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Uplift of the Continental Margin and Possible Continental Accretion off Oregon

Abstract. *Sedimentary rocks collected from the continental shelf and slope off the central coast of Orgeon contain fossil benthic foraminifers of Pliocene and Miocene age. These fossils indicate water depths much greater than those from which the rocks were collected, implying that the rocks have been uplifted as much as 1000 meters since their deposition. Uplift of this magnitude near the edge of the continent is interpreted as representing an early stage of continental accretion, possibly as a result of compression normal to the continental margin. The average maximum horizontal component of this accretion would be about 16 kilometers.*

West of Oregon the continental margin has a generally convex surface 65 to 110 km wide. The continental shelf, which forms the upper part of the surface, slopes seaward less than 1 degree and ranges irregularly in width from 17 to 65 km. The lower part of the surface, the continental slope, is modified by numerous hills, benches, and valleys. The slope increases in average declivity from about 1 degree in the upper part to almost 10 degrees along the basal escarpment.

Off the central coast of Oregon, the margin has an average width of about 100 km (Fig. 1), while the continental shelf, with an outer edge at a depth of approximately 160 m, varies in width from 28 to 65 km. Rocks are exposed on several elongate banks on the shelf and slope. The geomorphology of the continental margin in this area has been described (*1*).

Closely spaced bottom gravity measurements have been made over the inner shelf north of Heceta Head and landward of Stonewall Bank (*2*). These and other measurements have been interpreted by Whitcomb, Erickson, and Berg (*3*) as indicating the presence of a synclinal basin containing sedimentary rocks approximately 6000 m thick between Stonewall Bank and Yaquina Bay. These workers suggested that the syncline terminates southward against a subsurface igneous rock mass extending seaward from Cape Perpetua. Subbottom profiles substantiate the presence of the synclinal basin and reveal a number of anticlines, synclines, and faults near the outer edge of the shelf

Table 1. Relative abundance of dominant and distinctive benthic foraminifers from Oregon offshore rocks. Depths at each station were as follows: No. 14, 137 m; No. 24, 90 m; No. 35, 113 m; No. 41, 90 m; No. 46, 86 m; No. 60, 119 m; No. 99, 54 m; No. 102, 45 m; No. 113, 81 m; No. 118, 540 m; No. 128, 1575 m; No. 137, 648 m. (A = abundant, C = common, R = rare).

Species	Relative abundances at various stations											
	14	24	35	41	46	60	99	102	113	118	128	137
Baggina cf. B. californica (Cushman)									C			
Bolivina advena striatella (Cushman)									C			
Bolivina argentea (Cushman)										A		
Bolivina brevior (Cushman)									C			
Bolivina seminuda foraminata (R. E. and K. C. Stewart)					R							
Bolivina seminuda seminuda (Cushman)										C		
Bolivina semiperforata (Martin)					C							
Bolivina spissa (Cushman)	C	C	C	C		C						
Bolivina subadvena sulphurensis (Cushman and Adams)					R					C		C
Bulimina striata mexicana (Cushman)												C
Bulimina subacuminata (Cushman and R. E. Stewart)		C					C					
Buliminella californica (Cushman)									A			
Buliminella exilis (H. B. Brady)	A				A	C				C		
Cassidulina delicata (Cushman)	A		R			A				C		
Cassidulina cf. C. modeloensis (Rankin)									C			
Cassidulina subglobosa (H. B. Brady)			A				C					
Cassidulina cf. C tumida (Natland)					C							
Cassidulinoides cornuta (Cushman)						A						
Cibicides mckannai (Galloway and Wissler)												C
Epistominella carinata pacifica (Cushman)			C	C		C		C				
Epistominella carinata parva (Cushman and Laiming)									R			
Epistominella carinata smithi (R. E. and K. C. Stewart)			A									
Loxostomum pseudobeyrichi (Cushman)	C				C							
Nonion pompilioides (Fichtel and Moll)											R	
Nonionella costifera (Cushman)									R			
Plectofrondicularia advena (Cushman)	C											
Stilostomella adolphina (d' Orbigny)						C						
Stilostomella advena (Cushman and Laiming)						C						
Uvigerina juncea (Cushman and Todd)								A				
Uvigerina peregrina hispidocostata (Cushman and Todd)				C			A					C
Uvigerina peregrina peregrina (Cushman)	C	C	C	A	C	C				A		A
Uvigerina cf. U. segundoensis (Cushman and Galliher)										R		R
Uvigerina senticosa (Cushman)											C	
Uvigerinella californica ornata (Cushman)									C			

and the upper part of the continental slope.

