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FOSSIL SHARKS IN OREGON

Bruce J. Welton*

Approximately 21 species of sharks, skates, and rays are either indigenous to or occasionally visit the Oregon coast. The Blue Shark Prionace glauca, Soup-fin Shark Galeorhinus zyopterus, and the Dog-fish Shark Squalus acanthias commonly inhabit our coastal waters. These 21 species are represented by 16 genera, of which 10 genera are known from the fossil record in Oregon. The most common genus encountered is the Dog-fish Shark Squalus.

The sharks, skates, and rays, (all members of the Elasmobranchii) have a fossil record extending back into the Devonian period, but many major groups became extinct before or during the Mesozoic. A rapid expansion in the number of new forms before the close of the Mesozoic gave rise to practically all the Holocene families living today. Paleozoic shark remains are not known from Oregon, but teeth of the Cretaceous genus Scapanorhynchus have been collected from the Hudspeth Formation near Mitchell, Oregon.

Recent work has shown that elasmobranch teeth occur in abundance west of the Cascades in marine Tertiary strata ranging in age from late Eocene to middle Miocene (Figures 1 and 2).

All members of the Elasmobranchii possess a cartilaginous endoskeleton which deteriorates rapidly upon death and is only rarely preserved in the fossil record. Only under exceptional conditions of preservation, usually in a highly reducing environment, will cranial or postcranial elements be fossilized. The hard outer enamel of all sharks teeth enables them to resist weathering and transportation prior to deposition. Considering this fact and also the fact that tooth progression and replacement in the elasmobranchs is a perpetual process which continually contributes teeth to nearby sediments, it is no wonder that teeth constitute almost 100 percent of all the shark material found in Oregon.

* Student, Department of Earth Sciences, Portland State University

Previous Work

Although elasmobranch faunas from the Tertiary of Oregon have never received extensive taxonomic treatment, their existence has, however, been noted by early workers, dating as far back as the mid-1800's. In 1849, J. D. Dana explored the Astoria Formation in search of vertebrates and was one of the first to recognize shark remains from Oregon.

Packard (1940), in describing a leatherback turtle, Psephophorus(?) oregonensis, commented on the occurrence of sharks teeth in the Astoria Formation at the mouth of Spencer Creek. Packard (1947) again noted the presence of sharks teeth in the Astoria Formation, but unfortunately this material was never described.

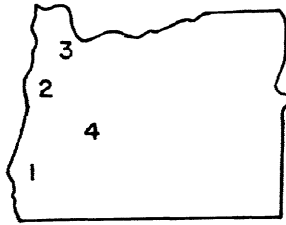
Steere, in a series of papers describing fossil collecting localities from the Tertiary marine sediments of western Oregon, mentions the occurrence of sharks teeth from the Cowlitz Formation (1957) and again in a later publication (1958, p. 58) states that "a few shark teeth have been collected from Oligocene marine sandstones of the Eugene Formation."

Sands of the Spencer Formation west of Monmouth, Oregon, have yielded an unusually high concentration of shark and ray teeth of late Eocene age. Schlicker (1962, p. 174) noted this concentration, stating that "Sharks teeth are abundant in a roadcut near the Luckiamute River just north of Helmick Park on U.S. Highway 99-W."

The first shark remains from Oregon to receive taxonomic treatment were collected from Scoggins Creek by members of the Oregon Department of Geology and Mineral Industries in 1967. Twenty-two vertebrae, one anterior tooth, and a few patches of calcified cartilage were collected from a well-bedded, fine-grained dark mudstone in the Yamhill Formation of Eocene Age. All of the specimens were forwarded for identification to Shelton P. Applegate, Associate Curator of Vertebrate Paleontology at the Los Angeles County Museum of Natural History. Shortly thereafter, an article appeared in The ORE BIN (Applegate, 1968) describing the dentition and skeletal elements as belonging to an Eocene Sand Shark Odontaspis macrota.

Hickman (1969, p. 104) described the occurrence of two sharks teeth in the Eugene Formation, south of Salem, Oregon. In her discussion she states, "Sharks teeth are occasionally found in the Eugene Formation. The teeth represent two major groups of sharks. The single cusps are typical of the modern galeoid type of shark (Hickman, 1969, pl. 14, fig. 12) and the saw-like teeth typical of the primitive hexanchoid genus Hexanchus (Notidanus) (Hickman, 1969, pl. 14, fig. 13). Both of these groups are abundantly represented by teeth in Tertiary marine deposits, although they are not well known from the Pacific Coast."

