Biogeographical/Geobotanical and Biogeochemical investigations connected with exploration for nickel-copper ores in the hot, wet summer/dry winter savanna woodland environment

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SYNOPSIS

The Empress nickel/copper deposit west of Gatooma in Rhodesia occurs within gabbro and amphibolite, disposed at the contact of a granodiorite stock (Barebottom Hill) and the surrounding greenstones of the Archaen Bulawayan System. The orebody has a pipelike form and a poor surface expression due to plantation of the area by Miocene (Africa) and later Victoria Falls erosion cycles. Barebottom Hill represents a monadnock remnant in the geomorphological surfaces while traces of the once larger Empress orebody have been removed.

Limitations in soil geochemistry necessitated both studies of the vegetation ecology and the biogeochemistry of the area, both of which were anomalous. The use of geobotany was found to be restricted but biogeochemistry offers a most effective prospecting tool and was found to define the sub-outcrop of the ore-body more precisely than soil geochemistry since these methods reflect and differentiate anomalies emanating from bedrock mineralisation and those due to surface phenomena.

INTRODUCTION

The Empress nickel/copper deposit occurs in level terrain covered by open savanna woodland some thirty miles west of Gatooma, Rhodesia (Fig. 1). It was known by ancient people whose old workings were prospected in 1926-29. Subsequently the ore body was outlined by soil geochemistry, magnetic and electro-magnetic surveys and by diamond drilling.

The poor surface expression of the ore body coupled with the problems of distinguishing between comparable geochemical anomalies over the ore body and over unmineralized bedrock both in the Empress area and elsewhere in Rhodesia suggested investigations aimed at establishing the role of geobotany and biogeochemistry in the search for nickel/copper ores in the savanna woodland environment.

Geobotanical reconnaissance was undertaken by the author in May, 1966, when a new species of *Barleria* growing only over the sub-outcrop of the nickel/copper deposit and over oxidized copper bearing material on Barebottom Hill, one mile to the west, was discovered. Follow-up geobotanical and biogeochemical investigations were carried out under the author's direction by Misses L. Coupland and J. Cudmore in March/April 1967 i.e. at the end of the rainy season when the grasses could be readily identified and most trees and shrubs were bearing fruit. Some small shrub and herb species, including the *Barleria sp. nov.*, which flower after the grasses have died down, were not apparent at this season, however, and some indicator species may have been missed.

A list of the various species of plants mentioned in the text is given in the Appendix for reference purposes.

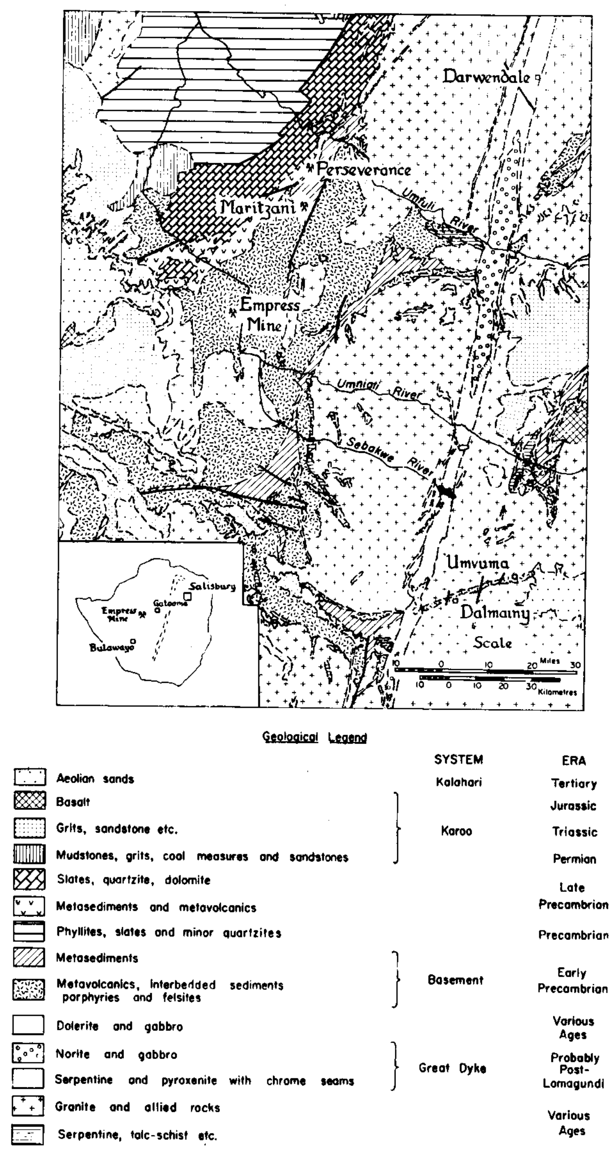

Fig. 1—Regional geology of the area around Empress Nickel mine.

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GEOLOGY

The Empress nickel/copper deposit occurs within gabbro or amphibolite host rock of proterozoic age disposed at the contact of a granodiorite stock and the surrounding greenstones of the Archaean Bulawayan system which forms part of the Basement Complex (Figs. 1 and 2). A gradational Mixed Zone occurs between the granodiorite and the gabbro. The stock, the Mixed Zone and the gabbro together have an oval trumpet-like form, inclined slightly to the north east, with dips of about 65°. The ore body, which has a pipe-like form, occurs at or close to the south western contact of the gabbro and greenstones. Andesitic dykes which are post mineralization and probably of Jurassic age cut through all the rock units.

Nickel/copper mineralization occurs in both the gabbro and the Mixed Zone, the ore body being defined by a combined nickel and copper content of one per cent and over. This occurs in the central portion of the gabbro; in places it extends to the greenstone contact but usually is separated by an intervening low grade section. At surface the ore body has a strike length of 3 000 ft and an average width of 70 ft, with a maximum of 200 ft. It tapers in depth. The mineralization comprises blebs, masses and minute veinlets of pyrrhotite and chalcopyrite, with pyrrhotite, pentlandite, the only significant nickel bearing mineral, chalcopyrite, pyrite and violarite as the most abundant minerals.

The nickel/copper ore body has very little surface expression. It does not produce a relief feature or a conspicuous gossan. Over the level terrain it weathers to a soft clayey decomposed rock with, in places, a single layer of rounded boulders of more resistant material beneath which weathering extends to a depth of 50 ft. The only evidence of sub-surface mineralization occurs, rarely, where the boulders have cavities formed by the leaching of sulphides on their outer weathered surfaces or display fresh rock with disseminated pyrrhotite and chalcopyrite in their centres. Occasional minute specks of malachite are the only indications of copper mineralization in the clayey decomposed rock.

