The Ore Bin

Vol. 30, No. 2
February 1968

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

• The Ore Bin •

Published Monthly By

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland, Oregon - 97201
Telephone: 226 - 2161, Ext. 488

Field Offices

2033 First Street
Baker 97814

521 N. E. "E" Street
Grants Pass 97526

Subscription rate $1.00 per year. Available back issues 10 cents each.

* *

Second class postage paid
at Portland, Oregon

* *

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

The ORE BIN
Volume 30, No. 2
February 1968

OCEANIC EXTENSION OF COASTAL VOLCANICS: NORTHWESTERN OREGON

By David A. Emilia*, Joseph W. Berg, Jr.** and William E. Bales*

Introduction

The object of this paper is to give an estimate of the oceanic extension of coastal volcanics in northwestern Oregon by correlating land and ocean geophysical data with land geologic data.

Volcanic flows and intrusions of intermediate to basic composition usually have high magnetic susceptibilities, in contrast to marine sedimentary and fine pyroclastic rocks. Magnetic surveys usually evidence these susceptibility contrasts as magnetic anomalies superimposed on a regional magnetic field. If volcanic formations are continuous from land to ocean, then, as long as there are susceptibility contrasts associated with them, the magnetic anomalies related to the volcanics on land should be observable at sea. Also, volcanic flows and intrusions sometimes have different densities than the surrounding rocks, thus giving rise to gravity anomalies. These gravity anomalies should also give an indication of the oceanic extent of the volcanic formations--providing the density contrasts extend from land to ocean. Magnetic and gravity anomalies may also arise from variations in depth to a volcanic surface or from local variations in thickness of a volcanic formation.

The total magnetic-field values used in this paper were taken from Emilia, Berg, and Bales (1966) and from Bromery and Snavely (1964). The former present a 50-gamma-contour map constructed from ship-towed magnetometer data and the latter present an aeromagnetic profile along the coast. Free-air gravity anomaly values were taken from the 10-milligal-contour maps for Oregon (Berg and Thiruvathukal, 1967) and for off-shore Oregon (Dehlinger and others, 1967). The geological information used during the course of this research was taken from Bromery and Snavely (1964).

---

* Dept. of Oceanography, Oregon State Univ., Corvallis, Oregon.
** Now at the National Academy of Sciences, Division of Earth Sciences, Washington, D. C.

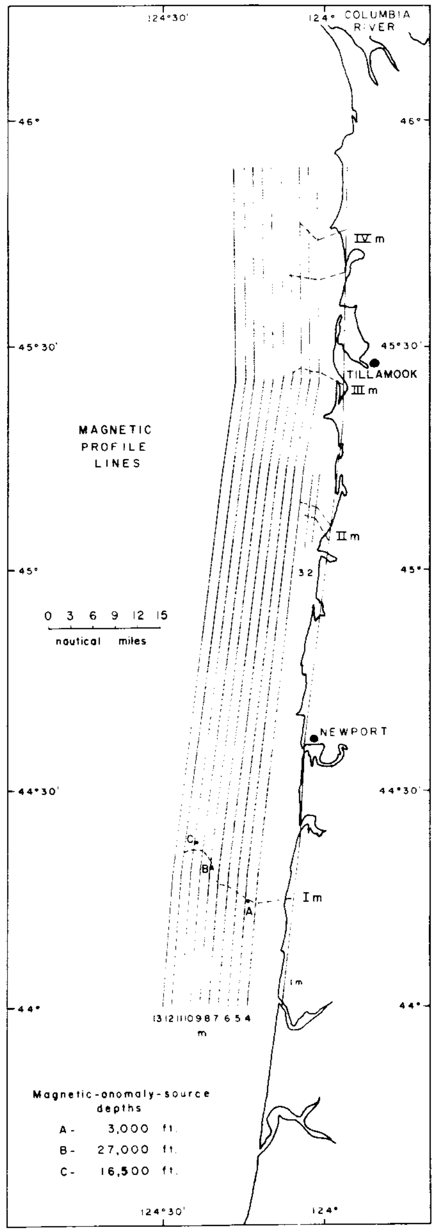


Figure 1. Magnetic profile lines. The dashed lines trace the locations of the correlated magnetic anomalies (see fig. 3).

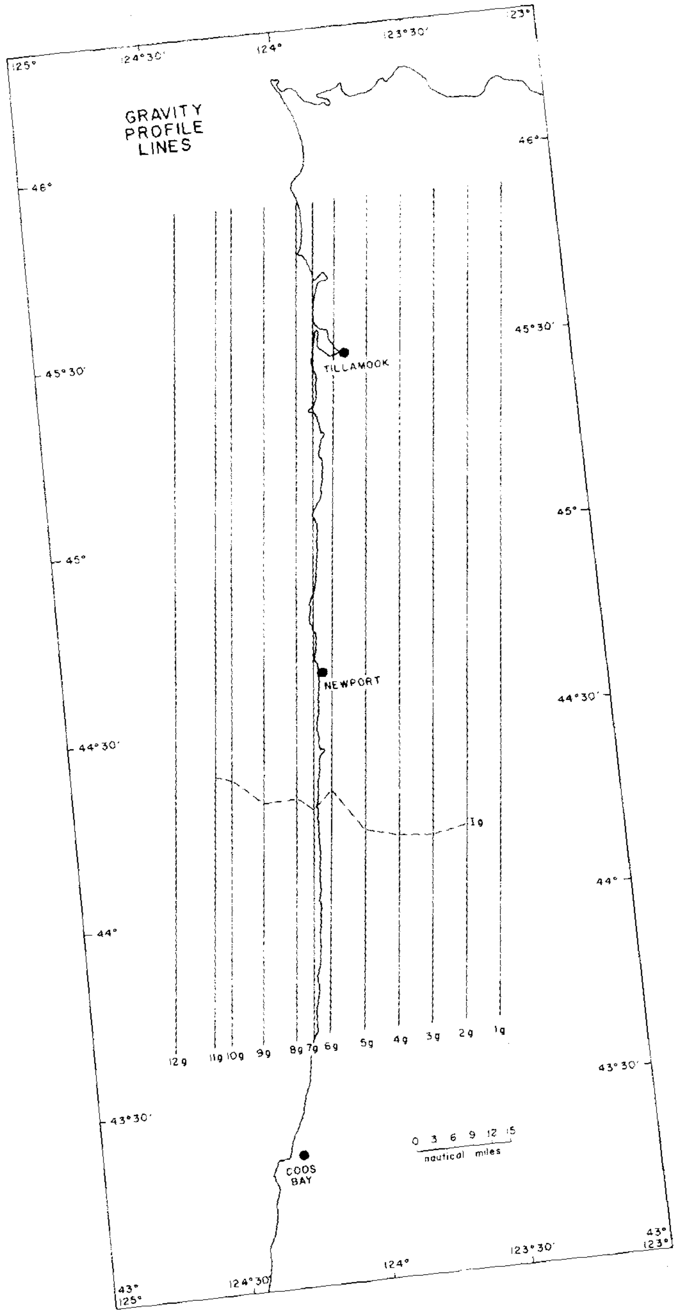


Figure 2. Gravity profile lines. The dashed line traces the location of the correlated gravity anomaly (see fig. 4).

