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MINERALOGICAL, PETROGRAPHIC AND GEOCHEMICAL STUDIES IN THE SOUTH ALLIGATOR REGION, PINE CREEK INLIER, N.T.

R.G. Warren & J.L. Kamprad

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CONTENTS

ABSTRACT

Regional metamorphic grade in the area covered by the erstwhile conservation zone is greenschist, rising to transitional amphibolite grade in the northeast. Metamorphism came late in the evolution of the region, and appears to affect units as high stratigraphically as the Katherine River Group.

Alteration in the mineralized zone took place in three stages. The first involved silicification (producing topographic highs), the second overprinted zones of sericitization within the silicified zones. The third, probably separated in time and PT conditions and perhaps the result of deep weathering, caused intense kaolization and fracture-controlled hematite replacement. A broader diffuse halo of carbonate alteration affects the district surrounding the mineralized zone. This involved an H_2O-rich, CO_2-bearing fluid, which appears to have moved SiO_2 and K out of mafic rocks. It may be part of the regional metamorphic pattern, but has the appearance of a fourth zone of alteration caused by widespread fluid circulation which was focused on the fault system, and in which the elements of economic interest were extracted from their primary hosts. Widespread traces of F suggest this element was also mobile in circulating fluids. Quartz veining in less dissected parts of the fault system may be the manifestation at high levels either of silicification or of sericitication (in which silica moved out) at depth.

Geochemical investigation of the Zamu Dolerite shows it to be a quartz-rich tholeiite with hints of calc-alkaline affinities. It has a well-defined fractionation trend and is quartz-normative throughout. The corresponding evolution in mineralogy progresses from early cumulus Opx with Cpx, through augite -pigeonite (now mostly inverted) to a single Pyx or brown horneblende. The Zamu Dolerite is characterized by graphic quartz-feldspar intergrowths, readily recognizable, even in overprinted specimens from the alteration zones. Available data show PGE concentrated within the fraction trend, probably with S, and not with early high Cr in the basal zone. The Zamu Dolerite is confined to the area SW of the Jim Jim Fault, extending a few kilometres

southwest of the South Alligator Fault Zone. Meta-dolerite previously mapped as Zamu Dolerite northeast of the Jim Jim Fault is, chemically, a separate unit. Samples of the Shovel Billabong Andesite show a tightly constrained chemistry, falling on the compositional trends of the Zamu Dolerite. Nevertheless, present data preclude the Shovel Billabaong Andesite from being part of the Zamu Dolerite. Goodparla dolerite (revision of Goodpalah Diorite) intrudes the Masson Formation in the southwest of the South Alligator Conservation Zone. It has a fractionation trend from olivine-normative to quartz-normative, but is distinct from the Oenpelli Dolerite, with which it has previously been equated. Only one of the several specimens analysed for PGE carries any trace. This may indicate the unit is barren, or that sampling to date has failed to locate any zone of concentration. The thin sills mapped as Zamu Dolerite in and westward from the Fracis Creek districtdiffer from the Zamu Dolerite of the South Alligator valley. They form a series from slightly olivine-normative to quartz-normative. Most of the samples that were analysed for Au and PGE carry traces, which may indicate the sills are too thin for the formation of zones with major concentrations.

INTRODUCTION

This record presents results from studies carried out as part of the work by BMR in the erstwhile South Alligator Conservation Zone of 1987-89 abbreviated to *SACZ*. In this report the zone of previously worked deposits, extending from Rockhole Mine to Coronation Hill Mine, is referred to as the *South Alligator Mineral Field*.

This record is presented in two parts. For the preparation of both parts, material held by BMR from previous mapping projects was utilized to supplement collections from 1987-89 within the SACZ. The first part contains an appraisal of regional metamorphism and superimposed alteration in the vicinity of mineralization in the South Alligator Valley region, eastern Pine Creek Inlier, based on petrographic and mineralogical studies. The second part summarizes the results of geochemical work on the layered mafic rocks exposed in the SACZ, and was extended to examine their relationship to similar rocks in the remainder of the Pine Creek Geosyncline. It uses analyses stored in the PETCHEM data-base for the Pine Creek Inlier, augmented by analyses of samples collected in the field and of drill core and hand specimens held from previous mapping projects. Plots used in this report were generated from the program GDA (Sheraton & Simons, 1988).

In this report *mg* = MgO/(MgO + total Fe as FeO), unless otherwise stated.

PART 1 MINERAL ASSEMBLAGES, METAMORPHISM AND ALTERATION

Regional Metamorphism

The problems of the style and distribution of prograde metamorphic assemblages in the SACZ and its surroundings have been addressed in the reports made during the regional mapping program (Stuart-Smith and others, 1986a, 1988a,b). In general the observations made in these reports are merely confirmed by the data from in this survey. Metamorphic grade is essentially upper greenschist, edging locally into the lowermost amphibolite facies. Regional grade rises to the northeast of Fisher Fault, so that the highest grade rocks crop out in the area north and northeast of Fisher airstrip; where grainsize is coarser in the pelitic rocks, cordierite occurs in some specimens and cleavage is better developed. However there are two points where this report is at variance with previous studies. Firstly, metamorphism (or the latest metamophism) came later in the evolution of the region than had previously been thought probable. Secondly, absence of deformation is not an indication of absence of regional metamorphism. Well developed cleavage is not present in the El Sherana Group or higher units, but the effects of metamorphism can be recognized in appropiate rock types and extends as high as the Katherine River Group in the stratigraphic column.

The possibility of more than one episode of metamorphism exists. In the northeastern Pine Creek Inlier a metamorphic unconformity is recognized between the migmatized Nimbuwah Complex and mildly metamorphosed volcanics and sediments, equated with the Edith River Group, beneath the Katherine River Group. In the SACZ, the intensity of the two events may have been reversed. In addition, the role of the phase of metamorphism that produced the carbonate alteration is not certain. In this report, it is treated as a separate event, related to mineralization. That there may have been overlap, either in style or in timing, between regional metamorphism, involving a mixed H_2O-CO_2 fluid, and carbonate alteration remains a definite possibility.

Metamorphic grade is lower in the west of the erstwhile SACZ. Pelites and greywackes collected west of the Kakadu Highway contain chlorite with calcite, occasionally muscovite and rarely biotite. Mafic rocks from the same area contain calcite and actinolite, with sphene replacing opaque phases. Plagioclase is commonly partly replaced by fine grained clinozoisite or epidote and albite. Andalusite has been reported previously from the contact aureole of the Cullen Batholith (Needham and others, 1978).

The increase in regional grade in the eastern part of the SACZ is most readily shown by the biotite-muscovite assemblages which predominate in pelitic rocks, with locally some chlorite, not necessarily indicative of lower-grade conditions. In some specimens it is retrogressive, and the distribution of prograde chlorite may have been compositionally controlled, so that in the most magnesian bulk compositions, chlorite remained stable throughout the region. Cordierite and retrogressive muscovite-biotite or muscovite-chlorite after cordierite occur in the highest-grade areas, and in the aureoles of intrusions.

Mafic rocks, where they are hydrated, contain chlorite-bearing assemblages; the assessment of assemblages is complicated by reactions with a fluid phase containing CO_2. Actinolite is the predominant amphibole; blue-green hornblende appears locally. Mafic rocks and the felsic volcanics of the El Sherana Group and Edith River Group contain metamorphic minerals indicating essentially the same metamorphic grade as in the nearby pelitic rocks. Samples from the dolerite dykes that cut the Malone Creek Granite contain hydrous minerals: green biotite and clinozoisite appropiate to the regional grade. These dolerites have only developed hydrous minerals where water infiltrated along fractures; absence of such minerals does not necessiarily indicate that the rocks escaped metamorphism. (The same observation should be made for the Zamu Dolerite: As this unit is not cleaved, hydration is rarely complete, and primary igneous minerals are, in many samples, partially preserved.) Metamorphism appears to have postdated intrusion of the dolerite dykes.

Increase in grade to the northeast of Fisher strip is also suggested by rougher terrain, steeper ridges and better outcrop. This may be due as much to relict hornfelsing related to the intrusion of thick sills of Zamu Dolerite in this part of the SACZ as to higher regional grade. The higher grade areas may extend into the region southeast of Coronation Hill, where assemblages in the poorly exposed metasediments are similar to those from northeast of Fisher strip.

Most of the collection from the El Sherana Group is from the zone of alteration; but the effects of regional metamorphism are apparent in specimens collected away from this zone. In a coarse fragmental rock from east of Koolpin Waterhole grains of suitable composition are replaced by fine muscovite and the matrix is fine-grained muscovite with some chert. A sandstone from the same outcrops contains epidote in the matrix, probably formed from a clay-calcite cement. A thin mafic unit in these outcrops consists of calcite, chlorite and sphene. Meta-rhyolite from the Pul Pul Rhyolite in the southern edge of the Motor Car Syncline consists of muscovite, quartz and biotite. Nearby basalt contains chlorite, calcite, sphene and albite.

The best indication of metamorphism in the Edith River Group is contained in mafic rocks from the Plumtree Volcanics. Thus mafic rocks from the Motor Car Syncline contain assemblages with calcite and chlorite, similar to those in the underlying El Sherana Group.

Some observations have been previously taken as indicating the Katherine River Group was unaffected by the regional metamorphism. Clay minerals in the matrix of sandstone from the Katherine River Group remain intact, even though silicification of some clastic rocks has occurred. However basalt from the

Katherine River Group does contain chlorite, epidote and altered feldspar (Stuart-Smith and others, 1986b), and pumpelleyite has been indentified in basalt from east of Sleisbeck. Thus, despite a probable decrease in grade vertically in the section, the Katherine River Group appears to have been affected by regional metamorphism.

The Alteration Zones

Valenta (1987, unpublished confidential report) identified four styles of alteration in the mineralized zone, using physical characteristics (Types I to IV, Table 1). Wyborn (1988) noted the distinctive depletion in Na_2O and CaO that occur in the zone, the increase in SiO_2 in some specimens and the intense chemical changes that accompanied kaolinite and hematite alteration. It should be noted that the nature of the alteration below the zone of weathering is known only from incomplete descriptions in early reports (e.g., Allen, 1954). All observations contained in this report have been made on surface samples, and the observations on relationships in outcrop are either taken from other reports or made outside the areas held under lease during 1988-89.

Our studies suggest that from a petrographic and mineralogical viewpoint three stages in alteration are recognizable. These, in paragenetic order, are silicification, sericitization and kaolinite/hematite replacement. Such alteration extends beyond the mineralized district, following the fault systems, and is superimposed on the regional metamorphism. It appears to be lower in grade in that muscovite-chlorite is common, although some rocks from the mineralized zone contain muscovite-biotite. The range of crystallinity indices in muscovite (Fig. B1) from the mineralized rocks suggests a range in temperature during alteration. If the carbonate-bearing assemblages are related to the more intense alteration in the mineralized zone, the the temperatures during alteration were not very different from those during regional metamorphism.

TABLE 1

Alteration Types (from Valenta, 1987)

Type I Penetrative alteration of original volcanic rocks to buff or white chalky lithologies.

Type II Partial sericitization of groundmass and complete sericitization of phenocrysts in volcanic rocks. Sericitic matrix and partial sericitization of clasts in sedimentary rocks. Characteristic pea-green colour.

Type III Patchy zoned sericitization, variable in intensity, commonly asssociated with fractures.

Type IV Fracture-controlled hematite and/or hematite-carbonate* alteration.

Silicification, the earliest phase in the alteration, created a broad halo up to several hundred metres wide, now obvious as erosion-resistant zones which form topographic highs (e.g., Scinto Plateau). Southeast of the recognized mineralized zone, where the fault systems appear to have been eroded less deeply, the zone of silicifaction passes vertically upwards into locally intense quartz veining which brecciates a zone several tens of metres wide either side of the main fault trace. Individual quartz veins show repeated episodes of growth into open spaces. In thin section silicification manifests itself as optically continuous haloes on quartz phenocrysts in felsic volcanics, and as quartz overgrowths and cement in clastic rocks. (This authigenic quartz was subsequently removed in the stages of alteration that introduced muscovite and/or hematite.) Textures are well-preserved so that parent rocktypes are readily recognized. Thus dolerite (87120054) from the Coronation Hill pit is identifiable as Zamu Dolerite from the palimpset graphic intergrowth of quartz and feldspar. Specimens in which silicifaction occurs have chemical signatures that show this stage was the one that involved the removal of CaO and Na_2O and addition of SiO_2.

Sericitization (Types II & III of Valenta, 1988) is confined to narrower zones within the silicified halo. Good examples of intensely sericitized rock come from the mine dumps at Rockhole, Palette and Saddle Ridge. Texturally, sericite preferentially replaces silica added in the first stage. Sericitic alteration involved the movement out of SiO_2 and movement in of Al_2O_3 and K_2O. Chlorite is a minor component of sericite alteration in general, though there are rare intensely chloritized rocks of probable mafic parentage, as for example poorly exposed outcrops at the northern end of the Scinto Plateau and near the Koolpin Mine.

Hematite and kaolinite alteration follow fractures and are irregular in form. In thin section kaolinite and hematite in their turn invade and replace sericite, as well as earlier minerals. Hematite replaces all other minerals except rare grains of muscovite in intensely hematized rocks. Some thin sections contain "fronts" of intense hematization. At its extreme limits it can be seen in outcrop to extend out from small fractures and joints and, in thin section, from hairline fractures in otherwise unaltered rocks. Such alteration is present, not only close to the mineralized rocks, but also in units removed from the mineralized zone, such as the Mundogie Sandstone south of UDP Falls. The relationship between the fracture-controlled hematite and coarse specular hematite at depth in Coronation Hill (Allen, 1954) is not known.

In kaolinitic alteration, textural features, including former quartz phenocrysts in felsic volanics, are preserved intact, though entirely palimpset by kaolinite. As the kaolinized rocks are from topographically high outcrops, it is possible that some kaolinitization may represent the base of a deep weathering surface which formerly extended below the landsurface corresponding to the level crest of the Scinto Plateau. One possible deep-weathering surface would be the pre-Cretaceous surface, preserved beneath the Cretaceous sediments and in hill crests in the area west of the Kakadu highway. Some kaolinized samples and outcrops show the same textural features as are present in samples from the base of the early Tertiary laterites of central Australia. The presence of kaolinite suggests lower temperatures were involved in this stage than during either regional metamorphism or the earlier stages of alteration.

In addition to the intense fracture-controlled hematite alteration, there is a less intense type, which gives a reddish cast to samples and produces a dust of fine desseminated hematite in thin section. This either accommpanied kaolinitic alteration or came after it. Like the kaolinitic alteration, it may be a result of surface weathering, oxidizing the finely divided pyrite which is reputed to occur at depth. Pyritic specimens have been recovered from some of the old mine dumps, and Allen (1954) recorded pyrite at depth in the Coronation Hill deposit.

If the hematite and kaolinitic alteration are the products of deep weathering, then they may be associated with secondary mineralization, and the development of zones of coarser grained secondary gold. Concentration of platinum into nuggets has been reported from lateritized outcrops elsewhere (Bowles, 1986), so zones of secondary platinum are also possible.

The Distribution of Carbonate Minerals

Carbonate (indentified as calcite, but perhaps including dolomite and/or ankerite) has a wide distribution in rocks in which it is unusual or unexpected. There are sedimentary units which contain primary carbonate as chemical or biogenic sediments (e.g., Masson and Koolpin Formations) or detrital grains (e.g., the Wildman Siltstone and the rhythmically bedded sequence above the Stag Creek Volcanics in the vicinity of new Goodparla HS). Some units may contain diagenetic carbonate. The Stag Creek Volcanics, with the appearance of a volcanic flow brecciated immediately after deposition (e.g., a basalt flow over wet sediments), may have been carbonated very early in their history. However, carbonate is widely distributed in units where it is diagenetic or metasomatic; as in the Pul Pul Rhyolite northeast and east of Big Sunday. Carbonate is also present in dolerite from dykes in the same district and in a specimen of Malone Creek Granite. Carbonate occurs in mafic and felsic volcanics collected east-southeast from Old Goodparla homestead along the southern rim of the Motor Car syncline and in alteration zones cutting the Zamu Dolerite. Dykes in Ranford Hill assigned to the Lewin Springs Syenite almost invariably contain carbonate. Carbonate alteration also occurs in mafic rocks from the north of the Pine Creek 1:100 000 Sheet area.

A plot of the distribution of specimens with carbonate suggests a concentration close to the major faults within and south of the SACZ. This may be an artifact of the distribution of sample sites given that the tracks follow the fault zones. Carbonate is more obvious in mafic volcanic rocks where the bulk chemistry of the mafic rocks most readily promoted the formation of carbonate. Recognition of carbonate alteration is therefore dependant on the distribution of mafic rocks.

Data on the chemical changes that accompanied carbonate alteration are very limited. The best come from comparisons among three samples from a basalt horizon about 1km north of Coronation Hill (Table 2). The three were collected about 100 m apart; two retain much of their orginal mineralogy, the third (88124549) is markedly affected by carbonate alteration. Movement out of SiO_2 and K_2O are apparent, possibly of Al_2O_3 and of some trace elements also. Changes in Na_2O and CaO are very slight (using either TiO_2/MgO or TiO_2/P_2O_5 as benchmarks.) Though these analyses suggest some chemical changes with carbonate alteration might be complementary to those that occurred with the intense alteration associated with the mineralized zone, more data are required.

TABLE 2 Mafic rocks, Coronation Sandstone

Sample number	88124506A	88124506B	88124549
Grid reference	397971	397971	397971
SiO2	52.52	52.49	42.37
TiO2	1.43	1.42	1.99
Al2O3	14.35	14.47	12.49
Fe2O3	4.39	4.63	3.06
FeO	7.03	6.82	9.96
MnO	.14	.14	.16
MgO	3.92	3.92	4.76
CaO	6.97	6.84	9.58
Na2O	2.22	2.20	2.81
K2O	2.29	2.18	.07
P2O5	.20	.19	.23
LOI	4.54	4.54	12.08
Rest	.26	.26	.17
Total	100.26	100.10	99.73
O=F,S,Cl	.00	.00	.00
Total	100.26	100.10	99.73

Trace elements in parts per million

Ba	616.00	644.00	74.00
Li	6.00	11.00	31.00
Rb	51	42	2
Sr	156	155	79
Pb	16	18	9
Th	8	8	<2
U	2.00	1.50	1.50
Zr	358	353	142
Nb	14	14	5
Y	52	51	42
La	55	56	14
Ce	98	94	23
Nd	49	48	17
Pr	11	9	-
Sc	29	28	43
V	121	123	196
Cr	112	108	106
Mn	1175	1179	1499
Co	34	32	50
Ni	20	22	39
Cu	43	43	99
Zn	151	152	212
Sn	<2	<2	<2
W	3	<2	3
Mo	<2	<2	<2
Au	-	-	-
Bi	<2	<2	<2
Hf	11	9	3
Ta	<2	<2	<2
Cs	<3	<3	<3
Ge	1.00	1.50	1.00

Allen (1954) reported carbonate within the Coronation Hill deposit. Neither the species of carbonate mineral nor the relationship to the other types of alteration are known. Condon & Walpole (1955) interpreted the quartz breccias (the Scinto Breccia and similar bodies) as silicified carbonate bodies, though this hypothesis seems to have been based on analogy rather than direct information from drill core. One sample, from close to the fault system, immediately to the south of Dinner Creek, has sufficiently a high proportion of carbonate minerals as to have obscured the original texture, and also a high REE content.

Fluorite

The Malone Creek Granite is a high fluorine granite, and specimens commonly contain fluorite. Fluorite is abundant in the fragmental facies of the Pul Pul Rhyolite between the southwestern margin of the Malone Creek and the Palette Fault. Fluorite and carbonate occur together in sediments of the Big Sunday Formation west of the Palette Fault near Big Sunday, and in a highly altered rock collected south of Dinner Creek between the South Alligator Fault and the Palette Fault. Traces of fluorite also occur in felsic volcanics of the Edith River Group collected south of Sleisbeck.

It may be that fluorine is visible as fluorite in the felsic volcanics, but less obvious in other rocktypes where it entered other minerals, particularly the phyllosilicates. If there is a diffuse halo of fluorine alteration, similar to the possible halo of carbonate alteration, then mineral or bulk chemical analyses may be needed to detect it. That many of the samples containing fluorite were collected in the region that surrounds the Malone Creek Granite may indicate that this was the principal source of the fluorine.

Significance of Carbonate Alteration

Circumstantial evidence suggests that there is a wide-flung, diffuse halo of carbonate alteration extending well beyond the zone of intense alteration that follows the South alligator fault system. If this is indeed so, then this would be another parallel between the mineralization in the South Alligator Mineral Field and other fault controlled mineral fields, particularly the Porcupine-Kirkland Lake-Larder Lake field of the Canadian Shield. A zoned halo of carbonate alteration surrounds the Solfala lodes, in the Lachlan Fold Belt of Eastern Australia (e.g., Barron & Barron, 1976); and the spatial relationship of these to a fault system suggests that these too may have many features in common with the deposits of the South Alligator Mineral field. Barron (1976) documented considerable chemical changes, including mobility of CaO, Na_2O and K_2O that accompanied the carbonation alteration near Sofala; however the activity of CO_2 in the fluid phase was much higher in the region surrounding the Sofala lodes.

Valenta (1987) has aready proposed a model in which seismic pumping accompanying movement on the fault systems of the South Alligator valley circulated fluids vertically. To suggest a causal link between the carbonate alteration and the intense altered mineralized zone is to extend this model so that the vertical circulation formed part of a more extensive system which pumped fluids into and/or out of the surrounding region. Furthur, models for fluid circulation and the transport and deposition of U, Au and PGE should consider complexes with $CO_3^=$ (and F), and redox reactions between an H_2O-CO_2 fluid and the carbonaceous Koolpin Formation.

A complete spectrum from regionally metamorphosed rocks, into which only a small amount of H_2O-CO_2 fluid penetrated, to completely carbonated rocks, formed as the result of focused fluid-outflow may be present. Speculation based on this would in turn lead to a modified model in which the mineralizing fluids were metamorphically generated and pumped out along the faults.

The uncomformity would then be important as a place where the fluid regime changed abruptly, as the fluids encountered rocks of different character. The source of the gold, platinum and uranium would be below the uncomformity, and the uncomformity a sink at which these were deposited.

Conditions of Metamorphism

The best interpretation of the mineral assemblages places the regional metamorphism in the temperature range 400-500^{0}C, at a pressure of less than 3kbar, and perhaps involving a H_2O-CO_2 fluid phase. Such a PT gradient is typical of Proterozoic metamorphism in northern Australia, but the fluid phase is unusual.

Estimation of the pressure is dependant on circumstantial evidence. The estimated thickness of overburden would suggest a pressure of about 2kbars would be expected, at least in the lower parts of the stratigraphic column. The assemblages developed in the immediate contact zone of the Cullen Batholith contain andalusite: this indicates extremely low pressure conditions, not more than about 2kbars, in the southwest region. Staurolite has not been recognized in the region. The occurrence of staurolite is, of course, dependant on composition, but as there are some ferruginous units, such as the shale unit in the upper part of the Stag Creek Volcanics, which do not contain staurolite, its absence also suggests low pressure conditions.

Incoming of cordierite northeast of Fisher strip indicates temperatures reached approximately 500^{o}C. Schreyer (1976) gives temperatures in excess of 500^{o}C for the Fe-free reaction, but the actual assemblage undoubtedly contains some Fe and therefore was stable at lower T.

The regional fluid phase appears to have contained some CO_2, as traces of carbonate extend far beyond the intensely carbonated rocks, being common in samples of mafic rock. The source of this

CO_2 may have been local, from decarbonatization reactions, as primary carbonate minerals are widely distributed. Both the Masson and Koolpin formations are in part carbonate sequences, and detrital carbonate occurs in the greywackes of the upper Stag Creek Volcanics and in the Wildman Siltstone.

Assemblages are consistent with low X_{CO2}, and commonly show signs of buffering. Chlorite-albite-calcite, chlorite-actinolite-epidote and chlorite-oligoclase-calcite all fall in the field of low to moderate X_{CO2} (e.g., Will and others, 1990). Temperatures for these assemblages fall in a range centred at about $450^{o}C$.

PART 2

GEOCHEMISTRY OF THE LAYERED MAFIC ROCKS

Revision of nomemclature of the layered mafic units

Present maps indicate the SACZ contains two units of dolerite, the Zamu Dolerite and the Oenpelli Dolerite. Assessment of the geochemical data on these has suggested that some revision of both units is necessary. Ferguson & Needham (1978) assigned all pre-metamorphic dolerite in the Pine Creek Geosyncline to the Zamu Dolerite, which thus includes all intrusive mafic rocks that predated the regional deformation (and metamorphism, the implication being that the two events occurred together). The Zamu Dolerite took its name from Zamu Creek, with the type locality in this area (Stow 1:100 000 Sheet area, GR 519996). The Oenpelli Dolerite forms sills and lopoliths that were intruded after the main high-grade metamorphism in the East Alligators region (Ferguson & Needham, 1978; Stuart-Smith & Ferguson, 1978).

