THE FEASIBILITY OF BIOGEOCHEMICAL AND GEOBOTANICAL PROSPECTING AT SPARGOVILLE, WESTERN AUSTRALIA

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ABSTRACT

Several plant species together with their associated soils from Spargoville, Western Australia, were analysed for chromium, copper, cobalt, manganese, nickel and zinc by atomic absorption spectrophotometry. Particular reference was given to nickel and copper to evaluate the usefulness of plant analysis for biogeochemical prospecting.

The nickel content in the soils gave plateaus of high values over ultrabasic rock types whereas the copper levels in the soils gave peaks over areas of mineralization at ultrabasic contacts. Consideration of the plant data showed that each species accumulated different amounts of the above elements, and that they distributed these trace elements in different ways between their leaves and twigs, or between their bark and wood.

Relationships between nickel and copper concentrations in the plants and in the soils were evaluated by computing correlation coefficients; promising statistical results were checked graphically. The nickel and copper concentrations in the bark of *Eucalyptus lesouefii* most accurately depicted the concentrations of these metals in the soils. It was also found that the barks of *Eucalyptus lesouefii*, *Eucalyptus longicornis* and *Eucalyptus torquata* could be used together for prospecting purposes. In the cases where the soil-plant relationship was either very good or very poor, it seemed to make no difference whether parametric or non-parametric correlation coefficients were used. When the relationship was intermediate between these extremes, however, the non-parametric statistic was superior.

A geobotanical study was also carried out to determine whether the distributions of the plant species was related to the geology. *Dodonaea lobulata*, *Pittosporum phillyraeoides* and *Trymalium ledifolium* were found to grow only on ultrabasic rock types, and the outer, black bark of *E. lesouefii* growing in mineralized ground was observed to grow to a greater height on the trunk than occurred when this species grew in non-mineralized soils.

When discriminant analysis was applied to plant mapping data, the different rock types could be effectively discriminated using the relative abundances of as few as one-third of the species present. These results were markedly superior to those obtained when discriminant analysis was applied to some biogeochemical data.

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GENERAL INTRODUCTION

The present level of civilization, allied as it is to ever-expanding populations, necessitates the demand for a continuous and adequate supply of raw materials. This demand not only includes fossil and nuclear fuels to fulfill energy requirements, but also metallic and non-metallic elements for use in the manufacture of consumer goods.

The result has been a world-wide "boom" in exploration for mineral resources since World-War II.

Prior to World-War II, metalliferous deposits were discovered by relatively untrained prospectors, guided only by what could be seen with the unaided eye. These surface deposits have long since been exploited, and more recently the search has been under way for the big deposits to be found under the various types of blanketing soil cover or barren bedrock.

The "great leap-forward" in technology during the last three decades has led to the use of increasingly sophisticated techniques for the mapping of geological structures and for detecting ore deposits at depth. These include geophysical techniques such as magnetics, electromagnetics, induced polarization and self polarization, as well as photogeological methods such as aerial remote sensing.

Consideration of the rock-soil-plant system has led to the use of geochemical prospecting as yet another tool in mineral exploration. The principles involved in this method are as old as man's first use of metals and can be considered using the concept of the prospecting prism (Fortescue and Hornbrook, 1967). This is a three dimensional representation of the different components of a landscape system which may be involved in geochemical mineral exploration (Fig 0-1). Hence mineralization at depth can theoretically be discovered by consideration of all the components of the prism, i.e. rocks, soils, and vegetation.

As defined by common usage, geochemical prospecting is the measurement of one or more chemical properties of a naturally-occurring material (Hawkes and Webb, 1962). The chemical property measured is most commonly the trace content of some element or group of elements, while the naturally-occurring material is a component of the prospecting prism. The purpose of the