Data Reduction and Presentation

Figures 1 and 2 show the magnetic and the gravity profiles lines (designated by the letters m and g, respectively) along which data were taken for the purpose of this study. These lines were drawn on the magnetic and gravity contour maps and the values of the fields along them plotted. Figures 3 and 4 show the resulting magnetic and gravity profiles. For example, profile 7m in fig. 3 corresponds to profile line 7m in fig. 1. The only profile not taken from a contour map is 1m, which is from Bromery and Snavely (1964). Thus, all the other profiles contain the errors intrinsic in contour maps and are not to be regarded as exact.

Since sea gravity measurements were not made closer than 5 miles from shore, there is a region on the contour map of Dehlinger and others (1967) where contours are the result of interpolation between their measured sea gravity values and the measured land gravity values of Berg and Thiruvathukal (1967) which extend to the coast. These interpolated contours probably give only a smoothed representation of the near-shore gravity field. Profile lines 7g and 8g (fig. 2) lie in this region of interpolation.

Figure 5 is a land-geology map showing the surface volcanics of the area under consideration.

Discussion and Interpretation

Examination of the magnetic profiles in fig. 3 yields four regions along the coast of northwestern Oregon where land and ocean magnetic anomalies can be correlated. These correlations are represented by correlation lines Im through IVm. Figure 4 shows only one region of strong correlation for land and ocean gravity anomalies (correlation line Ig). It is possible that the land-gravity anomaly located between 44°40' and 45°00' (fig. 4) may extend out to sea, but no definite correlation is apparent because the previously mentioned smoothing due to interpolation has probably obscured its seaward expression. We will not consider this anomaly further. The arrows in fig. 5 show where the correlation lines of figs. 1 through 4 cross the coast.

The sea-land correlation of gravity and magnetic anomalies is quite evident in region I (Im and Ig in figs. 3 and 4), and the gravity correlation extends well inland. Comparison of Im in fig. 1 with Ig in fig. 2 shows that they terminate at about the same place over the ocean and cross the coast very close to one another (see also fig. 5). Since each of these lines represents correlation of a different geophysical parameter, and, assuming that they result from the same geologic body, one would not expect them to coincide everywhere, but would expect them to have roughly the same characteristics. The similarity of location and directional trend of Im and part of Ig is quite evident, and we can only conclude that they do in fact represent the same body.

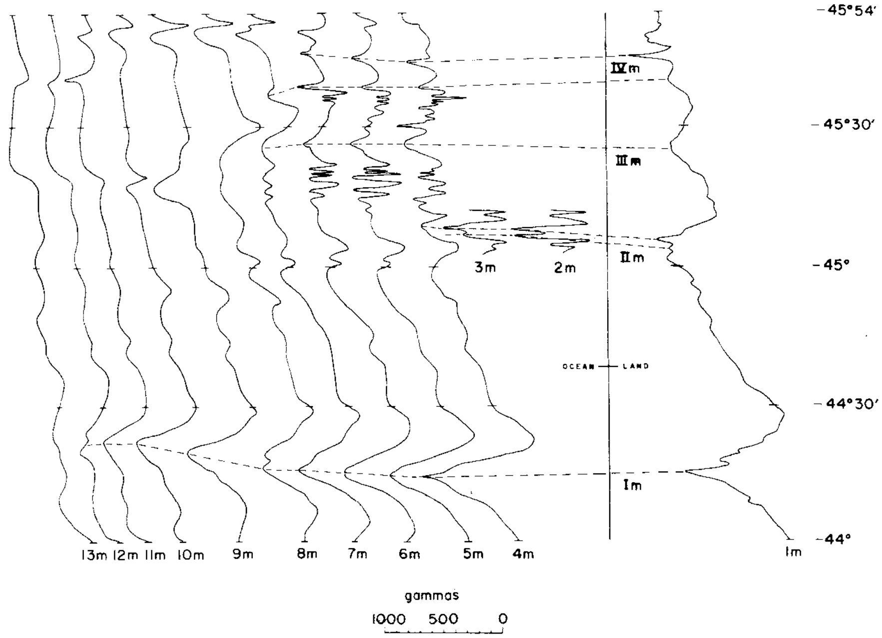


Figure 3. Magnetic values along correspondingly numbered profile lines in fig. 1

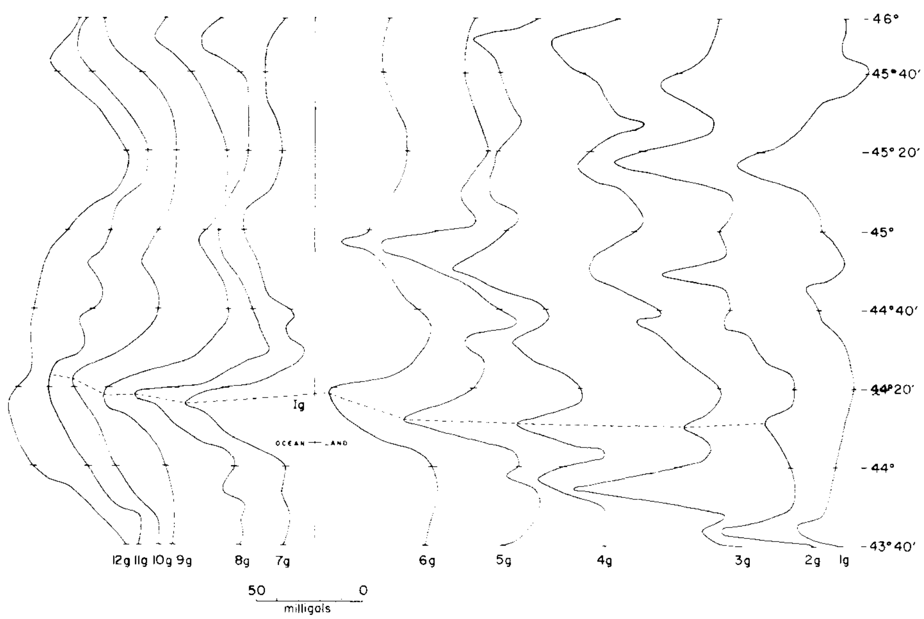


Figure 4. Gravity values along correspondingly numbered profile lines in fig. 2.

