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THE GRANDEUR OF CONCRETE: PART I

Also in this issue:

MINING ACTIVITY AND EXPLORATION, 1988

OIL AND GAS EXPLORATION AND DEVELOPMENT, 1988

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Information for contributors

Oregon Geology is designed to reach a wide spectrum of readers interested in the geology and mineral industry of Oregon. Manuscript contributions are invited on both technical and general-interest subjects relating to Oregon geology. Two copies of the manuscript should be submitted, typed double-spaced throughout (including references) and on one side of the paper only. If manuscript was prepared on common word-processing equipment, a file copy on 5¼-in. diskette may be submitted in addition to the paper copies. Graphic illustrations should be camera-ready; photographs should be black-and-white glossies. All figures should be clearly marked, and all figure captions should be typed together on a separate sheet of paper.

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

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

COVER PHOTOS

These photos of concrete structures in Oregon were made available to us by the Oregon Concrete and Aggregate Producers Association (OCAPA). Clockwise, from top left: One Financial Center building in downtown Portland, Oregon (Photo by Strode Eckert Photographic); Portland Center for the Performing Arts; interior of the State of Oregon Revenue Building in Salem; the Marquess Castle, a private residence in Creswell, Oregon.

OIL AND GAS NEWS

Mist Gas Field map revised

The map of Mist Gas Field published by the Oregon Department of Geology and Mineral Industries (DOGAMI) is now available with all 1988 changes included. Among these changes is the addition of 13 wells drilled by ARCO in the field and 5 service wells drilled by Oregon Natural Gas Development for its gas-storage project. The map is published at a scale of 1:24,000 as DOGAMI Open-File Report O-89-2 and sells for $5.00.

1989 legislation

DOGAMI is sponsoring legislation during the 1989 regular session of the Legislature including one bill related to oil and gas, HB-2089. This bill would give DOGAMI authority to write rules to oversee drilling of shallow holes such as seismic-shot holes, which are currently not covered in the law. No data derived from such holes would be collected, however. There is a strong movement to protect ground water in the state, and DOGAMI feels that such a program is best placed in this Department. The purpose of the bill is to provide for such ground-water protection and for surface cleanup. Once this legislation is adopted during the 1989 session, DOGAMI will initiate rulemaking for HB-2089, including public input. □

Forum on the Geology of Industrial Minerals to be held in Portland

The Twenty-Fifth Forum on the Geology of Industrial Minerals will be held at the Portland Center Red Lion Inn in Portland from April 30 to May 2, 1989. The Forum, which meets annually to share information on the geology of industrial minerals, has met all over the United States but until this year has never met in the Pacific Northwest. For that reason, the industrial minerals of this region will be highlighted during the Forum.

Topics to be addressed during the day and a half of paper presentations include Oregon perlite, emery, talc, limestone, and bentonite; Washington olivine; Idaho garnet and perlite; Northwest diatomite, zeolite, and pozzolan; playa resources; and state and provincial summaries, including Oregon, Washington, Idaho, Montana, and British Columbia.

Following the sessions in Portland, a three-day field trip by bus has been planned to showcase the industrial mineral resources of Oregon. Overnight stops are planned for Baker, Ontario, and Bend.

For additional information on the Forum, contact Ron Geitgey, Oregon Department of Geology and Mineral Industries, phone (503) 229-5580. □

CONTENTS

Mining activity and exploration in Oregon, 1988

by Mark L. Ferns, Baker Field Office, Oregon Department of Geology and Mineral Industries

INTRODUCTION

The pace of exploration and mining activity continued to increase in 1988. Preliminary estimates by the U.S. Bureau of Mines place the value of 1988 nonfuel mineral production at $169 million, an increase of $9 million from 1987. Total mineral production including natural gas was over $175 million.

Over 605 mine sites were active during 1988. The majority, about 575, were sand-and-gravel and crushed-stone operations. The rest were industrial-mineral and small precious-metal mines.

Precious-metal exploration programs continued to increase in 1988. Over 40 companies were actively searching for gold deposits in the State. The main area of interest continued to be the Basin and Range Province in southeastern Oregon, including Malheur County, where over 5,000 new claims were staked in 1988.

OREGON'S MINERAL PRODUCTION
MILLIONS OF DOLLARS

	ROCK MATERIALS (Sand & Gravel, Stone)	METALS & INDUSTRIAL MINERALS (Cement, Nickel, Pumice, etc.)	NATURAL GAS	TOTAL
1972	54	22	0	76
1973	55	26	0	81
1974	75	29	0	104
1975	73	33	0	106
1976	77	35	0	112
1977	74	35	0	109
1978	84	44	0	128
1979	111	54	+	165
1980	95	65	12	172
1981	85	65	13	163
1982	73	37	10	120
1983	82	41	10	133
1984	75	46	8	129
1985	91	39	10	140
1986	96	30	9	135
1987	102	52	6	160
1988	114	55	6	175

Summary of mineral production in Oregon for the last 17 years. Data for 1988 derived from U.S. Bureau of Mines annual preliminary mineral-industry survey and Oregon Department of Geology and Mineral Industries natural-gas production statistics.

PRODUCTION

Industrial minerals continued to be an important part of the State's mineral industry. Ash Grove Cement West (active mine site 6) continued to produce crushed agricultural limestone and cement at the Durkee plant in Baker County. Ash Grove is the second-largest payer of property tax in the county and currently employs about 100 people.

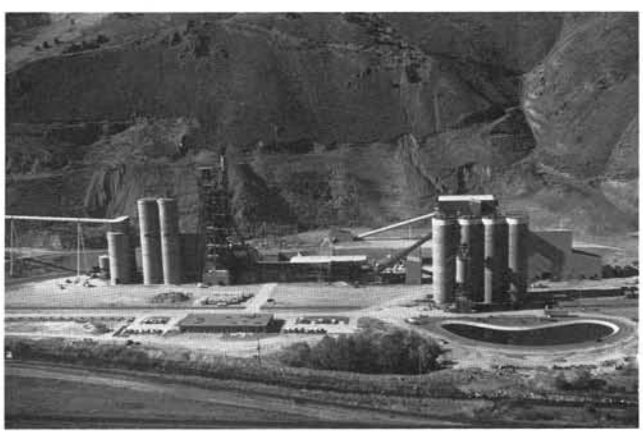
Eagle-Picher Minerals, Inc., continued production of filter-grade diatomite at its facility in Malheur County. Diatomite for the plant is mined from Miocene lake sediments along the Malheur-Harney County line.

Precious-metal production continued to be small, coming mainly from small placer mines in southwestern and northeastern Oregon. The main producer was again the Bonanza Mine (active mine site 7) on Pine Creek near Halfway in Baker County.

Dry-land dredge plant in operation at Bonanza Mine (active mine site 7) in Baker County.

Table 1. *Active mines in Oregon, 1988*

Map no.	Name	Location	Commodity	Comments
1	Pyx Mine	Sec. 1 T. 10 S., R. 35 E. Grant County	Lode gold	—
2	Lower Grandview Mine	Sec. 6 T. 14 S., R. 37 E. Baker County	Lode gold	—
3	Pine Creek area	T. 12 S., R. 38 E. Baker County	Placer gold	—
4	Dooley Mountain area	Tps. 11, 12 S. R. 40 E. Baker County	Perlite	—
5	Clarks Creek area	Sec. 12 T. 13 S., R. 41 E. Baker County	Placer gold	—
6	Ash Grove Cement West	Sec. 11 T. 12 S., R. 43 E. Baker County	Crushed limestone and cement	Yearly production estimated at over $25 million. Employs around 100 people.
7	Bonanza Mining Co.	Sec. 3 T. 7 S., R. 45 E. Baker County	Placer gold	Largest placer mine in Oregon with over 20 employees.
8	Cascade Pumice/Central Oregon Pumice	T. 17, 18 S. R. 11 E. Deschutes County	Pumice	—
9	Ctrl. Oregon Bentonite Co./Oreg. Sun Ranch, Inc.	Both sec. 4 T. 19 S., R. 21 E. Crook County	Bentonite clay	—
10	Oil-Dri Production Co.	Secs. 14, 21, 23 T. 27 S., R. 16 E. Lake County	Diatomite	—
11	Eagle-Picher Minerals, Inc.	Tps. 19, 20 S. Rs. 35, 36, 37 E. Harney/Malheur Counties	Filter-grade diatomite	Employs around 30 people.



Limestone quarry (background) and cement plant of Ash Grove Cement West, Inc., located south of Durkee, Baker County (active mine site 6).

Table 1. *Active mines in Oregon, 1988—continued*

Map no.	Name	Location	Commodity	Comments
12	Teague Mineral Products	Secs. 8, 28, 29 T. 23 S., R. 46 E. Malheur County	Bentonite clay and clinoptilolite zeolite	—
13	CooSand Corporation	Sec. 34 T. 24 S., R. 13 W. Coos County	Silica sand	—
14	Coyote Creek area	Sec. 24 T. 33 S., R. 6 W. Josephine County	Placer gold	—
15	Lower Grave Creek area	Secs. 31, 32 T. 33 S., R. 7 W. Josephine County	Placer gold	—
16	Galice area	Tps. 34, 35 S. R. 8 W. Josephine County	Placer gold	—
17	Josephine Creek area	Tps. 38, 39 S. R. 9 W. Josephine County	Placer gold	—
18	Sucker Creek area	Tps. 39, 40 S. Rs. 6, 7 W. Josephine County	Placer gold	—
19	Jones Marble	Sec. 31 T. 38 S., R. 5 W. Josephine County	Limestone	—
20	Bristol Silica and Lime Co.	Sec. 30 T. 36 S., R. 3 W. Jackson County	Silica	—
21	Steatite of Southern Oregon	Secs. 10, 11 T. 41 S., R. 3 W. Jackson County	Soapstone	—

EXPLORATION

Exploration for precious metals, mainly gold, continued on an upswing in 1988. Over 40 companies were searching for the yellow metal by year's end.

The main area of interest in late 1988 was the Vale-Weiser area in northern and central Malheur County. This area, which lies at the intersection of the northern Basin and Range Province and the western edge of the Snake River Plain, is emerging as a highly promising epithermal-gold province.

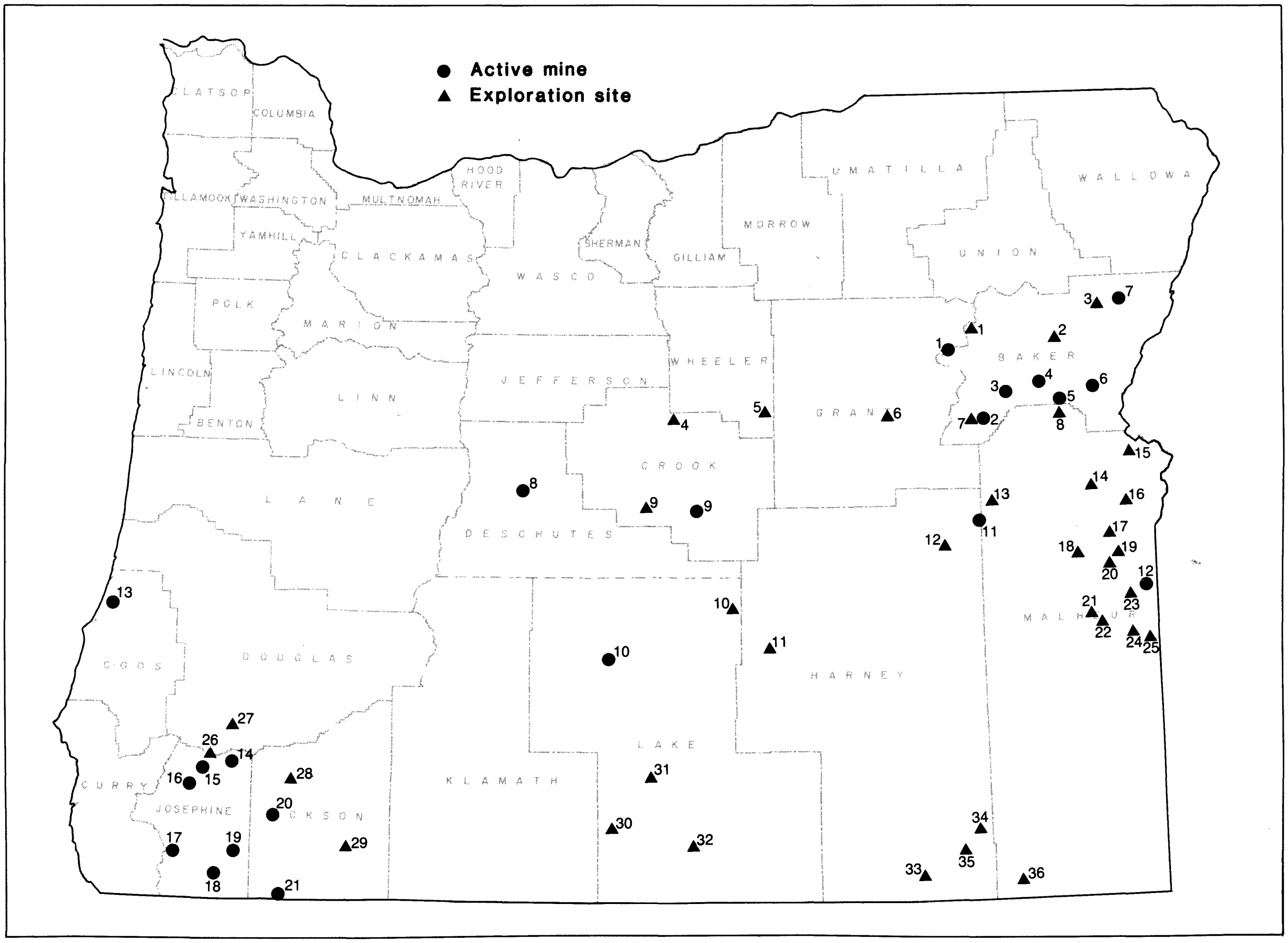
A "rush" was triggered when Atlas Corporation announced a major discovery at its Grassy Mountain prospect (exploration site 20) south of Vale. Published geologic gold reserves are over 1 million oz at an average grade of 0.065 oz per short ton. The deposit is an epithermal (hot-springs-type) system in middle Miocene arkosic sandstones. Despite heavy snows, Atlas continued an extensive drilling program through the winter and completed more than 70 reverse-circulation holes by mid-November.

