria Formation (Miocene age) and are concentrated in a zone 6 to 8 feet thick of thinly but indistinctly bedded mudstone near the base of the exposed unit. Many concretions eroded from the mudstones were found in the nearby stream bed.

Similar "glendonite" concretions were collected from Oligocene-age mudstones exposed near Cape Falcon on the northern Oregon Coast by Rauno Pertuu, a former geology student at the University of Oregon. "Glendonite" concretions and prisms were also collected from Astoria Formation mudstones near Megler, Washington by Dr. W. N. Orr, University of Oregon, and from similar beds exposed near Naselle, Washington by Dan Penttila, State of Washington Department of Fisheries. Parke Snavely, U.S. Geological Survey, reports (personal communication) that he has collected similar prisms and concretions from the Twin River Formation (Oligocene age) of the Olympic Peninsula and from the Lincoln Formation (Oligocene age) of southwestern Washington.

Description of Concretions

The concretions are highly variable in both shape and size. Some are ovoid to subspherical; others are subconical, discoid, or cylindrical (Figure 2). Many concretions have a thin, dark-brown to black weathering rind which is partially chipped away, producing a rough, hackly surface. The smallest concretion collected is 5.6 cm in length and 3.8 cm in diameter. Some concretions up to about 26 cm in length and 20 cm in diameter were collected and a few considerably larger than this were observed in the field.

An interesting characteristic of the concretions is their failure to completely enclose the "glendonite" nuclei. An excellent example of this feature is illustrated by Figure 3. The projecting part of the "glendonite" commonly breaks away from the concretion, leaving a rhombic-shaped scar on the surface of the concretion as shown in Figures 2 and 4. Study of sawed concretions shows that a few display faint concentric bands that terminate against the "glendonite" nuclei (Figure 5B); however, most concretions show no internal structures except indistinct biogenic(?) mottling (Figure 5C). This mottled texture and the presence of patches of fecal(?) pellets in some concretions suggest that the original muddy sediment in which the concretions formed was probably reworked by scavenging organisms. This could account for the scarcity of relict bedding in the concretions.

Small calcite crystals, ranging in size from about 0.0025-0.005 mm, make up approximately 80 percent of the body of the concretions, excluding

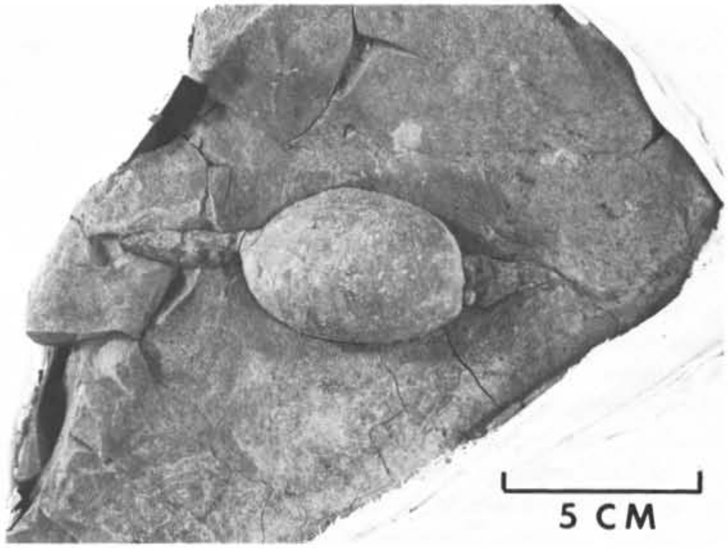

Figure 3. A complete concretion, with "glendonite" nucleus still intact, shown in place within host mudstone.

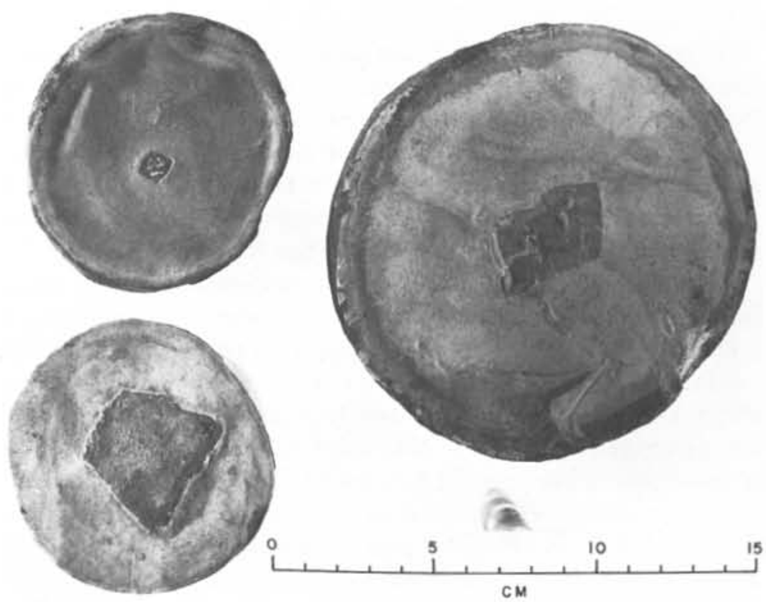

Figure 4. Cross-sectional view of concretions showing typical shape of "glendonites." "Glendonite" in largest concretion has "crusts" of mud (light areas) projecting in from sides.

the "glendonite" nuclei. The remaining material in the concretions is principally silt- to fine sand-size grains of quartz, plagioclase feldspar, biotite, muscovite, and rock fragments with a minor amount of clay minerals. Minor replacement of calcite by chert, opal, and pyrite is evident in a few specimens. Small fossils (microfossils) are common, though not abundant, and fine organic matter is disseminated throughout the concretions. The texture of a typical concretion, as viewed in the microscope, is illustrated in Figure 6.

Description of Glendonites

Most of the "glendonites" are partially enveloped by concretionary calcite as shown in Figures 3 and 5; however, a few escaped concretionary development and are simply enclosed in the host mudstone. A typical "glendonite" has the approximate crystal form of a slender, elongate, rhombic prism with dipyramidal terminations; none of the specimens has smooth, even crystal faces. The surface of most prisms is scored by irregular ridges and grooves that are transverse to the prism faces (Figures 7 and 8). The markings on some prisms are sharply angular and distinct, conveying the impression that they may be the result of multiple twinning of some original crystal. Many of the prisms appear distorted or "mashed" and, in addition to the more characteristic rhombic form, cross-sectional shape may vary from almost square to pseudo-rectangular, or even irregular.

