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Nos. 214, 215, 216, 217, 218, 219, and 220

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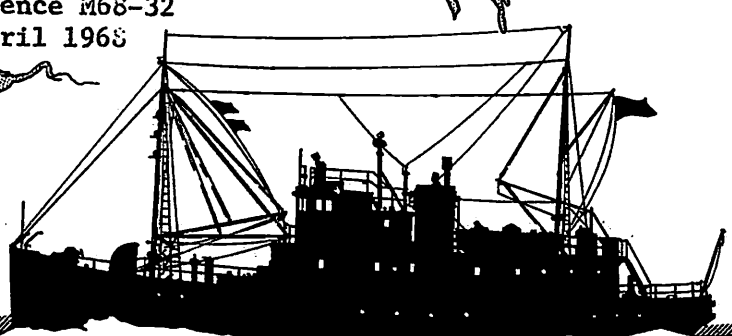

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Technical Report No. 214

SERGESTES SIMILIS HANSEN AND *S. CONSOBRINUS* N. SP. (DECAPODA) FROM THE NORTHEASTERN PACIFIC, by Darrelyn S. Milne. Crustaceana *14*(1):21-34. 1968.

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Technical Report No. 216

DISTRIBUTION AND MOVEMENT OF RADIOACTIVE CONTINENTAL SHELF SEDIMENT, NORTHWESTERN UNITED STATES, by M. Grant Gross. Collected Preprints of the International Sedimentological Congress. 4 p. 1967.

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CONTINENTAL SHELF SEDIMENT, NORTHWESTERN UNITED STATES, by M. G. Gross, D. A. McManus, and H-Y Ling. Journal of Sedimentary Petrology *37*(3): 790-795. 1967.

Technical Report No. 218

MAZAMA ASH FROM THE CONTINENTAL SLOPE OFF WASHINGTON, by Chester F. Royce, Jr. Northwest Science *41*(3):103-109. 1967.

Technical Report No. 219

A DEVICE FOR RELEASING A PISTON CORER AND DEACTIVATING THE PISTON, by James L. Woodruff. Deep-Sea Research *14*:809-810. 1967.

Technical Report No. 220

SINKING RATES OF RADIOACTIVE FALLOUT PARTICLES IN THE NORTH EAST PACIFIC OCEAN, 1961-62, by M. Grant Gross. Nature *216*(5116):670-672. 1967.

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Mazama Ash from the Continental Slope off Washington[1]

During the course of investigation of the sedimentology of Willapa Submarine Canyon (Royse, 1964), which extends seaward down the continental slope off the southern Washington coast, an ash layer was encountered at a depth of 240 cm in one of the piston cores. This core was obtained from station 36 during cruise 326 of the R/V BROWN BEAR and will be referred to as core 326-36 (Figure 1).

The bathymetric chart of Figure 1 shows that the vicinity of core 326-36 has less relief than is characteristic of the major portion of the continental terrace seaward of the shelf break (approx. the 100-fathom isobath); it may be a dissected bench, extensions of which can be seen to the north and south of Willapa and Guide canyons. Preliminary inspection of foraminiferids (B. J. Enbysk, personal communication) throughout the core interval above the ash layer gave no indication of depositional discontinuity. Likewise, examination of X-radiographs of the split core revealed no abrupt density (textural) changes. These observations suggest that the core represents a sequence of continuous deposition. Three radiocarbon dates were obtained for calculation of sediment-deposition rates, and computation of these rates permits extrapolation of the age of the ash.

Recent reports, including those of Mullineaux (1964), Powers and Wilcox (1964), Wilcox (1965), and Fryxell (1965), add testimony to the potential usefulness of ash layers in Quaternary studies in the Northwest. For this reason, although only a single occurrence of volcanic ash is involved, this occurrence is considered to be significant.