Much of the region adjacent to Grassy Mountain is undergoing extensive exploration. Other active prospects near Vale include Hope Butte (exploration site 14), Kerby (exploration site 15), Vale Buttes (exploration site 16), Double Mountain (exploration site 17), Harper Basin (exploration site 18), Shell Rock Butte (exploration site 19),

(Continued on page 31)

Table 2. *Exploration sites and areas in Oregon, 1988*

Map no.	Name	Location	Commodity	Comments
1	Herculean Mine	Sec. 22 T. 8 S., R. 36 E. Baker County	Gold and base metals	Small exploration and development program by Cable Cove Mining Co.
2	Virtue Mine	T. 9 S., R. 41 E. Baker County	Gold	Drill programs by Hecla at the Flagstaff and by Morris & Knudson at the Gray Eagle and Rachel.
3	East Eagle Mine	Secs. 19, 30 T. 7 S., R. 44 E. Baker County	Gold	COMINCO American continuing small exploration program.
4	Ochoco Mine	Secs. 29, 30 T. 13 S., R. 20 E. Crook County	Gold	Continued exploration by Orbana.
5	Spanish Gulch	T. 13 S., R. 25 E. Wheeler County	Gold	Evaluation program by ASARCO.
6	Prairie Diggings prospect	Sec. 33 T. 13 S., R. 32 E. Grant County	Gold	Evaluation program by Goldsearch.
7	Record Mine	Secs. 1, 2 T. 14 S., R. 36 E. Baker County	Gold	Exploration program by ICAN.
8	Malheur City area	T. 13 S., R. 41 E. Malheur County	Gold	Exploration programs by ICAN and Goldsearch.
9	Bear Creek area	Tps. 18, 19 S. R. 18 E. Crook County	Gold	Exploration and drilling program by Freeport-McMoran.
10	Glass Buttes	T. 24 S., R. 23 E. Lake County	Gold	Drilled and later dropped by Galactic.
11	Wagontire	Tps. 26, 27 S. R. 25 E. Harney County	Gold	Under evaluation by Cal-Ore Exploration Ventures.
12	Drewsey area	Tps. 20, 21 S. Rs. 34, 35 E. Harney County	Gold	Exploration and evaluation programs by Corona Gold and Reserve Industries.
13	Castle Rock	Secs. 8, 9 T. 18 S., R. 37 E. Malheur County	Gold	Under evaluation by Chevron.
14	Hope Butte	Sec. 21 T. 17 S., R. 43 E. Malheur County	Gold	Drilling program by Chevron.
15	Kerby	Secs. 22, 27 T. 15 S., R. 45 E. Malheur County	Gold	Intensive drilling program by Malheur Mining Co. Feasibility studies underway.
16	Vale Buttes	Secs. 28, 29 T. 18 S., R. 45 E. Malheur County	Gold	Under evaluation by Atlas.
17	Double Mountain	T. 20 S., R. 44 E. Malheur County	Gold	Three reverse-circulation holes drilled by Atlas.
18	Harper Basin	T. 21 S., R. 42 E. Malheur County	Gold	Exploration program by ACNC.
19	Shell Rock Butte	T. 21 S. Rs. 44, 45 E. Malheur County	Gold	Under evaluation by ASARCO.
20	Grassy Mountain	Sec. 8 T. 22 S., R. 44 E. Malheur County	Gold	Major discovery announced by Atlas.
21	Quartz Mountain	Sec. 6 T. 25 S., R. 43 E. Malheur County	Gold	Drilling program by Chevron.
22	Red Butte	T. 25 S., R. 43 E. Malheur County	Gold	Sampling program by Chevron.
23	Katey	Tps. 23, 24 S. R. 45 E. Malheur County	Gold	Drilling program by Manville.
24	Bannock prospect	Sec. 11 T. 26 S., R. 45 E. Malheur County	Gold	Under evaluation by Chevron.
25	Mahogany prospect	Secs. 25, 26 T. 26 S., R. 46 E. Malheur County	Gold	Drilling program by Chevron.
26	Goff Mine	Secs. 20, 29, 30 T. 33 S., R. 7 W. Josephine County	Gold, silver, copper	Continued evaluation program by Amselco/BP America.
27	Silver Peak Mine	Sec. 23 T. 31 S., R. 6 W. Douglas County	Gold, silver, copper	Drilling program by Formosa.
28	Shamrock Mine	Sec. 19 T. 34 S., R. 2 W. Jackson County	Gold, silver, copper, platinum	Exploration programs by Freeport and Boise Cascade.
29	Shale City	T. 38 S., R. 2 E. Jackson County	Gold	Drilling program by Boise Cascade.
30	Quartz Mountain	Secs. 26, 27, 34, 35 T. 37 S., R. 16 E. Lake County	Gold	Feasibility studies underway; evaluation of leach tests and engineering studies.
31	Paisley area	T. 34 S. Rs. 18, 19 E. Lake County	Gold	Joint-venture exploration program by Dergestrom and Inland Gold & Silver Corp.
32	Salt Creek	T. 38 S., R. 21 E. Lake County	Gold	Drilling program by FMC.
33	Pueblo Mountains area	Tps. 39, 40, 41 S. Rs. 34, 35 E. Harney County	Gold	Exploration programs by Lake Fork and Red Arrow Resources.
34	Whitehorse area	T. 37 S., R. 36 E. Harney County	Gold	Exploration program by Pegasus.
35	Flagstaff Butte	T. 38, 39 S. R. 37 E. Harney County	Gold	Exploration program by Geomex Minerals.
36	McDermitt area	Tps. 40, 41 S. R. 40 E. Malheur County	Gold	Exploration program by McDermitt Mines JV.



EXPLANATION

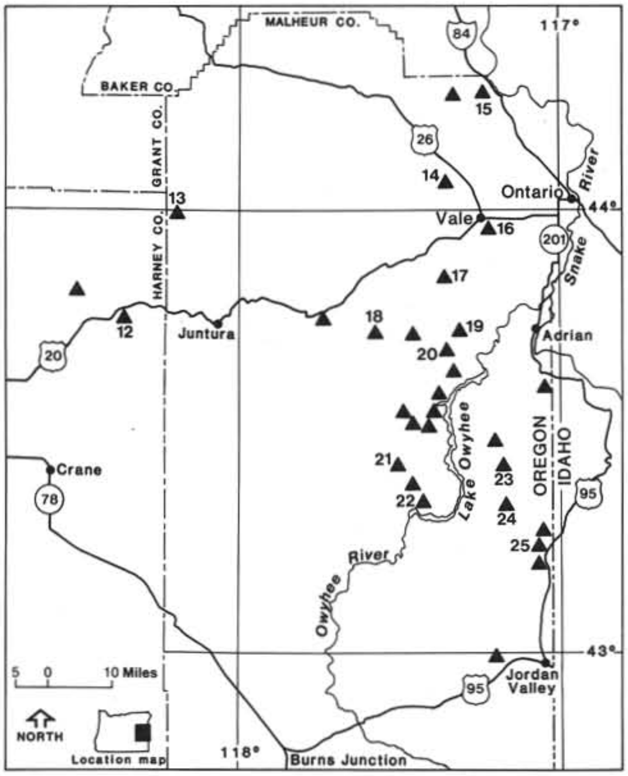
ACTIVE MINES

1. Pyx Mine (lode gold)
2. Lower Grandview Mine (lode gold)
3. Pine Creek area (placer gold)
4. Dooley Mountain area (perlite)
5. Clarks Creek area (placer gold)
6. Ash Grove Cement West (limestone, cement)
7. Bonanza Mining Co. (placer gold)
8. Cascade Pumice/Central Oregon Pumice (pumice)
9. Central Oregon Bentonite Co./Oregon Sun Ranch, Inc. (bentonite clay)
10. Oil-Dri Production Co. (diatomite)
11. Eagle-Picher Minerals, Inc. (filter-grade diatomite)
12. Teague Mineral Products (bentonite clay, clinoptilolite zeolite)
13. CooSand Corporation (silica sand)
14. Coyote Creek area (placer gold)
15. Lower Grave Creek area (placer gold)
16. Galice area (placer gold)
17. Josephine Creek area (placer gold)
18. Sucker Creek area (placer gold)
19. Jones Marble (limestone)
20. Bristol Silica and Lime Co. (silica)
21. Steatite of Southern Oregon (soapstone)

EXPLORATION SITES AND AREAS

1. Herculean Mine (gold, base metals)
2. Virtue Mine (gold)
3. East Eagle Mine (gold)
4. Ochoco Mine (gold)
5. Spanish Gulch (gold)
6. Prairie Diggings prospect (gold)
7. Record Mine (gold)
8. Malheur City area (gold)
9. Bear Creek area (gold)
10. Glass Buttes (gold)
11. Wagontire (gold)
12. Drewsey area (gold)
13. Castle Rock (gold)
14. Hope Butte (gold)
15. Kerby (gold)
16. Vale Buttes (gold)
17. Double Mountain (gold)
18. Harper Basin (gold)
19. Shell Rock Butte (gold)
20. Grassy Mountain (gold)
21. Quartz Mountain (gold)
22. Red Butte (gold)
23. Katey (gold)
24. Bannock prospect (gold)
25. Mahogany prospect (gold)
26. Goff Mine (gold, silver, copper)
27. Silver Peak Mine (gold, silver, copper)
28. Shamrock Mine (gold, silver, copper, platinum)
29. Shale City (gold)
30. Quartz Mountain (gold)
31. Paisley area (gold)
32. Salt Creek (gold)
33. Pueblo Mountains area (gold)
34. Whitehorse area (gold)
35. Flagstaff Butte (gold)
36. McDermitt area (gold)

Mining and mineral exploration in Oregon in 1988 (excluding sand and gravel and stone). Active mines are keyed to Table 1; exploration sites and areas are keyed to Table 2.



Map showing locations of exploration sites for epithermal gold in the Vale-Weiser area. Numbered sites are keyed to Table 2.

Quartz Mountain (exploration site 21), Red Butte (exploration site 22), Katey (exploration site 23), and Mahogany (exploration site 25). A number of additional prospects had been located by year's end (see location map of Vale-Weiser area). These include both middle Miocene sediment- and volcanic-hosted Basin and Range systems and early Pliocene systems related to development of the Snake River Plain.

The geology is complex in this part of Oregon, from which precious metals have not been previously produced. Geologists of the Oregon Department of Geology and Mineral Industries (DOGAMI), the U.S. Geological Survey, and Portland State University are currently conducting mapping programs to generate 1:24,000-scale geologic maps of the region.

DOGAMI has published maps of two quadrangles: Owyhee Ridge (GMS-53) and Graveyard Point (GMS-54). Publication is in progress on two more quadrangles: Owyhee Dam (GMS-55) and Adrian (GMS-56). Preliminary, unedited versions of the Grassy Mountain and Double Mountain quadrangles (GMS-57 and GMS-58, respectively) are available for inspection at the DOGAMI offices in Baker, Grants Pass, and Portland, and final versions of these two maps will be published later this year.

Elsewhere in the state, Tertiary volcanic-hosted epithermal systems continued to be the main focus of exploration. Areas of interest include south-central and central Oregon. Quartz Mountain Gold Corporation continued to reevaluate its Quartz Mountain prospect (exploration site 30) in Lake County. Metallurgical testing continued on samples from the property, which is reported to contain a resource of 10 to 15 million tons grading 0.04 oz of gold per ton. The company put down 50 drill holes in 1988 to obtain samples for further metallurgical testing.

Reverse-circulation drill site at the Grassy Mountain prospect of Atlas Corporation (exploration site 20), the area from which Atlas announced a major discovery in 1988.

Aerial view of exploration area at Grassy Mountain prospect of Atlas Corporation (exploration site 20).

Drill rig of Malheur Mining Company at its Kerby site (exploration site 15).

