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NOTES ON THE HISTORY OF THE SAND AND GRAVEL INDUSTRY IN OREGON

by

Pierre R. Hines*

Introduction

In 1917 George Bellows, American artist (1882-1925), painted a picture of two men loading a wagon with sand on a gravel bar at Monterey, Cal. (figure 1). In those days a team of horses would pull a cubic yard or so of wet sand and gravel in a wagon and haul it directly to the building site.



Figure 1. "The Sand Team," painted in 1917 by George Bellows, hangs in the Brooklyn Museum, Brooklyn, N.Y.

* Mining engineer, Portland, Oregon

Customarily, the wagon bottom was a layer of 2-by-6's which projected out the rear and could be twisted to dump the load; or, perhaps, the bottom had doors which took care of the dumping operation. If the load was sand to be used in mortar, it was screened by hand, mixed with lime and water, and carried to the masons or plasterers. If the load was sand and gravel for concrete, it was shoveled onto an inclined screen so that the separated components could be measured in the desired proportions. Rough proportions for concrete were usually one part of cement, two parts of sand, and about four parts of gravel. A certain amount of this gravel, measured in wheelbarrow loads, was spread on a mixing platform; then the required wheelbarrow loads of sand were added; and on top of the pile a specified number of sacks of cement was spread. The mass was turned over with straight-edge shovels until uniformly mixed. Water was added as needed and the mixture was transferred by wheelbarrows or buggies to forms, where the concrete mixture was thoroughly tamped. Usually steel re-enforcing rods had previously been placed and secured in the forms. This procedure was typical of the methods used in mixing and placing concrete around the turn of the century.

Development of the Cement Industry in Oregon

Oregon had a small population in the early 1900's so that construction was minimal. An abundance of building materials was readily available, however. The state had immense virgin forests containing the finest of timber and also plenty of good rock for foundation material. No local cement was at first available, so wood construction was usually the principal choice for housing and similar structures. Later, California cement was brought in by ship and became an essential ingredient in masonry construction. In 1916, the first Oregon cement plant began production at Oswego, near Portland.

Increase in sand and gravel production closely parallels the growth of the cement industry, and it follows that construction of the highway system in the United States created a great demand for aggregate and cement in Oregon as well as in other parts of the country. Oregon pioneered in highway construction in 1913-15 in building the Columbia River Highway from Astoria to Hood River. The primary object was to connect western and eastern Oregon with a paved highway and in so doing to take advantage of the scenery of the great Columbia River.

Bonneville Dam on the Columbia, east of Portland, was started in 1933. This was the first of several large, multipurpose dams built throughout the Columbia River system.

Oregon's population swelled during the middle part of the present century, especially after the end of World War II, and need for cement, sand, gravel, and crushed rock increased in a rapidly accelerating curve. Other factors affecting production and use of cement and aggregate in

construction, not restricted to Oregon alone but applicable to the country as a whole, are: 1) increased knowledge of how to manufacture high-quality cement, produce better aggregate, and make higher strength concrete at lower cost, and 2) improved highway engineering.

Delivery of ready-mix concrete from a central plant by mixer trucks rather than mixing at individual sites has revolutionized use of concrete in construction on practically all urban jobs*. Production of better aggregate is effected by such factors as: thorough washing of coarse aggregate; increase in the number of sizes made available for mixes; use of vibrating screens which do a more efficient job of screening; and new types of fine grinders which produce a wider range of sizes. The greatest improvement of aggregate is in the sand component. Sand classifiers now meet rigid screen analysis specifications, so that the resulting sand produces a higher strength concrete with less cement.

A central mixing plant which feeds the ready-mix trucks has accurate scale for proportioning the concrete mixture by weight and also has meters for measuring water to obtain the correct water-cement ratio as well as slump control, all of which elements make for better concrete. Certain additives such as air entraining compounds improve freezing resistance and fluidity. Ready-mix is now sold for all important work according to rigid specifications and guarantees. Large producers have their own testing laboratories and technical staffs. The improvements as described were initiated about 1935-40, which is the time also of the beginning of the rapid increase in use of sand and gravel in concrete aggregate.

Historical Outline of Sand and Gravel Operations

1900 - 1920

Uses of sand, gravel, and crushed rock were limited in this period, as has been indicated, and it follows that preparation for application in construction was simple compared to modern practice.

* Five types of portland cement are now manufactured. They are:

Type I. For use in general concrete construction when the special properties specified for types II, III, IV, and V are not required.

Type II. For use in general concrete construction exposed to moderate sulfate action or where moderate heat of hydration is required.

Type III. For use when high early strength is required.

Type IV. For use when a low heat of hydration is required.

Type V. For use when high sulfate resistance is required.

(A.I.M.E., "Industrial Minerals and Rocks," p. 165.)

Early producers of aggregate in the Portland area were: Star Sand Co., Columbia Contract Co., Nickum & Kelly, Diamond O Navigation Co. (Drake O'Reilly), Pacific Bridge Co., Columbia Digger Co., and Hackett Digger Co.