This report proposes that the name *Zamu Dolerite* should be restricted to dolerite of similar chemical, and so far as possible, petrographic character to the dolerite near the type locality. In the remainder of this report this unit will be referred to as the Zamu Dolerite *s.s.*; it appears to be restricted to the sill-like bodies that intrude the South Alligator and Finniss River Groups in the central and eastern Pine Creek Inlier (Fig. 1). A chemically distinct unit of mafic rocks, now mostly amphibolites, occurs in the East Alligator district in the northeast of the Pine Creek Inlier, cropping out within the sequence older than the South Alligator Group, and in the higher grade metamorphics. This unit provided most of the specimens on which Ferguson & Needham (1978) based their report: they noted the chemical characteristics which make this unit different from the Zamu Dolerite *s.s.*, but ascribed the differences to metasomatism concurrent with regional metamorphism. In the remainder of this report it is referred to

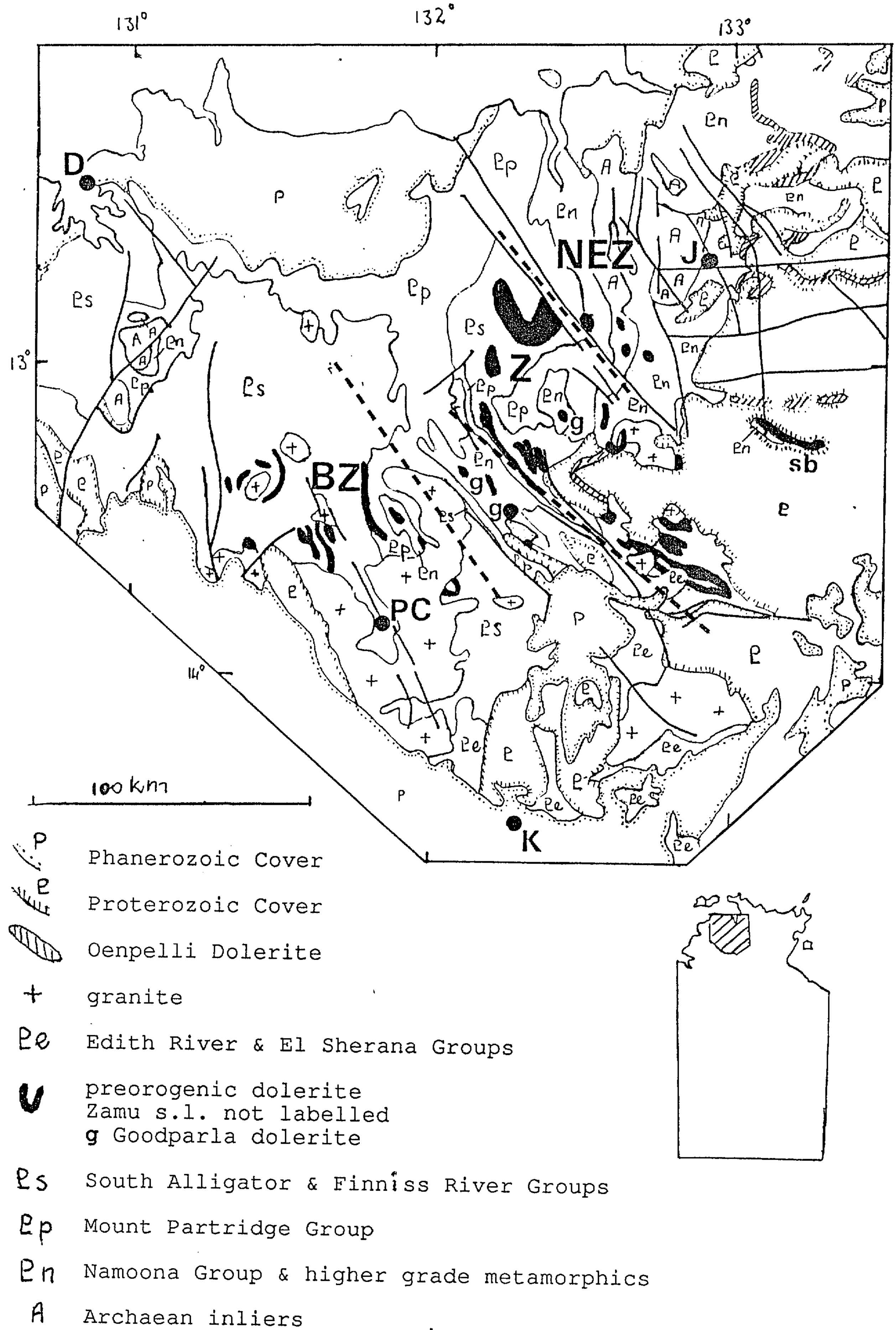

Figure 1 Distribution of the layered mafic units in the Pine Creek Inlier.

as the *northeastern Zamu Dolerite s.l.*, abbreviated to *NEZ dolerite*. A third distinct unit, presently delineated as Zamu Dolerite, crops out as thin sills and isolated exposures in the region between the abandoned Darwin-Larrimah railway and the Stuart Highway west and southwest of Burrundie Siding. This unit also occurs north of Ban Ban Springs, and in a belt extending northwards from Francis Creek, and east of the Cullen Batholith, near McCarthy's Mine (Fig. 1). Some of the amphibolites in the Masson Formation east of Francis Creek have the chemical signature of this unit. In the remainder of this report this unit is referred to as the *Burrundie phase of the Zamu Dolerite*, abbreviated to *BZ dolerite*.

Units mapped as Zamu Dolerite extend as far west as the western edge of the Pine Creek Inlier. The PETCHEM data-base includes four samples of Zamu Dolerite from the district south of the Rum Jungle Inlier. These are referred to as *Western Zamu Dolerite s.l.*, abbreviated to *WZ dolerite* in this report. Their affinities with other units of Zamu Dolerite are tenuous. Mafic rocks in the Litchfield Province, previously mapped as Zamu Dolerite, have now been placed in the Wangi Basics (Pietsch & Edgoose, 1988). The description of the Wangi Basics indicate its affinities might be with the Goodparla dolerite, rather than the Zamu Dolerite *s.l.*.

The PETCHEM data-base also contains analyses of other samples that have been assigned to the Zamu Dolerite at the time when these were collected. They have chemical characteristics that are incompatible with any unit of Zamu Dolerite, and most occur in a stratigraphic environment that indicates they are unlikely to be Zamu Dolerite *s.s.*. For some samples, their chemical signatures may in part reflect metasomatic alteration, as, for example, samples from the altered zones surrounding the major deposits of the East Alligators mineral field. Some samples of metadolerite are olivine-normative, but do not fall on trends for any of he major units of dolerite: this suggests that such samples are either metasomatically altered or have been collected from intrusions not part of any of the major units. The three samples of amphibolite from the South Beatrice Window (Howship 1:100 000 Sheet area, labelled sb in Fig.1)) have characteristics that place them outside any of the major units of dolerite. Two samples of meta-dolerite from the Myra Falls Inlier are likewise different from the major units.

This report includes a re-assessment of the problem of the relationship between the Zamu Dolerite *s.s.* and the Shovel Billabong Andesite, the chemical signature of which shows it to be closed related to the Zamu Dolerite *s.s.*.

The Oenpelli Dolerite has a distinctive chemistry, so that analyses of samples assigned to the Oenpelli Dolerite show a well-constrained trend, being olivine-normative for *mg* > , and quartz-normative at low *mg* (Stuart-Smith & Fergusson, 1979). The meta-dolerite that intrudes the Nanooma Group, essentially the Masson Formation, in the Mundogie and Ranford Hill 1:100 000 Sheet areas has been variously assigned to the Zamu Dolerite and, more recently, to the Oenpelli Dolerite (e.g., Stuart-Smith & others, 1986a); but is different chemically from either. It is proposed that this unit be given informal stratigraphic status as the *Goodparla dolerite*, a revision of the original *Goodpalah diorites* of Gray (1915). The reference locality, adjacent to the original Goodparla homestead, is the same, the spelling is adapted to current usage. The unit was originally termed *diorite* because outcrops at the type locality contain abundant amphibole, but as this is metamorphic actinolite, *dolerite* or *metadolerite* are more appropiate.

The Zamu Dolerite s.s.

The Zamu Dolerite *s.s.* forms sills within the South Alligator Group and Burrell Creek Formation of the Finniss River group in an arcuate zone fron northeast of Sleisbeck north as far as the Arnhem Highway, where it was intersected in BMR Kapalga 29. It extends north into Jim Jim 1:100 000 Sheet area, where it crops out in windows beneath the Katherine River Group. The thickest sills are in the region north and east of the Malone Creek Granite. Available data shows that, at least in the thicker sills, compositional layering developed during cooling; but detailed field studies of measured sections are yet to be carried out. Topographic variations, similar to strike ridges, occurring within the Zamu Dolerite appear to reflect a geomorphological response to compositional layering. The specimens with the highest *mg* come from the ridge adjacent to the Zamu Mine, suggesting that this is a basal contact of a thick sill. Similar material from north of Fisher Strip (GR 466020) indicates a basal zone is exposed here also. Basal zones appear to be marked by the development of red soils. The more fractionated compositions have been collected from topographically low areas, where yellow clay soil, more typical of the Zamu Dolerite, produces waterlogged conditions during the wet season, and formerly provided buffalo wallows. BHP Mundogie Hill 1 was drilled through parts of two thin sills. Thin sections, spaced through these sills show a clear compositional trend, with the dolerite fractionating here to a hornblende-bearing granophyre (Bryan, 1962).

Petrology

The collection of thin sections of Zamu Dolerite is extensive. Although the Zamu Dolerite is pre-metamorphic, most samples have retained their primary texture, and many have some primary minerals, usually the pyroxenes, preserved. Thin sills are more altered, but foliation is rarely developed. Only the most magnesian specimens do not contain the graphic intergrowth of quartz and feldspar that makes the Zamu Dolerite readily recognizable in thin section, despite weathering or alteration. The high *mg*, high Cr, high Ni samples contain cumulus orthopyroxene, with salite or augite as the second pyroxene. Many specimens contain inverted pigeonite, in some examples with an overgrowth of augite, and pigeonite itself is preserved in a few specimens (e.g., 89124647). The low *mg* specimens contain a single augitic pyroxene, or in rare examples, a brown hornblende (e.g., 89124643). Plagioclase is rarely well enough preserved to permit optical indentification. Previous reports have noted K feldspar, usually in the graphic intergrowths with quartz. Some potassium also entered into late biotite (red to red-brown) which overgrew ilmenite. Skeletal ilmenite, commonly partly altered to sphene, characterizes the more evolved specimens; and needles of apatite are present in the granophyres. Specimens from the central south of Jim Jim 1:100 000 Sheet area contain cumulus plagioclase.

Chemistry

Analyses of Zamu Dolerite form a well defined series (Fig. 2) in plots against *mg*. Early high Cr may be partly taken up in the cumulus orthopyroxene, and partly in the opaque phase, probably a high-Cr magnetite, present in accessory proportions. The early high Ni values were probably accommodated in the orthopyroxene, since there is no evidence for cumulus olivine. The incompatible elements show the expected increase with decreasing *mg* (Fig. 3).

Three samples, collected from within the area of outcrop of the Zamu Dolerite are somewhat anomalous, in that they have lower SiO_2 *and plot close to, but not on Zamu trends. There is insufficient data either to consider the possibility of a separate unit or to speculate on contamination. A point of some interest is that one sample carries high PGE.*

The Zamu Dolerite *s.s.* is quartz-normative throughout its entire compositional range and is the most siliceous of the several major dolerite units (Fig. 4). It is characterized by a higher differentiation index and normative plagioclase, and has a lower colour index and a less calcic normative plagioclase than the other units (Fig. 5).

The Zamu Dolerite falls mainly within the calc-alkaline field in an AFM plot as defined by Irvine & Baragar (1971); and also in a Ti-Zr-Y plot mainly in the calc-alkaline field as proposed by Pearce & Cann (1973) (Figs 6&7). In a plot of normative plagioclase against Al_2O_3, the Zamu Dolerite, in the main, plots

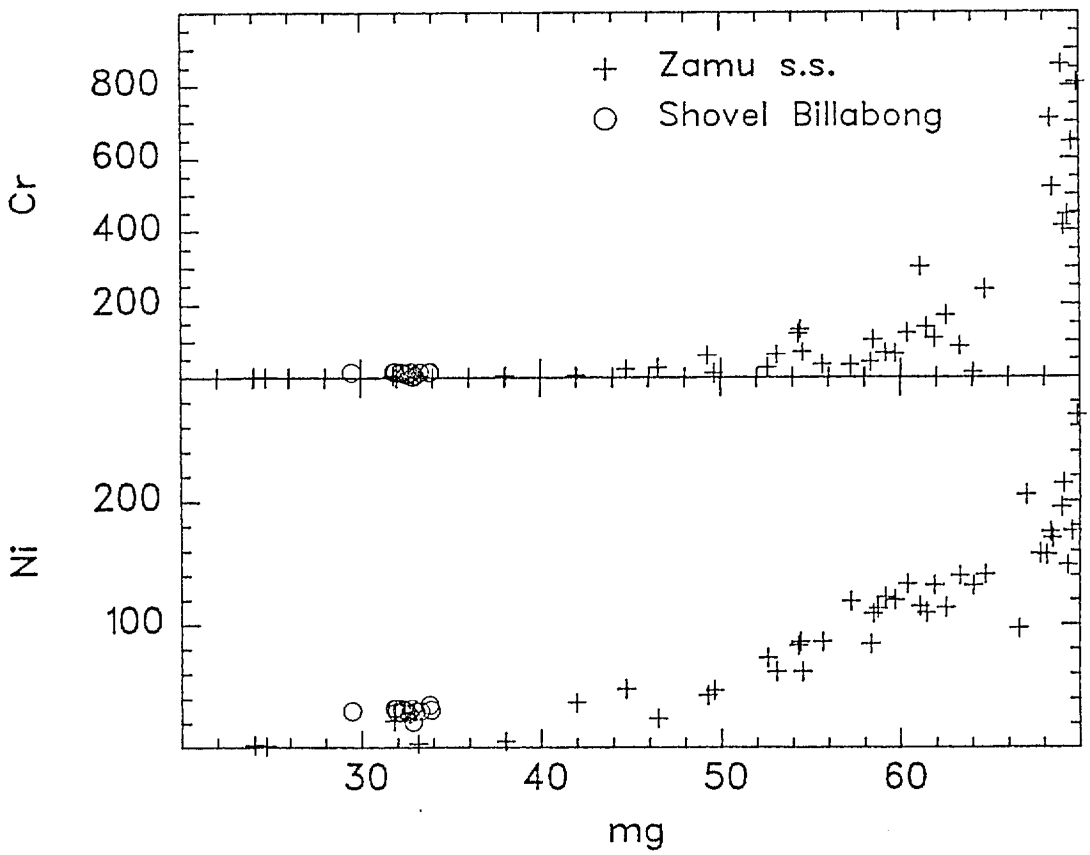

Figure 2 Fractionation trends for Cr & Ni (in ppm) plotted against *mg* in the Zamu Dolerite *s.s.* and the Shovel Billabong Andesite.

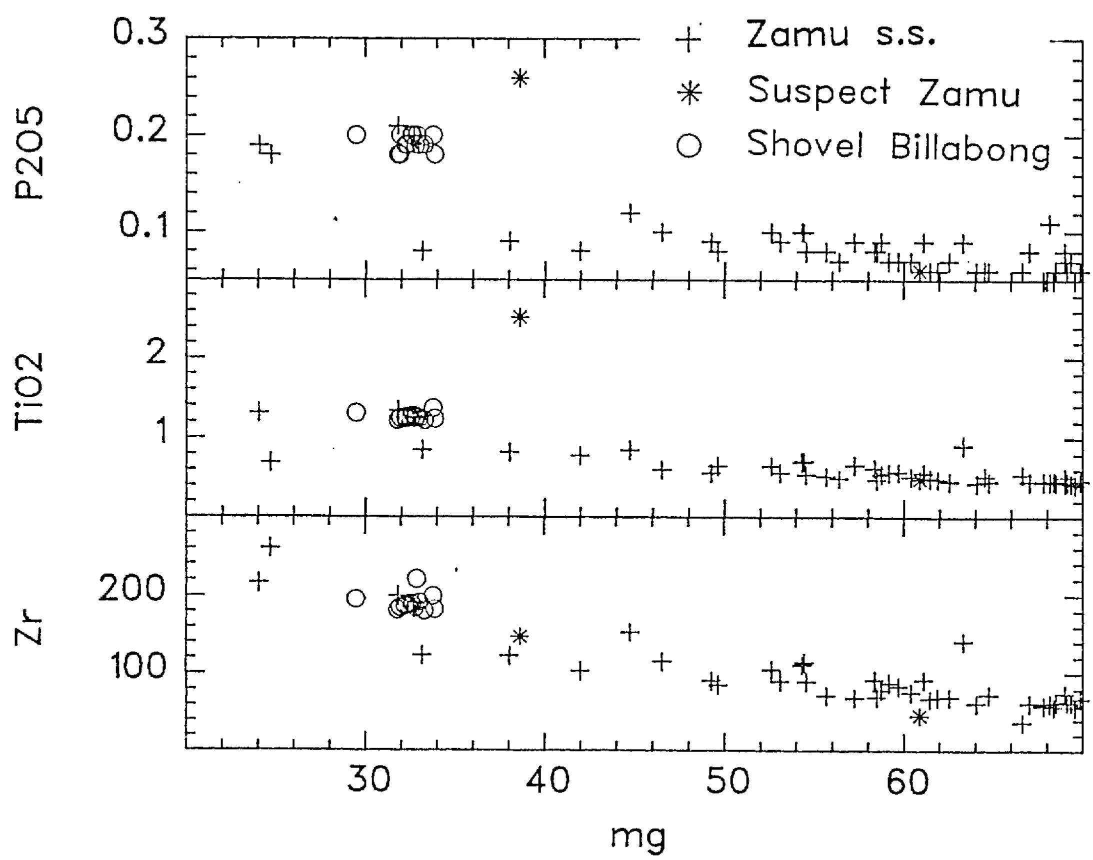

Figure 3 Fractionation trends for Zr (in ppm), TiO_2 & P_2O_5 (in percent) plotted against *mg* in the Zamu Dolerite *s.s.* and the Shovel Billabong Andesite.

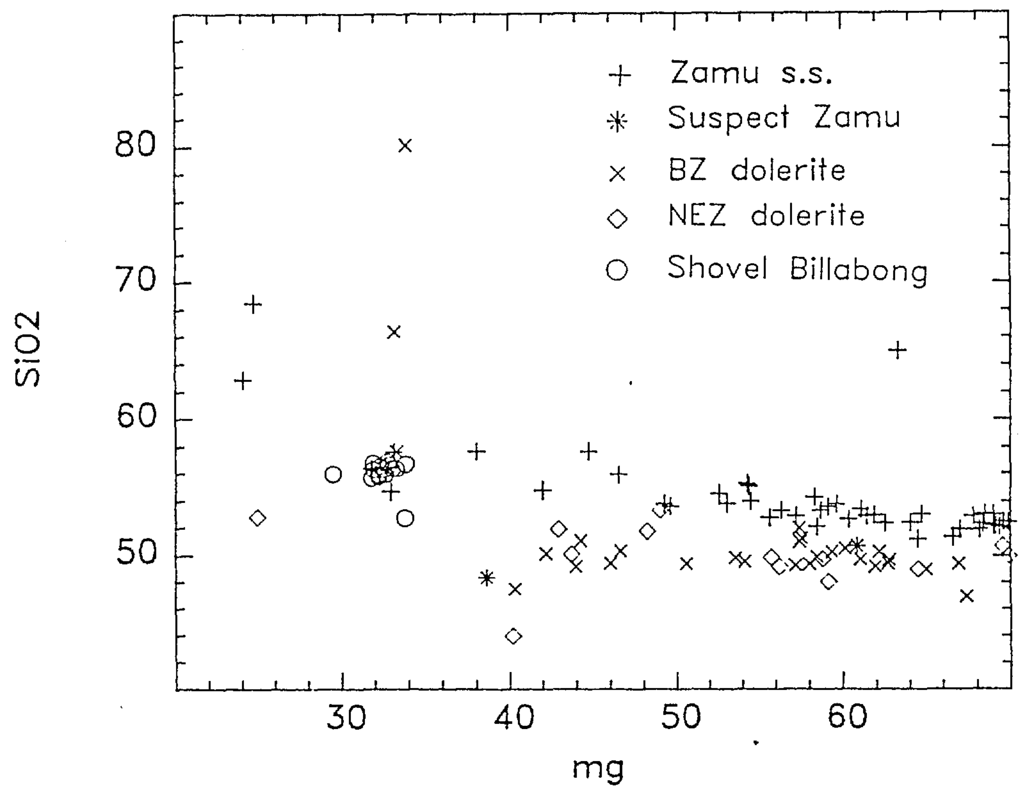

Figure 4 SiO_2 plotted against *mg* for the Zamu Dolerite *s.s.*, the NEZ dolerite, the BZ dolerite and the Shovel Billabong Andesite.

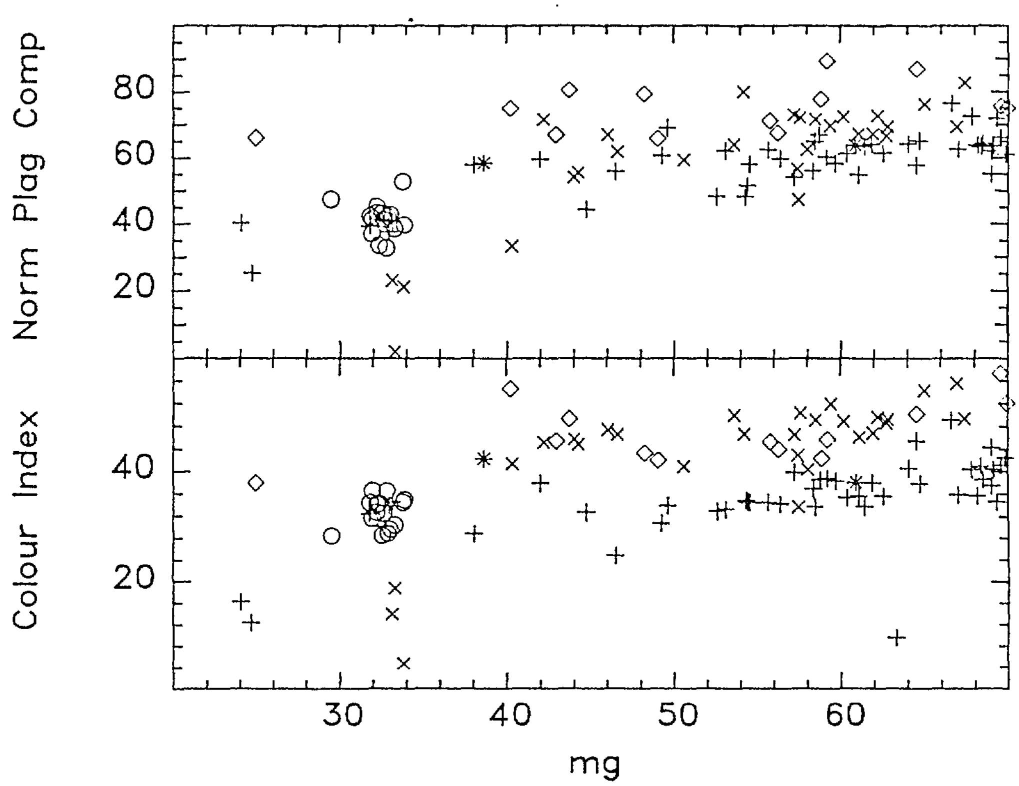

Figure 5 Colour index and normative plagioclase composition plotted against *mg* for the Zamu Dolerite *s.s.*, the NEZ dolerite, the BZ dolerite and the Shovel Billabong Andesite.

on the tholeiitic side of the dividing line as proposed by Irvine & Barager (1971), but forms a trend closer to the divide than other units of dolerite (Fig. 8).

A few samples have been analysed for PGE. The data show that Pt did not accumulate with Cr in the initial stage of crystallization, but instead the highest values occur within the fractionation series (Fig. 9). A plot of S values shows the same tendency to a broad peak at about *mg* 60 (Fig. 9). Given that many samples do not have measured S (S was previously reported as SO_3, or not analysed), a plot of Cu as an indicator of sulphur concentration shows the same broad peak at *mg* 60 (Fig. 9). These plots indicate that Pt, and by inference PGE, concentrated as a sulphide phase during crystallization.

The northeastern Zamu Dolerite s.l.:- *NEZ dolerite*

Metamorphosed mafic rocks, mainly amphibolites, have been mapped as Zamu Dolerite in the northeast of the Pine Creek Inlier. Some of the analysed samples are from the vicinity of the ore deposits in the district, and their chemistry reflects the metasomatism associated with mineralization. The samples from the South Beatrice Window (Howship 1:100 000 Sheet area) have high overall Al_2O_3 and general chemistry that indicates they are unrelated to the main units. After such units are deleted from the data base there remains a set of samples whose analyses give consistent trends on geochemical plots. This consistency is taken to indicate that there is an unit of mafic rocks, hitherto mapped as Zamu Dolerite, which should be considered as an entity, which in this report will be referred to as the northeastern Zamu Dolerite or NEZ dolerite.

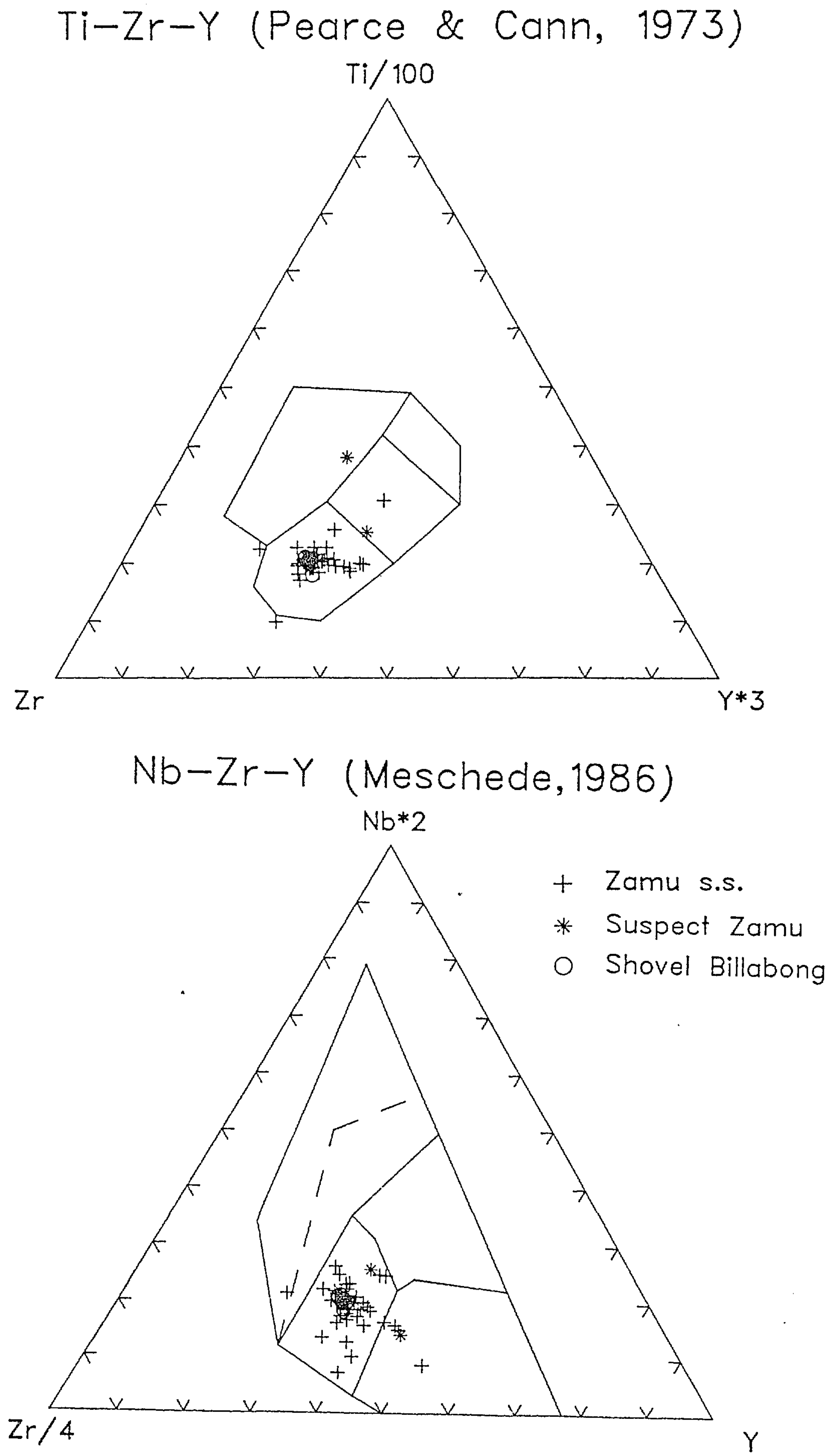

Figure 6 Ternary plots for Ti-Zr-Y & Nb-Zr-Y for the Zamu Dolerite *s.s.* and the Shovel Billabong Andesite.

