NOTES

10TH INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM AND THIRD SYMPOSIUM ON METHODS OF GEOCHEMICAL PROSPECTING

Symposium held in Espoo/Helsinki, Finland, August 29 – September 2, 1983

Geological surveys of Nordic countries organized the 10th International Geochemical Exploration Symposium and the 3rd symposium on Methods of Geochemical Prospecting in Espoo, Finland, between August 29 – September 2, 1983. This symposium was a joint meeting of the Association of Exploration of Geochemists and the International Association of Geochemistry-Cosmochemistry (IAGC) – Working Group on Geochemical Prospecting.

The symposium was attended by about 300 participants from 34 countries. Large groups came from host Finland, USA, USSR, Canada, Sweden, Norway, Federal Republic of Germany and the Netherlands. I was the single participant from India.

Topics selected for oral presentation at the symposium included (1) Bedrock geochemistry, (2) New approaches in exploration geochemistry, (3) Till geochemistry in exploration, (4) Mode of occurrence of elements, (5) Non-lithological factors affecting dispersion, and those included for poster session were (6) Reconnaissance geochemistry, and (7) Statistical method. Other special features of the symposium included: (a) State of art report and key note lectures by distinguished geochemists (b) Pre-symposium 2-day workshop on (i) Till geochemistry, (ii) Biogeochemistry, (iii) Hydro-geochemistry, (iv) Bulk standard samples to be used in exploration geochemistry and (v) Threshold and anomaly interpretation.

The four keynote papers presented during the symposium were (1) R. W. Boyle – The prospect for geochemical exploration—predicted advances and new approaches (2) S. V. Grigorian – Primary halos in mineral prospecting (3) V. K. Lukashov – Mode of occurrence of elements in the secondary environment and (4) W. W. Shilts – Till geochemistry in Europe and North America. Four invited papers included (1) R. Fritisch – Metallogenesis of Finland, Norway and Sweden, (2) R. J. Howarth – Statistical applications in geochemical prospecting: a survey of recent developments (3) N. A. Shaikh – Industrial minerals and rocks in Finland, Norway and Sweden, (4) L. V. Tauson – The geochemistry of Precambrian terrain.

The symposium was held in 6 sessions. *Session 1* included invited state of art papers, reported as has been mentioned above. *Session 2* concerned the 'Bedrock Geochemistry in Mineral Exploration'. In a paper entitled 'The Geochemistry of heavy mineral concentrates from rocks associated with the South Bay massive sulphide deposit, Ontario, Canada: An exploration technique' M. E. T. Allen and I. Nichol brought out a clear relationship between geochemistry of heavy mineral fraction in rocks and mineralization. This deposit is located in Archaean greenstone belts of the Canadian shield. In India, we have most of the base metal deposits located in similar situations, and therefore, the study is of interest to us. After removing the magnetic fraction, the heavy fraction was pulverized and analyzed for Pb, Zn, Ag, Fe, Mn, Co and Ni. Corresponding pulverized whole rock samples

were analyzed to provide basis for comparision of the composition of the heavy mineral concentration obtained from rocks.

The results of whole rock samples delineated halos of Pb and Ag extending 1.5 km, and Zn halo extending 2.5 km both along strike, and away from the deposit.