Specimens of the hexanchid sharks, Notorhynchus and Hexanchus, are relatively abundant in beds of lower Tertiary age in Oregon. Sharks of the genus Notorhynchus are known from sediments of Eocene and Oligocene



Locality map for stratigraphic sections

Epoch	Southern Coast Range (1)	Central Coast Range (2)	Northern Coast Range (3)	Southern Willamette Valley (4)
PLIOCENE	Port Orford			
	Empire Fm.			
MIOCENE		Astoria Fm.		
	Miocene Beds			
OLIGOCENE		Nye	Scappoose Fm.	
		Yaquina	Pittsburg Bluff Fm.	Eugene Fm.
	Tunnel Point Fm.	Upper Toledo Fm.	Keasey Fm.	
	Bastendorff			
EOCENE	Coaledo	Nestucca	Cowlitz Yamhill	Spencer

Figure 1. Correlation chart for geologic formations of western Oregon. Adapted from J. D. Beaulieu, 1971, p. 63.

age in northwestern Oregon, and early and middle Miocene beds of the central Oregon Coast Range have yielded teeth of the Six-gilled Shark Hexanchus. The first North American occurrence of the genus Heptranchias is represented by a single tooth collected from the Keasey Formation at Mist, Oregon.

Occurrence

Fine-grained black Cretaceous mudstones of the Hudspeth Formation crop out along numerous small exposures north of Mitchell in east-central Oregon. These sediments have yielded three teeth, the only Mesozoic shark teeth known at this time from Oregon. One of the teeth may be tentatively assigned to the common Cretaceous genus Scapanorhynchus. A more thorough search of these rocks will undoubtedly reveal an abundance of material.

Five upper Eocene formations in western Oregon have yielded elasmobranch remains, representing over 75 percent of all the Tertiary shark material known from Oregon.

The Yamhill Formation, cropping out along stream beds in Scoggins Valley, west of Forest Grove, Oregon, has yielded a disarticulated skeleton of the Eocene Sand Shark, Odontaspis macrota (Pl. 1, 3a, b) (Applegate, 1968). In association with this skeleton are five teeth of a yet undescribed species of echinorhinid or Spiney Shark (personal communication from Shelton P. Applegate). Apparently these teeth represent normal tooth loss during post-mortem scavenging by the Spiney Shark.

Coarse sandstones and fine-grained mudstones of the Coaledo Formation, exposed from Yokam Point south to Shore Acres State Park below Charleston, yield many teeth, usually included in biostromes of clastic shell material. Over 700 shark and ray teeth have been recovered from sediments at Shore Acres State Park. This assemblage is characterized by Odontaspis macrota, Squalus, and the Eagle Ray Myliobatis (Pl. 1, 8a, b, c). The abundance of myliobatid teeth at this locality far exceeds any other area in Oregon.

Sands of the Spencer Formation at Helmick Hill, 9 miles west of Monmouth, Oregon contain a single discontinuous lens of weathered limonite-stained pebbles and sharks teeth, not exceeding a foot in thickness. Disaggregation and screening of these sediments has yielded over 2,000 teeth, of which 95 percent belong to the Sand Shark Odontaspis macrota. Teeth of Squalus, Myliobatis, Isurus, the Angel Shark Squatina, and the Horn Shark Heterodontus (Pl. 1, 4c) are encountered.

Transport prior to deposition at the Helmick Hill locality has destroyed the roots and severely abraded most of the teeth. Weathering and leaching by groundwater have also contributed to tooth destruction. Lateral edges and crown points on most teeth are smooth and rounded, and lateral denticles have been broken off most of the odontaspids. Only by the sheer abundance of teeth is it possible to find a few specimens which still exhibit morphologic

Sharks	Yamhill Fm.	Coaledo Fm.	Cowlitz Fm.	Spencer Fm.	Nestucca Fm.	Keasey Fm.	Pittsburg Bluff Fm.	Scappoose Fm.	Nye Mudstone	Astoria Fm.	Miocene Beds at Cape Blanco
Carcharodon				X		X				X	
Centrophorus						X					
Centroscyrnus							X				
Echinorhinus	X										
Galeocerdo				X	X					X	
Galeorhinus		X									
Heptanchias						X					
Heterodontus		X		X							
Hexanchus									X	X	
Isurus		X	X	X	X	X			X	X	
Lamna		X	X	X	X	X			X	?	
Notorhynchus						X	X				
Odontaspis	X	X	X	X	X	X	X		X		
Pristiophorus			X			X	X		X		
Scyliorhinus		X									
Sphyrna				X							
Squalus		X	X	X	X		X		X		X
Squatina		X	X	X		X	X	X	X		
Rays											
Myliobatis		X	X	X					X	X	
Raja					X		X		X		
Rhinoptera		X									