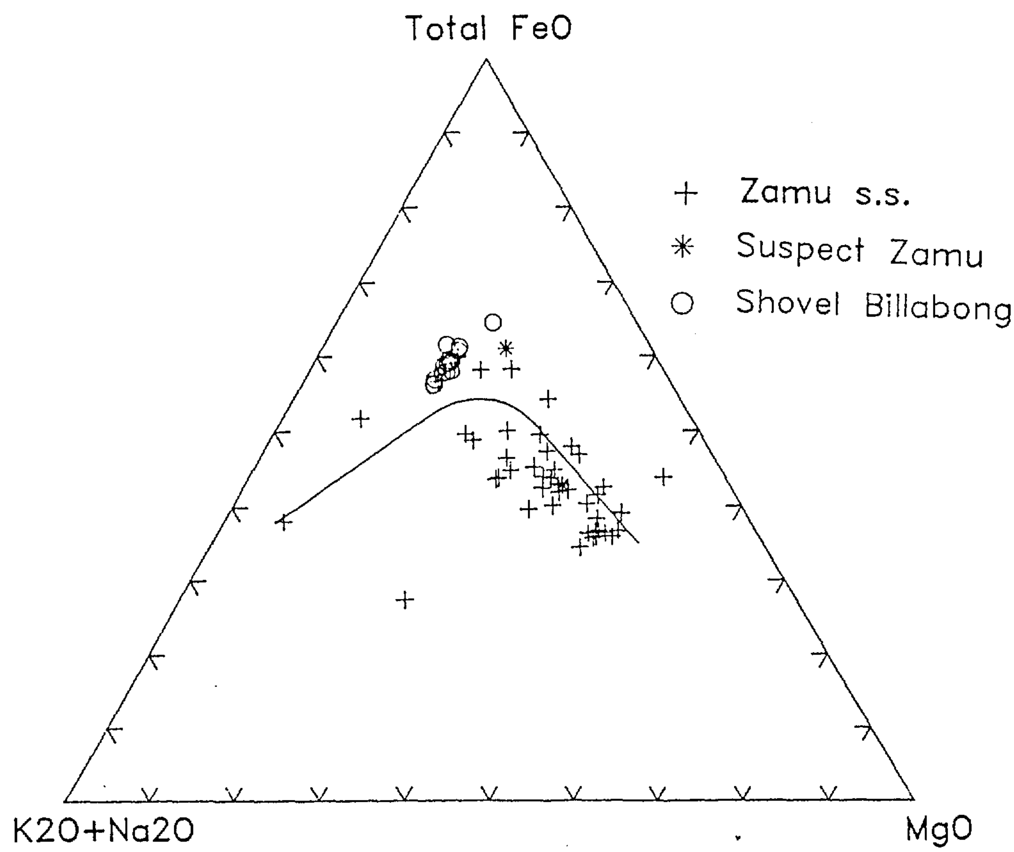

Figure 7 AFM plot for the Zamu Dolerite *s.s.* and the Shovel Billabong Andesite.

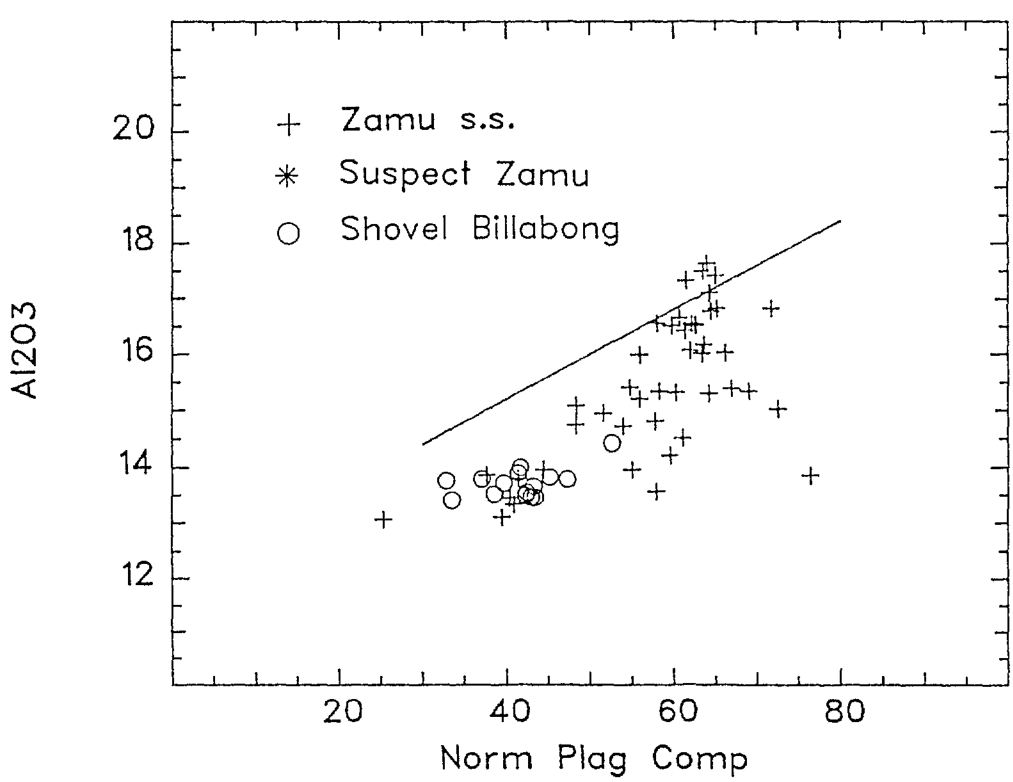

Figure 8 Plot of normative plagioclase against Al_2O_3 for the Zamu Dolerite *s.s.* and the Shovel Billabong Andesite.

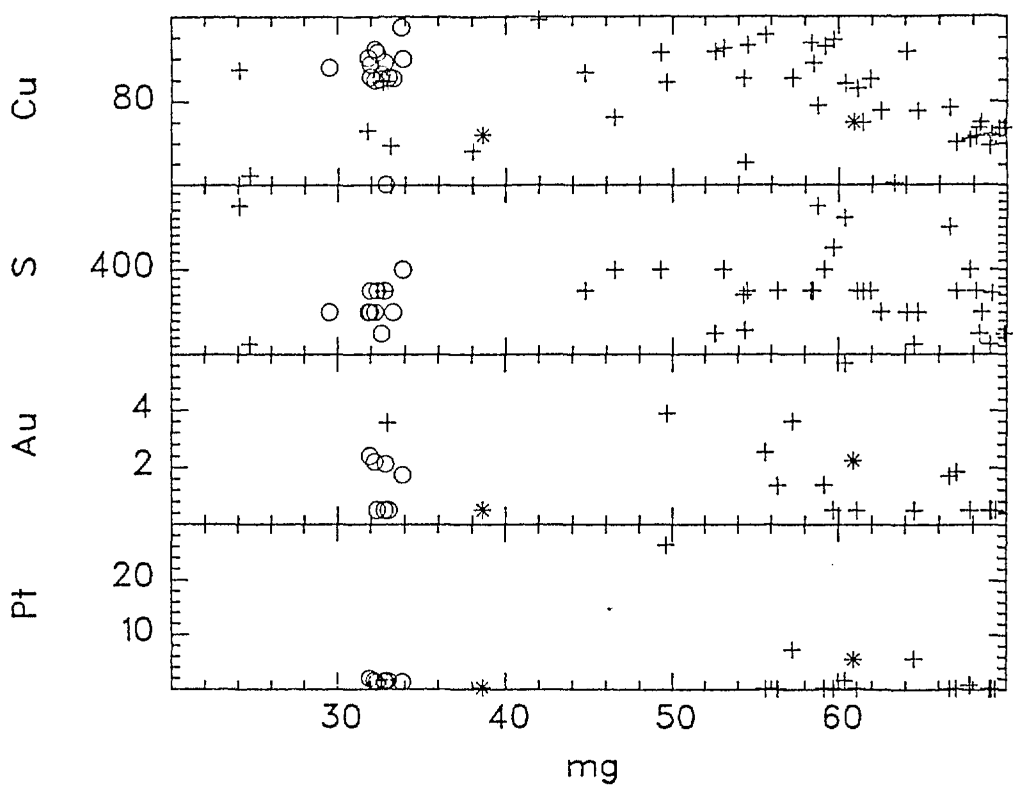

Figure 9 Au, Pt, (in ppb), S & Cu (in ppm) plotted against *mg* for the Zamu Dolerite *s.s.* and the Shovel Billabong Andesite.

The NEZ dolerite extends as far west as the eastern part of the Kapalga 1:100 000 Sheet area and southwest into the northeast of the Jim Jim 1:100 000 Sheet area where it has been intersected in drill core and collected from windows in the Katherine River Group.

The geological maps show the rocks surrounding the NEZ dolerite as units older than the South Alligator Group, principally the Cahill Formation, and metamorphic rocks which may include lateral equivalents of the Finniss River Group and the South Alligator Group, as well as older stratigraphic units.

Chemically the NEZ dolerite is less siliceous than the Zamu Dolerite *s.s.*, and differs from it in having a higher colour index, a lower differentiation index, less normative plagioclase and a more calcic normative plagioclase if compared to the Zamu Dolerite *s.s.* at similar *mg*. Analyses fall on a trend more clearly within the tholeiitic field on an Al_2O_3 versus normative plagioclase composition (Fig. 10), and on a well defined trend within the tholeiite field on an AFM plot (Fig. 11). The majority of the specimens studied by Ferguson & Needham (1978), which led them to conclude that the Zamu Dolerite was a tholeiitic intrusion, were from the NEZ dolerite. The NEZ dolerite also plots in fields distinct from the Zamu Dolerite *s.s.* in ternary plots such as Ti-Zr-Y and Nb-Zr-Y (Figs 6a&b).

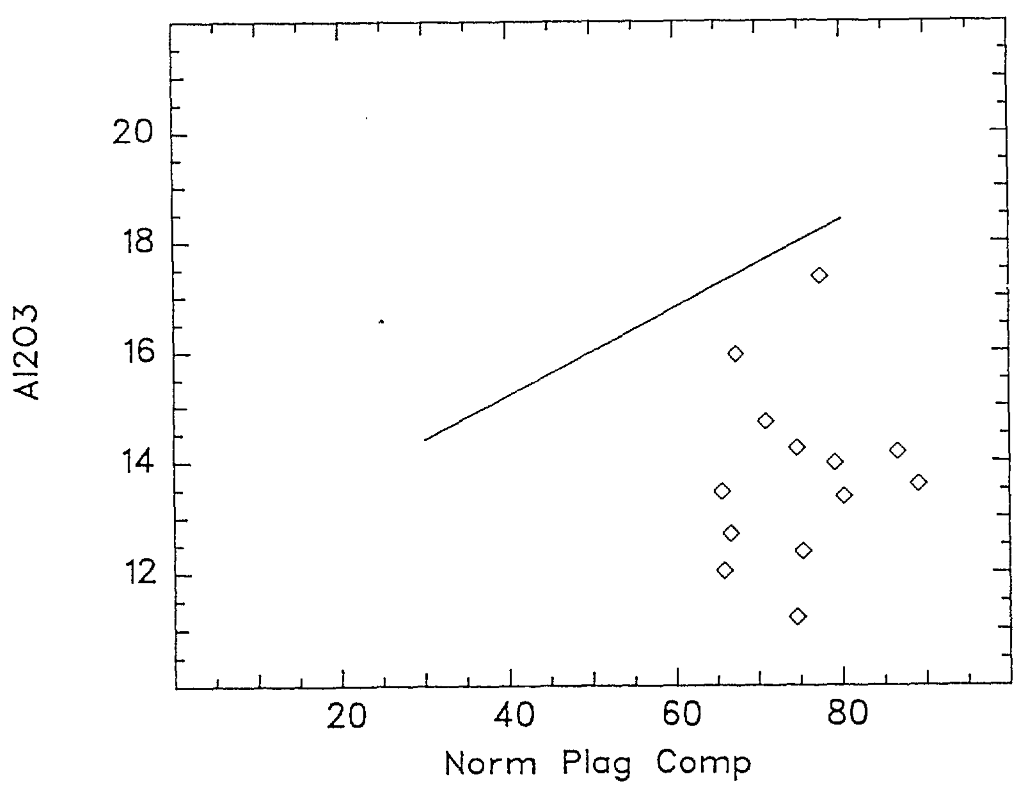

Figure 10 Plot of normative plagioclase against Al_2O_3 for the NEZ dolerite.

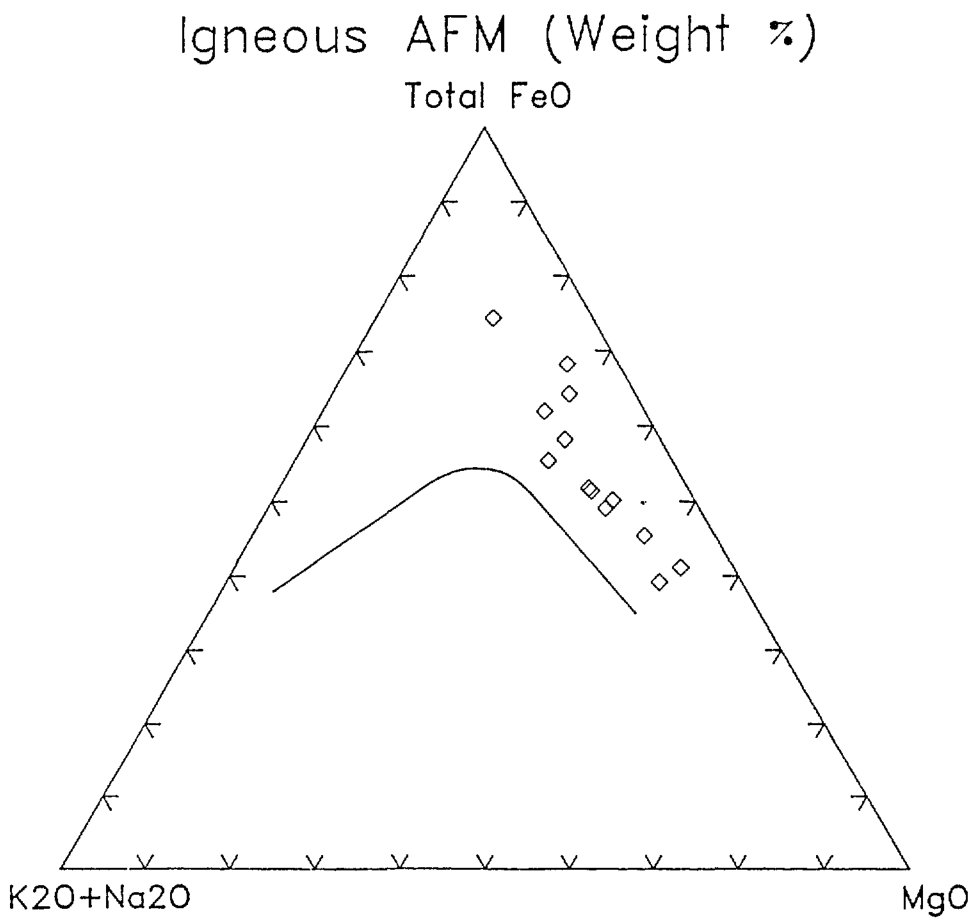

Figure 11 AFM plot for the NEZ dolerite.

The Burrundie phase of the Zamu Dolerite s.l.:- *BZ dolerite*

A third cohesive unit of dolerite, also previously mapped as Zamu Dolerite, occurs in the central region of the Pine Creek Geosyncline. This, the Burrundie phase or BZ dolerite, crops out as thin sills intruding the Koolpin Formation in the Burrundie and Golden Dyke domes (MacKinlay River & Pine Creek 1:100 000 Sheet areas, Stuart-Smith & others, 1986c, 1988c). The same unit occurs north of Ban Ban Springs and in a belt following the same stratigraphic level north from Francis Creek. A single sill of dolerite, exposed east of the Cullen Batholith, at the base of the Koolpin Formation near McCarthy's mine (Ranford Hill GR845780, see Stuart-Smith & others, 1988a) is an outlier of the unit. Some of the amphibolites within the Masson Formation east of Francis Creek have chemical signatures which show that they are part of the same unit. (Some appear to plot with the Goodparla Dolerite.)

Samples from the isolated dolerite within the Burrell Creek Formation (McKinlay River GR960096) have chemical signatures atypical of the BZ dolerite and should not be included with it.

Petrology

Much of the area of outcrop lies within the contact zone of the granite intrusion as defined during regional mapping. Specimens in the collection vary from completely recrystallized to slightly altered. The highest grade asemblages are in specimens from east of Francis Creek, where actinolite is developed, and igneous textures completely obliterated. Many specimens retain some textural evidence of their igneous parentage, but have been somewhat hydrated and in some examples, carbonated. Quartz is less abundant than in the Zamu Dolerite *s.s.*, but graphic intergrowths are present in some specimens.

Chemistry

Samples from the field collections made during regional mapping have been analysed for major and trace elements, and selected samples for PGE and Au.

The BZ dolerite shows a well defined fractionation trend (Figs 12&13). It is less siliceous than the Zamu Dolerite , and verges into olivine-normative compositions at high *mg* (Figs 4&14). (Cumulus olivine is not preserved, but may have been present in early members of the series.)

Samples from the *mg* end of the chemical series show significant values for PGE and Au (Fig 15), though there appears not to be a tendency to a peak within the series. The results from the samples collected east of Francis Creek are little different from those from the sills farther west. Gold deposits do occur in the vicinity of the BZ dolerite in the Golden Dyke dome and adjacent to the Hayes Creek Shear, but the Koolpin Formation is as likely a source of Au as the BZ dolerite.

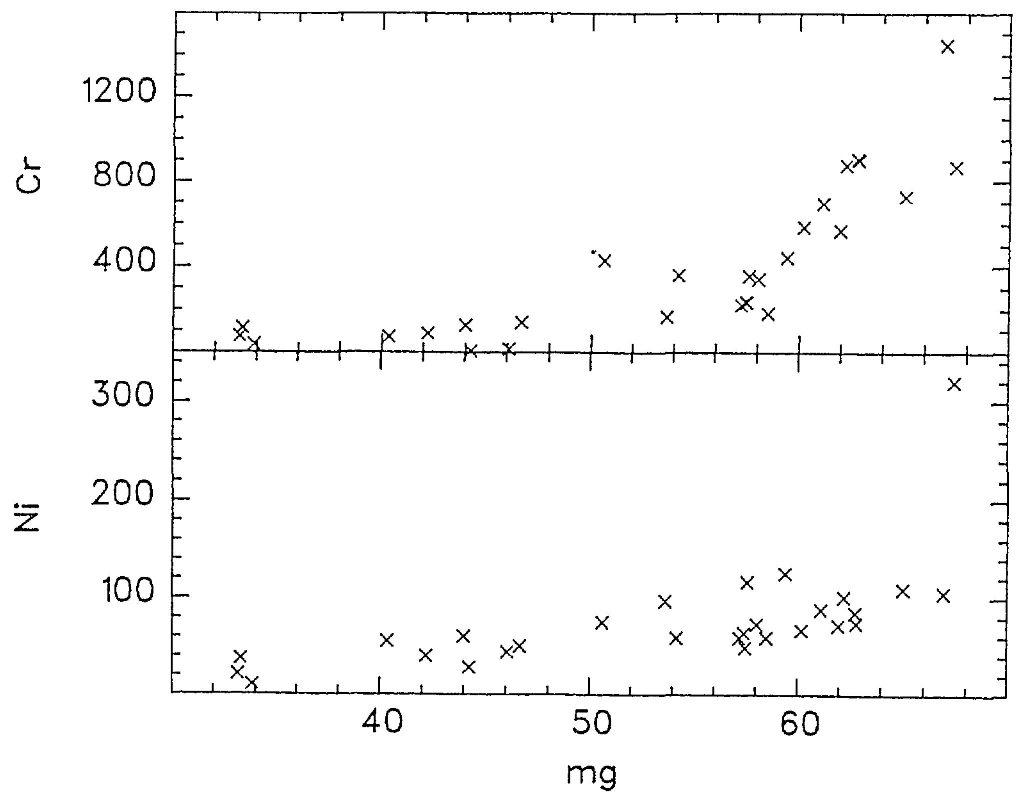

Figure 12 Fractionation trends for Cr & Ni (in ppm) plotted against *mg* for the BZ dolerite.

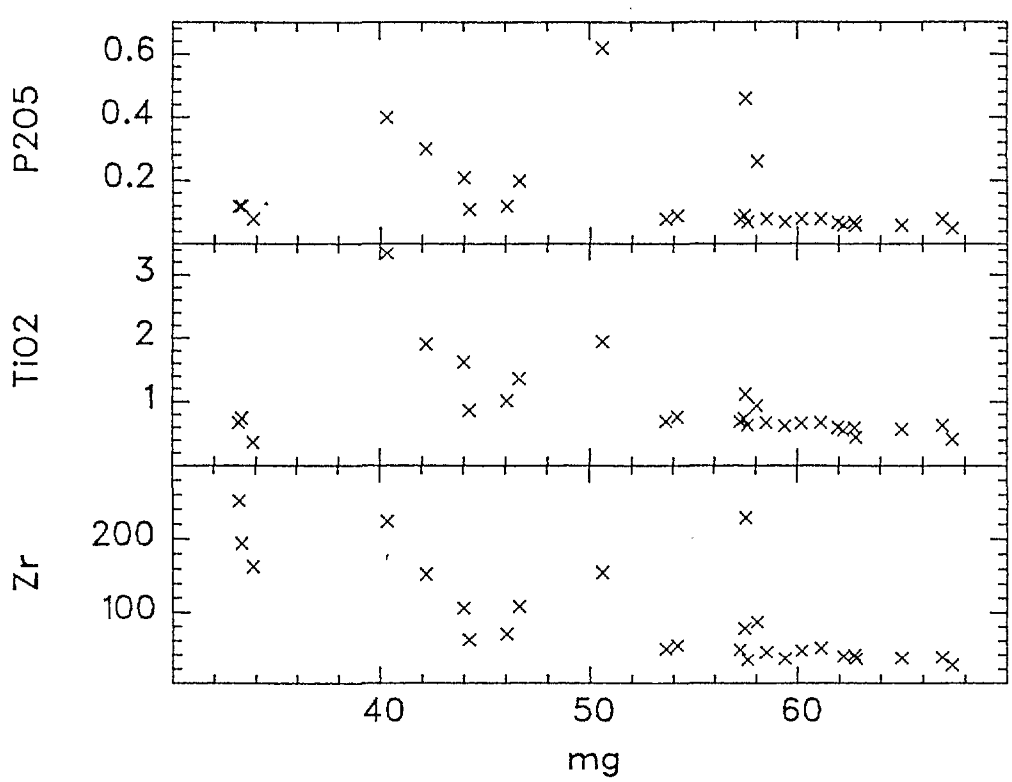

Figure 13 Fractionation trends for P_2O_5, TiO_2 (in percent) and Zr (in ppm) against *mg* in the BZ dolerite.

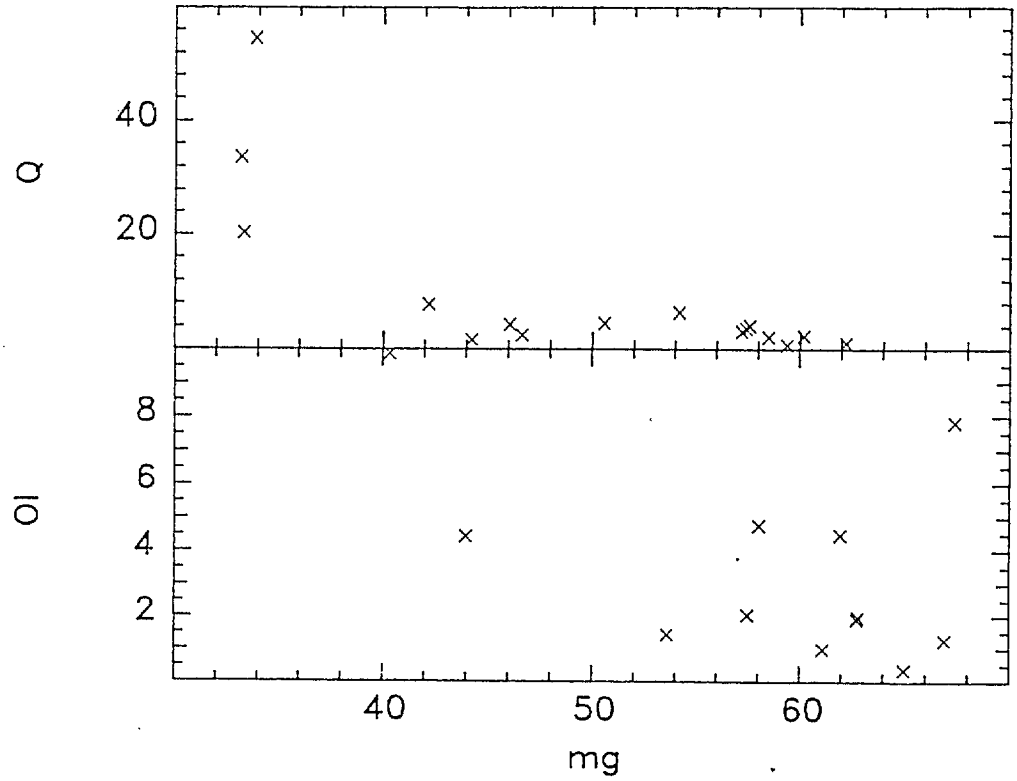

Figure 14 Plot showing normative olivine and quartz against *mg* in the BZ dolerite.

