

GEOMORPHOLOGY OF THE CONTINENTAL TERRACE
OFF THE CENTRAL COAST OF OREGON

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Introduction

The major submarine geomorphic features off the Oregon coast are the continental shelf, extending from low water to the first pronounced increase of slope to deeper water, and the continental slope, from the outer edge of the shelf to the decrease of slope at the edge of the abyssal plain (Figure 1). Together, these constitute the continental terrace. The terrace varies in width from more than 70 miles off Astoria to less than 40 miles ^{1/} off Cape Blanco, and extends to the 1,500- to 1,700-fathom^{2/} depths of the southward-deepening abyssal plain. Off the Columbia River, Astoria Canyon and Astoria Cone alter the shape of the continental terrace.

Astoria Canyon, the only major submarine canyon off the Oregon coast, heads 10 miles west of the mouth of the Columbia at a depth of 70 fathoms, and extends some 60 miles to a depth of 1000 fathoms, where its identity as a canyon is lost on Astoria Cone. It is somewhat serpentine in shape, is 4 miles wide where it crosses the edge of the continental shelf, and has an axial slope of about 2° near its head and 1° beyond the edge of the shelf.

Astoria Cone is a fan-shaped feature extending from 1000 fathoms along the continental slope to the abyssal plain at 1,500 fathoms, and covering an area of more than 3,500 square miles. It slopes about 0.5°, and is undoubtedly the result of deposition from turbidity currents which discharge from Astoria Canyon.

The continental shelf along the Oregon coast differs notably from the

^{1/} Statute miles will be used throughout this report.

^{2/} One fathom is a measure of depth equal to 6 feet.

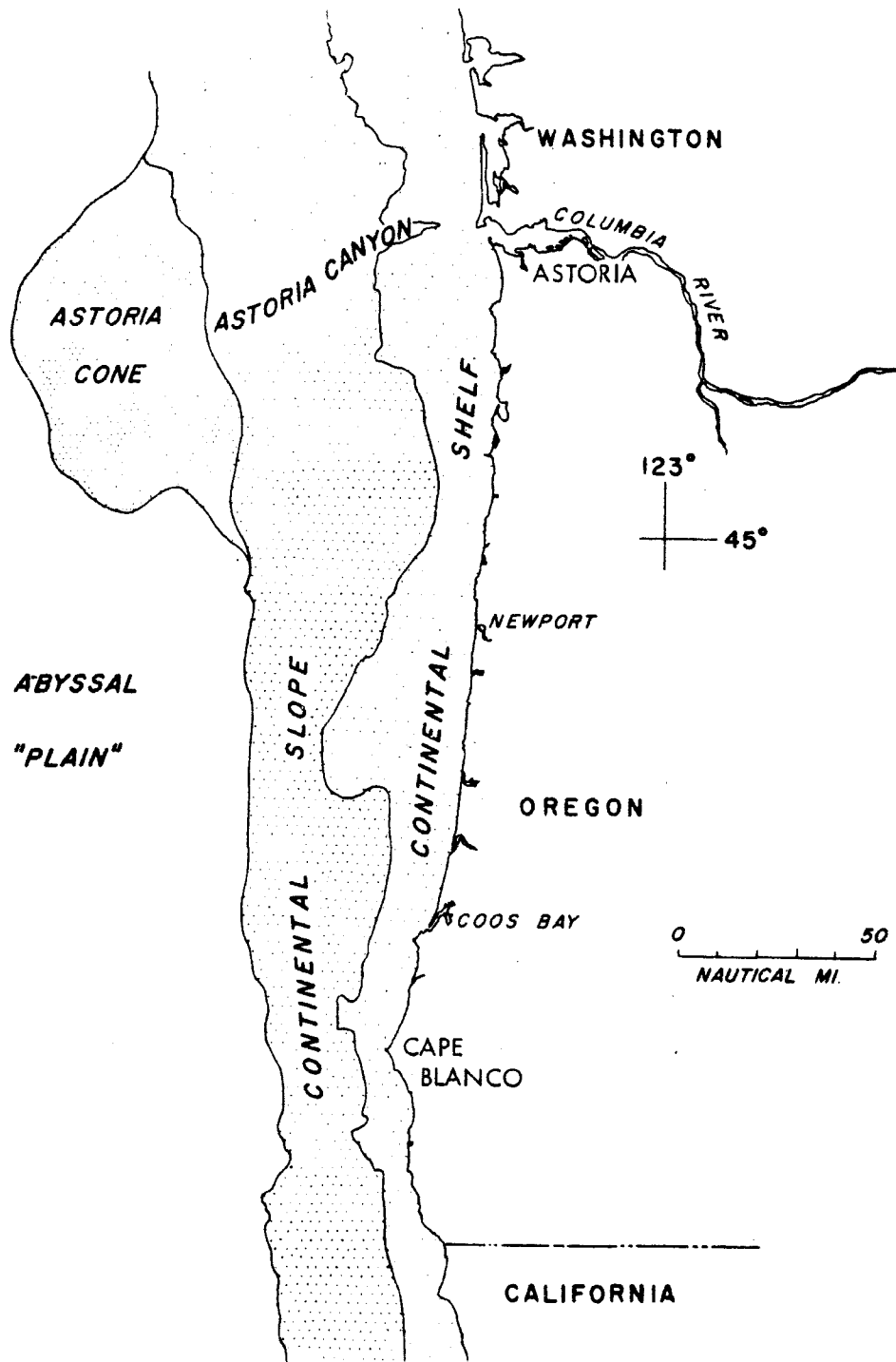


Figure 1. Index map of the submarine geomorphic features off Oregon.