Whitcomb (1965) did a marine geophysical survey of region I, out to 124°30', and postulated the existence of a large crystalline rock mass off Cape Perpetua (44°15', 124°07'). He placed the top of this "broad body containing areas of large magnetic susceptibility changes" at a depth less than about 3000 feet, five nautical miles off the cape (A in fig. 1). Emilia, Berg, and Bales (in press) have also made magnetic-anomaly-source depth calculations for anomalies off the coast at positions B and C in fig. 1. They compute maximum depths of 27,000 feet and 16,500 feet respectively. These calculations, as well as the calculation by Whitcomb, fall on, or nearly on, correlation lines Im and Ig.

Bromery and Snavely (1964) concluded that the magnetic and the gravity anomalies measured over land in region I are due to the early to middle Eocene volcanics known as the Siletz River Volcanic Series, and not to the relatively thin upper Eocene alkalic basalt shown exposed in fig. 5. Their analysis indicates that the Siletz Series starts as far east as longitude 123° 06', at latitude 44°09', and, at a depth less than about 5000 feet, continues to where it intersects the coast at Cape Perpetua. Also, they concluded that, moving south from Newport, the Siletz Series rises abruptly from a depth of 15,000 feet to within less than 5000 feet of the surface in region I, thus causing an arcuate gravity high. The free-air gravity contour maps that we have used show that this high is closed and extends from land to ocean. We feel that the gravity high in region I, as evidenced by the maps we have used (no regional correction applied), may not be entirely the result of shallowing of the Siletz River Volcanic Series but may in part be due to intrusions and/or deformation beneath the series. This latter interpretation is feasible, since the gravity anomaly under consideration is closed.

It is evident from the above data that correlation lines Im and Ig are partially determined by the Siletz River Volcanic Series. But, there appears to be a discrepancy in estimates of its eastern limit. Correlation line Ig (fig. 2) extends eastward only to 124°35' while, as already mentioned, Bromery and Snavely show the Siletz River Volcanic Series extending eastward to at least 123°06'. Since the gravity contour lines between 123°35' and 123°06' are nearly north-south (Berg and Thiruvathukal, 1967), our profile lines showed little or no correlation of gravity peaks. However, Bromery and Snavely constructed a geologic section by using a nearly east-west gravity profile line which would more readily show significant field variations due to a north-south-trending geological structure on the eastern end of the profile. An aeromagnetic profile along 123°00' has been published by Agocs, Rollins, and Bangs (1954), but is not presented in fig. 3 because comparison of this profile with profile 1m (fig. 3) indicated that any correlation of anomalies would be extremely tenuous. This difficulty of correlation is to be expected because of the large separation of these profile lines and because the geological structure at Cape Perpetua is different from that to the east.

If we assume that the gravity and the magnetic trends near the coast in region I are mainly due to the Siletz River Volcanic Series, then this Series appears to extend under the ocean, at a depth of about 3000 feet, for about 5 nautical miles until it dips sharply to a depth of 27,000 feet. Following the path represented by correlation lines Im (fig. 1) and Ig (fig. 2), these volcanics then shallow to 16,500 feet at longitude 124° 23'. The magnetic and the gravity anomalies give no indication that they extend farther to the west.

Bromery and Snavely (1964) show the Siletz River Volcanic Series to extend northward, along the coast, from Cape Perpetua at least to 45° 05'. In a northwest-southeast trending geologic cross-section ending on the coast at 45° 05', they also show the Siletz River Volcanic Series at the coast to be at a depth of about 16,000 feet and dipping steeply seaward.

Our geophysical data give no indication of an oceanic extension of this series between Cape Perpetua and 45° 05', but lines of correlation IIm (figs. 1 and 5) intersect the coast very near the northern point and seem to indicate oceanic extension of the steeply dipping Siletz Series. However, even though the character of the anomalous magnetic field in region II does not lend itself to anomaly-source depth calculations, the high frequencies in profiles 2m and 3m (fig. 3) imply a source much shallower than 16,000 feet. Since Bromery and Snavely's cross-section strongly suggests oceanic extension of the Siletz River Volcanic Series at 45° 05', we must look closely at our data to determine whether or not this is actually the case. We see from figure 3 that the section of profile 1m which determines correlation lines IIm is a broad positive anomaly with high frequency anomalies superimposed. If this profile were made at sea level, instead of from a flight elevation of 4000 feet, the superimposed anomalies would be of a much higher frequency and the broad anomaly would change very little. It is also apparent from figure 3 that profiles 2m and 3m consist of broad, positive anomalies with higher frequency anomalies superimposed. We postulate oceanic extension of both the Siletz River Volcanic Series and the relatively thin and shallow late Eocene volcanics which are shown exposed in figure 5. The latter probably cause the superimposed high frequency anomalies while the former probably causes the broad positive anomaly of profiles 1m, 2m, and 3m in figure 3. Correlation lines IIm (fig. 1) then indicate that parts of these formations extend to the northwest under the ocean floor, their anomalous magnetic expression being no longer evident past the western ends of these correlation lines. Although the magnetic correlation is quite strong (fig. 3), no strong gravity correlation exists (fig. 4). This situation could result from a susceptibility contrast without an accompanying density contrast.

Two additional regions of correlation are shown in figs. 1 and 5 (IIIm and IVm). Here again no gravity correlation is evident (fig. 4). No theoretical cross-sections or magnetic-anomaly-source depths are available for these areas, but the abundant surface expression of early to middle Eocene volcanics (Tillamook Volcanic Series) in the vicinity of IIIm (fig. 5) suggests a possible seaward extension of this series. Lines IVm show positive correlation of anomalies from land to sea, and the high magnetic gradients of these anomalies indicate a relatively shallow source depth. These anomalies could result from a seaward extension of the Tillamook Series and/or the exposed basalt flows and breccias in this region.

It is evident from figs. 3 and 4 that susceptibility contrasts are more pronounced and offer a better correlation parameter than density contrasts. If the Siletz River Volcanic Series terminates and if a density contrast exists between it and the adjoining rock, then the lateral boundary of this series should be evidenced by a step-like gravity anomaly. Between 44°17' and 45°54' we find no such anomaly to exist. This absence of a step-like gravity anomaly may indicate that the Siletz River Volcanic Series and the Tillamook Volcanic Series form a continuous series beneath the ocean floor in this area. Indeed, the correlation of magnetic anomalies along IIm and IIIm may represent susceptibility contrasts within a continuous north-south unit.

Acknowledgments

We would like to thank Dr. Donald F. Heinrichs for his helpful comments and suggestions. The National Science Foundation and the Office of Naval Research sponsored this work under grants GP-2186, GP-5581 and contract Nonr 1286(10), project NR 083-102.

References

Agocs, W. B., Rollins, J. C., and Bangs, E., 1954, Airborne magnetometer profile from Portland, Oregon to Albuquerque, New Mexico: Geophysics, v. 19, p. 270-280.

Berg, J. W., Jr. and Thiruvathukal, J. V., 1967, Free-air gravity anomaly map of Oregon: State of Oregon Dept. Geology and Mineral Industries map GMS 4-a.