Chris Minsinger, owner of Star Sand Co. (figure 2) and a pioneer in the industry, came to Portland from Pittsburgh, Pa., about 1902. He brought the ladder dredge to the Willamette from the Ohio River -- an innovation in digging river gravel for the local area.

Star Sand Co., Columbia Contract Co., and Nickum & Kelly dug the Willamette River gravel with ladder dredges which were equipped with screening and crushing machinery, and they delivered the crushed products to barges alongside. The barges were towed to the docks and unloaded into bunkers from which the material was trucked to building sites. Some of the other operators used clam-shell dredges, while Pacific Bridge Co. utilized a shovel dredge.

Willamette River gravel at this time was found at shallow depths and was easy digging. The sand component was not considered suitable for concrete, however, and sand from the Columbia River was used instead. Columbia River sand was dug by both clam-shell and suction dredges.

Star Sand, Columbia Contract, and Pacific Bridge Companies had their own rock quarries and produced commercial crushed rock. Star Sand's quarry was at Coffin Rock, a monumental shaft of columnar basalt on deep water at Longview, Wash. Coffin Rock was leveled off just after the end of World War II, and the Weyerhaeuser salt unloading dock and bleach plant were built on the site. Columbia Contract Co. had a quarry on the river at St. Helens and also one for jetty rock at Fisher's Landing just west of Camas, Wash. Their distribution yard was on the east bank of the Willamette River just north of the Hawthorne Bridge (figure 3). Pacific Bridge Co. had a rock quarry on the Columbia River at Corbett, east of Portland; later the operation was moved to the lower Columbia at a location between Scappoose and Linnton where the highway, railroad, and slough converge.

Oregon City, Salem, Albany, and Eugene each had dragline plants on the Willamette River for producing aggregate. Sand and gravel deposits of commercial size are rare on the Oregon coast, owing to the relatively short length of most coastal streams which have their sources in the Coast Range. The Umpqua River is an exception, since it drains a considerable area of the Cascade Mountains. The Umpqua Navigation Co. started to produce sand and gravel from the Umpqua at Gardiner and Reedsport about 1920.

Old placer-mine tailings in the Rogue River drainage area were a source of sand and gravel in southern Oregon.

1920 - 1930

The Federal Highway Act was passed in 1916. It was not until 1920



Figure 2. The Star Sand Co. office and yard in northwest Portland at the turn of the century. (Oregon Historical Society photograph)



Figure 3. Columbia Contract Co. distribution yard at east end of Hawthorne Bridge about 1920. (Photograph courtesy Miss Grace Kern)

that this act had much influence on Oregon highway construction. Highway engineers encountered many problems, and one was finding adequate construction material. In mountainous areas where no suitable gravel was available, some of the rock cropping out along the highway route had to be used. The State Highway Department designated quarry sites close to each project and let contracts for definite amounts of crushed rock for construction and stockpiles for maintenance. The quantities required would not warrant a single large permanent operation; thus, portable crushing and screening plants were developed at various locations on Oregon highways.

For concrete installations it was usually common practice to haul the sand, gravel, and cement to the construction site and mix them there. Portable mixers were designed for both building structures and highway work. Hoisting towers and chutes were used to place large quantities of concrete for both building structures and dams, all of which required free-flowing concrete and a high water-to-cement ratio. When research proved that better concrete was made with a lower water-to-cement ratio, these older methods were abandoned. Large quantities of coarse gravel up to 3 inches maximum size were used at this time, especially in highway construction.

By 1926 shallow gravel in the Willamette River near Portland was becoming exhausted and digging had become too deep for ladder dredges; consequently, Howard Puariea built a clam-shell dredge equipped with screening and crushing equipment (figure 4). Shore plants and large storage had not previously been needed on the Willamette at Portland.

Also in 1926, John Kiernan, who owned Ross Island and Hard Tack Island, both located on the east side of the Willamette River at Portland, sold them to the Ross Island Sand & Gravel Co., well known in the aggregate business in Portland. It had been previously organized and incorporated by Snellock & Co. W. G. Brown, Portland civil engineer, made several test borings for the company in the area to a depth of 80 feet and estimated that it contained a probable gravel reserve of 19,500,000 cubic yards, including 6,000,000 cubic yards of sand. This deposit was dug with an electrically driven suction dredge which pumped the material to a sump (figure 5). It was elevated from the sump by means of a clam-shell bucket and delivered to the top of the shore plant on Hard Tack Island which was equipped with crushing and screening machinery, including large bunkers and conveyors. An aerial tram delivered the aggregate to bunkers on McLaughlin Boulevard and to barges on the river.

Willamette River gravel at Portland had not been considered suitable for average concrete, but William Elijah Buell, a civil engineer associated with Schneelock & Co., found that, by removing the contained fine silt, a sand superior to Columbia River sand could be produced. Ross Island installed the required sand wheels and thus produced a satisfactory sand which gave a stronger concrete.

Treatment of the gravel to produce commercial sand by the Ross Island Co. marked a change in the sand and gravel business on the Willamette



Figure 4. Howard Puariea's first clam-shell dredge, 1926.



Figure 5. The first Ross Island Sand & Gravel Co. suction dredge, 1927.