Volcanogenic sulfide deposits in the older pre-Tertiary terranes of northeastern and southwestern Oregon continued to attract interest. Main areas of exploration continue to be the Goff (exploration site 26) and Silver Peak (exploration site 27) Mines in southwestern Oregon. Quartz veins in pre-Tertiary rocks also continued to be of some interest. Serpentinite-associated systems in northeastern Oregon, such as Spanish Gulch (exploration site 5), the Prairie Diggings prospect (exploration site 6), the Record Mine (exploration site 7), and the Malheur City area (exploration site 8) drew the most attention last year.

The search for industrial minerals also continued in 1988. Perlite and diatomite were again of dominant interest to the exploration industry. Other sought-after commodities included bentonite clay, zeolite, and talc.

In July 1988, the Oregon Department of Geology and Mineral Industries published a comprehensive study of talc in Oregon (DOGAMI Special Paper 18). Similar reports on bentonite (Special Paper 20) and limestone (Special Paper 19) are scheduled for publication this spring and later this year, respectively. □

Send us your announcements

One of our Medford readers has suggested that *Oregon Geology* serve as a clearing house for announcements on geological training sessions, workshops, or seminars for the professional geologist.

We think that is a good idea. So if you send us notices of your meetings and training sessions, we will print them in *Oregon Geology*, space permitting. Allow at least a month and a half—and preferably two months—lead time. □

Oil and gas exploration and development in Oregon, 1988

by Dennis L. Olmstead, Petroleum Engineer, and Dan E. Wermiel, Petroleum Geologist, Oregon Department of Geology and Mineral Industries

ABSTRACT

Oil and gas lease activity made a poor showing in 1988, but drilling was up 37 percent over 1987. One County, one State, and one Federal lease sale were held during the year, but a combined total of only 27,672 acres was taken at the three sales.

Mist Gas Field and vicinity had 13 wells and three redrills by ARCO Oil and Gas Company. Seven of the ARCO wells were successful, for a cumulative flow rate of 5.0 million cubic feet per day (MMcfd). The field now has fourteen producers making 9.1 MMcfd. Production value for the year was $6.4 million. ARCO also drilled a deep test in Morrow County.

Oregon Natural Gas Development Company drilled five gas-storage service wells at Mist to complete the drilling on their two-pool storage project. Surface-equipment engineering and construction were also carried out. Gas withdrawals will begin in the fall of 1989.

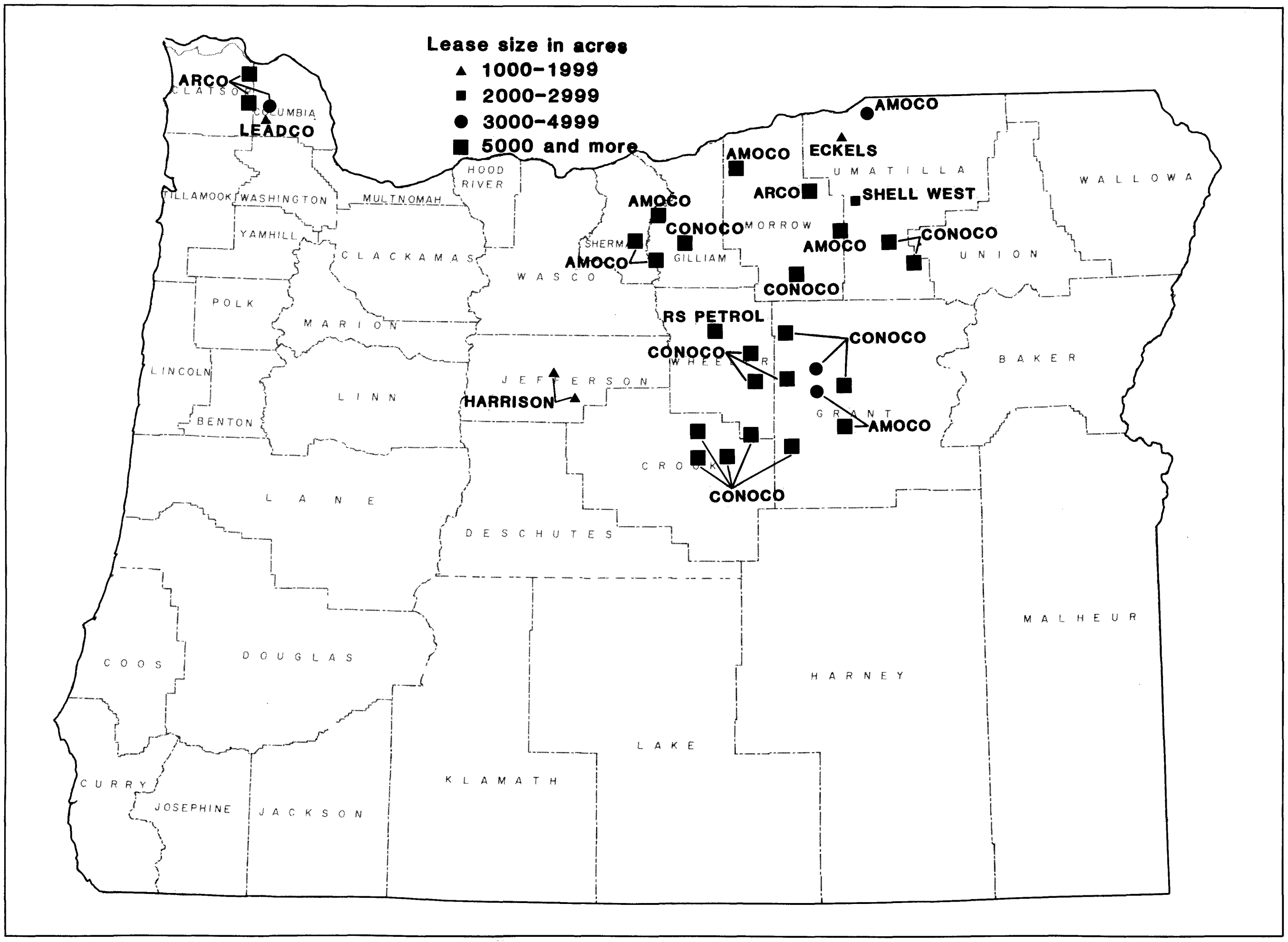
Northwest Natural Gas Company received approval to build a new 50-mi-long gas pipeline from Mist to Portland. Construction will take place in 1989.

The Department of Geology and Mineral Industries (DOGAMI) began a five-year study of the Tyee Basin in western Douglas and eastern Coos Counties. Emphasis will be on source rock, stratigraphy, and structure of the rocks in the basin.

LEASING ACTIVITY

Leasing of public land in 1988 consisted of three public-lands lease sales plus over-the-counter leasing of Bureau of Land Management (BLM) property. The accompanying lease map shows major areas of leasing. It includes over 220,000 acres issued early in the year to Amoco and Conoco. This acreage appeared in our 1987 report because the filing dates back to December 1987.

The first lease sale of the year was held on June 16, 1988, by Columbia County. At the sale, 94 parcels were offered, comprising 32,407 acres, all in and around Mist Gas Field. Successful bidders were ARCO and Leadco, taking 29 parcels totaling 8,079 acres. The high bid was $51 per acre in sec. 20, T. 6 N., R. 5 W. Income to the County from the sale was about $145,000. The terms of Columbia County leases are as follows: primary term of ten years, three-sixteenths royalty, and annual rental of $10 per acre.



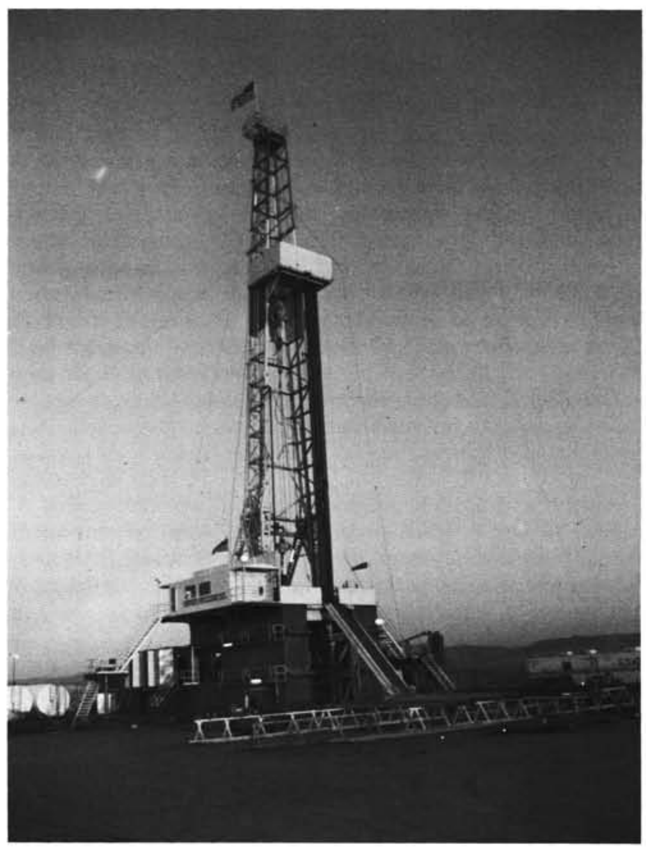
Major areas of public-land leasing in 1988. Map shows acreage applied for and issued during the year. Most issued acreage is from 1986 and 1987 applications; only 5,000 acres were filed for in 1988. Withdrawals and terminations are not shown. Data courtesy of Dolores Yates, LANDATA.

Table 1. *Oil and gas permits and drilling activity in Oregon, 1988*

Permit no.	Operator, well, API number	Location	Status, depth (ft) TD=total depth PTD=proposed TD RD=redrill
376	ARCO Columbia Co. 42-8-54 36-009-00213	NE¼ sec. 8 T. 5 N., R. 4 W. Columbia County	Completed, gas; TD: 2,255.
392	ARCO Longv. Fibre 32-20-65 36-009-00229	NE¼ sec. 20 T. 6 N., R. 5 W. Columbia County	Abandoned, dry hole; TD: 1,249.
397	ARCO Hanna 1 36-049-00002	NE¼ sec. 23 T. 2 S., R. 27 E. Morrow County	Abandoned, dry hole; TD: 9,211.
398	ARCO CFI 34-1-55 36-009-00232	SE¼ sec. 1 T. 5 N., R. 5 W. Columbia County	Completed, gas; TD: 1,370.
399	ARCO Johnston 44-19-65 36-009-00233	SE¼ sec. 19 T. 6 N., R. 5 W. Columbia County	Abandoned, dry hole; TD: 2,910.
400	ARCO Columbia Co. 12-19-65 36-009-00234	NW¼ sec. 19 T. 6 N., R. 5 W. Columbia County	Completed, gas; TD: 3,209.
401	Oregon Nat. Gas Dev. IW 42C-10 36-009-00235	NE¼ sec. 10 T. 6 N., R. 5 W. Columbia County	Completed, service well; TD: 2,769.
402	Oregon Nat. Gas Dev. IW 22D-10 36-009-00236	NW¼ sec. 10 T. 6 N., R. 5 W. Columbia County	Completed, service well; TD: 2,770.
403	Oregon Nat. Gas Dev. OM 43B-10 36-009-00237	SE¼ sec. 10 T. 6 N., R. 5 W. Columbia County	Completed, service well; TD: 2,616.
404	Oregon Nat. Gas Dev. IW 33D-3 36-009-00238	SE¼ sec. 3 T. 6 N., R. 5 W. Columbia County	Completed, service well; TD: 2,962.
405	Oregon Nat. Gas Dev. IW 23B-3 36-009-00239	SW¼ sec. 3 T. 6 N., R. 5 W. Columbia County	Completed, service well; TD: 2,974
406	ARCO Columbia Co. 44-27-65 36-009-00240	SE¼ sec. 27 T. 6 N., R. 5 W. Columbia County	Completed, gas; TD: 2,150.
407	ARCO Columbia Co. 24-9-64 36-009-00241	SW¼ sec. 9 T. 6 N., R. 4 W. Columbia County	Completed, gas; TD: 2,503.
408	ARCO CFW 12-15-64 36-009-00242	NW¼ sec. 15 T. 6 N., R. 4 W. Columbia County	Completed, gas; TD: 1,950.
409	ARCO Benson 14-7-64 36-009-00243	SW¼ sec. 26 T. 6 N., R. 4 W. Columbia County	Abandoned, dry hole; TD: 2,506.
410	ARCO CFI 23-16-64 36-009-00244	NW¼ sec. 16 T. 6 N., R. 4 W. Columbia County	Abandoned, dry hole; TD: 1,775.
411	ARCO Hamlin 33-17-65 36-009-00245	SE¼ sec. 17 T. 6 N., R. 5 W. Columbia County	Permit issued; PTD: 2,835.