During a study of the geology of this portion of the continental shelf and slope, 225 samples of surface sediments and 138 samples of rock were collected (*4*). Well-sorted, fine, detrital sand covers the inner continental shelf (0 to 90 m) and grades to poorly-sorted, glauconitic clayey silt on the outer shelf (90 to 160 m). Patches of relict detrital and glauconite sand are also present near the outer edge of the continental shelf and on the banks. Clayey silt with small percentages of foraminifers, radiolarians, diatoms, and sponge spicules covers the continental slope. On the abyssal plain this sediment gives way to silty clay.

Rocks crop out primarily on shoals of the continental shelf and on several hills and ridges of the continental slope (*5*). Most rocks dredged from the surface of the continental shelf are clayey siltstones with textures and compositions similar to those of the modern sediments of the middle and lower continental slope.

Foraminiferal faunas have been extracted from rocks collected at 34 locations. Study of these faunas reveals chronologically and paleoenvironmentally useful assemblages at 12 locations (Fig. 1). The assemblages are listed in Table 1. With the exception of the rock from location 113, all are of Pliocene age (*6*). Sample 113 is referred to the lower part of the Relizian Stage of the Middle Miocene as defined for the California section (*7*). Definitive foraminifers for this determination include *Baggina cf. B. californica, Bolivina advena striatella, Buliminella californica,* and *Uvigerinella californica ornata.* California zonations were used for the Pliocene determinations because there is no suitable Pliocene zonation for the Oregon area. The presence of species such as *Bolivina seminuda foraminata, Bolivina semiperforata,* and *Bolivina subadvena sulphurensis* provide reasonable assurance that most of these rocks are of Pliocene age. Assignment to definite portions of that epoch is not yet justified.

Specific conclusions can be drawn regarding the paleodepths represented by the faunas. All benthic foraminiferal faunas examined are indicative of water depths greater than 100 m, and most are representative of middle slope depths of 600 to 1000 m (Table 2). These latter depths are indicated by the abundance of typical specimens of *Bolivina spissa, Buliminella exilis, Cassidulina delicata, Epistominella carinata pacifica,* and *Uvigerina peregrina peregrina.* In every case the present depth of the rock is less than that at which the fauna lived. The amount of uplift of the sedimentary rocks since deposition is indicated in Table 2. Discrepancies of paleodepth between adjacent samples (such as samples 99 and 102) may be attributed to differences in position within the stratigraphic section, or juxtaposition of different formational units due to faults or unconformities.

