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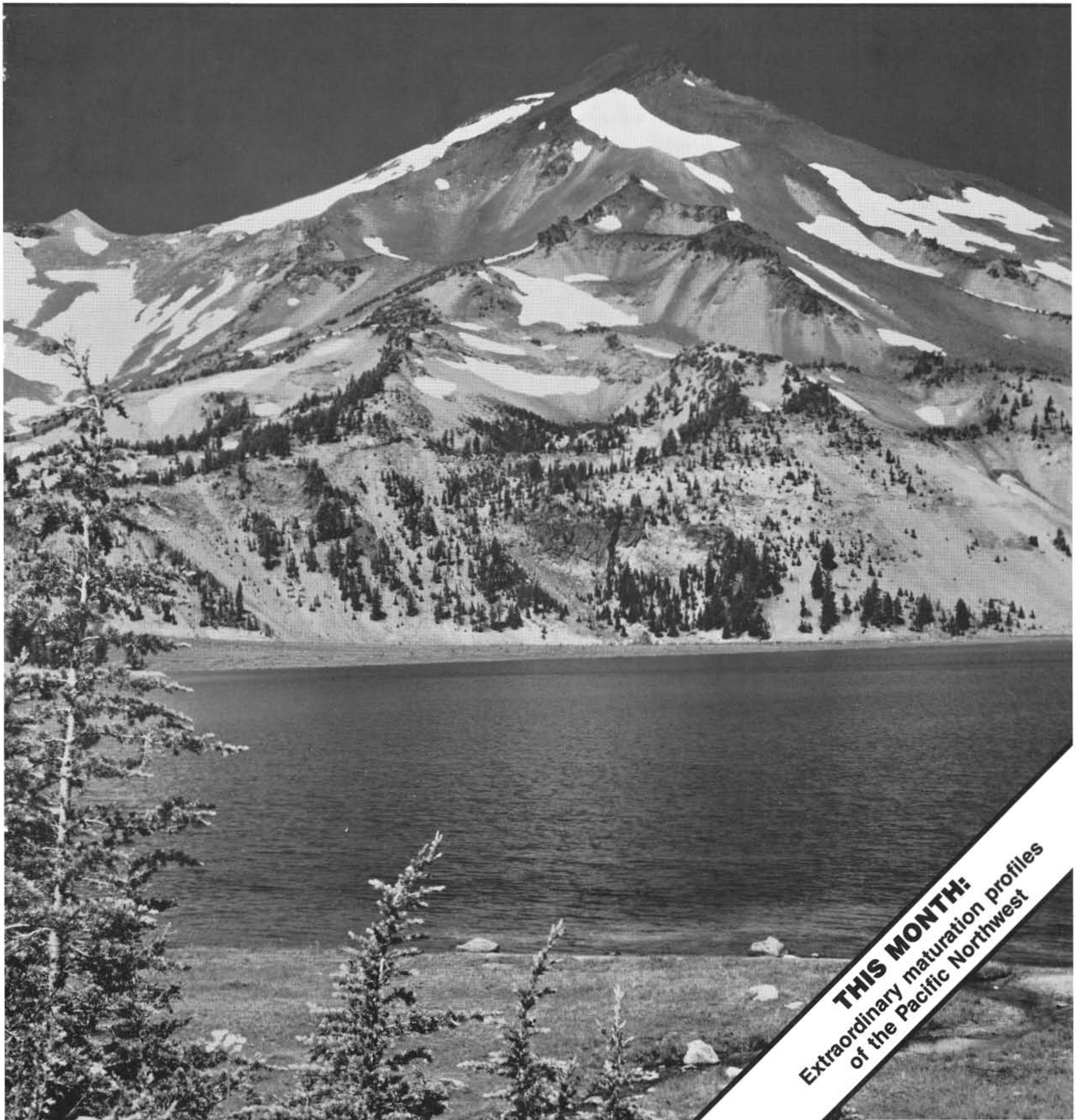

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Information for contributors

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

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

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

COVER PHOTO

South Sister, one of the Cascade volcanoes, as seen looking west across the Green Lakes basin. Article beginning on next page suggests that thermal fluids associated with this type of volcanism may have assisted in the maturation of sedimentary units with respect to oil and gas generation throughout the Pacific Northwest. Photo courtesy Oregon State Highway Division.

OIL AND GAS NEWS

ARCO remains active at Mist

ARCO has drilled the Columbia County 31-27-65 well to a total depth of 6,700 ft, which makes it a relatively rare test of the deeper sediments at Mist. Production casing was run on the well to a depth of 1,690 ft, and the well is currently suspended, awaiting completion. ARCO next drilled the Columbia County 31-34-65 well to a depth of 2,344 ft and has run production casing, and the well also is currently suspended, awaiting completion. ARCO is planning completion tests on both wells.

ARCO is currently drilling the Columbia County 34-4-65 well, the fifth well of ARCO's 1987 drilling program at Mist.

Damon plans conversion to water well

Damon Petroleum plans to convert its Stauffer Farms 35-1 well in Marion County to a water well. This well was abandoned in September 1987 after an unsuccessful attempt to reenter and deepen it. The well was erroneously listed in the October issue of *Oregon Geology* under permit number 397; the correct permit number is 358D. □

Republic, Wash., opens new fossil center

The town of Republic, Washington, hosted an open house at its new Stonerose Interpretive Center on August 18, 1987. Over 70 people attended the opening of this addition to the Republic town parks.

The Stonerose Interpretive Center is a small museum that houses a representative group of middle Eocene plant fossils and a few excellently preserved fish and insect fossils from the same strata as the Republic fossil flora. The Center is located adjacent to a major collecting site of the fossils it displays.

Important collections have been made here for a decade by Wes Wehr, Affiliate Curator of Paleobotany at the Burke Museum at the University of Washington, also by Kirk Johnson and Michael Spitz, with the help of several interested citizens of Republic. Wehr and Jack A. Wolfe, U.S. Geological Survey (USGS), recently completed a study of the Republic flora and published it in USGS Bulletin 1597 (1987).

Madilane Perry, Curator of the Stonerose Interpretive Center, explained that the town's recent acquisition of the fossil site was a major stimulus to create the Interpretive Center. She hopes the Center will bring a new attraction to this town of former gold-mining glory.