River at Portland. Harold Blake was the first manager of the company. He installed a vibrating screen at the Ross Island plant about 1929. Highway engineers questioned its performance, but tests showed that this screen was making a cleaner and sharper separation than the revolving screens then in use. Shortly afterwards the Highway Department issued more rigid screening specifications which only vibrating screens could meet.

1930 - 1940

The 10 years between 1930 and 1940 were years of depression; nevertheless, production curves show that the use of sand, gravel, and crushed rock began to accelerate in 1935.

Work on the Bonneville Dam started on October 7, 1933. This was the beginning of the construction of the great system of dams to develop power, flood control, navigation, and irrigation in the Columbia River basin by the U.S. Government. A number of these dams have been built between Oregon and Washington, and also on the Willamette and its tributaries wholly within Oregon.

J. F. Shea and General Construction Co. had the contract for the south section of the Bonneville Dam. The Big Five Co. had the spillway contract, and used sand and gravel from up the river. General Construction Co. had the subcontract for furnishing 300,000 yards of sand and gravel required for the south section, the power house, and the navigation locks. The gravel plant was built in Portland on the river within the Union Pacific Railroad yards at the foot of N. Portsmouth Avenue. The location was selected for the purpose of obtaining a special intrastate freight rate to the Bonneville Dam site by way of Union Pacific Railroad. Sand and gravel were dug from the Willamette River plus additional sand from the Columbia River, and material from both sources was barged to the Portland plant. Digging equipment was leased from Swigert-Hart Co. and Harold Blake. The gravel plant had a capacity of 2500 yards per day. It had large storage and fast loading equipment; the finished aggregate was shipped directly to the dam site. Harold Blake managed the whole operation and, when the contract was completed, received the plant in payment for his services. This was the start of the combined Pacific Building Materials Co. and the Readymix Concrete Co.

Some time in the 1930's a contractor in San Francisco mounted a concrete mixer on a truck body and patented a transmission by which he could drive the mixer from the truck engine shaft. This idea did not appeal to operators immediately, but eventually it revolutionized the aggregate industry in the United States.

During the late thirties, Porter Yett of Pacific Bridge Co. built a mixing plant at a location on East Water Street, Portland, and began to deliver ready-mix concrete in special trucks. This practice was followed successively by Ross Island Sand & Gravel Co. and Harold Blake of Pacific

Building Materials Co. The Porter Yett plant was one of the most important developments in the history of the sand, gravel, and crushed rock industry in Oregon. It did not change the industry over night, but it was a big step in its evolution.

1940 - 1950

World War II slowed down the increasing rate of rock-products production in Oregon, but did not effectively hinder construction. Ship-building plants and housing for shipyard workers, air fields and other adjuncts to defense plants all required concrete, thus greatly increasing demand for construction materials.

During the post-war period, the ready-mix business grew rapidly but selectively. When Coffin Rock at Longview was depleted, Star Sand faded away. Nickum & Kelly went out of business. Diamond O Navigation also closed down after the death of its owner, Drake O'Reilly.

Pacific Building Materials Co. built the Curry Street plant of steel and concrete on the west side of the river convenient to the city core. The plant was designed to produce a large number of sand and gravel sizes and arranged so that the material could be blended to meet a wide range of specifications. The plant could be run the year around, since it had a large storage area. The ready-mix plant had the latest batching equipment, as an outgrowth of large dam construction.

The whole State of Oregon was growing during this period, and even some of the smaller towns had a sand and gravel plant and a ready-mix truck or two.

Those who made the history of the sand, gravel, and crushed rock industry during the first half of the century are listed below. It is to be regretted that the biographies of these men cannot be written here. They were more than producers of sand, gravel, and crushed rock -- they were builders of the Pacific Northwest. All honor to them.

1950 - 1960

Detroit Dam and Lookout Point Dam were built during this period and the aggregate, both coarse and sand size, was made from rock near the dam sites. Although sand and gravel were available locally, the U.S. Corps of Engineers did not find them suitable for a permanent structure because of the presence of hydrous silicates, which may combine with alkalies in the cement and form undesirable compounds. The Vancouver and Longview areas took large amounts of aggregate for industrial construction and most of this was supplied from the Willamette River sand and gravel plants. The gravel at Astoria also required outside sand, since the Astoria gravel was inherently deficient in suitable material.

Pioneer Sand and Gravel Producers in Oregon	
Columbia Contract Co.: Dan Kern Kern & Kibbe Captain Puariea Diamond O Navigation Co.: Drake O'Reilly Eugene Sand & Gravel Co. Pacific Building Materials Co.: Harold Blake Harold Eykelbosch Frank Pennepacker Melvin Erlund Howard Puariea McGeorge Gravel Co. Lewis McGeorge Nickum & Kelly Pacific Bridge Co.: Charles Swigert Phil Hart Porter Yett	Milwaukie Sand & Gravel Co. and predecessors Ross Island Sand & Gravel Co.: Ralph Schneelock Harold Blake Dewey Carpenter W. H. Muirhead Star Sand Co.: Chris Minsinger William Minsinger David Minsinger Salem Sand & Gravel Co. and Oregon Gravel Co.: Mr. Miles Richard Slater James C. Tait Umpqua Sand & Gravel Co.: Howard Hinsdale

Very little sand and gravel was now sold as such, because practically all aggregate was incorporated in concrete or asphalt for highways. Pacific Building Materials Co. and Mason's Supply built lime-slacking plants which also mixed sand and lime for use as plaster. Gypsum wallboard, plywood, and veneer paneling replaced old wood-lath and plaster work in building construction.

