GEMSTONE CORPORATION OF AUSTRALIA LIMITED

E.L. 5684
NORTHERN TERRITORY

ILLOGWA CREEK (SF 53-15)
1:250,000 SHEET AREA

FINAL REPORT

PERIOD 14/6/88 - 13/12/88

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INTRODUCTION

E.L. 5684 occupies an area of 184 square kilometres in the Harts Range, north-east of Alice Springs. The centre of the E.L. is 35 kilometres south-east of Harts Range Police Station (Plan 5684-1).

Access is east along the Plenty Highway, then south and west using station tracks. The entire E.L. 5684 lies within Ambalindum Pastoral Lease.

Three days field work were carried out on the E.L. in September 1988.

The Company applied for E.L. 5684 to explore for gemstones. Previously local aborigines had located (in and adjacent to the E.L. 5684 area) deposits of garnets, beryl, green amazonite sphene, corundum, kyanite and iolite. The Company also believed that there existed a potential for diamond.


PLANNED EXPLORATION

The Company purchased coloured aerial photographs covering the E.L. area, and photogeological observations were made in the office in conjunction with a literature study. Prof. A.F. Wilson prepared his "Prospecting Philosophy" for E.L. 4976, 5683 and 5684 (copy below, and is also included in Final Reports for the other E.L.s).

A field survey was planned for April 1988, but was later changed to September 1988. The research showed that Proterozoic metasediments and metavolcanics are exposed within this E.L. They have been intruded by pegmatites, mafic dykes and quartz reefs and veins. Some of E.L. 5684 is covered by recent alluvium. Drainage is nearly all to the south, the E.L. being enclosed by mountains to the north, east and west.
PROSPECTING PHILOSOPHY FOR E.L.s 4976, 5683 AND 5684
- PROF. A.F. WILSON

Gemstone Corporation of Australia Limited acquired E.L. 4976 from Mr. R. Lavender with an immediate aim to search for hessonite, at the time being mined near Coggan Bore. Hessonite is a beautiful variety of the calcium garnet grossularite Ca$_3$Al$_2$(SiO$_4$)$_3$.

However, my own research (both in the field and laboratory) of highly metamorphosed carbonate rocks in South Africa, Zimbabwe, India, Madagascar, Canada, Sri Lanka, Brazil and the Cameroons, as well as within Australia has identified a wide range of gemstones, some of which had not previously been recognised in Australia.

To aid future workers, and to indicate the type of research and field studies I have carried out in the Harts Range, I am setting out here, with a few simple examples of the range of minerals that may occur in the region. Some aspects of our prospecting techniques are confidential at this stage, but the following principles aim to help future exploration.

1. ROLE OF IMPURITIES IN PRIMARY CARBONATE SEDIMENTS DURING METAMORPHISM

(a) *High magnesium* (Mg) **content**

Dolomite is a calcium magnesium carbonate. At high temperatures calcite CaCO$_3$ is created and Mg ions separate from the dolomite to combine with various proportions of aluminous and/or siliceous impurities. New minerals produced may include spinel (Mg, Fe) Al$_2$O$_4$, diopside CaMgSiO$_3$, forsterite Mg$_2$SiO$_4$, and grossularite Ca$_3$Al$_2$(SiO$_4$)$_3$. As these minerals will have grown in a calcite matrix, they are readily weathered out, or may be mined or extracted with acid. The presence of iron will increase the range of Ca or Mg rich minerals to include epidote Ca$_2$(Al,Fe)$_3$(Si$_3$O$_{12}$)(OH), actinolite Ca$_2$(Mg,Fe)$_5$Si$_8$O$_{22}$(OH), hornblende (a complex hydrous silicate of Ca, Na, Mg, Fe and Al) and sphene CaTiSiO$_5$.