From November 20 until (probably) mid-May, the Center will be closed. However, Curator Perry will answer mail inquiries. For more information, contact Madilane Perry, Stonerose Interpretive Center, P.O. Box 987, Republic, WA 99166, phone (509) 775-2295; or the Republic Town Hall office, phone (509) 775-3216.

—Melvin S. Ashwill, Madras

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Beverly F. Vogt, Publications Manager

Extraordinary maturation profiles of the Pacific Northwest

by Neil S. Summer, Department of Geology, Hebrew University, Jerusalem, Israel; and Kenneth L. Verosub, Geology Department, University of California, Davis, CA 95616

ABSTRACT

Unusually steep maturation profiles from over thirty drill holes spread throughout the Pacific Northwest imply near-constant maturity with respect to oil and gas over thousands of feet of sediment. Given the consistency of the data, the widespread occurrence of this type of maturation anomaly must be inferred to be a real and systematic phenomenon. In addition, the diverse sources of data and the qualitative agreement among the major maturation indicators support the model of a real maturation process that may be unique to such a geologically active area. Examination of the stratigraphy and maturation profiles of individual drill holes in the Pacific Northwest leads to the conclusion that the dominant maturation process is related to hydrothermal fluids associated with volcanic activity. This hypothesis implies that the source of the gas in the Mist Gas Field, Columbia County, Oregon, may be located in intruded sediments to the northeast and northwest of the field. In addition, vitrinite reflectance data from the Pacific Northwest cannot be interpreted using conventional models such as the Lopatin method, as short-term thermal events have overprinted the maturation data. Therefore an approach based on the concept of an "oil window" may be more appropriate, given the complex geological histories of basins within a tectonically active area such as the Pacific Northwest.

INTRODUCTION

Consideration of all of the available data from the Pacific Northwest reveals a pattern of anomalous maturation profiles that defy conventional interpretation. These unusual profiles are very steep, implying near-constant maturity with respect to oil and gas generation over thousands of feet of sediment. In this paper we examine the data and address the question of whether the anomalous profiles represent a real phenomenon.

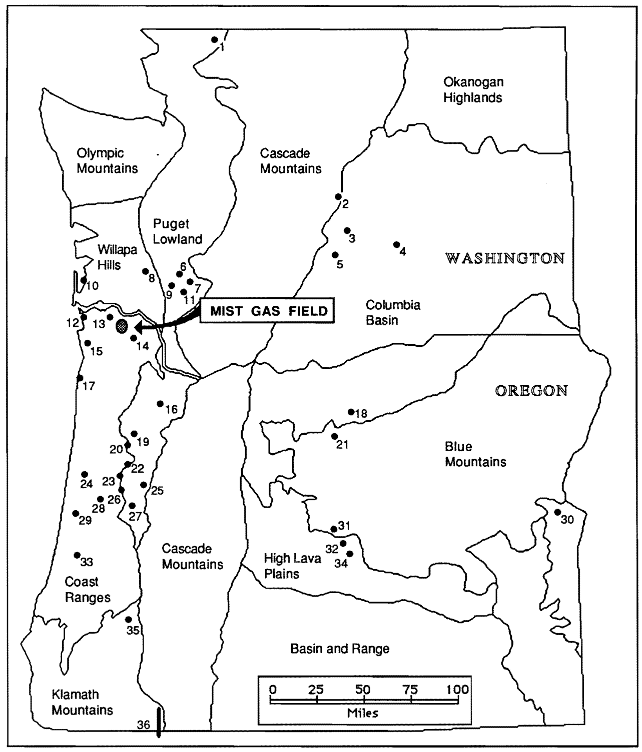


Figure 1. Physiography and location of drill holes in the Pacific Northwest with available maturation data. Numbered drill holes are keyed to well names and locations in Table 1.

MATURATION METHODS

Various organic geochemical methods are commonly used to ascertain the maturity and source rock potential of a sediment. These methods are used mainly to define the zone of peak hydrocarbon generation in source rocks so that updip reservoir rocks can be targeted for drilling. One such method, vitrinite reflectance (R_O), comprises the bulk of the maturation data on sediments in the Pacific Northwest. Vitrinite reflectance is based on the changes in the optical properties of vitrinite, which occur primarily in response to heating. During heating, the chemical composition of the organic matter in a sediment is irreversibly altered by a cracking process that generates volatile products such as CH_4 and H_2O. Cracking causes the organic matter molecules to restructure with a higher degree of order, increasing their reflectance. Vitrinite is one component of organic matter, and its reflectance increases in a uniform manner. Initially used to evaluate coal rank, vitrinite reflectance is now the most widely used optical technique in the petroleum industry for determining the maturity of a source rock.

The vitrinite reflectance technique has been developed over many years. International standards now define most of the steps in the acquisition of data (Baskin, 1979), although different approaches are used for the extraction of the organic matter and the subsequent preparation of polished sections. When vitrinite reflectance values are plotted on a logarithmic scale versus depth on a linear scale, the result is usually a straight line of increasing reflectance with depth (Dow and O'Connor, 1982). Deviation from a uniform slope can provide important geological information. For example, the location of an unconformity and the amount of section removed at the unconformity is commonly obtained by extrapolating the vitrinite reflectance profile back to R_O = 0.2 percent at the paleosurface (Dow and O'Connor, 1982). There are two methods for interpreting the thermal history of sediments using vitrinite reflectance data: (1) conventional approaches based on time/temperature relationships, one being the Lopatin technique (Waples, 1980); and (2) an approach that treats vitrinite reflectance as an absolute geothermometer (Price, 1983; Barker and Pawlewicz, 1986).

Over the past decade, extensive studies by the petroleum industry have resulted in a cross-calibration of vitrinite reflectance with two other maturation indicators. The Thermal Alteration Index (TAI), a well-established method, is based on the color changes that organic particles experience with increasing maturation or temperatures (Staplin, 1982). Rock-Eval pyrolysis is based on the release of volatiles during heating of whole-rock samples and provides information on thermal maturation (T_{max}) as well as the quantity and type of organic matter in the sediment. Rock-Eval pyrolysis has become accepted by the petroleum industry as a rapid, quantitative method for source rock evaluation.

