UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

THE DISTRIBUTION OF SELECTED ELEMENTS IN STREAM SEDIMENTS, CENTRAL MAINE

By M. A. Chaffee, J. M. Botbol,
and J. C. Hamilton

Open-file Report

1972

72-66

This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

The distribution of selected elements in stream sediments, central Maine

by

M. A. Chaffee, J. M. Botbol and J. C. Hamilton

Introduction

Samples of sediment were collected between 1956 and 1965 from 6,155 sites in streams in central and southeastern Maine by personnel of the U.S. Geological Survey. Approximately 5700 of these samples were collected during the period 1962-65. The remainder were collected by other projects engaged in geologic mapping and research in techniques of geochemical prospecting. Figure 1 shows the region sampled and the location of the sample sites.

The basic objective of the geochemical mapping project was to prepare a series of geochemical maps and subsequent interpretive reports based on the analysis of stream sediments. It was known from other geochemical studies in Maine and adjacent parts of Canada that geochemical exploration techniques based on the collection and analysis of stream sediments were fast, reliable, and inexpensive means of examining the mineral potential in this area. Thus, it was believed that regional geochemical maps and interpretive reports would provide fundamental geochemical data useful for resource appraisal, mineral exploration, public health purposes, and the understanding of geochemical processes.

The part-time assignment of project personnel in 1965 and 1966 to other activities concerned with higher priority programs slowed the compilation and study of the data from Maine. The massive size of the data set acquired from the analysis of the samples of stream sediments from Maine--over one-third of a million determinations--called for the aid of computer technology to complete the geochemical interpretation in any reasonable period, but at that time the Survey lacked its own computing facilities. The project was recessed in 1967 with the publication of two reports (Post and Hite, 1964; Post and others, 1967). These reports should be consulted for background information about the present study.

By 1968 adequate computing facilities had become available within the Geological Survey, and the large amount of data accumulated in Maine could be processed. The maps in this report and accompanying statistical tables are the initial result of data processing undertaken by Chaffee and Botbol. Hamilton made all of the spectrographic determinations used in this report.

Acknowledgements

The following individuals assisted in the collection and analysis of samples: A. L. Albee, T. M. Billings, E. L. Boudette, M. J. Bright, F. C. Canney, E. F. Cooley, N. P. Cuppels, W. H. Dennen, Maurice DeValliere, G. H. Espenshade, J. R. Fisher, D. L. Granner, Andrew Griscom, D. S. Harwood, D. B. Hawkins, T. D. Hessin, J. B. Hite, D. M. Larrabee, W. L. Lehmbeck, W. P. McKay, E. L. Mosier, G. A. Nowlan, E. V. Post, A. L. Sutton, Barbara Tobin, and G. H. VanSickle.

G. I. Evenden and Walter Anderson of the U.S. Geological Survey provided the computer programs necessary to smooth and contour the geochemical data.

Sample collection, preparation, and analysis

The 6,155 samples of sediment were collected from sites in the active channels of streams in central Maine. A maximum density for sites of approximately one per 2 square miles was attempted, but this density was rarely achieved because of the vagaries of the stream networks and the lack of accessibility in many areas (Post and Hite, 1964). Samples were oven dried at 100°C for 24 hours and then screened through a 250-micron sieve. The minus 250-micron portion was retained for analysis.

Each sample was analyzed for 55 elements using a 6-step semiquantitative spectrographic method modified after the procedure of Myers, Havens, and Dunton (1961), and for citrate-soluble heavy metals (abbreviated in this report as CxHM), cold acid-extractable copper (CxCu) and colorimetric zinc (CmZn), using methods described in Ward, Lakin, Canney, and others (1963).

Only 25 of the original 55 elements run spectrographically have sufficient determinable values to warrant evaluation.[1/] These 25 are aluminum, barium, beryllium, boron, calcium, chromium, cobalt, copper, gallium, iron, lanthanum, lead, magnesium, manganese, molybdenum, nickel, potassium, scandium, sodium, strontium, titanium, vanadium, ytterbium, yttrium, and zirconium. Including the three wet methods, then, 28 chemical variables were completely evaluated.

[1/] The following elements were eliminated in the preliminary evaluation of the spectrographic analyses because of insufficient frequency of detectable metal content: Ag, As, Au, Bi, Cd, Ce, Eu, Ge, Hf, Hg, In, Li, Nb, Nd, P, Pd, Pr, Pt, Rh, Sb, Si, Sm, Sn, Ta, Te, Th, Tl, U, W, and Zn.