(b) *High alumina* (Al) **content**

Modern carbonate sediments are commonly found interbedded with highly aluminous layers. These may become desilicated along their boundaries (or in fracture zones through the layer) to produce a range of Ca-Al silicates. Thus the interior layer becomes deficient in Si and corundum Al$_2$O$_3$ may
develop. Where the primary aluminous layer has been derived by weathering and erosion of ultramafic sources, the presence of sufficient chromium (Cr) will produce ruby. Otherwise trace amounts of iron (Fe) and/or titanium (Ti) will give rise to blue to green sapphires.

2. FOSSIL SOIL PROFILE

Fossil soils are common in Palaeozoic and more recent sedimentary successions and several examples of likely Precambrian fossil soils have been postulated. The formation of a terra rossa or laterite over a carbonate rock would produce a horizon suitable for the development of spinel (Mg,Fe)Al₂O₄, corundum, sillimanite Al₂SiO₅, hoegbomite (Mg,Fe)₂(Al,Ti)₅O₁₀ and a range of oxides of Fe, Ti and Mn.

In modern soil profiles a zone of calcium carbonate or dolomite is not uncommon. Metamorphism of such a carbonate zone, where it is in close proximity to highly aluminous or Fe-rich soil zones, could yield a range of gemstones.

3. METAMORPHISM OF ANORTHOSITE LAYERS IN ULTRAMAFIC BODIES

In Quebec, India, Madagascar and Transvaal there are examples of corundum (commonly ruby) and also spinel and some sapphirine (Mg,Al)₉(Al,Si)₆O₂₆ occur where the anorthite CaAl₂Si₂O₈ of the anorthosite layers is the source of Al. Indeed I suspect that the ruby located about 6km S.E. of Mt. Brady in the Harts Range could be of this origin.

4. ROLE OF PEGMATITIC ACTIVITY AND METASOMATISM

Hitherto I have assumed the development of the gem minerals has been largely without introduction of elements from outside the gem-mineral zones.

In the Harts Range (and also the Strangways Range to the west) mica-bearing pegmatites are very common. Moreover, the gneisses and related rocks are frequently cut by swarms of quartzofeldspathic pegmatitic veins (2-10cm wide). These veins are far more abundant than would be expected after normal metamorphic differentiation in high grade metamorphic terranes. Indeed, much of the ranges appears to have been regionally "soaked" with fluid.
Water, which is dominant in most pegmatitic activity is a key component in gem formation since it facilitates the migration of ions and enables large crystals to grow in structurally suitable zones. Elements which provide the possibility of a large range of other minerals include:-

Boron, B. This may be a minor primary element in certain marine shales. The development of abundant tourmaline (a complex borosilicate of Mg, Fe, Li, Al and Na) indicates boron metasomatism. Many of the brown gem tourmalines are found where boron has invaded phlogopite schists or magnesian marbles. Boron is also a major component of the gemstone kornerupine Mg₉Al₆(Si,Al,8)₅O₂₂(OH). Other boron-bearing minerals should be sought in appropriate metamorphic environments, e.g., datolite Ca(BO₃)SiO₄, axinite Ca₂(Fe,Mn)Al₃B Si₄O₁₅(OH), grandidierite (Mg,Fe)Al₃(BO₄)(SiO₄)O and dumortierite Al₇(BO₃)(SiO₄)₃O₂.

Beryllium, Be. Beryl Be₂Al₄Si₆O₁₈ is widespread in pegmatites in the Harts Range. However, little prospecting appears to have been done to locate Be-bearing minerals in lithologically and structurally suitable sites in the metamorphic rocks. The most prized beryllium mineral is emerald, where trace amounts of the chromium ion have entered the beryl structure. Other Be-bearing minerals to be sought include chrysoberyl BeAl₂O₄ and its chrome-bearing variety alexandrite. In addition there are taafeite Be₄Mg₂Al₄O₃₂, euchroite Be₁(Al₁₂OH)SiO₄ phenakite Be₅₂SiO₄ and helvite Mn₄Be₃(SiO₄)₃S.