Bromery, R. W., and Snavely, P. D., Jr., 1964, Geologic interpretation of reconnaissance gravity and aeromagnetic surveys in northwestern Oregon: U.S. Geol. Survey Bull. 1181-N, 13 p.

Dehlinger, P., Rinehart, W. A., Couch, R. W., and Gemperle, M., 1967, Free-air gravity anomaly map west of Oregon: State of Oregon Dept. Geology and Mineral Industries map GMS 4-c.

Emilia, D. A., Berg, J. W., Jr., and Bales, W. E., 1966, A magnetic survey off the Pacific Northwest coast: The ORE BIN, v. 28, no. 12, p. 205-210.

Emilia, D. A., Berg, J. W., Jr., and Bales, W. E. [in press], Magnetic

anomalies off the northwest coast of the United States: Geol. Soc. America Bull.
Whitcomb, J. H., 1965, Marine geophysical studies offshore - Newport, Oregon: Oregon State Univ. master's thesis, 51 p.

* * * * *

DETERMINATION OF SURFACE RIGHTS CONTINUES

The determination of surface rights for mining claims under provisions of Public Law 167, which contains the "multiple use" concept, is still continuing. The Bureau of Land Management last year examined 386,059 acres in Oregon. The Bureau has completed work on a total of 1,920,587 acres since passage of Public Law 167 on July 23, 1955. A summary of the Bureau's activities with respect to mining claims, and mining leases, permits, and licenses appears in the box. Areas currently under examination or soon to be examined by the Bureau include the following:

Township	Range	Township	Range
11 S.	3 E.	11 S.	4 E.
12 S.	3 E.	22 S.	1 W.
22 S.	2 W.	22 S.	3 W.
23 S.	2 W.	23 S.	3 W.
37 S.	32-3/4 E.	37 S.	33 E.
38 S.	34 E.	39 S.	34 E.
41 S.	34 E.	39 S.	35 E.
40 S.	35 E.	41 S.	35 E.
41 S.	39 E.	13 S.	40 E.
17 S.	41 E.	40 S.	42 E.

Item	Oregon FY 1966	Oregon FY 1967
Mineral patents issued-----	1	1
Mineral permits & licenses-	2	--
Mineral leases------------	39	6
P.L. 167 determinations completed, acres-------	125,077	386,059
Cumulative determinations, acres-----------------	1,534,528	1,920,587
Claims retaining surface rights, number-----------	95	99
acres------------	1,900	1,980
Percent of mineralized area on which P.L. 167 action is completed----	45	56

Mining claimants holding claims in the above areas who are not familiar with the rules and regulations regarding determinations under Public Law 167 should request this information from the Bureau of Land Management. Announcements of specific areas to be investigated are published in the official county newspapers for the areas in question.

* * * * *

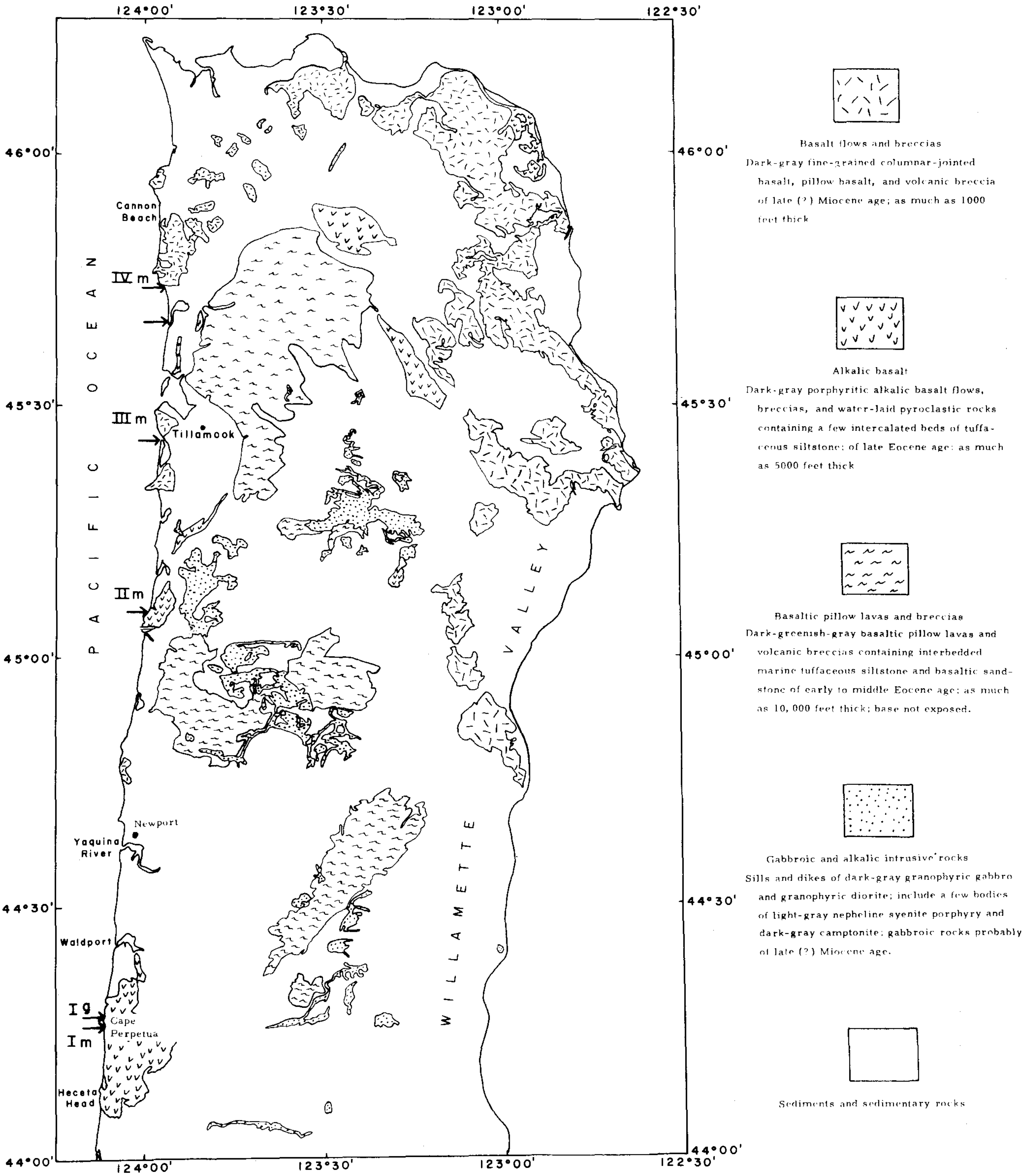
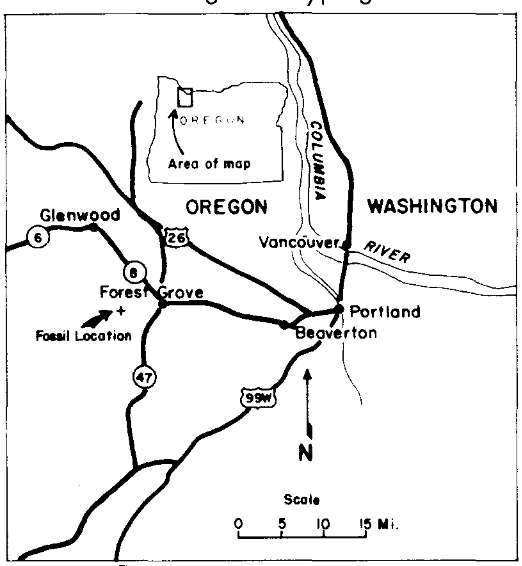


Figure 5. Land geology map of the area of interest. Adapted from Bromery and Snavely (1964). Arrows indicate where the magnetic and gravity correlation lines cross the coast.

