

GEOLOGY AND ECONOMIC EVALUATION OF THE MT. WELD
CARBONATITE, LAVERTON, WESTERN AUSTRALIA

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INTRODUCTION

The Mt. Weld carbonatite lies approximately 35 km. southeast of Laverton township and intrudes an Archean volcanosedimentary sequence within the Eastern Goldfields Province of the Yilgarn Block of Western Australia. Discovery of the carbonatite followed from an airborne magnetometer survey carried out by the Bureau of Mineral Resources, Canberra in 1966. A pronounced magnetic anomaly indicated the presence of a large circular feature (approx. 4 km. in diameter) lying beneath a surficial cover of alluvium and horizontally bedded lacustrine sediments.

Drilling of this feature by geologists of the Utah Development Company confirmed the presence of a carbonatite (Appleby et al., 1973; Cawsey et al., 1974).

K/Ar and $\text{Sr}^{87}/\text{Sr}^{86}$ isotopic dating of the carbonatite gave post-Archean ages of $2,064 \pm 40$ m. yrs. (Amdel, 1973) and $2,020 \pm 17$ m. yrs. respectively (Collerson, 1982).

Intrusion of the Proterozoic carbonatite near Mt. Weld appears spatially and tectonically related to the deep-seated long-active Laverton tectonic zone. Drilling of the host Archean sequence in the vicinity of the carbonatite intersected weathered aphanitic basic volcanics, serpentinites (some members amygdaloidal) and rarely, acid to intermediate volcanics. Rare carbonatite dyking was encountered up to 5 kms. from the intrusion (Hallberg, 1985).

Exploration by Union Oil (1981-85) led to the discovery of significant deposits of residual apatite within the regolith of the carbonatite. These deposits are currently being evaluated as a source of raw material for local fertiliser manufacture.

GEOLOGY OF THE CARBONATITE

Wallrock Alteration

An annulus of brecciated glimmerite approximately 0.5 km. in width, encloses a sovitic pipe. This annulus is a zone of lower density altered country rock, the glimmerite consisting of a fine grained felted matrix of "ferri-biotite".

It would appear that the wallrock alteration was one of alkali metasomatism under oxidising conditions associated with brecciation and assimilation (xenoliths).

Subsequent carbonate invasion of the brecciated wallrock, veined and pervaded the felted biotite matrix introducing calcite, dolomite and accessory phases such as apatite, pyrochlore, barite, magnetite, ilmenite and sulphides. Minor chloritic and riebeckitic alteration was associated with the invasion of carbonate.

Primary Carbonatite

Sovite is the dominant carbonate-rich variety of carbonatite with rauhaugite, calcitic rauhaugite and dolomitic sovite present as subdominant rock types. Locally apatite or biotite may dominate the carbonate phase forming a phosphorite or glimmerite.

Relict cumulate textures are discernible in some of the sovites and rauhaugites. Primary carbonate occurs as subidiomorphic to rounded grains forming the cumulate phase with minor apatite, biotite, carbonate and magnetite present as an intercumulate. Fine dense schillers of iron oxide cloud the primary carbonate and enhance the cumulate texture.

Large elongate and branching carbonate grains comprise the primary cumulate phase in some sovites. Such textures are reminiscent of the "harrisitic cumulates" first

described by Wadsworth (1960) for rocks in the Rhum intrusive and later referred to as "harrisitic spinifex" by Nesbitt (1971) when describing skeletal olivine in Archean ultramafic rocks. Donaldson (1974), when discussing these textures for olivine cumulates in the slowly cooled Rhum intrusive, attributed their formation to crystallising under conditions of magma supersaturation.

Rare spherulitic and orbicular textures are present in the intrusive. They arise from the tangential arrangement of biotite laths about calcite grains in olivine sovite (Mariano, 1981) or contain olivine, apatite and biotite cores rimmed by magnetite in a calcitic matrix (Bartram, 1973).