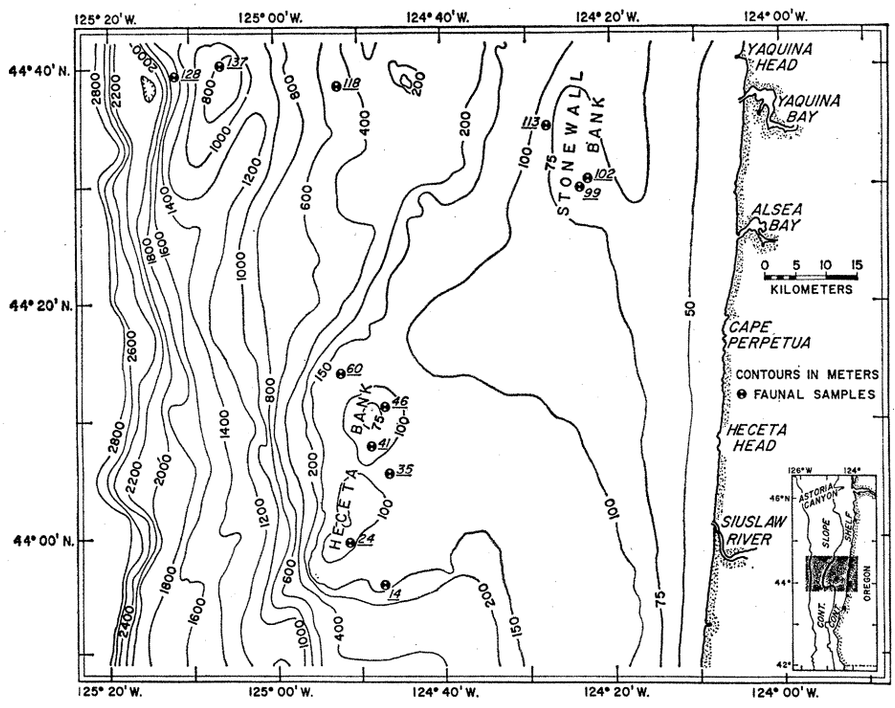

Fig. 1. Bathymetry of continental margin off Oregon and sample locations.

Table 2. Paleodepth and approximate uplift. The approximate uplift is equal to the approximate paleodepth minus the present depth. P, Pliocene; MM, Midde Miocene.

Station	Present depth (m)	Approx. paleodepth (m)	Approx. uplift (m)	Age
14	137	750	610	P
24	90	750	660	P
35	113	750	640	P
41	90	1050	960	P
46	86	900	810	P
60	119	750	630	P
99	54	1050	1000	P
102	45	100	60	?
113	81	300	220	MM
118	540	900	360	P
128	1575	2700	1120	?
137	648	1050	400	P

The significant uplift of late Tertiary sediments along the seaward portion of the continental margin suggests that appreciable accretion to the continent has taken place during and since the Pliocene. The subsurface evidence of anticlines and synclines near the outer continental shelf and upper continental slope, together with the bench and ridge morphology (probably structurally controlled) of the continental slope, presents the possibility that compressional forces were directed normal to the continental margin.

A reliable estimate of the amount of accretion cannot be made because of the structural complexities resulting from the compression. However, if the simplest model, that of vertical uplift, is assumed, an approximation of the maximum horizontal accretion can be derived. Under this assumption, horizontal accretion is equal to the map distance between the sample location and the nearest position of the present continental slope equivalent to the sample's paleodepth. With this assumption, the maximum horizontal accretion of sedimentary rock to the continent since their deposition during the Pliocene has been from 5 to 50 km, with an average of about 16 km.

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Galactic Depolarization of the 21-Centimeter-Wavelength Radiation of Extragalactic Sources

Abstract. *The dependence of the degree of linear polarization of the radiation from 213 extragalactic sources on galactic coordinates was investigated at 21-centimeter wavelength. In addition to the previously known latitude effect, the depolarization of the radiation during transit through our galaxy is also a function of galactic longitude. One possible explanation is that galactic depolarization is a simple function of the distance traveled by the radiation through an extended galactic halo.*

Observations at wavelengths near 21 cm have shown that the radiation from extragalactic sources located in directions of low galactic latitude is measurably depolarized during its passage through our galaxy (*1, 2*). In addition, internal depolarization is believed to take place in the sources themselves. The galactic depolarization may be caused by differential Faraday rotation across the angular extent of the source as a result of differences in the interstellar magnetic field, or electron density, or both, occurring over distances of the order of 1 parsec or less (*1*).

Polarization results are now available for a larger sample of extragalactic sources, and our results indicate that the depolarization is a function of galactic longitude as well as latitude, with the amount of depolarization tending to increase as the direction to a source approaches the direction of the galactic center.