1960 - 1970

Concrete is now usually pumped to where it is to be placed, ready-mix trucks delivering it to the pump. Round gravel, as distinguished from angular material from crushers, is preferred for pumping and the balance is crushed for blacktop. Three-inch sizes are no longer required for highway work; minus 1½-inch is now the largest size used in most work except for large dams.

Future supplies

Outside of the Portland area, few of the sand and gravel deposits show signs of exhaustion. The life of some sand and gravel bars has been extended by systematic regulation of the digging, allowing one dug-out portion to fill from stream flow during flood season while another area is



Figure 6. Metcalf gravel pit in east Portland about 1910.

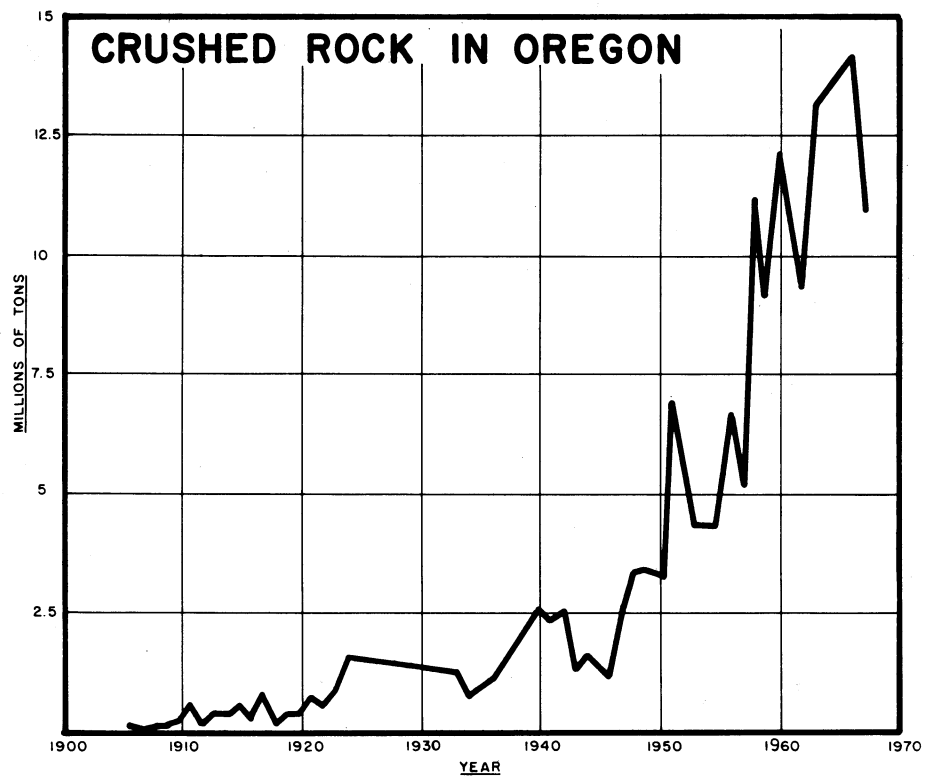
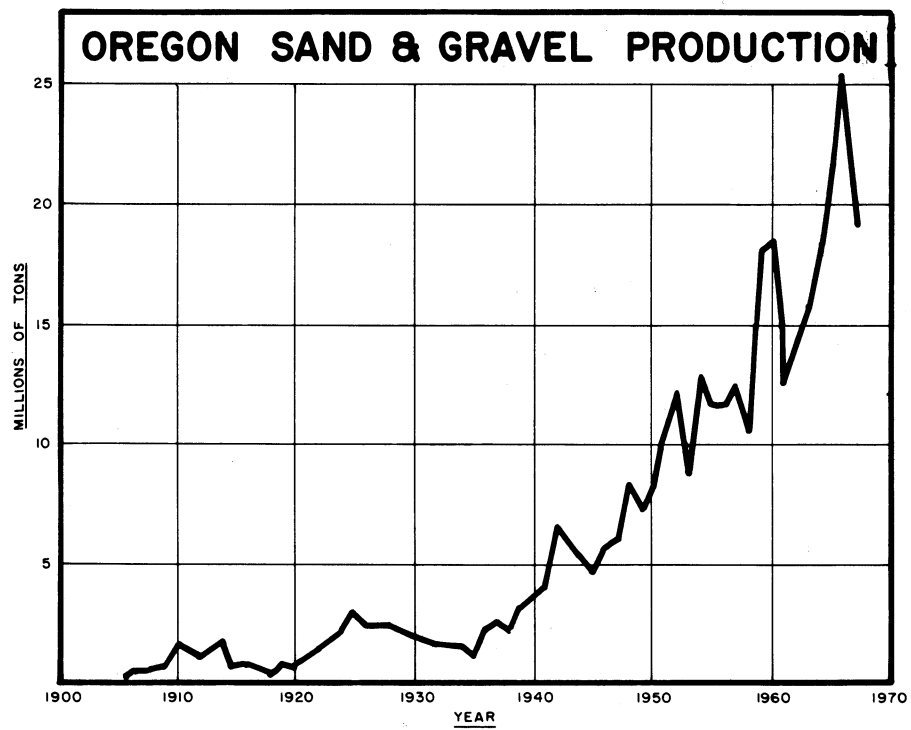
dug out. This, of course, is limited to a certain annual yield.