Fluorine, F. This element commonly replaces water in metamorphic and igneous fluids. It assists metasomatic reactions and thus many of the boron and beryllium minerals mentioned above are commonly associated with fluorine-bearing minerals. Thus an exploration program should be involved at an early stage with a reconnaissance study of micas and amphiboles to detect fluorine anomalies.

Few gemstones in the Harts Range contain fluorine as an important component. However, the presence of F is a major catalyst for other gems. These include topaz Al₂SiO₄(F,OH) and the humite group of minerals (Mg,Fe)₇(SiO₄)₃(F,OH)₂.
Phosphorus, P Many deep-seated fluids in metamorphic terranes are rich in both fluorine and phosphorus. This is commonly shown in the wide distribution of fluor-apatite Ca₅(PO₄)₃(F,OH,Cl). In places fluor-apatite carries rare earths and may be a worthwhile gemstone.

However, P-bearing gemstones of likely interest are rare, for example, brazilianite NaAl₃(PO₄)₂(OH)₄.

5. KIMBERLITE SEARCH

In an E.L. within central Australia we are aware of the possibility of the occurrence of kimberlites. Stream sediment samples should be investigated for indicator minerals, namely chrome rich pyrope, chrome diopside, magnesium rich ilmenite (picroilmenite) and of course micro-diamonds.

However, owing to the fact that most kimberlites do not yield outcrop, careful structural and geomorphological studies are required using aerial photographs and contour maps (where available) to identify likely foci for kimberlitic intrusions. As many of these in Australia and southern Africa do not disperse their characteristic indicator minerals into major streams, it is necessary to select drill-sites to penetrate Cainozoic and even Mesozoic in-wash into the weathered kimberlite zones.

6. CARBONATITE SEARCH

The Mud Tank Carbonatites, in the eastern Strangways Ranges are surely not unique to the region. These carbonatites are easy to recognise by virtue of the abundance of eluvial crystals strewn about these bodies. These include zircon (crystals 10-20kg have been found), yellowish to greenish fluoro-apatite (crystals up to 1.5m x 1m x 1m may still be seen in situ) and blocks of magnetite (commonly 20cm x 20cm x 20cm). The host calcite (or dolomite) and the abundant phlogopite (some altered to vermiculite) are usually only observed in drill core.
However, in other parts of the world, I have seen highly deformed and also grossly recrystallized carbonatites (central Africa, Ontario, Manitoba and India). These meta-carbonatites are commonly confused with impure marbles. The economic importance of carbonatites, deformed or otherwise, cannot be overlooked as they are a source of niobium and uranium. Their distinction from other carbonate rocks is of paramount importance.

About 10 years ago I carried out a novel stable isotope analytical approach to determine if diagnostic stable isotope evidence could distinguish the carbonates in carbonatites from the carbonates in marbles of sedimentary origin. This research showed conclusively a clearly defined difference between both the carbon and oxygen isotopes of the carbonate from the Mud Tank Carbonatites, and the carbonates of the very coarse impure phlogopitic marbles of granulite facies in the nearby Woolangara region of the Strangways Ranges. This research was published by me in 1979 in the Journal of the Geological Society of Australia, Vol. 26, pp. 39–44.

The significance of this isotope approach is that some of the bodies of coarse carbonates in the Harts and Strangways Ranges may turn out to be of carbonatitic origin. This would point to major deep crustal fluorine-rich sutures or pipes. The gem potential of recognising such features is obvious.

FIELD WORK

Prof. A.F. Wilson and S. Kennedy carried out a limited field survey in September 1988. The investigation took the form of a reconnaissance survey. Sixteen samples were collected and later microscopically analysed. Appendix I contains the results of these analyses, while Plan 5684–2 shows the sample locations. Some of the old mica mines were inspected.

Of particular interest are the Carrara Mines, about two kilometres west south-west of Mt. George. Here, muscovite, beryl, garnet, ilmenite, epidote, perthitic microcline and amazonite have been located.