During August and September 1964, we measured the effective linear polarizations of 76 additional sources at 21.2-cm wavelength with the 300-foot (91.4-m) transit radio telescope of the National Radio Astronomy Observatory at Green Bank, West Virginia. These observations were a continuation of measurements made with the same telescope and receivers in 1963 (*1*). Two identical receivers were connected to orthogonal, linearly polarized outputs of a circular wave guide feed antenna mounted at the focus of the reflector. The orientations of the planes of polarization accepted by the receivers could be varied by rotating the feed antenna. The equipment and methods of observation have been described in detail (*1*). Both the 1963 and 1964 observations were confined to small-diameter (average $< 1'$) sources of nonthermal spectra selected primarily from the 3C catalog (*3*). Sources for which the data indicate that polarized foreground radiation from our galaxy may introduce appreciable errors were eliminated, leaving a total of 134 presumably extragalactic sources measured at 21.2-cm wavelength with the 300-foot telescope. The estimated uncertainties in the degrees of polarization average about 1 percent standard error. We have combined our data with the results of other observers to give the linear polarizations of 213 extragalactic sources at 21-cm wavelength, and have analyzed these data for a dependence on galactic longitude as well as latitude. We have included the results from the Owens Valley Radio Observatory as given by Morris and Berge (*4*), and the results of Bolton, Gardner, and Mackey; Gardner and Davies; and Gardner from the Parkes catalog of radio sources (*5, 6*).

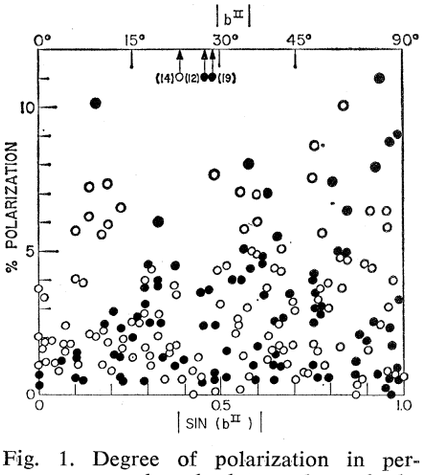

Fig. 1. Degree of polarization in percent versus the absolute value of the sine of the galactic latitude. Open circles represent sources in the galactic longitude range $90° < \ell^{II} \leq 270°$ and solid circles represent sources in the range of $270° < \ell^{II} \leq 360°$ and $0° < \ell^{II} \leq 90°$.

The degrees of linear polarization of the 213 sources are plotted as a function of the absolute value of the sine of the galactic latitude in Fig. 1. The open circles represent sources in the 180° range of galactic longitudes on the galactic anticenter side of Earth, and the solid circles represent sources in the hemisphere centered on the galactic center side of Earth. The sample contains 93 sources on the galactic center side in longitude and 120 sources on the anticenter side. Figure 1 indicates that sources at low latitudes tend to be less strongly polarized than sources at high latitudes; this finding confirms the latitude dependence found previously (*1*). However, the present larger sample shows that the effect is especially pronounced for sources having longitudes on the galactic center side of Earth. Figure 1 shows that almost all the sources of low galactic latitude (less than 15°) that are appreciably polarized are on the galactic anticenter side of Earth, where the distances traveled by the radiation through our galaxy are relatively short. The chi-square test applied to the distribution of polarization versus latitude for the data represented by the open circles in Fig. 1, or applied to the data represented by the solid circles, or applied to all the data combined, gives in each case probabilities of less than 5 percent that the distributions of polarizations are intrinsically the same for high and low latitude sources.

Figure 2 is a plot of degree of polarization versus galactic longitude for each of the 213 sources. The sources of the sample having absolute values of latitude equal to or less than 15° are represented by solid circles, and the sources of absolute latitude greater than 15° are represented by open circles. Figure 2 again illustrates that most low latitude sources in the 180° range of longitudes toward the galactic center are not appreciably polarized, while about one-third of the low latitude sources on the anticenter side show appreciable polarization. The chi-square test gives a probability of about 6 percent that the apparent difference in the polarization distributions for the low latitude sources is due to random sampling.

One possible interpretation of the data is that the depolarization is a direct function of the length of the path traveled by the radiation through the galaxy. In this case, if the depolariza-