A LARGE FOSSIL SAND SHARK OF THE GENUS <u>ODONTASPIS</u> FROM OREGON

By Shelton P. Applegate*

An association of numerous preserved hard parts of a single fossil shark are only rarely encountered in the Cenozoic marine beds. Therefore, we were quite excited when a package arrived from the Oregon Department of Geology and Mineral Industries which contained not only fossil invertebrates and fish scales but remains which from their similar size and close occurrence must have come from a single individual shark. The fossils in question were collected by geologists with the Oregon Department who also provided the geologic summary quoted below. Acknowledgment is made to the following members of the Museum staff: to Anita Daugherty for her assistance in editing the manuscript, to Pearl Hanback for the fine illustrations, and to Dorothea Barger for typing the manuscript.



The fossils occurred in a blackish gray marine shale associated with small pelecypods and gastropods. A few plant fragments were also present, as well as a number of bony fish scales and a pair of fish-ear bones (otoliths). In cross section some of the sediment showed foraminifera.

The following description of the fossil site was provided by the Oregon Department of Geology and Mineral Industries:

"The locality is in the bed of Scoggin Creek about 40 miles by road west of Portland and about 5 airline miles southwest of Forest Grove (see index map). The rocks containing the fossil shark remains belong to the Yamhill Formation, which crops out in a north-trending belt about a mile wide. Here the formation is composed of about 2000 feet of siltstone and thin-bedded black shale which weathers to a yellowish color. The beds dip to the southeast from 7° to 15° and are well exposed in the

---

*Associate Curator, Vertebrate Paleontology, Los Angeles County Museum of Natural History.

creek bed at time of low water.

"The sediments have been dated as late Eocene from microfauna by W. W. Rau (written communication, 1962), who states that the foraminiferal assemblage is diagnostic of the Narizian stage of Mallory, A-2 zone of Laiming, and typical of that found at the type locality of the Yamhill Formation along Mill Creek about 30 miles to the south.

"The Yamhill Formation lies between older Eocene marine sediments and associated volcanic rocks that make up the Coast Range to the west and sandstone of the Spencer Formation of later Eocene age to the east."

Since the conditions for preserving vertebrate fossils must have been excellent, the abundance of this material gives us promise of finding other interesting vertebrate remains. Such a find as this is probably another indication of the rich undescribed fossil marine fish fauna that occurs along the Pacific Northwest. If more of these fossils are collected and described, we will know a great deal more about the history and distribution of fossil fishes.

The shark material consists of 22 vertebrae, one of which is shown in figure 3B. There are numerous patches of hollow cubes of calcified cartilage which form a mosaic (figure 3A is a sketch of such a patch in place); each cube is called a tessera. In living sharks these cubes make up the skull (chondocranium), jaws, and gill and fin supports (Applegate, 1967). Fossil tesserae are more often than not dissolved by ground water or at least detached, so that they are either missing or overlooked. The tesserae in this specimen appear to be similar to those which occur in the living sand-shark genus Odontaspis. The vertebrae in cross section (figure 3C) are of the typical lamnoid type, showing radial supports with branching similar to what is found in Recent Odontaspis. The illustrated vertebra is from the caudal region. Figure 1 shows a typical member of this genus Odontaspis taurus.

The most important part of these fossil remains is a single tooth (figures 2, A & B). By comparing this with those teeth in Recent sand-shark jaws, a method which I have discussed elsewhere (Applegate, 1965), it becomes apparent that the tooth is a second lower right anterior, or the

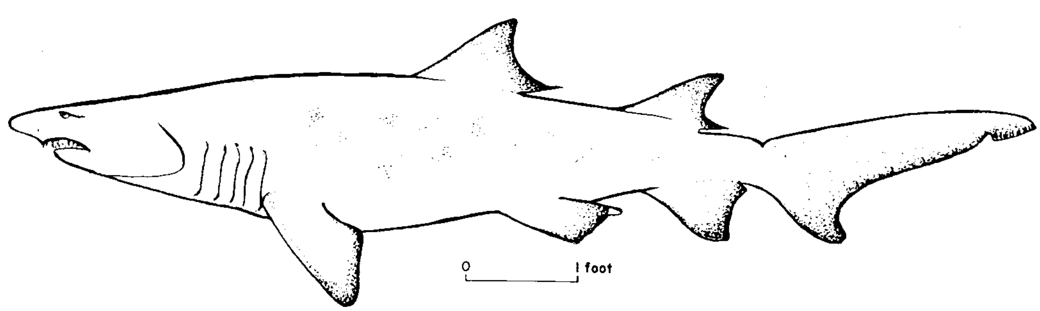


Figure 1. Drawings of the Recent Odontaspis taurus, which is related to the nine-foot Oregon sand shark.

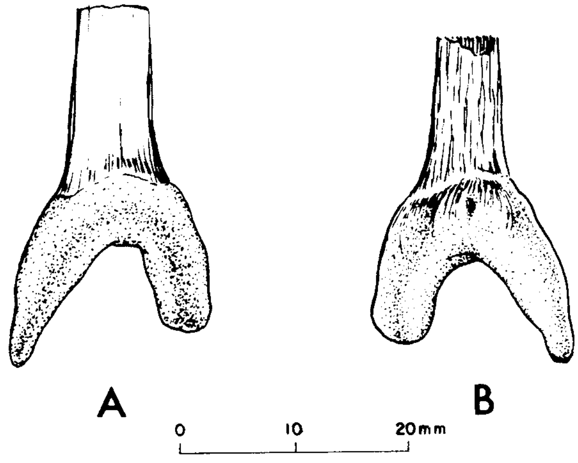


Figure 2. Two views of the shark tooth.