Data analysis

Frequency analysis, linear correlation analysis, and factor analysis were used to study the chemical data. In addition, a series of computer-drawn maps was made to show the distribution of each of the 28 elements.

A cumulative frequency distribution of the logarithms of concentrations was compiled for each of the 28 elements. The 25th, 50th, 75th, and 90th percentiles were interpolated from each frequency distribution and are presented in table 1. For all pairs of variables, product moment linear correlation coefficients were computed for the logarithms of the concentrations. The matrix of these correlation coefficients and of the number of valid pairs[2/] is presented in table 2.

An R-mode factor analysis program was used to partition the correlation matrix into from two to ten components. Each component can be considered to be a group of elements that characterizes the geochemistry of a geologic feature or features. We consider the seven-component analysis as most compatible with known geological and geochemical associations. The chemical elements are grouped into each of these seven components in tables 1 and 2.

[2/] The product moment linear correlation coefficient is computed from all observations where both of the variables have detectable metal content. Such observations constitute a valid pair of variables.

Logarithms of the analytical data were used to make a series of computer-contoured geochemical maps (figures 2 through 29). A square coordinate system with lines 0.3 inches apart [3/] (at a compilation scale of 1:250,000) was superimposed on the study area for purposes of gridding the chemical data. All data for a given element within each 0.3-inch grid block were averaged and plotted at the center of the grid block. The gridded data were than smoothed mathematically using a modified bicubic spline function, and the resulting data points were contoured by a Gerber Model 600 plotter. All square areas greater than 4.41 sq inch (at a scale of 1:250,000) that did not contain data were flagged as non-contourable. Contour lines were truncated against non-contourable boundaries. Interpolation in contouring was done on a linear basis.

In order to expedite the release of this report, we utilized the only smoothing and contouring routine available that would acceptably process geochemical data. The contouring routine used was designed specifically for processing aeromagnetic data which characteristically have smooth uncrowded contours and which do not require extensive annotation. The geochemical maps presented in figures 2 through 29 commonly have gradients that change quite abruptly; consequently, some of the small isolated contours are not labelled. Figures 2 through 29 are reproduced at a scale of 1:500,000 to be compatible with the scale of the geologic map of Maine (Doyle, 1967).

[3/] The origin of the coordinate system is the intersection of the east-west line passing 0.15 inch south of the southernmost sample and the north-south line passing 0.15 inch west of the westernmost sample.

General comments

We have not attempted to interpret the geochemical maps presented in this report. We will only call attention to the fact that anomalies do exist and general concentration trends of various elements are present.

Elements associated with manganese (table 2) are commonly enriched in stream sediments because of the efficient scavenging properties of secondary manganese (and probably iron) oxides. Any further geochemical investigations of anomalous areas of any of the manganese-scavenging group elements should be done only after a careful comparison with associated manganese anomalies.

With reference to the previously published geochemical maps showing citrate-soluble heavy metals and cold-extractable copper (Post and Hite, 1964; Post and others, 1967), we would like to point out that the maps of these two variables that are included in this report (figs. 10 and 27) may show anomalies which did not exist on the earlier maps. These new anomalies were produced by new data not available at the time of publication of the earlier maps. In addition, some anomalous values which were present on the earlier maps do not appear as anomalies on the new maps. These values were attenuated on the new maps by the averaging of neighboring values in the gridding process.

REFERENCES

Doyle, R. G., ed., 1967, Preliminary geologic map of Maine: Maine Geological Survey, Augusta.

Myers, A. T., Havens, P. G., and Dunton, P. J., 1961, A spectrochemical method for the semiquantitative analysis of rocks, minerals, and ore: U.S. Geol. Survey Bull. 1084-I, p. 207-229.

Post, E. V., and Hite, J. B., 1964, Heavy metals in stream sediment, west-central Maine: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-278, rev. ed.

Post, E. V., Lehmbeck, W. L., Dennen, W. H., and Nowlan, G. A., 1967, Map of southeastern Maine showing heavy metals in stream sediments: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-301.

Ward, F. N., Lakin, H. W., Canney, F. C., and others, 1963, Analytical methods used in geochemical exploration by the U.S. Geological Survey: U.S. Geol. Survey Bull. 1152, 100 p.