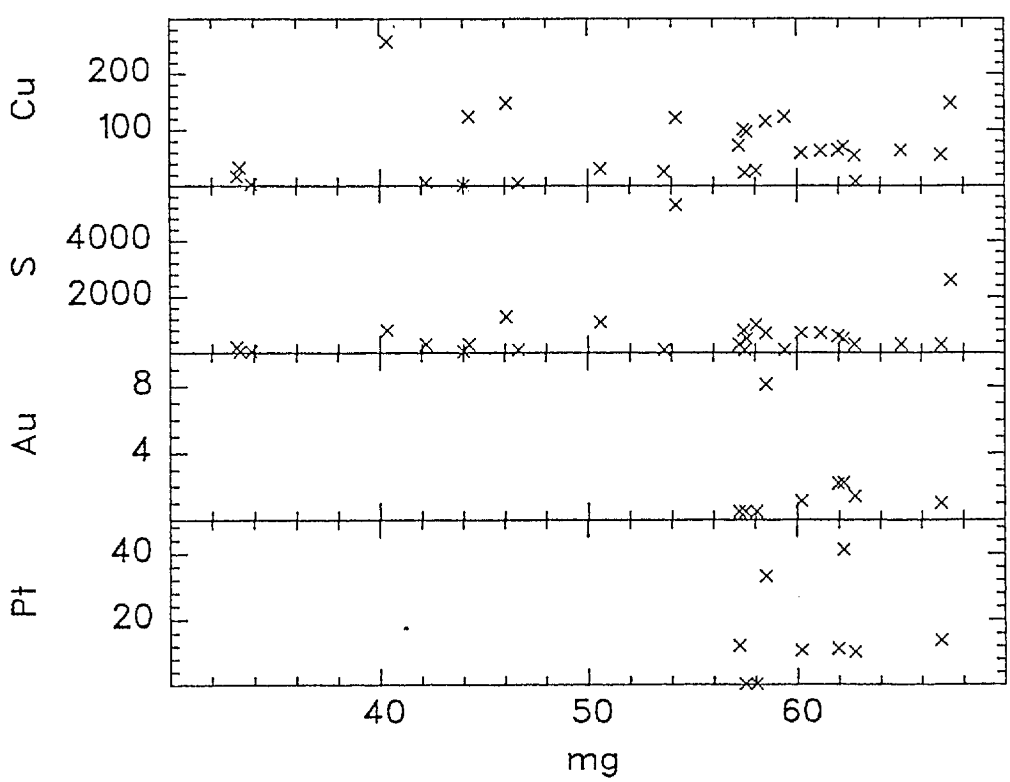

Figure 15 Pt,Au (in ppb), S & Cu (in ppm) plotted against *mg* in the BZ dolerite

The western outcrops of Zamu Dolerite s.l.:- *WZ dolerite*

Five samples of amphibolite from the district south and southeast of the Rum Jungle Inlier have been analysed as Zamu Dolerite. Two samples are from within the Burrell Creek Formation, but are uncharacteristically low in Al_2O_3, and their chemistry overall suggests that, if they are related to the other Zamu Dolerites, then they have undergone metasomatic disturbance. Two samples come from a drillhole close to a fault and probably from within the Mount Partridge Group. One is corundum normative, the other appears to share some characteristics with the Goodparla dolerite and the NEZ dolerite. The fifth specimen comes from an amphibolite between the Mount Partridge Group and the Wildman Siltstone in the rim of the Burnside dome. It is olivine normative, its chemistry does not have indications of major disturbance, but it has no affinities with any of the main units.

The Goodparla dolerite (revised name, informal unit)

A unit of massive dolerite occurs within the outcrop area of the Masson Formation (Nanooma Group) in the southwest of Mundogie and extreme north of Ranford Hill 1:100 000 Sheet areas, where it has been mapped as Oenpelli Dolerite. Outcrops are dark green and commonly produce a red soil as opposed to the predominantly yellow soil over the Zamu Dolerite *s.s.*. For reasons summarized below, this dolerite is considered to be neither Oenpelli Dolerite nor Zamu Dolerite; and is assigned to a separate unit, the Goodparla dolerite. This is a revision of the name Goodpalah Diorite originally given to all the mafic rocks in the district by Gray (1915). The reference outcrops extend west-southwest from the abandoned Old Goodparla homestead (Mundogie GR049096), the same locality from which Gray proposed his unit.

BMR Mundogie 42 intersected dolerite in subcrop within the Nanooma Group in the northeast of the Mundogie 1:100 000 Sheet area. In thin section this is an olivine-bearing gabbro; and it has a chemical signature which lies on the trends for the

Goodparla Dolerite. The Goodparla Dolerite has not been traced northeast beyond this point, though three specimens from the vicinity of the Narbelek Mine show chemical affinities with the Goodparla dolerite. Investigation of the samples of metadolerite held from the regional mapping of the Jim Jim 1:100 000 Sheet area did not reveal any Goodparla dolerite.

Dolerite, mapped as Zamu Dolerite, occurs within the Nanooma Group in the southeast of the McKinlay River and northeast of the Pine Creek 1:100 000 Sheet areas. The available samples are all metamorphosed. The more magnesian samples show affinities with the BZ dolerite. Some of the less magnesian samples have affinities with the Goodparla dolerite, but the correlation is uncertain, and all samples from this area have been assigned to the BZ dolerite

Petrology

All samples show some effects of metamorphism. Many samples contain olivine or mineral aggregates pseudomorphing olivine. Quartz occurs in some samples and apatite in some. Part of the outcrop immediately to the north of Buk Buk Lookout (Mundogie GR026074) contains large euhedra of plagioclase. The sample of this (8912407B) tends to plot off the geochemical trends of the Goodparla dolerite; this suggests that it is atypical of the unit as a whole.

Chemistry

Analyses fall on a clear trend from olivine-normative at high *mg* to quartz-normative at low *mg* (Fig. 16). On many plots the samples lie on the same trends as the suite of Oenpelli Dolerite, with which they have been equated. From the present data set, the best discrimants are P_2O_5, TiO_2, and Ba:- XY and ternary plots using these elements can be used to separate the Goodparla dolerite from the Oenpelli Dolerite (e.g., Figs 17&18). There is also an apparent separation in a ternary Ti-Zr-Y plot, with the

Goodparla dolerite samples lying distinct from a tight cluster for the Oenpelli Dolerite (Fig. 19). These plots indicate three samples from the Narbelek district (75080289, 75080307 and 88126035; one olivine normative Zamu Dolerite *s.l.* and two Oenpelli Dolerite) may belong to the Goodparla dolerite.

Analysis of selected samples of Goodparla Dolerite revealed no significant PGE or Au values. This is discouraging, but should not be taken as definitive, as there is no certainity either that the basal unit has been sampled or that the sampling has been adequate within the unit.

Olivine normative Zamu Dolerite s.l. *and Zamu Dolerite* s.l. *of uncertain affinities*

Several samples in the data set previously assigned to the Zamu Dolerite have normative olivine, but are not part of the BZ dolerite. All are from the northeastern Pine Creek Inlier, and are metamorphosed. Some of the samples show chemical affinities with the Oenpelli Dolerite, but as they are metamorphosed, would not be presently considered as such. The specimens put into the class of dubious Zamu Dolerite *s.l.* are likewise from the northeasthern Pine Creek Inlier. The features that shift these specimens off the trends for the major units may reflect incipent metasomatism or the specimens may belong to minor non-regional intrusions.

Isolated outcrops of Zamu Dolerite about 10 km north of Burrundie Siding are not part of the BZ dolerite.

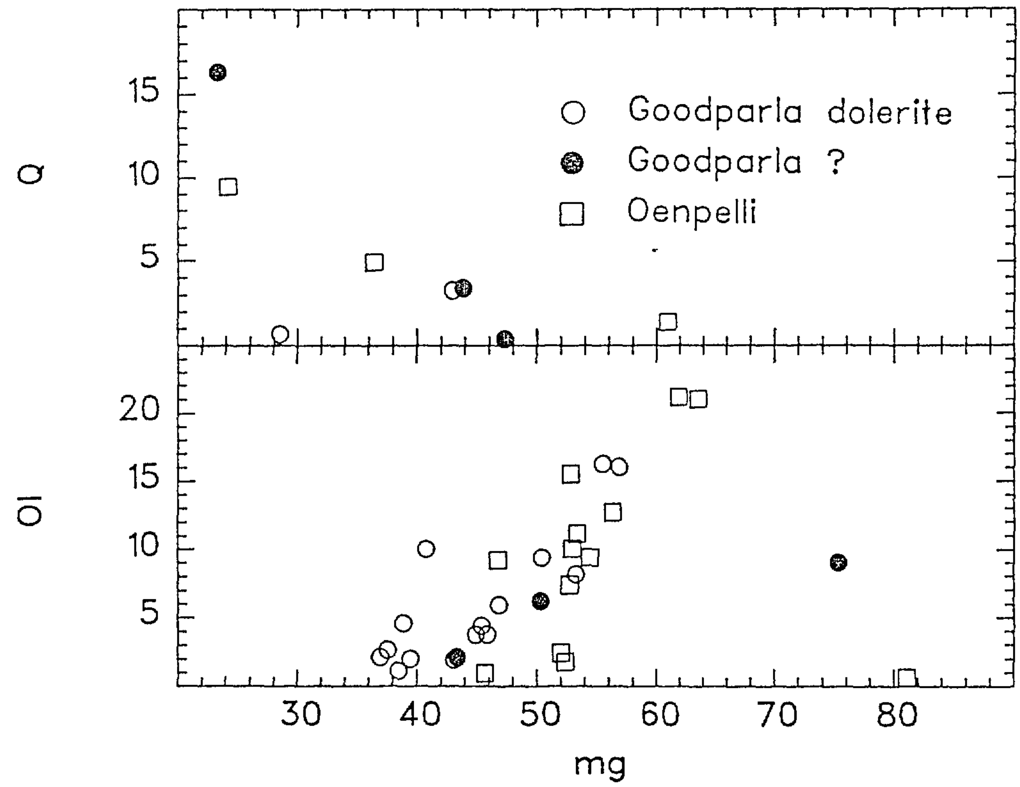

Figure 16 Plot showing normative olivine and quartz against *mg* for the Goodparla dolerite and the Oenpelli Dolerite.

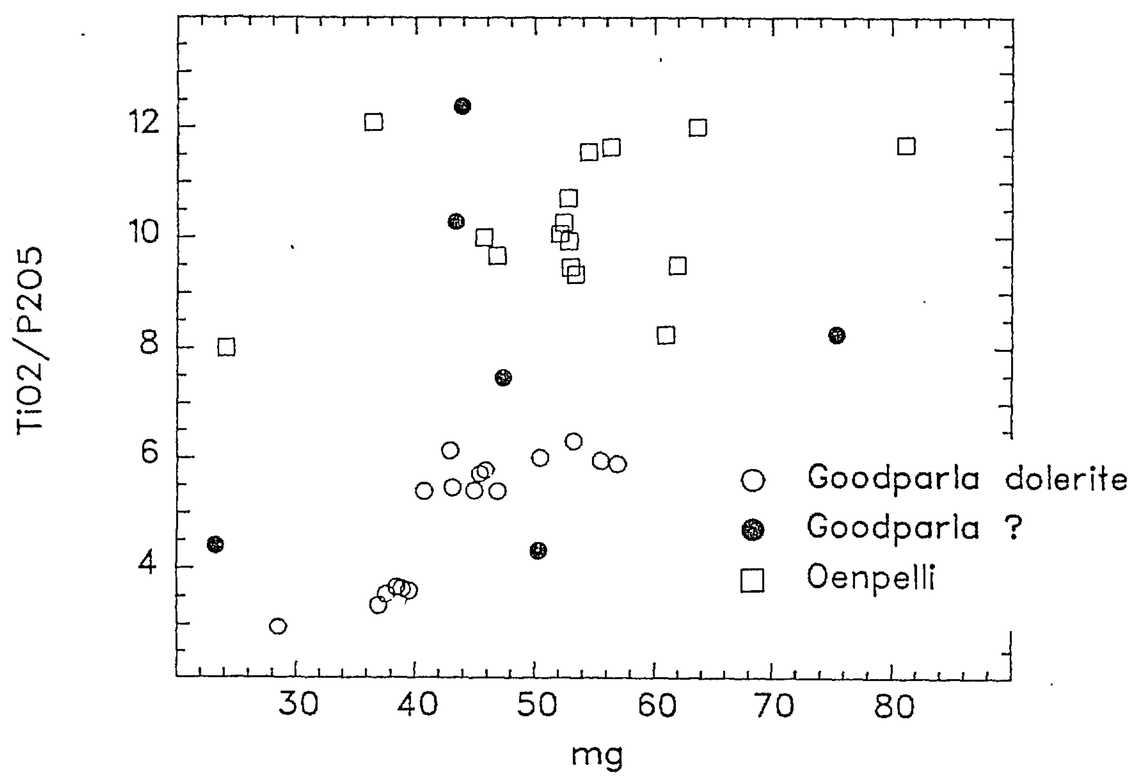

Figure 17 Plot showing TiO_2/P_2O_5 in the Oenpelli Dolerite, the Goodparla dolerite and possible equivalents of the Goodparla dolerite in the northeastern Pine Creek Inlier.

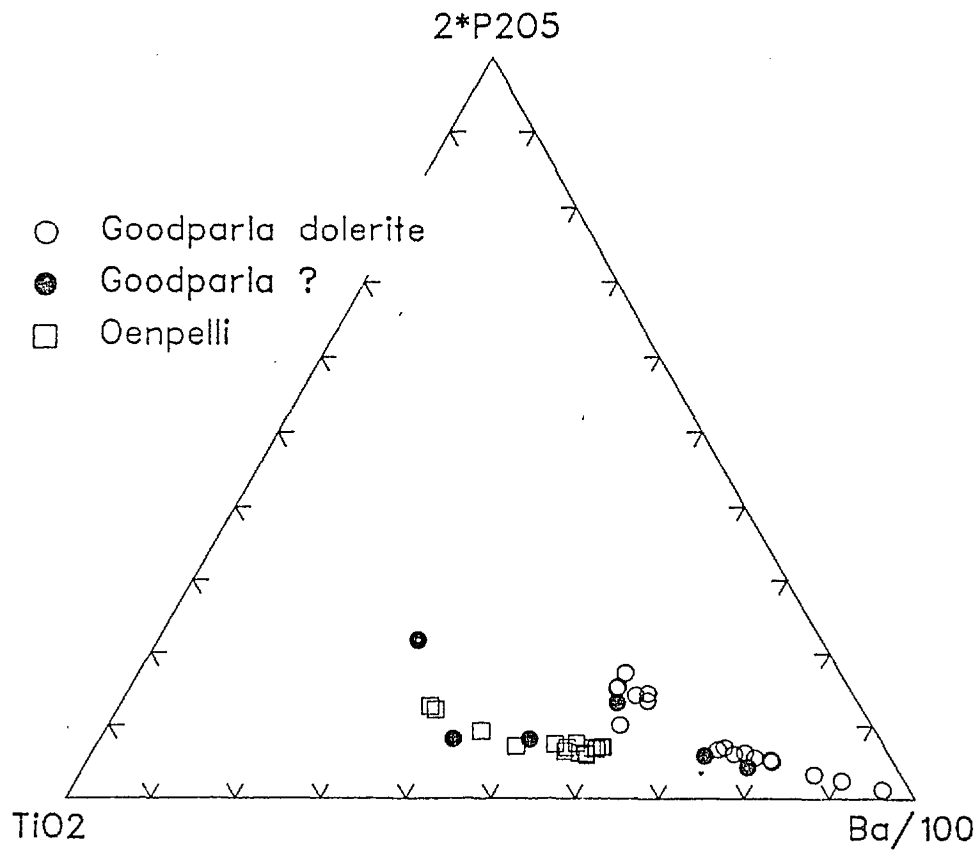

Figure 18 Ternary plot for TiO_2-P_2O_5-Ba showing the distinction between Goodparla Dolerite and Oenpelli Dolerite.

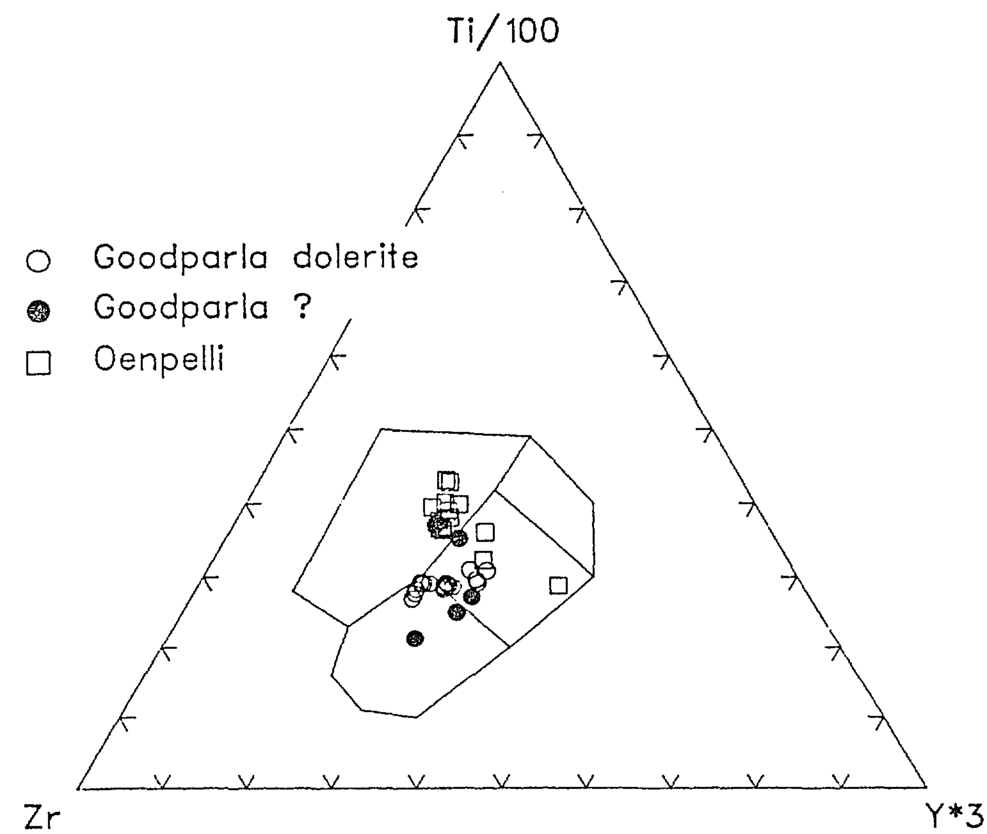

Figure 19 Ternary plot for Ti-Zr-Y, showing the distinction between Goodparla dolerite and Oenpelli Dolerite.

Shovel Billabong Andesite

The Shovel Billabong Andesite is a unit of metamorphosed mafic rocks with limited lateral extent, placed stratigraphically within the Koolpin Formation of the South Alligator Group. It extends from northeast of the Malone Creek Granite in Stow 1:100 000 Sheet area northwest into Mundogie 1:100 000 Sheet area and reassessment of fine grained rocks from Kapalga 1:100 000 Sheet area indicates it extends farther northwards. Previously it was included with the Zamu Dolerite; and earlier, analyses of fine-grained rocks were assigned to the Zamu Dolerite. The current assessment of the Shovel Billabong Andesite is that it is a single extrusive unit, repeated by folding and faulting (e.g., REF).

In thin section the Shovel Billabaong Andesite is very fine grained, with a texture that indicates rapid chilling. Rare microcrysts appear to have been plagioclase, but are invariably replaced by metamorphic minerals, especially epidote. An exception is 88126206, a fine grained olivine-bearing micro-dolerite with minor interstitial quartz. As this has a chemistry indentical to the Zamu Dolerite, it may be a thin intrusion inadvertently mapped as part of the Andesite. A fine-grained quartz micro-diorite, 88124537, collected from outcrops assigned to the Shovel Billabong Andesite, ressembles Zamu Dolerite, which forms extensive outcrops nearby. 89124642B which texturally ressembles Zamu Dolerite from the nearby BHP Mundogie Hill 1 was collected from poorly exposed outcrops typical of Shovel Billabong Andesite.

The chemical composition of the Shovel Billabong Andesite places it in the class of basaltic andesites. Most samples fall in a tight cluster as would befit an extrusive, unfractionated unit, though if *mg* = $Mg/(Mg + Fe^{2+})$ is used as the x-axis there is more separation of the analyses. K_2O has the most pronounced spread. 88126206 is more magnesian than the fine-grained rocks, and plots on the trends for Zamu Dolerite *s.s.*. Its *mg* of 60, is in the critical range for high Pt in the Zamu Dolerite, and it too has enhanced Pt. Samples of fine-grained Shovel Billabong Andesite carry traces of PGE.

The problem of the physical relationship between the Shovel Billabong Andesite and the Zamu Dolerite *s.s.* was previously considered by Bryan (1962). The chilled margin of the Zamu Dolerite *s.s.* is generally thin: Bryan reported that it was less than 1 metre at the edges of the sills in BHP Mundogie Hill 1, but very similar in appearance to the Shovel Billabong Andesite. Moreover in places there is no clear margin between thick Shovel Billabong Andesite and coarse-grained Zamu Dolerite, the one appears to pass laterally into the other. Investigation of outcrops mapped as Shovel Billabong Andesite commonly yields coarser grained material similar to Zamu Dolerite. Nevertheless, cf Bryan (1962), it seems improbable that simple chilling of a sill of Zamu Dolerite would have produced the thick Shovel Billabong Andesite.

Any attempt to reconcile the chemistry of the two units also presents problems. The Shovel Billabong Andesite plots on trends for the Zamu Dolerite (e.g., Figs 2&3). No sample assuredly indentified as chilled margin of the Zamu Dolerite has been analysed. 88124537 could be a near approximation, as it was collected very close to the margin of a large body of Zamu Dolerite. Its chemistry is that of the Shovel Billabong Andesite. However, if the Shovel Billabong Andesite represents the chilled parent to the Zamu Dolerite, then there is a conspicuous lack of samples of Zamu Dolerite with lower *mg* and a total lack of samples with more FeO than the Shovel Billabong Andesite (Fig. 20). This might be ascribed to sampling problems, given that a substantial volume of Zamu Dolerite has poor outcrop. Even though this seems to include the more evolved compositions and the granophyres, to suppose that appropiately evolved material has been entirely overlooked seems improbable. Thus, though the Shovel Billabong Andesite appears chemically akin to the Zamu Dolerite, available data indicate it sits in the wrong place on the fractionation trend to be a chilled margin.

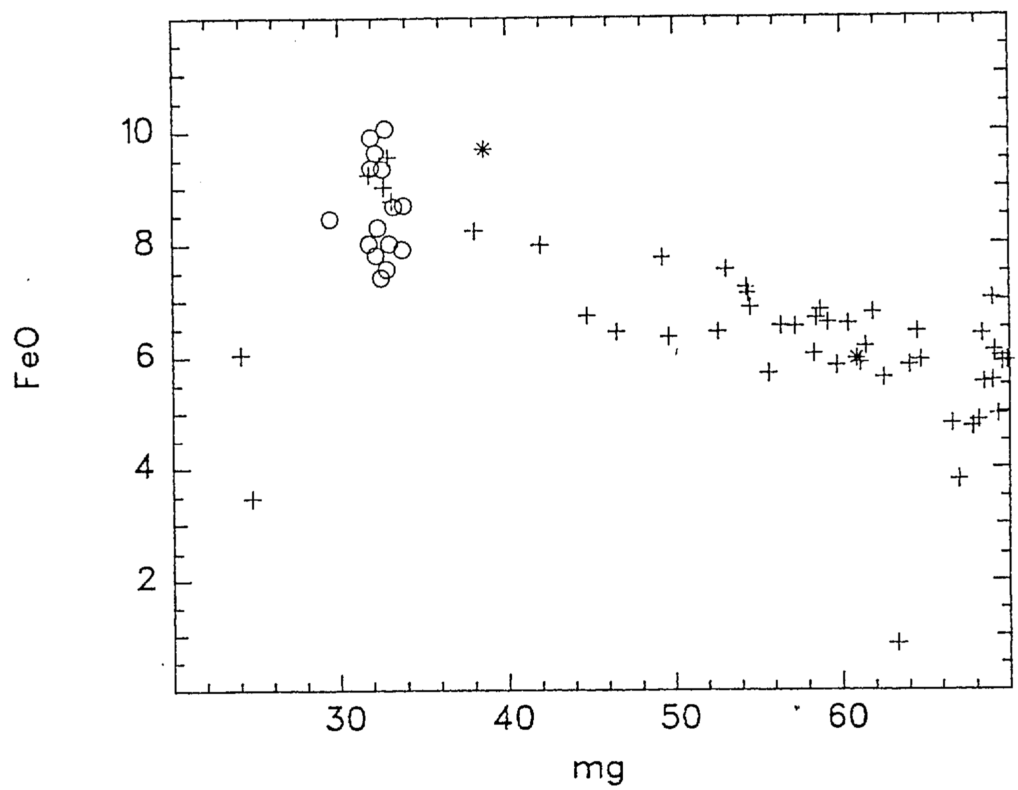

Figure 20 Plot of FeO against *mg* for the Zamu Dolerite *s.s.* and the Shovel Billabong Andesite.

Mafic extrusives in the El Sherana Group

Basalts form thin layers in units of the El Sherana Group. These tend to have poor outcrop, though their presence is indicated by red soils. Fresh samples indicate a range of compositions. Some flows are olivine-bearing, the basalt at the base of the Pul Pul Rhyolite is amygdaloidal, with noodules of chert (poor quality agate). The basalts are commonly affected by carbonate alteration. Analysis of one sample, from the Coronation Sandstone, showed a trace of Au but PGE were below limits of detection.