Over Barebottom Hill, which forms a prominent feature rising some 120 ft above the level terrain west of the Empress ore body, the bald appearance caused by the absence of trees coupled with abundant malachite staining on the rock outcrops provide obvious evidence of mineralization. This, however, is confined to a capping of oxidized copper bearing material within a zone of altered gabbro which is underlain in turn by barren altered lineated rock and greenstones. This oxidized

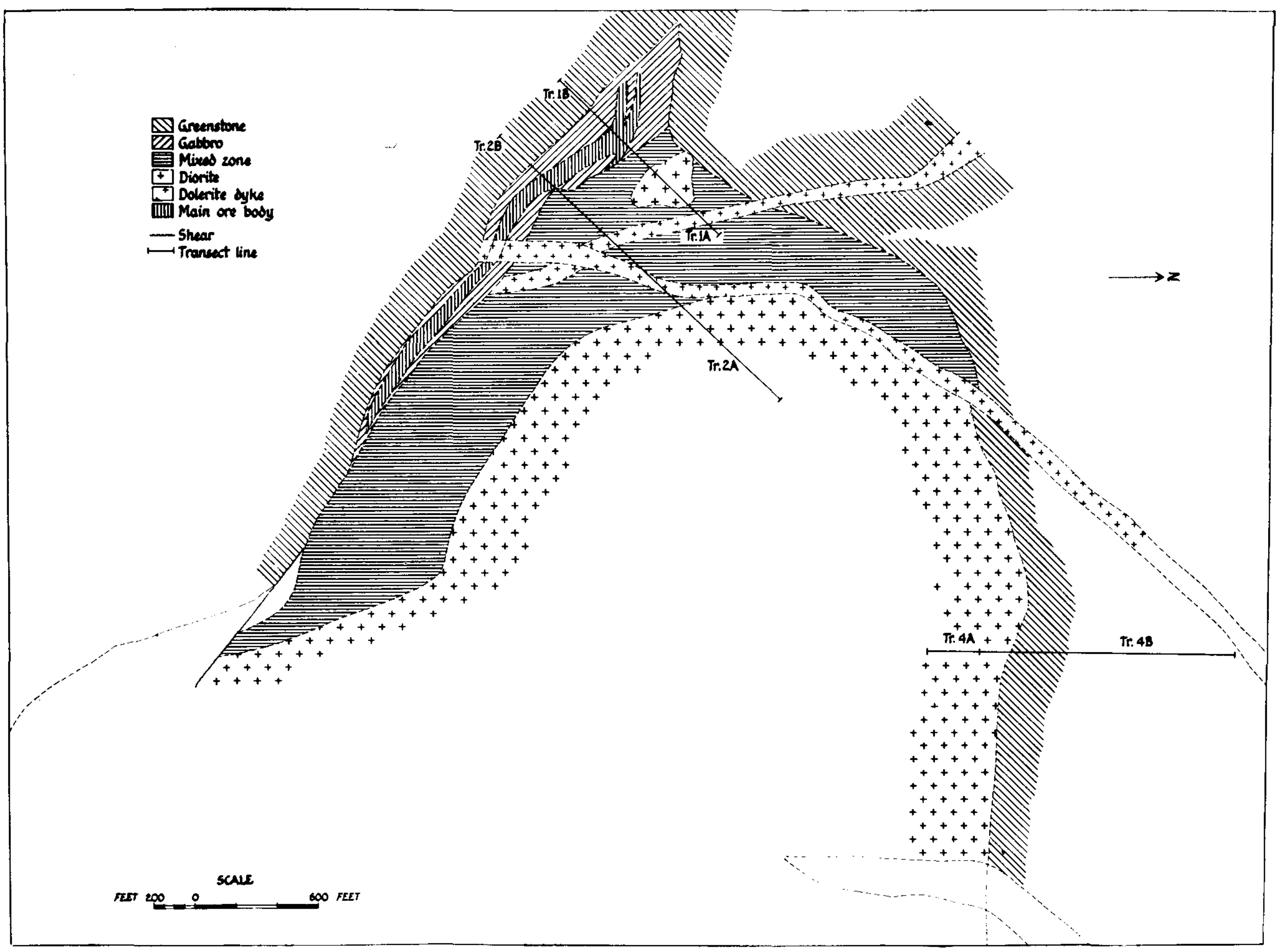

Fig. 2—Empress Nickel prospect. Geology and location of transects.

material which was worked by ancient people from open pits, may in fact represent a remnant of the main ore body which was folded over, lip like, in a westerly direction. Today greenstones underlie the surface between Barebottom Hill and the main ore body and there is no trace of mineralization between the two.

Thus today, in the Empress area the paradoxical situation exists whereby the nickel/copper ore body has little surface expression while a remnant of its former greater extent, now completely oxidized and valueless, provides obvious evidence of mineralization. This situation is readily explained by study of the physiography and geomorphology of the area.

PHYSIOGRAPHY AND GEOMORPHOLOGY

Physiography and geomorphology influence, in turn, the degree and nature of bedrock exposure, the extent of overburden, the depth, properties and characteristics of the soils and the vegetation distributions. Their study is important for our understanding of the geochemistry, geobotany and biogeochemistry of the Empress area.

In the immediate vicinity of the Empress nickel/copper deposit the terrain is level to very slightly undulating with an average height of 3 400 ft above sealevel. Barebottom Hill is the only prominence. To the north west, however, a pronounced east facing escarpment marks the edge of the Mafungabusi plateau. This plateau, some 4 000 ft high and formed of Karoo and Sijarira sediments and lavas, forms part of the Miocene African surface whose formation under hotter and wetter conditions than those prevailing today was accompanied by intense leaching and laterization. This surface formerly extended over the Empress area, where, however, it has been largely destroyed by erosion along the Umniati river and its tributaries during the later and drier Victoria Falls planation cycle. This has exposed the underlying Basement rocks.

Barebottom Hill represents a partially consumed remnant of the old surface and its cap of oxidized copper/nickel bearing material is a relic of the period when the whole thickness of the ore body in that area was subjected to intense leaching and oxidation. All trace of the former cover has been removed ,probably recently, from the Empress ore body which hence has little surface expression today.

SOILS AND OVERBURDEN

Consequent on the physiographic evolution of the landscape the soils are residual, immature and with little or no evidence of horizon development. Being derived from rock units with only minor mineralogical differences, they show only minor differences of texture and composition. Of red to reddish brown colour, they tend to be clay loams over diorite and sandy loams over greenstones; over gabbro they are brown to dark brown silt loams with, in places, a high percentage of rocks or boulders. All have a remarkably low pH value of 5.0 to 6.0 for soils derived from basic parent material.