It was not possible to carry out more extensive field work as Gemstone Corporation of Australia Limited had decided to withdraw from exploration. However, the survey showed that the area has a definite potential for gemstone mineralisation.
STREAM SEDIMENT SAMPLE

H20

SCALE

METRES 1000 0 1 2 3 4 KILOMETRES

Base map compiled from 1:100 000 map sheet of QUARTZ prepared by Division of National Mapping.

GEMSTONE CORPORATION OF AUSTRALIA LTD.

STREAM SEDIMENT SAMPLE LOCATIONS
EL 5684
HARTS RANGE, NORTHERN TERRITORY
SEPTEMBER 1988
A.F. Wilson  S. Kennedy

PLAN 5684-2
REASON FOR SURRENDER OF E.L. 5684

The sole reason for the surrender of E.L. 5684 is because of the Company's decision to withdraw from exploratory activities.

The writers believe that the E.L. 5684 area has definite potential for gemstone occurrences and that the result of the Company's work has not down-graded the area.

Prof. A.F. Wilson, D.Sc.
S. Kennedy, M.Sc.

Compiled by R. Grasso, M.Sc.
REFERENCES


APPENDIX 1

BY PROF. A.F. WILSON

MINERALOGICAL DETAILS OF SAMPLES FROM E.L. 5684

1. SAMPLING

Samples were taken from water courses. Rock particles in excess of 2.5mm were screened off and rejected after selection of several particles representative of the rock types in the stream. Particles less than 2.5mm were panned and heavy minerals identified with binocular microscope by Prof. A.F. Wilson. An electron probe was not used in this reconnaissance.

2. PURPOSE OF SAMPLING

The purpose of examination of the stream samples was to try to identify indicator minerals of three gemstones. In order of priority these are gem garnet (especially hessonite), corundum (ruby and sapphire) and diamond.

(1) **Hessonite** is a grossular garnet ranging in colour from pale yellow through orange to a pale brown. In this region hessonite is invariably associated with impure limestones or dolomites. Minerals commonly associated with the hessonite are primarily diopside and dark green spinel but other minerals such as the bronzy mica phlogopite and brown magnesian tourmaline are found in some impure marbles in the Harts Range. Discovery of even microscopic fragments of several of these minerals may justify detailed examination of rocks upstream from the sample.

(2) **Corundum** is the general name for oxide of aluminium. In the presence of trace elements chromium and titanium-iron dull white or grey chromium may be supplanted by ruby or sapphire, respectively. In a metamorphic terrane such as the Harts Range the host rock of corundum may be rich in bronzy phlogopite and/or one of several highly aluminous minerals such as kyanite, sillimanite, the calcium feldspar anorthite, cordierite and aluminous anthophyllite or gedrite. Corundum was not found in any of the samples of this reconnaissance; but pink corundum crystals have been found by aboriginals in the western part of the E.L. area.
(3) **Diamond.** Kimberlite and related deep-seated rocks are host rocks for diamond. Large bulk samples must normally be panned before diamond itself is discovered. However, recognition of a characteristic suite of minerals may alert the geologist of the nearness of a Kimberlite.

These are a deep red or purplish red pyrope, an apple green chrome diopside or omphacite and a magnesian ilmenite picro-ilmenite. Although the first two minerals can be provisionally recognised with some confidence by careful microscope study, the picro-ilmenite can only be detected by special X-ray or electron probe techniques. In this reconnaissance the use of these latter techniques were not justified because the "easier" minerals were not found. Bronzy phlogopite is another mineral commonly found in Kimberlite, but is also found in many other rocks.

During this stream sediment reconnaissance of these tenements, pyrope and chrome diopside were not found. This does not mean that the tenements do not have diamond potential. The sampling of streams is very incomplete and no bulk samples were treated.

It should be pointed out, however, that not all pyrope is of Kimberlite origin. Indeed, pyrope of non-Kimberlite origin is present in gem quality in the Harts Range.