average continental shelf. According to Shepard (1948, p. 143), shelves around the world have an average width of 42 miles, an average slope of $0^{\circ}07'$, and an average depth at the outer edge of 72 fathoms. The shelf along Oregon is 9 to 40 miles wide, slopes $0^{\circ}08'$ to $0^{\circ}43'$, and has a depth at its outer edge of 80 to 100 fathoms. Thus, the Oregon continental shelf is characteristically narrower, steeper, and deeper than the average continental shelf.

The Oregon continental slope, from the edge of the shelf to the abyssal plain, is 13 to 60 miles wide and, eliminating irregularities, has an inclination of from $1^{\circ}24'$ to $7^{\circ}18'$, with 2° to 3° the most common. In general, the slope is narrowest and steepest where the shelf is widest. Shepard (1948, p. 187) states that the typical continental slope averages $4^{\circ}17'$ for the first 1000 fathoms.

A bathymetric chart of the continental shelf and upper two-thirds of the continental slope (to a depth of 1000 fathoms) for the area between $43^{\circ}30'N.$ and $45^{\circ}00'N.$ has been prepared from unpublished soundings of the United States Coast and Geodetic Survey and Precision Depth Records obtained by the Oregon State University Research Vessel ACONA (see chart, Plate I, p. 72 - 73). The bathymetric detail represented on the chart is a function of sounding density and contour interval. On the shelf the sounding density varies from 15 to 20 soundings per square mile except in selected areas, such as Stonewall and Heceta Banks, where there are as many as 60 per square mile; the density is much less on the continental slope, 2 to 5 soundings per square mile. In order to show geomorphic detail of the continental shelf, a 10-fathom contour interval has been used to a depth of 100 fathoms; the interval is 50 fathoms for depths greater than 100 fathoms.

Continental Shelf

In the chart area the continental shelf widens from 16 miles at $45^{\circ}00'N.$ to a maximum of 40 miles at $44^{\circ}12.7'N.$ At approximately $43^{\circ}55'N.$ the shelf narrows abruptly to about 20 miles, and then narrows gradually to 15 miles at $43^{\circ}30'N.$ The depth of water at the edge of the shelf varies locally from 80 to 95 fathoms. The slope of the shelf averages $0^{\circ}09'$ to $0^{\circ}22'$, and is steepest where the shelf is narrow. The slope is generally greatest close to shore. The break in slope at the edge of the shelf is most pronounced in the central part of the area, particularly in the vicinity of Heceta Bank, and is least evident to the north and south (Figure 2).

Numerous shoals, which may be geologically related to the exceptional width of the shelf, characterize the Central Shelf Extension between