GEOCHEMISTRY

Soil geochemistry effectively defined the Empress nickel/copper ore body.[1] Values of 3 000 ppm nickel and 500 ppm copper outlined the ore body and those of 500 ppm and 100 ppm respectively limited the dispersion areas for these metals. Maximum values of 8 000 ppm nickel were obtained in places over the ore body.* The analytical results, however, posed certain problems for exploration over a wider area. High nickel values of up to 1 000 ppm in surface soil samples collected over unmineralized serpentinite and diorite in the Empress area and much higher values exceeding 3 500 ppm found in surface soils over unmineralized serpentinite in several other localities in Rhodesia, indicated the limitations of surface soil sampling in the search for nickel ore bodies.** Profile soil sampling at Empress, however, disclosed that whereas nickel values consistently increase with increasing depth from surface into the weathered bedrock over the ore body, over barren rocks they increase to the top of the weathered bedrock and thereafter decrease. While a promising exploration tool, profile sampling is, however, costly. Plant sampling which in effect examines the weathered bedrock zone is cheaper and within the savanna woodland environment might be expected to yield results complementary to those obtained from surface soil sampling.

BIOGEOGRAPHY/GEOBOTANY AND BIOGEOCHEMISTRY AS EXPLORATION TOOLS

The biogeographical/geobotanical and biogeochemical investigation had four main objectives. The first was the recognition of either an anomalous plant community or of indicator species confined to the nickel/copper ore body which might assist the discovery of other similar deposits elsewhere. The second was the establishment of levels of nickel and copper uptake by plants growing over this type of ore body in the savanna woodland environment. The third, related to the second, was the appraisal of biogeochemistry as a more precise prospecting tool than geochemistry for locating the bedrock mineralization in the Empress environment. The fourth was a comparison of the metal contents of plants growing over the Empress ore body and over Barebottom Hill to see whether biogeochemistry could differentiate between the two comparable geochemical anomalies which respectively emanate from sulphides in the ore body and from oxidized copper and nickel bearing material overlying barren bedrock on Barebottom Hill.

THE ROLE OF BIOGEOGRAPHY/GEOBOTANY AS A GUIDE TO GEOLOGY AND BEDROCK MINERALIZATION

In order to achieve the objectives outlined above the vegetation was investigated by means of a series of suitably located belt transects along which geobotanical data recording, soil and plant sampling were under-

*Values obtained in the 1957 geochemical survey.

**This problem has now been overcome by very recent advances in interpretation — to the extent that drilling targets can now be outlined over 'blind' deposits where no vegetation anomaly exists (F. C. Bohmke, March, 1970.)

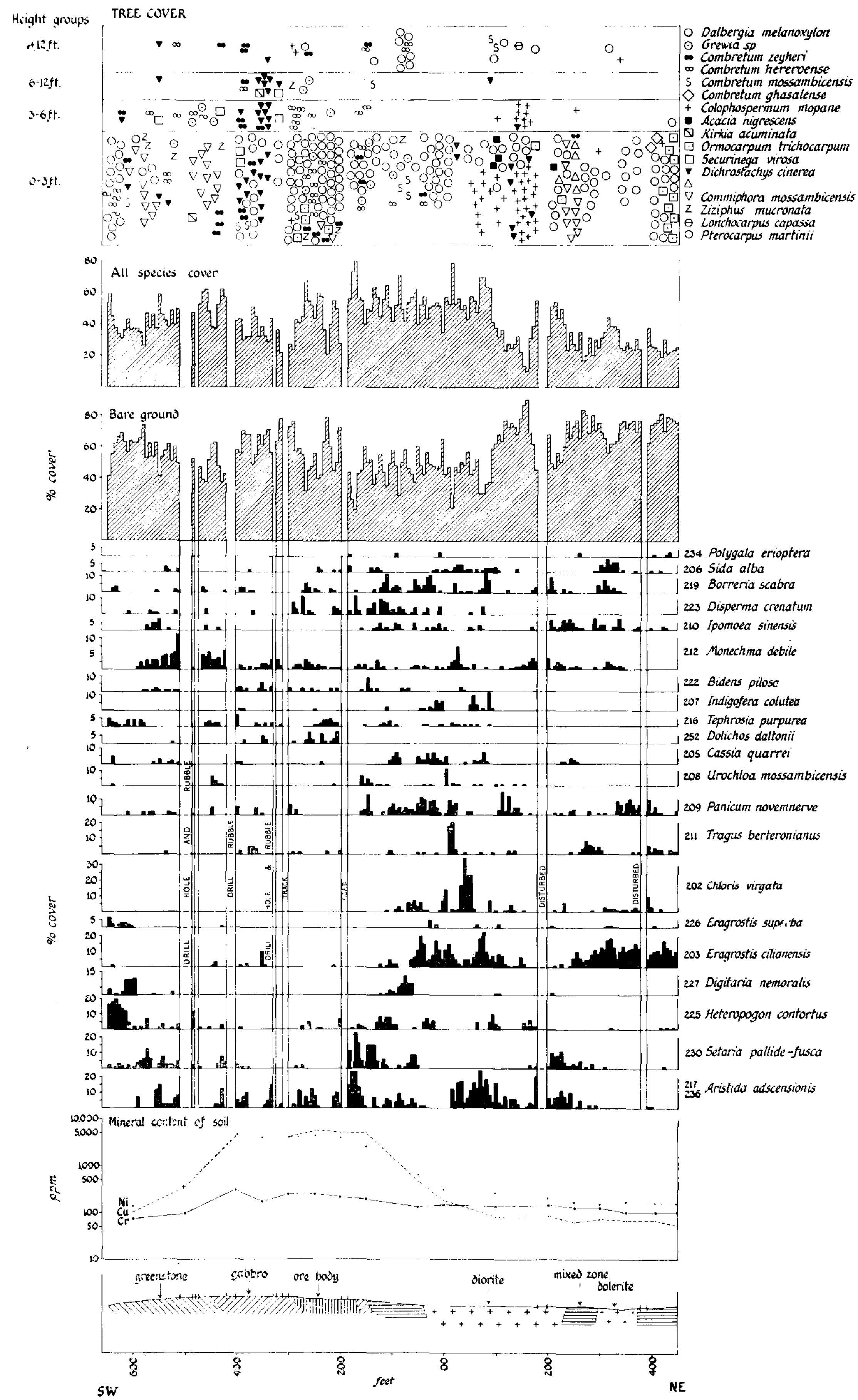

Fig. 3—Transect 1 showing the relationships between plant distributions, soil geochemistry, relief and geology.