The prisms are much elongated compared to the terminating dipyramids, and most appear to have a distinct twist so that the ends are turned in somewhat different directions. The gradual diminution and twisting of the prisms is evident in Figures 7 and 8.

The smallest complete "glendonite" collected is about 2 cm in length, with a maximum cross-sectional dimension of about 0.4 cm. The largest specimen (about 27 cm) is incomplete and total length is probably much greater. The largest cross-sectional dimension of any "glendonite" measured is about 4 cm.

Although the "glendonites" display the external form of a twinned crystal, microscope study shows that the interior of the prisms is composed of an aggregate of crystals of various sizes. Calcite makes up about 98 percent of these crystals. Replacement chert occurs in small patches in many "glendonites" and a small amount of quartz fills some voids. Small, irregular patches of replacement pyrite are also common. Sand-size terrigeneous mineral grains, such as quartz, were observed in a few prisms, but most contain no coarse terrigeneous material. Fine organic matter, trapped within calcite crystals, is common in all of the "glendonites." With a single exception, fossils were not found in the prisms. The absence of fossils is in sharp contrast to the Australian glendonites in which fossils, particularly brachiopods, are common (David and others, 1905).

The calcite crystals that make up the prisms have four distinct crystal habits. Calcite occurs as large (up to 3.0 mm) tabular to ovoid crystals and

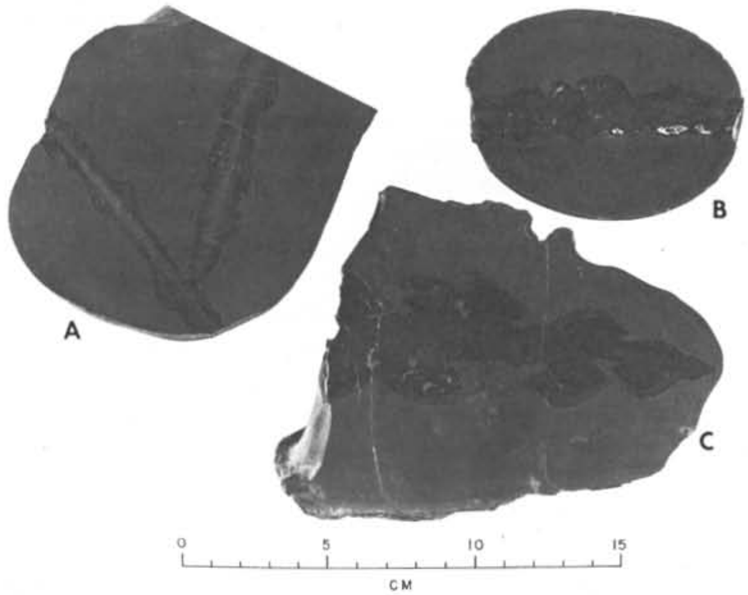

Figure 5. Specimens sawed longitudinally to show interior of concretions and "glendonites."

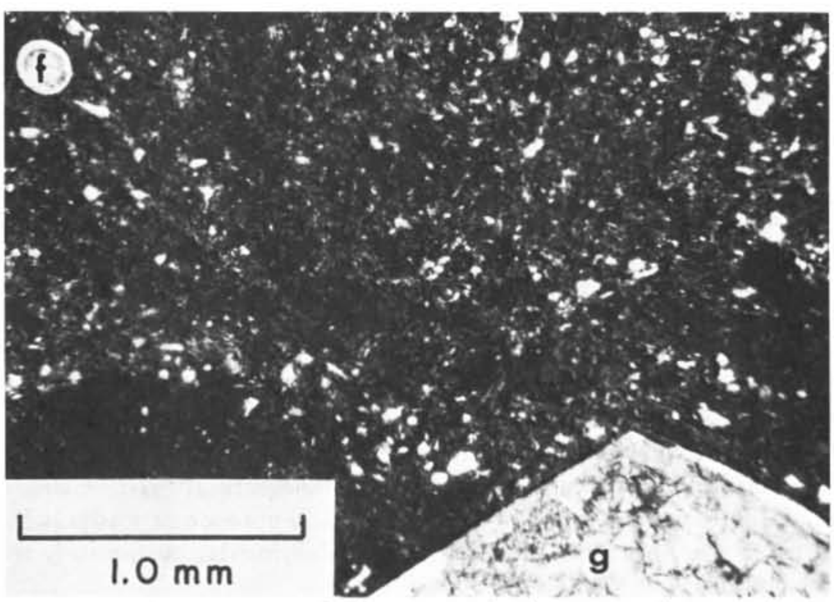

Figure 6. Photomicrograph showing typical texture of concretions. Note "glendonite" nucleus (g) and small fossil (f).

clusters (rosettes) of crystals, radial or spherulitic masses, fibrous but non-radial crystals oriented normal to the prism surfaces, and mosaic crystals that fill former void space.

The large tabular crystals and rosettes are extremely abundant in most specimens (Figure 9). They are commonly clustered near the center of the prisms but may occur throughout and even project into the surrounding concretion. Most of these crystals contain abundant organic matter trapped within the crystal structure. The organic matter occurs both as a very fine brown "dust" and as larger (0.0025-0.01 mm) black particles. The larger particles are particularly abundant and are randomly distributed throughout most crystals (Figure 10); however, they are arranged into more or less distinct zones in some crystals (Figure 11).

Fibrous radiating or spherulitic calcite (Figure 12) is best developed in the outer parts of the prisms but may occur in any part. In some specimens large single crystals or rosettes have acted as nuclei around which the radial calcite was deposited. The spherulites invariably contain abundant fine, brown organic "dust" which colors them light to deep reddish brown. Brown (1925) attributes the yellowish color of the fibrous radiating calcite in New South Wales glendonites to the presence of iron. However, chemical data (Boggs, 1972) show that only a minute amount of iron is present in the spherulites of Oregon and Washington "glendonites." Their brownish color is clearly due to the presence of organic matter. In some prisms the organic matter is concentrated into distinct dark bands that seem to outline the position of former cavities (Figure 12).

Some "glendonites" contain a thin layer (up to 1.5 mm thick) along their outer edge that is composed of fibrous calcite oriented normal to the prism face. This zone is absent in many prisms and is well developed in only a few. The zone may be very complex, containing both fibrous calcite and small spherulites arranged in alternating bands (Figure 13), or may be composed of a single layer of fibrous calcite.