The supply of economic sand and gravel in the Portland area is rapidly becoming depleted. The Willamette River bed from Portland to the Oregon City Falls is now almost exhausted and will not supply the area's needs. Ross Island Co. is using a pump dredge again for the shallow bank work, followed by a clam shell which digs deeper than the suction dredge. Ross Island still has plenty of gravel below the original drilling of 80 feet, but it alone could not supply Portland's requirements. The locks at West Linn are a bottleneck in barging from above the falls -- they take only a 36-by-150-foot barge and the locking time is prohibitive.

Parker-Schramm built a sand and gravel plant at Scappoose near the SP&S Railway years ago. Several companies are now getting ready to take sand and gravel from the Scappoose area. This will not last long at the present rate of demand and further sources are necessary.

The eastside of Portland is underlain by good sand and gravel. Small plants along 82nd Avenue and Johnson Creek supplied suburban home construction nearby (figure 6). Portland's growth built up the area but the home dwellers objected to the aggregate plant's operations. The plants then moved eastward, where the cycle was repeated. In a few words, the growth choked the plants which supplied the materials necessary for the growth. The result is that an enormous quantity of sand and gravel is now covered by residential developments.

The accompanying graphs (page 236) show the production of sand, gravel, and crushed rock from 1906 to 1967; they depict better than words how rapid the increase has been. It is estimated that Oregon has produced



450,000,000 cubic yards of sand, gravel, and crushed rock in this period. At the present rate of more than 30,000,000 cubic yards a year, it will be necessary to preserve some areas for future needs before they are zoned for other purposes and we are then forced to bring in outside aggregate.

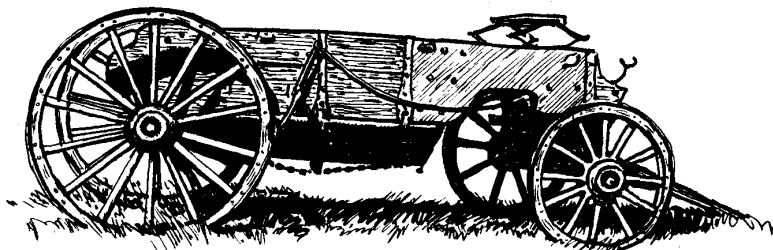
Present open-pit methods of mining rock on a large scale have kept ahead of rising costs of labor and material, but these are still the limiting factors in production of aggregate for concrete. Modern crushing and grinding practice has also progressed so that over-all costs of aggregate are not excessive. The final solution for economical production eventually may be a large-capacity plant making aggregate from rock on either the Willamette or the Columbia Rivers. Oregon has all of the suitable rock needed.

Acknowledgments

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Sketch by Ernest Richardson, The Oregonian

OREGON "MOON ROCK"

When astronauts make their third landing on the moon, after completing the ride into space early in 1970, they are expected to do some drilling into rocky portions of the moon's surface. When they do, they probably will use drills tested and developed by the Martin-Marietta Co. at Denver.

When Martin-Marietta began testing drills to be used on the moon, they called on the State of Oregon Department of Geology and Mineral Industries because of the work the Department has done in past years on the recent volcanic rocks in the Bend area. A special type of lava was needed in order to simulate what the geologists assumed to be the bedrock on the moon.



Norman V. Peterson, district geologist in the Department's Grants Pass office, was able to locate the required rock because he remembered where large blocks of this material had been blasted loose during a construction project and were left lying on the surface. The rock was a vesicular basalt from a relatively young lava flow near Lava Butte, a well-known volcanic peak beside U.S. Highway 97 approximately 10 miles south of Bend. The age of this lava flow was determined by radioactive carbon dating to be 5800 ± 150 years. Approximately 10 tons of the basalt was shipped to Denver in 1966 and an almost equal amount was sent off about May 1 of this year when the supply at Denver had been used up. (Photograph courtesy of Grants Pass Courier.)

THE NORTH POWDER EARTHQUAKE OF AUGUST 14, 1969

by

Richard Couch and Robert Whitsett*

The North Powder earthquake of August 14, 1969 occurred at 07:37 a.m. PDT approximately 4 km southeast of the Thief Valley Reservoir in north-eastern Oregon. A magnitude of 3.6 and a depth of focus of 32 km are estimated for the shock. Records list only two other earthquakes for the area between Baker and Union, Oregon -- both of intensity III. Intensities up to V - VI are indicated for the 1969 shock. Consequently, it is the largest earthquake to have occurred in recorded history in this relatively aseismic area (figure 1).