Table 1. *Oil and gas permits and drilling activity in Oregon, 1988 —continued*

Permit no.	Operator, well, API number	Location	Status, depth (ft) TD=total depth PTD=proposed TD RD=redrill
412	ARCO, Longview Fibre 32-20-65R and Redrill 36-009-00246 36-009-00246-01	NE¼ sec. 20 T. 6 N., R. 5 W. Columbia County	Completed, gas; TD: 3,230, RD: 3,088.
413	ARCO Columbia Co. 22-17-75 36-009-00247	NW¼ sec. 17 T. 7 N., R. 5 W. Columbia County	Permit issued; PTD: 3,250.
414	ARCO, Sterling 12-24-66 and Redrill 36-009-00019 36-009-00019-01	NW¼ sec. 12 T. 6 N., R. 6 W. Clatsop County	Abandoned, dry hole; TD: 3,144, RD: 2,845.
417	ARCO, Longview Fibre 24-8-75 and Redrill 36-009-00248 36-009-00248-01	SW¼ sec. 8 T. 7 N., R. 5 W. Columbia County	Abandoned, dry hole; TD: 2,814, RD: 3,039.
418	ARCO OR 21-33-86 36-007-00020	NW¼ sec. 33 T. 8 N., R. 6 W. Clatsop County	Permit issued; PTD: 6,000.
419	ARCO OR 13-33-86 36-007-00021	SW¼ sec. 33 T. 8 N., R. 6 W. Clatsop County	Permit issued; PTD: 6,000.



Drilling at the ARCO Hanna 1 well in the Columbia Basin, Morrow County.

BLM held a lease sale on September 7, offering 314,635 acres in 185 parcels. No bids were received, and the acreage was made available the following day for noncompetitive over-the-counter filing. Subsequently, applicants filed for four parcels consisting of 4,335 acres in central Oregon, at a total fee and rental cost of $6,802.

During 1988, several changes took place in the way BLM conducted its leasing program. The agency made modifications in the way over-the-counter filings may be made. Additional changes last year included initiation of quarterly lease sales by BLM, with the September 7 sale being the first on this schedule. Subsequent sales were scheduled for January 25 and March 1, 1989. The January 25 sale received no bids, while results of the March 1 sale were not available in time for this report. The 1988 rental income for Federal leases totaled $1,139,822, and at year's end, 876,135 acres in 397 parcels were under lease, an increase of 15 percent in leased acreage over the previous year.

The Oregon Division of State Lands held a lease sale on November 1, 1988, offering 19,553 acres in 43 parcels, mainly in Clatsop County. Successful bidders included ARCO (15,553 acres), and W. Cooper (3,200 acres). L. Fisk also took 800 acres in Wheeler County with no bidding. These leases were issued December 7, 1988. Fees and bonus payments totaled about $75,000 to the State.

Terminated Federal and State lease acreage totaled 324,535 acres.

DRILLING

Fourteen exploratory oil and gas wells, five gas storage wells, and three redrills were drilled in the state in 1988. This is a significant increase over the level of the 1987 drilling activity. All but one of the wells were drilled in the Mist Gas Field area, a pattern that has continued since the field was discovered in 1979. The other well was a wildcat well drilled by ARCO in the Columbia Basin of northeastern Oregon. This well, the Hanna 1, was the first well drilled for oil and gas in Morrow County and was a rare attempt to penetrate the volcanic rocks covering this geologic province and to reach the underlying strata that are interpreted to contain favorable conditions for oil and gas accumulation and entrapment. The well was drilled to a total depth of 9,211 ft, making it the deepest well drilled in Oregon during 1988, but was plugged and abandoned as a dry hole.

At Mist Gas Field, two operators were active during the year. As has been the case for the past several years, ARCO Oil and Gas Company was the most active operator, drilling 13 exploratory wells and three redrills. Of these, seven were successful gas completions, while the rest were dry holes. Oregon Natural Gas Development Corporation, a subsidiary of Northwest Natural Gas Company, drilled five wells as part of the natural-gas storage project. Details of these wells are provided in the natural gas storage project portion of this summary.

Logging operations at well IW 42C-10 of Oregon Natural Gas Development Company as part of the natural-gas storage project at Mist Gas Field.

Total footage drilled for the year, including the gas-storage wells, was 61,523 ft, a significant increase over the 42,665 ft drilled during 1987. The average depth per well was 2,797 ft, about the same as the average of 2,896 ft per well drilled the previous year.

During 1988, DOGAMI issued 21 permits to drill (Table 1), while two expired permits were canceled, and three permits were denied during the year (Table 2).

DISCOVERIES AND GAS PRODUCTION

Mist Gas Field saw seven new producers, which ties last year's results as the record for the number of new gas wells discovered in a single year at Mist. ARCO Oil and Gas Company is the operator of all these wells, which include the CFI 34-1-55, CFW 12-15-64,

Table 2. *Canceled and denied permits, 1988*

Permit no.	Operator, well, API number	Location	Issue date	Cancellation date	Reason
356	ARCO Columbia Co. 13-21 36-009-00195	SW¼ sec. 21 T. 6 N., R. 5 W. Columbia County	3-28-86	3-28-88	Permit canceled; expired.
369	ARCO CFI 31-22 36-009-00206	NE¼ sec. 22 T. 6 N., R. 5 W. Columbia County	7-18-86	7-18-88	Permit canceled; expired.
396	Interwest Exploration Cavenham 31-5 36-007-00018	NE¼ sec. 5 T. 6 N., R. 7 W. Clatsop County	—	—	Permit denied; incomplete application.
415	ARCO Greenup 1 36-049-00003	NE¼ sec. 19 T. 2 S., R. 28 E. Morrow County	—	—	Permit denied; operator withdrew application.
416	ARCO Greenup 2 36-049-00004	NE¼ sec. 20 T. 2 S., R. 28 E. Morrow County	—	—	Permit denied; operator withdrew application.

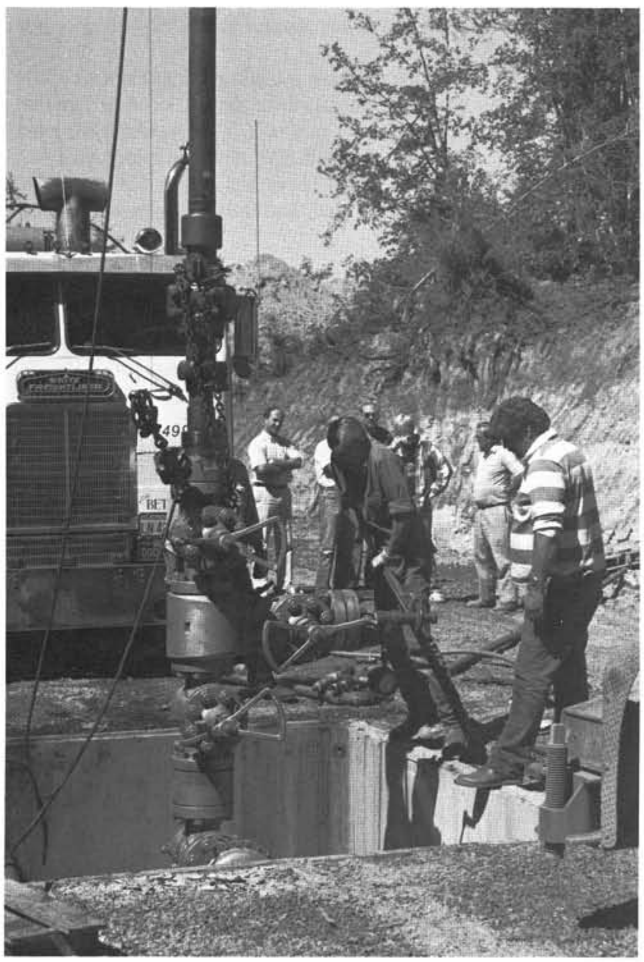
CC 12-19-65, CC 24-9-64, CC 42-8-54, CC 44-27-65, and LF 32-20-65R-RD1. Cumulative flow rate for these wells is 5.0 MMcfd of gas. This brought the total number of producers in the field to 14 at year's end, with an additional six wells awaiting pipeline connection. Seven wells at the field are shut in.

Three of the seven new gas producers discovered during 1988 extend the geographic limits of established production in the Mist Gas Field: Two are now the easternmost producers in the field and are located some 4 mi from the nearest previous producers. In addition, one of the new producers is the westernmost gas well in the field and is within a quarter of a mile of the Clatsop County line.

Gas production for the year totaled 4.0 billion cubic feet (Bcf), an increase from the 3.8 Bcf produced during 1987. The cumulative field production through the end of 1988 was about 35.8 Bcf. The total value for the gas produced for the year was $6.4 million, an increase of 16 percent over the $5.5 million during 1987. Gas prices varied between 14 cents and 20 cents per therm.

GAS STORAGE

Drilling for the Mist gas-storage project was completed by Northwest Natural Gas Company in 1988, adding to two previous years of storage- and monitor-well drilling. Five wells were drilled during the year—four injection-withdrawal wells and one observation-monitor well. Total footage drilled for these wells was 14,091 ft, for an average depth of 2,818 ft per well. Two of the injection-withdrawal wells were added to the Flora Pool and two were added to the Bruer Pool, completing a total of three injection-withdrawal wells for each of these pools. Injection-withdrawal wells are used to add gas to and remove gas from the storage reservoir.



Swabbing Oregon Natural Gas Development Company well IW 23B-3 at Mist Gas Field, one of the procedures preparing the well for service as an injection-withdrawal well.

During 1988, the Miller Natural Gas Station was being redesigned, and the only gas injection done during the year was during February, when 4.2 MMcf of gas was injected into the Bruer Pool to test the compressors at Miller Station. Withdrawals are scheduled to begin during fall 1989. The observation-monitor well was drilled on the southern edge of the storage area, bringing to seven the total number of observation-monitor wells drilled. Observation-monitor wells are used to monitor the gas levels and pressures in the storage reservoir. No additional drilling is expected at the gas-storage project at this time.

OTHER ACTIVITIES

DOGAMI began a five-year study of the Tyee Basin during 1988. The Tyee Basin is located in the southern Coast Range and contains Eocene sandstone strata that are believed to have similarities to the sands that produce gas at Mist Gas Field. The study area is located primarily in western Douglas and eastern Coos Counties. In the study, emphasis will be placed on those characteristics needed to generate and trap gas and oil, namely, source rock, stratigraphy, and structural framework. Funding for the study is being provided by landowners in the study area and by County, State and Federal agencies. DOGAMI will release publications reporting the results of the ongoing study to keep the public informed of its progress.

The Northwest Petroleum Association remained active during 1988, showing a membership of about 140 at year's end. At monthly meetings, papers related to the oil and gas industry were presented, and a field symposium with a geologic field trip was held in May. The 1988 symposium took place in Ocean Shores, Washington, and included field trips to the Chehalis and Grays Harbor Basins as well as the coastal area of the Olympic Peninsula.

Northwest Natural Gas received approval from the Energy Facility Siting Council to build a natural-gas pipeline from the Mist Gas Field to Portland. The pipeline, the South Mist Feeder, will be of 16-in. steel, 50 mi long, and will extend from the Mist storage project to West Union Road, west of Portland, where it will connect with existing pipeline facilities. With the new pipeline, Northwest Natural Gas Company will increase deliverability when producing or storing gas. The line will also provide a back-up capability in the event the existing gas line needs to be turned off.

Offshore oil and gas exploration is still several years away in the region, but planning is underway at the State and Federal levels. The Oregon Ocean Resources Management Task Force, established by the 1987 Legislature, met six times and released an Interim Report. Public workshops were also held to gather input on the concept of planning for new uses of the ocean, primarily mineral development. The consensus from the public was that existing uses such as fishing and tourism should be preserved, whereas mining or oil and gas exploration should be prevented. Further meetings will result in a draft plan in September 1989, followed by additional public input. A final plan is scheduled for July 1990.

Meanwhile, the U.S. Minerals Management Service is moving ahead with its plans for an April 1992 oil and gas lease sale for the outer continental shelf off Oregon and Washington. The agency held a workshop in Portland in June 1988 to gather input about its environmental studies program in preparation for the sale. Several studies are underway, and more are planned for 1989 and 1990. Industry interest will not be gathered until November 1989 and may ultimately determine whether there will be a 1992 offering.

The Mist Gas Field map (1:24,000) has been updated as DOGAMI Open-File Report O-89-2. It reflects all 1988 drilling activity in the field, including gas-storage and monitor-well activity. □

The grandeur of concrete: Part I

by Don Dupras, Geologist, California Division of Mines and Geology

This article first appeared in the January 1989 issue of *California Geology* and is reprinted by permission here because we believe it will be of interest to our readers. It is the first of a two-part series describing how concrete is made, how it is used, and how important it is in our lives. Part I presents the history of the development of concrete, the advent of the concrete industry in America, and the composition of modern concrete. Part II will appear in a later issue and will describe our dependence on concrete and modern advances in concrete technology.
—*Editor*

INTRODUCTION

Concrete literally forms the foundation of our society. Our homes, factories, offices, schools, roads, runways, dams, sewers—in short, our quality of life depends on inexpensive and abundant concrete (Figure 1). Engineers and architects utilize its versatility for thousands of specialty uses. The fire-resistant property of concrete is a structural advantage over wood; concrete does not burn or rot. Its insulating properties are widely employed to save on heating and cooling costs. The density of ordinary concrete enables it to store solar heat and to slowly release it at night. Concrete is relatively inexpensive, readily available, permanent, very durable, and easy to make; all that is needed is a mold and sufficient time for curing. As important as concrete is to our society, this triumph of human ingenuity is so commonplace that hardly anyone appreciates it.