Many of the "glendonites" show evidence of the presence of former cavities. Most such cavities were subsequently filled with clear, sparry calcite that commonly displays a mosaic habit (Figure 14), but small openings are still present in a few prisms, as shown in Figure 5B.

Orientation to Bedding in Mudstones

Bedding in the mudstones is generally rather poorly developed, but it is sufficiently distinct in places to permit measurement of concretion and "glendonite" orientation with respect to bedding (Figure 15). Concretions having a flattened or discoid shape commonly lie with the plane of flattening parallel to the plane of bedding. The orientation of elongate concretions, which have the same orientation as their enclosed "glendonites," ranges from parallel to bedding to an angle of about 30 degrees to bedding. Relict bedding preserved in some concretions also permits the orientation of

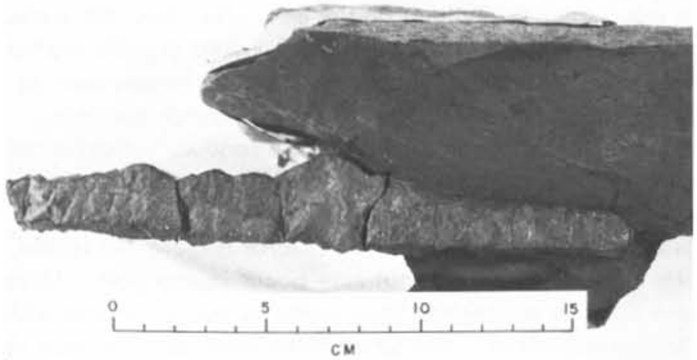

Figure 7. "Glendonite" about 27 cm in length within enclosing mudstone; specimen is broken off at left end.

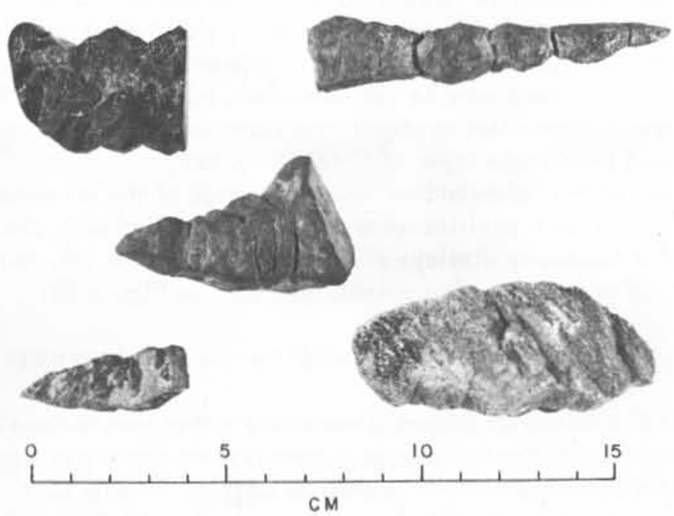

Figure 8. Typical "glendonites" from various localities in Oregon and Washington.

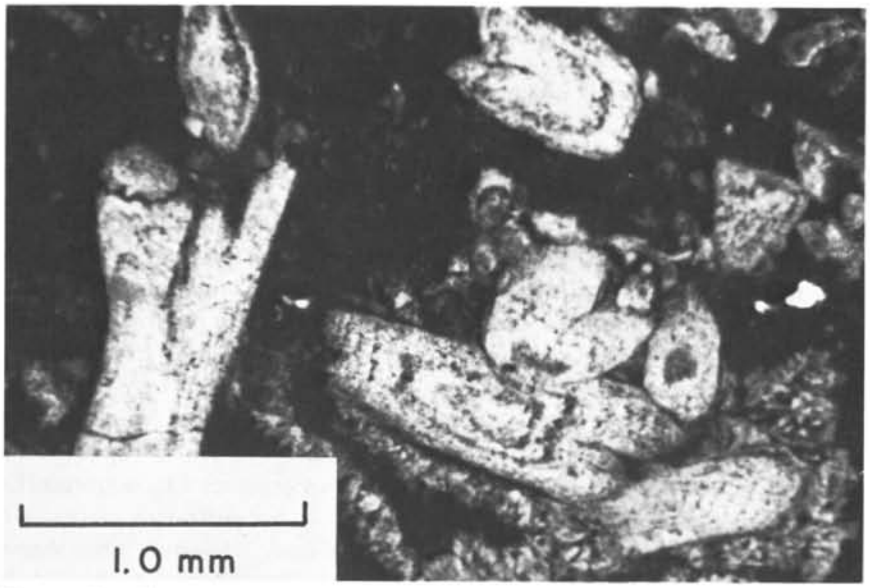

Figure 9. Photomicrograph showing large ovoid calcite crystals and clusters (rosettes) in a typical "glendonite." Dark patches within the crystals are organic matter.

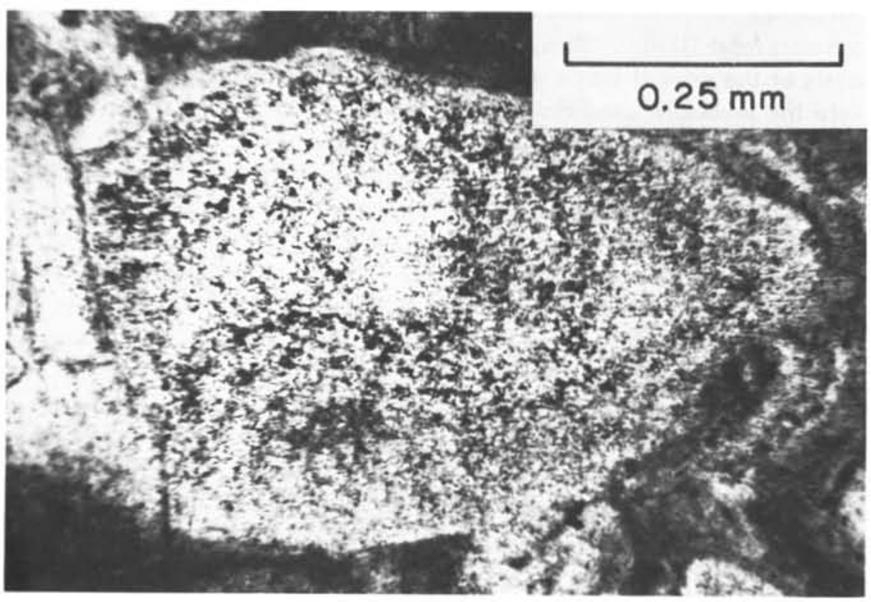

Figure 10. Enlarged view of a single calcite crystal showing abundant organic matter (black) trapped within the crystal.

the "glendonites" to be measured. This orientation ranges from parallel to the bedding to almost 90 degrees to the bedding. A few concretions contain two "glendonites" (Figure 5A) that may lie either in the same plane or at distinctly different angles. Some "glendonites" actually cut across bedding planes, a factor that is of importance in interpreting their origin.