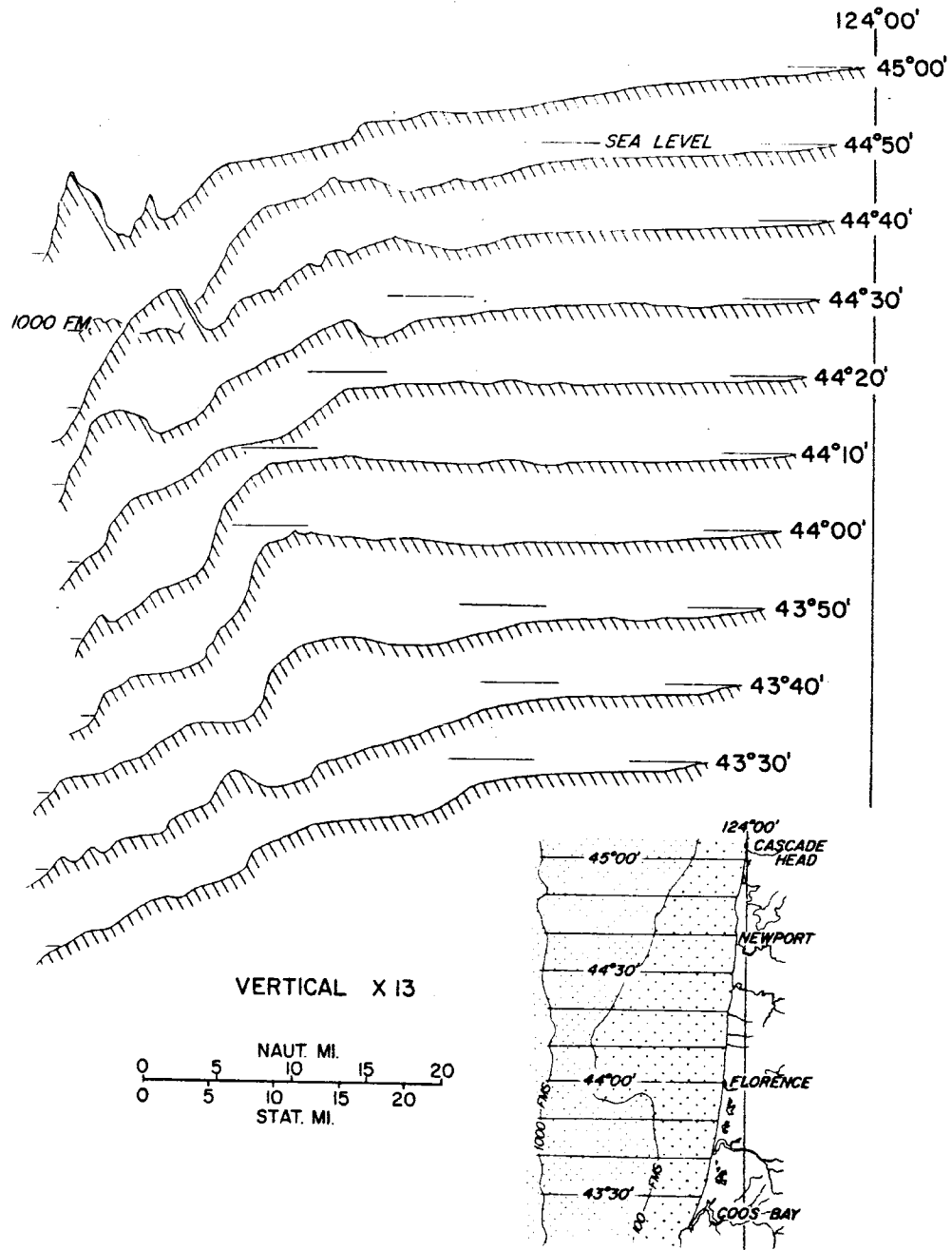


Figure 2. Profiles of the continental terrace from 43°30'N. to 45°00'N.

43°55'N. and 45°00'N. Of possible economic interest are the topographic highs Stonewall Bank, Heceta Bank, and the unnamed shoals lying between them.

Stonewall Bank

Stonewall Bank, located 17 miles southwest of Yaquina Bay, is a rise approximately 14 miles long and 9 miles wide, with 210 feet of relief, and with a crest in less than 20 fathoms of water. It consists of two high areas (delineated by the 30-fathom contour) separated by a shallow east-trending submarine valley. The bank, as outlined by the 40-fathom contour, trends N. 18°W.

Rocks have been collected from two places on the bank. At the northern end of the shoal (44°37.2'N., 124°26.4'W.) dense light-gray fossiliferous mudstone was dredged from about 46 fathoms of water. Dense gray siltstone or fine sandstone was taken from the southern part of the bank at 44°30.2'N., 124°22.6'W. The faunal content of the siltstone from the southern part of the bank was determined independently by the geologic research section of the Humble Oil & Refining Co. and by the western operating division of the Standard Oil Co. of California to be of Pliocene to Recent age. On the basis of these faunal analyses and the extreme induration of the rock, it is considered to be of Pliocene age.

Precision depth records which traverse the bank reveal an exceptional topographic symmetry. The presence of several ridges remarkably alike in shape and size on both sides of the shoal suggest that Stonewall Bank is the surface expression of a symmetrical fold, more likely an anticline than a syncline.

Heceta Bank

Heceta Bank, lying approximately 35 miles west of the mouth of the Siuslaw River, is a shoal area 25 miles long, 6 to 8 miles wide, and less than 60 fathoms deep. It has a total relief of 240 feet, and consists of two individual highs outlined by the 50-fathom curve. The southern part of the bank, which is 8.5 miles long and 3 miles wide, is asymmetrical (30 to 60 fathoms) with 2° to 3° slopes on the east side and slopes less than 1° on the west. The southern part of the bank, which appears to be offset from the northern part, is aligned with an escarpment to the southwest which trends N. 32° E. The alignment of the southern part of the bank with the escarpment and the lack of symmetry suggest the possible existence of a northeast-trending fault between the northern and southern

portions of the bank.

The northern part of Heceta Bank is more or less equidimensional and may be structurally related to the unnamed shoal to the northeast.

Although no rocks have been dredged by the ACONA from Heceta Bank itself, the published notations "hard brown clay" (U.S.C. & G.S. Chart 5802) at two positions on the southern part of the bank ($44^{\circ}01.5'N.$, $124^{\circ}52.3'W.$; $44^{\circ}03.0'N.$, $124^{\circ}51.3'W.$) are more than likely based on the collection of water-soaked shale or mudstone.

Other high areas

Other high areas on the shelf of possible geologic interest are the ridge southeast of Heceta Bank ($43^{\circ}57.5'N.$, $124^{\circ}40'W.$) and the unnamed shoal, outlined by the 60-fathom contour, 15 miles northwest of the mouth of the Umpqua River. The ridge southeast of Heceta Bank is 8 miles long, has 120 feet of relief on the northeast side, and is oriented $N. 35^{\circ}W.$ The unnamed shoal is 4 miles long, exhibits 90 feet of relief, and is oriented $N. 18^{\circ}W.$, the same orientation as Stonewall Bank.