EARLY HISTORY

As we casually use sidewalks, roads, and swimming pools, it is easy to overlook the distinguished lineage of concrete. Cement, the principal matrix material of concrete, has been utilized for over 5,000 years. The ancient Egyptians used a cement mortar made with heated or "calcined"[1] gypsum in the construction of the great pyramids at Giza and other structures. Cement was used for the construction of the harbor at Kition, Cyprus, in about 600 B.C. (Stapleton, 1981; Encyclopedia Britannica, 1984).

Mediterranean area

Lime-based cement, a significant improvement over gypsum-based cement and quite similar to the cement used today, was used by the Mycenaeans and Phoenicians in about 500 B.C. The oldest lime cement so far discovered is in the ruins of a Phoenician temple on Cyprus (Draffin, 1943). Lime cement was made by calcining limestone and then crushing it to a fine powder. Gypsum required a calcining temperature of 300 to 400 °F. In contrast, lime required a calcining temperature of 1,500 to 1,650 °F. In the early lime calcining process, heated limestone ($CaCO_3$ + heat) produced carbon dioxide gas (CO_2) and lime (CaO). Water added to crushed lime causes a chemical reaction and results in firm hydrated lime cement [$Ca(OH)_2$]. When mixed with water and sand, the lime cement made a durable mortar (Lea, 1970).

The use of lime cement spread from Crete to Greece, where it was used to line hand-dug cisterns and was mixed with sand and gravel to form a primitive concrete used in construction. From Greece, the use of lime cement spread to Rome, Carthage, and other cities around the Mediterranean Sea. A problem encountered with this early lime mortar was that it gradually dissolved when exposed to rainwater (Encyclopedia Britannica, 1984).

Roman concrete

The fame of Roman engineers as master builders is due in no small part to their use of lime cement mixed with broken tile, stone, volcanic ash, and water to form strong, long-lasting concrete structures. The Romans greatly improved the strength and durability of concrete and were the first to use it in significant amounts. The words "cement" and "concrete" come from the Latin words *caementum*, for pieces of rough uncut stone, and *concretus*, which means to grow together. Roman masons screened and washed sand and gravel (called "aggregate"[2]) in preparation for use in concrete. The practice of screening and washing sand and gravel is still necessary for making sound concrete.

Figure 1. Transamerica Building, San Francisco, California. Concrete products are pervasive, and it is hard to imagine our society without them. The graceful Transamerica Building in San Francisco is one example of the varied forms and functions of concrete design. At 853 ft high, it is the second tallest building in California. Photo by Don Dupras.

[1] Calcining is a heating process that drives off volatile gases, such as water vapor and carbon dioxide, and makes the cement reactive with water. Calcined gypsum is partially dehydrated and is known today as plaster of Paris.

[2] Aggregate is a general term that refers to any hard inert material such as sand, gravel, smelter slag, or crushed rock. Strong and durable aggregate is of prime importance in cement products such as concrete, mortar, and plaster. These materials commonly contain more than 70 percent aggregate by volume.

In about 150 B.C., the Romans discovered that a glassy, fine-grained volcanic ash added to lime cement in place of sand made the concrete water-resistant and gave it superior strength. The best Roman cement was made with volcanic ash they called "*pozzuolana*," which was quarried near the town of Pozzuoli, Italy. The ash had been erupted from the volcano Mount Vesuvius (Hansen, 1982).

Roman pozzolan cement had the ability to harden under water. This water-resistant property is caused by silica in the volcanic ash chemically reacting with lime to form insoluble compounds in concrete. This superior cement enabled the Romans to construct resistant concrete marine facilities such as seawalls, piers, lighthouses, and breakwaters. The remains of these ancient structures can be seen today on the shores of the Mediterranean Sea (Encyclopedia Britannica, 1984). Today, cement of this type such as portland cement is termed "hydraulic cement." Pozzolan is a common admixture used in modern concrete structures, and concrete made with such hydraulic cement can be placed under water through a hose called a "tremie line."

Roman engineers were the first to use lightweight concrete in building construction. Broken pumice, a lightweight porous volcanic glass, was used as aggregate when lightweight concrete was required. Lightweight pumice concrete improved wall insulation, reduced construction weight, and was better able to withstand frost action (Stapleton, 1981).

After 2,000 years, many examples of Roman concrete remain in place and illustrate the important contribution this material has made to modern civilization. Roman engineers constructed the world's earliest and most enduring examples of concrete architecture. The Pantheon, Colosseum, Hadrian's mausoleum, Roman baths, aqueducts, and Roman roads throughout Europe are monuments to the varied forms and functions of early concrete design. Concrete enabled the Romans to experiment with circular walls, vaulted ceilings, and domes; Roman concrete architecture still influences and inspires contemporary engineers.

Figure 2. The Pantheon, Rome, Italy. The entrance portico inscription, "M. AGGRIPPA. L.F.COS. TERTIVM. FECIT" (Latin for "Marcus Agrippa, son of Lucius and three times consul, built this"), refers to an earlier rectangular temple that was built on this site about 25 B.C. and later destroyed by fire. The domed Pantheon was added to the portico in 124 A.D. and dedicated to the seven major Roman gods. It is unique not only for its innovative concrete architecture but also because it is one of the very few buildings of Imperial Rome that have remained intact—a testament to solid concrete design. The large interior drum-shaped room has inlaid marble floors and is covered by a poured concrete dome 143 ft in diameter that was not exceeded in size until the mid-1800's. The dome has a 30-ft-wide oculus or round opening in the top to illuminate the interior. The 21-ft-thick walls are not solid concrete but are honeycombed with concrete arches. The Pantheon is one of the first large concrete buildings and still serves as an architectural model for other domed buildings. This and following photos courtesy of the Portland Cement Association except as noted.

The circular-domed Pantheon in Rome has survived virtually intact and is the most famous early concrete structure in the world. It was an architectural experiment and one of the first large concrete structures to incorporate lightweight aggregate concrete. The Pantheon was completed in 124 A.D. and dedicated as a religious temple. At the time, it was more than twice the size of any other domed building (Figure 2). Its 21-ft-thick circular wall is honeycombed with cast pozzolan concrete arches and sandwiched by marble veneer (Norwich, 1978; Mark, 1987).

Although the wall is an engineering feat in itself, the most interesting aspect of the Pantheon is its dome. The dome is 143 ft in diameter, 4 ft thick at the center, and incorporates nearly 5,000 yd^3 of poured pozzolan concrete (Hansen, 1982). The base of the dome was made with normal sand and gravel aggregate for strength, because concrete strength is lost when lightweight aggregate is used. As the builders approached the top of the dome, they used lighter and lighter aggregate in the concrete until at the center, only pumice aggregate was used. The Pantheon is the only Roman building with its dome still intact (Stapleton, 1981).

The Roman Colosseum, a limestone, mortar, and concrete stadium, was completed in 80 A.D. and could accommodate 60,000 people. The word "colossal" is derived from the Latin word meaning huge. The Colosseum included miles of barrel-vaulted and groin-vaulted concrete passageways that provided smooth movement for the crowds. The foundation was built with 40-ft-deep concrete pilings.

Many other large Roman public works such as aqueducts, mausoleums, and sewer systems were constructed with cement mortar and concrete. One example of this type of construction is the extensive Cloaca Maxima sewer system beneath the streets of Rome. Another example is the graceful Roman aqueduct near Nimes, France, which was completed in 18 B.C. The portion of the 24-mi-long aqueduct that crosses the river, called the Pont du Gard, still stands and is 155 ft high. The top level supports a mortared water conduit 4 ft wide and 5 ft high (Stapleton, 1981).

The illustrious Roman road system that connected the empire had nearly 54,000 mi of highways and another 200,000 mi of connected roads. Engineers provided adequate drainage and carefully surveyed highway routes for directness between towns. Commonly, these highways were 4 ft thick and layered, with sand and gravel at the base, concrete in the middle, and stone blocks at the surface. The rigid roadbeds normally lasted 30 to 40 years without repairs. Several of these roads lasted for hundreds of years after the fall of the Roman Empire—even without repairs (Stapleton, 1981; Weisburd, 1988).

The technology of making high-quality, sound concrete declined after the fall of the Roman Empire. The low point of inferior concrete design in Europe occurred between the 9th century and the 11th century, when the practice of using sufficient heat to calcine limestone was abandoned. During the 12th and 13th centuries, proper calcining temperatures were again initiated, and the quality of cement gradually improved. By the end of the 1500's, pozzolan materials were again used in concrete mixtures. Concrete development progressed very slowly from that period until the Industrial Revolution (Lewis, 1981).

By the 1700's, engineers throughout Europe were experimenting with various natural cementitious materials that included limestone, limy mud, gypsum, pozzolan ash, oyster shells, diatomaceous earth, and chalk. Because the ingredients in these "natural cements" varied widely, and because procedures for making concrete were often haphazard, the quality of concrete structures made in the 1700's was erratic.

It should be noted that natural cements are still used, mainly in nonindustrial countries, and make fairly durable concrete structures. Natural cements have less durability, are less versatile, and harden faster than portland cement. However, some have remarkable compressive strength of 11,000 lb per in^2 (Draffin, 1943).

PORTLAND CEMENT

The Industrial Revolution in England caused a serious shortage of timber for the building trades. During that time, there was an intense demand for canals, factories, harbors, and other structures. Builders sought to reduce their dependence on wood structures by using increasing amounts of mortar, brick, and concrete.

In 1757, civil engineer John Smeaton was hired to design and build the Eddystone Lighthouse off the coast of Plymouth, England. After conducting several experiments to determine what cementing materials would set and remain stable under seawater, he chose a mixture of calcined argillaceous limestone from the Isle of Portland and pozzolan ash brought in from Italy. His studies showed that the best cement could be made from limestones that had the highest clay content. The concrete proved to be exceptional, and the Eddystone Lighthouse lasted for 126 years before it was replaced. Smeaton is said to have rediscovered the Roman pozzolan cement formula by examining an old Roman document (Skinner, 1976).

Joseph Aspdin

Nearly all concrete used today incorporates portland cement. The credited inventor of this exceptional cement was Joseph Aspdin, a brick layer and mason from Leeds, England. After much experimentation, Aspdin developed the process of carefully proportioning limestone and clay collected from local quarries, pulverizing it, and heating the mixture on his kitchen stove. He then ground the compound into a fine powder. The resulting hydraulic cement made a very strong and durable concrete when mixed with the proper proportions of water and aggregate. Jospeh Aspdin named it "portland cement" because the limestone he used was quarried on the nearby English Isle of Portland (Figures 3-5) (Legget and Karrow, 1983).

Aspdin took out a patent on his portland cement in 1824. Shortly thereafter, he built a small kiln that produced up to 6 tons of clinker after several days of heating (Figure 6). Aspdin later discovered that a higher calcining temperature produced a superior cement, and he secretly incorporated the heating process (Lewis, 1981). For a number of years, Aspdin's portland cement process slowly expanded.

Figure 3. Drawing of Joseph Aspdin at his workshop. He patented his process of making artificial stone in 1824 and called it "portland cement." Nearly all construction concrete used in the world today incorporates portland cement as its fundamental binding ingredient. Most portland cement used today is nearly the same as that discovered by Joseph Aspdin.

Figure 4. Aspdin's original cement plant in Wakefield, England, around 1860. The first extensive use of cement was in the Thames Tunnel in 1828. The engineer in charge of the project insisted on using portland cement and faced strong opposition because it cost more than twice as much as other natural cements then available. The cement proved worthy, and in the 1860's, nearly 70,000 tons of portland cement were used in the construction of the London sewer system. Aspdin's son William tried to keep his father's formula a secret by placing trays of copper sulfate in the kilns during the calcining process. The noticeable smell was intended to deceive competitors.

However, portland cement concrete proved to be so durable, versatile, and efficient that by the 1850's, the process for making the cement was well established in England, Germany, and Belgium.

It is generally agreed that Joseph Aspdin was not the sole inventor of portland cement, because other English inventors were also working on similar cementing materials in the region during that time. In any event, within a month after pouring, portland cement concrete developed nearly twice the compressive strength of many other natural concretes then used.

Aspdin lived to see the first bulk use of portland cement as a masonry liner in a tunnel that went under the Thames River. Portland cement today is manufactured basically the same way as Aspdin's patented process, but it is made with far greater precision and in far greater tonnages than he ever dreamed.

Figure 5. The famous limestone quarry on the Isle of Portland, south coast of England (around 1850). When Joseph Aspdin was experimenting with his cement concoctions, he had no efficient way of grinding the limestone. He found that the steel-rimmed wagons had sufficiently pulverized the limestone along the quarry road for his experiments. In 1825, while collecting crushed limestone samples along the main quarry road, he was arrested and fined for theft of public property.