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REFERENCES

Allen, R.B., 1954 - The Coronation Hill uranium prospect Katherine-Darwin area, Northern Territory. Preliminary report. *Bureau of Mineral Resources, Australia, Record* **1954/17.**

Barron, B.J, 1976 - Recognition of the original volcanic suite in altered mafic volcanic rocks at Sofala, New South Wales. *American Journal of Science*, **276**, 604-636.

Barron, B.J. & Barron, L.M., 1976 - A model for greenschist facies equilibria in altered mafic rocks at Sofala, New South Wales. *American Journal of Science*, **276**, 637-669.

Bowles, J.F.W., 1986 - The deveopment of platinum-group minerals in laterites. *Economic Geology*, **81**, 1278-1285.

Bryan, R., 1962 - Lower Proterozoic basic intrusive rocks of the Katherine-Darwin area, Northern Territory. *Bureau of Mineral Resources, Australia, Record* **1962/7.**

Condon, M.A. & Walpole, B.P., 1955 - Sedimentary environment as control of uranium mineralization. *Bureau of Mineral Resources, Australia Report* **24.**

Ferguson, J. & Needham, R.S., 1978 - The Zamu Dolerite. A Lower Proterozoic preorogenic continental tholeiitic suite from the Northern Territory, Australia. *Journal of the geological Society of Australia*, **25**, 309-322.

Gray, G.J., 1915 - Geological recconnaissance of Arnhem Land. *Bulletin of the Northern Territory of Australia*, **14**, 20-31.

Irvine, T.N. & Baragar, W.R.A., 1971 - A guide to the chemical classification of the common volcanic rocks. *Canadian Journal of Earth Sciences*, 8, 523-548.

Needham, R.S., 1987 - A review of mineralization in the South Alligator Conservation Zone. *Bureau of Mineral Resources, Australia, Record* **1987/52.**

Needham, R.N., Crick, I.H., Stuart-Smith, P.G. & Roarty, M.J., 1978 - Mundogie 1:100 000 Sheet area data record. *Bureau of Mineral Resources, Australia, Record* **1978/103.**

Pearce, J.A. & Cann, J.R., 1973 - Tectonic setting of basic volcanic rocks determined using trace element analysis. *Earth and Planetary Science Letters*, **19**, 290-300.

Peitsch, B.A. & Edgoose, C.J., 1988 - The stratigraphy, metamorphism and tectonics of the Early Proterozoic Litchfield Province and western Pine Creek Geosyncline, Northern Territory. *Precambrian Research*, **40/41**, 565-588.

Schreyer, W., 1976 - Experimental metamorphic petrology at low presures and high temperatures. *in* Bailey, D.K. & MacDonald, R., editors, *The Evolution of the crystalline rocks* Academic Press, London, 261-331.

Sheraton, J.W. & Simons, L., 1988 - Geochemical data analysis System (GDA) - Reference Manual. *Bureau of Mineral Resources, Australia*, **Record 1988/45.**

Stuart-Smith, P.G., 1977 - Shallow stratigrapic drilling in the Kapalga 1:100 000 Sheet area, Alligators Rivers region N.T., 1974. *Bureau of Mineral Resources, Australia*, **1977/53.**

Stuart-Smith, P.G. & Ferguson, J., 1978 - The Oenpelli Dolerite - a continental tholeiitic suite from the Northern Territory, Australia. *BMR Journal of australian Geology and Geophysics*, **3**, 125-133.

Stuart-Smith, P.G. & Hone, I.G., 1975 - Shallow stratigraphic drilling in the Cahill and Jim Jim 1:100 000 Sheet areas, Alligators Rivers region, N.T. *Bureau of Mineral Resources, Australia*, **1975/79.**

Stuart-Smith, P.G., Needham, R.N., Lachlan, P.R. & Blythe, P., 1978 - Kapalga, Northern Territory, 1:100 000 Preliminary geological map. *Bureau of Mineral Resources, Australia.*

Stuart-Smith, P.G., Needham, R.N., Roarty, M.J. & Crick, I.H., 1986a - Mundogie, Northern Territory *Bureau of Mineral Resources, Australia, 1:100 000 geological Map and Commentary.*

Stuart-Smith, P.G., Needham, R.N. & Bagas, 1., 1986b - Stow region, Northern Territory. Data record of 1:100 000 scale mapping. *Bureau of Mineral Resources, Australia, Record* **1986/23.**

Stuart-Smith, P.G., Needham, R.N., Wallace, D.A., & Roarty, M.J., 1986c - McKinlay River, Northern Territory *Bureau of Mineral Resources, Australia, 1:100 000 geological Map and Commentary.*

Stuart-Smith, P.G., Bagas, L., & Needham, R.N., 1988a - Ranford Hill, Northern Territory *Bureau of Mineral Resources, Australia, 1:100 000 geological Map and Commentary.*

Stuart-Smith, P.G., Needham, R.N. & Bagas, L., 1988b - Stow Region, Northern Territory *Bureau of Mineral Resources, Australia, 1:100 000 geological Map and Commentary.*

Stuart-Smith, P.G., Needham, R.N., Bagas, L. & Wallace, D.A., 1988c - Pine Creek, Northern Territory *Bureau of Mineral Resources, Australia, 1:100 000 geological Map and Commentary.*

Will, T.M., Powell, R., Holland, T. & Guiraud, M, 1990 - Calculated greenschist facies mineral equilibria in the system CaO-FeO-MgO-Al_2O_3-SiO_2-H_2O. *Contributions to Mineralogy and Petrology,* 104, 353-368.

APPENDIX A

SUMMARY OF XRD & THIN SECTION DATA:- 1987 collection

87120001 GRS404971

XRD

Whole sample — Quartz major, feldspar major, mica major.

-5u — Mica no significant mixed layering(no s m l)

TS Recrystallized acid volcanic
rounded phenocrysts of Qtz, with haloes of optically continuous Qtz, aggreagates of Qtz
Intergrowths of sericite +He ± Qtz
Groundmass fine Qtz, sericite, minor Bi, ?epidote
desseminated He, yellow Fe oxide

87120002 GRS419961

XRD

Whole sample — Quartz major, feldspar major, mica major, kaolinite trace.

-5u — Mica (no s m l) major, kaolinite trace+.

TS Metavolcanic
Phenocrysts euhedral Qtz, ghosts of euhedral feldspar
Spherical Qtz outlines in groundmass
Groundmass Qtz, ghosts of ?feldspar. Mu, desseminated He
Vein of He + ?minor Qtz

87120003 GRS406969 Coronation Hill Mine

XRD

Whole sample — Quartz major, mica major, kaolinite minor+.

-5u — Mica (no s m l) major, kaolinite major.

TS Metavolcanic
Phenocrysts Qtz, some with rims of ?Qtz
Groundmass Unaltered part: Qtz, Mu
Altered patchs of very fine, c'less phyllosilicate, increased He and yellow to brown ?Fe oxide

87120004 S412945 2k S Coronation Hill Mine

XRD

Whole sample Quartz major, mica major.

-5u Mica (no s m l) major.

TS Metavolcanic

Phenocrysts:- Qtz, abundant with haloes of Qtz, Ghosts of feldspar
Small cubic voids lined with Fe oxide
Radiating Qtz, chert or chalcedony
groundmass mainly sericite, devitrified quartz-rich glass.
rare spherules

87120005 GRS402968 NW side of Coronation Hill

XRD

Whole sample Quartz major, mica major.

-5u MIca (no s m l) major+, kaolinite trace.

TS Metavolcanic

Phenocrysts Qtz some euhedral, some corroded, overgrowths of clear Qtz, Ghosts of feldspar
Groundmass Qtz, sericite, minor He
Areas of He + sericite, fracture controlled, surruond threads of He.

87120006 GRS338040 Monolith Mine

XRD

Whole sample Quartz Major, mica trace+, kaolinite major.

-5u Mica (no s m l) major, kaolinite major

TS Metasediment

Clasts Qtz, quartzite, Mu-Qtz granofels, rare volcanic fragments. Well rouded
Matrix fine grained Qtz, interstitial quartz, minor fine sericite. He

87120007 GRM255092 Rockhole Mine

XRD

Whole sample Quartz major, kaolinite major, mica major.

-5u Mica (no s m l) major, kaolinite major.

TS Vein quartz, space infilled by Fe stained fine Mu.

87120008 GRS408967 Coronation Hill Mine
XRD
Whole sample Quartz major, feldspar minor+, mica minor+.

-5u Mica (no s m l) major.

TS Metavolcanic
Phenocrysts Qtz, some corroded with haloes of recrystallized optically continuous Qtz
Ghosts of feldspar laths
Single Zircon cryst
Matrix fine grained Qtz, Mu, recrystallized glass
desseminated Opq, increasing in density locally
Fine fractures with Mu

87120009 GRM255092 Rockhole Mine

XRD
Whole sample Quartz major, mica major.

-5u Mica (no s m l) major, possible kaolinite trace

TS Metasediment
Clasts Qtz, quartzite, ?metavolcanic, ?schist, ?Kfs (now Mu aggregates), tourmaline, Mu
Matrix Mu, Cherty Qtz, fine desseminated Opq
One patch of He-rich material, He replaces matrix, outlines Qtz clasts

87120010 GRM255092 Rockhole Mine
XRD
Whole sample Quartz major, mica major, kaolinite major.

-5u Mica (no s m l) major. kaolinite major.

TS ?chemical or organic sediment
Ovoids filled by Qtz, chert, Fe oxide stained ??kaolinite
Matrix: laths of chert outlined by black Opq (not He), Mu, ?kaolinite

87120011 GRS354026
XRD
Whole sample Quartz major, mica trace.

-5u Mica (no s m l) trace, kaolinite trace.

TS Breccia or deformed metasediment
Clasts of Qtz, all strained
Matrix smaller fragments of Qtz, variable Opq,
Numerous veinlets: some clear, others dust of He, abundant He
Variable Fe staining extending away from veins

87120012 GRS408967 Coronation Hill area
XRD
Whole sample Quartz major, mica major.

-5u Mica (no s m l) major.

TS Metavolcanic
Phenocrysts Qtz, mostly euhedral, some corroded
Ghosts of feldspar
Matrix Fine grained, lighter patchs
Mostly Qtz, Felts of Mu. dusts of Opq. Cubic Opqin Fe stained areas. rare sphene, very rare zircon

87120013 GR436935
XRD
Whole sample Quartz major, mica major.

-5u Mica (no s m l)major+.
TS Fragmental metavolcanic, very recrystallized
Phenocrysts Qtz
Groundmass Qtz, Mu, dust of Opq

87120014 GRS403967
XRD
Whole sample Quartz major, mica major.

-5u Mica (no s m l) major+.

TS Metavolcanic
Phenocrysts: Qtz, some corroded, others euhedral
Spherules: recrystallized Qtz
Groundmass: Qtz, recrystallized and diffuse grains. Mu, dust of Opq, minor epidote

87120015 GRS406969 Coronation Hill Mine
XRD
Whole sample Quartz major, mica major.

-5u Mica (no s m l) major+.

TS Metavolcanic **NB Mg mineral not located**
Phenocrysts Qtz, mostly euhedral

Groundmass Qtz, Mu, Fine Opq
Gren-yellow mineral in pockets: ?epidote (very low Ca in analysis). single grain of unidentified mineral: elongate, cleavage parallel to elongation. low δ, RI ~ 1.5-1.6. oblique extinction
Fractures mostly recrystallized Qtz, rare Mu

87120016 GRS369005 Saddle Ridge Mine
XRD
Whole sample Quartz major.mica trace+.

-5u Mica (no s m l) major.

TS Quartz rock
Qtz, mainly recrystallized vein fill, brecciated, areas of dusty, very fine grained Qtz + Mu

87120017 GRS369005 Saddle Ridge Mine
XRD
Whole sample Quartz major,mica major.

-5u Mica (no s m l) major+.

TS Metavolcanic
Phenocrysts euhedral Qtz, ?ghosts of feldspar
Groundmass Qtz, Mu, He concentrated at one end
Sphene, ?after ilmenite
small zircons

87120018 S
XRD
Whole sample Quartz major,mica minor+.

-5u Mica (no s m l) major.
TS Metavolcanic: fragmental rock
Phenocrysts Qtz
Fragments of quartzite, Bi-Mu rock, ?pumice
Matrix very fine-grained Mu, Qtz, ?epidote
Opq skeletal, associated with quartz

87120019 S 2.5 km E El Sherana Camp
XRD
Whole sample Quartz major, possible hematite minor, mica major, kaolinite trace.

-5u Mica (no s m l) major, kaolinite trace.

TS Metavolcanic with hematite
clasts of Qtz
He-rimmed laths of feldspar replaced by Mu
Matrix diffuse fine-grained Qtz & Mu
He replcement along grain boundaries:- near complete in some areas of slide.

87120020 GRM254068 SE Rockhole Mine
XRD

Whole sample	Quartz major, mica major.
-5u	MIca (no s m l) major+.

TS Sandstone
Clasts prodominantly Qtz, Qtz mylonite, some tourmaline, quartzite, Mu rare composites: very fine grained
Quartz overgrowths on some grains
Matrix Mu, minor He

87120021 GRS406969 Coronation Hill Mine
XRD

Whole sample	Quartz major, mica major.
-5u	Mica (no s m l).

TS Metavolcanic
Phenocrysts euhedral Qtz, possibly some replacement of Qtz by Mu + ?
spherules
Groundmass very fine grained Qtz, Mu, replaced by He in parts of the slide

87120022 GRS407965 250m SSW Coronation Hill Mine
XRD

Whole sample	Quartz major, mica trace+, chlorite trace kaolinite(?)
-5u	Mica (no s m l) minor, chlorite trace, kaolinite(?).

TS Sandstone
Clasts Qtz, minor quartzite, tourmaline, patches of Mu, ?after feldspar, Mu, rare zircon
Matrix patches of white mica, patches with variable He, some small, elongate patchs of near solid He

87120023 GRS406969 Coronation Hill Mine
XRD
Whole sample Quartz major, mica major

-5u Mica (no s m l) major+, kaolinite trace

TS Metavolcanic
Phenocrysts Qtz, ghosts of feldspar laths
Matrix Very fine grained, patchy: some c'less, some with fine dust of He
Blind veinlet of intense He

87120024 GRS369005 Saddle Ridge Mine
XRD
Whole sample Quartz major, mica minor.

-5u Mica (no s m l) major.

TS Meta-sandstone
Clasts mainly Qtz, minor quartzite, one ?volcanic, one ?metasediment, one chert, possible lithics
Matrix Mu, ?Qtz, rare Ch
Zone of recrystallization

87120025 GRS367014 Adit N of Palette Mine
XRD
Whole sample Quartz major, mica major, kaolinite trace.

-5u Mica (no s m l) major, kaolinite trace.

TS Cleaved pelitic sandstone (or deformed volcanic rock)
Qtz: large deformed masses, separating felted Mu ± Ch ± Qtz
zircon, Opq skeletal, sphene, ? in small cubic grains, c'less, RI ~ Mu

87120026 GRS372011 Skull Mine
XRD
Whole sample Quartz major,mica major.

-5u MIca(no s m l) major+.

Ts Schist - multiple deformation
Very fine green ?Mu & Mu ± Qtz
Several generations of Qtz & Qtz-He veins

87120027 GRS366005 100m N of Saddle Ridge Mine

XRD

Whole sample Quartz major, mica major.

-5u Mica (no s m l) major+.

TS Metavolcanic

Phenocrysts Qtz, generally euhedral, some corroded
Patchs of coarser grained Qtz-Mu
One patch of Q-Mu with shape of feldspar
Patchs of Qtz_Mu outlined by Fe oxide
Rare zircon, Opq in feathery patch

87120028 GRS360036 Scinto IV Mine

XRD

Whole sample Quartz major,mica major

-5u Mica (no s m l) major+.

TS ??Very altered sediment or exensely recrystallized volcanic texture unusual: angular quartz, optically continuous Qtz in spherical structures and in separate grains outside the spheres
Opq black, skeletal & in thick dusts contained within square or rectangular outlines
Mu abundant, fine to medium grained
Rare zircons

87120029 GRS369013 Palette Mine

XRD

Whole sample Quartz major, mica major.

-5u Mica (no s m l) major+.

TS Mica Schist

Mu very fine grained
Qtz in thin veins, interstitial aggregates, possbly very fine grained with Mu

87120030 GRS408967 Coronation Hill area

XRD

Whole sample Quartz major,mica major.

-5u Mica (mo s m l) major+.

TS Metavolcanic

Phenocrysts with haloes of optically continuous Qtz

Matrix Qtz-Mu
Minor Opq skeletal grains

87120031 GRS367014 adit N of Palette Mine

XRD

Whole sample Quartz major,possible hematite minor+, Mica major, kaolinite trace.

-5u Mica (no s m l) major+, kaolinite trace.

TS Deformed and partly replaced rock
Angular fragments of Qtz, some adjacent grains in optical continuity. Strained extinction common
Matrix Very fine Mu + Qtz
He veining, rounded particles of He, distributed in zones

87120032 GRS369005 Saddle Ridge Mine

XRD

Whole sample Quartz major,mica major.

-5u

TS Brecciated volcanic
Very fine grained rock: Qtz, Mu, green Bi, minor zircon, Broken up by Qtz-filled veinlets
Two grains of /: Moderate RI, mod to high ß, near c'less ?clinozoisite

87120033 GRS408969 Coronation Hill Mine

XRD

Whole sample Quartz major, hematite minor, mica minor+, chlorite trace+, kaolinite(?).

-5u Mica major (no s m l) , chlorite major, kaolinite(?).

TS Altered ?volcanic rock
Single euhedral Qtz cryst
Matrix Fine grained Qtz + Mu + c'less to pale green Ch
Veins of Qtz, Ch
Desseminated He

87120034 GRS408965 300m SSW of Coronation Hill Mine

XRD

Whole sample Quartz major, possible hematite minor, possible feldspar trace, mica major, chlorite trace. kaolinite(?).

-5u   Mica major (no s m l), chlorite trace, kaolinite(?).

TS Hematitic deformed volcanic rock with fragmental texture
Qtz, Mu, He
Qtz in cloudy patchs
Mu veins & ? replacements after Kfs
He veins & concentrations

87120035   GRS344035 200m SE of Koolpin Mine

XRD

Whole sample   Quartz major, hematite major, mica major, kaolinite major.

-5u   Mica major (no s m l) major, kaolinite major+.

TS Hematitic, possible altered mafic volcanic rock
Qtz radiating masses : ?recrystallized chert
cloudy irregular grains in groundmass
Lath shaped aggregates of Mu + C'less Ch
Opq ?mostly He: two grain sizes, dust in Qtz, gloular grains in aggregates along grain boundaries, clumping into aggregates locally

87120036   GRS312052? El Sherana Mine

XRD

Whole sample   Quartz major, hematite minor+, mica major, kaolinite trace.

-5u   Mica (no s m l) major+, kaolinite trace.

TS Hematitic sandstone
Clasts mainly Qtz, minor quartzite, tourmaline, ?feldspar, ?siltstone, very rare zircon
Qtz overgrowths on Qtz
Interstitial He, lesser Mu

87120037   GRS312052? El Sherana Mine

XRD

Whole sample   Quartz major, mica major, kaolinite major.

-5u   Mica (no s m l) major+, kaolinite major+.

TS Hematitic sandstone
Clasts Qtz, ?felsic volcanic, tourmaline, rare zircon, Mu, single fragment of sphene

Qtz overgrowths
Matrix c'less Ch, Mu, He

87120038 GRS369005 Saddle Ridge Mine
XRD
Whole sample Quartz major, mica majro.

-5u Mica (no s m l) major.

TS Hematitic ?volcanic breccia
Phenocrysts Qtz
Fragments of sedimentary rock: quartzite, layered sediment
Patchs of very fine Mu
Patchs and irregular veinlets of recrystallized Qtz
He outlining curved grain boundaries

87120039 GRS312052? El Sherana Mine
XRD
Whole sample Quartz major, hematite major, mica minor+, kaolinite major.

-5u Mica (no s m l) major, kaolinite major.

TS altered volcanic rock: section is cobble from conglomerate
Phenocrysts Qtz, ghosts of Qtz crysts - replaced by fine-grained c'less ?kaolinite as per XRD
Hematitic, fine grained groundmass
Rare zones and patchs of slightly coarser Mu

87120040 GRS341020 N of Scinto VI Mine
XRD
Whole sample Quartz major, mica major.

-5u Mica (no s m l) major+.

TS ?volcanic rock: texture suggest mafic, composition felsic
Qtz patchs of irregular grains
Opq large, also feathery zones of desseminated He
Rectangular Mu aggregates: ?ghosts of feldspar grains
Ch c'less

87120041 GRS385991 Pul Pul Hill
XRD
Whole sample Hematite major, kaolinite major.

-5u Kaolinite major.

TS Hematitic felsic volcanic
Phenocrysts ghosts of Qtz, replaced by c'less kaolinite
zone of fine-grained kaolinite
remainder fine-grained He

87120042 GRS314058 N of El Sherana Mine
XRD

Whole sample	Quartz major, possible hematite trace, kaolinite major, mica trace.
-5u	Kaolinite major+, mica (no s m l) trace+.

TS Quartz breccia
Fragments: Qtz, rounded to angular, quartzite, ?chert, ?acid volcanic, rare zircons
Matrix Qtz, He, 2 patchs with low He

87120043 GRS321044 1km SE of El Sherana Mine
XRD

Whole sample	Quartz major, hematite major, kaolinite major, mica trace.
-5u	Kaolinite major+, mica (no s m l) trace.

TS Hematitic schist
Zones of mainly He, remainder fine-grained Qtz + Mu
Patchs with Qtz veins, and of kaolinitic veins

87120044 GRM262089 O'Dwyers mullock heap
XRD

Whole sample	Quartz major, mica major.
-5u	Mica (no s m l) major.

TS Black layered rock with quartz veins, almost opaque, some layers with some transparent minerals.
Opq as layers and desseminated grains: ?graphite
Qtz, Mu, ?kaolinite
Veins of Qtz

87120045 GRS369013 Palette Mine, underground stockpile
XRD

Whole sample	Quartz major, mica major.
-5u	Mica (no s m l) major.

TS Black, layered rock with folds

Qtz, Mu, Black Opq, ?graphite in fine layers
Crosscutting veins of Qtz, Mu

87120046 GRS369013 Palette Mine, second level adit
XRD
Whole sample Quartz major, mica major, chlorite minor.

-5u Mica (no s m l)major, chlorite minor.

TS Dark irregularly layered rock: Brecciated, crumpled microtexture, layering defined by Opq, but irregular
Qtz, Mu, Black ?graphite
Ch identified in XRD must be c'less or pale brown: not obvious in TS

87120047 GRM254092 Rockhole Mine
XRD
Whole sample Quartz major, mica major.

-5u Mica (no s m l) major+.

TS Black rock with contorted layering
Qtz, Mu, black layered ?graphite

87120048 GRS408969 Coronation Hill Mine
XRD
Whole sample Quartz major, mica major.

-5u Mica (no s m l) major+.

TS Very fine-grained green rock
Mu with finely desseminated Opq/rutile
Qtz mostly in veins & pods
Zones with Hematite, black mineral

87120049 GRS408969 Coronation Hill Mine
XRD
Whole sample Quartz major, mica major, kaolinite major.

-5u Mica (no s m l) major, kaolinite major.

TS Red, very fine-grained layered rock, layering outlined by Hematite. Bleaching adjacent to some fractures
Qtz, mainly in veins
?Mu, Kaolinite in XRD
Opq in some fractures

87120050 GRM254092 Rockhole Mine

XRD

Whole sample Quartz major, pyrite major.

-5u Mica (no s m l) minor+.

TS Dark, pyritic vein rock: breccia-like texture, with pyrite cubes
Qtz, Mu, Cubes of Opq
Limonite in vein

87120051 GRS312052 El Sherana Mine

XRD

Whole sample Quartz major, pyrite trace, kaolinite trace, mica trace.

-5u Mica (no s m l) major+, kaolinite major+.

TS Altered, hematitic volcanic rock
Qtz: euhedral grains, diffuse in groundmass
He
Epidote - clear grains in areas of erstwhile feldspar
Mu in one aggregated mass

87120052 GRS372011 Skull Mine

XRD

Whole sample Quartz major, mica trace.

-5u Mica (no s m l) minor.

TS Metasediment: Qtz sandstone
Clasts Qtz, quartzite, rare zircon
Interstitial limonite
Qtz overgrowths, cement, recrystallized

87120053 GRM262088 S of O'Dwyers Mine

XRD

Whole sample Quartz major, mica major.

-5u Mica (no s m l) major+.

TS Fragmental rock: sedimentary breccia
Qtz: angular grains, Lithic/tuff grain, one zircon, one tourmaline, several large Mu, Opq
Matrix Mu. fine-grained Qtz, finely divided Opq, tourmaline

87120054 GRS406969 Coronation Hill area

XRD

Whole sample Quartz major, mica major, chlorite major.

-5u Mica (no s m l) major, chlorite major.

TS ?Altered Zamu Dolerite

Qtz: relict grains

Mu abdundant, fine-grained, ?after Plag

Bi + Ch in felted aggregates

Skeletal Ilmenite + Ch, Bi

Numerous fractures with He

87120055 GRS322062 N of Fisher fault

XRD

Whole sample Quartz major, possible hematite trace.

-5u Kaolinite major, mica trace.

TS Altered felsic volcanic rock

Phenocrysts Qtz

Qtz ?as replacements

Opq: desseminated dust

Minor Mu, ?kaolinite

87120056 GRS322062 N of Fisher Fault

XRD

Whole sample Quartz major, possible hematite trace.

-5u Kaolinite major, possible mica trace.

TS Altered volcanic rock

Phenocrysts Qtz, some with overgrowths

Qtz in patchs

Opq: desseminated, patchs of fine grains

kaolinite radiating patchs

Minor Mu

87120057 GRS334048 1.3km NW of Koolpin Mine

XRD

Whole sample Quartz major, mica major.

-5u Mica major (no s m l) major.

TS ?Altered mafic volcanic rock: texture of lath-like shapes, angular shapes and vuggy areas indicate mafic volcanic rock

Mu in laths and vugs

Qtz with Mu in angular shapes
He desseminated, concentrated between laths

87120058 GRS439032 4.5km SE of Coronation Hill Mine
XRD
Whole sample Quartz major, feldspar(plageoclase) major, kaolinite major, chlorite trace, mica trace.

-5u Kaolinite major, possible chlorite trace.