TECHNIQUE LIMITATIONS

Although vitrinite reflectance is a widely used and accepted indicator of thermal maturation, there are problems associated with the technique. First, the method is subjective because the microscope operator must identify and measure only unweathered, unoxidized vitrinite, and the ability to do this is a function of the operator's

Table 1. *Published and public-domain maturation data from the Pacific Northwest.*

Ref#	Drill hole	Position	Ro at	depth (Ft)	Reference	Comment
1	Daymont, Stremler #2	T40N, R 3E, Sec.4	0.55-0.52	1,390-4,720'	4	
2	Norco, Norco #1	T22N, R 20E, Sec.26	0.39-0.51	1,751-4,850'	8	Under Columbia River Basalt Group (CRBG)
3	Shell, Bissa 1-29	T18N, R 21E, Sec.29	0.43-0.57	4,620-10,080'	8	Under CRBG
4	Shell, BN 1-9	T15N, R 25E, Sec.9	0.54-1.32	11,280-15,820'	8	Under CRBG
5	Shell, Yakima Minerals 1-33	T15N, R 19E, Sec.33	0.86-1.38	9,840-11,870'	8	Under CRBG
6	Humble, Everett Trustee	T13N, R 1E, Sec.23	0.63-0.53	1,800-3,101'	4	Hydrothermal effects
7	Humble, Rosa Meyer	T12N, R 2E, Sec.8	0.40-0.60	1,607-4,080'	4	Normal
8	Shell, Thompson #1	T12N, R 1W, Sec.34	0.27-0.44	278-7,468'	3	Retarded/ coal seam/ mud additive ?
9	Humble, Roscoe B. Perry	T12N, R 1W, Sec.12	0.31-0.52	1,320-9,540'	4	Marked effects of intrusion
10	Tidelands, Weyerhauser 7-11	T11N, R10W, Sec.7	0.38-0.92	400-5,990'	3	Under 5,000' of basalts, overthrust?
11	Humble, John Brown #1	T11N, R 1E, Sec.15	0.47-0.48	40-3,454'	4	Retarded/ coal seam/ mud additive ?
12	Standard, Hoagland	T 7N, R10W, Sec.11	0.3-0.43	520-7,090'	3, 6	Retarded?, interlayered basalts
13	Diamond, Boise Cascade 1-14	T 7N, R 7W, Sec.14	0.41-0.46	840-7,440'	3, 7	Constant, near Mist Gas Field
14	Texaco, Clark & Wilson 6-1	T 6N, R 4W, Sec.19	0.25-0.64	485-8,405'	3, 6	Volcanic effects
15	Crown Zellerbach 31-17	T 5N, R 9W, Sec.28	0.4-2.4	1,000-5,000'	7	+600 m effect of gabbroic sill
16	Texaco, Cooper Mountain	T 1S, R 2W, Sec.25	0.63-0.44	2,808-8,100'	3, 6	Under CRBG
17	Reichold, Crown Zellerbach	T 2S, R10W, Sec.22	0.36-0.41	680-5,120'	3	Retarded?
18	Standard, Kirkpatrick #1	T 4S, R21E, Sec.6	1.01-1.15	6,846-8,720'	I, 3, 9	Under Clarno, John Day, and CRBG
19	Reichold, Finn #1	T 6S, R 4W, Sec.17	[421-433]	490-6,310'	3, 6	Near-constant, T_{max} only
20	Reserve, Bruer #1	T 6S, R 4W, Sec.31	0.46-0.52	1,660-4,380'	10	Near-constant
21	Oregon, Clarno #1	T 7S, R19E, Sec.27	[433-437]	1,000-3,200'	3, 9	Melange, under Clarno, T_{max} only
22	Quintana, Gath #1	T 8S, R 2, Sec.16	0.50-0.67	4,020-5,925'	10	Intercalated volcanics 1200-5700'
23	Humble, Miller #1	T10S, R 3W, Sec.10	0.52-0.56	1,415-4,430'	10	
24	Oregon O&G, Robert #1	T10S, R 8W, Sec.25	3.5-2.5	340-2,415'	10	
25	Reserve, Esmond #1	T12S, R 1W, Sec.7	0.51-0.54	2,920-3,805'	6, 11	Steep
26	American Quasar, Hickey	T12S, R 2W, Sec.9	0.49-0.46	1,800-4,670'	10	
27	Gulf, Porter #1	T13S, R 4W, Sec.27	0.38-0.55	600-7,940'	3, 6	Effects of 2,500' volcanics
28	Mobil, IRA Baker	T15S, R 3W, Sec.28	0.49-1.26	1,130-10,125'	10	Intercalated basalts 2800-6700'
29	Sinclair, Federal-Mapelton	T16S, R10W, Sec.12	0.64-0.64	270-6,520'	3, 6	Vertical, good agreement with T_{max}, TAI
30	Sinclair, Eastern Oregon Land	T16S, R44E, Sec.15	1.57	at 4,430'	3	Within volcanics
31	Sunray, Bear Creek #1	T17S, R19E, Sec.30	0.78-1.18	3,180-7,165'	1, 3, 5,11	Steep, geothermal effects
32	Texaco, Logan Butte #1	T19S, R20E, Sec.17	1.11-1.26	2,005-6,475'	11	Near-constant, hydrothermal effects
33	General, Long Bell	T20S, R10W, Sec.27	0.46-0.58	530-6,880'	3, 6	Near-constant, hydrothermal effects
34	Standard, Pexco State #1	T20S, R20E, Sec.36	0.58-1.3	5,920-7,386'	3	Under thick volcanics
35	Mobil, Sutherlin	T24S, R 5W, Sec.36	0.48-0.57	460-3,850'	3	Vertical, good agreement with T_{max}, TAI
36	Hornbrook Fm.	CA/OR Borderlands	0.6-0.52	over ≈3,300'	2	Under thick volcanic strata

[ ] = T_{max}

Key to numbered references: 1 = Newton, 1979. 2 = Law and others, 1984b. 3 = Brown and Ruth Laboratories, Inc., 1983 (Contract 1)*. 4 = Amoco Production Co., 1981-1983**. 5 = Green and Associates, 1982 (Contract 3)*. 6 = Ogle Petroleum, 1981 (Contract 2)*. 7 = Niem and Niem, 1985. 8 = Lingley and Walsh, 1986. 9 = L.H. Fisk, personal communication, 1986. 10 = Sohio Petroleum Co., 1984 (Contract 10)*. 11 = Summer and Verosub, 1987.

*Data released by Oregon Department of Geology and Mineral Industries.