Figure 6. A bottle kiln for calcining limestone used in Aspdin's cement plant (around 1850). The kiln was 36 ft high, 17 ft in diameter at the base, and had a capacity of 21 tons of limestone per burn. It was much larger than Aspdin's original kiln, which had a capacity of about 6 tons of limestone. Early kilns of this type had a natural draft. Therefore, calcining and cooling might take several days, depending on the prevailing winds.

U.S. portland cement

In an effort to expand their markets, European manufacturers began shipments of portland cement to the United States in 1868. To reduce freight costs, the cement was first shipped in wooden barrels[3] as ship ballast. Portland cement proved to be so durable and versatile that engineers in the United States soon preferred it to other natural cements then in use, and shipments increased (Figure 7). The portland cement market in the U.S. quickly spread.

David Saylor had previously worked in the manufacture of natural cement concrete and felt that he too could make Portland cement (Figure 8). In 1871, he made the first portland cement in the United States at Coplay, Lehigh Valley, Pennsylvania. Saylor found that an argillaceous limestone[4] in that valley contained the proper proportions of ingredients needed to make quality portland cement. Like Smeaton and Aspdin, Saylor systematically studied the physical properties of cement and concrete to improve it. His operation was a success, and his company prospered.

There was a strong demand for cement to accompany the rapid American industrialization during the 1870's and 1880's. Large engineering projects such as the Erie Canal, factories, sewer systems, and bridges fostered the spread and manufacture of portland cement in the United States.

[3] Cement is purchased and measured by weight because its volume changes due to compaction. The concrete industry still measures cement in barrels, a practice that dates back to the mid-1800's, when it was shipped in barrels. By definition, a barrel weighs 376 lb and contains four bags that are 94 lb each. A bag of cement is roughly 1 ft^3.

[4] Argillaceous limestone is common and contains as much as 50 percent clay minerals. This natural "cement rock," as it is sometimes known, needs few additional materials to make good cement. An argillaceous limestone that would make a good portland cement would contain 50 to 65 percent lime, 10 to 20 percent silica, and 15 to 35 percent clay minerals, including alumina and iron oxide.

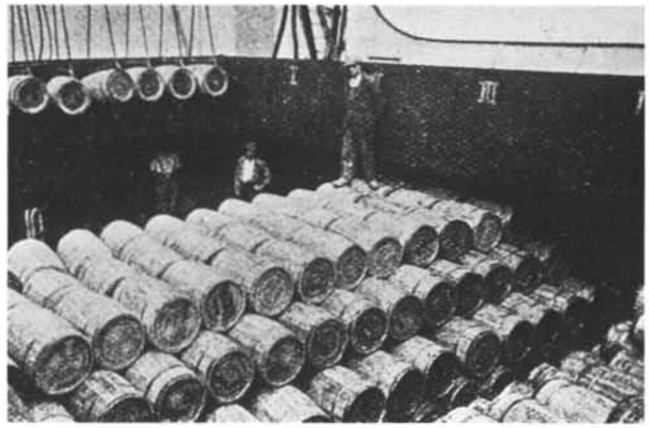


Figure 7. An early shipment of portland cement in wooden barrels to the United States during the 1860's. Large quantities of natural cements were used in the United States during the early 1800's. Engineers began to switch to portland cement when they realized its superior performance.

Rotary kiln

By the mid-1880's, the demand for portland cement products was rapidly growing, but the process of making it was labor intensive and time consuming. It proved to be difficult to mass produce, and rows of large vertical brick kilns were constructed to meet the demand. Cement made in these kilns required a great deal of heat for calcining the limestone. After the calcining process, the mixture was allowed to cool and was removed for processing. The cooling process was dependent on wind conditions and commonly took several days. The process of manufacturing portland cement in vertical kilns was costly and inefficient.

Frederick Ransome, an English engineer and inventor, revolutionized the building industry by making it possible to mass produce portland cement. In 1885, Ransome patented a slightly inclined

Figure 8. David Saylor, the first American to produce portland cement at Coplay, Pennsylvania. As a manufacturer of natural cement, Saylor became convinced that portland cement produced a superior concrete. After experimenting with a local argillaceous limestone in 1871, he began producing high-quality portland cement in bottle kilns he had built from English design. By 1876, Saylor's cement was accepted and recommended for use by the United States Engineer's Office.

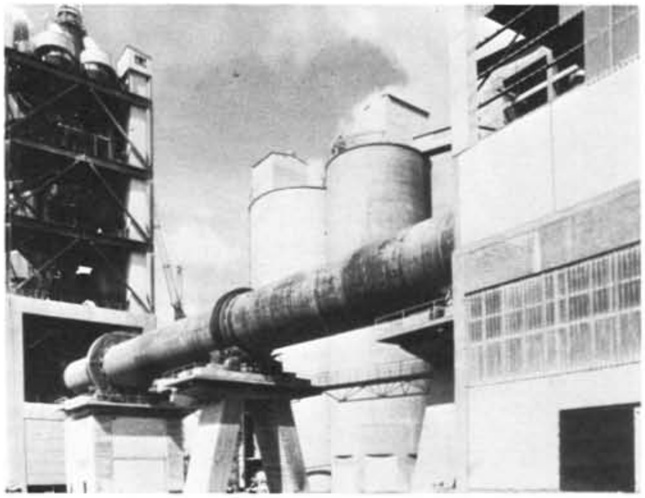


Figure 9. A modern rotary kiln. The kiln is about 500 ft long and 14 ft in diameter. It is made of steel, lined with firebrick, and rotates around giant roller bearings about one complete turn a minute. Raw materials for portland cement are fed into the kiln at the right, gradually travel down the kiln to the left as it rotates, and are steadily heated to a temperature of about 2,700 °F. The gases produced by the calcining process are collected in the building at the left. For a kiln of this size, it takes about three hours for the materials to make a complete passage.

cylindrical kiln that slowly rotated. Crushed raw material could be continuously added at the top of the rotating kiln, calcined, and then removed. Early rotary kilns developed several problems that took years to remedy. Regardless of these problems, the invention of the rotary kiln is comparable to the development of the Bessemer process for making steel. Rotary kilns dramatically increased output, decreased costs, and improved the uniform quality of portland cement (Figure 9).

Thomas Alva Edison (Figure 10) was instrumental in improving the rotary kiln. He was convinced that mass-produced portland cement could provide affordable housing for everyone, and in 1898, he formed the Edison Portland Cement Company in Orange, New Jersey. In 1902, his company introduced the long rotary kiln. At 150 ft long and nearly 9 ft in diameter, the kiln ensured more nearly complete calcining, which resulted in a better cement. By 1905, the company was producing 715 tons of cement per day (Conot, 1979). In 1908, Edison realized his dream of an all-concrete, low-cost housing project and was one of the first to use tilt-up wall construction—a method in which concrete walls are poured into a mold at the job site, allowed to harden, and then raised into place (Figure 11).

In a nearby magnetite mining operation managed by Edison and his associates, there was a problem of crushing the hard iron ore for processing. So, in his characteristic manner, Edison invented the modern roll crusher, which, like many of his other inventions, is universally used today in the cement and other mining industries. The crusher had two mammoth, rapidly rotating iron cylinders equipped with iron studs, and it could grind six tons of very hard magnetite boulders in half a minute. He fondly called it his "Giant Rolls"(Conot, 1979).

The construction of the 41-mi-long Panama Canal took 32 years; the canal was finally completed in 1914. An estimated 5 million yd^3 of concrete were used, and nearly 900 million yd^3 of earth were excavated (Legget and Karrow, 1983). Canal construction did much to foster the improvement of concrete standards and equipment in the United States. One example is the refinement of the ready-mix truck commonly seen on highways today.

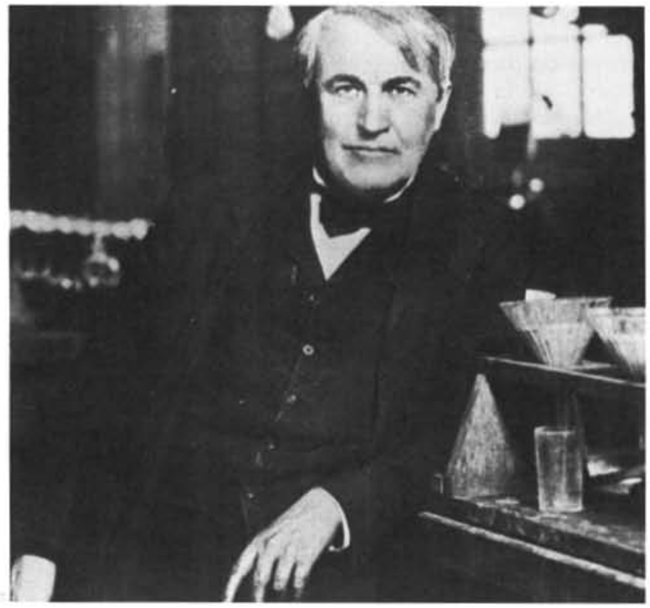


Figure 10. Thomas A. Edison, inventor. Edison pioneered the long rotary kiln and improved the crushing and grinding equipment used to make portland cement.

Modern production

As important as portland cement is to society, it is reassuring to know that the resources used to make it are abundant and occur worldwide. The basic raw materials for making modern portland cement include about 60 percent lime (CaO), 25 percent silica (SiO_2), 5 percent alumina (Al_2O_3), 4 percent gypsum ($CaSO_3 \cdot 2H_2O$), 3 percent iron oxide (Fe_2O_3), and 3 percent

Figure 11. Tilt-up construction. The first tilt-up concrete buildings in the United States were used to store Army ammunition in the early 1900's. The thick, reinforced concrete walls are cast in place at the job site, allowed to harden, and tilted into place. Compared with other types, concrete tilt-up buildings take less time and money to construct and maintain. They require less insulation and cost less to heat in the winter and to cool in the summer compared with other types of buildings. They can be constructed quickly; some are completed 90 days from the time ground is broken. They eliminate the need of reinforcing beams and columns and require little long-term maintenance. Many innovative designs are used to make tilt-up buildings attractive. Photo by Don Dupras.

magnesium oxide (MgO). Lime comes from limestone and marl.[5] Silica and alumina are found in clays, shales, soils, and silica sand. Iron oxides occur in iron minerals, such as limonite, hematite, and siderite and in lateritic soils.

Magnesium oxide is a deleterious ingredient because in excessive amounts it expands over time and disintegrates concrete. However, all limestone contains small amounts of magnesium oxide, and it does not harm concrete if it is limited to amounts of less than 5 percent (Lea, 1970).

These raw cement materials are crushed, proportioned under exact chemical control, and ground to a sandy powder. The powder is then fed into a slightly inclined rotary kiln (some kilns are as long as 700 ft), and the load (or "charge") slowly moves toward the lower end, where it is first calcined and then gradually heated to a temperature of nearly 2,700 °F. This heating process normally takes approximately three to four hours. About 44 percent of the original load is lost as gases such as carbon dioxide and water vapor. When the charge reaches the "clinkering" temperature of 2,700 °F, it partially melts, changes composition, and emerges from the kiln as irregular, marble-sized balls called clinker[6] (Table 1) (Figure 12). The clinker is mixed with 2 to 4 percent gypsum to regulate setting time and is then ground to a powder finer than flour. The resulting gray powder is portland cement (Kosmatka and Panarese, 1988).

Over 99 percent of all concrete used today contains portland cement. An estimated 1,700 portland cement plants annually produce nearly a billion tons of cement worldwide (Huhta, 1988; Kosmatka and Panarese, 1988). California produces more portland cement, concrete aggregate, and portland cement concrete than any other state, and demand is expected to increase throughout the 1990's.

Table 1. *Compounds in portland cement clinker**

Chemical name	Formula	Industry abbrev.	Percent	Function in concrete
Tricalcium silicate	$3\ CaO{\cdot}SiO_2$	C_3S	55	Cementitious compound that adds strength, causes concrete to harden rapidly.
Dicalcium silicate	$2CaO{\cdot}SiO_2$	C_2S	25	Cementitious compound that adds strength, causes concrete to harden slowly.
Tricalcium aluminate	$3CaO{\cdot}Al_2O_3$	C_3A	10	An essential flux that promotes fusing of hydrous crystals, liberates a large amount of heat during the first few days.
Tetracalcium aluminoferrite	$4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$	C_4AF	8	Reduces heat of hydration, assists in the formation of cement crystal growth.

* Clinker plus 4 percent ground gypsum ($CaSO_4{\cdot}2H_2O$) constitutes portland cement; cement plus aggregate and water produces concrete.

[5] Marl is gray to dark gray. The term is loosely applied to rocks with 35 to 65 percent calcium carbonate and 35 to 65 percent clay. It is commonly called a "dirty limestone."

[6] Clinker and a small amount of gypsum are ground to a powder so fine that it will pass through a 200-mesh sieve with 40,000 openings per in² (about 10 microns in diameter). It is necessary to grind the cement this fine to increase the surface area so that it will properly hydrate.