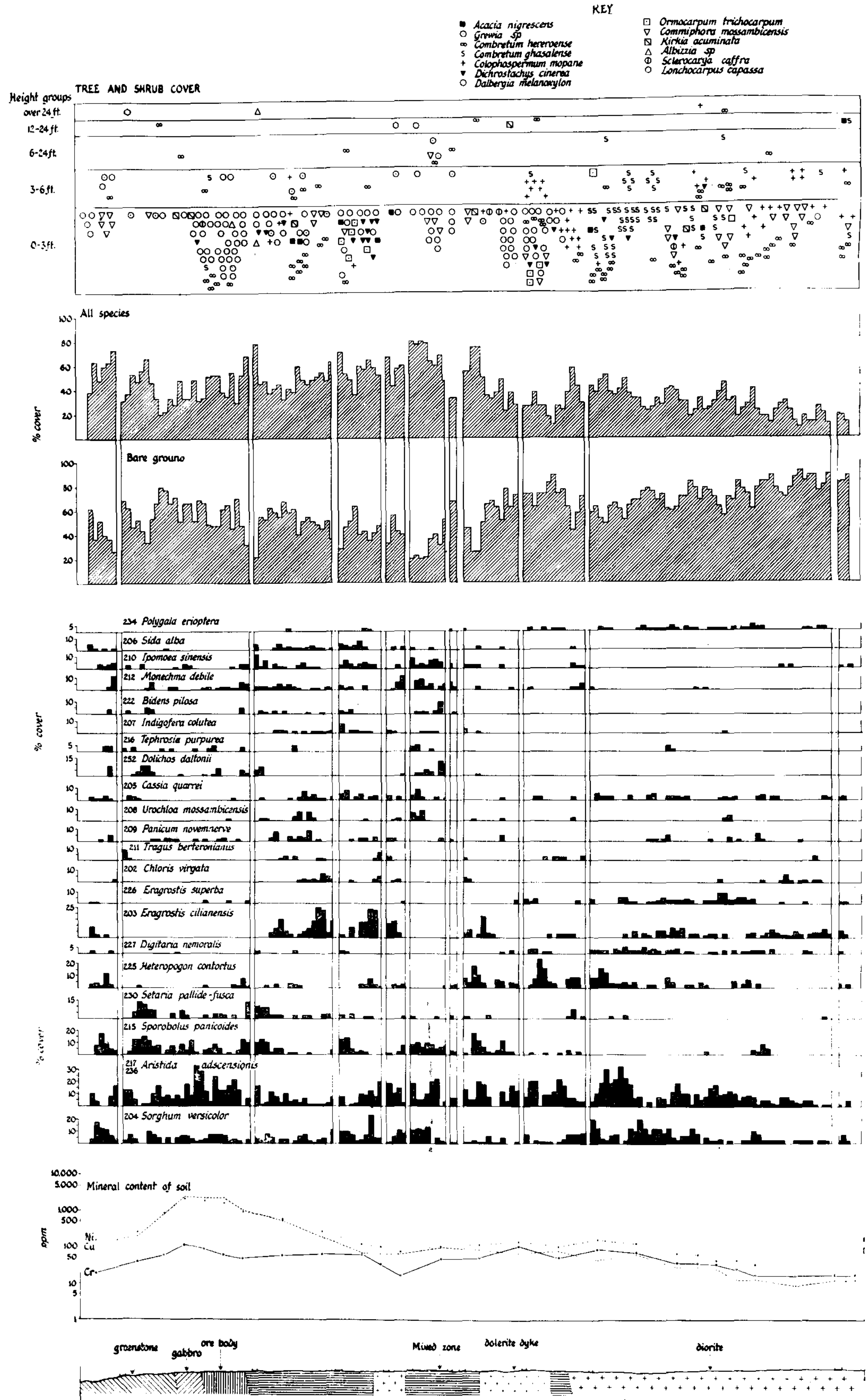

Fig. 4—Transect 2 showing the relationships between the distribution of plant species, soil geochemistry, relief and geology over the Empress Nickel/Copper ore body and adjacent rock units.

taken, supplemented by ground reconnaissance and vegetation mapping over the intervening areas.

These studies established that the characteristic vegetation of the country in which the Empress nickel/copper ore body is located is a savanna woodland dominated by fairly closely spaced relatively tall trees of the *Brachystegia* and *Isoberlinia* genera over the higher ground of the old African surface and by *Colophospermum mopane* trees along the valleys representing the younger geomorphological surfaces. This gives way, however, to a very open woodland of small trees mostly of the *Combretum* genus over the whole of the area underlain by the nickel/copper ore body, by the gabbro host rock and by rocks of the gradational mixed zone. Within this area small *Dichrostachys cinerea* trees distinguish the area underlain by the gabbro host rock while a fairly dense growth of low *Dalbergia melanoxylon* shrubs demarcates the ore body (Figs. 3 and 4). Shrubs of the latter species occur sporadically over the other bedrock units. In sharp contrast *Colophospermum mopane* and *Commiphora mossambicensis* trees and shrubs are largely confined to the greenstones and diorites.

Due to the similarity of the soils arising from the similar mineralogical composition of the bedrock units present there are no clear-cut boundaries between vegetation associations characteristic of individual units such as occur in areas with highly contrasting rock types. Nevertheless the perceptible changes in the form of the vegetation and in the composition of the tree and shrub layers, noted above, provide some guidance to the bedrock geology and to the nickel and copper levels in the soils. This may be illustrated by reference to Figs. 3 and 4 which record the geobotanical and geochemical data along two of the transects run across the area. The most notable features are the changes of species composition which occur where the nickel and copper values in the −80 mesh fraction of the soils sampled at 4 to 6 in depth, exceed 5 000 ppm,* the association of *Dichrostachys cinerea* trees with the gabbro host rock and the fairly dense growth of *Dalbergia melanoxylon* shrubs over the ore body. The extension of the geochemical anomaly and associated with it low pH values of 5 to 5.5 over the areas underlain by gabbro and mixed zone rocks explains the absence of *Colophospermum mopane* and *Commiphora mossambicensis* trees from these areas. It also explains the contrast between the vegetation over the ore body, gabbro host rock and mixed zone rocks on the one hand and that of the barren diorite and greenstones, on the other and likewise the absence of a clearly defined vegetation anomaly confined to the ore body. Marked differences in the composition of the grass and herb layer between the anomaly and background areas are also apparent. Most notable are the sparse cover and paucity of grass species other than *Aristida adscensionis* over the ore body and gabbro host rock and the restriction of *Barleria sp. nov.* and *Celosia trigyna* to the actual ore body. These species are believed to be the nickel/copper indicators in this particular environment.