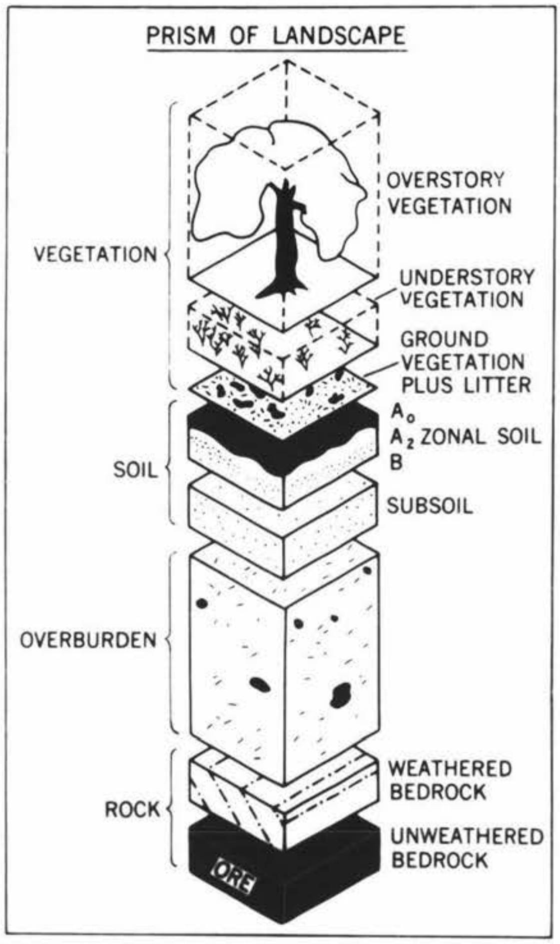
GEOPHYSICAL METHODS OF EXPLORATION

AIRBORNE METHODS

(1) REMOTE SENSING
(2) PHOTOGRAPHY
(3) MAGNETICS
(4) ELECTROMAGNETICS
(5) RADIOACTIVITY

GROUND METHODS

(1) MAGNETICS
(2) ELECTROMAGNETICS
(3) INDUCED POLARIZATION
(4) SELF POTENTIAL
(5) GRAVITY
(6) RESISTIVITY
(7) SEISMIC
(8) RADIOACTIVITY



GEOCHEMICAL METHODS OF EXPLORATION

(1) PLANT GEOCHEMISTRY
(2) SOIL GEOCHEMISTRY
(3) BOG GEOCHEMISTRY
(4) WATER GEOCHEMISTRY
(5) STREAM SEDIMENT GEOCHEMISTRY
(6) OVERBURDEN GEOCHEMISTRY
(7) ROCK GEOCHEMISTRY

SPECIALIZED GEOLOGICAL METHODS OF EXPLORATION

(1) HEAVY MINERAL ANALYSIS
(2) BOULDER TRACING
(3) DIAMOND-DRILLING
(4) TRENCHING
(5) EXPLORATORY MINING

Figure 0-1

The "prospecting prism"

measurements is the discovery of abnormal chemical patterns, or geochemical anomalies, related to mineralization.

The most widely used geochemical prospecting technique has been the analysis of soil samples. This method relies on the principle that under suitable weathering and topographical conditions, the ore metal will be dispersed chemically or mechanically from the mineralization at depth into the overlying soil. In areas of good drainage where soil samples may not be readily available, sampling of stream sediments has been used successfully; in this method the assumption is made that the sediment represents a composite sample of the soil and unweathered rock in the area drained by the stream.

Plant exploration geochemistry involves two fields of study. These are geobotanical prospecting and biogeochemical prospecting. Although these two methods are different in scope and application, the principles underlying both are the same. The root systems of plants act as powerful sampling mechanisms, collecting aqueous solutions from a large volume of moist ground below the surface. These solutions then serve as a source of inorganic salts that may be deposited in the upper parts of the plant, or that may stimulate, inhibit or otherwise modify the growth habits of the plant.

Geobotanical prospecting involves a visual survey of the vegetation cover in order to determine whether the presence or absence of distinctive plant communities, individual species, or whether morphological changes in the vegetation can be attributed to mineralization.

The associated technique, biogeochemical prospecting, relies on the analysis of plants to obtain evidence of mineralization at depth. This method may have the following advantages over the analysis of soil samples:

(i) The amount of ground sampled both vertically and horizontally by a given plant represents a much larger area than that of a given soil sample.

(ii) The depth of penetration of roots may permit the sampling of a deep horizon not accessible by surface soil sampling. This is particularly true where "geochemical barriers", such as

siliceous hardpans, are found beneath the surface soil.
(iii) Plant sampling eliminates the possibility of interference from transported surface soils and permits prospecting in areas where residual soil is either nonexistent or varied.
(iv) Some plants have the ability to concentrate higher levels of certain elements in their ash than exists in the underlying soil.