Characteristics of the Ash

The ash layer was not readily apparent when viewed in the newly opened core, but its greater bulk density (lower water content) was apparent both in X-radiographs and by differential desiccation of the core upon drying. While wet, the ash was olive gray (5Y4/2), but upon drying it became a light grayish white (5Y7/1 to 5Y8/1). The olive-gray color is a manifestation of contamination by other lithogenous material, probably largely illite, Fe-chlorite, and kaolinite in that order of abundance. No attempt

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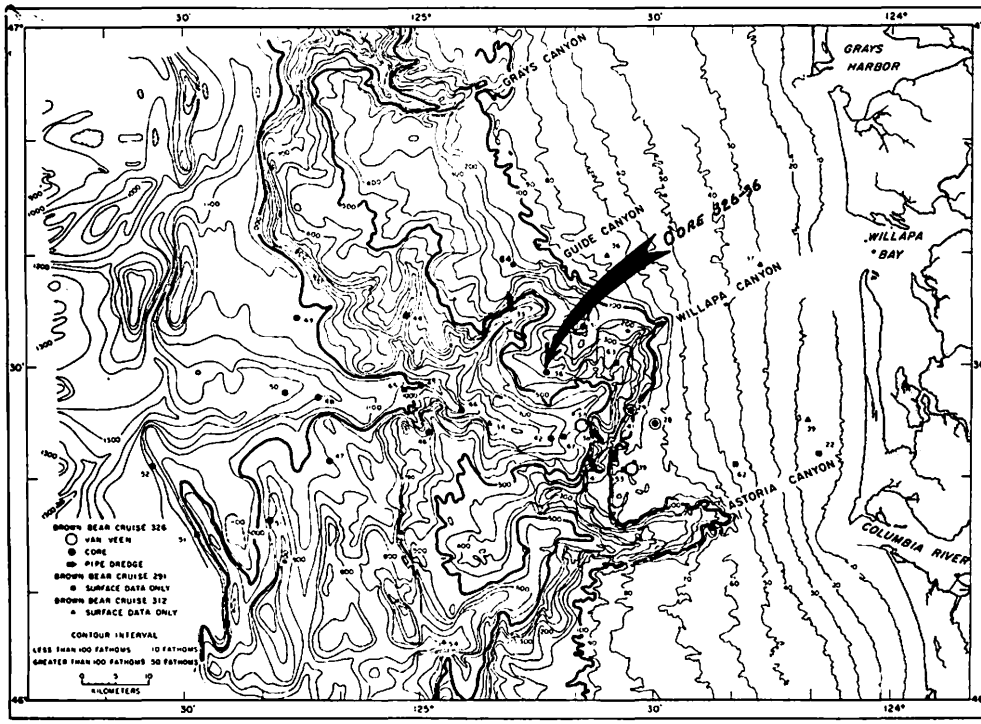

Figure 1. Bathymetric chart showing location of core 326-36 on the continental terrace off southern Washington. (Bathymetry compiled by McManus from unpublished USC & GS data.)

was made to determine the compositional percentage of the crystalline contaminants, but microscopic inspection and the weak intensity of diffracted X-rays indicate they are relatively minor, certainly less than 20 per cent.

The ash is fine-grained (clayey silt) with a mean grain diameter of 7.36 phi (.006 mm), and a relatively strong mode in the very-fine silt class. The phi-deviation (Inman, 1952) is 1.83 phi-units, and the phi-skewness is 0.33. Mean and median diameters of the ash do not differ greatly from the sediments above and below, although both are less than the average values for other analyses in the core (Table 1). The phi-deviation, 1.8 phi-units, is significantly lower than the average for the core, 2.9 phi-units, and reflects the relatively good sorting of the ash. The size distribution is unimodal with a slight positive skewness, 0.3. Skewness values for other samples in the core are also small and positive, but their particle-size distributions are either polymodal or somewhat uniform, and comparison of their skewness values with that of the ash has little interpretive value (modal comparison is far more meaningful). Positive skewness (tail of fine sediment) is characteristic of sediments which have undergone transport by tractive currents (Friedman, 1961: 520-521). Statistical parameters for particle-size analysis of samples from core 326-36 are given in Table 1, and particle-size distribution curves and sand-silt-clay bar graphs are plotted in Figure 2.

Table 1. Particle-size distribution parameters (in phi notation) from core 326-36 (computed according to Inman: 1952).