Origin of "Glendonites" and Concretions

The granular interior of the "glendonite" prisms clearly indicates that their external crystal-like shape is inherited from some pre-existing mineral that has subsequently disappeared. The principal problems concerning the origin of the "glendonites" are 1) the identity of the original mineral, and 2) the manner of origin and the time of formation of the "glendonites."

One of the most striking features of the "glendonites" is the highly elongated form of the prisms. The transverse, angular ridges and grooves on the prism surfaces suggest that the elongation is due to repeated twinning. Dana (1849) thought that the form was produced by superposition of one rhombohedron upon the face of another in a continuous series with gradual diminution of the prisms toward the end. However, the shape of all of the "glendonites" is not uniformly rhombic. The growth of multiple crystals in cluster (Figure 5C) seems responsible for some variations in the basic rhombic form; however, it is not clear whether the pseudo-rectangular to square cross-sectional shape of other prisms is a primary feature or has been produced by distortion of originally rhombic-shaped prisms. It is impossible on the basis of available evidence to establish with certainty the crystallographic system of the original mineral, although the orthorhombic system appears most likely. Thus, the original mineral cannot be identified on the basis of the crystal shape of the prisms. Other data do provide some insight into the probable conditions under which this original mineral crystallized and permit an "educated guess" as to its identity.

Associated marine fossils show that the host mudstones for the "glendonites" were deposited under marine conditions. As described above, many of the "glendonites" are oriented at a distinct angle to bedding and some transect or cut across bedding planes. Similar relationships of Australian glendonites to bedding are reported by David and others (1905) and Raggatt (1938). These relationships indicate that the "glendonites" probably grew beneath the water-sediment interface rather than on or above the sediment surface. The association of "glendonites" with biogenic structures such as stirred bedding and fecal pellets, their tendency toward extreme elongation, and the branching character of some "glendonites" (Figure 5A) suggests that the original mineral may have crystallized in the burrows of some type of marine organism.

Several factors show that the "glendonites" and their enclosing concretions are syngenetic. Many of the concretions contain fossils and relict textures which indicate that concretionary development took place by calcite

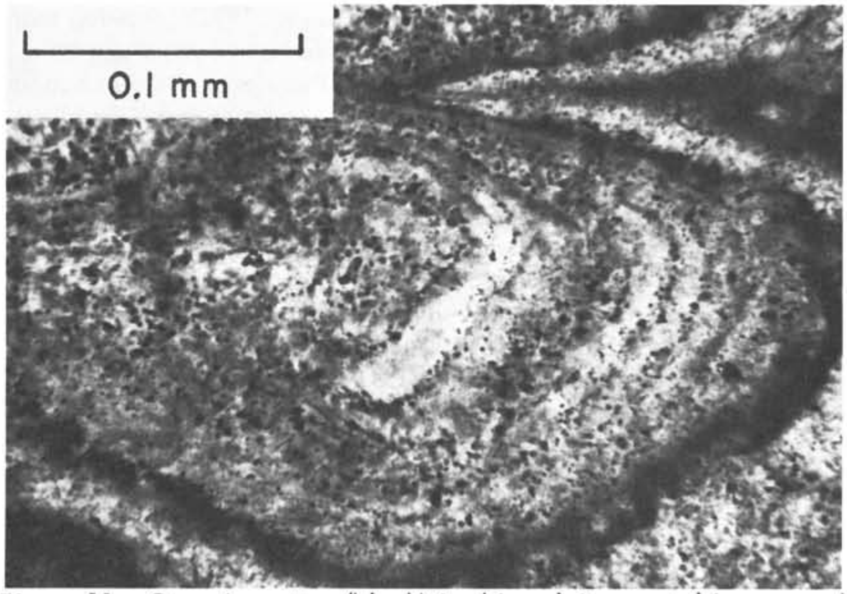

Figure 11. Organic matter (black) in this calcite crystal is arranged in distinct bands or zones.

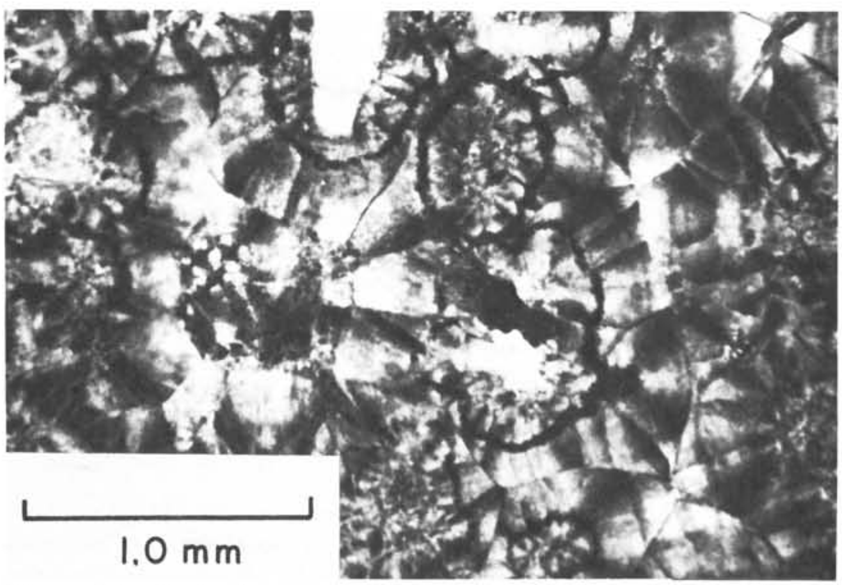

Figure 12. Photomicrograph of calcite spherulites. The black rings in the central part of the photograph are bands of concentrated organic matter.

infilling of pore space in detrital mud. The $CaCO_3$ content of the concretions ranges from about 75 to 80 percent (Boggs, 1972), showing that the porosity of the original detrital mud must also have been about 75 to 80 percent at the time of concretion formation. Therefore, the mud had undergone virtually no compaction by that time. Early concretionary development is also suggested by the preservation of certain textures such as fecal pellets. These pellets would have been partially crushed or otherwise deformed had extensive compaction preceded cementation.