TS Breccia-like texture of atolls sepatated by veins
Veins central zone of Qtz + Ch, edged by Cc-enriched areas, with Mu, Qtz and ?Plag
Atolls fringed by Ch + ?kaolinite, interiors Mu, Cc, ?
Opq desseminated throughout
Rectangular grains, mostly Mu, outlined by fluorite
Fluorite also in small, irregular grains

87120059 GRS367016 N of Palette Mine, underground
XRD
Whole sample Quartz major, mica major.

-5u Mica(no s m l) major.

TS Laminated dark rock
NB Analysis K>Al for Mu, but no visible Bi, high MgO, but no visible Ch
Mu, Qtz, Black mineral defining lamination
He desseminated
Small, near cubes of isotropic mineral, c'less, moderate RI: possible analcime, or ?holes after ?.

87120060 GRS360036 Scinto IV Mine
XRD
Whole sample Chlorite major, amhpibole major. Identification of amphibole types by XRD is unsatisfactory. However considering the expected formation conditions, the aluminum, Mg and Fe contents of the whole rock sample plus the XRD trace the amphibole of best fit is hornblende, followed by tremolite.

-5u Amphibole (hornblende? tremolite?) major, Chlorite major, possible talc(?) trace.

TS Meta-basic, vuggy texture
Fibrous mineral, small extinction angle, ?tremolite
Ch, pale green, blue interference colours
Sphene
very finely devided black Opq

87120061 GRM254092 near Rockhole Fault
XRD
Whole sample Quartz major, mica trace+.

-5u Mica (no s m l) possible montmorillonite trace.

TS Quartzite
Qtz: recrystallized and strained
Mu in pockets
minor Apatite?, sphene?, tourmaline?
rae, tiny cubes of Opq

87120062 GRM214091
XRD
Whole sample Quartz major, kaolinite trace+.

-5u Kaolinite minor+.

TS Quartzite: orthoquartzite
Clasts of Qtz with Qtz cement
Mnior Mu, ?kaolinite in aggregates
Opq desseminated along grain boundaries

87120063 GRS369013 Palette Mine area
XRD
Whole sample Quartz major, possible feldspar trace, mica major.

-5u Mica (no s m l) major.

TS Schist/mylonite: finely layered - crumpled & folded - outlined by dark mineral
Qtz rare augen, fine-grained aggregates in some layers
Mu

87120064 GRM253066
XRD
Whole sample Quartz major, mica major.

-5u Mica(no s m l) major.

TS Quartz sandstone
Clasts mainly Qtz with Qtz overgrowths, Mu, tourmaline
Matrix mainly Qtz, Mu, He

87120065 GRS342022 N of Scinto V Mine
XRD
Whole sample Quartz major, possible hematite minor.

-5u No clays

TS Hematitic breccia
Qtz, chert, He

87120066 GRS369005 Saddle Ridge Mine
XRD
Whole sample Quartz major, possible feldspar(?) trace, hematite trace, mica major.

-5u Mica (no s m l)major.

TS Fine-grained, finely layered hematitic rock, bleached at one end of thin section
He, Mu, Qtz in aggregates with Mu
Qtz-Mu structurally controlled by fractures

87120067 GR S314052 El Sherana Mine
XRD
Whole sample Kaolinite major.

-5u Kaolinite major, mica trace.

TS Limonitic rock - brecciated appearance: ? Sst or volcanic
Fine grained ? Kaolinite, He, Fe oxides

87120068 GRS321044 1km SE of El Sherana Mine
XRD
Whole sample Quartz major, hematite major, kaolinite major, mica trace.

-5u Kaolinite major, mica (no s m l) trace.

TS Fine-grained hematitic rock, with 3 generations of fractures
He, Qtz, Kaolinite
Veins of Qtz, Qtz cores with He margins, Cores of Ch?, Kaolinite, with He margins

87120069 GRS406969 Coronation Hill Mine

XRD

Whole sample	Quartz major, mica trace.
-5u	Mica (no s m 1) major.

TS Breccia with Qtz veins
Fragments of volcanics, layered rock.
He locally intense
Qtz, Mu, He, minor Opq

87120070 GRS406969 Coronation Hill Mine

XRD

Whole sample	Quartz major, mica major.
-5u	Mica (no s m 1)major, kaolinite trace.

TS Zamu dolerite
Relict Qtz, Pigeonite
Replacement of feldspar by white mica
Opq skeletal, dusts after Cpx
He

87120071 GRS408969 Coronation Hill Mine

XRD

Whole sample	Quartz major, mica major.
-5u	Mica (no s m 1)major, kaolinite trace.

TS Felsic volcanic rock
Phenocrysts: Qtz, ghosts of feldspar
Qtz, minor Mu, He, ?kaolinite
Fractures with ribbons of Qtz and vugs surrounded by Qtz

87120072 GRS406969 Coronation Hill Mine

XRD

Whole sample	Chlorite major, mica major.
-5u	Chlorite major, mica (no s m 1)major.

TS Fine-grained ?metasediment
Mu, abundant desseminated Opq
Ch?:- if Ch, then a brown species

87120073 GRS408969 Coronation Hill Mine

XRD

Whole sample	Quartz major, mica trace, chlorite trace.
-5u	Mica trace+, chlorite minor.

TS ?Altered volcanic rock
Qtz in fine grained areas, and in veins
Mu, He
?Epidote in some Qtz veins

87120074 GRS402968 750m W of Coronation Hill Mine
XRD
Whole sample Quartz major, mica trace.

-5u Mica(some mixed layering) minor+,possible montmorillonite trace.

TS Breccia
Fragments Qtz, some recrystallized, one zircon
Matrix Qtz, finely divided He, minor Mu, Opq

87120075 GRS408965 200m S of Coronation Hill Mine
XRD
Whole sample Quartz major, mica trace.

-5u Mica(no s m l) minor, possible montmorillonite trace.

TS Very fine grained hematitic rock
Veins of He/Opq, cores of Qtz

87120076 GRM255092 Rockhole Mine
XRD
Whole sample Quartz major, mica minor+.

-5u Mica(no s m l) major.

TS Fine-grained green-brown rock, vein of Qtz-He
Groundmass Very fine-grained Mu, ?Bi/Ch, ?minor sphene
Qtz in small lensoid patchs
Veins of Qtz, with finely divided dark minerals/ fluid inclusions, He lining open veins, bleeding out along cleavage.

87120077 GRS312052 El Sherana Mine
XRD
Whole sample Quartz major, kaolinite major, mica trace.

-5u Kaolinite major, mica(no s m l) major.

TS Sandstone
Clasts mainly Qtz, rarely quartzite, one Qtz-tourmaline
Rutile, zircon, tourmaline, Mu, ?altered feldspar

Interstitial Mu, He, ?kaolinite, some fine Qtz and Qtz overgrowths

87120078 GRS332047 1.5km NW of Koolpin Mine
XRD
Whole sample Quartz major, mica minor.

-5u Mica (no s m l) major.

TS ?siltstone: very fine-grained
Clasts of Qtz, Mu, rare Bi, tourmaline, zircon
Interstitial illite

87120079 GRS407965 500m SW of Coronation Hill Mine
XRD
Whole sample Quartz major, possible mica trace.

-5u Mica trace.

TS Chert, recrystallized in veinlets
He throughout thin section, more intense in coarser-grained areas - front of He, separating more hematitic area from less.
Qtz vein with crystalline He

87120080 GRS332047 1.5km NW of Koolpin Mine
XRD
Whole sample Quartz major, hematite minor, mica minor.

-5u Mica(no s m l) major.

TS Breccia
Fragments of Qtz, quartzite, chert, some with Qtz overgrowths - ?orthoquartzite, composite grains with intense He, remainder Qtz or Mu (?after feldspar)
Vugs filled by fine Qtz, He, Mu

87120081 GRS339047 Monolith Mine
XRD
Whole sample Quartz major, hematite major, kaolinite major, mica major.

-5u Kaolinite major, mica (no s m l) major.

Ts altered volcanic rock, fine-grained hematitic rock
He, Qtz, Mu, ?kaolinite in lath and radiating aggregates

87120082 GRS334048 1.3km NW of Koolpin Mine

XRD

Whole sample Quartz major, mica minor+, kaolinite trace.

-5u Kaolinite major, mica(no s m l) major.

TS Altered vuggy volcanic rock:- texture of mafic volcanic rock, with laths now filled by fine-grained Qtz
Groundmass Qtz, Mu, He, needles of ?rutile, patchs of Qtz grains.
Vugs lined by Qtz, He layer, fine-grained Mu

87120083 GRS333045 300m NW of Monolith Mine

XRD

Whole sample Quartz major, possibble hematite minor, kaolinite major, mica trace.

-5u Kaolinite major, mica trace.

TS Hematitic fine-grained sandstone
Clasts sub angular Qtz, minor tourmaline, rare zircon, Mu
Interstitial Qtz, ?Mu

87120084 GRS358024 600m NW of Palette Mine

XRD

Whole sample Quartz major, mica major, kaolinite minor+.

-5u Kaolinite major, mica(no s m l) major.

TS Sandstone: fine-grained, matrix supported, with He zones
Clasts Qtz, tourmaline, zircon, Mu, aggregares of felted Mu
Matrix Mu, Qtz
Desseminated He
Authigenic tourmaline

87120085 GRS355021 Scinto Hill

XRD

Whole sample Quartz major, hematite major, kaolinite minor+, mica minor+.

-5u Kaolinite major, mica(no s m l) major.

TS Vuggy volcanic rock: texture of mafic volcanic rock
Groundmass angular, Opq (?He), Mu, Qtz, ? kaolinite
Vugs filled by manily Opq, some Qtz, Mu
Veins of Mu, ?Actinolite

87120086 GRS312052 500m W of El Sherana Mine

XRD

Whole sample Quartz major, hematite major, kaolinite major, mica(no s m l) minor+.

-5u Kaolinite major, mica(no s m l) major.

TS Hematitic ?volcanic rock (thin section of pebble from conglomerate)

Groundmass lath-like forms, outlined by He, filled by kaolinite, minor Mu

Vuggy spaces kaolinite

Mu outines veins/fractures

87120087 GRS332044 El Sherana road

XRD

Whole sample Quartz major, mica minor+, possible kaolinite trace.

-5u Mica(no s m l) major, kaolinite trace.

TS Sandstone

Clasts Qtz, chert, minor tourmaline

Qtz overgrowths:- in part orthoquartzite

Interstitial He, Mu, ?kaolinite

Technical Details

The diffractograms were obtained from a Philips Diffractometer with a PW1010 gonimeter. Cu radiation with Ni filter, 1-.02-1 degree slits, T.C. 4, 4 x 10^2 c.p.s. and where necessary 10^3 c.p.s. were the operating conditions. Glass slides were used in all cases.

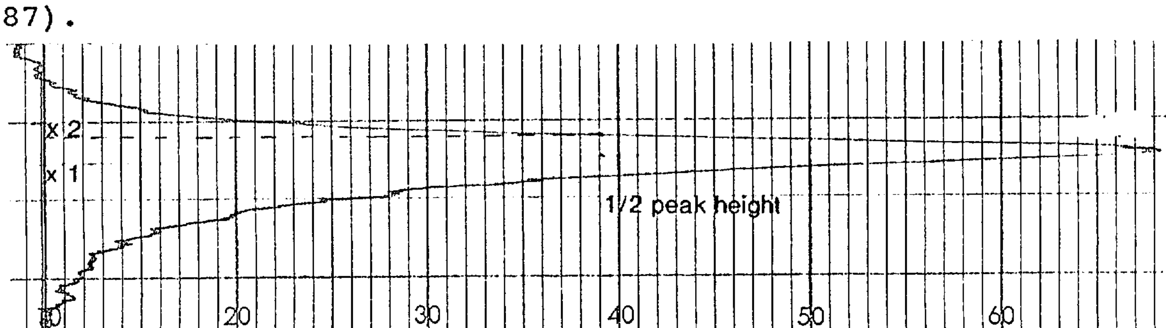
All samples were mounted as an alcohol slurry and run from 4^o-60p^o 2θ to establish whole rock mineralogy. A gram of lightly ground sample was set aide for separation of the -5 micron clay portion. Water was added to the gram of sample and an ultra sonic bath was used to disperse the minerals. The heavier minerals were removed by centrifugation at 500 RPM. The clays were extracted from the supernatant by centrifugation at 2500 RPM. After air drying the samples were examined for their clay content at room temperature the heated to 60^oC with ethylene glycol to establish the presence or absence of montmorillonite. The operation conditions were as described as above with a run lenght of 4^o-60^o 2θ

APPENDIX B

CRYSTALLINITY INDEX

The crystallinity index (C.I.) of mica is established by measuring the width at half peak height of a trace run at half a degree per minute over a 2θrange of 4^{o}-60^{o}. C.I. is a measure of the crystal stacking, phase substitution and thickness. An inherent difficulty is the instrumental artifact of the time delay between the diffraction and its measurement. To this there is added the ever present problem of mixed layering within clays. As these compromises have been made, the C.I. results should used only for broad implications.

Only a few of the Kakadu samples submitted for this study show strong mixed layering. Those that do are indicated both in the mineral identification and with an * in this summary. To reduce the effects of mixed layering and delay between diffraction and measurement the C.I. has been measured as indicated in Figure B.1. The distribution of measured C.I. values (Fig. B.2) is skewed, with a marked peak in the .40-.70 range, and a few specimens with C.I. in excess of 1.0. This is interpreted as showing that the micas formed over a range of temperatures, but most formed at comparatively high temperatures. There is no distinction between the alteration types as defined by Valenta (1987).



x = 2 θ C.I. = 2 (x 2 -x 1)

y = peak intensity

Fig. B.1 An example of trace showing how the Crystallinity index (C.I.) is established. The C.I. is expressed in ^{o} 2 θ

DIOCTAHEDRAL AND TRIOCTAHEDRAL MICA

Despite the constant presence of quartz an attempt was made to establish the dioctahedral state or trioctahedral state of mica by examining the (060) reflection which would fall in the 58°-63° 2θfor Cu radiation. For this study traces examined were run at a quarter of a degree 2θper minute.The K alpha 1 & 2 of the (211) reflection of quartz fall in the 60° 2 θregion. Samples that contained both kaolinite and quartz were not considered as kaolinite reflects in the 61° 2θegion. However small but distinguishable humps of reflections did appear in the 61.5° to 62° (1.50Å) region in some of the samples where mica was the only significant clay mineral. **This indicates dioctahedral micas such as muscovites in all samples that were suitable for measuring.**

The samples that unmistakably show (060) reflections are:

87120013, ..16, ..18, ..19, ..26, ..27, ..36, ..38, ..53, ..64, ..76, ..78, ..80, and ..87.

TABLE B1 CRYSTALLINITY INDEX SUMMARY

87120001	.50	87120024	1.0
87120002	.55	87120025	.40
87120003	.84	87120026	.40
87120004	.80	87120027	.36
87120005	.60	87120028	.55
87120006	.56	87120029	.40
87120007	.56	87120029	.40
87120008	.64	87120030	.56
87120009	.42	87120031	.46
87120010	.50	87120032	.60
87120011	N/A	87120033	1.20
87120012	.60	87120034	.52
87120013	.35	87120035	.80
87120014	.70	87120036	.60
87120015	.60	87120037	.44
87120016	.60	87120038	1.20
87120017	.60	87120039	.36
87120018	1.46	87120040	.50
87120019	.60	87120041	N/A
87120020	.60	87120042	.40
87120021	1.40	87120043	.44
87120022	.80	87120044	.40
87120023	.80	87120045	.46

Table 1 continued

87120046	.55	87120070	.65
87120047	.50	87120071	.90
87120048	.45	87120072	.80
87120049	.60	87120073	N/A
87120050	.56	*87120074	.50
87120051	.45	87120075	.40
87120052	.65	87120076	.40
87120053	.45	87120077	.50
87120054	.60	87120078	.50
87120055	N/A	87120079	N/A
87120056	.60	87120080	.45
87120057	.50	87120081	.50
87120058	.30	87120082	.40
87120059	.36	87120083	N/A
87120060	N/A	87120084	.40
87120061	.64	87120085	.50
87120062	N/A	87120086	.40
87120063	.60	87120087	.50
87120064	.65		
87120065	N/A		
87120066	.30		
87120067	N/A		
87120068	.50		
87120069	.46		

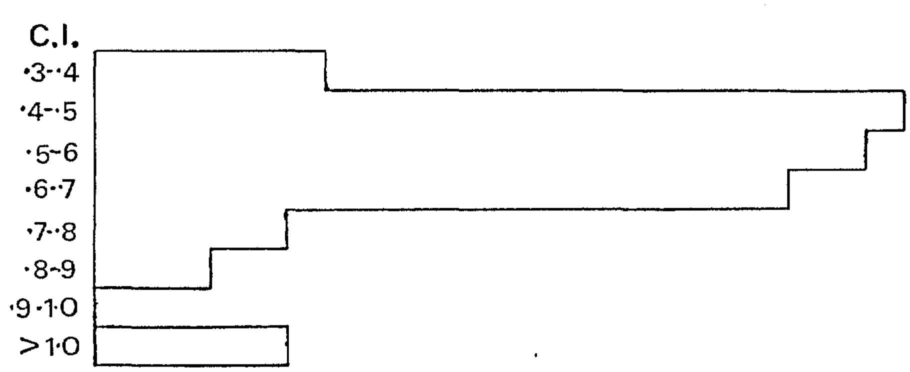


Figure B.2 Distribution of C.I. as listed in Table B1.

APPENDIX C

SUMMARY OF SPECIMEN DATA, 1988-9 FIELD COLLECTION

G geochemical analysis, F sample collected for fluid inclusion studies.
GR grid reference, S Stow 1:100 000 Sheet area, M Mundogie 1:100 000 Sheet area

Samples collected by RGW

88124501 Zamu Dolerite GRS473987
palimpset texture
Actinolite aggregates of needles, ext angle to 26^{o}
(actinolitic hornblende?)
Chlorite pale green, anomalous blues
Quartz minor, interstitial grains
Opq minor
Symplectites Qtz + mineral RI>Qtz, ?after plagioclase
Sphene fine aggregates, orange/brown, RI v high,
?isotropic

88124502A Malone Creek Granite GRS478968
altered
Quartz
Orthoclase Perthitic, plag replaced by fine phyllosilicate
Graphitic Qtz-Or intergrowths
Plag, rare, Ab-> fine ?Mu
Pale green Bi + Mu + F
Ch + ?, possibly sphene

88124502B Zamu Dolerite GRS477968
amphibolite with fabric
Actinolite: large ragged grains, needle-like intergrowths
Qtz
Qtz + ? in symplectites
aggregates of felted Bi, Bi + Ch + ?rutile
zones rimming actinolite of ?clinozoisite + ??
Cc along grain boundaries

88124502C Burrell Creek Fm GR477968
recrystallized sediment, finely layered, crosscutting fractures
Qtz large polygonal totally recrystallized
Mu & Bi in fine layers
Tourmaline small ragged grains
rare Zircon, fine desseminated Rutile
crosscutting fractures lined by golden brown ?limonite, later Qtz

88124502D Burrell Creek Fm GR477968
fine-grained metasediment, fine layering parallel to length of section. More a pelite than 2C
Mu felted fabric
Fe oxide, ?hematite, defines layering
Qtz rare, interstitial rounded grains
Tourmaline
Rounded aggregates of Qtz-Mu-Fe oxides, after ? Crd, outlined by more intense Fe oxide concentrations.

88124502E Malone Creek Granite GRS477968
Tourmaline-quartz rock: Radiating tourmaline suns: near colourless to blue, suggests Li tourmaline.

88124502F Burrell Creek Fm GRS477968
?retrogressed Crd rock
Aggregates of felted Bi + ?Crd, some with felted Mu in the interior: outline suggests Crd
Felted Bi in diamonds: ? after staurolite
Qtz, rounded, separated by Bi
Rare ?Andalusite: High RI, twinned, low δ, interstitial to Qtz grains
patches of green-brown fine, felted ?Mu

88124502G Malone Creek Granite GRS477968
Quartz-tourmaline rock: Tourmaline in fine-grained suns, evidence of sucessive phases of growth
Minor apatite, Fe oxide

88124503 Zamu Dolerite GRS443002
Plag: relict grains, igneous zoning
Cpx: relict grains with exsolution lamellae, ?inverted pigeonite
Qtz
Bi rimming skeletal ilmenite
cores of Plag replaced by Mu + ?epidote
Overgrowths of green Hbe, cummingtonite on Cpx
some cummingtonite with Bi.

88124504 Zamu Dolerite GRS452998 G.
Pale green, even grained, medium grained rock
Plag: relict, partly replaced in grain cores by very fine grained ?zoisite
Cpx
Bi, rare, partly altered to c'less Chl
Qtz, Qtz-Plag symplectite
Actinolite, cummingtonite, chlorite

88124505 Zamu Dolerite GRS484986
Dark, fine to medium grained dolerite
Cpx: relict
Plag, mid An range (est 40-45)
Qtz interstitial
Ilmenite: partial replaced by Sphene?
Bi rims on Ilmenite
Cummingtonite, Actinolite
Very fine grained ?zoisite in Plag interiors

88124506A mafic volcanics in Coronation Sst GRS371971
Dark green altered basalt with ?vesicles
Plag phenocrysts: altered, cores of ?Mu, rims of Ca-rich Plag, inclusions of augite, Opq, ?
Augite, Ca-plag, ilmenite as relics
Alteration to green ?Bi/pumpellyite, augite to brown ?
Vesicles ined by Cc, filled by Chl.

88124506B mafic volcanics in Coronation Sst GRS371971
Dark green altered volcanics
Plag phenocrysts: rims of Ca plag cores of Plag + Augite
Qtz single rounded inclusion
Groundmass: larger grains of Plag, augite, ilmenite, finer plag, opq, devitrified.

88124507A felsic volcanics GRS361035
Hematitic alteration of felsic volcanic rock
Rare Qtz phenocrysts preserved
Ghosts of feldspar laths: to Mu + Opq
Qtz as euhedral grains with dendritic inclusions of c'less ? + dust of hematite
Hematite replaces everything except Qtz, invades areas within TS as irregular front, forms irregular interstitial grains

88124507B felsic volcanic GRS361035
Chalcedony with dusts of ?hematite
Pseudomorphs after feldspar: Mu + ?
aggregates of Mu + ?, with dusts of ?hematite
Invasive hematite along grain boundaries

88124508A Quartz-mica schist GRS363037
Schist with kink bands, limited hematite replacement
Grains of Qtz, rare Mu, zircon, tourmaline, +Opq, rare recrystallized chert
Matrix very fine grained Mu
2 cleavages: poorly defined older one, new one slightly oblique, outlined by Fe oxide along cleavage planes
Clots of fine grained ? after ?/

88124508B Quartz-2 mica schist GRS363037
Two cleavages, quartz veins
Grains: Qtz, minor recrystallized chert, rare zircon, tourmaline, Mu, Bi
Matrix: Mu, lesser Bi
Veining Qtz, ?recrystallized, some deformed grains, cleavage bends into larger vein

88124508C very fine grained schist GRS363037
Qtz veins lace TS, He along fractures
Mu, Opq, Qtz

88124509 Zamu Dolerite GRS374047
Cpx, Opx, Plag, ilmenite, Bi
graphic intergrowth of Qtz-feldspar
Alteration Ch, ??actinolite

88124510A Mudstone GRS368043
very fine grained
Bi, Mu, ?Ch, Qtz, ?Opq/organic particles
Veinlets of Qtz, with concentrations of Opq etc on margins
one Zircon needle

88124510B Meta arkose GRS368043
Grains: Qtz, some single, some composite, strained; Plag, andesine, variably altered; Mu, rare Tourmaline
Interstitial Mu, Bi
Qtz veining

88124510C Zamu Dolerite GRS368043
Altered and weathered, texture retained
relict Plag, Cpx, Qtz-feldspar intergrowths
Bi, Ch, ?Mu, ?Actinolite

88124511 Zamu Dolerite GRS375048
Cpx exsolution lamellae
Opx minor, altered along fractures
Plag, partly altered
Qtz-feldspar intergrowth
rare apatite
ilmenite
Bi
Alteration: Ch, ?epidote, ?/

88124512 Zamu Dolerite GRS377049
Relict Cpx
graphic Qtz-feldspar intergrowths
Plag laths

Ilmenite, brown Bi
Alteration: Ch, green Bi, actinolite, rare epidote, sphene rims

88124513A ?mafic rock/mafic tuff GRS380050
Plag; altered
actinolite
Bi both brown & green
Opq
minor Qtz
veins of Ch, Qtz

88124513B cleaved sediment: ? greywacke GRS380050
grains Qtz: single, composite & ?chert; ?lithic grains, fine, recrystallized granules; rare small tourmaline, zircon, hematite clots; Mu & Bi flakes
2 cleavages; Bi & Mu belong to earlier set

88124513C fine grained lithic sandstone GRS380050
Clasts Qtz, quartzite, chert, Mu-rich pelite, felsic volcanic, Bi aggregates, zircon
Matrix Bi, Mu, minor Tourmaline

88124513D Greywacke/lithic sandstone GRS380050
very fine grained
Clasts Qtz, chert, aggregates, plag
Matrix abundant, Bi, Mu, ?Ch, Qtz, Opq
Aggregates of Bi-enriched zones rimming Mu, ?after Andalusite/Cd
Flakes of Bi and Mu cutting randomly across fabric.