**Data released by Washington Division of Geology and Earth Resources.

training and experience. Second, different extraction and polishing procedures can lead to widely differing values being reported for the same sample (Dembicki, 1984). Another problem with vitrinite reflectance is that its normal increase due to rising temperatures may be subject to an effect known as retardation (Price and Barker, 1985).

TAI is also a widely accepted method, although it is highly subjective because a microscope operator must match the color of the organic particles to colors on standardized charts. On the other hand, Rock-Eval pyrolysis is an automated, objective technique, but it is not without problems (Katz, 1983; Peters, 1986). Importantly, Rock-Eval data are most easily reproduced in interlaboratory comparisons (Dembicki, 1984).

In fact, the reproducibility of most organic geochemical data between laboratories is not good, with the result that interlaboratory comparison of maturation data is often not possible. A further problem common to all the techniques is that most maturation data are based on rock cuttings taken at the well head at the time of drilling, and caving and mud contamination can be major causes of error.

MATURATION DATA FROM THE PACIFIC NORTHWEST

Published maturation studies from Oregon are primarily based on weathered outcrop samples (Law and others, 1984a,b; Armentrout and Suek, 1985; Sidle and Richers, 1985), although three subsurface source rock evaluations are available (Newton, 1979; Niem and Niem, 1985; Summer and Verosub, 1987). Similar work in Washington is based mainly on subsurface samples (Walsh and Phillips, 1982; Lingley and Walsh, 1986). However, extensive unpublished data are available from the state core repositories of Oregon and Washington, primarily on drill cuttings.

Analysis of all the available maturation data (including R_O, TAI, and T_{max}) (Figure 1, Table 1) reveals that the maturation profiles from drill holes in the Pacific Northwest are remarkable for the persistent occurrence of unusually steep maturation profiles (Figures 2-4). Moreover, in some instances, vitrinite reflectance values fail to increase from nascent levels (R_O = 0.4 percent) even though buried to depths of 6,000-8,000 ft in areas of normal geothermal gradient (Table 1, drill holes 2, 8, 12, 14). When corresponding R_O, TAI, and T_{max} data are available for the same drill hole, they generally show agreement in maturation profile, even if the maturation levels are not comparable. Therefore, some underlying geologic process must be responsible for the anomalous maturation gradients in the drill holes of the Pacific Northwest.

DISCUSSION.

We will not attempt to examine in detail the available data, given the fact that maturation data from different laboratories cannot be directly compared. For example, consistent with Dembicki (1984), the four independent studies on a drill hole in north-central Oregon (Figures 2A,B) indicate significantly different maturation levels. More importantly, however, the profiles or best-fit lines for each data set are all anomalously steep, showing that all of the studies are consistent in implying an unusual maturation process. Further examination of the data base reveals that the unusual maturation profiles that prevail within most of the drill holes in the Pacific Northwest are independent of the laboratories that generated the data. Therefore, given the widespread occurrence of drill holes with steep maturation profiles, the diverse sources of the data, and the agreement between the different maturation techniques, the profiles are interpreted to be real and not the result of some methodological error.

As previously mentioned, in some individual drill holes, vitrinite reflectance levels are remarkably low, compared to TAI and T_{max} results. One possibility is that the results are due to retardation of vitrinite reflectance. This has been reported to occur in sediments with appreciable amounts of exinite or hydrogen-rich Type II kerogens (Price and Barker, 1985). However, the sediments of the Pacific Northwest generally have low hydrogen contents probably due to an aerobic depositional environment (Armentrout and Suek, 1985), and Type II kerogen does not predominate. While retardation may account for some anomalously low vitrinite reflectance data in central Washington (drill hole 2), near the Mist Gas Field in northwest Oregon (drill holes 12, 13, 14), and elsewhere (drill holes 6, 8) where Type II hydrogen-rich strata occur, it cannot be shown to have occurred systematically over the data base.