No rocks have been dredged from the ridge or the unnamed shoal by the ACONA. However, grayish-brown mudstone was collected from the northwestern flank of the shoal lying between Heceta and Stonewall Banks ($44^{\circ}21.5'N.$, $124^{\circ}43.6'W.$). Other rocks collected from the shelf by the United States Bureau of Commercial Fisheries vessel JOHN N. COBB are described as "phosphatized siltstone or sandstone," from the low area east of the north end of Heceta Bank (about $44^{\circ}11.0'N.$, $124^{\circ}39.4'W.$); "light olive-gray siltstone," from water 75 to 100 fathoms deep west of the north end of Stonewall Bank (approximately $44^{\circ}34.5'N.$, $124^{\circ}32.5'W.$); and "olive-gray fine to medium sandstone," from the same area (approximately $44^{\circ}36.6'N.$, $124^{\circ}33.7'W.$) (Gerald A. Fowler, oral communication, 1961).

Continental Slope

The continental slope to a depth of 1000 fathoms has an average inclination of $1^{\circ}12'$ to $4^{\circ}18'$ in the chart area, and is generally steepest where the shelf is widest. Locally, a maximum slope of 40° is attained along a 600-foot high escarpment south of Heceta Bank ($43^{\circ}56.6'N.$, $124^{\circ}56.0'W.$). The escarpment west of Heceta Bank averages 16° for 1,500 feet, but slopes as much as 30° for vertical distances of 300 feet. With the exception of the previously mentioned "fault scarp" southwest of

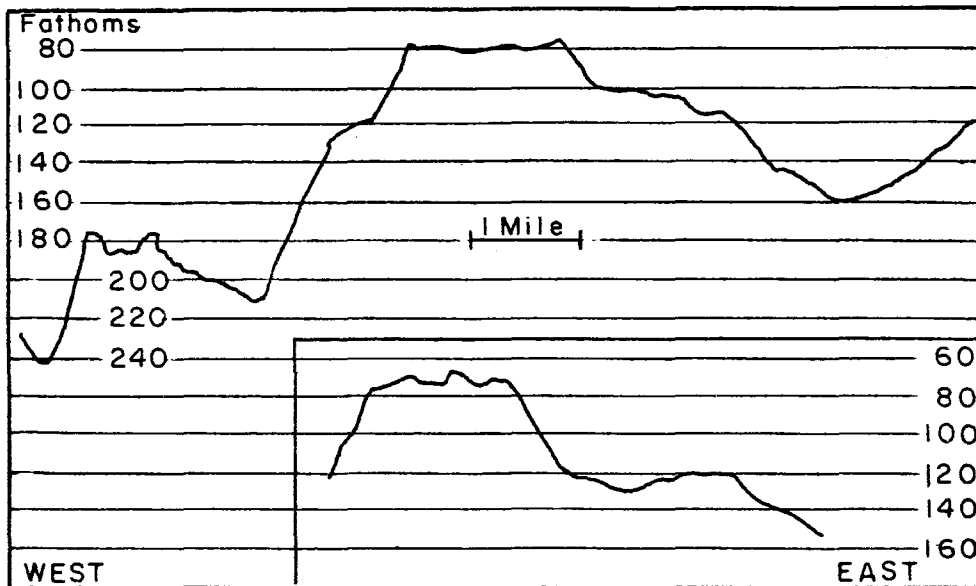


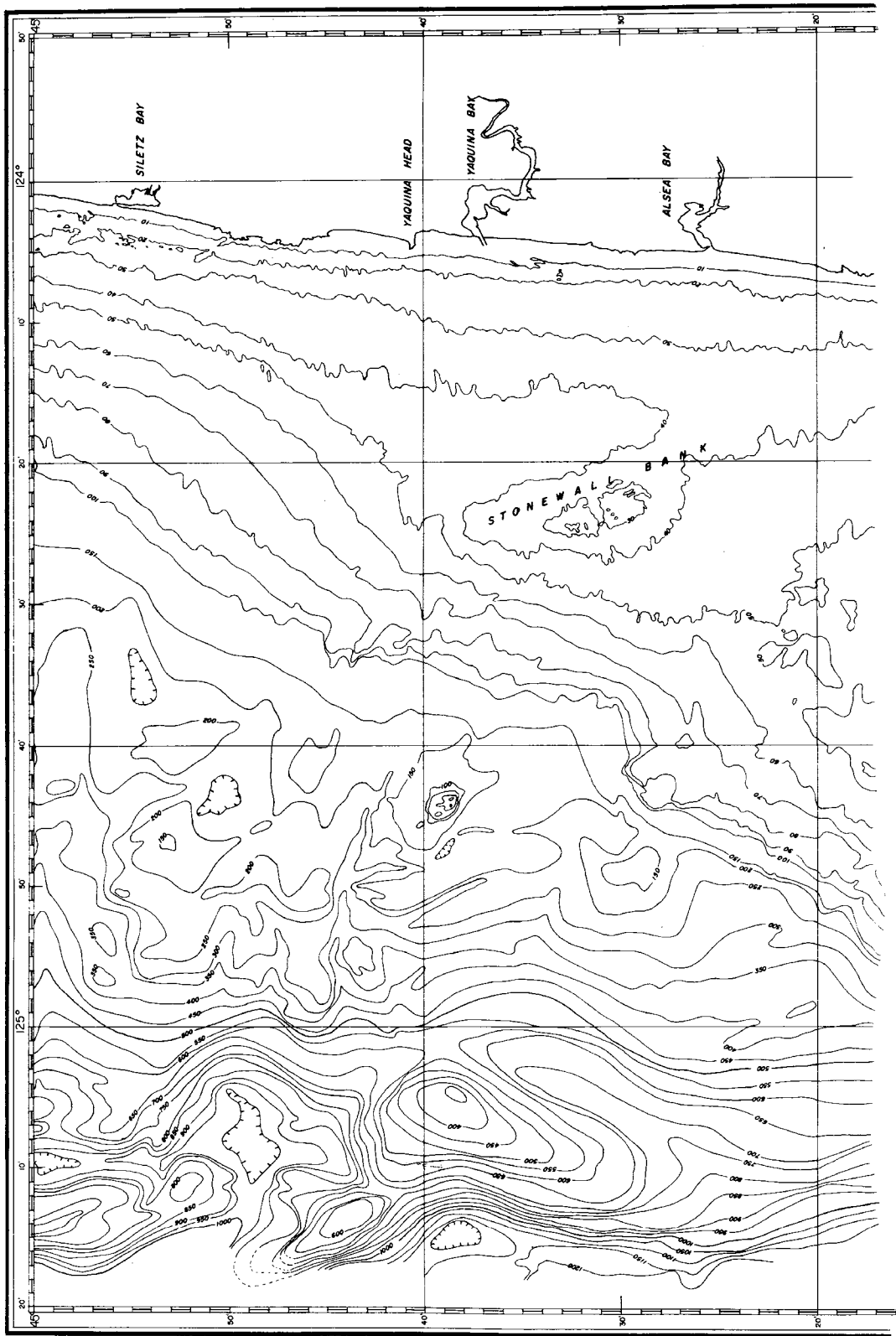
Figure 3. Precision Depth Records across the truncated seamount near the edge of the continental shelf west of Yaquina Head ($44^{\circ}39'N.$, $124^{\circ}44'W.$)