Thus while a clearly defined vegetation anomaly represented by a distinctive plant assemblage indicative of mineralization comparable with those found over copper ore bodies in other parts of Africa and over copper and lead/zinc deposits in the Cloncurry and Bulman areas of Australia[3] is not present over the Empress nickel/copper ore body, nevertheless, changes in the form and composition of the vegetation provide guides both to bedrock geology and to the nickel and copper levels in the soil and thereby assist location of the ore body.

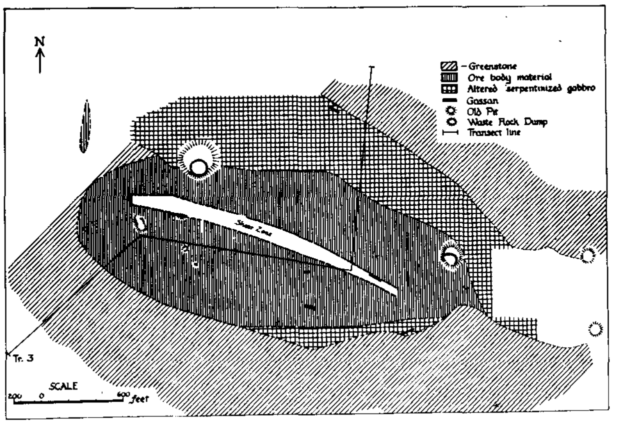

Fig. 5—Barebottom Hill. Geology and location of Transect 3.

By contrast striking changes of vegetation feature Barebottom Hill (Figs. 5, 6 and 7) where differences of aspect, relief and drainage complicate evaluation of the influence of geochemistry. As the name suggests, its summit, which is underlain by oxidized copper/nickel bearing material within altered serpentinized gabbro, is virtually bare of trees and covered by a dense growth of tall grasses and low shrubs while its slopes, underlain by altered lineated rocks and greenstones, carry trees of numerous species, mostly different from those of the surrounding plateau, with below a dense undergrowth of

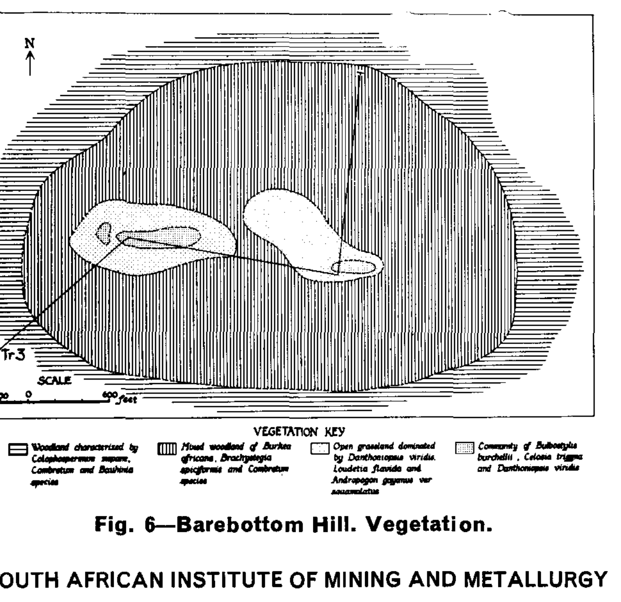

Fig. 6—Barebottom Hill. Vegetation.

*Values from the 1967 geobotanical/biogeochemical investigation.

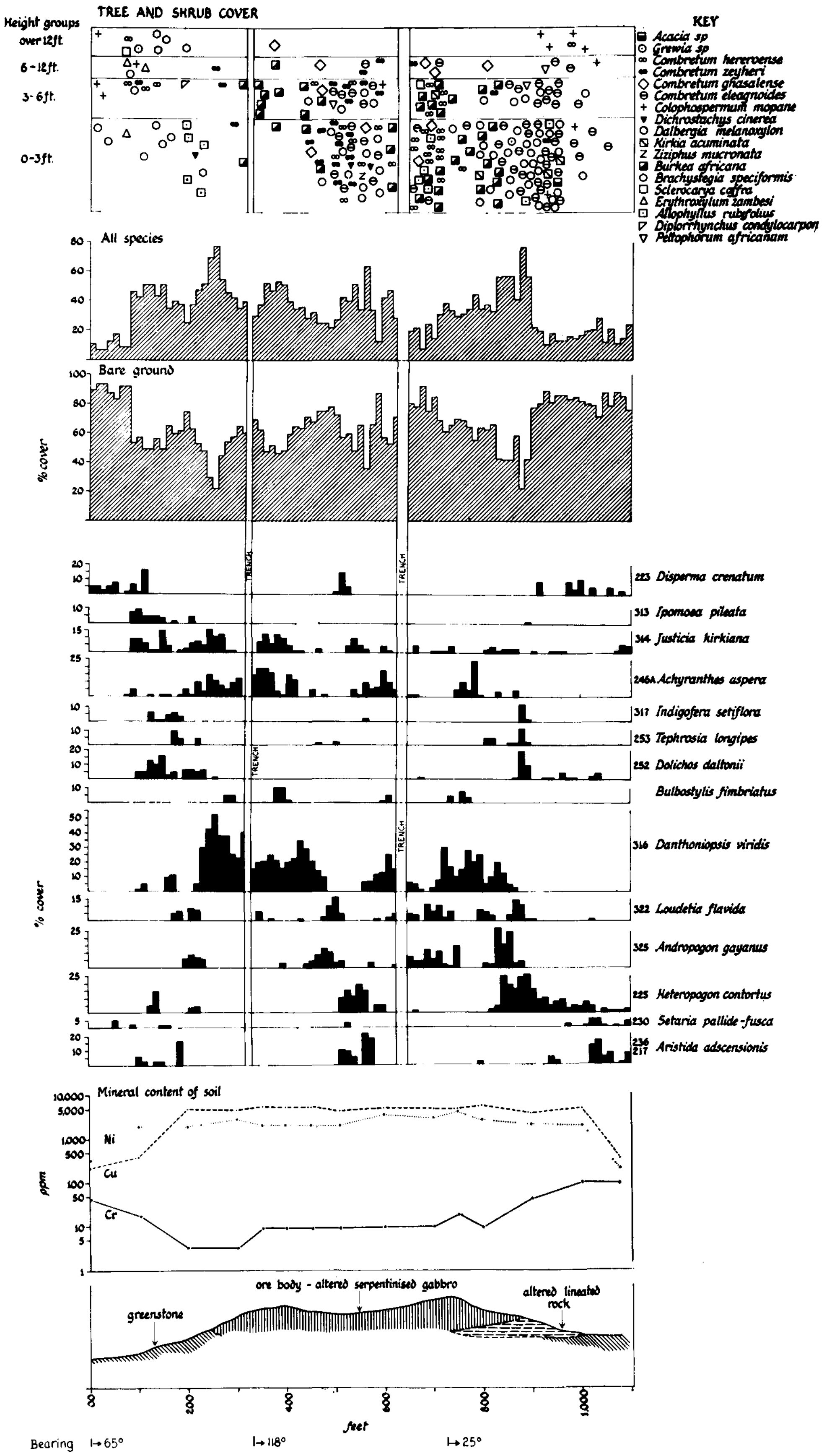

Fig. 7—Transect 3 showing the relationships between plant distributions, soil geochemistry, relief and geology over Bare Bottom Hill.