Analysis of the corresponding heavy mineral fractions of rocks revealed strong and extensive halos of Cu, Pb, Zn and Ag surrounding the South Bay massive sulphide deposit. Likewise papers of interest to us in India concerning exploration/case histories of tin-tungsten deposits were also presented. The tin-tungsten deposit in the Surprise Lake, Canada (S. B. Ballantyne and D. J. Ellwood) was discovered by stream sediment and stream water survey method during a regional reconnaissance programme. The survey first indicated a 'metallogenetically specialized granitoid'. Computer-generated coloured maps of regional data showed Mo-W-Zn-Sn-F elemental association, and pointed out Sn-W and Sn-Zn anomalies. Lithogeochemical investigation and detailed follow-up stream sediment studies (heavy mineral, size fraction analyses) led to the discovery of unknown Sn-W mineralization. The geochemical characteristics and similarity to Tischendorfs 'specialized' tin-granite classification indicates that this 'tin-fluorine' granite intrusion is taken as an example of highly evolved silicic magma enriched is such fluoropile elements as U, Th, F, Sn, Pb, Nb, Y, Cs, REE, Be etc. and depleted in Sr, Ba and Zr compared to average low-calcium granites. Boron was found to be absent. It is found that Sn-W and Sn-Zn mineralization is dependent on availability of magmatic meteoric hydrothermal fluids circulating in convection cells releated to deeply penetrating fractures produced during the rupturing of the outer crystallized granitic carapace.

In a paper on 'Composition of cassiterite and its application in geochemical prospecting' I. Happella (Finland) showed that in a rapakivi granite (1600 Ma) in sw Finland, cassiterite showed three different rypes of occurrences, namely (a) as an accessory mineral in geochemically specialized topaz-bearing alkali-feldspar granite (average tin content 80 ppm), (b) in pegmatite veins and pockets, and (c) in greisen veins. Electron microprobe analyses showed that the composition of the cassiterite varied systematically with the occurrence specially of Nb, Ta and Fe contents as under:

	Nb_2O_5%	Ta_2O_5%	FeO%
Cassiterite granite	3.5	2.5	1.8
Cassiterite in pegmetite	2.2	0.5	1.2
Cassiterite in greisen	0.3	0.0	0.1

The composition difference indicates that the accessory cassiterite was not formed in association with the greisenization but was probably a primary constitutent of the rock. In view of the deficiency of tin-tungsten deposits in India, and attempts to survey for cassiterite in Gaya and Bastar regions, these studies may be of particular interest.

Similarly a paper by G. J. S. Govett *et al* in the use of rock geochemistry in exploration for gold in Australia should be of interest to us.

The London-Victoria Lode-type deposit of gold lies within Palaeozoic tuffaceous, andesitic rocks. Soil geochemistry was the main technique used to define drill targets, whereas rock geochemistry was utilized as an aid to drill-core interpretation. Rock geochemical work led to information that base metal mineralization was present 30-70 metres from the lode gold deposits. Interpretation of the geochemical signature for major elements (Ca, Mg, Na, K, Fe) and trace elements (Cu, Pb, Zn, Mn) is confused by an overlap and merging of responses from the two types of mineralization.

The measurement of bromine-soluble Sb, As, Bi and Te, along with conventional major and trace elements allowed for the discrimination of geochemical halos due to gold and base metal mineralization. These results demonstrate the use of rock geochemistry for gold exploration, its usefulness in understanding geological features, and the utility of a bromine-soluble trace elements commonly associated with gold mineralization.

E. M. Cameron and C. E. Dunn presented work to illustrate the role of geochemistry in the integrated search for deeply burried deposits of uranium at the Athabasca Basin, Saskatchevan, Canada. Geologically the area consists of metamorphosed Archaean-early Proterozoic basement and unmetamorphosed sandstone of late Proterozoic age. At first sight the Basin is unpromising for geochemical surveys. The Athabasca sandstone is silica-rich, and has a very low background for most elements, including uranium. However, there is dispersion of ore and associated elements along fracture zones which host the deposit.