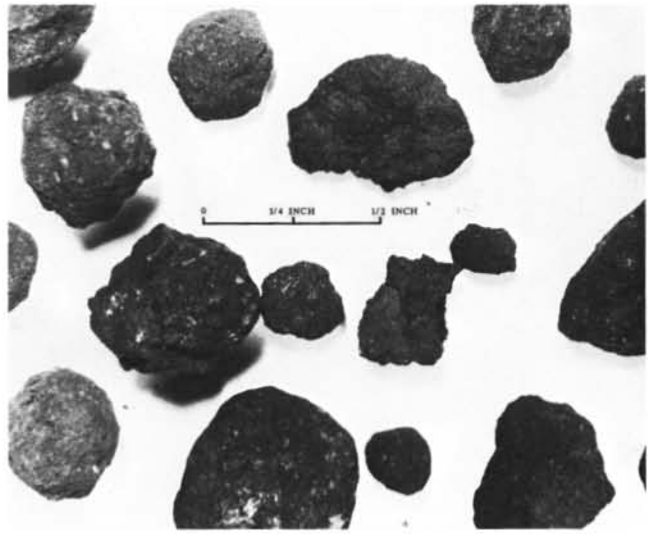


Figure 12. Grayish-black portland cement clinker pellets with an average diameter of ⅜ in. The raw materials for portland cement are heated to the clinkering temperature of approximately 2,700 °F. After the clinker is made in the rotary kiln, it is cooled, mixed with gypsum, and ground to the very fine powder known as portland cement. Photo by David Parke.

PORTLAND CEMENT CONCRETE

Portland cement is rarely used by itself but must be mixed with aggregate to make concrete, grout, mortar, stucco, and the various other cement products used in the building industry. Portland cement mixed with fine aggregate (sand and gravel less than a quarter inch in diameter) is used to make cement plaster, mortar, and stucco. When it is mixed with sand and coarser aggregate (above a quarter of an inch in diameter), it makes concrete.

Nearly 99 percent of all structural concrete in the United States is made with portland cement. Portland cement is the most expensive component of concrete, and most types of concrete contain only about 7 to 14 percent cement by volume. When portland cement is mixed with the proper proportions of water (commonly 14 to 20 percent) and aggregate (commonly 60 to 80 percent by volume), the resulting concrete mix hardens—not by drying but by a process called hydration (Kosmatka and Panarese, 1988).

Curing

At the instant water is added to the concrete matrix, anhydrous compounds in the cement chemically react and begin to form new compounds. During this hydration process, the new complex compounds firmly bind the concrete matrix with criss-crossed, interlocking hydrous crystals (Hansen, 1982). The rate of hydration is affected by the composition and fineness of the cement powder, temperature, the amount of water present, and admixtures that can either accelerate or retard the hydration process.

The hydration reaction is so rapid that it is necessary to lengthen the curing time by adding materials. Gypsum is almost universally added to cement to retard the setting, although many other additives are also available. For common concrete that is used in sidewalks, patios, and driveways, about 90 percent of the hydration process takes place within 28 days from the time it is poured. The hardening process, however, continues for months or years afterwards.

Long curing periods are desirable to yield more nearly complete hydration of concrete. Theoretical tests indicate that common concrete that is precisely engineered and cured will continue to strengthen for 25 years or longer (Kosmatka and Panarese, 1988).

Water must be available for the hydration process to continue. It is a common misconception that concrete hardens upon drying by evaporation. To avoid cracking and other problems, recently poured concrete projects should be kept moist for at least a week after they are placed. If poured concrete is not kept moist during the curing process, it can lose up to 50 percent of its designed strength. A common method of preventing the loss of moisture is to periodically spray the concrete with water or cover it with wet rugs or burlap bags. Another method used in large construction projects is to spray membrane-curing compounds on the fresh concrete; the membrane acts as a barrier to evaporation.

To make sound concrete, only that amount of water necessary for hydration is required. However, a concrete mix that contains only the amount of water necessary for hydration is stiff (or "lean," as it is known in the trade) and is laborious to place. Because such a lean concrete is difficult to place and work, more water is commonly added to make the mix easier to pour and finish. The addition of more water than is required for hydration lowers the strength of the concrete (Waddell, 1974, 1985).

For example, an average machine-mixed concrete blend can withstand pressures of 3,000 lb per in^2 28 days after it is placed. If extra water is added to the mix to make it easier to place and finish, the concrete strength may be only 1,500 lb per in^2 after 28 days. If the concrete is used to make a front yard mowing strip, the reduction in strength is not important. If, however, the concrete is used for a building foundation, the strength reduction may be serious. If too much water is added to the mix, there is not only a significant loss of strength but also the risk that the pieces of aggregate may separate from the matrix and the concrete will fail.

Heat is generated during the hydration process, and when large amounts of concrete are poured, as in dams or bridge abutments, the heat from the hydration is reduced or drawn off to avoid damaging the concrete. For large construction jobs (dams, bridge foundations, or freeway overpasses), specialty cements that produce less heat and take longer to cure are used (Kosmatka and Panarese, 1988).

Placing

Portland cement concrete for dams and large bridges is mixed near the construction site. For smaller jobs, it is brought to the construction site ready-mixed in agitator trucks. Ready-mix trucks, with their characteristic tilted, rotating, barrel-shaped mixers, deliver the concrete in readiness from a central plant called a "batch plant." The truck operator then places the fresh concrete by means of a metal chute that folds out from the back of the truck. It is important to place concrete from the mixer to the form as rapidly as possible so that no initial setting occurs. The entire ready-mix operation from batch plant to placement is usually completed within 90 minutes.

When placing fresh concrete in difficult-to-reach areas, such as when constructing skyscrapers, concrete is pumped through a long tremie hose attached to a crane. Some concrete pump trucks can lift and place concrete above 500 vertical ft. For large jobs or when structural support is critical, the concrete is agitated after it is poured by portable vibrators to ensure that no void spaces remain in the corners and recesses of the form.

Reinforced concrete

Although sound concrete can withstand intense vertical pressure called "compressive strength," its resistance to tensile stress (or pull-apart force) is relatively weak. In other words, a standing pillar of concrete that is 4 in. wide and 6 ft tall would be easy to break with a sideways hammer blow. To remedy this imperfection, engineers use reinforcing materials that have high tensile strength. The most common type of material used is steel rebar (rods). In addition to its high tensile strength, concrete reinforced with steel rebar will expand in the summer and contract in the winter at an even rate, with no damage to the concrete. Steel rebar is ribbed to improve its bond with concrete (Figure 13). In general, the thicker the reinforced concrete structure, the thicker the rebar used. Welded, high-strength wire meshes are used in the construction of road, floor, and flat-roof concrete slabs.

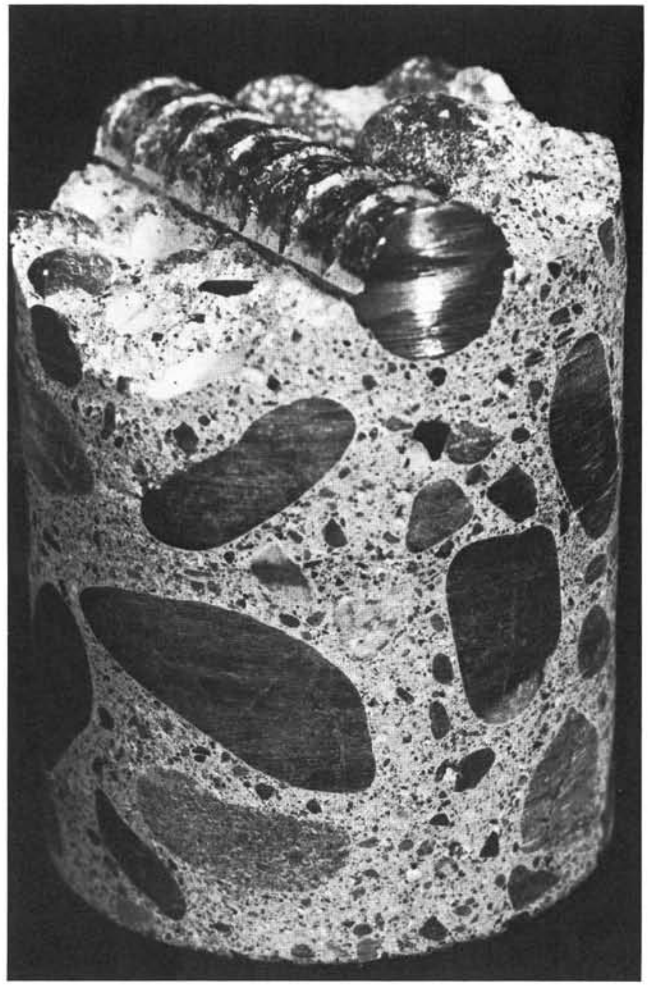


Figure 13. Columnar section of rebar concrete taken from a building foundation. Samples such as this are extracted from building foundations and tested to ensure that the rebar and concrete are sound. Note how the cement-and-water paste completely coats each aggregate particle. Photo by David Parke.

Concrete failure

Concrete failures are usually caused by faulty construction techniques rather than by flawed design. When a large concrete structure fails, engineers use a variety of forensic tools to determine what happened. High-frequency sound waves, for example, are commonly used to determine the structural strength of concrete. Because the speed of sound in concrete is known, the time it takes the sound wave to pass through concrete can be translated into feet and inches. Similarly, sound waves sent through concrete foundation footings, walls, or columns can be monitored for unusual patterns of deflection that indicate the presence of interior cracks, air pockets, or extraneous items. In one failed concrete structure, a lunch pail was found to have been inadvertently left behind when the concrete was poured (Allman, 1988).

To ensure that reinforcing steel rebar has been properly placed in concrete structures, portable X-ray machines and instruments that measure fluctuations in a magnetic field are used (Allman, 1988).

A common problem that is especially prevalent in marine structures is rebar corrosion hidden within the concrete. Engineers use portable instruments to measure the rebar corrosion by measuring the electric potential on the surface of the concrete. Sharp surges and variations of electric potential that differ from calibrated electric amounts of undamaged concrete indicate the amount of concealed corrosion.

CONCLUSION

Concrete is the most common building material in the world. It is a marvel of civilization that has been used for thousands of years and will remain a necessary building material for a long time to come. In the days of ancient Rome, the development of concrete was made by trial and error. In contrast, researchers today are aggressively using the scientific method to fully understand the myriad complex chemical reactions that take place to create lighter, stronger, and more durable concrete structures. The introduction of innovative types of concrete is changing the way architects and engineers design and build bridges and the many other concrete structures we rely upon and take for granted.

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NEW PUBLICATIONS RECEIVED IN LIBRARY

From time to time, we announce the receipt of new publications from outside sources that we think will be of interest to our readers. Copies of these publications are currently in the library of the Oregon Department of Geology and Mineral Industries, where they may be examined. Information about ordering and prices are listed below.

The Art of Geology, edited by Eldridge M. Moores, Department of Geology, University of California at Davis, and F. Michael Wahl, Geological Society of America. Published in 1988 as Special Paper 225 by the Geological Society of America, 3300 Penrose Place, P.O. Box 9141, Boulder, Colorado 80301. Hardbound, 9-in. by 12-in. format, 147 pages, full color throughout, with dust jacket, price $37.50 postpaid.

Designed to celebrate the 1988 Centennial of the Geological Society of America (GSA) and inspired by geologic photos submitted for the cover of GSA's monthly journal *Geology*, this handsome volume contains 250 scenic and geologic photographs arranged in 69 essays, each accompanied by a brief nontechnical text. Following a colorful rendition of the geologic time scale and an introduction discussing briefly the history of GSA, geologic time, geologic processes, and plate tectonics, the book opens with a startlingly beautiful series of photographs of slot canyons of the Colorado Plateau. Places such as Svartifoss Waterfall in Iceland, Tambora Volcano in Indonesia, Teton National Park in Wyoming, Cordillera del Paine in Chile, the Brooks Range in Alaska, Rodadero in Peru, Arches National Park in Utah, Suez Rift in Egypt, and Central Park in New York City are subjects of photographic essays. The scale of pictures ranges from photomicrographs of peridotite from a South African diamond pipe to radar imagery of folds on the planet Venus. Geologic features such as thrust faults in Spain, unconformities in the Grand Canyon, ground-water erosion in Utah, and karst towers in China produce striking photographs.

All in all, this fascinating book is an appropriate way for GSA to celebrate its first 100 years—by sharing the visual wonders of geology with those of us who have not yet had the opportunity of seeing them first hand.

Northwest Correlation Chart, Correlation of Stratigraphic Units in North America (COSUNA) Project, chart coordinators, Donald A. Hull, John M. Armentrout, Lehi F. Hintze, John D. Beaulieu, and Weldon W. Rau; chart editor, F. Alan Lindberg; with contributions by W.O. Addicott, J.M. Armentrout, E.M. Baldwin, J.D. Beaulieu, M.H. Beeson, M.E. Brownfield, W.G. Bruer, R.J. Deacon, D.J. Easterbrook, V.A. Frizzell, L. Hintze, D.A. Hull, S.Y. Johnson, K.B. Kelty, D.L. Lander, V.S. Mallory, K.A. McDougall, D.R. McKeel, G.A. Miles, A.R. Niem, W.N. Orr, W.W. Rau, P.D. Snavely, Jr., R.O. VanAtta, and R.E. Wells. Published in 1988 as part of its Chart Series by the American Association of Petroleum Geologists, P.O. Box 979, 1444 South Boulder, Tulsa, Oklahoma 74101. Multicolored chart 55 in. by 41 in., price $8 plus $1.75 shipping charges.