Recording stations

Eight permanent and four temporary seismograph stations recorded the North Powder earthquake. Table 1 lists the P-wave arrival time and initial phase observed at the 12 stations. Only the Baker and Bend, Oregon stations recorded a well-defined first arrival.

Epicenter and origin time

The geographic coordinates of the earthquake are 44°59'N latitude, 117°45'W longitude. The epicenter, as shown in figure 1, is located approximately 12 km (7.6 miles) south-southeast of North Powder and 4 km (2.4 miles) southeast of the Thief Valley Reservoir. This determination is based on the observed arrival times listed in table 1 and the local travel-time curves prepared for the Pacific Northwest states by Dehlinger, Chiburis, and Collver (1965). The origin time of the earthquake is estimated to be 06 hrs. 37 min. 39.5 sec. PST, August 14, 1969. The seismic wave arrival times at Blue Mountains Seismological Observatory, although well defined, were not used in determining the epicenter.

Depth of focus

The earthquake occurred at a depth of 32 ± 3 km. Focal depth calculations depend on the seismic velocities of the crustal and subcrustal

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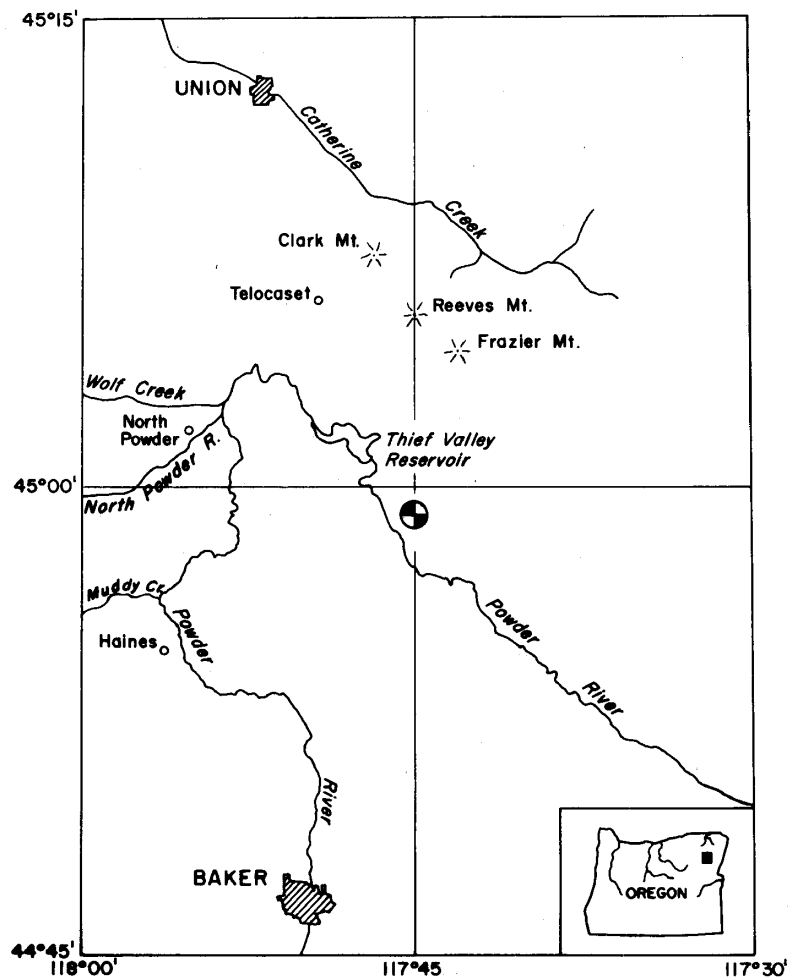


Figure 1. The sectored circle indicates the epicenter of the North Powder earthquake of August 14, 1969.

layers and are quite sensitive to small changes in velocity. A depth of 30.3 km is obtained from calculations using the p-wave travel time to Blue Mountains Seismological Observatory and a crustal structure (Dehlinger, Chiburis, and Collver, 1965; and Dehlinger, Couch, and Gemperle, 1968) consisting of an upper crustal layer 9 km thick with a p-wave velocity of 6.1 km/sec and a lower crustal layer 33 km thick with a p-wave velocity of 6.6 km/sec. French (1970) developed a method of determining earthquake focal depths based on the arrivals of post P_n phases of seismic waves.

A focal depth of 32.0 km is obtained from post P_n arrivals at Pine Mountain Observatory. This depth determination is independent of uncertainties in origin time and the location of the epicenter.

Magnitude

The magnitude of the earthquake is estimated to be 3.6 on the Richter Scale. Magnitudes according to this scale are based on the amplitude of ground motion recorded at seismic stations. Magnitudes are logarithmically scaled and range from 0 or less for the smallest recorded shocks to $8 \frac{3}{4}$ for the largest, most destructive earthquakes (Richter, 1958, p. 340). A magnitude estimate of 3.5 was furnished by the Newport Seismological Station at Newport, Wash., and a magnitude estimate of 3.7 was furnished by the Blue Mountains Seismological Observatory at Baker, Ore.