Similar spherulitic and orbicular structures have been described for the Sokli (Finland) and Vvorijarvi (U.S.S.R.) carbonatites by Lapin and Vartiainen (1983). They postulate that segregation of the initial melt into phoscoritic and carbonatitic fractions of limited mutual miscibility combined with the difference in density and viscosity of each fraction gave rise to these structures.

Associated with the primary cumulate rocks (subidiomorphic, harrisitic and orbicular varieties) are medium grained granular sovites and rauhaugites. In contrast with the cumulate rocks, carbonate is usually free of iron oxide schillers. Secondly, these rocks exhibit marked flow alignment of grains and flow layering of minerals. Apatite and biotite, in particular, form elongate (prismatic and tabloid) crystals which are strongly aligned.

Granular sovite and rauhaugite may be seen replacing primary cumulate carbonatite. These rocks do not appear to be the products of recrystallisation because they exhibit magmatic textures (grain alignment and flow layering) and contain accumulations of apatite, magnetite, biotite and pyrochlore relative to the primary carbonatite. Thus it would appear that accumulations of apatite-magnetite-biotite-pyrochlore precipitated out of the primary cumulate carbonatite and formed a denser "crystal mush" that was subsequently injected into crystallised carbonatite. Layering of minerals is produced by their mutual segregation and concentration in the near vertical plane of magma flow.

Conditions appear to have been reducing during crystallisation of the carbonatite. The presence of pyrite with magnetite, crystallisation of olivine with high fayalite contents, presence of Fe^{2+} in dolomite and the occasional presence of primary salite would suggest this (Mariano, 1981). Minimal late stage alkali buildup and alteration is indicated by fibrous riebeckite and aegirine in late veining and interstices, and the development of "ferri-biotite" rims on phenocrystal biotite. Accessory finer grained "ferri-biotite" is also present.

Late veining also carries calcite, dolomite and trace quantities of barite, magnesiochrochrolite, strontianite and fluorite. Polycrystalline apatite and monazite appear to be contemporary with magnesiochrochrolite in some examples.

Regolith of the Carbonatite

Regolith development of the carbonatite was a complex process involving weathering of the primary carbonatite, development of a lateritised residuum and formation of a soil horizon.

The base of the regolith is defined simply as the limit of weathering. Partway up through the weathering profile a natural division occurs in which accumulations of residual minerals (residual zone) are superceded by a supergene minerals assemblage (supergene zone).

Formation of the residual zone resulted from the leaching and removal of carbonate minerals en masse by circulating groundwater. Concentration, by volume reduction, of primary minerals such as apatite, magnetite, ilmenite, Nb-rutile, remnant silicates, zircon and baddeleyite occurred. Concurrent ferruginisation of the residual zone led to the present laterites.

The supergene zone is characterised by insoluble ferric iron oxides with adsorbed Nb, Ta, Ti, V and Cr, aluminous oxides, clays, crandallite group minerals, secondary

phosphates, REE oxides and manganiferous wads. Residual primary minerals are rare.

Extreme conditions of lateritic weathering appear to have prevailed for the supergene zone over a prolonged period causing the degradation of resistant minerals and oxidation of metal ions. Florencite pseudomorphs after pyrochlore, leaching of Nb and Ta from pyrochlore and their reprecipitation in goyazite and florencite, and the complete degradation of magnetite to hematite and maghemite are examples. The formation of cerianite (Ce⁴⁺) and fractionation of LREE from HREE throughout the regolith are further indications.

ECONOMIC EVALUATION OF THE REGOLITH

Drilling of the regolith outlined an extensive sheet of residual apatite mineralisation covering most of the carbonatite. A geostatistical study of this resource by Gregory (1984) gave a global estimate of:

250 ± 37 million tonnes (precision @ 95%) @ 18% P₂O₅
using a cutoff grade of 10% P₂O₅ as apatite.

Not all this apatite-bearing rock is considered potential ore for fertiliser manufacture. Some material will be too costly to extract from the ground and other material is contaminated with iron, aluminium and magnesium. Studies underway are aimed at quantifying the amount of "ore grade and quality" material suitable for exploitation as a principal source of rock phosphate for fertiliser manufacture in Western Australia.

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