Depth in core cm.	Mean Ø	Median Ø	Deviation Ø-units	Skewness Ø
*00	7.3	7.2	3.1	0.0
10	8.3	8.1	2.7	0.1
50	7.9	7.6	2.9	0.1
100	7.8	7.3	2.9	0.2
150	7.9	7.7	3.0	0.1
200	7.7	6.4	3.2	0.4
240 (ash)	7.4	6.8	1.8	0.3
250	8.0	7.2	2.8	0.3
290	7.8	7.4	2.9	0.1
Average exclusive of ash	7.8	7.4	2.9	0.16

* Surface sample is from the top of a small gravity corer used as the activating mechanism for the piston corer.

Figure 2 also shows the vertical distribution of total carbon, carbonate carbon, and organic carbon. Total carbon and carbonate carbon were determined by gasometric analysis using a LECO (Laboratory Equipment Company) induction furnace and carbon determinator (details of procedure are given by Royse, 1964). The difference between per cent total carbon and per cent carbonate carbon is reported as organic carbon. As might be expected, all forms of carbon are low in the ash layer. The low total carbon value is largely a reflection of the absence of organic carbon in the ash, for carbonate carbon is present only in minor percentages throughout the core.

Water contents of subsamples (defined as the ratio of the weight of water in a sediment mass to the weight of the oven-dry solid particles) range from 39.5 to 62.2 per cent. The maximum deviation of water contents from an eye-fitted regression curve is about 3.5 percentage units, except for the value for the ash layer at 240-cm depth which plots 7 percentage units below the regression line.

The bulk of the ash consists of unaltered, clear glass fragments with an average refractive index of 1.505 ± .005. A majority of the grains are subequant in section, with a subordinate number of elongate forms. With the exception of gas bubbles, inclusions of any type are rare, and their minute sizes prevented quantitative treatment. Associated clastic material (less than 20 per cent) consists largely of clay particles with some fresh, angular feldspar and traces of anisotropic mafic minerals.

Age of the Ash

Although the volcanic ash was not dated directly, radiocarbon dates for intervals near the top, middle, and base of the core permitted calculation of depositional rates from which the age of the ash could be approximated. The radiocarbon dates obtained by the total organic-carbon method from Isotopes, Inc., 123 Woodland Avenue, Westwood, New Jersey, were:

Upper core	(0-19 cm)	1,677 ± 120 years
Middle core	(132-150 cm)	4,860 ± 200 years
Lower core	(250-265 cm)	7,754 ± 300 years

The dates were applied to the midpoints of the core interval dated.