Where a significant relationship exists between plant distributions and mineralization, geobotanical prospecting would be expected to be superior to all other methods because no analytical work is required, and maps of mineralized ground may be drawn directly from observation of occurrences of plants.

The use of biogeochemistry as a guide to mineralization has not been as readily accepted as the more conventional geochemical techniques such as soil or stream sediment sampling. This may seem surprising when it is remembered that two-thirds of the world's land surface is covered with vegetation (Draeger and Lauer, 1967). However, biogeochemistry is considerably more complex than soil geochemistry because it involves a study of such factors as the particular plant species sampled, the particular part of the plant sampled, the availability of elements in the soil, and plant nutrition. These factors have been discussed by Webb and Millman, 1951; Carlisle and Cleveland, 1958; Shacklette, 1962; Fortescue and Hornbrook, 1967. Finally a major disadvantage of plant geochemistry in general is the need for skilled personnel, both in the execution of the work and in the interpretation of the data.

It is to be hoped however, that in the field of mineral exploration, the presence of vegetation will come to be regarded as an asset rather than as a hinderance. The distribution and the elemental content of plant species should be regarded as extra "tools" to be utilized in building up the complex picture necessary for the discovery of mineral deposits.

The work described in this thesis was initiated to evaluate the usefulness of biogeochemistry and geobotany in the search for nickel mineralization in Western Australia. It was carried out with the permission and assistance of Australian

Selection (Pty.) Limited on part of their concession area at Spargoville, Western Australia. The particular region of study was chosen because it was known to contain nickel mineralization, and the geological structure was known.

The aims of this thesis can be summarized as follows:

(i) To carry out an orientation survey to discover which, if any, of the plant species present were suitable for biogeochemical prospecting for nickel.

(ii) To evaluate the usefulness of correlation coefficients in the handling of biogeochemical data.

(iii) To investigate some factors affecting the usefulness of biogeochemical prospecting in this area.

(iv) To carry out an orientation survey to evaluate the usefulness of geobotany in mineral exploration in the area of study.

(v) The application of discriminant function analysis to geobotanical data.

(vi) To test the biogeochemical and geobotanical conclusions obtained during the orientation survey on another area of similar lithology and ecology.

SECTION 1

THE AREA OF STUDY

A. INTRODUCTION

The area chosen for this work was at Spargoville, Western Australia, located about 330 miles east of Perth and 60 miles south of Kalgoorlie (Fig. I-1).

Two grids of different sizes were used. Systemmatic soil and plant sampling for the biogeochemical orientation survey and plant mapping for the geobotanical orientation survey were carried out on Grid 5B. Grid 5D was used to test the findings from the orientation work. These two grids were separated by a distance of approximately three-quarters of a mile.

Grid coordinates used in this thesis contain the south coordinate followed by the east coordinate.

The topography is gently undulating. On Grid 5B, the elevation is from 1115 ft. at the outer extremities rising to 1140 ft. at the centre of the grid, whereas for Grid 5D, the elevation ranges from 1150 ft. to 1170 ft.

There are no definate drainage patterns. However, there does exist a number of shallow watercourses which very rarely carry running water through more than a limited portion of their channels. The directions of these channels closely follow topographical trends.