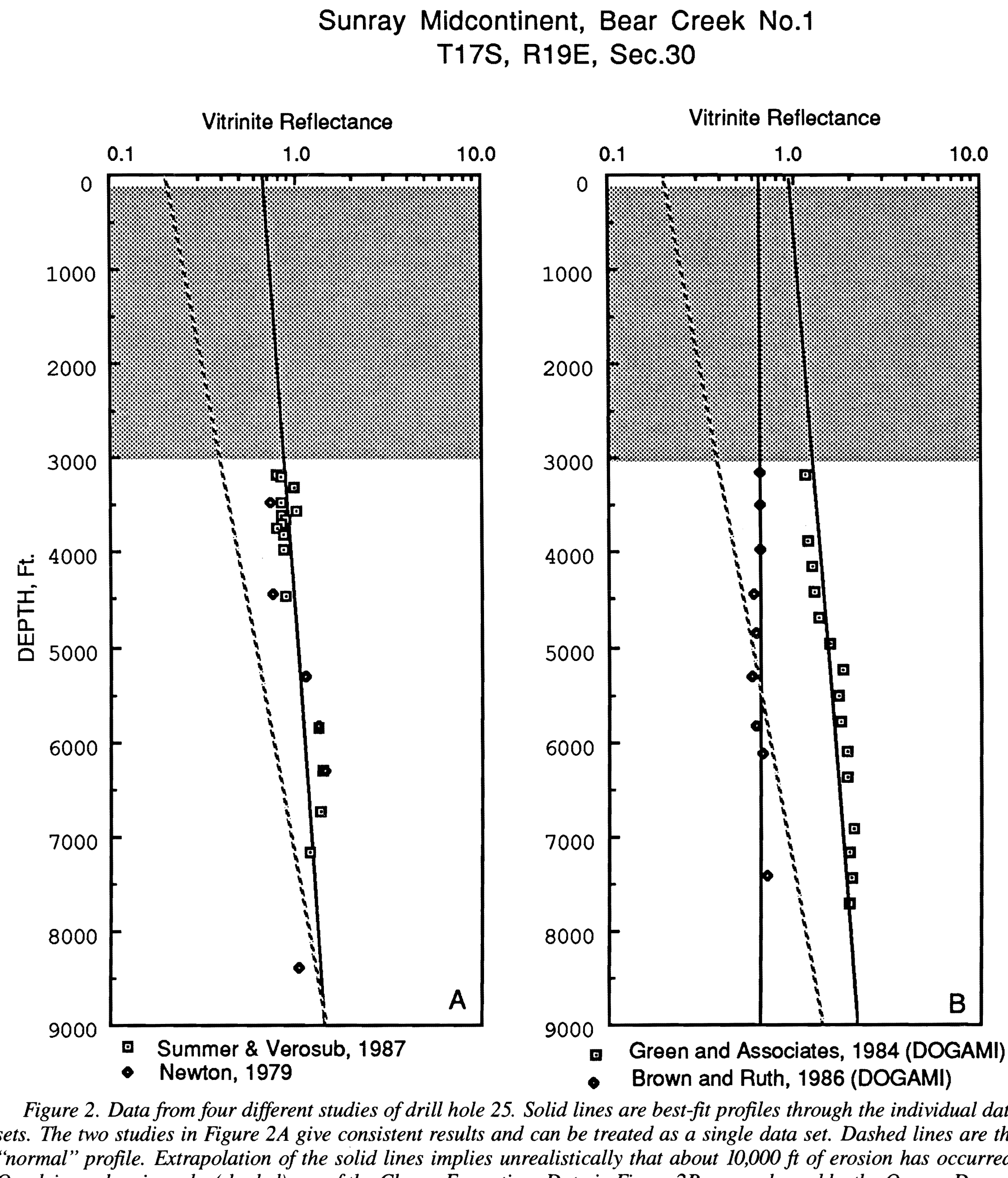
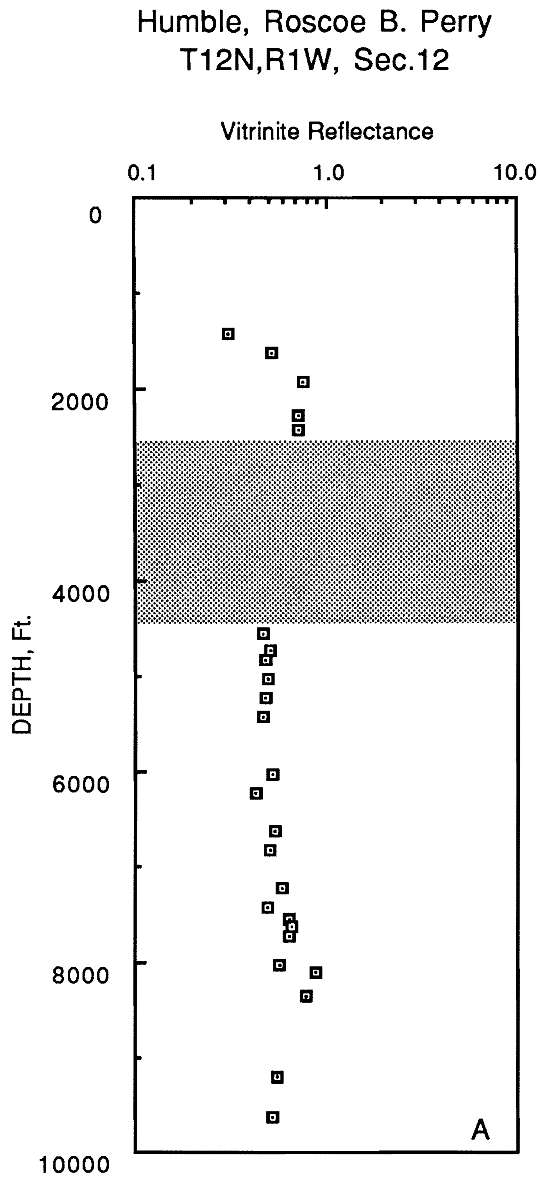


Figure 2. Data from four different studies of drill hole 25. Solid lines are best-fit profiles through the individual data sets. The two studies in Figure 2A give consistent results and can be treated as a single data set. Dashed lines are the "normal" profile. Extrapolation of the solid lines implies unrealistically that about 10,000 ft of erosion has occurred. Overlying volcanic rocks (shaded) are of the Clarno Formation. Data in Figure 2B were released by the Oregon Department of Geology and Mineral Industries (DOGAMI), Portland (see references in Table 1).



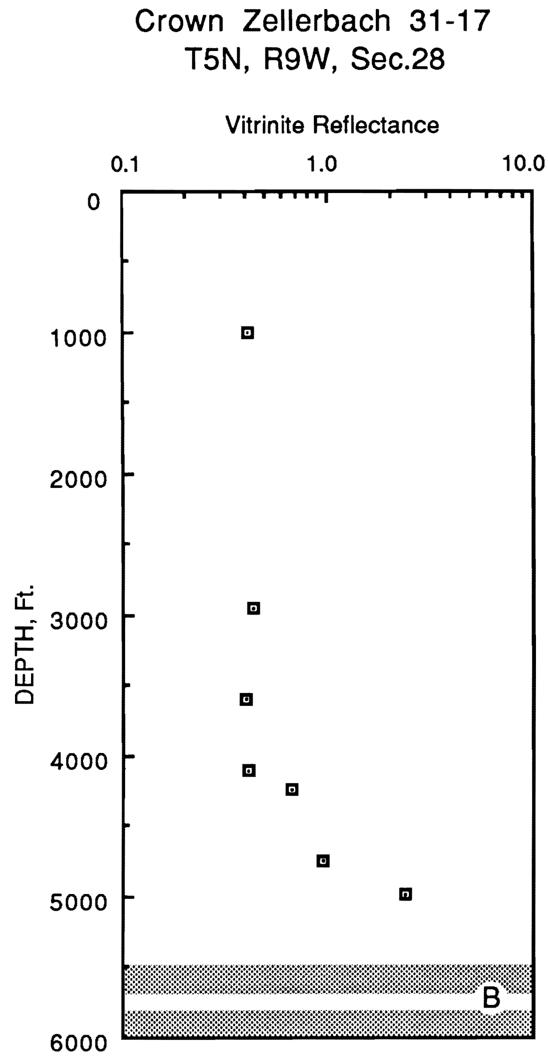


Figure 3. Data from southwest Washington (A = drill hole 9) and northwest Oregon (B = drill hole 15). Drill holes are less than 40 mi from the Mist Gas Field, Oregon. Data in A are from a study by Amoco Production Co. and released by the Washington Division of Geology and Earth Resources, Olympia (see reference in Table 1). Data in B are from Niem and Niem, 1985. The intrusive bodies (shaded) have not been named or dated at the present time.