Figure 2. Checklist of Tertiary Elasmobranchii from Oregon.

features suitable for description and identification. Unfortunately, less frequently occurring forms are usually quite abraded and classification beyond the generic level may be impossible for many. The probability also exists that these teeth were reworked from older underlying sediments.

Explanation of Plate 1

1. Notorhynchus sp. Agassiz (Seven-gilled Shark), Pittsburg Bluff Formation, Oligocene, lower left lateral tooth. X 2, PSU 13-17.
2. Hexanchus sp. Rafinesque (Six-gilled Shark), Nye Mudstone, lower lateral tooth. X 1.8, Taylor collection, Portland, Oregon.
3. Odontaspis macrota Agassiz (Sand Shark), Yamhill Formation, second lower right anterior tooth; a. lingual view, b. lateral view. X 1.5, PSU 13-24.
4. Heterodontus sp. Blainv. (Horn Shark), lateral pavement teeth, a. lateral view, b. dorsal view, both collected from the Quimper Sandstone, Washington; c. dorsal view of tooth collected from Spencer Formation, Oregon. X 2.5, PSU 13-18 and PSU 13-19.
5. Squatina sp. Valmont (Angel Shark), Nye Mudstone, a. Lateral view, b. labial view. X 1.7, PSU 13-23.
6. Pristiophorus sp. Muller and Henle (Saw Shark), Pittsburg Bluff Formation, rostral spine. X 1.7, PSU 13-22.
7. Squalus sp. Linne (Dog-fish Shark), Pittsburg Bluff Formation. X 4.2, PSU 13-21.
8. Myliobatis sp. Cuvier (Eagle Ray), Coaledo Formation, pavement tooth, medial row, a. ventral view showing roots, b. lateral view, c. dorsal view. X 2.2, PSU 13-20.