88124513E very fine grained rock, laced by Qtz veins GRS380050
Qtz, ?Ab, ?epidote, Bi, ?organic matter
Veins Qtz, minor epidote + Qtz + ?Mu

88124513F very fine grained meta pelite GRS380050
?2 cleavages
Qtz small granules
Mu random, Bi along cleavages
? minor andalusite, surrounded by Bi & Fe oxide

88124514A Zamu Dolerite with vein GRS374060
Fine grained end: relict Cpx, relict graphic intergrowth, skeletal Opq
Alteration of Cpx to Ch, Plag to clinozoisite, epidote
Coarse grained end similar, but more Ch, some Bi, some Cc

88124514B Zamu Dolerite GRS374060
Relict Cpx, graphic intergrowths, Qtz, skeletal Opq
Aleration of Plag to epidote

brown amphibole, ?common Hbe or actinolitic Hbe
Ch, green Bi

88124515 geochem specimen from site of 4506

88124516 dolerite dyke GRS478882
partly metamorphosed
Qtz
relict Cpx: cloudy
magnetite
Bi: green, alteration of Cpx
alteration of Plag: ?clinozoisite

88124517 Series of volcanics collected outwards from the edge of the Malone Creek Granite

88124517A Junction of granite and volcanics GRS492883
Granite end of TS
Qtz, rare minor Bi, F, zircon, apatite, Opq
?Kf: completely altered
Plag: cloudy, oligioclase
Volcanic end of TS: fragmental rock
Bi, both green and brown; Ch bright green, Opq, Qtz
Very fine grained groundmass

88124517B Fragmental rock
Fragments Qtz, mafics, zoned ?vug-fill
Actinolite, ?Ca-rich plag.
Groundmass Qtz, ?Kf, minor zircon, F, variable actinolte
Zoned fragment: core ?tremolite
Fracture traced out by actinolite

88124517C Fragmental rock
Fragments mafic, "intermediate" rock
Qtz grains and aggregates, feldspar-opq aggregates, rare euhedral zircons, devitrifed spherules, ?pumice fragments
Qtz, ?Kf-untwinned, Plg - ?Ab, has near parallel extinction, Ch, Bi - golden brown, esp nr F, F, Cc - esp in mafics, minor Opq, Fe oxide
Fracture filled by Ch, F, Bi

88124517D Fragmental rock
Vugs: zoned Qtz rims F, Cc, Ch in cores
Mafic fragments: Ab, Ch, Opq $\pm$ Ch, F
Qtz aggragtes, devitrified spherules
Ch, minor Bi, acc F, zircon

88124517E Fragmental rock
Fragments mafic, Qtz, also Qtz filled vesicles
Bi: both green and brown, ass with F
bight green Ch, Ab, ?Kf - altered
minor F, ?epidote

88124517F Mafic "clast"
Relict igneous texture
Plag relict, igneous zoning, andesine range, altered to phyllosilicate: ?Mu
Augite relict, altered to actinolite, Bi, Ch
Opq relict, cubic
late Opq from breakdown of augite
88124517G Fragmental rock, large patch Fe stained
Mafic fragment, rimmed by Qtz: Plag: ?Ab, Opq rimmed by sphene, Ch/Bi,?Bi earlier, partly replaced by Ch
?Spherules
?Felsic ghosts: aggregates of larger grains with numerous inclusions; Qtz crysts
Matrix fine grained ?Ch, OPq
Abundant F; veins with Ch, core of Qtz aggregates

88124517H Two TS: mostly mafic with fine "pods"
Plag ?Ab-Ol, ome very altered to fine white mica
Bi mostly golden brown, some green to brown
?Clinozoisite
Actinolite deep apple green to pale lemon green, locally felted in veins
rare F
Opq fine inclusions in Bi

88124517I Fragmental rock
totally devitrified
Qtz grains, laths of ?, ?vug fills, mafic fragments with Bi, ?Ab, Opq
Interstitial F

88124518 meta dolerite GRS460896
Relict Cpx, ?augite
minor Plag, altered to white phyllosilicate, Qtz, Opq
Bi green, Actinolite

88124519A Mafic rock GRS457899
Aggregates of Ch + Qtz + ?magnetite, after ?Opx
Plag: Ab
Ch, Opq
?amygdaloidal cavities, now Qtz, Ch

88124519B Very fine grained ?mudstone
Minor fragmental Qtz, Plag
Mu, F, Cc, Bi, zircon, Opq: ?He & black Opq

88124519C Meta-arkose?micaeous sandstone, distinct fabric
Qtz, Kf, Plag (Ab-Ol), zircon, single Opx
Fabric of Bi, Mu: sedimentary with overgrowths
Interstitial Bi, Mu

88124519D Metasediment
Qtz, Kf, Plag, Chert, ?clinozoisite, tourmaline, zircon, Opq
Abundant Mu, Bi: probably sedimentary, but with overgrowths
Fe oxide along fracture planes

88124519E Metamafic
Feldspar in laths, Ch + Qtz, ?after ferromag phase, Opq, Qtz
abundant Cc, mostly irregular interstitial, but some sparry
Qtz in vein, Cc inpregnation parallel to fracture trace

88124520A Lithic sandstone GRS458900
Fragment of Zamu, devitrified volcanic, composite Qtz grains
Qtz, Kf, Plag, Mu, Bi, Cc, Ch, Opq, apatite, zircon

88124520B sediment
Grains Qtz, metaquartzite, microcline
Matrix part quartz fragments, part Ch = Mu, minor Fe oxide
evidence of Qtz overgrowths on larger grains
matrix Ch & Mu has preferentially replaced smaller grains and invaded metaquartzites

88124521A Fragmental rock: sedimentary
Fragments mostly Qtz, some Mu, tourmaline, zircon, Opq apatite
Matrix Mu, Bi, minor Fe oxide

88124521B sediment, cleavage oblique to S_0
Mu, Bi, Opq, Qtz, Fe oxide
rare larger grains
crosscutting Qtz veinlets

88124521C metasediment
Qtz, rare zircon, tourmaline, Opq, some Qtz composites
?Plag, ?Ab interstitial with Mu, undulose or patchy extinction.
Mu in aggregates, ?after Kf & in matrix
Bi
Qtz veinlets

88124521D Schist
Ch, Bi, Fe oxide schist, minor Qtz
veinlets of colourless Ch

88124522A Zamu dolerite GRS425955
Relict graphic intergrowths, palimpsett igneous texture, esp laths of plag.
Bi brown:relict, and green
Ch, ?actinolite, Plag altered to ?Ab, Opq to sphene in part
?Kf
minor clinozoisite
Cc in veins

88124522B Zamu Dolerite
Relict palimpsett texture, laths, graphic intergrowths
Relict Cpx, ?Opx, Qtz, apatite
Cpx altered along cleavage and edges
Plag to cloudy masses, Ch
88124522C Zamu Dolerite
Relict Cpx, some exsolved laminae, core entirely altered
Laths of Plag, mostly clouded, some clear edges of ?Ab
Symplectites of Qtz + erstwhile feldspar
Opq, minor Bi
?Actinolite partly replacing Cpx

88124522D Zamu Dolerite
Cpx: augite with exsolution laminae, extensively replced by Ch
Plag: Ab-Olig
Opq
Fracture filled by epidote, Qtz, Mu

88124523 meta-porphyry Gerowie Tuff GRM104281
Crysts: Qtz, minor and partly resorbed; Feldspar, zoned, twinned, with some zones very altered, ?what remains is Ab, alteration is ?clinozoisite
Cpx: augite, some altered to Ch $\pm$ actinolite + sphene
Opq, zircon, very rare Bi
Groundmass: cloudy poikiloblastic grains of ?plag, enclosing clinozoisite, ??

88124524 Shovel Billabong Andesite: meta mafic volcanic GRM118243
Plag: zoned laths, very altered
Cpx Rimmed or partly rimmed by Opq
Opq in dendritic growths and as small grains
Groundmass cloudy, High RI, minor Qtz, Plag altered top ??
Ch dark green.

88124525 Shovel Billabong Andesite meta mafic volcanic GRM078275
Feldspar laths, completely replaced by ?
radiating needles of Cpx, ?plag
Aggregates of cherty Qtz, minor Ch, Opq
Vug with Qtz, Ch, rim of epidote, vein of epidote, some Opq, Cc.

88124526 Shovel Billabong Andesite meta mafic GRM068268
Laths of Plag: altered to ??
Groundmass of fine radiating crystallites in cloudy matrix
fine opq, lat Ch
Vein of ?prehnite + minor epidote.

88124527 Zamu Dolerite GRM057263
Cpx: pigeonite, large twinned grains
Opx: relict grains, commonly with cores altered to Bi, Ch
Plag: zoned and altered, cloudy, ?Ab, rare relict high An plag preserved in pigeonite
Bi: early red, partly altered to green Bi and partly to Ch
Opq, rare apatite

88124528A mafic pod in layered rocks above Stag Creek GRM066200
Veins of epidote, minor Ch, Qtz, with margins of unidentified ?
Groundmass very fine grained, epidote, Opq, ?Qtz, dark green ?Sp/Ch, needles of ?actinolite

88124528B Fine grained metasediment above Stag Creek
Layers of opaque material
rounded grains: red, He; aggregates of white mica; rare Qtz

88124528C Stag Creek
Vugs with cherty Q, Ch, epidote, ?prehnite, ??
Groundmass cloudy, epidote, ?Ab, Ch
Veins with Ch, epidote, Fe oxide

88124528D Stag Creek
Laths, ?feldspar, now epidote + ?
Groundmass cloudy contains epidote, Ch, Opq
Veins Ch, minor epidote

88124528E vuggy Stag Creek
Vugs filled by Chert, chalcedony, Ch, rare Cc: epidote & ?Ch/stipnomelane/? as cores of radiating brown minerals within Ch
Groundmass sphene, Ch, actinolite, ?Ab

88124529A Unit above Stag Creek GRM078186
Fine grained dark rock
Diffuse aggregates 2-3 mm in fine matrix
Aggregates cores of poikiloblastic Cc within bright green Ch & Opq

Rounded dark aggregates of minute grains
cloudy grains: brownish
Matrix of green Ch, c'less High RI, high δ felted grains

88124529B vuggy Stag Creek
Vugs varied: several Chert + Qtz, Chert + Ch, Chert, Qtz, Ch ± epidote; large "messy" Ch-epidote; single zoned chert, Bi + Qtz, Qtz + Cc, Cc, one with zircon in core; one coed by ?stilpnomelane
framboids of Qtz-sphene
Matrix laths replaced by ?clinozoisite
groundmass Ch, epidote, ?/; large cube of Opq

88124529C vuggy Stag Creek
Vug Ch, epidote, actinolite, Qtz, sphene
Matrix: laths replaced by ?clinozoisite, Ch, actinolite, Opq, clusters of cubes of ?pyrite
Veins with Ch, Fe oxides

88124529D Finely layered dark brown rock above Stag Creek
He, Qtz in rounded grains with inclusions, ?clinozoisite, ?Bi or Stilpnomelane

88124530 Zamu Dolerite GRM146192
Cpx: pigeonite, inverted pigeonite, diopside
Plag laths, zoned with altered cores & rims of ?Ab
Bi, early red, late green rims of Bi & Ch
symplectites of Qtz + feldspar
Opq mostly large, ?ilmenite, some desseminated, minor apatite

88124531A Zamu Dolerite GRM125222
Abundant symplectite Qtz + feldspar
Relict diopside s.l. & Opx
Opq needles, platlets and equant grains
Bi: early red, mostly late, green; Qtz, apatite, rare ?zircon; sphene as clumpy aggregates, inclusions in late Bi & cloudy masses, ?after ilmenite

88124531B Zamu Dolerite
Abundant symplectite
Plag: laths equant, zoned, probably mid An range
Aerigine-augite, partly altered to Ch, Bi + sphene
Opq, equant, twinned or two phases intergrown
Qtz, apatite, Late epidote, sphene

88124532 Zamu Dolerite GRM084284
Cpx: large skeletal twinned grains, pigeonite
Opx: numerous small euhedral grains, somewhat altered
Plag: laths, altered in cores, zoned, reversed

fine grained symplectite
Bi: minor, small, brown
Opq, interstitial, ?ilmenite, one zircon
Alteration: abundant pale green Ch, ?sericite and ?epidote in plag core, sphene at edges of Opq

88124533 "dacite" in Gerowie Tuff GRM093296
Plag: euhedral, zoned and altered, probably mid An range
Rare relict Cpx: probably augite, mostly replaced by prehnite, Ch, sphene, rims of epidote
Qtz, embayed, with reaction rims
Apatite, Opq
groundmass: ?Ab, small epidote

88124534 Mundogie: pebble conglomerate GRM221096
Pebbles mainly quartz, some quartzite, chert
finer grained raction includes zircon, tourmaline
Grains pseudomorphed by He + Mu
Interstitial He & Mu invading along boundaries
Qtz-Qtz contact rare, boundaries are blurred by recrystallization
?He invasion preceded metamorphism

88124534B Stag Creek
Fine grained, one area of vugs
Ch, epidote, sphene with cores of Opq, minor Qtz
Cloudy brown areas: ?Bi
clots of Mu = Fe oxide ? replacing Kf crysts

88124534C Stag Creek Vuggy mafic
Vugs mainly Ch ± quartz/chert rim, ± epidote, rarely Qtz, Bi, Mu, one with Cc
Groundmass Ch, actinolite, epidote, ?Ab, Qtz, sphene, Opq
Vein of Qtz, fibrous actinolite, epidote

88124534D Fe-rich rock above Stag Creek
Palimpset texture of vuggy volcanic rock
Vugs mainly cherty Qquartz, Fe oxide, rare Bi
Matrix: Plag laths, ?Ab; Fe oxide; Bi, mainly close to margins of vugs

88124534E Fe-rich rock
palimpset texture of vuggy mafic rock
Vugs mainly cherty Qtz, outlined by increased Fe oxide, golden epidote, minor sphene
Matrix: Fe oxide; Plag, ?Ab; Qtz;rare Bi; possibly sphene

88124535A Stag Creek GRM210098
Vuggy fragmental rock

Vugs variously Qtz, Ch, epidote, Cc, Mu, Sphene
edges of vugs outlined by darker zones
Matrix: cloudy, amber, very fine-grained, high RI, with laths of ?

88124535B Stag Creek
Fine grained metavolcanic
Epidote, sphene, brownish clots with mod RI, ?prehnite, also c'less mod RI mod δ mineral interstitial to epidote, ?actinolite
minor Cc, pale green Ch
area of Cc, Ch, opq, ?Mu + unidentified mineral

88124536A Koolpin Fm metasediment GRM218115
Matrix supported sediment
clasts of Qtz, quartzite, minor mafics, ?felsic volcanics, tourmaline, zircon, flakes of Mu
Matrix Mu, minor Qtz, Opq

88124536B Fe-rich metasediment
Fine grained with anastomosing, wavy "cleavage" outlined by Fe oxide + ?Bi
Mu, Bi, minor Qtz, Fe oxide with nodules of quartzose composites

88124537 Zamu Dolerite GRM221116
Relict Cpx, ?augite
Relict Qtz, palimpset Plag, now epidote + ?Ab
Opq, mostly replaced by sphene
Ch, Hbe/actinolite zoned brown to pale green
symplectitic feld-Qtz, ?single crystal of Kf

88124538 Zamu Dolerite
Pigeonite: inverted and exsolved
Qtz with graphic texture
rare plag, Opq, Bi
late Ch, actinolite, fine grained ?sericite after plag

88124539 Coronation Sandstone
Fragmental rock coarse grained sandstone
Clasts Qtz, volcanic, quartzite, schistose fragment, He impregnated fragment, fine grained illite, ?after feldspar

88124540 Coronation Sandstone
green meta mafic volcanic rock
Crysts , now Cc-CXh, ?Cpx, ghosts of laths outlined by high RI dark minerals
matrix Cc, pale green Bi, minor Qtz

88124541 Zamu Dolerite
cleaved, metamorphosed
Epidote, Qtz, ?Ab with epidote, sphene, Ch

88124542 fine grained mafic rock
Veinlets of Cc, Qtz; small pods of Cc-Qtz
groundmass actinolite, epidote, Ch, ?Ab, Qtz, Sphene

88124543A Burrell Creek deformed greywacke
clasts Qtz, quartzite
Plag Oligoclase
?Cd: dusty grains, checkered extinction, large 2V, minor Bi in fringes
Mu, minor tourmaline, zircon, ?He

88124543B Burrell Creek
clasts: Qtz, feldspar plag, aggregates Bi ± Mu, rare tourmaline
groundmass: Bi, Mu, ?He

88124543C Burrell Creek
Clasts Qtz, quartzite, Plag, clots of Bi ± Ch
matrix Bi, Mu, Ch, Qtz, fine dark ??

88124543D Burrell Creek
Clasts, Qtz, lithics, quartzite, Plag
Clots of Bi-Mu, Ch-Mu
Zircon, including euhedral grains
Matrix Mu, Qtz, Ch, minor Bi
Cc in Qtz-Plag

88124543E Burrell Creek
Clasts of Qtz, lithics, quartzite, Plag,
Clots of Mu-Ch
Opq, Zircon,
Mu, Ch, Bi, ?Cc in Plag

88124544 Burrell Creek
Clasts Qtz, ?Cd, infilled with Mu, Ch, minor To, Ap, zircon
fabric Bi, Mu

8124545A Burrell Creek
ribbons of Qtz aggregates
rounded aggregates of Mu, Ch
Groundmass Mu, Ch, Qtz, minor Bi

88124545B Burrell Creek
Clasts of Qtz, Plag, aggregates of Mu-Ch, ?Cd
groundmass Mu, Ch, ?Bi, Opq, rare To

88124545C Burrell Creek
Compositionally layered with near pure Qtz and Mu-rich layers
"clasts" Qtz, Mu
Groundmass Mu, Ch

88124546 Foliated Burrell Creek
"Clasts" Qtz, Bi, Ch, Ch + Qtz, Mu, To
fabric Mu, Bi
Opq ?after Pyrite

88124547 ?Gerowie Tuff: mapped as Koolpin, above battery
very fine grained, foliated
Mu, Qtz
Fe oxide along foliation and joints

88124548 Shovel Billabong M143212
C'less crysts pseudomorphed by Mu ?, possibly some plag
Green Ch after ?
Groundmass of featery, very fine grained material, brown in TS, dark green against light

88124549 mafic volcanic in Coronation Sandstone
Vugs Ch, Cc
Laths of Plag, now ?Ab
Opq?ilmenite in skeletal grains, pseudomorph after ? augite
groundmass

88124550A green mafic rock at NE end of Scinto Plateau
Qtz, fine brown ?, rutile

88124550B Ibid
C'less Ch, Opq, brown staining

88124551A Layered rock above Stag Creek: 2J Prospect
He stained
Coarse grained Fragments of Qtz, chert, rounded clasts of fine grained ??
fine grained ?epidote

881245551B Amygdaloidal mafic volcanic rock Stag Creek
Vugs Epidote, Ch, Qtz, ?actinolite
Groundmass laths of actinolite, Plag, ?Ab, cubes of ?Py
Veins of epidote

88124552 alterites from N side of glory hole at Palette

88124552A Schistose rock
He staining

knots of Qtz aggregates
fine grained, schistose ?sercite

88124552B breccia
fragments of Qtz + ?Mu, outlined by He

88124552C fine grained schist
Qtz + Mu

88124553 edge of glory hole Palette
Schistose rock
Qtz, Mu, pod of very fine grained Qtz

88124554 specimens from the Koolpin workings

88124554A ?Zamu Dolerite
Cpx laths, replaced by ?actinolite (some cf serpentinite after Olivine)
relict Qtz
Ch, Sphene, Actinolite, ?clinozoisite

88124554B metasediment
Variable grain size, not related to bedding
Qtz, Mu, Bi, Opq, ?graphite
He along fractures

88124554C metasediment
layering/pseudolayering
Qtz, Mu, ?Bi, Opq, irregular To grains

88124554D altered metasediment
Layered rock, partly hematized
Non He end: Qtz, Mu, To, Opq, ?includes graphite
Mu both in flakes and in fine groundmass
He end: He, Qtz, Mu flakes
Darkest near front, paler patches ne ?graphite

88124554E very fine grained metasediment
Mu, Qtz, minor Bi, Opq

88124554F metasediment with He front
non He zone: Mu, Qtz, To, Opq, rare Bi, zircon
He zone: He, Qtz, Mu. ?He replaces fine Mu

88124554G very fine grained metasediment
Mu, Qtz, Bi, Opq
Zones, pods, veinlets of Qtz

88124555A Chert west of rubbish tip SE UDP falls
network of slightly coarser Qtz veinlets, separating islands of very fine grained ?cherty quartz + Mu
He along fractures & invading one side of the TS

88124555B very fine graind rock
?Qtz, Ch, ?Mu

88124556 Stag Creek west of Stag Creek
fragmental rock
Vugs with Ch, epidote, recrystallized chalcedony

88124557 Zamu Dolerite
Cpx: altered at margins
Qtz: some in graphic intergrowths
Mu: groundmass alteration
Opq, skeletal, ?ilmenite
Ch, pale green to c'less
fine grained ?? after plag

88124558 Sediments above Pup Pul 478873
Clasts Qtz; Plag, ?Ab; microcline; Mu; Bi; schist/mylonite; Opq; rare zircon, symplectite from Zamu; grain of calcite, ?primary; ?organic fragments
Interstitial Ch, Cc, sericite, rare F
Ch dark green, at least partly after Bi

88124560A & B specimens supplied by BHP
layered rocks, essentially the same in both samples:
Tourmaline, Blue green to c'less, zoned, Two generations: earlier is fine grained and outlines the layering, the second is coarser and discordant
Qtz very fine grained in the groundmass, coarser grained in veins

89124600 S2/87/9 GR410498 Coronation Sandstone
sandstone
Fragments Quartz, quartzite/chert, ?muscovite
very close packing, little sign of overgrowths,
cement clay/illite, some Opq
some shearing, zones of polygonal grains.

89124601 S2/87/10 GR411497Coronation Sandstone
sandstone, He stained
fragments quartz, quartzite/chert, includes chert after ?stromatolite fragment
cement some quartz overgrowths, mainly He-chert, clay

89124602A S2/87/12 GR409497 G Coronation Sandstone
micro-gabbro
Ol rare
augite
Plag, slight zoning
Opq
Ch, after some augite, ?Ol, minor ?hydro Bi with Ch
?Mu after Plag

89124602B Coronation Sandstone
sandstone
fragments quartz, quartzite, Qtz-Mu rock
cement green, near amorphous, maybe Bi converted to goethite, minor Ch

89124602C Coronation Sandstone
mafic rock
Plag zoned
augite
Opq
Ch, after ?Ol and in veins

89124603A S2/87/13 G GR405497 Coronation Sandstone
Mafic rock
Plag
augite
Opq
?Ol now pseudomorphed
Ch, veinlets of Ch

89124603B Coronation Sandstone
mafic rock
Plag
augite
rounded ?Ol
Opq
Ch, ?Mu as alteration
89124604 S3/10/20 G GR418496 Zamu
altered quartz dolerite
Cpx:some diopside-slite-augite, some ?pigeonite
Quartz-intergrowths
one ?ilmenite, now fine-grained sphene
zone of intense alteration, with Mu, Ch, sphene

89124605 RH1/24/13 G GR137026 Pul Pul
altered rhyolite
one altered mafic clast

rare Qtz phenocrysts, very slight overgrowths
groundmass Mu, Qtz, ?hydrobiotite, Opq

89124606 RH1/24/14 G GR134028 Pul Pul
amygdaloidal basalt
texture preserved, minerals replaced
one amygdale chert, Cc, Ch
groundmass Ch, Opq/sphene, ?Ab after Plag, Cc

89124607A M13/43/40 G GR025507 Goodparla
meta mafic
Cpx augite
Qtz minor
Opq euhedral shapes, ?ilmenite in skeletal grains
Ch after ?, Mu, Epidote, actinolite

89124607B M13/43/40 G Goodparla
meta dolerite
large Plag altered to ?prehnite (radiating laths), Cc, ?Ab
Cpx, minor Qtz
Opq i. skeletal, altered to sphene & ii. dendrite-like phase
Ch
two large patches of Ch + minor Cc, one with two Qtz euhedra

89124608 M13/43/41 G GR036508 Goodparla
meta dolerite
texture retained
Cpx relic grains
Opq skeletal some altered to sphene
Qtz
Ch, Act, minor epidote

89124609 M13/45/38 G 048509 Goodparla **reference locality**
meta dolerite
texture retained, meta minerals
Cpx augite
Plag, some relic, some altered to prehnite
Qtz

Actinolite aggregates, zoned light to dark green
Cc minor
Opq small cubes and skeletal grains

89124610 M12/85/6 G GR035511 Goodparla
meta dolerite
Cpx relict
skeletal Opq

Plag
Actinolite, Ch, rare epidote

89124611A M12/85/7 G GR014514 Masson
sandstone, or cherty mudstone with dusty opq
rare coarser patches
Opq framboidal, irregular, ?carbonaceous

89124611B Masson handspecimen only: oxidized vein in tension structure with Qtz, limonite.