Substitution of granular calcite for the original mineral did not occur by replacement in the sense of essentially simultaneous solution and precipitation. Instead, there is considerable petrographic evidence to indicate that the original mineral dissolved, leaving a mold that was then filled by precipitation of small calcite crystals. Filling may have occurred in stages, and some open space was present within the original mineral mold at times. Crusts of mud projecting into some "glendonites," the largest specimen in Figure 4 for example, suggest partial collapse of soft mud into a cavity. Also the distorted shape of many of the "glendonites" suggests solution of the original mineral and some deformation of the cavity in the still soft mud before refilling with granular calcite. The inclusion of organic matter within the calcite crystals and the concentration of some organic matter into bands, outlining the former shape of cavities, as well as the presence of sparry calcite filling obvious cavities, are all evidence that the original mineral dissolved, at least in part, before precipitation of granular calcite began. The presence of crude zoning in a few "glendonites" (Figure 5C) indicates the possibility of reversals in environmental conditions, causing two or more separate stages in solution and precipitation.

The following sequence of events in formation of the "glendonites" is indicated: Detrital muds were deposited under marine conditions and then reworked or stirred by organisms of some type. These organisms, living and feeding near the sediment-seawater interface, probably left open burrows in the soft mud. It seems likely that the precursor mineral of the "glendonites" crystallized within these open burrows because the extreme elongation of many of the prisms suggests that they were constrained to grow within some type of tube-like opening. The original mineral must have precipitated as isolated crystals within the watery mud, as no evidence of a more widespread deposit is now preserved. This mineral was stable under the initial conditions of formation but dissolved before virtually any compaction of the mud occurred, and the resulting cavity or mold was quickly filled with granular calcite to form the pseudomorph.

Initial precipitation in the crystal molds resulted in crystallization of large ovoid crystals and rosettes that grew in loosely packed masses within the cavities. Fine organic matter, suspended in the water-filled cavities, was incorporated into the crystals as they grew. This initial stage was followed by formation of spherulitic calcite which crystallized in much of the remaining pore space among the larger grains. Minor pore space that still

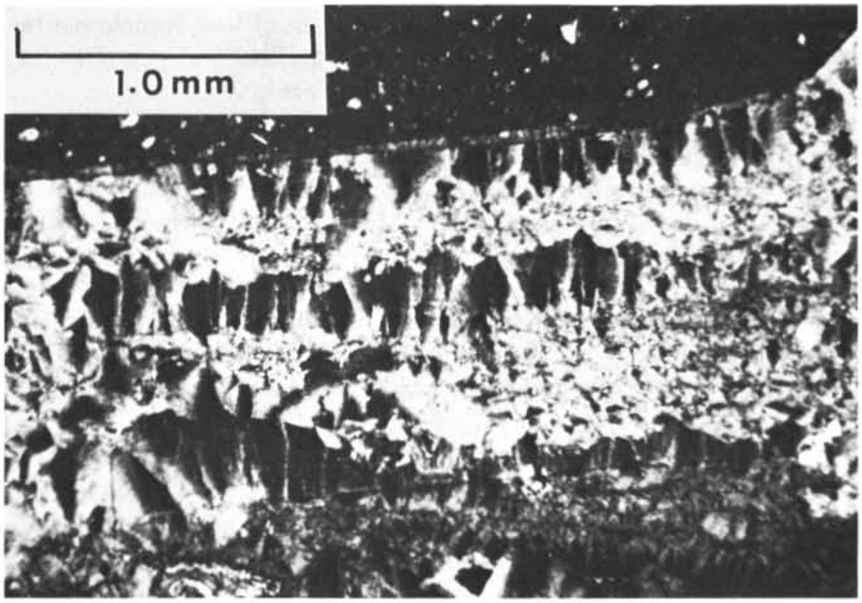

Figure 13. Fibrous, non-radial calcite along the edge of one "glendonite" at the point of contact with the enclosing concretion. Three zones of fibrous calcite, recognizable by dark stripes oriented normal to the pseudomorph surface, are shown separated by two zones of small interfering spherulites.

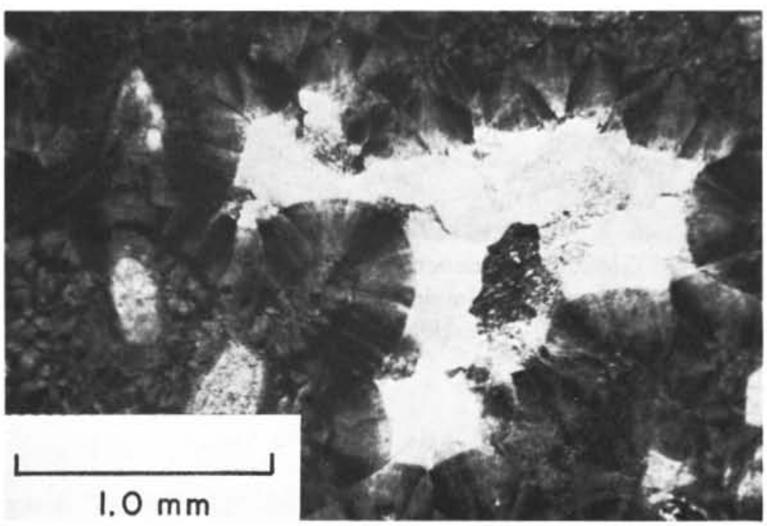

Figure 14. Sparry, mosaic calcite (white) filling former open space among calcite spherulites.

remained after crystallization of the spherulites was later filled by clear sparry calcite. This clear spar, which is devoid of fine organic matter, probably has a much later origin than the spherulites and may even have formed after uplift of the deposits above sea level.

The original mineral from which the "glendonites" inherited their shape is believed to be a carbonate - possibly aragonite or one of the hydrated carbonated minerals such as monohydrate - $Na_2CO_3.H_2O$. Positive identification of the precursor mineral seems unlikely, however, until the crystal system of the "glendonites" can be definitely established. My hope is that this paper will stimulate additional investigation of these interesting objects by other workers and that the crystal system of the pseudomorphs and the identity of the precursor mineral can be established as additional specimens of "glendonite" are discovered and studied.

Figure 15. "Glendonite" concretion in place in enclosing mudstone. The concretion and "glendonite" nucleus are oriented at an angle of about 30° to bedding.