Integrated geology, geochemical and biogeochemical surveys in mineral exploration was illustrated in a report presented by B. F. Leonard and T. A. Erdman of the US Geological Survey. The survey was conducted for exploration of Mo, W, Sn deposits. The Idaho batholith in Red Mountain, Yellow Pine District, U.S.A. has several varieties of granites, granodiorite, alaskite, narrow dykes of rhyolite, and latite. There are also alteration zones. Although metal anomalies in soils are weak and small, the metal anomalies in plants are strong, large and consistent with the inference of a concealed elliptical zone which may contain more than one mineralized belt. This work illustrates that non-detection or weak anomalies need not be interpretated as absence of mineralization. In this case ash analysis of fir trees indicated anomalies. Papers of interest in *Session 3* included use of metal indicator microorganism, *bacillus cerus* as possible aid in mineral exploration by J. R. Walterson *et al,* and a paper on use of lead isotopes in assessing mineral prospect by B. L. Gotson and M. Vaasjoki. Mercury cup technique for locating base metal mineralization was presented by J. Dunkhase *et al.* The mercury cup technique is rather old now, following the principle of use of soil gas mercury, as recommended by Robbins a decade back. Paper by M. Hale *et al* on Laser ablation of stream sediment pebble coatings for simultaneous multielement analysis in geochemical exploration should be of equal interest. *Session 4* dealt with 'Till Geochemistry in mineral Exploration'. This included keynote address by W. Shilts on the topic. Till geochemistry is not likely to be applied very much in India, except in some regions of higher Himalayas, where we would like to apply this technique. G. H. Wabber and R. H. Grice showed the use of water and stream sediment composition in exploring Zn-Pb-Au deposit at Montauban, Quebec. *Session 5* which dealt with 'Mode of Occurrence of Elements and Non-lithological Factor Affecting Dispersion Patterns' had the keynote address by V. K. Lukasheo on 'Mode of occurrence of elements in the secondary environment'. This session had 9 papers dealing with the application of statistical methods, analysis technique, and methods in reconnaissance surveys. Paper by C. V. Chork and B. I. Cruikshank on the application of statistical map analyses technique to reconnaissance stream sediment data from the Seigal (N.T.) and Headleys Creek (QLP) areas, Australia was very much appreciated, as also the paper on multivariate screening of training sets for classification and the definition of geochemical background by B. L. Olesene and A. Armour – Brown. Use of Plasma mass spectrometer method in base metal and gold determination was discussed by T. A. Smith *et al.* D. T. Runnells. R. R. Lindberg presented geohydrologic exploration modelling using

equilibrium modelling (pH-Eh) relationship. *Session 6* was a poster session. In this session were displayed posters of 73 papers/investigations covering aspects of geochemical exploration as sampling methods, anomaly detection and path finder elements, biogeochemistry in marine mineral exploration, statistical data interpretation, and several case histories, which were indeed very informative. In the paper entitled ' A simple field character in mineral exploration programme : an example of geobotanical prospecting in India ', G. S. Roonwal, K. M. M. Dakshini and S. K. Gupta, identified *Vernonia Cinerea* and *Asphodelus tenuifolius* as the plant species which could be helpful in locating copper deposits. The investigation established a relationship between flower colour, geochemistry of the plants and geochemistry of soils.

Use of Primary Halos in mineral prospecting : In his keynote address Prof. Grigorian (read in absentia) emphasised development of a theoretical basis for geochemical prospecting. Such studies have to be based on detailed investigation of primary geochemical halos around ore bodies. Multicomponent primary geochemical halos accompany all endogenous ore deposits. Primary geochemical halos are larger than the ore body itself. Further, the geochemical zonality is a distinctive feature of the primary halos of ore bodies. Many sulphide deposits are characterized by common path-finder elements of endogenous deposits such as W-Be-Sn-Mo-Co-Ni-Bi-Cu-Zn-Pb-Ag-Cd-As-Sb-Ba-Hg-I. In the case of primary halos of small size and intensity, they can be enhanced by employing a method of multiplication of element contents to detect the anomaly. The zonality of multiplicative halos can be useful also in distinguishing supra-ore halos (useful for locating blind deposits) as well as in obtaining information on the level of erosion with respect to mineralization.