hrubs, herbs and grasses. The thick woodland on the slopes is partly related to good soil drainage conditions and partly to greater freedom from cattle grazing compared with the level plateau. The differences of the composition between the northern and southern slopes suggest that aspect and variations in soil character associated with differences in the bedrock parent material are important influences. Reference to Fig 7 suggests that the stunted form of the tree and shrub species over the hill summit coupled with the cut-out of the grass species characteristic of the slopes, notably *Heteropogon contortus* and their replacement by *Danthoniopsis viridis,* is associated with an overall nickel/copper geochemical anomaly in the -80 mesh fraction of the surface soil. This anomaly in which copper values exceed 5 000 ppm and nickel values are between 1 000 ppm and 2 000 ppm extends over the slopes of the hill where it is a surface drainage phenomenon caused by contamination from old copper workings and has little influence on tree growth. The *Danthoniopsis viridis* which dominates and, in this area, is unique to the summit vegetation is joined by *Bulbostylis burchelli* and *Celosia trigyna,* which also occurred over the sub outcrop of the Empress ore body, over the malachite stained rubble in the vicinity of the old copper workings. Thus over Barebottom Hill there is a marked geobotanical anomaly which is associated with a surface geochemical anomaly of similar order to that over the Empress ore body, but due to the presence of oxidized copper bearing material in altered gabbro from which drainage contamination has spread over the slopes from old workings.

Stunted trees and shrubs and a virtually monospecific grass layer are features common to the vegetation over the Empress ore body and the summit of Barebottom Hill. Whereas only *Dalbergia melanoxylon,* as dominant, and *Combretum hereroense* are the only common shrubs over the Empress ore body, over Barebottom Hill they are accompanied by a variety of other species including some characteristic of the vegetation of the African land surface. Despite this and due largely to the density of *Danthoniopsis viridis* the vegetation anomaly over Barebottom Hill is more obvious than that over the Empress ore body. The differences may be explained by the differing nature of the geochemical anomalies. The particularly strong anomaly in the ground layer over Barebottom Hill suggests a connection with the oxidized copper bearing material yielding readily available toxic minerals to shallow rooting species, whereas the paucity of tree and shrub species over the Empress ore body suggests a relationship with toxic conditions at depth emanating from the sulphide ore body and affecting particularly the deeper rooting species.

THE ROLE OF BIOGEOCHEMISTRY IN LOCATING BEDROCK MINERALIZATION

For the biogeochemical investigation *Dalbergia melanoxylon, Combretum hereroense* and *C. ghasalense* were sampled along two transects across the Empress ore body. *Burkea africana* and *Combretum ghasalense* together with two samples of *C. hereroense* and one each of *Dalbergia melanoxylon* and *Colophospermum mopane* were sampled along one transect across Barebottom Hill and *Dalbergia melanoxylon, Colophospermum mopane* and *Brachystegia boehmii* were sampled along one transect over the area at the northern margin of the diorite mass.

The results of the analyses show that both *Dalbergia melanoxylon* and *Combretum hereroense* take up very large quantities of nickel and quite large amounts of copper where they grow over the ore body. Here, as may be seen from Figs. 8 and 9 the nickel and copper contents of the plants define the sub-outcrop of the ore body more precisely than those in the surface soils.

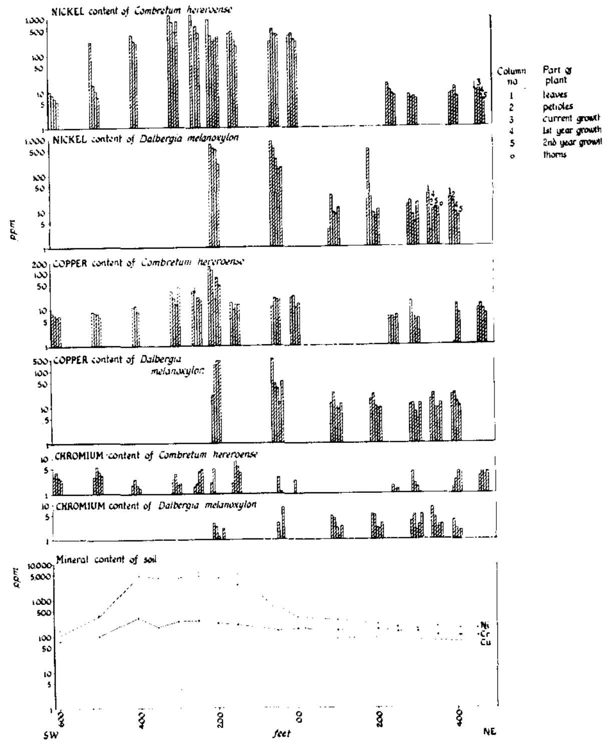

Fig. 8—Transect 1 showing the nickel, copper and chromium contents of Dalbergia melanoxylon and Combretum hereroense and those in soils sampled at 4-6 inches at the same sites over the Empress Nickel/Copper ore body and adjacent rock units.

Thus leaf samples containing 500 ppm to 1 350 ppm nickel and between 20 ppm and 200 ppm copper and twig samples containing 300 ppm to 900 ppm nickel and 20 ppm to 200 ppm copper define the sub-outcrop of the ore body. Over the gabbro host rock west of the sub-outcrop of the ore body, whereas the geochemical anomaly continues with nickel and copper levels in the surface soil is in excess of 5 000 ppm, the nickel and copper contents in the plant leaves drop to less than 400 ppm and just over 10 ppm respectively and those in the plant twigs to less than 300 ppm and less than 10 ppm respectively. East of the sub-outcrop of the ore body, nickel and copper values in the leaves and twigs of both plant species are high over the geochemical anomaly over the mixed zone rocks. The ore body within the gabbro host rock dips in this direction while mineral-