Conclusions

(1) Elongate, prismatic structures called "glendonites" that are commonly found in carbonate concretions in northwestern Oregon and Washington are pseudomorphs. Their rhombic, prismatic shape is inherited from some

original mineral that crystallized in soft muds of the ocean floor during the Tertiary Period. This mineral subsequently dissolved, leaving a mold in the mud that was filled by crystallization of calcium carbonate (calcite).

(2) The original mineral, subsequent pseudomorphs, and the concretions that enclose the pseudomorphs are all syngenetic. They formed in an organic-rich mud a short distance below the depositional interface, and crystallization was completed before significant compaction of the mud occurred. The extreme elongation of the prisms suggests that they may have formed in the burrows of marine organisms.

(3) The crystal system of the original mineral cannot be definitely established on the basis of available data but appears to be orthorhombic. Based upon the probable conditions of origin and general shape of the prisms, the original mineral is believed to be a carbonate - possibly aragonite or one of the (orthorhombic) hydrated carbonates such as monohydrate.

Acknowledgments

The research reported in this paper was supported in part by a grant from the Office of Scientific and Scholarly Research, University of Oregon. I wish to thank Douglas Nelson, Rauno Pertuu, William N. Orr, Dan Penttila, and Parke Snavely for aid in collecting specimens for the study.

References

Boggs, Sam, 1972, Petrography and geochemistry of rhombic, calcite pseudomorphs from mid-Tertiary mudstones of the Pacific Northwest, U.S.A.: Sedimentology, v. 19, p. 219-235.

Brown, Ida A., 1925, Notes on the occurrence of Glendonites and glacial erratics in upper marinal beds at Ulladulla, N.S.W.: Proc. Linneau Soc. of New South Wales, v. 1, no. 2, p. 25-31.

Dana, J. D., 1849, Geology, in United States Exploring Expedition, 1838-1842 under the command of Charles Wilkes, U.S.N.: Philadelphia, v. 10, 756 p.

David, T. W. E., Taylor, J. G., Woolnough, W. G., and Foxall, H. G., 1905, Occurrence of the pseudomorph glendonite in New South Wales: Rec. Geol. Surv. N.S.W., v. 3, no. 2, p. 161-179.

Raggatt, H. G., 1938, On the occurrence of glendonites in New South Wales, with notes on their mode of origin: Royal Soc. New South Wales Jour. and Proc., v. 71, no. 2, p. 336-349.

* * * * *

GEOTHERMAL STUDIES IN THE VALE AREA, MALHEUR COUNTY, OREGON

Don Hull, Economic Geologist
Oregon Dept. of Geology and Mineral Industries Baker Field Office

Introduction

The Oregon Department of Geology and Mineral Industries has been engaged in studies of Oregon's geothermal energy potential for the past 10 years. The results of these activities have been described by Groh (1966), Peterson and Groh (1967), Bowen (1972), and Bowen and Blackwell (1973). Detailed studies of heat flow have been conducted since 1972 in the vicinity of Vale

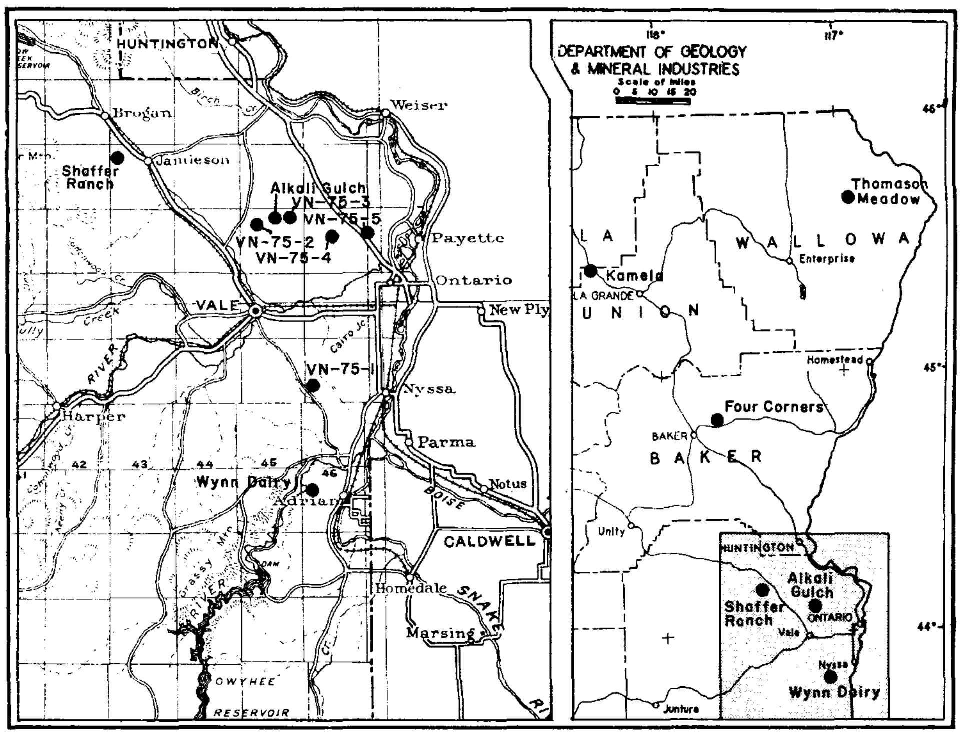

Figure 1. Index maps showing locations of temperature-gradient measurements taken by the Oregon Department of Geology and Mineral Industries between 1972 and 1975. Blow-up of Vale area map on left shows location of holes listed on Table 1; regional map on right shows location of holes listed on Table 2.

in northern Malheur County in southeastern Oregon (see Figure 1) under contract No. S0122129 with the U.S. Bureau of Mines. The studies, initiated by R. G. Bowen in cooperation with Dr. David D. Blackwell of Southern Methodist University, Dallas, Texas, are continuing, and a detailed report is being prepared summarizing the geothermal research conducted by the Department to date. The preliminary results tabulated herein are being released in the hope they will aid in the exploration for and development of geothermal resources.

The final phase of the current geothermal investigation of the Vale area, consisting of the drilling of five holes to obtain heat-flow data, was completed in May and June 1975. Temperature gradients measured in the drill holes are given in Table 1. Thermal conductivity measurements on drill core from these holes and heat-flow calculations are in progress. All gradients are uncorrected for topographic effects. Hole locations are shown in Figure 1.

Temperature Gradients

Four of the five holes in the Vale area were drilled to a depth of 152 meters (500 feet) in siltstone of the Idaho Group of Pliocene age. Hole VN-75-2 was drilled in silty claystone from 0 to 95 feet and in altered basalt (?) from 95 feet to a total depth of 203 feet. Drilling was done by a combination of air rotary, down-hole hammer, and coring techniques.