Heceta Bank, the Heceta Bank escarpment strikes north and is undoubtedly a structural feature.

South of Heceta Bank the continental slope is fairly gradual, and in the vicinity of $43^{\circ}40'N.$ is characterized by a series of isolated hills. A broad trough evident below 450 fathoms opposite the Umpqua River is aligned $N. 30^{\circ}W.$ with a hill having 600 feet of relief ($43^{\circ}35'N.$, $124^{\circ}48'W.$) and with a submarine canyon northeast of the hill. This alignment may also be structurally controlled.

North of Heceta Bank the continental slope is dominated by numerous hills and small seamounts, one-half to 6 miles wide, up to 1,800 feet high on the landward side, and with side slopes as high as 10° . The maximum relief of any of the hills shown on the chart occurs on the seaward side of the seamount at $44^{\circ}38'N.$, $125^{\circ}05'W.$ This hill drops a total of 5,352 feet, from 322 fathoms to 1,214 fathoms, in a distance of 8 miles. (See section $44^{\circ}40'N.$ on Figure 2.)

The small seamount near the edge of the shelf opposite Yaquina Head is of some interest, since it is the only one which extends into water less than 100 fathoms deep (Figure 3). The flat top of this hill is clearly the result of truncation by wave action in shallow water. Such erosion most



