

Mining Geodesy And Geophysics

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ABSTRACT

The technology of mining geophysics is advancing rapidly in methodology, instrumentation and interpretation techniques. A surprising diversity of approach exists in a number of methods, because of differences in the local geological, geophysical, topographic or even socio-political setting. A general trend is towards the simultaneous gathering of increasingly large amounts of independent geophysical data in airborne, ground or borehole surveys. The resultant challenge is to extract the maximum amount of useful geological information from the mass of field data generated by these surveys. Increasingly, computers perform the task of routine interpretation, using either direct inversion programs or automatic selection from a family of theoretical models. Minicomputers are routinely employed in the control of multisensor airborne systems and in the recording of their output in digital form on magnetic tape. Some simple data manipulation is even being done by such minicomputers in real time prior to recording. Microprocessors are being increasingly incorporated into field portable geophysical instruments for surface and borehole surveys.

INTRODUCTION

The science of geophysics applied to mineral exploration includes a kaleidoscope of methods and techniques, many of which are in a state of rapid flux. At least eighteen fundamentally different methods are in major or minor use in mining geophysics around the world, some being employed in up to twenty variants. There is a zestful difference of opinion on the relative merits of methods, techniques and instrumental approaches, not only between the two main centres of development in North America and the U.S.S.R., but also among the scientists in each centre. These differences of opinion have, through scientific or commercial competition, been instrumental in stimulating advances in the art in both centres. In my opinion, the most significant factor at present in mining geophysics is the data explosion. Through the miracles of 1977 microelectronics we can now endow a man or an aircraft with far more geophysical data gathering capability than would have been dreamed of only a few years ago. For example, airborne radiometric systems record 256 to 1024 channels of data simultaneously, whereas only a year or two ago four channels were standard and ten years ago only a single channel. Airborne electromagnetic systems today rarely gather fewer than six channels of data and many more channels are contemplated. Ground induced polarization receivers commonly produce six channels of data and one even makes one thousand channels available. Computer controlled data acquisition systems are increasingly being used in airborne surveying as are microprocessors in ground based equipment, to facilitate the gathering and manipulation of multichannel data. As a typical example of an integrated airborne geophysical system designed for multi-resource mapping at low level, we may find six audio frequency electromagnetic channels, two VLF EM channels,

four gamma-ray spectrometer channels and a magnetometer channel. The thirteen independent geophysical channels in all are recorded digitally on magnetic tape every half second, or every thirty metres on the ground. Figure 2.1 shows a computer printout of a section of the digital tape from such a survey, with the various geophysical data streams, the altimeter output and the fiducial numbers identified. Eight sets of plans of stacked profiles or contours are normally produced by computer from these various data. This great volume of data strains the human capability to correlate and fully utilize its potential at the present time.

REGIONAL GEOLOGICAL

MAPPING In the field of basic geological mapping, the magnetometer remains the primary airborne geophysical tool, indicating the distribution of the various rock types and minerals through their variation in magnetic susceptibility and remanent magnetization. However, the gamma-ray spectrometer is now almost a constant companion of the magnetometer for regional airborne geophysical surveys, providing a classification of rock or soil types based on their content of potassium, uranium and thorium. A third mapping parameter, namely conductivity, utilizing one of several airborne electromagnetic devices is now available. For this application, multiple frequency measurements or multichannel transient measurements are commonly made in order to cover a broad range of earth conductivities. Radio transmission measurements using VLF and broadcast band stations as source and measuring the ratio of electric and magnetic field components, can also map nearsurface conductivities. These are quantitatively discriminating only in a somewhat lower range of conductivities than those mentioned above since their basic operating frequencies are high by normal airborne electromagnetic standards.

The Airborne

Magnetometer The proton magnetometer is the most commonly used airborne magnetometer. In a stable, well-compensated installation, the best of these can now achieve a useful sensitivity of about 0.1 gamma (at one reading per second). Some high sensitivity (cesium, rubidium or helium) optically pumped magnetometers are also being used for identification of subtle features in areas of low magnetic activity and as vertical gradiometers. Surprisingly enough, many total field self-orienting fluxgate magnetometers are still in operation, mostly in the East, but also in the West because the smooth analog profile data is still preferred by many interpreters.

Upward-Looking

crystal which is lead-shielded from gamma radiation of terrestrial origin. Five hundred and twelve channels of gamma radiation may be similarly recorded from this upward-looking crystal. At least theoretically, the recording of the resulting 1024 channels of radiometric data permits corrections for the effect of atmospheric radon and cosmic radiation into the natural terrestrial spectrum, rock-type identification through absolute levels of uranium, thorium and potassium, as well as their ratios, and an independent check on the energy calibration of the gamma-ray spectrometer at all times. Some attempts are being made to recognize spectrum changes due to overburden attenuation and soil moisture changes, but with as yet uncertain success (e.g. Geodata, 1978). The copious results of such multichannel surveys cannot possibly be compiled and presented in their entirety. In practice, they are corrected for terrain clearance variations, cosmic and atmospheric background and then grouped into four channels, one being "total count" and the other three centred about the primary gamma peak for each of K, U and Th. Corrections are made for Compton interference of the elements so that three "stripped" elemental channels are presented, one for each of K, U and Th, as well