TABLE 1

Station	Location	Time (PST) hr/min/sec	Initial Motion C-Compression D-Dilatation
COR	Corvallis, Oregon	06:38:40.9	--
BMO	Baker, Oregon (Blue Mts. Seis. Obs.)	06:37:47.0	C
HHM	Hungry Horse, Montana	06:38:45.0	--
NEW	Newport, Washington	06:38:30.0	--
NIT	Newport, Washington (Temporary)	06:38:35.0	--
PMT	Bend, Oregon (Pine Mt. Obs.)	06:38:22.2	D
PTD	Portland, Oregon (O. M. S. I.)	06:38:35.2	--
SPO	Spokane, Washington	06:38:26.0	--
BDG	Hanford, Washington ($46^{\circ}14.08'$, $119^{\circ}19.05'$)	06:38:05.5	D
ELT	Hanford, Washington ($46^{\circ}27.90'$, $119^{\circ}03.50'$)	06:38:06.9	D
OTH	Hanford, Washington ($46^{\circ}44.40'$, $119^{\circ}13.00'$)	06:38:10.9	D
MID	Hanford, Washington ($46^{\circ}36.80'$, $119^{\circ}45.65'$)	06:38:12.1	D

Intensity

Estimated intensities on the Modified Mercalli Intensity Scale of 1931 are: Wolf Creek V-VI, Muddy Creek IV-V, North Powder IV, Haines III, Baker II. Intensity estimates are based on the observed or felt effects of the earthquake at these various places. The M.M. scale extends from intensity I, which is not felt, to intensity XII, in which damage is nearly total (Richter, 1958, p. 137). The intensity estimates are based largely on observations as reported by local newspapers. The higher intensities appear to occur in the valleys. This may be attributed to higher population densities in the valleys and also to the surficial material - composed largely of fluvial deposits - which tends to amplify the ground motion. Undulations of the ground were reported in the Wolf Creek area. The earthquake was reportedly heard before it was felt in the North Powder, Haines, Radium Hot Springs, and Wolf Creek areas.

Source motion

The direction of first motion of the longitudinal wave (P_n) at Pine Mountain Observatory indicated a dilatation and the direction of first motion of the longitudinal wave (p) at Blue Mountains Seismological Observatory indicated a compression. The first motion directions observed at the four Hanford, Wash. stations indicated a dilatation. The first motion directions suggest right lateral faulting along a northwest-southeast trending strike-slip fault or left lateral faulting along a northeast-southwest strike-slip fault. Weak longitudinal wave onsets and motions at Spokane and Newport, Wash., and relatively strong shear wave motions observed at North Powder and Wolf Creek also suggest strike-slip movement. Mapped surface faults in the region trend northwest-southeast. Although the limited data do not permit a definite conclusion regarding fault motion, right lateral motion along a northwest-southeast trending strike-slip fault appears the most likely cause of the North Powder earthquake.

Discussion

The area about North Powder and the Thief Valley Reservoir is relatively aseismic. The area is bordered on the east by a seismically active area along the Snake River and on the north by activity in the vicinity of the Walla Walla River in the Deschutes-Umatilla Plateau. Berg and Baker (1963), in their historical summary of earthquakes in Oregon, list only two shocks for the region about Baker: September 1, 1906 and May 28, 1916. An intensity of III is listed for these two earthquakes, whereas an intensity of approximately V-VI is assigned the August, 1969 earthquake. The earthquake history of this region is too short to calculate an average seismic energy release rate.

The earthquake occurred in the vicinity of the Blue Mountain uplift, an area of glacial and fluvial deposits. These deposits are mostly of Pleistocene and Holocene age and are concentrated in the numerous valleys of the region. These deposits which are not well consolidated tend to enhance ground vibrations due to seismic waves. Their occurrence may partially explain the relatively high intensities associated with an earthquake 32 km deep.

It is unlikely that changes in the heat source of Radium Hot Springs or levels of the Thief Valley Reservoir are the cause of the earthquake. The focal depth of the earthquake, in this relatively aseismic area, suggests a regional rather than local cause and the method of faulting suggests a sub-crustal tectonic cause rather than isostatic adjustment due to load removal by erosion.

The agreement in focal depth of the earthquake, determined from the compressional wave travel-time to Blue Mountains Seismological Observatory and independently by the method of French (1970), indicates that the depth beneath the surface of the Mohorovicic discontinuity - the interface between the Earth's crust and mantle - near Baker, Ore. is approximately 42 km as previously depicted by Dehlinger, Couch, and Gemperle (1968), and Thiruvathukal (1968).

Acknowledgments

The following people supplied arrival-time data and are gratefully acknowledged: F. Brecken, Oregon Museum of Science and Industry, Portland, Ore.; L. Jaksha and D. Newsome, Blue Mountains Seismological Observatory, Baker, Ore.; A. Travis, Newport Seismological Observatory, Newport, Wash.; Robert Bechtold, NASA, Houston, Texas; M. Castner, Mt. St. Michels Seismological Observatory; A. M. Pitt, Regional Center for Earthquake Research, Menlo Park, Cal. We thank Dr. William French, Gulf Research, Pittsburg, Pa., for introducing us to a new method of determining earthquake focal depth and Stephen Johnson, Oregon State University, for technical assistance.