POPULAR PUBLICATIONS ON OREGON GEOLOGY

<u>Descriptions of Some Oregon Rocks and Minerals</u>		Miscellaneous paper no. 1 \$.40	_____
Non-technical descriptions of commonly found rocks and minerals.			
<u>Geologic Units:</u>	Geologic Formations of Western Oregon	Bulletin 70	2.00 _____
	Geologic Formations of Eastern Oregon	Bulletin 73	2.00 _____
Comprehensive references to formally named rock units in Oregon: description, distribution, contacts, lithology, age, references.			
<u>Geology of Selected Lava Tubes in the Bend Area, Oregon</u>		Bulletin 71	2.50 _____
More than 20 lava-tube caves in the Bend area are mapped, described, illustrated.			
<u>Geology of Selected State Parks</u>		Each pamphlet \$.25 Total	_____
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<u>Oregon's "Moon Country"</u>		Lunar Conference Guidebook - Bulletin 57	3.50 _____
Five trips - illustrated with maps, diagrams, photos - through the volcanic area of central Oregon used by lunar astronauts as geologic study area for walks on the moon.			
<u>Gold and Silver in Oregon</u>		Bulletin 61	5.00 _____
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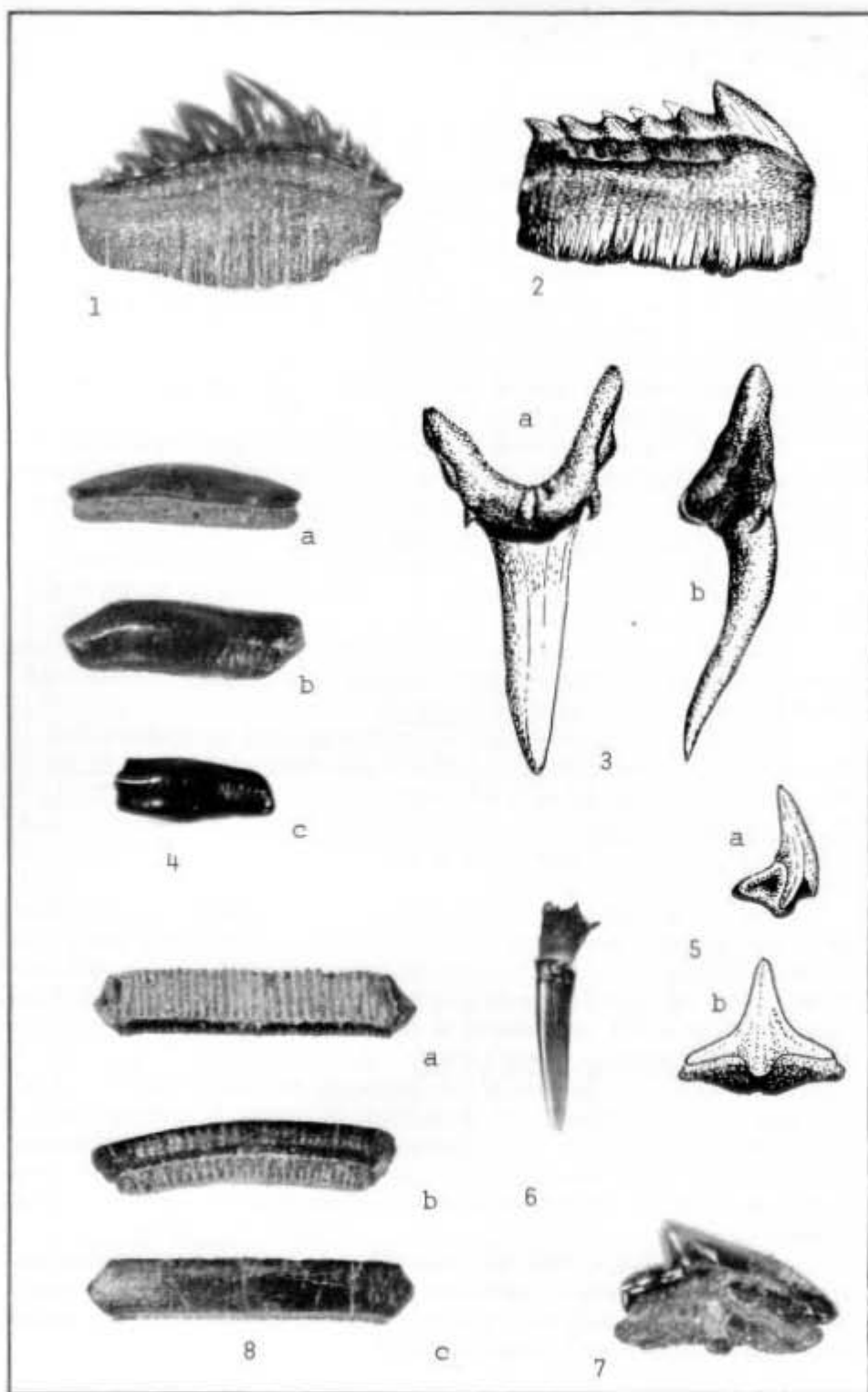
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Glaucinitic green sands of the Nestucca Formation at Toledo yield fair to poorly preserved teeth of the Mako Shark Isurus, the Tiger Shark Galeocerdo, and what appears to be small teeth of the skate Raja. Mammalian bone fragments and teleost remains have also been found.

A well-known Tertiary crinoid locality at Mist, Oregon has contributed a number of smaller sharks from sediments of the Keasey Formation of late Eocene to early Oligocene age. Aside from such forms as Squatina, Odontaspis, the Seven-gilled Shark Notorhynchus, and Centrophorus, a new species of Seven-gilled Shark Heptanchias is being described from this locality by the author. Elsewhere the Keasey sediments have yielded a large and well-preserved tooth of the White Shark Carcharodon, Saw Shark Pristiophorus, and the Mako Shark Isurus.

Coquina-like concretionary biostromes of clastic shell material which crop out along roadcuts in the lower sections of the Pittsburg Bluff Formation yield numerous teeth of a small squalid shark Centroscyrnus and not uncommonly teeth of Raja, Squatina, Odontaspis, Squalus, Pristiophorus (Pl. 1, 6), and Notorhynchus (Pl. 1, 1). These genera, plus several additional forms, collectively constitute the most diverse assemblage yet known from the middle Oligocene of Oregon.

Younger Oligo-Miocene sands of the Scappoose Formation, which conformably overlies the Pittsburg Bluff Formation, have produced teleost teeth and a fragmentary tooth crown of Squatina.