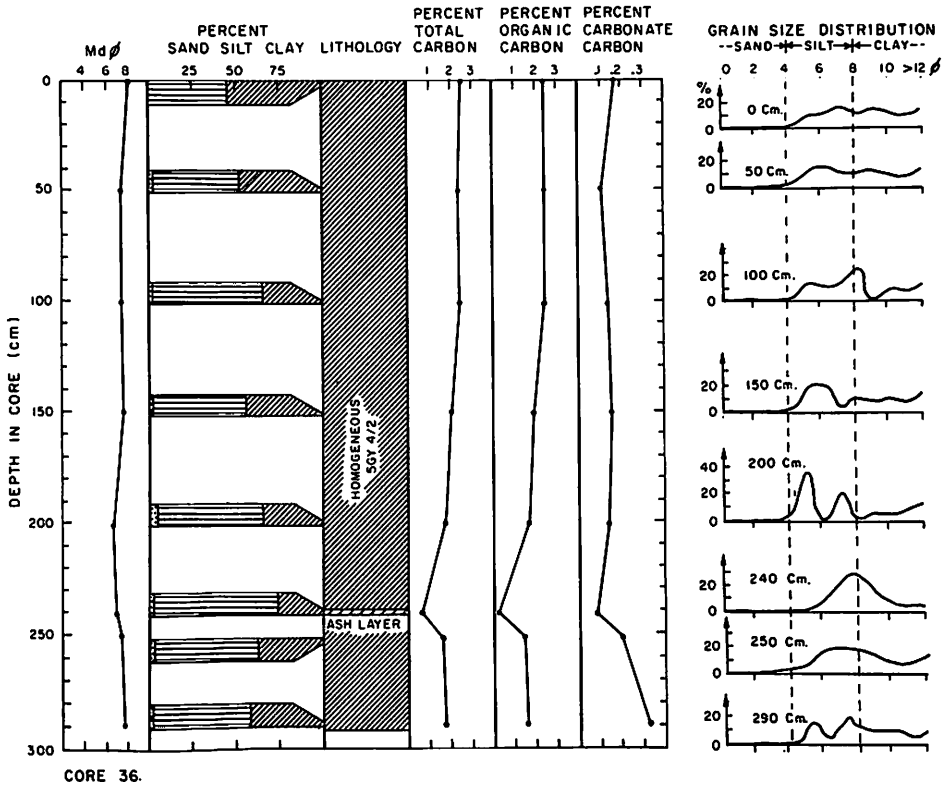

Figure 2. Vertical distribution of sedimentary parameters in core 326-36. Carbon values are expressed as per cent, by weight, of dry sediment.

The average specific gravity of four subsamples from the core was found to be 2.53 g cm^{-3}. This value was used with the average dry bulk densities (calculated from water-content values of Table 2) of the intervals between radiocarbon dates to compute depositional rates. The rates, expressed as mass/area per unit time, are given below.

Upper core	(10-140 cm)	45.7 mg $cm^{-2}yr^{-1}$
Middle core	(140-157 cm)	53.6 mg $cm^{-2}yr^{-1}$
Average	(10-257 cm)	49.7 mg $cm^{-2}yr^{-1}$

Applying the depositional rate and bulk density determined for the lower core to the 13.5 cm of sediment between the base of the ash layer and the lower date, a value of 390 years is obtained for the duration of its deposition. Thus the ash is about 390 years younger than the lower date, or about 7360 $\pm$ 300 radiocarbon years. This calculation is sensitive to the values obtained for bulk and particle densities (particle density is considered constant, but bulk density increases downward as a function of sediment compaction), and the accuracy of the age is therefore subject to the assumptions involved in obtaining these densities.

Table 2. Water content of samples from core 326-36.

Depth cm.	Water %	Depth cm.	Water %
10	62.2	160	51.2
20	58.4	170	50.7
30	59.8	180	52.7
40	58.9	190	48.3
50	56.5	200	48.1
60	57.8	210	47.2
70	56.4	220	45.4
80	53.1	230	47.5
90	52.5	240 (ash)	39.5
100	58.5	250	46.5
110	55.3	260	46.7
120	51.6	270	45.1
130	51.0	280	44.7
140	51.0	290	43.6
150	53.1		

Discussion and Conclusions

The fine texture, good sorting, and thickness (about 4 cm) of the ash layer of core 326-36 suggest it is the product of a single volcanic eruption which occurred a relatively great distance from the continental slope off southern Washington. Ash deposits documenting such events are relatively common in the Northwest and have been the object of increasing interest in recent years. Volcanic activity and ash deposits from Mount Rainier and Mount St. Helens have been discussed most recently by Crandell *et al.* (1962), Hopson *et al.* (1962), Fiske *et al.* (1963), and Mullineaux (1964). Products of the great Mount Mazama and Glacier Peak eruptions have been studied by Rigg and Gould (1957), Powers and Wilcox (1964), and Fryxell (1965).

Crandell *et al.* (1962) recognized six ash beds in the vicinity of Mount Rainier, only two of which are attributed to activity of that volcano. The same beds are noted by Fiske *et al.* (1963). These have inferred ages of 1000-3000 years and greater than 8750 years, respectively, and are of relatively local extent. The other beds are attributed to eruptions of Mount Mazama (6500 years), Mount St. Helens (two beds; 3200 and 300 years), and an unknown source (65-215 years).

Ash falls from Mount St. Helens are apparently quite extensive, extending in a north-northwest direction. But none of those thus far studied (Mullineaux, 1964) are of sufficient antiquity to correlate with the ash of core 326-36.

Of the numerous ash falls recognized in the Northwest by various workers, only those of Glacier Peak and Mount Mazama are of extreme regional extent. The known distributions of these deposits have been presented by Fryxell (1965) and Wilcox (1965). Glacier Peak ash extends eastward and southward from its source into Idaho and Montana, and has an approximate fallout area of 9×10^5 km^2. Mazama ash extends north and east from Crater Lake into southern British Columbia and Alberta, western Montana, and all except the southeastern portion of Idaho; two occurrences are recorded from northern Nevada. It originally blanketed an area of more than 2.6×10^5 km^2 and apparently overlaps the entire region of Glacier Peak ash deposition.