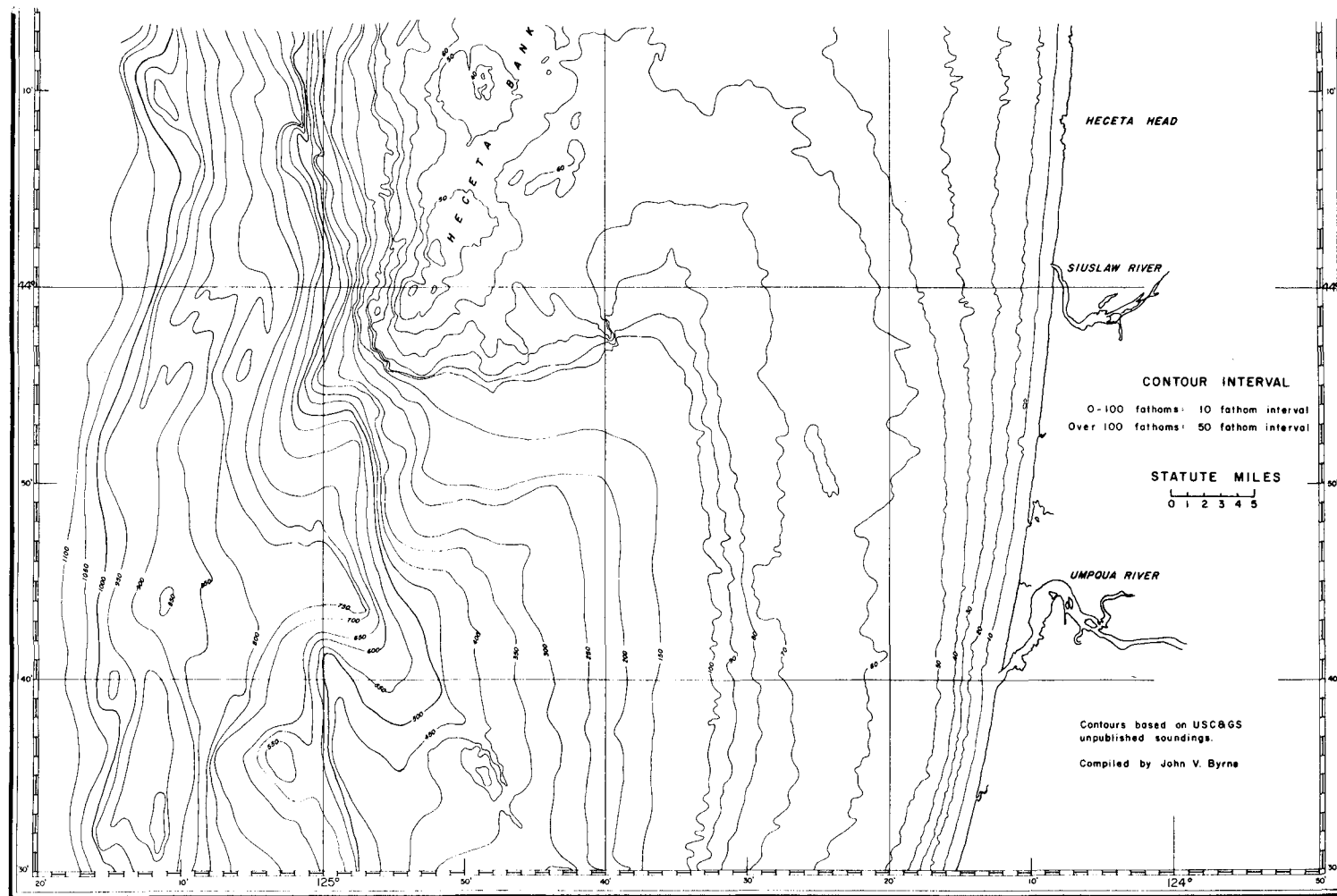


Plate 1. Bathymetric chart of the continental terrace off central Oregon, 43°30'N. to 45°00'N. and offshore to 1000 fathoms.

likely took place during the most recent Pleistocene lowering of sea level. The sides of this seamount are fairly symmetrical and slope about 5° . Phosphorite-coated limestone was dredged from the flat top, indicating that the seamount is nonvolcanic in origin. The symmetry of the sides and the rim along the top suggest that it is the surface expression of an anticlinal fold.

As erosion is relatively insignificant in deep water, most of the topographic features on the continental slope are primary and have been modified only by deposition. Thus, the hills on the continental slope must be of either volcanic or structural origin. To date, only sedimentary rocks have been collected from this small seamount province, indicating that the hills are structural features. Rocks taken from deep water in this area are: dense silty limestone, dredged from 235 fathoms of water at $44^{\circ}39.6'N.$, $124^{\circ}52.6'W.$; small fragments of shale, taken in 850 fathoms at $44^{\circ}27.6'N.$, $125^{\circ}14.2'W.$; and phosphorite-covered dense limestone, collected from approximately 1000 fathoms at $44^{\circ}21.0'N.$, $125^{\circ}14.3'W.$

Conclusions

On the basis of the general geomorphology of the continental shelf and slope, on the detailed character of the bottom determined from precision depth records, and on the distribution of sedimentary rocks it is concluded that in the area of the Central Shelf Extension (1) volcanic rocks are scarce if not absent in the vicinity of the submarine banks, hills, and seamounts, (2) a reasonably thick sedimentary section is present with rocks as young as Pliocene, and (3) fault and fold structures exist on both the continental shelf and continental slope.

Acknowledgement: This study was carried out under Office of Naval Research contract NONR 1926(02).

Reference

Shepard, F. P., 1948, *Submarine Geology*. Harper & Bros., New York, 348 p.

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A REPORT ON THE WILDERNESS BILL HEARINGS

The House Interior Subcommittee on Public Lands concluded public hearings May 7-11 on S. 174 and similar House bills to establish a "National Wilderness Preservation System" comprising some 14.6 million acres of national forest lands. Subcommittee Chairman Gracie Pfost, Idaho, has not announced when the Subcommittee will begin executive consideration of the measure.

As passed by the Senate, the bill would for all practical purposes exclude mineral exploration and development of lands now or hereafter included in the Wilderness System. American Mining Congress witnesses and others familiar with the mining industry made a strong case for continuation of the right to search for and mine any mineral deposits in these lands.

Interior Secretary Stewart L. Udall, in reiterating President Kennedy's support of the bill, deprecated the need to provide for mineral development. "Although the physical potential for future discoveries is reported by mineral resource experts to be fairly high in certain of these areas," the Secretary said, "there were few producing mines in national forest wilderness areas in 1960. The vigorous application of new discovery and processing techniques is a more promising approach to meeting future mineral requirements than is reliance on wilderness areas." Udall's views were seconded by Agriculture Secretary Orville L. Freeman. The subcommittee also heard many conservation and wildlife spokesmen endorse S. 174.

Alan M. Bateman, Silliman professor emeritus of geology, Yale University, testified as an independent geologist concerned for many years with strategic mineral supplies and with the problems of exploration and development of mineral resources. He pointed out the lessons learned from domestic mineral shortages in World War II and Korea, the necessity for replacement of exhaustible minerals, the steps taken by government and nonprofit foundations to bolster and accelerate mineral development, and the fact that the wilderness areas are geologically the most favorable for discovery and development of new mines to maintain the Nation's mineral reserves. "I strongly urge that mineral prospecting and development be not excluded from the areas of S. 174," Bateman said, adding that "scattered pinpoints of any mining operations would in no way mitigate against wilderness areas."