89124612 M12/87/27 GR002514 Goodparla
meta dolerite
texture retained
Cpx, partly altered
Plag altered to ?clinozoisite
Opq altered to sphene in part
Actinolite, Ch
minor Qtz

89124613 M11/163/1 GR987515 Masson
sandstone
fragments mostly Qtz, rare composite, one zircon
matrix fine Qtz, He, Opq

89124614 M11/163/4 G GR991515 Goodparla
texture retained
Cpx, mostly altered
Plag altered to ?prehnite, ?clinozoisite
Ch, Actinolite
Opq altered to sphene

89124615 M11/161/29 G GR975517 Goodparla
meta dolerite
Cpx some preserved
Opq skeletal, altered to sphene
Plag altered to ?
round aggregates of Ch, Act after ?Ol/Opx

89124616 M10/201/1 GR930522 Stag Creek
He altered ?sediments

89124617A M9/36/15 GR920524 Stag Creek s.l.
Greywacke/lithic sandstone unit above Stag Creek
Fragments Qtz, minor chert/quartzite, microcline, coarse perthite, calcite/dolomite, aggregates of ?Ab, rare ?chert, very rare zircon
matrix Cc, Ch, sphene

89124617B
greywacke/lithic sandstone
similar to A, but slightly coarser & lacks abundant sphene

89124618 M9/36/4 GR919524 Stag Creek
lithic sandstone unit above Stag Creek
Fragments of Qtz, Qtzite, feldspar, mafic volcanic, minor Tour
Ab-Ch after mafic volcanic
matrix Qtz, Ch, Cc, sphene

89124619 M9/36/30 GR930525 unit above Stag Creek
lithic sandstone, high proportion of matrix
fragments mafic rock, quartzite, quartz, chert, carbonate, feldspar, microcline
matrix Cc-Ch, sphene

89124620A M9/36/24 GR911525 unit above Stag Creek
graded beds, coarse layer
clasts Quartz, minor feldspar, quartzite, tourmaline, lithics, He filled voids
quartz overgrowths

89124620B
fine unit, claystone
dispersed fragments quartz, rare feldspar
matrix green ?Mu, some Ch, rare brown Bt
abundant dispersed irregular Opq, ?sphene

89124621 M8/234/20 GR813526 Prospect no ts

89124622 M8/234/21 814526 no ts

89124623 M9/38/38 G GR950523 Goodparla
texture preserved
Cpx
Plag laths, largely replaced
Opq, partly altered to sphene
Actinolite, Ch, rare Bt

89124624 M8/222/48 G GR074530 Zamu
Pyx pigeonite (small 2V, +ve), inverted pigeonite
Augite

Plag, altered
Qtz, rare apatite, Opq, Bt, Ch, Actinolite

89124625 M8/222/21 GR049528 G Shovel Billabong
meta mafic

colourless lath shapes in dark matrix
laths now ?Mu, epidote
matrix contains ghosts of fibrous minerals in radiating bundles

89124626 M8/222/54 GR057527 G Zamu
meta dolerite
Cpx, small +ve 2V (2V>pigeonite?)
Ch after ?
Plag altered Mu, zoisite
graphic Quatrz
Opq altered to sphene

89124627 M8/222/55 GR050526 G Zamu
meta dolerite
Cpx
inverted pigeonite
Plag altered cores of zoisite, Mu
minor Bt
Opq rimmed by Bt
Ch, ?Act

89124628 M9/36/27 GR920525 no ts Stag Creek

89124629 M8/232/37 GR868528 no ts ?Stag Creek

89124630 RH1/24/9 GR132024 G Goodparla
gabbro
Ol
Cpx
Plag
Opq
alteration to green Bt, He staining

89124631 M6/109/1 GR977535 G Shovel Billabong
meta basalt
fractures with Ch, and a bleached zone
crystal shapes of Mu + Epidote
matrix of ghosts of fibrous crystals

89124632 M6/109/3 GR991535 G Zamu
granophyre
abundant graphic quartz
Opq altered to sphene
Plag, altered
Cpx s.l. altered to Ch
Bi, altered
carbonate

89124633 S6/232/11 GR506824 Pul Pul
altered felsic volcanic
Phenocrysts Qtz, corroded, feldspar
matrix Mu, some Cc, Ch, ?Ab, fine He
Veins mainly Cc, Qtz where they cut Qtz phenocrysts
He zone

89124634 S6/230/6 GR476846 G Big Sunday
fragmental felsic volcanic: ignimbrite or tuff
phenocrysts Qtz, microcline, Plag
fragments/pumice Opq + Cc + ?Ab + ?Zo
matrix recrystallized shards

89124635 S5/203/17 GR463883 Big Sunday
meta mafic
residual Cpx, Qtz
Act, Cc, epidote, ?Ga
Sphene

89124636 S4/155/27 GR442929 Big Sunday
meta sediment, probably has a reworked tuff component
Fragments of Qtz, Mu, Bi, Tour, round grains outlined by He with Qtz, zircon
?pyrite replaced by He
matrix Mu, Bt, ?Ab/plag, Qtz

89124637 S1/38/19 GR465502 G Zamu
altered dolerite, texture retained
Cpx relict
Plag some relict,
Qtz graphic, minor
Act, Ch, epidote
Opq altered to sphene

89124638 S1/38/20 GR464502 Burrell Creek
meta sediment
Mu, Ch/Bt (some of each in different parts of the ts), Qtz
He desseminated
Cherty Qtz vein

89124639 S2/84/7 GR439499 Pul Pul? (lens NE Fisher Strip)
meta felsic volcanic
Phenocrysts Qtz, feldspar: voids or replaced by Mu, Opq + Mu as pseudomorps after ?
matrix Mu (yellow), fine grained patches may be Mu, minor Qtz
single zircon

89124640A M3/219/M1148 GR917551 G Koolpin
chert breccia with dispersed fine He

89124640B ts G
chert breccia with He-Qtz veins

89124641A M4/70/1 GR902542 Koolpin
He-chert cut by Qtz veins

89124641B
fine grained recrystallized mudstone
Ghosts of ?Mu
matrix Mu, ?fine Qtz, rare Qtz grains
dispersed fine He

89124642A M5/71/1 GR940541 G Shovel Billabong
meta basalt
phenocrysts of feldspar, ?epidote/Cpx (euhedral, moderate bi-refringence, small +ve 2V), pseudomorphs rectangular, clear margins, Opq cores
matrix feathery radiating ghosts, some possibly have Cpx or epidote cores

89124642B G
dolerite: may be Zamu or dyke within Shovel Billabong
euhedra of pyx, rare (small 2V, +ve)
Cpx
Plag generally intergrown with amphibole, some altered to ?Mu
amphibole: ?Actinolite, but brown to green pleochorism
Opq partly altered to sphene

89124643 M5/71/2 GR935541 G Zamu
meta dolerite
Cpx partly altered
Plag laths very altered
Qtz, includes graphic intergrowths
Opq aggregates of squares
apatite rare needles
Ch (pale green) Hbe (brown)

89124544 M5/67/1 GR834541 Wildman
lithic sandstone
clasts Qtz, single fine quartzite, carbonate rock, dirty ?chert
matrix cherty Qtz + Cc, dark ?carbonaceous material, some He

89124645 M8/20/67 GR108530 Zamu
altered,dolerite, with actinolite vein
unaltered end ts Cpx, exsolved pigeonite, altered Plag, Opq

altered zone with Qtz-Act vein, Plag altered to Mu, Ch, Opq altered to sphene, ?rutile or He

89124647 M8/20/68 GR114529 G Zamu
meta dolerite
Cpx augite
pigeonite and inverted pigeonite
Plag very altered to Mu + ?zoisite
Qtz & graphic Qtz-feldspar
Opq: skeletal ?ilmenite and small black particles with ?zoisite (colourless, high RI, first order grey)

SURFACE SAMPLES

W weathered or surface rubble. Underlying unit indicated.

89125000 M10/201/20 W unit above Stag Creek
89125001 M8/222/21 W Shovel Billabong
89125002 M8/222/53 W Gerowie
89125003 M8/222/56 W pisolithic laterite, ?Tertiary
89125004 M9/36/27 W ?Stag Creek
89125005 M8/222/50 W Gerowie
89125006 M10/201/21 W Masson
89125007 M9/36/27 W Stag Creek
89125008 M9/40/28 W Koolpin
89125009 M/222/49 W Koolpin
89125010 M11/113/14 W Masson
89125011 M8/222/53 W Koolpin
89125012 S1/38/19 W Zamu
89125013 M6/109/4 W Gerowie
89125014 S4/155/27 W Big Sunday
89125015 M6/193/1 W Koolpin
89125016 S1/34/27 W Burrell Creek
89125017 M6/109/1 W Shovel Billabong
89125018 S1/34/30 W Burrell Creek
89125019 S1/38/20 W Burrell Creek
89125020 S1/34/6 W copper prospect east of Scinto V
89125021 S5/203/15 W Big Sunday
89125022 S2/84/37 W Burrell Creek
89125023 S2/84/39 W Burrell Creek
89125024 S2/84/7 W Pul Pul
89125025 S1/34/33 W ?Pul Pul, Scinto V
89125026 S1/34/31 W Burrell Creek
89125027 S6/232/13 W Big Sunday
89125028 S1/34/32 W ?Kalapa
89125029 S6/232/11 W Big Sunday
89125030 S2/84/38 W Burrell Creek
89125031 S2/88/24 W Masson
89125032 S1/32/40 W Kurundi
89125033 S1/32/41 W Stag Creek
89125034 S2/88/25 W Stag Creek
89125035 S2/87/7 W Coronation Sst basalt
89125036 M6/109/2 W Koolpin
89125037 S5/203/16 W syenite
89125038 M12/85/5 W Masson
89125039 M10/197/19 W Masson

89125040A M11/165/1 W Masson pink weathered siltstone
89125040B M11/165/1 W Masson yellow exposed siltstone
89125041 M12/85/6 W Goodparla
89125042 M12/85/2 W Masson
89125043 M9/42/57 W Koolpin
89125044 M5/67/1 W Wildman
89125045 M5/71/1 W Shovel Billabong
89125046 M8/20/68 W Zamu
89125047 M8/22/12 W Shovel Billabong
89125048A M8/20/66 W Gerowie tuff
89125048B M8/21/13 W Gerowie dacite
89125049 M8/221/11 W Koolpin
89125050 M9/42/57 W Zamu

PETROGRAPHIC SUMMARY OF SAMPLES COLLECTED BY R. VALENTA, 1988
PROPOSED WORK: T thin section, G geochemistry, F fluid inclusion studies, S saw cut only

88120001 S1/32/29A S344067 T,G
conglomerate with abundant rhyolite clasts
ts Fragments of clear quartz, quartzite, felsic volcanics, dusty quartz-rich grains (?ex-volcanics or chert)
matrix mostly quartz
grains of quartz have quartz overgrowths
some opq, ?graphite
late hematite

88120002 S1/32/29B S344067 T,G
Massive hematite-calcite rock
ts abundant hematite
Qtz small scattered grains
?kaolinite intergrown with hematite
rare ?sercite: higher δ

88120003 S1/32/29D S344067 T,G
Matrix sample
ts hematitic sandstone: enough He to make slide reddish
Most clasts cloudy and hematitic, some clear quartz, cherty fragments
matrix partly finely crystalline quartz and partly epidote/clinozoisite
Felted sericite, dusty He, some coarser, mainly along grain boundaries

88120004 S1/32/29E S344067 T,G
Fragment of purple volcanics
ts Hematitic sandstone
Clasts clear quartz, fragments that are largely clinozoisite, some composite (?volcanic) fragments
matrix layered

88120005 S1/33/24A S352024 T,F
Veined Scinto Breccia
ts Quartz-hematite rock with veins
Veins Coarse grained Qtz (Core of one with ?prehnite)
He-rich zone
Mostly fine-grained and polygonized quartz

88120006 S1/33/24B S352024 T,F
Veined Scinto Breccia
Veinlets Qtz with ?apatite (hexagonal sections) and ?prehnite/epidote
Groundmass fine-grained quartz, ?sericite, ?? kaolinite

88120007 S1/33/24C S352024 T,F
Veined Scinto Breccia
ts laced by Qtz veinlets, coarsest with ?prehnite in centre intergrown with light brown ?chlorite
Groundmass very fine grained Qtz, ?Kaolinite, deseminated He

88120008 S1/33/25A S347028 T,F
Quartz vein along main fault in Scinto V pit
ts Qtz with dusty trails inclusions
He along fractures
Fe oxide after ? in fracture

88120009 S1/33/25B S 347028 T
Cleavage (S_2?) perpendicular to S_0, Scinto V pit.

88120010 S1/33/23B S352024 T
Highly chloritic (GTS-like) foliated Koolpin Fm.
Brown-green rock with quartzose blebs
Groundmass anastomosing lines of Fe stained material zoned outwards into low-relief yelllow-brown fine-grained?, wrapping round patches with very fine-grained dark-brown dust,
and rare ghosts of euhedral quartz
This thin-section looks like a deformed felsic volcanic rock

88120011 S1/33/23C S352024 T
bleached surface sample of carbonaceous Koolpin Fm.
ts Contorted layering
Pods of Qtz, black dust, voids
Layers of sercite, ?kaolinite, Qtz, ?graphite

88120012 S1/37/1 S461031 2T
Bfb fg-mg sandstone with strong S_2 foliation
ts ?two cleavages, metapelite
Qtz, Mu, Bi, ?sphene

88120013 S1/37/2 S461032 T
Breccia vein cutting Bfb sandstone

ts Veins of Qtz
Qtz grains, Mu, Bi, Ch, ?sphene

88120014 S1/36/19 S411053 T,G**Xrd/probe**
Green quartzose veined mg volcanic, Coronation Sandstone
Pseudmorphs after ?Plag

Aggregates of Qtz + Ch (?possibly also Crd or Plag)
Groundmass Mu, Ch, Brown fine-grained mineral

88120015 S1/36/20 S411054 T
Ebc conglomerate
Hematitic breccia/conglomerate. Some fragments He-rich, others He at margins.
Grains Qtz, Quartzite, cloudy, He-stained ?lithics
Cement interstitial epidote, ?kaolinite, phyllosilicate: ?margarite (c'less, δ OK, RI low)

88120016 S1/36/21 S410053 T,G
Ebc volcanic, purple, abundant lithics
ts Volcanic texture
Qtz to Kaolinite + He
Groundmass to He + kaolinite

88120017 S1/32/33 S319051 T,G
Ebp rhyolite
ts Volcanic
Qtz crysts, lithic fragments, rare ?feldspar crysts
Pods of epidote* + dusty Qtz
Groundmass He dust, diffuse ?Qtz
* Not epidote: no Ca in bulk analysis

88120018 S1/32/31 S320064 T,G
Ebp rhyolite
ts He stained volcanic
Qtz, lithics, pumice,
Matrix very fine grained: suspect kaolinite

88120019 S2/84/19 S455008 2T
kinked Ch-Mu schist
ts Well layered rock: two-mica schist
Granules, augen shaped:Qtz, Plag (?andesine), composites Bi, Ch, rare Tourmaline
some zircon crysts
Groundmass Mu, Bi, minor Ch

88120020 S2/84/20 S455010 2T
box-like kinks in Ch-Mu schist

ts Folds showing migration of material
Qtz, Mu, Ch, Bi; minor tourmaline, zircon
He, Fe oxide in fold crests, and along fractures crosscutting layering

88120021 S2/84/21 S456011 T
Ch-Mu schist with well-developed diff. crenulatio cleavage
ts Schist, with micro-augen of Qtz, Feld (?Ab, microcline), minor tourmaline
Groundmass Mu, Bi, fine Qtz, ?feldspar
Fractures with He

88120022 S2/84/24 S456012 T
Zamu dolerite with S_2 cleavage
Carbonate
Actinolite
Epidote/clinozoisite
?Mu, ?sphene, ?Ab: smoky lavender in groundmass
Qtz

88120023 S2/84/25 S456013 T
Ch-Mu schist with S_2 diff. crenulation cleavage
micro-augen of Qtz, Plag
Mu, Ch, Bi, Tourmaline
?apatite
Opq: vugs lined with He, Fe oxide

88120024 S2/84/26 S456014 T
dark shale layer with 2 cleavages
Mainly Bi-Ch-Mu, ?sphene, Fe oxides
Qtz in crosscutting podiform segregations and veins

88120025 S2/84/27 S456014 T
Ch-Mu schist with S_2 diff. crenulation cleavage, possibl containing staurolite and andalusite
Micro-augen Qtz, Plag
Mu, Bi, Ch, rare tourmaline
Fe oxides

88120026 S2/84/28 S457015 T
lower grade chloritic Ebc
Micro-augen mainly Qtz, minor Plag
Qtz, Mu, Bi, rare zircon
Finely desseminated Opq, ?Sphene

88120027 S2/84/29A S456016 T
Ch-Mu schist with 2 diff. crenulation cleavages

(S_2 & S_3)
Micro-augen of Qtz, Feldspar with **Cc**, ?Crd: diffuse sector twins, elongate cloudy grains, grains with cubic inclusions after ?pyrite
Mu, Bi, Ch: Ch zoned to Bi, rare tourmaline
abundant Fe oxide, several zoned euhedral zircons

88120028 S2/84/29B S456016 2T
as for 0027
Qtz veinlets
Micro-augen of Qtz, Plag
Mu, Bi, Qtz, tourmaline in ragged ?new grains
Zircon, zoned ?new growth
Fe oxide

88120029 S2/84/30 S457019 T
red-green fg Efb sandstone showing ~30cm pencil structur
Qtz, Ch, Mu, Bi, minor tourmaline
Sphene, Fe oxides
Ch in large flakes, with minor Mu & Opq at edges
Patches of Mu-Bi with two clevages

88120030 S2/84/30 S457019 T
mg siliceous rock with abundant Bi flecks
Micro-augen/crysts Qtz, Crd, ?Plag, rare Ap, Ch
(Crd altered to Ch in part)
Groundmass Ch, Mu, some Bi
Opq/sphene: small grains in aggregates
Cc patchy, in vein-like zones

88120031 S2/84/33 S431010 T
actinolite-bearing Zamu Dolerite
ts pseudomorphed igneous texture
Relict Pyx, Plag
Actinolite (?and cummingtonite) after Pyx
Plag altered to ?Ab, phyllosilicate, + fine??
Ilmenite altered to rutile with black rims
Veins of actinolite

88120032 S2/84/34 S431010 T
Actinolite-bearing Zamu Dolerite
ts Pseudomorphed igneous texture
relict Pyx: diopside, altered to actinolite, blue-green Hbe
Plag altered to epidote
skeletal ilmenite, altered to sphene + Opq
Bi: recrystallized

Qtz
Fractures with Actinolite

88120033 S2/84/35A S431010 T
Black hornblende-bearing Zamu Dolerite
ts Pseudomorphed igneous texture
Relict Pyx: Diopside, ?pigeonite
largely altered to actinolite
Plag: mostly altered to epidote/clinozoisite
Qtz, sphene, Opq, ?relict ilmenite
Fractures with Actinolite

88120034 S2//84/35B S431010 T
Quartz vein with voids after ?barite
Cherty quartz with lath-shaped voids lined with Fe oxide

88120035 S2/88/24 S364017 T,G
deformed El Sherana Group volcanics
ts Fine grained, laced with quartz veins
Mu, Qtz, ?epidote (unlikely: no Ca)
Fe oxide staining

88120036 S2/88/25A S363018 T
Kombolgie Fm: Conglomerate and purple siltstone
above Koolpin Fm near Palette
ts Clasts mostly Qtz, well-rounded, even-sized, minor quartzite: fine foliated rock, carbonaceous fragments, ?pumice, larger and some flattened
grains rarely in contact, well rounded, outlined by Fe oxide
Matrix optically contiuous quartz overgrowths on grains.

88120037 S2/88/25A S363018 T
Kombolgie Fm: Conglomerate and purple siltstone
above Koolpin Fm near Palette
ts He end & light coloured end
He end: ? replaced amyg. volcanic: "bubbles" with quartz lining and fine and coarse Mu filling in groundmass lath-shaped grains, mostly Mu in He matrix
Light coloured end: irregular fragments of Qtz, Mu, flat dark ?/, rounded Opq, zircon, tourmaline, permated by He dust, cut by illite-filled fractures

88120038 S2/88/25A S363018 T
Kombolgie Fm: Conglomerate and purple siltstone

above Koolpin Fm near Palette
ts layered He rock: He, Mu, rare Qtz.

88120039 S2/88/22 S371981 T,G
Ebp? Rhyolitic volcanic with abundant lithics and quartz phenocrysts
ts very altered volcanic:
Qtz phenocrysts with qtz overgrowths: 40%
kaolinite: 60%

88120040 S2/88/23 S378978 T,G
Ebc mafic volcanic with hematite-calcite±pyrite clots (possibly actinolite)
ts Vug of Cc and Ch
Laths pseudomorphed by Cc-?Ab
Ch, Opq
Cloudy, smoky patches, Ch, Cc ??
Some Opq in cubes: pyrite, other diffuse: ?rutile/He

88120041 M13/53/13 M248096 T,G
Ebc lava, flow banded, weathered
ts Phenocrysts of Qtz, some with Qtz overgrowths
Groundmass Patchy Qtz, Mu, ?kaolinite

88120042 M12/77/27B M210119 T
green tuffaceous sandstone
ts grains widely separated: Qtz rarely quartzite
Ghosts of fine-grained ? volcanic, rare tourmaline, zircon crysts
Matrix Mu, Opq, ?.

88120043 M12/77/27C M210119 T,G
fine-grained buff-cream jointed siliceous rock, ?Gerowie Tuff
ts ?flow-banded volcanic, jointed, ferruginous
Fine grained Qtz, Mu, kaolinite, Opq

88120044 M10/193/32 M124222 T
Zamu Dolerite
ts: abundant graphic Qtz-feldspar
Pure Qtz
Plag laths, altered to Ab-Epidote
Ch + Opq
Bi, mostly altered to Opq-Ch
Opq & late sphene

88120045 M10/193/32 M124222 T
Zamu Dolerite

ts Qtz-Plag graphic intergrowths
zoned plag laths: altered cores with phyllosilicate
Cpx: augite s.l., ?pigeonite or finely laminated Cpx
altered to Ch, Actinolite, rare Hbe
Bi, recrystallized to green Bi
Apatite needles
Opq rimmed by sphene

88120046 M10/193/32 M124222 T
Zamu Dolerite
ts Abundant Qtz-feldspar graphic intergrowths
Plag euhedral, altered to ?Ab + epidote
Opq

88120047 M10/193/32 M124222 T
Zamu Dolerite
ts Abundant Qtz-feldspar graphic intergrowths
Plag laths
Hbe: ?igneous: yellow to green-brown
Opq altered to sphene
Ch, Actinolite after Hbe
?Bi to Ch + sphene

88120048 M8/220/65 M103282 T,G
Gerowie Tuff
ts Very fine-grained
Ilite, Qtz, small illite/Mu aggregates
veinlets of Qtz, rare square Opq, ?after pyrite
layering outlined by He

88120049 S4/156/1 S472905 T
Fine-grained black dolerite
ts relict Cpx, abundant Opq
Plag altered to ?clinozoisite + phyllosilicate + ?Ab
Qtz: patchy
Late green Hbe, ?actinolite

88120050 S4/156/2 S474906 T
Kf rich granite with quartz-amphibole clots
Ts very altered: Qtz, Plag, mostly altered to Mu, ?Kfs, almost totally clouded
Bi rarely brown-yellow, mostly recrystallized to green
Opq

88120051 S4/155/16A S457900 T,G,F
breccia veining in sericitized ?crystal tuff
Clear Springs Fault

ts Mostly vein Qtz, dusty, Minor Cherty Qtz
Sericite islands within vein Qtz

88120052 S4/155/16B S457900 T,F
massive quartz reef on Clear Springs Fault

88120053 S4/155/16C S457900 T,G,F
veined, altered ignimbrite on Clear Springs Fault
ts ressembles 88120051, but more Mu relative to Qtz, and some coarser Mu

88120054 S4/155/17 S457900 T,G
altered crystal tuff near Clear Springs Fault
ts Sandstone:
clasts: Qtz, quartzite, ?He-Qtz, ?carbonaceous rock
Matrix: Mu, Opq, rare Qtz overgrowths

88120055 S4/155/18 S458901 T,G
altered crystal tuff 125m from Clear Springs Fault
ts Sandstone
Clasts Qtz, quartzite, deformed Qtz, chert, single microcline, mafic volcanic, shale, other lithics
Matrix very fine kaolinite-Ch, sphene, ?He

88120056 S4/155/19 S458901 T,G
altered eutaxitic ignimbrite 150m from Clear Springs Fault
ts Sandstone with widely dispersed clasts: Qtz, quartzite, rare lithics, rare zircon
Matrix Mu, diffuse ? Qtz, abundant Fe oxide staining

88120057 S4/155/20 S458902 T,G
altered eutaxitic ignimbrite 250m from Clear Springs Fault
Clasts of Qtz, Chert, quartzite, lithics dispersed in layered matrix
Matrix fine-grained, Mu + Ch + ?
abundant Fe oxide staining

88120058 S4/155/21 S459902 T,G
unaltered eutaxitic ignimbrite 335m from Clear Springs Fault
ts abundant **Cc**
Clasts of Qtz, lithics
Matrix layered irregularly
Qtz, Mu, Cc, Opq
unidentified Opq/ V. high RI mineral
desseminated He dust

88120059 S4/155/24 S460904 T,G
banded Ebp, red-brown with brick-red quartz-rich lenses
ts Altered fragmental volcanic rock with **Cc**
Fragments of Qtz, mafic lithics, chert
Groundmass Mu, Cc, zircon, high RI mineral, Opq
desseminated He dust

88120060 S4/155/23A S460903 T,G
dark grey-green volcanic with coarse-grained fluorite
ts Fragmental volcanic rock with **Cc, F**
patchy texture: ?vugs
Groundmass Qtz, Ch, F, rare Cc, pale green ?Mu

88120061 S4/155/23B S460903 T,G
??banded Ebp
ts Fragmental Volcanic rock with **F, Cc**
Fragments Qtz, mafic volcanic, quartzite
patchs: ?vugs of Ch, ?Mu, F ±Cc
veinlets of Opq, ?Mu, Cc
Groundmass Mu, Qtz, Cc, Dust of He,

88120062 S4/155/22 S459902 T,G
Ebp with fiamme
ts Fragmental altered volcanic rock with **F, Cc**
Fragments Qtz, feldspar (?both Plag and Kfs) minor lithics
?Vugs
patchy dust (?followingvugs and lithics) of Ch, Cc, F, late Qtz
Groundmass fine dust of He, Cc, ?Ab

88120063 S1/32/30 S343062 T
red micaeous siltstone of Ebp
ts Abundant He
Qtz with Qtz overgrowths
?Ab/Crd cloudy, with inclusions
Ch, colourless
Mu, minor Bi
Zircon, Tourmaline, ?some late

88120064 S1/34/29 S360025 2T
Green foliated coarse-grained quartz-rich Ebc volcanic
ts Qtz, some cloudy-bluish, numerous inclusions
fine Mu
rare zircon

?sphene: dark high RI ovoid
?? mineral with square sections, c'less, moderate δ

88120065 S4/155/25 S441918 T,G,F
altered Ebp in breccia veins of Clear Springs Fault
ts Vein Qtz, ?volcanic fragment
Qtz, Mu, ?kaolinite
Cloudy, fine-grained inclusions

88120066 S4/155/14A S464891 T,G,F
altered Ebp in breccia veins of Clear Springs Fault
ts Breccia of vein Qtz, fine-grained rock
?mostly kaolinite, some Mu, includes coarser flakes
Fe oxide, fine dusts

88120067 S4/155/14B S464891 T,G,F
altered Ebp in breccia veins of Clear Springs Fault
ts Breccia Vein Qtz lacing cream to red fine-grained blocks, rare epidote in the veins
Blocks: fine-grained Qtz, Mu, kaolinite
He locally along fractures parallel to Qtz veins, also dust of He
black Opq along fractures in places

88120068A&B S1/32/29C S344067 T,G
agglomerate with crusted bomb, A:bomb & B:matrix
ts A Fragmental rock, fragments mostly Qtz, some composites: quartzite brownish with numerous inclusions
interstitial clinozoisite, Mu, kaolinite
rare zircon
B Altered fragmental rock, ressembles a sandstone: rounded Qtz, lithics, mostly altered to kaolinite, Qtz, minor tourmaline
Matrix kaolinite, Mu, Fe oxide

88120069 S8/91/5 S648755 2T
mylonitized Kapalga Fm
ts crosscutting Qtz veinlets
Qtz, Mu, minor Bi, rare tourmaline
pyrite locally abundant.