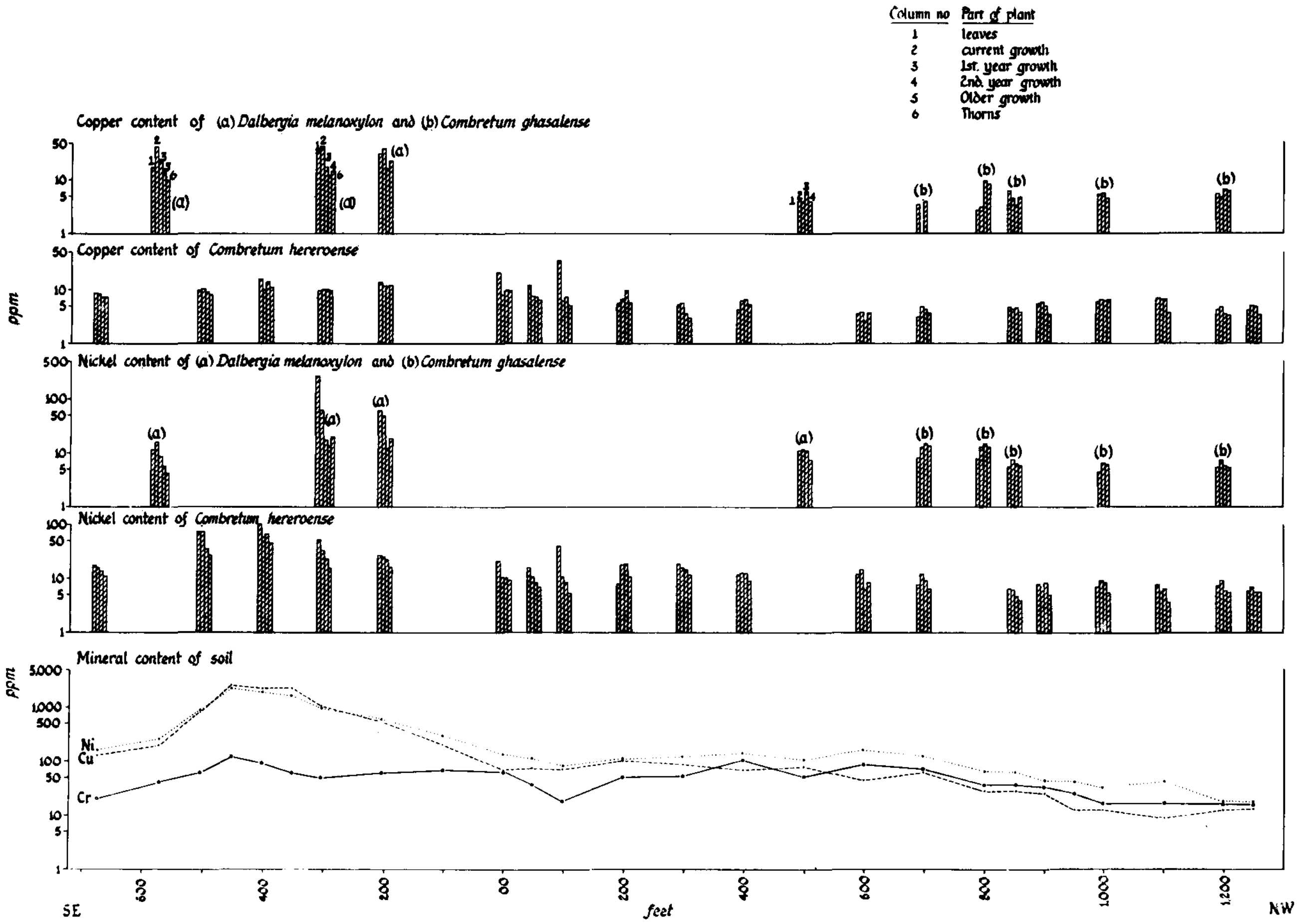

Fig. 9—Transect 2 showing the nickel and copper contents of Dalbergia melanoxylon, Combretum hereroense and Combretum ghasalense and those of soils sampled at 4-6 inches at the same sites over the Empress nickel/copper ore body and adjacent rock units.

ization occurs also in the mixed zone, so that the higher values in the plant samples may be truly reflecting values at depth. Further east over the diorite values fall sharply to around 10 ppm nickel and between 5 ppm and 10 ppm copper in the leaves and twigs of both species. Similar values occur also in samples of *Dalbergia melanoxylon* collected near the northern margin of the diorite mass where nickel levels in the surface soil are around 100 ppm.

Although both geochemical and biogeochemical values were generally lower along the second transect over the ore body the nickel and copper contents of the leaves and twigs of *Dalbergia melanoxylon* and *Combretum hereroense* again defined the sub-outcrop of the ore body more accurately than the values in the surface soil. The *Combretum ghasalense* sampled over diorite in the background area contained around 10 ppm nickel and between 5 and 10 ppm copper in both leaves and twigs, the actual values being closely related to those in the surface soil.

The very high nickel values in the plant samples collected over the ore body indicate that, in this environment, trees and shrubs take up this metal freely. The contrast with background values is very great, greater than that between the anomalous and background geochemical values. The results indicate that the

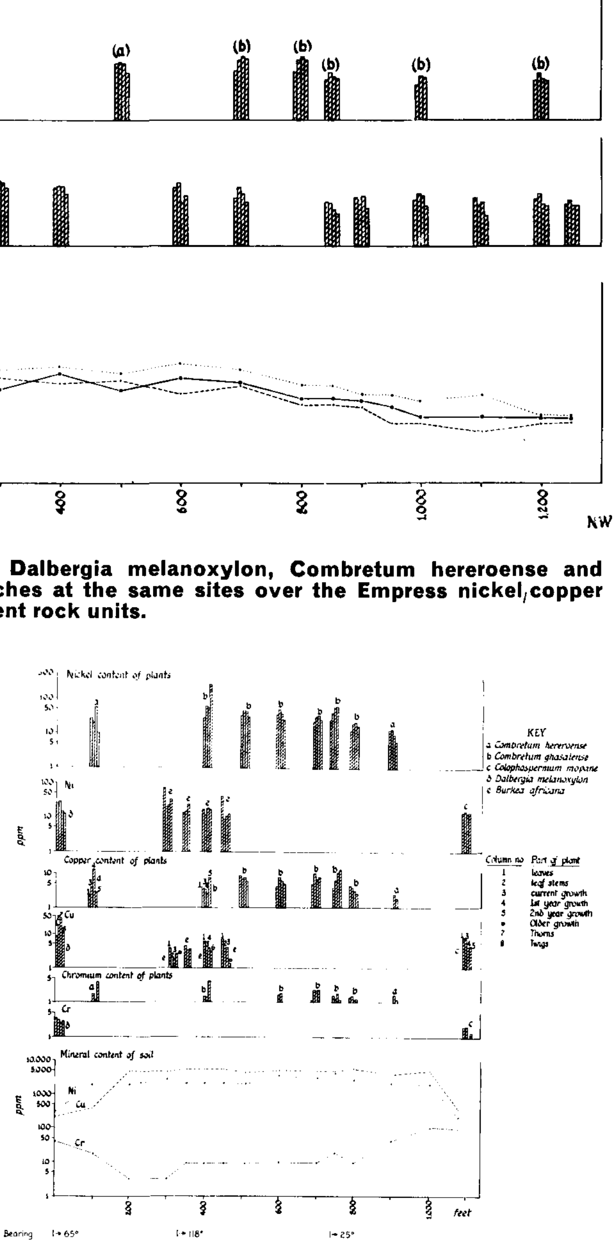

Fig. 10—Transect 3 showing the nickel, copper and chromium contents of Combretum hereroense, Combretum ghasalense, Colophospermum mopane, Dalbergia melanoxylon and Burkea africana and those of soils sampled at 4-6 inches at the same sites over Barebottom Hill.