Rep. Wayne N. Aspinall, Colo., chairman of the full Interior Committee, asked Bateman whether the prospecting and mining provisions of S. 174 would be of any use in the event of a war. Bateman replied that

it would "just be too late" -- the war would be over before the minerals could be developed. He emphasized the need for an incentive to prospecting and exploration through assurance that any mineral deposits found could be mined as a matter of right and without undue restrictions.

The next witness, Charles H. Behre, Jr., professor of geology, Columbia University, said he was opposed to the present form of S. 174 because "it does not take account of the fact that changes in technology may make hitherto unimportant minerals critically valuable." He described the various newer prospecting methods which make it possible to find ore bodies not detectable by older methods, and emphasized the extremely limited effect such prospecting has on the wilderness nature of the land. He noted that geophysical methods for prospecting -- using instruments that can be carried on foot or horseback or flown by helicopter or airplane -- are not destructive of the wilderness nature of the landscape.

Behre also pointed out that "there is a very appreciable time lag, usually two to 10 years, between finding an important deposit and working it. We cannot, therefore, defer the search until the moment we need the minerals, for instance, in time of war."

Dr. James Boyd, president, Copper Range Co., and a former director of the U.S. Bureau of Mines, testified as president of the Mining and Metallurgical Society of America. He used a map of the United States in showing that (1) mineral occurrences are confined to distinctive areas coextensive with present mountain ranges or those that have existed in the remote geological past, and (2) wilderness areas in the western States are coextensive with lands having a high potential for minerals. He urged that the mining laws continue to be operable in lands subject to S. 174, subject to reasonable regulations. "Responsible miners have no objection to having their activities regulated so long as the restrictions are reasonable, not prohibitive, and are promptly promulgated," he said.

W. Howard Gray, Reno, Nev., attorney and chairman of the AMC Public Lands Committee, and Roger H. McConnel, chief geologist, Bunker Hill Co., testified on behalf of the American Mining Congress. Gray referred to the Declaration of Policy adopted by the AMC at its Seattle Convention last fall, which states that "We believe that the public interest is best served by keeping the public domain open for the discovery and mining of minerals." He proposed that the Wilderness bill be amended to extend the mining laws to all of the areas embraced within S. 174 or any extension thereof, subject to "reasonable but not prohibitive" regulations relating to right of ingress and egress, rights-of-way for transmission lines, water lines, telephone lines, or rights-of-way for facilities necessary in mining and processing operations, and restoration as near as

practicable of the surface of the land disturbed in performing prospecting, location and discovery work as soon as these have served their purpose. He made it clear that the mining industry desires only to use the lands lying within the boundaries of the wilderness system for mining or processing operations and for uses reasonably incident thereto.

Gray suggested that consideration should be given to the fact that our increasing population will make greater demands on mineral resources which are, by their inherent nature, exhaustible. "As the present mineral and nonmineral mining properties continue to meet the enlarged demands of our increasing population," Gray declared, "the need must necessarily arise for the search and discovery, development, and mining of new resources to take the place of the old and exhausted mines; the fact of survival may well depend upon our metal and nonmetallic resources." He reemphasized the importance of the proposed wilderness areas as the most likely locations for finding and development of mineral resources.

McConnel told the subcommittee that S. 174 "is a spectacularly large land grant for the exclusive enjoyment of an extremely small minority of the recreation-seeking public. In total, this bill would set aside at least 45,000 square miles -- an area larger than Indiana, or Kentucky, or Ohio, or Virginia -- as the privileged playground of the very few."

McConnel referred to the recently published report of the Outdoor Recreation Resources Review Commission which, he said, "strongly suggests that wilderness users, though they appear to think of themselves as conservationists, are dedicated only to conservation of wilderness and clearly are not dedicated to the conservation of natural resources in general, or even to recreation in general."

As did other mining witnesses, he emphasized that the total new area that would conceivably be physically involved in significant mining activity is small -- especially small in comparison with the tens of thousands of square miles which, under S. 174, would be permanently set aside as wilderness. "The old mineral districts will not always continue producing," McConnel said. "They must be replaced by yet undiscovered districts, some of which must certainly exist in areas now either formally designated as primitive, wilderness, or just actually wilderness."

All five mining witnesses were extensively questioned by the subcommittee members, who evidenced real interest in the question of whether -- if the proposed legislation becomes law -- the land included in the wilderness system should remain open to mineral exploration and development.

A score of other spokesmen for natural-resource industries testified in opposition to the bill or in favor of amendments which would make these lands available for proper development of their resources. (American

Mining Congress Bulletin Service, May 17, 1962.)

Editor's note: All are again urged to convey their thoughts on this very important bill to their Congressman.

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CHROMITE BULLETIN AVAILABLE

The long awaited Bulletin 52, "Chromite Deposits of Southwestern Oregon," is now available. This publication is for sale at the Department offices for \$3.50, postpaid. The bulletin is the result of an intensive study on chromite in the southwestern part of the state by Department field geologist, Len Ramp, of Grants Pass.