Hole VN-75-2 encountered warm artesian water at a depth of 105 feet which flowed at a rate of 10 to 14 gallons per minute with a temperature of 75°F (24°C) and a well-head pressure of 5 pounds per square inch. The average gradient, as shown in Table 1, was measured after the hole had been cemented to stop the artesian flow, but the gradient reflects the presence of the thermal water at shallow depth.

Table 1. Temperature gradients in the Vale area, Malheur County

Hole	Section	Township	Range	Depth	Average gradient (°C / km)
VN-75-1	30	19 S.	46 E.	152m (500 ft)	91.9
VN-75-2	8	17 S.	45 E.	62m (203 ft)	153.8
VN-75-3	2	17 S.	45 E.	152m (500 ft)	71.5
VN-75-4	16	17 S.	46 E.	152m (500 ft)	115.3
VN-75-5	13	17 S.	46 E.	152m (500 ft)	73.4

The Department also has a continuing program of measuring temperature gradients in pre-drilled holes such as water wells and mineral exploration holes. The results from holes measured from 1971 through 1973 were placed on open file status in March 1975. Holes probed in 1974 and 1975 are summarized below in Table 2. Detailed temperature logs from all of the holes listed in Tables 1 and 2 are available for inspection, or copying at cost, in the Portland, Grants Pass, and Baker offices of the Department.

Table 2. Temperature gradients in pre-drilled holes

Locality	Section	Township	Range	County	Depth	Average gradient (°C/km)
Thomason Meadow	26	3 N.	47 E.	Wallowa	65m (213 ft)	23.0
Kamela	36	1 S.	35 E.	Union	70m (230 ft)	24.5
Four Corners	34	8 S.	41 E.	Baker	130m (427 ft)	42.7
Schaffer Ranch	7	16 S.	43 E.	Malheur	115m (377 ft)	33.4
Alkali Gulch	3	17 S.	45 E.	Malheur	180m (591 ft)	61.6
Wynn Dairy	7	21 S.	46 E.	Malheur	70m (230 ft)	108.2

References

Bowen, R. G., 1972, Geothermal gradient studies in Oregon: Ore Bin, v. 34, no. 4, p. 68-71.

Bowen, R. G., and Blackwell, D. D., 1973, Progress report on geothermal measurements in Oregon: Ore Bin, v. 35, no. 1, p. 6-7.

Groh, E. A., 1966, Geothermal energy potential in Oregon: Ore Bin, v. 28, no. 7, p. 125-135.

Peterson, N. V., and Groh, E. A., 1967, Geothermal potential of the Klamath Falls area, Oregon, a preliminary study: Ore Bin, v. 29, no. 11, p. 209-231.

* * * * *

!!! CORRECTION !!!

GEOTHERMAL INFORMATION TELEPHONE NUMBER

In the May issue of The ORE BIN (page 85), the telephone number given for Don Hull, geothermal specialist at the Baker Field Office, should be changed to 503 - 523-3133. Our apologies for inconvenience this may have caused you.

* * * * *

GEOTHERMAL LEASE BIDS ANNOUNCED ON ALVORD KGRA

Acceptable bonus bids totaling $179,604.82 have been received on 14 of the 44 units designated for geothermal leasing in the Alvord Known Geothermal Resource Area (KGRA) in Harney County, Oregon. The bids cover 31,182 acres of the 92,000 acres offered for lease; one unit was withdrawn from bidding by BLM. Bids on six of the units were determined to be unacceptable by the U.S. Geological Survey and Bureau of Land Management. There were no bidders on 23 of the parcels. Successful bidders for the June 5, 1975 sale were as follows:

Al-Aquitaine Explorations	Unit 7	2,560 acres	$7.17 per acre
Al-Aquitaine Explorations	Unit 8	2,400 acres	3.83
Al-Aquitaine Explorations	Unit 12	2,560 acres	6.51
Republic Geothermal	Unit 15	1,920 acres	2.07
Republic Geothermal	Unit 16	649 acres	5.38
Republic Geothermal	Unit 17	2,560 acres	2.07
Republic Geothermal	Unit 18	2,560 acres	10.56
Republic Geothermal	Unit 21	2,402 acres	2.13
Chevron Oil Co.	Unit 24	2,561 acres	17.90
Mapco, Inc.	Unit 30	2,397 acres	4.47
Mapco, Inc.	Unit 31	1,920 acres	2.17
Mapco, Inc.	Unit 32	2,016 acres	6.03
Getty Oil Co.	Unit 34	2,126 acres	5.25
Southern Union Production Co.	Unit 42	2,560 acres	2.53

Following a hearing in the U.S. District Court June 10, 1975, on a petition filed by environmental groups to halt geothermal leasing in the Alvord KGRA, the Court allowed the 14 leases to be awarded.

* * * * *

CITIZENS' FORUM ON ENERGY PUBLISHED

"Proceedings of the Citizens' Forum on Potential Future Energy Sources" has been published by the Oregon Department of Geology and Mineral Industries as Miscellaneous Paper 18. Six papers presented at the Forum, held at Portland State University January 17, 1974, are contained in the volume. Wind power, solar energy, geothermal power, oil-shale conversion, and coal-to-gas process are discussed by authorities in those fields. The 62-page publication, illustrated with many photographs and line drawings, is for sale by the Department at its Portland, Baker, and Grants Pass offices for $2.00.

* * * * *

NOTICE TO ORE BIN SUBSCRIBERS

Effective with the July, 1975 issue, The ORE BIN subscription rate will be $3.00 yearly, or 3 years for $8.00. Single copies sold over the counter will continue to be 25¢, but copies ordered by mail will cost 35¢ each. Current subscriptions will continue at the former rate until expiration.

GOLD AND SILVER BULLETIN PRICE GOES UP

"Gold and Silver in Oregon," Bulletin 61, formerly priced at $5.00 is now selling for $7.50. Increased costs of printing, mailing, storing, and handling are making it necessary for the Department to raise the price of all of its publications. New prices for other bulletins will be announced later.

* * * * *

JOSEPHINE COUNTY AGGREGATE STUDY PUBLISHED

"Aggregate Resources of Josephine County, Oregon," has been issued by Josephine County Planning Department in cooperation with the Oregon Department of Geology and Mineral Industries. Authors are H. G. Schlicker, R. A. Schmuck, and Pedro Pescador. Construction aggregates, in the form of sand, gravel, and crushed rock, are necessary commodities for continuing growth of the County. Resources are in alluvial deposits along floors of the larger valleys and in bedrock exposures at higher elevations.