Anomalous maturation profiles in the Pacific Northwest drill holes generally occur where sediments are mantled or intruded by volcanic rocks, although in some instances no volcanic rocks are present (drill holes 1, 27). Intrusive and extrusive volcanic rocks are known to have a direct thermal effect on country rock, but these effects are overshadowed by associated hydrothermal effects. We have suggested that the unusual near-constant maturation profiles are the result of the thermal effects of hydrothermal aquifers perched high in the rock column (Summer and Verosub, 1987). Such aquifers can be found in any highly permeable strata, and fractured volcanic rocks as well as porous sediments can provide the necessary conduits. These aquifers can be wide-ranging in extent, and their thermal effects on underlying sediments have been simulated by Ziagos and Blackwell (1981) and documented by Wood and Low (1986).

Thermal fluids from generations of Cascade volcanism may have affected a wide area (Walsh and Phillips, 1982), and there is evidence that emplacement of the Columbia River Basalt Group was preceded by a thermal event with coincident hydrothermal activity east of the Cascades (Summer and Verosub, 1987). Thus, marked maturation perturbations (drill holes 6, 9, 15, 22, 26) and extensive evidence of fossil hydrothermal systems suggest that fluids associated with intrusive and extrusive bodies have assisted in the maturation of sedimentary units throughout the Pacific Northwest. This mechanism thus implies a much wider diagenetic influence of intrusive activity, well beyond contact metamorphic effects (Summer, 1987).

The anomalous maturation profiles cannot be explained using conventional techniques used to integrate the effects of temperature and time on organic maturation. For example, the widely used Lopatin method is based on a calculated time-temperature interval (TTI) derived solely from vitrinite reflectance data (Waples, 1980). Because of the assumptions of the method, the Lopatin technique cannot account for strata of different geological age with the same TTI. To do so would require that the sedimentary units had been subject to downwardly decreasing temperatures. In addition, the maximum burial depth usually obtained from extrapolation of the vitrinite reflectance profile gives unrealistic values (Figures 2A,B). These

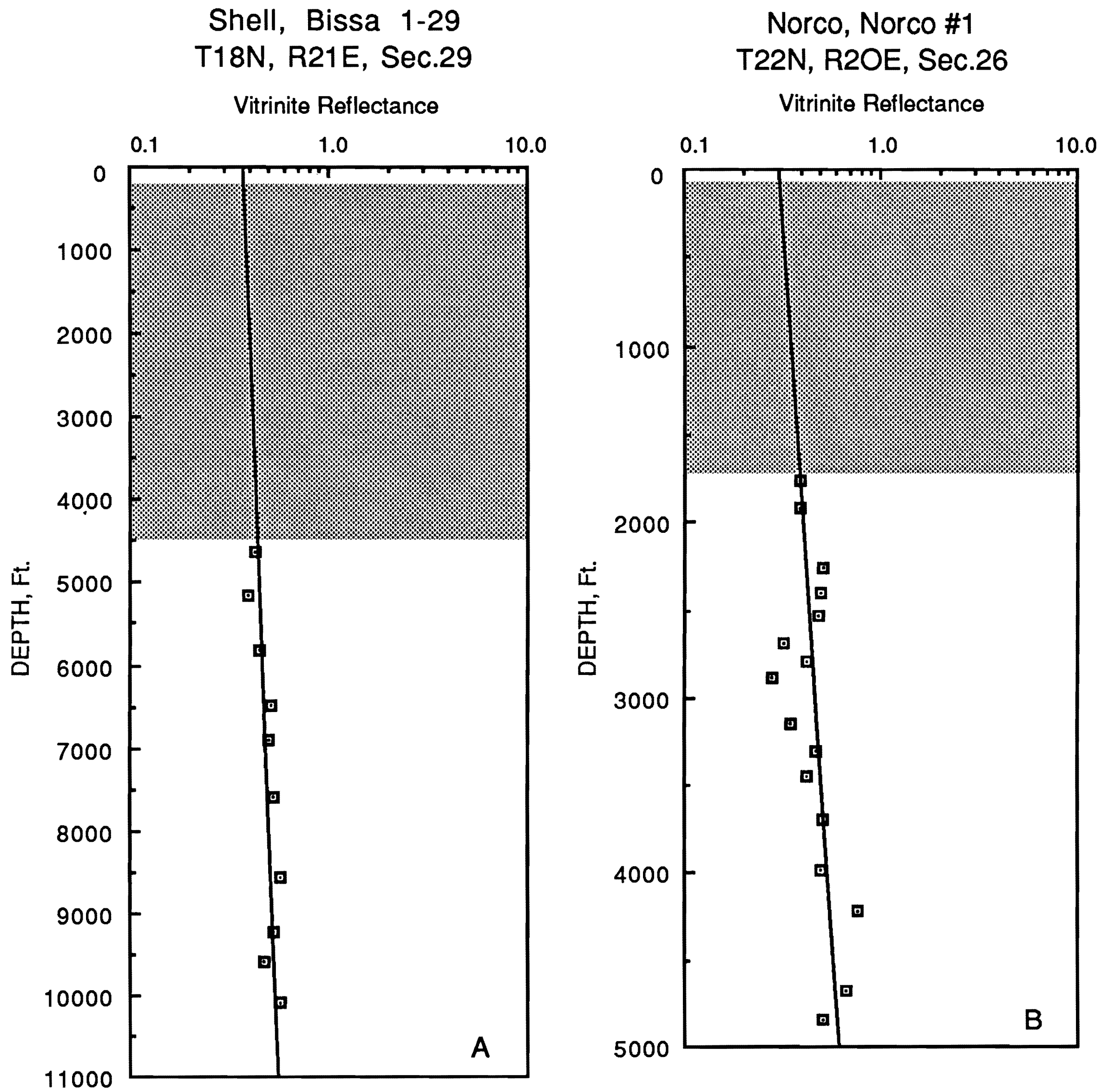


Figure 4. Data from drill holes 3 (A) and 2 (B), central Washington, after Lingley and Walsh (1986), presented with permission of T.J. Walsh. Overlying volcanic rocks (shaded) are of the Columbia River Basalt Group.

limitations, in addition to assumptions regarding the thermal fluxes over geological time (usually based on a combination of the local tectonics and again on the R_O values), make the use of the Lopatin method in these circumstances questionable.