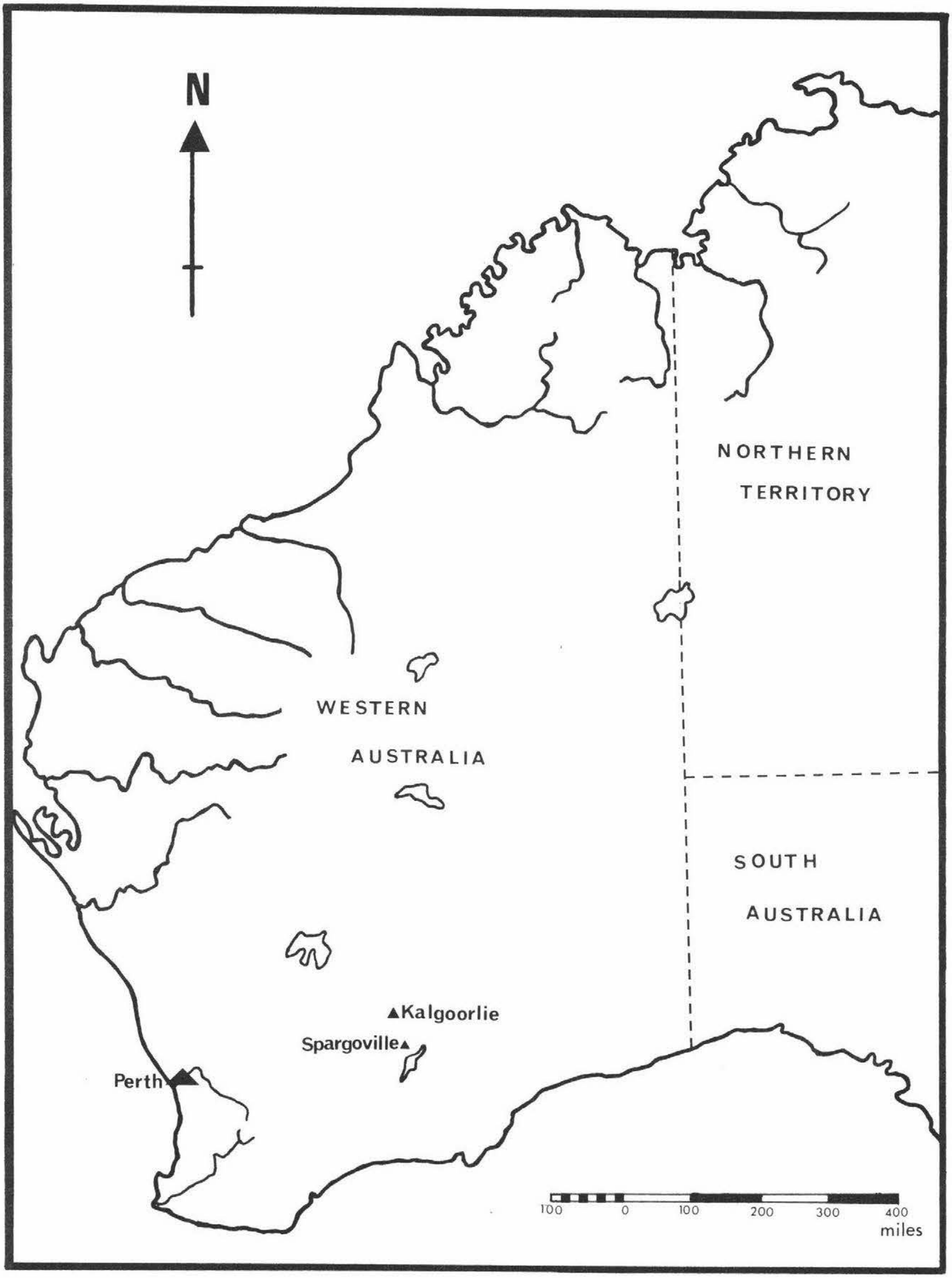


Figure I-1. Locality Map

B. CLIMATE

At Spargoville, the annual average rainfall is approximately 10 inches, falling mainly during the winter months of June, July and August. However, summer rain is also experienced in March.

The average temperature per annum ranges from 60°F to 70°F. The summer months of December, January and February are the hottest with an average temperature of approximately 75°F, and the winter months of June and July are the coolest with an average of 50°F.

The region also experiences strong, dry winds from the southern and south-western quarters.

C. LITHOLOGY

Spargoville lies on a pronounced magnetic trend which correlates with a greenstone belt comprising basic and ultrabasic rocks, as well as minor sediments.

The basic rocks are amphibolitic and readily recognized in the field by their reddish-brown texture, while the sediments are usually fine-ground shales and cherts. The composition of the ultrabasic rocks vary from tremolite to tremolite-chlorite to talc carbonate; a few small pockets of serpentinite are also present. In contrast to other rock types, the ultrabasics occur as relatively narrow banks which have a N.N.W. trend.

The bedrock is weathered and highly altered in places by processes of lateritisation and by carbonate replacement. It seems that the laterite, which occurs as a mottled zone over the whole area, is much deeper than the soils; in fact the whole of the weathered profile probably bears the imprint of lateritisation. The weathering profile extends from the surface to fresh bedrock, which is encountered at depths down to 200 ft. vertically.