The bulletin contains 176 pages, 30 figures, 22 plates (3 in pocket), 16 tables, and 73 references. Its three parts cover nature and origin of the deposits, descriptions of the main chromite producing areas, and geologic descriptions of the other occurrences. More than 250 separate chromite occurrences are described.

Deposits of chromite in southwestern Oregon occur as magmatic segregations along definite zones or horizons in sill-like ultramafic intrusions. Original chromite layers have been folded, distorted, and stretched out in large part during intrusion of partly consolidated magma. Further deformation has taken place during alteration of the rock to serpentine, resulting in a seemingly haphazard, scattered distribution of lens-shaped orebodies. Mapping of a complex folded pattern of peridotite and serpentine in the central Illinois River area helps interpret the distribution of the numerous chromite occurrences which lie in the upper portion of the intrusive.

Bodies of massive chromite as much as 20 feet thick and containing 5,000 tons have been mined at the Oregon Chrome Mine in Josephine County. Zones of banded disseminated ore as much as 14 feet thick occur in the area. The majority of other occurrences described are small. The ore bodies are discontinuous, but appear to extend to great depth.

Ores analyzed have a wide range of chemical composition from metallurgical grade to refractory grade but average about 45 percent Cr_2O_3 with a 2.6 Cr-Fe ratio. In 18 years of production from 1917 to 1948 a total of about 117,500 long tons of metallurgical grade chromite valued at about $5\frac{1}{2}$ million dollars has been produced in the area studied.

The best guide to prospecting and development is knowledge of the position and trend of chromite ore zones in an area. A summary of geophysical and geochemical prospecting methods shows some promise in their application to chromite in southwestern Oregon.

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COMING EVENTS CAST THEIR SHADOWS...

"Bureau of Land Management field employees from Oregon and Washington are in attendance this week at a school on trespass prevention at the BLM office at 710 NE Holladay St.

"The school is conducted by the regional office of BLM and is designed to bring BLM men up to date on the latest investigative techniques and methods of collecting and presenting evidence in cases of unlawful use of public lands, according to a BLM spokesman.

"The BLM investigated and closed 308 cases of trespass on public lands in 1961, noted the spokesman. Damages from these cases amounted to more than \$97,000 he said." (Press release appearing in THE OREGONIAN, Thursday, May 17, 1962.)

Based on announced policies appearing in official Bureau of Land Management publications, miners can view the above meeting as boding them no good.

The BLM publication, "Our Public Lands," for January 1962 states "All should avoid trespassing on public lands. Going onto public lands and using them for hunting, fishing, and camping isn't trespassing. But going onto public lands without permission and building a house on the land - that is trespassing." (Emphasis not supplied.) Also in "The BLM at Work in Oregon and Washington - 1961," the Bureau states "The mining laws allow a miner to live on his claim when this is necessary for the prudent development of the claim. The wild character of the Pacific Northwest fifty years ago required a miner to live near his work for efficient operation and for the protection of his equipment. Today, a miner can often live in a nearby town and commute to his mining operation. Where this is possible, residence on the claim is unnecessary and seldom desirable since a residence could conflict with the uses of surface resources."

Contrast these statements with the following excerpts from the mining law: "All valuable mineral deposits in lands belonging to the United States shall be free and open to exploration and purchase and the lands in which they are found to occupation and purchase by citizens of the United States." (Emphasis supplied.) And "The locators of all locations on any vein shall have the exclusive right of possession and enjoyment of the surface included within the lines of their locations." (Emphasis supplied.)

The recently passed Forest Service Multiple Use Act gave official sanction by Congress to the use of lands for "hunting, fishing, and camping."

There is no law, however, giving official sanction to these land uses on federal lands other than U.S. Forest Service lands. The right to "hunt, fish, and camp" is merely an implied right.

The Bureau of Land Management and their officers must recognize that the law giving mineral claim locators "exclusive right of possession and enjoyment of all the surface included within the lines of their locations" is a law of the land and should not be open to administrative frustration. There is nothing in this law regarding necessity or desirability of residence on the claim. It is hoped that the outcome of the recent meeting by the BLM field employes was made to stress this point and not to contrive some administrative procedure to obviate the law.

Hollis M. Dole, Director

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GROUND WATER IN COLUMBIA RIVER BASALT

A recent publication of the U.S. Geological Survey is Professional Paper 383-A, "Storage of ground water behind subsurface dams in the Columbia River Basalt, Washington, Oregon, and Idaho," by R.C. Newcomb. The 15-page report, which includes several geologic and structure maps, may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., for 20 cents.

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OIL TEST PERMIT GRANTED

Reserve Oil & Gas Co. of San Francisco was issued drilling permit no.46 by the Department on May 21, 1962. The company plans to drill at a site 2 miles east of Lebanon. This is about 3 miles southwest of the Barr property, where Linn County Oil Development Co. drilled in 1958 and reported shows of gas and oil.

The new well will be Reserve's second try in Oregon. The first hole drilled by the California organization, in northeastern Polk County, failed to find commercial amounts of oil or gas after reaching a depth of 5,549 feet. The official name for the present drilling will be Reserve Oil & Gas Co. "Esmond No. 1." Location is given as 1,194 feet north and 575 feet west of the south quarter corner of section 7, T. 12 S., R. 1 W., Linn County. Elevation according to the U.S. Geological Survey topographic map of the Lebanon quadrangle is 450 feet above sea level.

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