Rigg and Gould (1957) apparently confused samples of Glacier Peak and Mazama ash, which have strong similarity, and assigned an age to the Glacier Peak which is

much too young. This confusion has been rectified by Powers and Wilcox (1964), whose petrographic and petrochemical data provide a basis for differentiation of Glacier Peak and Mazama ash, and by Fryxell (1965), who has provided preliminary radiocarbon determinations which indicate the age of the Glacier Peak ash to be 12,000 ± 310 radiocarbon years. According to Powers and Wilcox, Glacier Peak ash has indices of refraction in the range of 1.495 to 1.500 with values as low as 1.486 rarely encountered. Mazama ash has a slightly higher range with dominant values between 1.500 and 1.510.

A sample of the ash from core 326-36 was submitted to Miss Virginia Steen at the Washington State University Department of Anthropology for examination and comparison with Holocene ash samples of known affinities. According to Steen, many of the ash fragments have indices as great as 1.513 with other fragments indicating a much lower index, the indices for the total sample being somewhat bimodally distributed. A similar bimodal tendency for ash samples presumably derived from Mount Mazama had been previously observed by Steen, and, according to her (personal communication), R. E. Wilcox has also commented on this phenomenon. Miss Steen concluded that the observed index, plus the tendency for material of lower refractive index to be present, spells out Mazama. Thus on the basis of refractive index and age, the ash of core 326-36 closely resembles Mazama ash.

The possibility that the ash was derived from a source other than those discussed above, although apparently slight, is not discounted. Nayudu (1964) recognized three ash layers in cores from the northeast Pacific (primarily the Gulf of Alaska). The youngest of these is correlated with the Katmai eruption of 1912. A middle (or basic) layer is of basic composition (index of refraction equals 1.562-1.565) and has an inferred age of 12,000-15,000 years. The lower (andesitic) layer was found only in the two southernmost cores studied, about 300 and 600 statute miles west of the northern ends of Queen Charlotte and Vancouver Islands, respectively. Physically, this ash resembles that from core 326-36, having the same refractive index (1.505 ± .002) and consisting dominantly of triangular, plate-like, and irregular-shaped fragments. Although Nayudu presents results of size analysis for the upper and middle layers, none are given for the lower layer, and comparison with the size-distribution parameters for the ash of core 326-36 is not possible. Radiocarbon dates from both cores containing the lower (andesitic) ash layer indicate that its age is greater than 25,000 years. The source of the ash is undetermined, but its great age, if it be correct, precludes correlation with the Mazama ash and with that of core 326-36.

Although somewhat greater than the accepted average of 6600 radiocarbon years (Fryxell, 1965), the age of 7360 years is within the range of values reported for Mazama ash. On the basis of age and physical characteristics, the ash from core 326-36 is correlated with the eruption of Mount Mazama.

To the writer's knowledge, no terrestrial ash deposits of known Holocene age have previously been reported west of the Willamette Valley, Oregon, or the vicinity of Olympia, Washington. The proposed correlation of the ash layer in core 326-36 extends the distribution of Mazama ash about 100 miles westward of the nearest reported occurrence. As previously demonstrated by the writer (Royse, 1964), the continental terrace off Washington is essentially an area of sediment bypass. Perhaps a major portion of the ash layer on the continental terrace has been transported down-

slope and mixed with sediments in deeper water. If the ash is not widely distributed, its significance as a stratigraphic marker is reduced, and the chances of obtaining additional samples to substantiate data presented here are lessened. It should be noted, however, that, if it lies at a depth of 2.5 m or more beneath the sediment surface, few cores of sufficient length to penetrate the layer have been taken from the continental slope off Washington.

Particular significance can be placed on the occurrence of Mazama ash on the continental terrace off Washington, because this environment, ecologically as well as sedimentologically, has responded to events on the adjacent continent during Holocene time. The extent of its usefulness in correlating marine and terrestrial postglacial events, however, must await additional evidence of its extent in marine sediments.

Acknowledgments

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