3. DETAILS OF THE SAMPLES

**Abbreviations of Minerals**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Mineral Name</th>
</tr>
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<tbody>
<tr>
<td>Alm</td>
<td>almandine</td>
</tr>
<tr>
<td>Bi</td>
<td>biotite</td>
</tr>
<tr>
<td>Cor</td>
<td>corundum</td>
</tr>
<tr>
<td>Diop</td>
<td>diopside</td>
</tr>
<tr>
<td>Ep</td>
<td>epidote</td>
</tr>
<tr>
<td>Hb</td>
<td>hornblende</td>
</tr>
<tr>
<td>Hess</td>
<td>hessonite</td>
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<tr>
<td>Ilm</td>
<td>ilmenite</td>
</tr>
<tr>
<td>Mag</td>
<td>magnetite</td>
</tr>
<tr>
<td>Phil</td>
<td>phlogopite</td>
</tr>
<tr>
<td>Py-Alm</td>
<td>pyrope-almandine</td>
</tr>
<tr>
<td>Py</td>
<td>pyrope</td>
</tr>
<tr>
<td>Qz</td>
<td>quartz</td>
</tr>
<tr>
<td>Rut</td>
<td>rutile</td>
</tr>
<tr>
<td>Spin</td>
<td>spinel</td>
</tr>
</tbody>
</table>

(6) Clear Alm mostly less than 3mm diam. Hb, Diop, Mag, Ilm. Py, Cor not found.

(7) Low quality Alm mostly 2 to 3mm diam. Hb, Bi, Mag, Ilm, Ep. Py, Cor not found.

(13) Pink Alm, pale green Hb, some green Diop, Mag. Py not found.
(14) Small particles (less than 0.5mm) pink Alm, cleavage fragments black opaque Hb and some green or khaki Hb, clear Zir which is not zoned as normal from paragneisses, some Mag. and IIm. No Py, Cor, Diop.

(15) Few small grains (less than 0.25mm) pale pink Alm, some darker pink to red Alm, khaki green Hb, deep bluish green Diop, Mag, IIm. Py, Cor, Ep not found.

(16) Few grains red Py-Alm but not Py of Kimberlite, pale khaki-green amphibole but most Hb is almost opaque black, orange Rut, zoned Zir mostly with inclusions, abundant Mag, some IIm. No Cor.

(17) Pink Alm, pale to dark green Diop, brown Bi, almost black Hb, Ep, Mag, IIm. Py, Cor not found.

(18) Pink Alm, Phl, khaki-brown and khaki-green Hb, Ep, Mag, IIm. Py, Cor not found.

(19) 5x3x2cm fragment of pale orange superficially resembling Hess. Sp. Grav. 2.65 shows that sample is iron-stained Qz which is lighter than Hess (3.6).

(20) Pink Alm, khaki Hb, zoned Zir, brownish orange Rut, abundant Mag. and some IIm. Py, Cor not found.

(21) Pale pink Alm with brown platy inclusions, pale green Diop, Rut, zoned Zir, Mag and some IIm. Py, Cor not found.

(22) Very pale pink Alm, brown Hb, plentiful green tabular particles of clinopyroxene, plentiful Mag, at least 3 varieties of zoned Zir. Py, Cor not found.

(23) Very pale pink grossular, Phl, khaki-green tabular particles of clinopyroxene, rare Ep, plentiful Mag, almost opaque black Hb. Py, Cor not found.

(24) Very pale pink garnet probably grossular, bluish Spin, green Diop, zoned clear Zir from metasediments, abundant Mag, IIm. Py, Cor not found.
(25) Pink to very pale pink grossular or Alm, octahedra of black or very dark green Spin, detrital Zir from metasediments, dark green Hb, abundant Mag, Ilm. Py, Cor not found.

(26) Grossular, pale green Diop, some opaque Spin and Ilm, Mag. Py, Cor not found.