as total count. These elemental channel values may be presented directly, or as ratios, in profile or contour form. Figure 2.3. Computer interpretation of lower layer conductivity derived from Tridem airborne electromagnetic data. Onakawana lignite deposit, Ontario. (Courtesy Ontario Ministry of Natural Resources) Regional aeromagnetic surveys for mapping purposes are normally flown at a mean terrain clearance of about 150 to 300 m (terrain permitting) and with line spacings depending on the ultimate plotting scale. For example, if the plotting scale is to be about 1:50 000 the line spacing may be 500 m (or 0.25 mile) and for 1:100 000 the line spacing may be 1 km (or 0.5 mile) etc. Surveys for specific exploration targets will have line spacings dependent on the expected target dimensions. Compilation of the resultant aeromagnetic data, most of which are now digitally recorded, is now mostly carried out using computer techniques.

Airborne Conductivity Mapping Details of airborne electromagnetic systems for conductivity mapping will be found in the section of this paper on base metal exploration, for which they are more commonly employed. As an example of such conductivity mapping for other applications, consider Figure 2.3. This shows the mapping, by a multifrequency in-phase/quadrature system, of a lignite deposit which is buried under 10 m to 40 m of glacial clays and tills. In this case, the lignite and its associated fire clay horizon has a significantly higher conductivity (25 to 60 millimhos/m) than that of the overlying materials (about 5 to 10 millimhos/m). The conductivities of this contour pl; m were derived by computer interpretation using techniques described more fully in Seigel and Pitcher

GEOPHYSICAL INVESTIGATIONS IN GEOENVIRONMENTAL STUDIES

The major geoenvironmental concerns related to investigations described below include (1) identifying abandoned and concealed mine openings, (2) tracing toxic substances, including metals or radiative species released to air and (or) water, resulting from sulfide mineral oxidation, and (3) delineating geologic structures that control the flow of potentially toxic water. Geologic relations outline the surficial distribution and concentration of potentially toxic sources. Geophysical investigations can provide limited means to trace pollutants and their sources in the subsurface without drilling or opening shafts (King, 1993; Paterson, 1995). If drilling and mine shaft operations are permissible, an additional array of geologic, geochemical and geophysical surveys, including cross-hole tomography and in-shaft techniques, become available, but these are beyond the scope of this discussion.

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REFERENCES CITED

1. Birnie, R.W., Francica, J.R., 1981, Remote detection of geobotanical anomalies related to porphyry copper mineralization: *Economic Geology*, v. 76, p.637-647. Brown, G.C., Cassidy, J. Oxburg, E.R., Plant, J., Sabine, P.A., and Watson, J.V., 1980, Basement heatflow and metalliferous mineralization in England and Wales: *Nature*, v. 288, p. 657-659.
2. Corwin, R.F., 1990, The self-potential method for environmental and engineering applications, in Ward, S.W., *Geotechnical and environmental geophysics*, v.I: p. 127-145. Criss, R.E., and Champion, D.E., 1984, Magnetic properties of granitic rocks from the southern half of the Idaho batholith--Influences of hydrothermal alteration and implications for aeromagnetic interpretation: *Journal of Geophysical Research*, v. 89, no. B8, p. 7061-7076.
3. Dave, N.K., Lim, T.P., Siwik, R., Blackport, R., 1986, Geophysical and bihydrogeochemical investigations of an inactive sulfide tailing basin, Noranda, Quebec, Canada. National Symposium on Mining, Hydrology, Sedimentology and Reclamation, University of Kentucky, Lexington, KY, Dec. 8-11, 1986, p.13-19. Davis, J.L., and Annan, A.P., 1992, Applications of ground penetrating radar to mining, groundwater, and geotechnical projects: selected case histories, in Pilon, J., ed.,
4. Ground penetrating radar, Geological Survey of Canada, Paper 90-4, p.49-55. Durrance, E.M., 1986, Radioactivity in geology, principles and applications: Ellis Horwood Ltd., 441 p. Guerin, Roger, and Benderitter, Yves, 1995, Shallow karst exploration using MT-VLF and DC resistivity methods: *Geophysical Prospecting*, v. 43, no. 5, p. 635-654. Hanna, W.F., 1969, Negative aeromagnetic anomalies over mineralized areas of the Boulder batholith, Montana: U.S. Geological Survey Professional Paper 650-D, p. 159-167. Henderson, R.J., 1992, Urban geophysics-a review: *Exploration Geophysics*, v. 123, p. 531-542. Hoover, D.B., Grauch,
5. V.J.S., Pitkin, J.A., Krohn, D., and Pierce, H.A., 1991, Getchell trend airborne geophysics-an integrated airborne geophysical study along the Getchell trend of gold deposits, North-Central Nevada, in Raines, G.L., Lisk, R.E., Schafer, R.W., and Wilkinson, W.H., eds., *Geology and Ore Deposits of the Great Basin*, Geological Society of Nevada, v. 2, p. 739-758. Hoover, D.B., Heran, W.D., and Hill, P.L., eds., 1992, The geophysical expression of selected mineral deposit models: U.S. Geological Survey Open-file Report 92-557, 129 p.