Predicted advances and new approaches : Geochemical surveys based on secondary dispersion patterns in waters, soils and stream sediments have successfully guided in locating mineral deposits. R. W. Boyle, in his lecture brought out that in future we can expect refinements of these methods and use of floats, light and heavy mineral surveys in soils, lake and stream sediments etc. Such surveys will prove to be particularly usefull in locating gold, tin-tungsten, and platinoid deposits. He also predicted that more sophisticated overburden drilling techniques for sampling would be employed in future exploration.

Another new line which would be used in exploration is the use of primary halos and primary and secondary leakage halos. Such surveys offer good possibility in discovering blind mineral deposits, either buried below overburden or within their host rocks. In this category we can expect increased use of various techniques utilizing analyses of surface rock samples and drill cores to define the anomaly. Recommended particularly is the application of various ratios such as K/Na, Th/U etc. to estimate approach to ore, the determination of changes in both vertical zonation of elements in mineral deposits for estimating occurrence of ore, and in the determination of changes in geothermometric, geobarometric thermoluminescence parameters to aid in assessing extension of ore in depth or in areal distribution.

Another approach is the use of groundwater, since groundwaters generally have deep penetrative power in most mineral belts. Groundwater samples thus provide excellent media for analysis in geochemical surveys. According to Boyle, this media will find more use in detailed surveys both for discovering of raw mineral deposits and in working out the extension of existing deposits.

Geobotanical surveys utilizing analyses of plant ash will find more use, because shrubs and trees can draw metals from relatively deeper zones. We should anticipate refinements in the techniques of biogeochemical prospecting.

Geochemical methods in the near future will be more used in search for petroleum and natural gas deposits. New approach will be based on detection of hydrocarbon halos in overburden and bed rocks to locate concentration of oil and gas. Gas as indicator, such as radon should find use in such surveys.

Further research in refinement of use and detection of pathfinder elements should attract more attention. Attention is likely to be given also to mineralizers such as B, CO_2, S, Cl, Br, I and F. All this will involve finer tuning of rock, soil, stream sediments, and biogeochemical surveys. Another predicted use is that of stable and radioactive isotope in locating mineral deposits. Such studies are attempted in Sweden, and a paper to this effect was presented by O. Toverud on work carried out for locating tungsten deposits in Sweden. Boyle concluded by adding that mathematical interpretative procedures will certainly be improved for use in geochemical surveys. Another line of improvement will be in analytical methods for estimating the content of less abundant elements such as Au, Pr, Bi in geological materials.

It may be concluded that geochemical exploration will come to play a more important role in future exploration programmes. But such methods are being adopted generally by advanced countries where new technology is developing during exploration jobs. In less advanced countries the situation is different. Even normal geological base maps are not available. Nevertheless, in areas where such information is available, geochemistry can play a significant role in national development. In India, the Geological Survey of India and the Mineral Exploration corporation and other sister organisations could entrust investigations to university departments on a limited basis. In Australia, America and Canada services of University graduate students are utilized as one can see from the papers presented in this symposium. Involvement of University teachers in mineral exploration programmes could perhaps be planned on a project basis with mutual benefit to both the organisations.

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SYMPOSIUM ON HYDROLOGIC REMOTE SENSING AND REMOTE DATA TRANSMISSION

An International Symposium on Hydrological Applications of Remote Sensing and Remote Data Transmission was held during the period August 18-25, 1983 in Hamburg, Federal Republic of Germany.

The symposium brought together international specialists in research, operational procedures, and training related to remote sensing and remote data transmission in the broad fields of hydrology, hydrometeorology, and water resources. Over 100 papers related to these broad fields formed the programme for 19 oral and three poster sessions covering such topics as precipitation, snow and ice, surface water, soil moisture, groundwater, hydrogeology, water quality, coastal and wetlands hydrology, water use, and water-resources planning and management. Authors from 22 countries were represented by the presentations. Most of the papers will be post-printed in an IAHS proceedings volume. The proceeding will be available by spring and may be purchased from the IAHS Treasurer, 2000 Florida Avenue, N.W., Washington, D.C. 20009, U.S.A.