plants generally resist the uptake of copper to about 10 ppm provided values in the soil do not exceed 500 ppm beyond which uptake increases rapidly to levels of 200 ppm, a phenomenon found over ore bodies elsewhere.[4]

At levels generally below 50 ppm and 10 ppm respectively the nickel and copper contents of *Combretum ghasalense*, *C. hereroense* and *Burkea africana* sampled over Barebottom Hill (Fig. 10) were very much lower than those in *Combretum hereroense* and *Dalbergia melanoxylon* sampled in the vicinity of the Empress ore body although the nickel and copper values defining the geochemical anomaly were comparable over the transect lines. While comparison of results of different species may be questionable the fact that levels in the *Combretum hereroense* sampled on Barebottom Hill were lower than those in *C. ghasalense* and *Burkea africana* suggests that overall biogeochemical values are genuinely lower over Barebottom Hill than over the Empress ore body, reflect marked differences in metals content at rooting depth and in bedrock and confirm the Barebottom Hill geochemical anomaly as a surface phenomenon.

Thus the results of the biogeochemical investigation suggest that plant sampling is a most effective exploration technique in the savanna woodland environment, capable not only of detecting the presence of a nickel/copper ore body but also of locating it more precisely than surface geochemistry and of distinguishing between a geochemical anomaly emanating from a nickel/copper body and one produced by near surface oxidized copper-bearing material.

CONCLUSION

An Assessment of the Roles of Geobotany and Biogeochemistry as Prospecting Tools in the Hot Summer Wet Winter Dry Savanna Woodland Environment

The treeless vegetation over the area bearing oxidized material on Barebottom Hill contrasts so strongly with the surrounding woodland as to attract the attention of any prospector. The vegetation anomaly over the Empress ore body, however, is less obvious and probably would be recognized only by the trained geobotanist. The use of geobotany in the search for similar ore bodies with equally poor surface expression in this particular environment is thus probably restricted. Biogeochemistry on the other hand offers a most effective prospecting tool. In this environment the trees and shrubs growing over a nickel ore body take up nickel freely during the hot wet summer period of active growth and produce biogeochemical anomalies which may contrast more sharply with background values then geochemical anomalies over the same area. More important, the nickel and copper contents of the plants may define the sub-outcrop of an ore body more precisely than those in the surface soils while by virtue of reflecting metal values at rooting depth they differentiate between geochemical anomalies emanating from bedrock mineralization and those due to surface phenomena.

ACKNOWLEDGEMENT

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The plants were identified at the Salisbury and Kew Herbaria where the assistance of Professor H. Wild and Mr P. G. Taylor respectively, is gratefully acknowledged.

The diagrams have been drafted and produced by Misses L. C. Coupland (now Mrs Gadd), E. Smith and K. A. Keeble at Bedford College, University of London.

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APPENDIX

SPECIES MENTIONED IN TEXT

ACANTHACEAE
Barleria sp. nov.
Dicliptera verticillaris (Forsk) C.Ch. =*Hypoestes verticillaris* R.Br.
Dychoriste monroii S. Moore
Hypoestes verticillaris R. Br.
Justicia kirkiana T. Anders.
Monechma debile (*Forsk.*) =*Justicia debilis*

AMARANTACEAE
Achyranthes aspera L.

BURSERACEAE
Commiphora mossambicensis (Oliv.) Engl.

COMBRETACEAE
Combretum eleagnoides Klotzsch.
C. ghasalense Engl. et Diels.
C. hereroense Schinz.
C. mossambicensis Klotzsch.
C. zeyheri Sond.

COMMELINACEAE
Aneilema hockii de Wild

COMPOSITAE
Aspilia mossambicensis (Oliv.) Wild.
Bidens pilosa L.

CONVOLVULACEAE

Ipomoea pileata Roxb.
I. sinensis (Desr.) subsp. belpharosepala.

CYPERACEAE

Bulbostylis burchelli C. B. Clarke.

GRAMINEAE

Andropogon gayanus Kunlh
Aristida adscensionis L.
Chloris virgata Swartz.
Danthoniopsis viridis (Rendle) C. E. Hubb.
Digitaria nemoralis Henr.
Ergrostis cilianensis Link ex Lutati.
E. superba Peyr.
Hackelochloa granularis (L.) Kuntze.
Heteropogon contortus (L.) Beauv.
Loudetia flavida (Stapf.) C. E. Hubbard.
Panicum novemnerve Stapf.
Setaria pallide-fusca (Schumach.)
Sorghum versicolor Anderss.
Sporobolus panicoides A. Rich.
Tragus berteronianus Schult.
Urochloa mossambicensis (Hack) Dandy.

LEGUMINOSAE

Acacia spp.
Brachystegia spiciformis Beuth.
Burkea afrikana Hook.
Cassia quarrei (Ghesq.) Steyaert.
Colophospermum mopane J. Kirk ex Beuth.
Crotalaria cephalotes Steud ex A. Rich.
Dalbergia melanoxylon Guill. et Perr.
Dichrostachys cinerea (L.) Wight et Arn.
Dolichos daltonii Webb.
Indigofera colutea (Murmif) Merr.
Isoberlinia spp.
Peltophorum africanum
Tephrosia longipes Meisn.
T. purpurea (L.) Pers var pubescens Bak.

LILIACEAE

Asparagus sp. of A. aspergillus Jessop.

LINEAE

Erythroxylum zambesiacum N. Robson.

MALVACEAE

Sida alba L.

PEDALIACEAE

Ceratotheca sesmoides Endl.

POLYGALACEAE

Polygala erioptera D.C.

RUBIACEAE

Borrera scabra (Schumach et Thonn).
Disperma crenatum (Lindan) Milne Redh.
Xeromphis obovata (Hochst) Keay = Randia

SAPINDACEAE

Allophyllus rubifolius (Hocht ex A. Rich.) Engl.

SOLANACEAE

Solanum panduriforme E. May.