Particularly ignored in the Lopatin model is the importance of transient thermal events (<200,000 years) in maturing sediments, although the effects of hydrothermal systems and intrusives are known to have produced hydrocarbons (Altebaumer and others, 1983; Reiter and Clarkson, 1983; and many others). Since important exploration decisions are based on these Lopatin plots, a more objective method based on an oil window of approximately R_O = 0.6-1.4 percent pertaining to Type III kerogen should be utilized. Although the Lopatin technique may work well in tectonically quiescent terranes, its use is not appropriate in volcanically or tectonically active areas.

Low maturation levels in sediments around the Mist Gas Field have led to uncertainty with regard to the source of the gas in the field. Yet there are sediments on both sides of the field and within the structure upon which the field is found that have experienced heating from igneous intrusives (Figure 3)(Niem and Niem, 1985; Summer, 1987). The maturation data from these downdip sediments indicate that they are within the oil generative window (drill holes 9 [see Figure 3A], 14, 15). In addition, the coals of the Skookumchuk Formation in the Centralia area of Washington (Figure 1), 30 mi northeast of the field, show elevated coal rank (R_O = 0.3-0.42)(Hadley, 1981), yet were never buried to more than 1,500 ft (Walsh and Phillips, 1983). The Skookumchuk Formation correlates stratigraphically with the reservoir sands of the Mist Gas Field, and this area lies on the eastern flank of the structure upon which the field is found (Armentrout and Suek, 1985). Armentrout and Suek (1985) concluded that the source of the gas lay to the east, under the cover of the Columbia River Basalt Group. We support these conclusions, as the fluids expelled by the emplacement of the aforementioned intrusive bodies may not only have matured the sediments and coals of the area but may also have assisted in the transport of the gas to the field 40 mi away.

CONCLUSION

The near-vertical maturation profiles in the Pacific Northwest are a real and systematic phenomenon implying near-constant maturity with respect to oil and gas over thousands of feet of sediment. Agreement among the major maturation indicators over a broad data base suggests a real maturation process that may be unique to such a geologically active area, namely thermal input from warm-water aquifers within the sedimentary column. Given the widespread effects of such aquifers and their effects on underlying sediments, the systematic occurrence of near-constant maturation profiles throughout the area should be expected.

Understanding the unusual maturation processes is made more difficult by problems with the major maturation indicators and the fact that data from different sources are not amenable to direct comparison. However, examination of the stratigraphy and maturation profile of individual drill holes leads to the conclusion that the maturation process is related to hydrothermal fluids associated with volcanic activity. Furthermore, hitherto unpublished data indicate that the source of the gas in the Mist Gas Field may lie in intruded sediments to the northeast and northwest.

Interpretation of the vitrinite reflectance data from the Pacific Northwest cannot be done in the conventional manner because such methods cannot accommodate short-term thermal events. As an alternative method of interpreting the unusual maturation data from the Pacific Northwest, an approach based on the established "oil window" is more appropriate, given the complex geological histories of basins within such a tectonically active area.

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New map describes geology of Breitenbush River area

The complex volcanic geology of the Breitenbush River area is described and discussed in a new publication of the Oregon Department of Geology and Mineral Industries (DOGAMI). The area is located at the transition between the older Western Cascade Range and the younger High Cascade Range and has been known for its thermal springs and, in some parts, for its mineral potential.

Geologic Map of the Breitenbush River area, Linn and Marion Counties, Oregon, by DOGAMI staff geologists G.R. Priest, N.M. Woller, and M.L. Ferns, has been released in DOGAMI's Geological Map Series as map GMS-46. It covers over 200 square miles, extending from Detroit Lake 12 miles to the east and from Hawk Mountain in the north to Bachelor Mountain in the south.

The report consists of two parts, a map sheet and a 4-page text. The map sheet (approximately 27 by 40 inches) contains a multicolored geologic map (scale 1:62,500), a geologic cross section, a location map, and a table listing ages of almost 50 samples from the area. The map explanation identifies and describes 50 separate units of surficial and volcanic rocks, vent complexes, and intrusives. The accompanying text discusses the structural geology, mineralization, and geothermal resources of the study area and presents a table of radiometric data for some rock-unit samples collected outside the map area.

The new map GMS-46 is now available at the Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201. The purchase price is $6. Orders under $50 require prepayment. □

Oregon surface-water resources detailed in National Water Summary

Oregon's surface-water resources provide about 85 percent of the state's total water needs. Use is limited in part by the uneven distribution of surface water across the state, according to the Oregon section of the 1985 National Water Summary by the U.S. Geologic Survey (USGS), Department of the Interior.

The 1985 National Water Summary is the third in an annual series of comprehensive reports on the status and supply of the nation's vital water resources. It provides an extensive state-by-state look at the country's surface-water resources, which provide about 80 percent of the daily water needs of the United States.

"Western Oregon has a good supply of surface water, whereas surface water is a limited resource in eastern Oregon," said Marvin O. Fretwell, chief of the USGS Water Resources Division office in Portland, Oregon. "Many of the smaller streams in eastern Oregon are dry by summer's end, but the larger streams, which follow a similar seasonal pattern, still flow in late summer. Reservoir storage is necessary throughout the state to augment summer flows with captured winter and spring runoff.

"The efficient use of surface-water supplies is an important state water issue, and one that is severely limited because of the competitive and sometimes incompatible demands for surface water. The many competitive demands involve municipal supplies, irrigation, Indian lands, industry, recreation, fisheries and hydroelectric power. Specific issues of current concern are the establishment of minimum flows for instream use and the sustained flooding of Malheur and Harney Lakes," Fretwell said.

The Oregon Water Resources Department (OWRD) has the major responsibility for managing the state's surface and ground waters for beneficial uses. The OWRD also has the responsibility of ensuring that water supplies are adequate for human consumption.

The OWRD is the principal cooperator with the USGS in investigating the state's surface-water resources. These activities include data collection, data analysis, and interpretive studies that together form an information base for surface-water planning and management.

The Oregon Department of Environmental Quality is responsible for establishing and enforcing rules designed to prevent contamination of Oregon's surface-water resources. Each state section contains maps and graphs that portray runoff and precipitation; the location of principal rivers, reservoirs and hydropower plants; trends in average streamflow discharge; how surface-water resources are managed and a table on surface-water use.