Underlying the Astoria Formation at Newport and south toward Seal Rock are found sediments of early Miocene age which are assigned to the Nye Mudstone. A Six-gilled Shark Hexanchus (Pl. 1, 2), Squalus (Pl. 1, 7), Pristiophorus, Squatina (Pl. 1, 5a, b), Odontaspis, and Isurus are found. This constitutes the only assemblage of early Miocene sharks yet known from Oregon.

The Miocene Astoria Formation has extensive exposure along the Oregon coast north of Newport, yet it has yielded only a few sharks teeth. This is quite surprising in light of the great abundance of teeth found in sediments of equivalent age from California and the Atlantic Coast of the United States. The assemblage at this time consists of the following: Carcharodon megalodon, Hexanchus, Myliobatis, Isurus planus?, and Galeocerdo cf. aduncas. In addition, Dr. E. M. Baldwin of the University of Oregon Department of Geology has in his possession a large tooth belonging to a Mako Shark, Isurus hastalis. This tooth was collected from sediments which were dredged up in Coos Bay and presumably are Miocene in age. Two Squalus teeth have also been collected from late Miocene sandstones immediately south of Cape Blanco, Oregon.

To my knowledge, teeth of sharks or rays have not yet been collected from Pliocene or Pleistocene sediments in Oregon. This is not to say that they do not exist but only that very little attention has been directed towards searching for shark teeth in these sediments.

Discussion

It is difficult to identify unassociated fossil sharks teeth; to do so requires a thorough understanding of the variability of tooth morphology among species of modern sharks and rays. Teeth may be individually examined for the presence or absence of the following general features: crown and root shape; position of nutrient canals; serrations on the crown and denticles; number of lateral denticles; tooth size; and flexures in the crown. Any number of these characteristics may require critical examination in order to segregate teeth of different species.

Variations in tooth morphology may be observed within the jaws of almost any modern shark or ray. Teeth of a single species may differ in the upper and lower jaw or laterally in a single tooth row. Tooth variation also occurs as a result of age and sexual dimorphism. In order to establish valid taxa when working with unassociated fossil teeth, it is necessary to construct entire tooth sets which define the total range of variation within the species. This technique has proven to be useful for the interpretation of large faunas in California and is presently being applied to Oregon sharks and rays.

The paucity of some of the faunas previously described is for the most part apparent rather than real. It is due to the nature and conditions of deposition of the sediments and does not accurately represent the characteristics of the actual biotic community. The physical conditions of sedimentation and biologically limiting factors in the environment directly influence the resultant fossil assemblage. Where active transport or agitation of sediments occurs during deposition, organic remains may be subjected to severe abrasion, often resulting in the accumulation of clastic shell debris and total destruction of all softer parts. Sorting of teeth may occur as a result of strong current action, and post-depositional leaching by ground water can destroy tooth dentine. The latter best describes the conditions which must have existed during the formation of the Helmick Hill shark tooth bed. Only rarely do Oregon localities yield nontransported shark material. However, excellent undisturbed faunas have been obtained from a few outcrops of the Coaledo, Nestucca, and Keasey Formations.

Summary

The purpose of this paper is to give some account of the fossil shark faunas of Oregon. This has been, at best, only introductory to the more than 5,000 specimens now being studied by the author. Many of the genera are listed in Figure 2, but species determinations have not yet been completed. In most instances, more than one species exists for each genus listed. Newly developed localities are continuing to yield more material, and it is hoped that each of the faunas mentioned herein will be treated in full at a later date.

Acknowledgments

Special thanks are expressed to Dr. Shelton P. Applegate, Los Angeles County Museum of Natural History, for the opportunity to study specimens of sharks at the Museum and for his assistance in the verification of the Oregon material.

I am also grateful to David Taylor of Portland, Oregon, the Oregon Museum of Science and Industry, and the State Department of Geology and Mineral Industries for making their collections of Tertiary sharks teeth available for this study.

Thanks are given to Dr. R. E. Thoms, Brian Gannon, Dr. Ronald Wolff, Margaret Steere, and Frank Kistner, who kindly read and criticized the manuscript. Photographic equipment was loaned by Larry Chitwood, and the manuscript was typed by Chris Lewis.

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* * * * *

GEOLOGY, KEY SCIENCE IN RESOURCE AND ENVIRONMENTAL PROBLEMS

Geological sciences are the key to understanding many of the problems related to resource development, land use, and the preservation of environmental quality, according to Dr. V. E. McKelvey, Director, U.S. Geological Survey, Department of the Interior.

