Evaluation of Geochemical Data

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SYNOPSIS

The results of prospecting operations involving geological data and a large number of geochemical determinations of the metal content of soil samples are plotted and evaluated by computer. Anomalous areas are identified in each type of environment by selecting probability or population boundary values from frequency distributions. The anomalies are plotted to permit correlation with geographical or geological features. Ranking of prospecting targets is made using geographic pattern, geology, absolute value and metal ratios. Three short case histories are presented.

INTRODUCTION

Geochemical prospecting is employed to obtain evidence of concentrations of metals or minerals. In systematic prospecting, an area is selected and soil samples are taken at pre-determined and regular intervals along lines laid out at right angles to the known or suspected mineralized zone. These are, statistically, random samples and evaluation using statistical techniques can be employed. If there is a large amount of data, the plot-out and assessment are done efficiently and accurately by a computer.

In Rhodesia, the prospecting organisation of the Anglo American Corporation applies geochemical prospecting of soils to define targets in its search for base metal orebodies. Their laboratories in Salisbury are capable of making $1\frac{1}{2}$ million geochemical determinations annually by the atomic absorption method. To process these data, programs were written in 1969 for an I.C.L. 1500 computer. These were designed primarily for routine plotting and evaluation, but it is possible to use them to do a certain amount of applied research. At the time of writing the programs, there was very little literature directly related to this topic to act as a guide. Much information has been published in the last two years to support the approach and confirm the methods of evaluation.

In routine prospecting, observations are made in the field to record the environmental conditions which exercise the greatest control of metal dispersion at each sample point. Parent lithology of the soil has proved adequate (provided the soil 'horizon' is kept constant) in conditions of relatively thin residual soils. The concentrations of two or three metals in the samples are determined geochemically. The frequency distribution of the metal values shows characteristic patterns for each type of environment.

A graph is plotted with the cumulative percentage frequency on a probability scale and the metal values on a logarithmic or normal scale. The mean, standard deviation and coefficient of linear correlation with the two other metals, can be calculated or estimated.

EVALUATION

Evaluation is made of each type of environment using one, two or three metals. A study of the (non-dimensional) frequency distribution is used to select values whose (two-dimensional) geographical or geological associations are then considered.

In the simplest case, where a single population is present in any one environment type, a value is selected based on the number of samples in the population and the degree of risk the prospecting company is prepared to accept. A map is printed indicating the position of the samples with values greater than the selected values. If they are judged to be unrelated, it is assumed that they form part of the population. If they show geographical or geological association, the reason for the association is investigated further. It should be emphasized that this value (the 'threshold' of some writers) is not 'the upper limit of background fluctuation', but is a measure of probability based on the judgment of the geologist.

Where two or more populations are present, the same technique is used, if the populations are discrete. Where they overlap, separation is attempted on the map rather than on the frequency distribution. From the graph of frequency distribution, the range of values and number of samples are estimated for each population. The break in the curve is used to supply values for the isopleths (isograds). If the mixed zone between two populations is large, it is treated as a separate population. A study of the population map will separate those areas which correlate with data from those which require explanation. These values are assessed using the number of sample positions, their location, pattern and the absolute values to distinguish between areas of overlap and those which are anomalous.

In more complex situations, a comparison is made of the geographical position of the populations of one metal with those of the other metals to test whether there is a relationship. This relationship may be indicated statistically by a coefficient of linear correlation.

The ratios of one metal to another have in some instances shown a characteristic frequency pattern and, using the methods described, have been used to identify areas of abnormal conditions.

CASE HISTORIES

Mphoengs

Some 60 000 soil samples were taken in an area of 197 square miles at 100 × 900-ft centres and the copper and nickel contents were determined. The lithology was mapped on every second or third sampling line, augmented by interpretation of aerial photographs. The lithological boundaries were adjusted to the geochemical populations and all anomalous features listed. These ranged from the identification of an 18 mile-long linear (found to be a fault zone) to an area 10 000 × 1 000 ft (found to be underlain by plagioclase-amphibolite). Priorities for further work were assigned according to absolute value, field relationships, and the copper-to-nickel ratio.

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Majoga

An area of 19 square miles was sampled at 100 × 800-ft intervals. Determinations for copper, nickel, and zinc were made on 5 600 soil samples. The lithology was determined by geological mapping. A population analysis permitted a boundary between two different types of granite, the positions and trends of dolerite dykes, and the boundary between different lithological types beneath a thin pediment cover, to be distinguished. Ten areas were classified as anomalous by the statistical analysis. Work showed that three of the anomalies of highest rank were not related to concentrations of economic promise.

Sheep Farmer

Some 2 600 samples were taken at 50 × 100-ft intervals in an area 2 500 × 5 000 ft overlying a dolerite sheet in granite. A study of the geochemical populations identified a dolerite dyke within the sheet, A- and B-zone sampling over the sheet, areas of brown soil underlain by dolerite, and the position and trend of contaminated granite.

CONCLUDING REMARKS

Interpretation of geochemical populations during routine prospecting is not exact and requires considerable judgment by the geologist at various stages. When compared with the less sophisticated techniques or those requiring a more complex mathematical treatment, the many practical advantages outweigh the risk of misinterpretation.

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SELECTED REFERENCES

BOLVIKEN, B. (1971). A statistical approach to the problem of interpretation in geochemical prospecting. *C.I.M.M., Proc. Third Inter. Geochem. Explor. Symp.*, Spec. vol. no. 11, pp. 564-567.

LEPELTIER, C. (1969). A simplified statistical treatment of geochemical data by graphical representation. *Econ. Geol.*, vol. 64, pp. 538-550.

WILLIAMS, X. K. (1967). Statistics in the interpretation of geochemical data. *N.Z. Jl. Geol. Geophys.*, vol. 10, pp. 771-797.