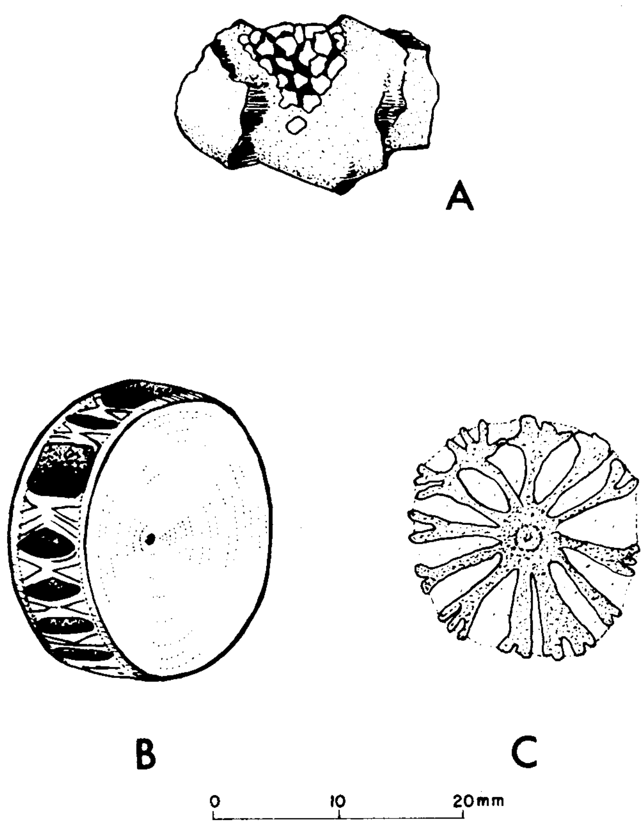


Figure 3. Vertebrae and cartilage of the sand shark.

third tooth from the center line. The greatest width of the tooth base is 17 mm. The height of the tooth is 28 mm., to which must be added a good portion of what is missing. A similar tooth from a female sand shark, (No. 12) (Applegate, 1965), had the following measurements: width 17 mm., height 34 mm. The total length of this shark was 273 cm., or approximately nine feet. The fossil shark might be assumed to have had a similar length.

On the inner surface of the crown the tooth has definite razed lines or striations (fig. 2). There is a tendency for some of these striations to be faint. Some branch, and others join together. Such striations are known from only a few species of fossil sand sharks.

Undoubted fossil odontaspids are known from the Cretaceous to the present. The Cretaceous genus *Scapanorhynchus*, related to the Recent deep-sea goblin shark *Mitsukurina*, has very strong, straight, well-defined striations on the inner crown surface; at least two species in *Scapanorhynchus* are close to *Odontaspis*, a situation that needs further investigation by the establishment of artificial tooth sets as suggested by Applegate, 1965. In the Paleocene at least three species of small odontaspids with striae occur: *Odontaspis substriata substriata*, *Odontaspis substriata atlasi*, and *Odontaspis whitei*. All three species have been found in the Midway near Fort Benton, Ark., L.A.C.M. Locality 6510. *O. whitei* and *substriata* are also known from the Paleocene of Africa, and from the beds that range from Thanetian to upper Ypresian age in Africa we find *O. substriata atlasi*. According to White, another species *Odontaspis striata* (his *O. macrota striata*) is characteristic of the early Eocene of England, while the most recent recognized striated species *O. macrota* is more characteristic of the late Eocene. Probably *O. whitei* or *O. substriata* is the ancestor of *O. striata* which in turn gives rise to *O. macrota*. The teeth of the Paleocene species are quite small, averaging around one-half inch or less in total length; those of *O. macrota* and *O. striata* are longer, more than one inch. Those of *O. macrota* are said to be the longer and thicker of the two. This general type of tooth occurs also in the Miocene, and is here interpreted as being from *O. macrota*. I believe that the Oregon tooth is also referable to *O. macrota*.

It is of special interest that the Recent sand shark *Odontaspis taurus* shows occasional striations on its crown. Since the *O. macrota* type of tooth is close in many ways to those of *O. taurus*, it may be the ancestor of this modern form.

Fossil teeth of the *O. macrota*-*O. striata* type are known from Europe, Russia, Africa, New Zealand, and North America. They have been taken at the L.A.C.M. Locality 2024 called "Pipehill," in Baja California (Tepatate Formation, thought to be late Paleocene). Another example from the Pacific Coast is known from Trabuco Canyon, Orange County, Cal., where it was found in the topsoil: its age is not known, but it is probably Eocene or lower Miocene. A few small teeth of this complex are known from L.A.-C.M. Locality 1649, Tejon Formation, in the Santa Ynez Mountains, Cal.

In the eastern United States, Odontaspis cf. macrota is known from Miocene beds at New Bern, N.C.; near Charleston, S.C.; and near Wallmeyer Fish Camp, Va. Any or all of these teeth could represent reworking from underlying Eocene sediments.

The genus Odontaspis is rare in typical West Coast Miocene beds and the few that are known are referable to the O. ferox type. The only living sand shark in the eastern Pacific is Odontaspis ferox, reported by Daugherty (1964) on the basis of two specimens taken off California. This species is also represented in the L.A.C.M. collection by the jaw of a third specimen purchased by Mr. Donald Cocke in La Paz, Baja California. O. ferox is a deepwater shark with almost world-wide distribution in temperate waters, though most commonly taken in the Mediterranean. The tooth crowns of this shark are smooth, and the teeth quite different in shape and number of lateral denticles from the Oregon specimen.

If we may assume that O. macrota was the ancestor of O. taurus, it may have occupied a similar niche. The modern taurus is a comparatively sluggish fish-eating shark, capable of short bursts of speed. It is a bottom dweller, occurring in very shallow water from about 1 to 15 fathoms. It is known from the eastern United States, Brazil, Europe and the Mediterranean, South Africa, and perhaps Australia. Recently, the possibility of its occurring in Japan has been brought to my attention by Mr. Toru Taniuchi; yet there is no record of its having ever been taken in the eastern Pacific. If O. macrota had a similar distribution to that of O. taurus and similar teeth, and was the ancestor of taurus, we can at least theorize similar habits. The Pacific Eocene forms may have inhabited ancient shallows and bays which were lost during later mountain building. The fact that these coastal sharks seem to shun the tropics or very cold water plus the presence of the Isthmus of Panama may be what has kept the eastern Pacific free of this species since the Miocene. Certainly as we discover more fossils, our knowledge of these interesting sharks will become clearer. One should keep in mind that fossil fishes can tell us a great deal about past climates, currents, continental outlines, and the evolution of life.

Selected References

Applegate, S. P., 1965, Tooth terminology and variation in sharks with special reference to the sand shark, Carcharias taurus Rafinesque: Los Angeles County Museum Contrib. Sci. No. 86, p. 3-18.

__________, 1967, "Shark Hard Parts" from Johns Hopkins Press: Applegate Chapter entitled A Survey of Shark Hard Parts, p. 37-67, 2-1/2-7 text figs., plates 2-1/2-4.

Bigelow, H. B. and Schroeder, W. C., 1948, Sharks: in Fishes of the western North Atlantic. Sears Found. Mar. Res. Mem. 1, Part I, p. 59-576.