Magmatic nickel-copper sulphide mineralization occurs at the ultrabasic-basic rock contacts. The grade of the ore can be as high as 2%, while the concentration of copper is approximately 1/10th this value (Pers. comm. J.E. Martin). Arsenic also occurs in areas of mineralization; up to 1.5% arsenic has been detected in some of the ore concentrates now being mined at Spargoville (Pers. comm. N.J. Marshall).

A total of three gossans occur at ultrabasic rock contacts on the two grids used for the present study. Gossans consist of residual hydrous iron oxides derived from the weathering of sulphides (or carbonates). Other minerals, as well as metallic constituents of the ore, may be associated with the ubiquitous iron oxides. Thus, depending on the parent material and on the degree of weathering that has occured in the gossan, it is not surprising that elemental concentrations in these outcrops often reflect bedrock geochemistry.

Soils are seldom more than 2 ft. deep and are not differentiated into horizons. This implies that they are relatively young, and if not residual, are locally derived. Hence the chemical composition of the soils in the study area could be expected to reflect the underlying geological structure.

Fig. 1-2 shows the topography, the sampling stations, the geological contacts between the various rock types and the positions of the gossans on the two grids.

Figure I-2

The two sampling grids

Contact

Gossan

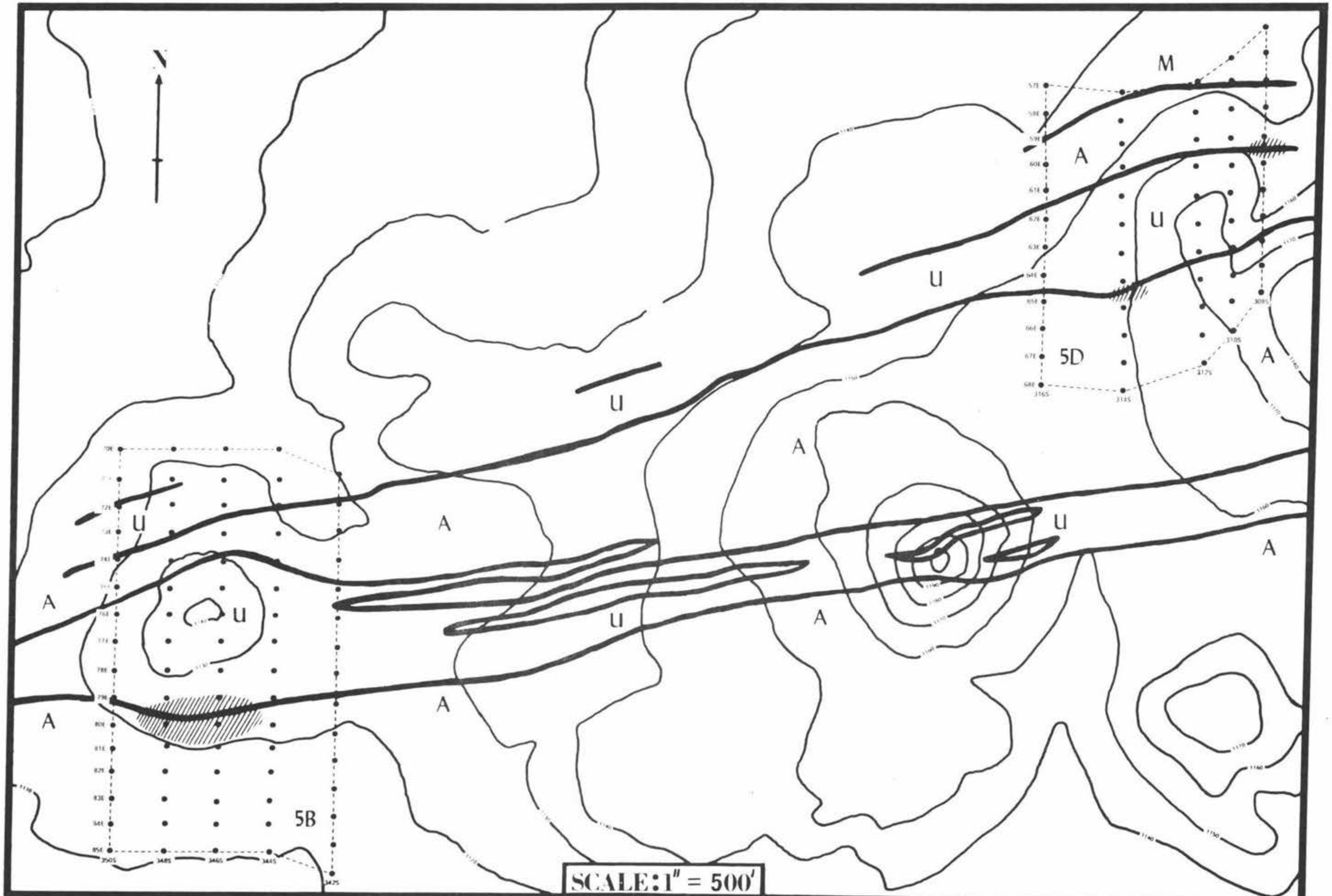
Sampling site

—1130— Topographic isocontour

A Amphibolite

M Metasediment

U Ultrabasic


N
M
A
U
5D
A
U
U
A
A
U
A
U
A
A
U
U
A
U
A
A
5B
SCALE: 1" = 500'

D. VEGETATION

The following description is taken from Elkington, 1969, as well as from the author's own observations.

The vegetation consists of sclerophyllous woodland in which several *Eucalyptus* species occur. The dominant species is *Eucalyptus lesouefii*, together with lesser numbers of *E. calycogona*, *E. longicornis*, *E. salmonophloia*, *E. salubris*, and *E. torquata*. These trees may grow up to sixty feet in height.

Several types of low, woody, perennial shrubs are also present. In particular, *Acacia colletioides*, *A. aff. - colletioides*, *Dodonaea stenozyga*, *Eremophila dempsteri*, *E. ionantha*, *E. oppositifolia* and *E. pachyphylla* are common.

Other species of shrubs occur in lesser numbers as well as some ephemeral herbaceous species and a few perennial grasses.

Plate I-1 shows the topography and vegetation cover in the vicinity of the sampling areas.

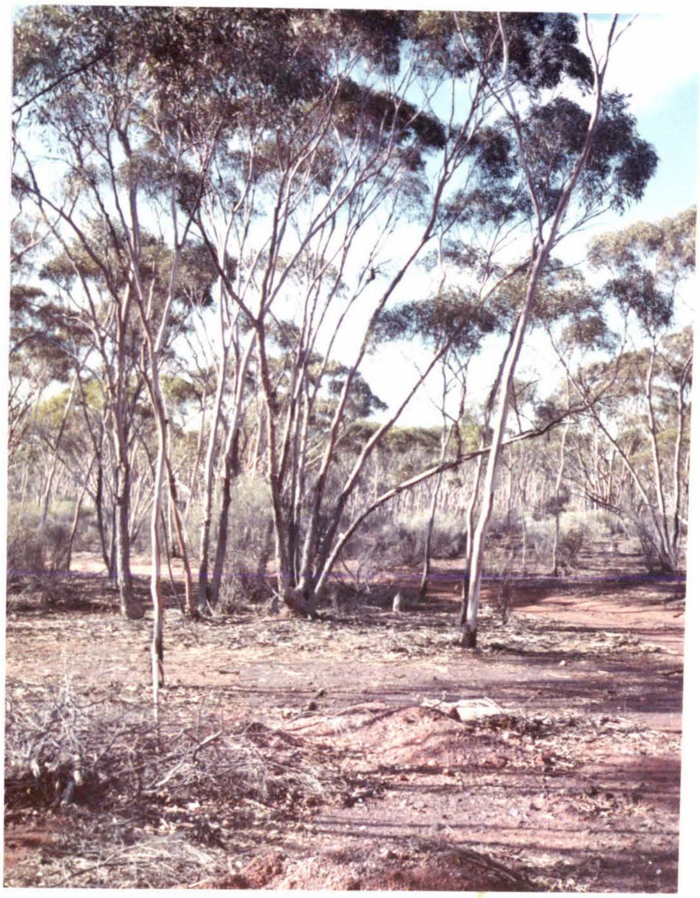


PLATE I-1. The vegetation cover in the vicinity of the two grids