The 47-page illustrated bulletin describes the deposits, lists 310 source sites, and gives the quantity and quality of the material. Twenty-six fold-out photo maps show distribution of the sand and gravel deposits and adjacent bedrock units.

Copies of the aggregate resource publication are available from Josephine County Planning Department, 200 N.W. D Street, Grants Pass, Oregon, 97526. The price is $3.00 over the counter and $3.50 mailed.

* * * * *

ICE BERGS MAY BE TOWED TO ARID LANDS

The Department of Interior reports in a news release that towing tabular icebergs from the Antarctic to some arid areas to provide a freshwater source is considered feasible and warrants further study.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order; postage free. All sales are final – no returns. Upon request, a complete list of Department publications, including out-of-print, will be mailed)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	$0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st suppl.) geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Papers on Tertiary foraminifera: Cushman, Stewart & Stewart. vol. 1 $1.00; vol. 2	1.25
39.	Geology and mineralization of Morning mine region, 1948: Allen and Thayer	1.00
46.	Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
57.	Lunar Geological Field Conf. guidebook, 1965: Peterson and Groh, editors	3.50
60.	Engineering geology of Tualatin Valley region, 1967: Schlicker and Deacon	5.00
61.	Gold and silver in Oregon, 1968: Brooks and Ramp	5.00
62.	Andesite Conference Guidebook, 1968: Dole	3.50
64.	Geology, mineral, and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor (photocopy)	10.00
67.	Bibliography (4th suppl.) geology and mineral industries, 1970: Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970	1.00
69.	Geology of the Southwestern Oregon Coast, 1971: Dott	3.75
70.	Geologic formations of Western Oregon, 1971: Beaulieu	2.00
71.	Geology of selected lava tubes in the Bend area, 1971: Greeley	2.50
72.	Geology of Mitchell Quadrangle, Wheeler County, 1972: Oles and Enlows	3.00
73.	Geologic formations of Eastern Oregon, 1972: Beaulieu	2.00
75.	Geology, mineral resources of Douglas County, 1972: Ramp	3.00
76.	Eighteenth Biennial Report of the Department, 1970-1972	1.00
77.	Geologic field trips in northern Oregon and southern Washington, 1973	5.00
78.	Bibliography (5th suppl.) geology and mineral industries, 1973: Roberts and others	3.00
79.	Environmental geology inland Tillamook Clatsop Counties, 1973: Beaulieu	6.00
80.	Geology and mineral resources of Coos County, 1973: Baldwin and others	5.00
81.	Environmental geology of Lincoln County, 1973: Schlicker and others	7.50
82.	Geol. hazards of Bull Run Watershed, Mult. Clackamas Cos., 1974: Beaulieu	5.00
83.	Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	3.50
84.	Environmental geology of western Linn Co., 1974: Beaulieu and others	8.00
85.	Environmental geology of coastal Lane Co., 1974: Schlicker and others	7.50
86.	Nineteenth Biennial Report of the Department, 1972-1974	1.00

GEOLOGIC MAPS

Geologic map of Oregon west of 121st meridian, 1961: Wells and Peck $2.00; mailed	2.25
Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bulletin 37)	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
Geologic map of Bend quadrangle, and portion of High Cascade Mtns., 1957: Williams	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon: 1962, Corcoran and others	1.50
GMS-3: Preliminary geologic map, Durkee quadrangle, Oregon, 1967: Prostka	1.50
GMS-4: Gravity maps of Oregon, onshore & offshore, 1967: Berg and others [sold only in set] flat $2.00; folded in envelope	2.25
GMS-5: Geology of the Powers quadrangle, 1971: Baldwin and Hess	1.50
GMS-6: Prelim. report, geology of part of Snake River Canyon, 1974: Vallier	5.00

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

Second Class Matter
POSTMASTER: Form 3579 requested

Available Publications, Continued:

SHORT PAPERS

18.	Radioactive minerals prospectors should know, 1955: White and Schafer	$0.30
19.	Brick and tile industry in Oregon, 1949: Allen and Mason	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Mason	0.25
24.	The Almeda mine, Josephine County, Oregon, 1967: Libbey	2.00

MISCELLANEOUS PAPERS

1.	Description of some Oregon rocks and minerals, 1950: Dole	0.40
2.	Oregon mineral deposits map (22 x 34 inches) and key (reprinted 1973): Mason	0.75
4.	Rules and regulations for conservation of oil and natural gas (rev. 1962)	1.00
5.	Oregon's gold placers (reprints), 1954	0.25
6.	Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton	1.50
7.	Bibliography of theses on Oregon geology, 1959: Schlicker	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts	0.50
8.	Available well records of oil and gas exploration in Oregon, rev. 1963: Newton	0.50
11.	A collection of articles on meteorites, 1968 (reprints from The ORE BIN)	1.00
12.	Index to published geologic mapping in Oregon, 1968: Corcoran	0.25
13.	Index to The ORE BIN, 1950-1969, 1970: Lewis	0.30
14.	Thermal springs and wells, 1970: Bowen and Peterson	1.00
15.	Quicksilver deposits in Oregon, 1971: Brooks	1.00
16.	Mosaic of Oregon from ERTS-1 imagery, 1973:	2.00

OIL AND GAS INVESTIGATIONS SERIES

1.	Petroleum geology, western Snake River basin, 1963: Newton and Corcoran	2.50
2.	Subsurface geology, lower Columbia and Willamette basins, 1969: Newton	2.50
3.	Prelim. identifications of foraminifera, General Petroleum Long Bell no. 1 well	1.00
4.	Prelim. identifications of foraminifera, E. M. Warren Coos Co. 1-7 well: Rau	1.00

MISCELLANEOUS PUBLICATIONS

Landforms of Oregon: a physiographic sketch (17" x 22"), 1941	0.25
Geologic time chart for Oregon, 1961	free
Postcard - geology of Oregon, in color . . . . . 10¢ each; 3 - 25¢; 7 - 50¢; 15 -	1.00
Oregon base map (22 x 30 inches)	0.50
Mining claims (State laws governing quartz and placer claims)	0.50
The ORE BIN - Annual subscription . . . . . ($5.00 for 3 yrs.)	2.00
Available back issues, each	0.25
Accumulated index - see Misc. Paper 13	