* * * * *

THE PORTLAND EARTHQUAKE OF JANUARY 27, 1968

By Donald F. Heinrichs and Leonard J. Pietrafesa
Department of Oceanography, Oregon State University

Introduction

The earthquake of January 27, 1968 occurred at 12:28 am., PST.; the epicenter was near the eastern edge of the city of Portland. This shock was the first sizeable disturbance in the immediate area since the damaging shock, and accompanying aftershocks, of November 5, 1962 (Dehlinger and Berg, 1962; Dehlinger and others, 1963). The estimated magnitude is 3.7, in contrast to a magnitude of 5 for the 1962 Portland earthquake. The depth of focus is between 20 and 24 km, similar to the estimate of 15 to 20 km for the 1962 shock.

The earthquake was recorded at a number of seismic stations, and the data are presently being analyzed. The detailed results from this shock will be reported at a later date, but sufficient information has been received to make several preliminary comments and conclusions.

Seismology

The epicenter and the origin time of a shock indicate the location on the earth's surface and the time of occurrence of the initial source motion. The depth of focus is the distance of the source below the surface. The direction of the initial source motion controls the directions of ground displacements resulting from the incident compressional wave at the receiving stations. The source is considered to be a fault in which the rupture travels along the fault surface for the duration of the shock. It is estimated from the seismograms of the shock that the source motion lasted no more than a few seconds.

The shock was recorded at the stations named in Table 1, with initial P-wave arrival times indicated by Pacific Standard Time. Not included in the table are later arrivals, compressional, shear, and surface waves, which were used to help determine the location of the epicenter and the depth of focus. We have studied only the records from Corvallis and Portland; the other times and motions have been received by letter or telephone.

Epicenter and origin time

From the known arrival times and the local travel-time curves prepared for the Pacific Northwest states (Dehlinger and others, 1965), the earthquake

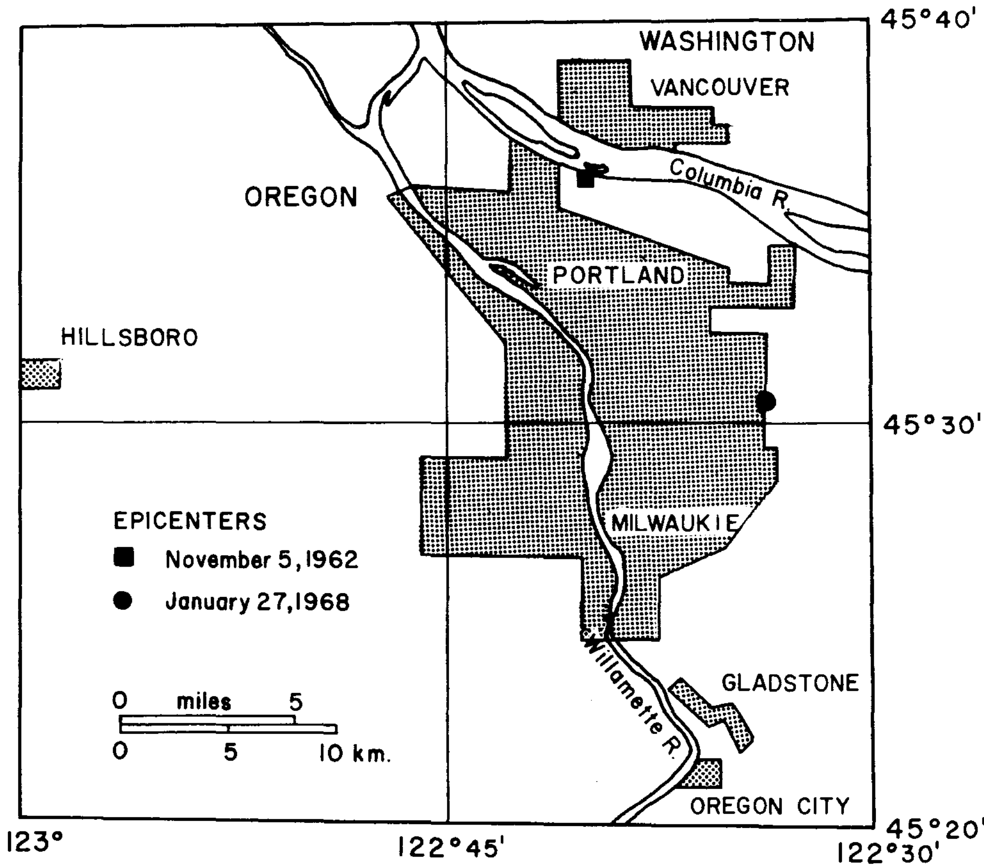


Figure 1. Base map of Portland area with earthquake epicenters.

Table 1. P Wave Arrival Times.

	hr.min.sec.
Portland (Oregon Museum of Science and Industry)	00:28:28.3
Corvallis, Ore.	00:28:43.3
Baker, Ore. (Blue Mt. Seis. Obs.)	00:29:22.3
Longmire, Wash.	00:28:45.4
Tumwater, Wash.	00:28:46.2
Seattle, Wash. (Marshall)	00:28:55.2
Spokane, Wash.	00:29:33.0
Newport, Wash.	00:29:36.0
Victoria, B. C.	00:28:51

epicenter was placed at latitude 45°30.5' N., 122°33.8' W., which is south of the Columbia River and near the eastern Portland city limits (figure 1). The shock origin time is estimated to be 0 hr. 28 min. 23.7

sec. a.m., PST, January 27. These values give a very good fit to the travel-time curves for the Corvallis, Baker, Tumwater, Spokane, and Victoria stations, except for an early shock origin time for Tumwater. Longmire, with a good seismic signal, and Newport and Seattle, with weak signals, exhibit some additional scatter. The seismic amplitudes were so large at the Portland station that only the initial P wave was observed; the later phases were obscured by excessive pen motion. This station was not used in the epicenter determinations.

Depth of focus

The depth of focus of the earthquake was between 20 and 24 km. Depth calculations were based on epicentral distances and travel times to the Portland, Corvallis, and Tumwater seismic stations. Focal depth calculations depend on the average seismic velocity of the crustal and subcrustal layers and are quite sensitive to small variations in velocity. Average velocities were chosen based on earlier work by Dehlinger and others (1963, 1965) and reflect the diverse local structures in the Northwest. Velocities of 6.1 km/sec and 7.67 km/sec to Corvallis give a focal depth of 19.2 km. Velocities of 6.4 km/sec and 7.9 km/sec to Tumwater give a depth of 20.3 km. The calculated shock origin time and an unpublished calculated velocity log for the Portland station give a depth of 24 km. The average velocities used in the above calculations are consistent with the arrival times on the travel-time curves.

