GEOBOTANICAL EXPLORATION

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The effective use of geobotany and biogeochemistry in mineral exploration requires an under standing of the relationship between the distribution of vegetation communities and all the environmental factors in space and time. While this may appear a formidable task, in practive the experienced biogeographer/geobotanist can readily distinguish individual vegetation units, appreciate the factors governing their distribution and recognize anomalous plant communities and indicator species. Geobotanical data recording, geochemical and biogeochemical sampling, however, is normally required to elucidate the precise relationships which assist the location of ore deposits.

Since 1945 geobotany has formed an integral part of mineral exploration in the U.S.S.R. In the 1950's it was successfully used in the search for copper ores in Katanga (Duvigneaud 1958 and 1963) and Zambia (Mendelsohn ed: 1961) where *Becium homblei* effectively demarcates toxic ground within the savanna woodlands and in the search for uranium ores on the Colorado plateaux of the U.S.A. where the selenium accumulators *Astragalus pattersoni, A. preussi, Aster venustus* are restricted to seleniferous soils which occur over the uranium bearing rocks in semi arid low shrub country (Cannon 1957, 1960).

Subsequently an assemblage of *Polycarpaea glabra, Eriachne mucronata* and *Tephrosia sp. nov.* was found to delineate lead/zinc and copper deposits within the low tree and shrub savanna of the Mt. Isa - Cloncurry area of Australia, (Nicholls, Provan, Cole and Tooms, 1965) and one of *Polycarpaea synandra* var *gracilis* and *Tephrosia* affin *polyzyga* to be restricted to lead/zinc deposits in the savanna woodlands of the Bulman area of Arnhem Land (Cole, Provan and Tooms 1968) while within the tropical forests of Bougainville Island, New Guinea, a particular tree assemblage featured the highly copper toxic ground and a distinctive *Albizia sp.* tree was confined to the now well known porphyry copper deposit. (Cole, 1966 unpublished). In all these areas geobotany was effectively used in exploration.

In the above mentioned areas the mineralized bedrock either outcropped or suboutcropped at shallow depth.

In a recent exploration programme in South West Africa and Botswana which was aimed at the discovery of stratiform copper deposits in concealed Proterozoic sediments, believed to be correlatives of the Katanga System of Zambia, geobotany located mineralized bedrock beneath a variable cover of Kalahari sand and calcrete. In low trees and shrub savanna near Witvlei, S.W.A., the recognition of anomalous communities of *Helichrysum leptolepis* led to the discovery of several zones of cupriferous argillite and one of these has become an exploration target. (Cole and le Roex in preparation). The same species was subsequently found over the copper/nickel ore deposits at Thakadu, Matzitamma and Pikwe in eastern Botswana. South of N'Gwaku pan in western Botswana, a monospecific shrub community of *Ecbolium lugardae* which replaces a mixture of diverse shrubs and grasses as the understorey in the low tree savanna woodland characterized by *Acacia fleckii, A. erubescens* and *Terminalia prunioides*, outlines an area where copper bearing argillites and

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limestones suboutcrop beneath some ten feet of calcrete (Cole 1971, Cole and le Roex, in preparation). Subsequent checking disclosed that *Ecbolium lugardae* occurred with other indicator species over the Palabora carbonatite copper deposit, likewise in a calcareous cupriferous environment.

On the fringes of the Kalahari south east of Rehoboth in South West Africa where long parallel dunes are orientated at right angles to the inferred geological strike of the same sequence of rocks, biogeochemical sampling of deep rooting shrubs in the intervening swales or straate has proved the most effective exploration tool in locating mineralized bedrock. It has also proved the most succesful in areas with colluvial and alluvial cover. (Cole and Boshoff, in preparation).

The distinctive plant communities which, in Europe and North America, distinguish areas underlain by ultra basic rocks, including serpentinites, which contain relatively large amounts of nickel, suggested that geobotany and biogeochemistry might assist exploration for nickel ores.

Investigations carried out in Rhodesia demonstrated discrete compositional changes in the savanna woodland vegetation producing a weak geobotanical anomaly, and the presence of indicator species over the Empress nickel/copper ore deposit. They revealed, that biogeochemistry most effectively outlined the ore body and distinguished between geochemical anomalies of similar magnitude emanating respectively from the sulphide ore body and from near surface oxidized copper/nickel bearing material, capping the nearby Barebottom Hill. (Cole, unpublished, 1968. In press, 1971, and in preparation).