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INTERIOR SUPPORTS MINING LAW OF 1872

Secretary of the Interior Walter J. Hickel has given full support to the existing Mining Law of 1872, completely reversing the position taken by former Interior Secretary Stewart Udall. Hickel has recommended the following changes for improving the law without sacrificing its basic concepts:

1. Revision of the patenting procedures to grant claimants only a patent to subsurface mineral resources with a right to use so much of the surface as is necessary for mining and related activities. The patentee would have preference in any sale of the remaining surface rights.
2. Provisions for realistic increases in the purchase price per acre for mining claims upon patenting. Such increases should adequately reimburse the federal government for expenses incurred in issuing the patents. Prices established in 1872 are far from in line with prices today.
3. Retention by the United States of surface rights should be accompanied by a provision enabling the federal government to exercise a reasonable degree of control over the impact upon the surface and environment as a result of mining and related operations.
4. Elimination of the distinction between lode and placer claims. Countless problems have been caused by this needless distinction and it is generally agreed that it serves no useful purpose.
5. Establishment of a means to clear the public land of stale and abandoned mining claims. The present system is ineffective and extremely expensive. As a result, very slow progress has been made in clearing public land of questionable claims which adversely affect both the mining industry and the public interest.
6. Elimination of local laws and customs for the regulation of claims locations and the establishment of clear and modern federal requirements applied uniformly which recognize the technological development made in the mining industry. These regulations should require claim locations to conform to the lines of public survey.

7. Elimination of extralateral rights. Amend existing laws to provide that mining claims include only minerals within the vertical extensions of claim boundaries.

8. Establishment of a system of prediscovery claims subject to reasonable requirements for time of development. This should provide necessary protection for one engaging in exploration with reasonable diligence and intending to develop any workable deposits found.

* * * * *

DOTHAN (?) FOSSILS DISCOVERED

By Len Ramp

While we were mapping in the Kalmiopsis Wilderness Area* of Curry County in September 1968, Vernon Newton and I discovered fossils unexpectedly in an area mapped as Dothan Formation by Wells and Peck (1961) on their Geologic Map of Oregon West of the 121st Meridian. Because of the lack of diagnostic fossils in the Dothan Formation, we were quite excited about our find, and spent considerable time breaking rock to get a representative collection.

The fossils were in loose boulders of a dark gray to black, limy argillite which was brownish on weathered surfaces. The boulders are along the east bank of the Chetco River about 1000 feet upstream from the mouth of Boulder Creek in sec. 7, T. 38 S., R. 11 W., and they appear to have originated from a rock slide. Similar rocks are exposed in place along the river banks nearby.

The fossils have been examined by Dr. R. W. Imlay, U.S. Geological Survey, Washington, D.C. and by Dr. D. L. Jones, U.S. Geological Survey, Menlo Park, Cal. Both men agree that the fossils appear to be Buchia piochii (Gabb). This small clam indicates a latest Jurassic (Tithonian) age for the rocks in which it occurs. If the beds on the Chetco River are indeed part of the Dothan Formation, then the Dothan is appreciably younger than the Late Jurassic Galice (Oxfordian-Kimmeridgian). The age relationship between the Galice and Dothan Formations has been a controversial matter ever since the two units were described by Diller in 1907. Diller (1914) believed that the Dothan was the younger and that the eastward-dipping Dothan-Galice section, with the Dothan on the west, was overturned. Subsequent authors -- Taliaferro (1942), Wells and Walker (1953), Irwin (1964), Dott (1965), and Baldwin (1969) -- have discussed the problem with conflicting views. None of them, however, had the benefit of adequate

* Part of a study concerning the geology and mineral resources of the Upper Chetco River to be published by the Department.

fossil evidence for the age of the Dothan. What is needed now is more detailed mapping within the formation to trace out these sedimentary rocks along the Chetco River and make sure that they are equivalent to similar-appearing rocks at the type locality of the Dothan Formation along Cow Creek in Douglas County, 35 miles to the northeast. Of course, the discovery of Buchia piochii (Gabb) in the type locality would be the best proof.

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* * * * *

FOSSIL WOOD ON EXHIBIT

The Department has a new exhibit in its "loan case" at the Portland office. It consists of a group of beautifully polished fossil woods that was collected and identified by Mrs. Irene Gregory, authority on fossil woods in Oregon. The wood specimens are from a wide variety of localities in the state, including Sweet Home, Clarno, Greenhorn Mountains, and many other areas. Most of the specimens are cut and polished to reveal identifiable woodgrain. In addition, there are agate limb casts and features such as bark, knots, insect eggs, and replacement crystals. At least 28 genera of Late Cretaceous and Tertiary woods are represented in this fine exhibit.

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27.	Geology and coal resources of Coos Bay quad., 1944: Allen and Baldwin	1.00
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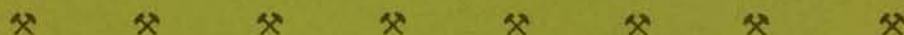
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