This is the last of the 20 correlation charts of the United States published as part of the COSUNA project by the American Association of Petroleum Geologists (AAPG) Research Committee in cooperation with the Committee on Stratigraphic Correlations. The charts are intended to show stratigraphic columns that provide fairly complete coverage of the geology of the United States. The Northwest Correlation Chart contains sections for Oregon, Washington, and Idaho, including the Roseburg area, Cape Blanco area, Coos Bay area, Reedsport (subsurface), Eugene area, central Coast Range, McMinnville-Sheridan area, Oregon City-Molalla area, Astoria area, Columbia County area, south flank of the Willapa Hills, Grays Harbor Basin, Centralia-Chehalis area, western Olympic Peninsula, northwest Olympic Peninsula, northeast Olympic Peninsula, Bremer-

*(Continued on page 46, **New Publications**)*

DOGAMI releases first reports of 1989

State Map Advisory Council publishes annual report for 1988

The State Map Advisory Council for Oregon (SMAC) has released its annual report, a summary of its activities and accomplishments in 1988. The Council was established by Governor Neil Goldschmidt by Executive Order in 1987.

The 122-page report, which was produced under the chairmanship of State Deputy Geologist John D. Beaulieu and published by the Oregon Department of Geology and Mineral Industries (DOGAMI) as Open-File Report O-89-1, sells for $5.

The report provides summaries of over 20 meetings of the Council in its Executive Board, the Oregon Map Advisory Committee, the Oregon Geographic Information Systems Committee, and the Oregon Land Records Committee. Appendices describe the nature, mission, and goals of the State Map Advisory Council and its committees and present selected major plans, proposals, and budget priorities for 1989. The report concludes with membership lists of the various committees.

The Oregon SMAC is the lead governmental body in Oregon for mapping discussions. It consists of representatives from Federal and State agencies, local government, and private industry. Its purpose is to focus computerized mapmaking activities in Oregon and to further most efficient coordination of efforts.

Map for Mist Gas Field updated

The Oregon Department of Geology and Mineral Industries (DOGAMI) has released an updated version of the Mist Gas Field map. The new map reflects all 1988 drilling activity in the field, including gas-storage and monitor-well activity. It has been published as DOGAMI Open-File Report O-89-2 and sells for $5.

The Mist Gas Field Map defines a 141-mi^2 area within which special setback distances for gas wells are applied. The map is at a scale of 1:24,000 and measures approximately 40x50 in. It shows the Mist Gas Field divided into quarter sections and the setback lines for each section. Also shown on the map are the locations of all wells drilled, their total depth and year of completion, and all drilling locations permitted through 1988.

The official boundaries of the Mist Gas Field were approved by the DOGAMI Board of Governors in 1983, after a public hearing in which the previously accepted, unofficial field boundaries were revised.

New geologic quadrangle map for Owyhee region released

Geology and Mineral Resources Map of the Graveyard Point Quadrangle, Malheur County, Oregon, and Owyhee County, Idaho, by DOGAMI geologist Mark L. Ferns, has been released in DOGAMI's Geological Map Series as map GMS-54 and sells for $4. The publication, resulting from an ongoing study of southeastern Oregon areas with a potential for mineral resources, was prepared in cooperation with the U.S. Geological Survey (USGS) and the Idaho Geological Survey and was partially funded by the COGEOMAP program of the USGS.

The Graveyard Point 7½-minute quadrangle covers approximately 48 mi^2 east of Lake Owyhee and Owyhee Ridge and extends a little over a mile across the state line into Idaho. The new two-color map of the quadrangle (scale 1:24,000) identifies 19 Tertiary and Quaternary rock units, the oldest of which may date back to the late Oligocene (25 million years before the present). Geologic structure is described both on the map and in an accompanying cross section.

The approximately 28- by 40-in. map sheet also includes a discussion of the area's mineral-resource potential and tables showing whole-rock and trace-element analyses of rock samples. A variety of valuable and potentially valuable mineral resources were found or indicated by the study, including bentonite clay, clinoptilolite zeolite, gold, mercury, semiprecious gemstones, building stone, and geothermal resources. □

Earthquake hazard workshop to be held in Portland

The 1989 Workshop on Earthquake Hazards in the Puget Sound/Portland Area will be held March 28, 29, and 30, 1989, at the Portland Marriott Hotel in Portland, Oregon.

Sponsored by the Oregon Department of Geology and Mineral Industries (DOGAMI), the Oregon Department of Emergency Management, the Washington Department of Natural Resources, the Washington Department of Community Development, the Federal Emergency Management Agency, and the U.S. Geological Survey, the workshop has been designed to facilitate transfer of technical information from the geoscience community to engineers, planners, emergency responders, government officials, and members of the business community.

To improve the transfer of information, the first day of the workshop will have two parallel sessions: (1) a technical session in which geoscientists will present and discuss short papers, and (2) a nontechnical tutorial session in which basic technical issues will be explained and case histories illustrating major principles will be presented. The technical session will address topics such as faulting and seismicity of northwestern Oregon, southwestern Washington, and British Columbia; megathrust paleoseismicity; Cascadia margin deformation and megathrust ground motions; coastal terraces and subduction earthquakes; crustal and intraplate earthquake ground motions; liquefaction hazards; and tsunami modeling. The nontechnical session will cover such topics as Pacific Northwest plate tectonics and earthquake sources, basic seismology, special features of subduction zone earthquakes, ground response and failure, and building response and design. The first day will conclude with an evening poster session.

The second day of the workshop will provide brief technical summaries of the state of knowledge about earthquake hazards in the Portland and Puget Sound regions and an afternoon session on mitigation and policy, addressing such topics as existing earthquake hazard policies, response to changing earthquake hazards at the Trojan nuclear power plant, the Pacific Northwest view of earthquake hazards, and the Armenian earthquake of 1988.

The third day of the workshop will be a field trip to Netarts Bay, Oregon, to view evidence for Holocene and Pleistocene subsidence events presumably associated with large earthquakes. The trip will be led by Mark Darienzo, one of the authors of the *Oregon Geology* 1988 field trip guide to the same area ("Coastal Neotectonic Field Trip Guide for Netarts Bay, Oregon," by C.D. Peterson, M.E. Darienzo, and M. Parker, *Oregon Geology*, v. 50. no. 9/10, p. 99-106).

Cost of registration for the workshop, which includes the first two days of the workshop and a luncheon on the second day, has been tentatively set at $35. The field trip will cost $15, which will cover transportation to Netarts Bay, lunch, and a field trip guide. For additional information, in Oregon, contact Ian Madin, phone (503) 229-5580. In Washington, contact Ray Lasmanis, phone (206) 459-6372, or Linda Nosen, phone (206) 481-4694. □

To our readers

Oregon Geology changed from monthly to bimonthly publication after last year's April issue, and eight issues were published in 1988. We marked the change by giving the last four issues double numbers and putting the names of two months on each issue.

This year, however, we are publishing a total of six issues, published in January, March, May, July, September, and November. These issues will all carry plain numbers, from one to six.

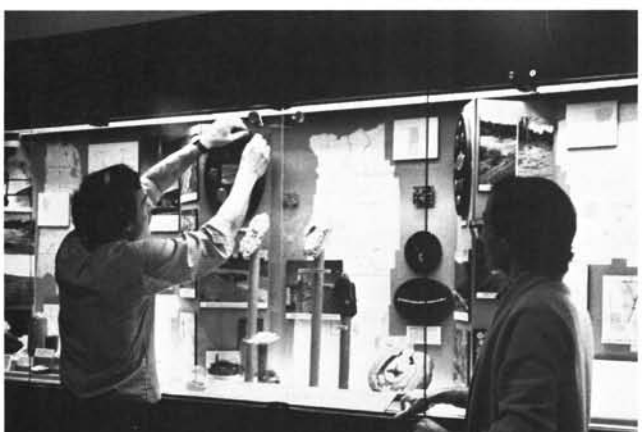
We value our subscribers, and we thank you for your continued support of *Oregon Geology*. Please do not hesitate to let us know of your wishes, comments, and news, so that we may serve you even better in the future. □

DOGAMI installs display at Capitol

Staff members of the Oregon Department of Geology and Mineral Industries (DOGAMI) installed a new display on the main floor of the State Capitol in January 1989. Housed in the display case of the Oregon Council of Rock and Mineral Clubs near the gift shop, the display is built around the theme "Oregon's Hidden Wealth: Minerals."

DOGAMI display with theme "Oregon's Hidden Wealth: Minerals" will be at State Capitol until mid-May.

In the display, a minerals map of the State of Oregon has been divided into five sections—northeast, southeast, central, northwest, and southwest—and information about the mineral resources in each section is presented by photographs, maps, and actual samples. Included are samples of placer gold, sunstones, thunderegg, limestone, gold ore, soapstone sculpture, pumice, obsidian, the Clark and Wilson sandstone, and numerous cut and polished semiprecious stones. Featured are samples of rock brought up from a depth of more than 10,000 ft from the Gorda Ridge off the coast of Oregon and black sand samples from the Oregon coast, including garnet, ilmenite, chromite, and platinum concentrates. Also included is a sample of black sand concentrate containing numerous flakes of gold.



DOGAMI staff members Paul Staub and Mark Neuhaus installing display at State Capitol.

The importance of less glamorous but economically important materials is stressed by photos of and information about sand and gravel, brick, diatomite, zeolite, and bentonite operations in the state. Photographs of examples of the State's extremely successful Mined Land Reclamation Program are included.

The display, which will remain in place until mid-May, is designed to inform Oregonians about the importance of their mineral resources. □

Faceters to meet in May

The 14th Annual Northwest Faceters Conference will be held starting Friday evening, May 26, and continuing on through the weekend of May 27 and 28, 1989, at the Lloyd Center Red Lion Inn in Portland. Sponsored by the Columbia-Willamette Faceters Guild, the meeting is designed to provide a forum where faceters and gemcutters can learn more about obtaining material and cutting it to best advantage. Included on the program will be presentations by Ron Geitgey, Oregon Department of Geology and Mineral Industries, on sunstones and other gemstones of Oregon; and by Ron Aggee, the man who cut the world's largest topaz. A competition to decide who cut the best single stone will be held, and awards will be given at the Saturday noon banquet. Dealers will also be present at the conference, with equipment, uncut gemstone material, and jewelry findings.

Registration price for the conference, which will be $35, includes cost of the banquet. For additional information, contact Grover Sparkman, 3327 SE 50th Avenue, Portland, Oregon 97206, day phone (503) 775-6725, and evening phone, (503) 774-0048. □

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*(**New Publications**, continued from page 44)*

ton area, Seattle area, Carbon River area, Pasco-Yakima-Ellensburg area, Columbia River-The Dalles area, Bend-Madras-Ochoco Mountains, Lakeview-Fort Rock-Klamath Falls, John Day-Suplee, Harney Basin to Steens Mountain, Pullman to Snake River Gorge, Baker County and Wallowa Mountains, Juntura-Vale-Owyhee Dam, and Boise Basin. The Oregon Department of Geology and Mineral Industries (DOGAMI) published a preliminary form of this chart along with data sheets in 1983 as Oil and Gas Investigation 7, *Correlation of Cenozoic Stratigraphic Units of Western Oregon*, which may be purchased from DOGAMI for $8.

The complete set of 20 COSUNA charts may be purchased from AAPG for $99. Prices for individual charts range from $8 to $12, and AAPG should be contacted for prices of specific charts. Detailed information regarding contacts, lithology, paleontology, references, and other data for each of the units on any of the charts is available by accessing the computerized data base through the University of Oklahoma, Norman, Oklahoma.

Fire Mountains of the West: The Cascade and Mono Lake Volcanoes, by Stephen L. Harris, Sacramento State University. Published in 1988 by Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806. Paperback; 6-in. by 9-in. format; 389 pages; 148 illustrations including photographs, two-color maps, cross-sections, and schematic diagrams; price $15.95; available at local bookstores.

Fire Mountains of the West is a complete revision of Harris' popular book *Fire and Ice*. Designed for the nontechnical reader, *Fire Mountains of the West* describes the major Cascade volcanoes and those in California's Mono-Mammoth Lake area, describing locations; geography; history—both human and geologic; hazards; and ways to approach and explore each particular area. The theory of plate tectonics, categories of volcanoes, types of magmas, evolution of the Cascades, and glaciation are topics that are presented in simple terms with numerous easy-to-understand illustrations and appropriate photographs.

Although not designed to be used as a field-trip guide, this book provides rich details that will enhance anyone's appreciation of a specific volcano, even though he or she has visited it before. Because the book is nontechnical in style, Harris has not had to encumber his prose with the numerous citations that most technical papers require, making *Fire Mountains of the West* much easier to read and enjoy. He is careful, however, to cite and thank the people whose work have made this book possible, and he includes a bibliography for each chapter. Also included are a glossary and index.

For people who want to learn more about the Cascade volcanoes—their origins, histories, and futures—this book is highly recommended. □

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