In western Australia geobotany and biogeochemistry are prejudiced by the unfavourable combination of winter rainfall and summer drought which favours the dominance of sclerophyllous trees and shrubs which restrict transpiration and reduce moisture uptake so that the effects of toxic elements in the soil are minimal. Additionally, the widespread occurrence of laterite and lateritic weathering products over the higher ground, and of colluvial, alluvial and lacustrine material over the lower ground, limits the extent of residual soils derived from bedrock and complicates the relationships between vegetation and geology. Nevertheless in the search for nickel ore bodies, differences in the species composition of the woodlands provide some guide to the nature of the underlying bedrock, while treeless zones with distinctive shrub communities occur in areas where there are respectively either high copper and nickel or high chromium concentrations in the soil.

Striking geobotanical anomalies characterized the great iron ore bodies of Cerro Bolivar, Cerro Altimira and San Isidro in Venezuela and, of the Hammersley range area of Australia where the close relationships between vegetation, geomorphology and bedrock geology provided direct leads to the existence of iron rich provinces.

Recent applications of geobotany and biogeochemistry to the elucidation of some circular features in Botswana, have made it possible to distinguish between some kimberlites and the slight eminences representing topographic highs in the Cave Sandstone landscape prior to its burial by the Stormberg lavas of the Karoo System and subsequent cover by Kalahari Sand.

Recently a combination of geobotany, biogeochemistry and multispectral photography has been tried out in an attempt to locate mineral deposits in both calcareous and sand covered environments in South West Africa and Botswana. Here the detection of weak biogeochemical anomalies by enhanced infra-red photography offers some promise. A remote sensing programme, using multispectral photography and an infra-red line scan, will begin shortly over areas with known geobotanical anomalies associated with known bedrock mineralization in Australia.

Summarising, geobotany and biogeochemistry are effective tools in exploration for lead, zinc, copper and nickel deposits in diverse environments, provided always that the influences of all environmental factors are considered both in programming the investigations and in interpreting the field and analytical data. They are especially effective in areas of summer rainfall which causes particularly toxic conditions during the period of active growth. In semi arid areas the well defined anomalous plant communities may be composed of indicator species belonging to genera of winter rainfall areas which survive by virtue of their ability to restrict moisture uptake. Biogeochemical anomalies are generally of higher magnitude in summer rainfall areas. Geobotanical and biogeochemical anomalies are most strongly developed over deposits of highly toxic metals, notably lead, and copper, while they are more prevalent in an acid environment than a calcareous one where calcium carbonate in the soil counters the effect of toxic elements. Geobotany and biogeochemistry are most effectively used when appropriately phased with remote sensing, geochemistry, geophysics and field geology in an integrated exploration programme.

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Discussions

S. Dijkstra thought that M.M. Cole's remark to the effect that no special botanical knowledge was required in the application of geobotany, appeared to belittle her own professional investigations in this field. He would like to ask the author if she could give any practical hints in terms of plant species selection, parts of plants to be sampled and ashing produces in biogeochemical exploration.

M.M. Cole replied that indeed the ability to observe the unusual was one of the primary requirements in geobotany. The presence of a wide variety of plant species, including deep rooting shrubs, constitutes favourable conditions under which to perform a biogeochemical survey. In principle all parts of the plant can be sampled including leaves, twigs, etc. Copper anomalies, for example, are often most clearly revealed by the leaves. As far as ashing is concerned, the author replied that this was usually done in the laboratory rather than in the field.

A member of the audience suggested that the application of geobotanical exploration might be rather difficult in tropical areas with dense vegetation.

M.M. Cole's answer was that in such a situation the use of indicator trees instead of shrubs was quite feasible and had in fact been done on the Solomon islands. She illustrated her point by showing an infrared photograph of an area in which copper anomalies had been found. Due to a lower degree of reflectance, leaves of trees close to the anomalies displayed a less bright colour than leaves of trees outside the anomalous areas.

To I. de Magnée's question concerning the mode of occurrence of copper in slates, the author replied that the copper occurred in the form of copper sulphides.

A.G.A. Everts wanted to know when one should consider the use of infrared photography.

Miss Cole answered that this depends on the aim and the scale of the operation. Such techniques are probably most effectively employed in large scale operations.