Magnitude

The magnitude of the shock is estimated to be 3.7 on the Richter scale. Magnitudes according to this scale are based on ground amplitudes recorded at seismic stations. The scale ranges on a logarithmic scale from 0, the smallest recorded shocks, to 8 3/4, the largest and most destructive earthquakes (Richter, 1958, p. 340). The information for the magnitude estimate was supplied by the Blue Mountain Seismological Observatory at Baker, Ore., one of the most sensitive seismic stations in the world.

Source motion

The initial ground motion at Corvallis was down, south, and west; at Portland up (?) with the other two components not recorded. We do not have complete information from all the other seismic stations, but we do know whether the first motion was a dilatation or compression. All stations, except Baker and Portland, had a dilatation as a first motion. The observed initial ground motions are consistent with a right-lateral displacement along a northwesterly trending strike-slip fault. The first motions will fit equally well a northeasterly trending strike-slip fault with a left-lateral displacement. The data are not consistent with a predominantly vertical fault motion.

The faulting cannot be primarily normal or reverse; however, some vertical motion may have accompanied the strike-slip motion.

Discussion

The epicenter locations for both the 1968 and the 1962 Portland earthquakes are plotted in figure 1. This preliminary analysis and the more complete investigation of the 1962 earthquake (Dehlinger and others, 1963) show a striking similarity between the two shocks. The depth of focus and the first motions of displacement are the same. The two epicenters are located along a northwesterly trending zone, the same direction indicated by the observed first motions for a right-lateral strike-slip motion. Even though the present evidence (two shocks) is not conclusive, it appears likely that the two earthquakes have a common source. This source would be a northwesterly trending strike-slip fault, or fault zone, with right-lateral displacement. We do not wish to imply motion on any specific mapped surface faults in the area. The 15-20 km focal depths are well below the sedimentary section and the fault may not extend to the surface.

The seismic data will have to be analyzed in more detail before additional results on the source mechanism and the crustal structure can be determined. The earthquake data will be important in extending our knowledge of the seismicity of Oregon and adjacent regions.

Acknowledgments

The following people supplied arrival-time data and are gratefully acknowledged: Mr. H. Butler of the Blue Mountain Seismological Observatory; Dr. W. G. Milne of the Dominion Astrophysical Society, Victoria, B. C.; Mr. Normal Rasmussen of the University of Washington; Mr. Mark Castner of Gonzaga University; Mr. F. Brecken of the Oregon Museum of Science and Industry; and Mr. R. J. Brazee of the Environmental Science Services Administration, Rockville, Md.

References

Dehlinger, P., and Berg, J. W., Jr., 1962, The Portland earthquake of Nov. 5, 1962: The ORE BIN, v. 24, no. 11, p. 185-188.

Dehlinger, P., Bowen, R. G., Chiburis, E. F., and Westphal, W. H., 1963, Investigations of the earthquake of Nov. 5, 1962, north of Portland: The ORE BIN, v. 25, no. 4, p. 53-68.

Dehlinger, P., Chiburis, E. F., and Collver, M. M., 1965, Local travel-time curves and their geologic implications for the Pacific Northwest states: Seismol. Soc. Am. Bull., v. 55, no. 3, p. 587-607.

Richter, C. F., 1958, Elementary seismology: San Francisco, W. H. Freeman & Co., 768 p.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

2.	Progress report on Coos Bay coal field, 1938: F. W. Libbey	$ 0.15
8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller .	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel.	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin .	3.00
36.	(1st vol.) Five papers on Western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	(2nd vol.) Two papers on Western Oregon and Washington Tertiary foraminifera, 1949: Cushman, Stewart, and Stewart; and one paper on mollusca and microfauna, Wildcat coast section, Humboldt County, Calif., 1949: Stewart and Stewart	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
44.	Bibliography (2nd supplement) of geology and mineral resources of Oregon, 1953: Steere	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite Mining Dist., Grant County, Ore., 1959: Koch . .	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
55.	Quicksilver in Oregon, 1963: Brooks	3.50
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass . .	5.00
59.	Fifteenth biennial report of the State Geologist, 1964-1966	Free
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00

GEOLOGIC MAPS

Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . . .	0.40
Geologic map of the St. Helens quadrangle, 1945: Wilkinson, Lowry & Baldwin .	0.35
Geologic map of Kerby quadrangle, Oregon, 1948: Wells, Hotz, and Cater . .	0.80
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37) . .	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts . . .	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams . . .	1.00
GMS-1 - Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka . . .	1.50
GMS-2 - Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al. .	1.50
GMS-3 - Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka . .	1.50
Geologic map of Oregon west of 121st meridian (over the counter)	2.00
folded in envelope, $2.15; rolled in map tube, $2.50	
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set] flat . .	2.00
folded in envelope, $2.25; rolled in map tube, $2.50	

[Continued on back cover]

Printed by Duplicating Systems, Inc.

State of Oregon
Department of Geology & Mineral Industries
1069 State Office Bldg., Portland, Oregon 97201
POSTMASTER: Return Requested

The Ore Bin

SHORT PAPERS

2.	Industrial aluminum, a brief survey, 1940: Leslie L. Motz	$ 0.10
18.	Radioactive minerals the prospectors should know (2nd rev.), 1955: White and Schafer	0.30
19.	Brick and tile industry in Oregon, 1949: J.E. Allen and R.S. Mason .	0.20
20.	Glazes from Oregon volcanic glass, 1950: Charles W. F. Jacobs . . .	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Ralph S. Mason . . .	0.25
22.	Prelim. report on tungsten in Oregon, 1951: H.D. Wolfe & D.J. White .	0.35
23.	Oregon King Mine, Jefferson County, 1962: F.W.Libbey and R.E.Corcoran	1.00
24.	The Almeda Mine, Josephine County, Oregon, 1967: F. W. Libbey . .	2.00

MISCELLANEOUS PAPERS

2.	Key to Oregon mineral deposits map, 1951: Ralph S. Mason	0.15
3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (revised 1962)	1.00
5.	Oregon's gold placers (reprints), 1954	0.25
6.	Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . .	1.50
7.	Bibliography of theses on Oregon geology, 1959: H. G. Schlicker . .	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: M. Roberts	0.50
8.	Available well records of oil & gas exploration in Oregon, rev. 1963:Newton	0.50
10.	Articles on Recent volcanism in Oregon, 1965: (reprints, The ORE BIN) .	1.00

MISCELLANEOUS PUBLICATIONS

Oregon mineral deposits map (22 x 34 inches), rev. 1958	0.30
Oregon quicksilver localities map (22 x 34 inches) 1946	0.30
Landforms of Oregon: a physiographic sketch (17 x 22 inches), 1941	0.25
Index to topographic mapping in Oregon, 1961	Free
Index to published geologic mapping in Oregon, 1960	Free
Geologic time chart for Oregon, 1961	Free

OIL and GAS INVESTIGATIONS SERIES

1.	Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963: V. C. Newton, Jr., and R. E. Corcoran	2.50