Copies of the 506-page 1985 National Water Summary including all state sections plus an overview of hydrologic conditions for the 1985 water year and articles on record-high levels of the Great Lakes, the disintegration of Columbia Glacier, snow and ice and their effects on climate and transferring water to meet water needs, among others, are available for $31.00 each. Orders must include check or money order payable to Department of the Interior-USGS and should be directed to: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225.

Single copies of the Oregon section of the 1985 National Water Summary are available from the Oregon Office, U.S. Geological Survey, Suite 300, 847 N.E. 19th Ave., Portland, OR 97232.

Selected Oregon surface-water facts from the 1985 National Water Summary compiled by the USGS in cooperation with state and local agencies:

- Irrigation comprises 88 percent of the total water used in Oregon; surface water provides 85 percent of the water used for irrigation. Many of the major cities, such as Portland, Salem, Eugene, Corvallis, Pendleton, Coos Bay, and Astoria, depend on surface water as their primary source of supply.
- Oregon is second only to Washington in the amount of water used for hydroelectric power. In fact, Oregon and Washington used more water for hydroelectric power than all of the eastern States combined.

— USGS news release

USGS tests implementation of mapping changes

The National Geodetic Survey has completed the readjustment of the horizontal control net, creating the new North American Datum 1983 (NAD 83) to replace the present North American Datum 1927 (NAD 27). The present NAD 27 is based on the Clarke 1866 ellipsoid, while NAD 83 is an Earth-centered datum based on the newly adopted Geodetic Reference System 1980 ellipsoid.

In consequence of the adoption of the new ellipsoid base, two mapping grids will have their locations changed in respect to the geographic coordinates and with each other: the State Plane Coordinate Systems and the Universal Transverse Mercator grid.

Conversion to NAD 83 will be of increased importance as use is made of satellite-derived data that basically are referenced to the center of mass of the Earth. The conversion will also remove known existing anomalies in the horizontal network.

The U.S. Geological Survey (USGS) is faced with the problem of converting nearly 55,000 maps to the new NAD 83. The evaluation of many options, ranging from continuing on NAD 27 to recompiling the maps on NAD 83, has now led to a pilot project in which a conversion is tested. The project consists of 36 7½-minute maps covering the State of Rhode Island and uses a cartographic adjustment that holds the existing map detail limits.

Oregon State Resident Cartographer Glenn Ireland has provided the following table showing how much the geographic values of features change in Oregon due to the new NAD 83. The table compares the NAD 27 and NAD 83 geographic values for points at opposite corners of the State.

NW Oregon (Station ASTOR)

	NAD 27	NAD 83	Difference
Latitude	46°10′53.413″	46°10′52.801″	0.612″S (19 m)
Longitude	123°48′58.707″	123°49′03.202″	4.495″W (96 m)

SW Oregon (Station ONIDA)

	NAD 27	NAD 83	Difference
Latitude	42°01′37.904″	42°01′37.510″	0.394″S (12 m)
Longitude	117°02′20.215″	117°02′23.677″	3.462″W (80 m)

Differences in the mapping grid systems would not be the same as in the geographic values because of concomitant changes in the system parameters.

The USGS invites written comments from interested persons to: Chief, National Mapping Division, U.S. Geological Survey, 510 National Center, Reston, VA 22092.

An inspection packet is available that contains a quadrangle map from the Rhode Island pilot project and additional explanations, the map sheet showing the quadrangle based on NAD 27 on one side and based on NAD 83 on the other side. The packet may be obtained from the Portland office of the USGS National Mapping Division, 847 NE 19th, Suite 300, Portland, OR 97232, phone (503) 231-2019. □

Glimpses of DOGAMI history—On the moon in Oregon

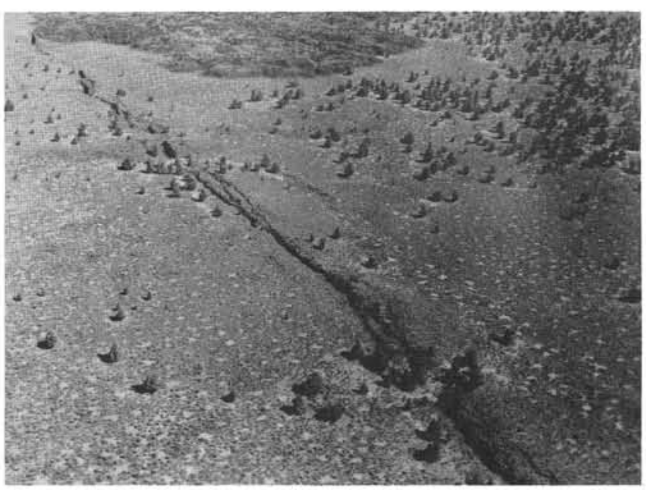
Between 1960 and 1965, the Oregon Department of Geology and Mineral Industries (DOGAMI) saw considerable involvement in the exploration and research that eventually put U.S. astronauts on the moon.

Rock samples and photographs were provided for the National Aeronautics and Space Administration (NASA) and a large number of companies working on technology and instrumentation for the lunar landing—even as late as 1967, when lunar reference rocks from Oregon were shown at the EXPO '67 in Montreal, Canada. Counseling, guidance, and assistance were given to a variety of visitors related to the lunar program: Scientists came from the U.S. Geological Survey and its astrogeology branch, from aircraft companies such as Boeing, and from NASA-related research institutions. Several groups of NASA astronauts were trained in Oregon in techniques they used to move about and explore the moon's surface. Even a CBS television team arrived to film astronauts in Oregon's "lunar environment."

In 1965, this activity culminated for DOGAMI in the cosponsorship (with the New York Academy of Science) of the International Lunar Geological Field Conference. The same year also saw the establishment of the Center for Volcanology at the University of Oregon.

Why in Oregon? — Well, certain areas of central and southeastern Oregon show volcanic landforms quite similar to the volcanic features one expected to find on the lunar surface. The barrenness or sparse vegetation of such recent and thus relatively fresh, unweathered volcanic terranes as the areas at Diamond Craters, Newberry volcano, Hole-in-the-Ground, Devils Garden, Crack-in-the-Ground, and Jordan Craters invited the comparison with the moon—as the pictures on this page demonstrate. □

Twin Craters, Diamond Craters area, Harney County



Crack-in-the-Ground, Devils Garden area, Lake County

Cinder cones, Devils Garden area, Lake County

Hole-in-the-Ground, Lake County

Lava field, Jordan Craters area, Malheur County

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