In an address at Syracuse University, Syracuse, N.Y., McKelvey emphasized the urgency of advancing our knowledge about the earth and its resources. "In a physical sense," he said, "our life is dependent on the use we make of the earth and its resources."

"Between now and the end of the century," he said, "we will need to build a Second America in the sense that we have to duplicate the entire U.S. plant -- factories, homes, highways, and hard goods."

"We will need at least as much in the way of mineral and fuel resources in the next 28 years as we have used in all our previous history," the Survey Director warned, noting also that "if we do not conduct our activities in an environmentally safe manner, we could do as much harm to the environment as we have done previously. In some areas of environmental stress, this might well mean that we would destroy the suitability of our environment for human habitation."

"With our dependence on minerals and fuels," McKelvey said, "the consequences of failure to anticipate mineral shortages in time to make appropriate adjustments could well be catastrophic. And if, as some fear, potential resources are not adequate to support continued economic growth, considerable time would be required to bring about the economic and social changes necessary for our society to function at a far lower level of resource consumption without suffering economic collapse and perhaps social chaos."

Noting that many doubt that we can long continue our accelerating use of resources, McKelvey cited a study (conducted at M.I.T. under the sponsorship of the Club of Rome) concluding that world resources would be exhausted in less than 100 years if we continue our exponentially increasing consumption, and that consequent growth in pollution and environmental damage would be equally disastrous.

"While I find much to commend in this study," McKelvey said, "I do not share fully in the conclusions, partly because they substituted assumptions about the magnitude of resources for knowledge of the potential, and partly because they did not allow for the effects of exponentially accelerating knowledge and ingenuity in creating resources and controlling the effects of their production and use. Nevertheless, the study shows clearly that we will have to scramble to meet future needs, and to preserve the viability of our environment."

"In appraising these problems we need to substitute knowledge for the optimism or pessimism that is now the principal basis for speculation about man's future," McKelvey said.

* * * * *

COAST ENVIRONMENTAL GEOLOGY PUBLISHED

Engineering geologists, stratigraphers, and ground-water specialists have collaborated in preparing the Department's latest publication, Bulletin 74, "Environmental Geology of the Coastal Region of Tillamook and Clatsop Counties, Oregon." The authors are H. G. Schlicker, R. J. Deacon, J. D. Beaulieu, and G. W. Olcott.

The bulletin and accompanying maps are designed primarily for county officials, planners, engineers, and private citizens concerned with future construction and development appropriate to the geologic character of the region. In this part of Oregon, unstable bedrock, heavy rainfall, topographic extremes, and proximity to the ocean are inherent features that combine to produce geologic hazards such as landsliding, flooding, soft ground, wave erosion, and dune movement.

The 164-page publication is abundantly illustrated by photographs and charts. Eighteen full-color maps in a separate envelope illustrate engineering geology, geologic hazards, and degree of slope for each of six quadrangles. The report itself describes the geologic units, engineering characteristics of each unit, economic mineral resources, and geologic hazards. A summary and recommendations and a glossary of technical terms are also included. Quarry sites, water-well logs, and other pertinent data are given in the appendix.

Bulletin 74 and maps are for sale as a unit by the Oregon Dept. of Geology and Mineral Industries at its Portland office. The price is \$7.50.

* * * * *

DOLE OUTLINES GROWING RELIANCE ON MINERAL IMPORTS

Hollis M. Dole, Assistant Secretary of the Interior for Mineral Resources, recently outlined the degree to which the United States is becoming dependent on foreign supply sources for its mineral requirements. Speaking Oct. 3 at an AIME meeting, Dole said, "The gap between our supply and our demand (for minerals) has risen from \$2 billion in 1950 to \$8 billion in 1970 and is projected to increase to \$31 billion in 1985 and \$64 billion in the year 2000." He based these figures on Interior's first annual report under the Mining and Minerals Policy Act of 1970.

Among the problems that prevent the full potential of the nation's resources from being realized, Dole stated, are environmental constraints that have forced the closing of almost half the nation's zinc refining capacity; the loss of markets by coal which is unable to meet sulfur content limitations; the denial of access or withdrawal from development of mineralized lands; and competition from other nations for access to foreign supplies.

(American Mining Congress News Bull., Oct. 13, 1972)

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