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Distribution, Composition, and Transport of Suspended Particulate  
Matter in the Vicinity of Willapa Submarine Canyon, Washington

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INSTRUMENTS AND METHODS

The light scattering measurements recorded during this study were made with an integrating nephelometer designed after a principle introduced by Beutell and Brewer (1949). Its operational components closely resemble those of an atmospheric-nephelometer designed at the Atmospheric Chemistry Laboratory at the University of Washington (Ahlquist and Charlson, 1968; Charlson, Ahlquist, Selvidge, and MacCready, 1969).

The nephelometer consists of a flashing light source, a scattered light detector system, a data recorder, and the necessary battery power mounted in a self-contained, easily portable, deep-sea housing. As the instrument is lowered through the water column, it continually measures the light scattered from the suspended particulate matter. The scattering profile is recorded internally on a strip-chart recorder, enabling the data to be directly observed and utilized upon completion of a cast. A complete description of the instrument is given by Sternberg and others (1974).

Samples of the suspended particulate matter (for mineralogic and elemental analysis) were collected at each station by means of an *in-situ* filter dump (Baker and McManus, 1971; Baker, 1973b), a system designed to filter large water volumes (as much as several hundred liters) at each sampling point in order to collect sufficient particulate matter for accurate X-ray diffraction (XRD) analysis. Seawater is drawn through a 239 mm diameter cellulose membrane filter (mean pore size, 0.45  $\mu$ ) and a cumulative flowmeter by a flexible impeller pump, then

pumped up a tube and expelled about 7 m above the filter intake. Power is provided by lead-acid batteries completely encased in a pressure-compensating container.

Upon each retrieval of the instrument, the membrane filter was washed free of sea salt by several rinses with filtered, distilled water and stored in a sealed petri dish. In the laboratory, the filters were treated for 24 hrs with 15 percent  $H_2O_2$  to remove the oxidizable organic matter. The remaining inorganic sediment load was isolated by repeated dissolution and centrifugation of the original filter in acetone. The resulting suspension was subsampled for analysis of both clay mineralogy and major element composition.

Oriented mounts for XRD analysis were prepared by filtering the acetone suspension through Sela<sup>R</sup> silver membrane filters (mean pore size,  $0.45\mu$ ). Samples were analyzed on a Phillips diffractometer with  $CuK_{\alpha}$  radiation and graphite focusing monochromator, scan speed  $1^{\circ}20/\text{min}$ . Percentages of clay minerals were computed by the method of Biscaye (1965).

The major element composition ( $MgO$ ,  $Al_2O_3$ ,  $SiO_2$ ,  $CaO$ ,  $MnO$ ,  $Fe_{\text{total}}$ ) of the suspended particulate matter was determined by thin-film X-ray fluorescence (XRF) (Liebhafsky and others, 1972). This technique requires that the sample is very thin (on the order of  $10\mu$ ) relative to the depth of penetration of the characteristic X-rays of the elements of interest, causing the intensity of the measured X-rays to be directly proportional to the mass of each element in the sample. In the usual XRF analysis of pelletized samples which are "infinitely" thick, the measured X-ray intensity is a function both of the concentration of a given element, and of non-uniform matrix effects related to the bulk composition of the sample itself. Applications of this principle to the analysis of thin layers of particulate matter collected on membrane filters have been discussed by Cann and Winter (1971) and Baker and Piper (in press).

The present samples were prepared by filtering a small amount of the acetone suspension through polycarbonate Nuclepore<sup>R</sup> filters (mean pore size, 0.4  $\mu$ ). The characteristic X-ray intensity of each element measured on the sample filters was calibrated by comparison to filters with thin layers of USGS standard rocks W-1, AGV-1, and BCR-1. Samples and standards were counted for 2000 sec at 45 ma and 45 kv on a Kevex<sup>R</sup> energy dispersive XRF system with a Si(Li) detector. The precision of the technique was better than 6 percent for all components except MnO (9.3 percent).

#### CALIBRATION

In order to convert the light scattering data into a geologically useful format, the nephelometer output was calibrated in terms of the mass concentration of particles. Absolute quantification of the light scattering data is a complicated and necessarily inexact procedure, since the total scattering value of a parcel of water is a complex integral of all the properties of all the particles, of which particle mass concentration is only one, albeit major, factor (Jerlov, 1968). The most appropriate and simplest method of calibration thus appeared to be an empirical technique of comparing the recorded light scattering values to the inorganic mass concentration of simultaneously collected suspended particulate matter samples.

During the portion of the cruise this report is concerned with, the flowmeter on the *in-situ* pump system failed and concentration calculations could not be made for comparison to the light scattering records. Since the flowmeter operated successfully during the rest of the cruise, a calibration curve of light scattering intensity vs. inorganic particle concentration has been constructed with data from adjacent waters (Fig. 2 from the main body of the text) (Baker and others, 1974).

It is important to note the limitations on the relationship illustrated in Fig. 2. The sampling program utilized on this cruise yielded concentration values of only the inorganic (and, therefore, depositionally important) fraction of the suspended matter; the data fit might have been improved if values of the total suspended load were available to plot against the light scattering intensity. Furthermore, since the present data cover only a limited and relatively dilute concentration range, it is difficult to predict how or if this empirical relationship may change due to differences in particle size distributions, organic-inorganic ratios, and other properties of natural suspensions which may vary with the particle concentrations.

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