GEMSTONE CORPORATION OF AUSTRALIA LIMITED

E.L. 5683
NORTHERN TERRITORY

ALICE SPRINGS (SF 53-14) & ILLOGWA CREEK (SF 53-15)
1:250,000 SHEET AREAS

FINAL REPORT

PERIOD 8/3/88 - 13/12/88

DATE SUBMITTED: 11 APRIL 1989

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INTRODUCTION

E.L. 5683 covers an area of 77.28 square kilometres in the Spriggs Creek area of the Harts Range near where Mistral Mines N.L. operated their ruby mine (Plan 5683-1). The area was chosen because it was thought that it may contain similar geology to the ruby deposit mined by Mistral Mines N.L. The central part of E.L. 5683 is approximately 9 kilometres a little east of south from Harts Range Police Station (Plan 5683-1).

G.F. Joklik with his "The Geology and Mica-Fields of the Harts Range, Central Australia" (B.M.R. Bulletin No. 26, 1955) was one of the early workers who was able to carry out both extensive field work (B.M.R.) and laboratory work (University of Sydney). Some other more recent workers include R.D. Shaw et al in 1979, 1982 and 1984, as well as A.J. Stewart et al in 1984 and R.W. Lawrence et al in 1987. D.H. McColl and R.G. Warren (1979) carried out investigations relative to the ruby occurrence.

PLANNED EXPLORATION

At the time of the E.L. application, it was decided that research into the Mistral Mines N.L. ruby occurrence may lead to possible targets within the E.L. application area.

Coloured aerial photographs were bought and it was the Company's intention to have followed the research with a photogeological study prior to field investigations which were to have commenced in April 1988.

RESEARCH

A literature study was made of published papers and reports and initial photogeological observations made of the E.L. area in preparation for the field investigation. In addition, Prof. A.F. Wilson prepared his "Prospecting Philosophy" for E.L.s 4976, 5683 and 5684 (copy below, and is also included in Final Reports for the other E.L.s).

The study has indicated that corundum (ruby) may occur within some folded ultramafic bodies, especially within a silica deficient environment where highly altered anorthosite feldspars are robbed of silica during the production of the ultramafics.
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)$_2$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$_2$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 desilated 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)ₙ(Al,Si)₆O₂₀ 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 Mg$_3$Al$_6$ (Si,Al,B)$_5$O$_{21}$(OH). Other boron-bearing minerals should be sought in appropriate metamorphic environments, e.g., datolite Ca(B,OH)SiO$_4$, axinite Ca$_2$(Fe,Mn)Al$_3$B Si$_4$ O$_{12}$(OH), grandidierite (Mg,Fe)Al$_3$(BO$_4$)(SiO$_4$)O and dumortierite Al$_7$(BO$_3$)(SiO$_4$)$_3$O$_3$.

**Beryllium, Be** Beryl Be$_3$Al$_2$Si$_6$O$_{18}$ 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 BeAl$_2$O$_4$ and its chrome-bearing variety alexandrite. In addition there are taaffeite Be$_4$Mg$_4$Al$_6$O$_{22}$, euclase Be(Al,OH)SiO$_4$ phenakite Be$_2$SiO$_4$ and helvite Mn$_4$Be$_3$(SiO$_4$)$_3$S.

**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 Al$_2$SiO$_4$(F,OH)$_2$ and the humite group of minerals (Mg,Fe)$_7$(SiO$_4$)$_3$(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 $\text{Ca}_7(\text{PO}_4)_3(\text{F,OH,Cl})$. 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 $\text{NaAl}_3(\text{PO}_4)_2(\text{OH})_4$.

**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 fluor-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 Woolanga 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

Unfortunately it was not possible to commence field work prior to September 1988. By this time, Gemstone Corporation of Australia Limited had decided to withdraw from exploration. The decision meant that only a "token" effort could be made in the field.

Prof. A.F. Wilson and S. Kennedy undertook a limited field investigation in September 1988 with the intention of exploring the three Gemstone Corporation of Australia Limited's Exploration Licences during the one field trip. Their field work near E.L. 5683 was limited to a reconnaissance survey along Spriggs Creek designed to compare the geology of the rocks surrounding the Mistral Mines N.L. ruby occurrence with that of the rocks within E.L. 5683.
Five samples were collected along Spriggs Creek (immediately to the east of E.L. 5683). Intentions to investigate the E.L. area proper, were abandoned when their 4-wheel drive vehicle was destroyed by fire (Plan 5683-2). Appendix 1 contains the results of the microscopic analyses of the five samples.

REASON FOR SURRENDER OF E.L. 5683

The sole reason for the surrender of E.L. 5683 is because of the Company’s decision to withdraw from exploratory activities.

The fact that Gemstone Corporation of Australia Limited has surrendered E.L. 5683 should not be indicative of any downgrading of the ruby potential of the area. In fact, the Company would probably be prepared to carry on with the investigation at another time if and when it decides to re-enter exploration.

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

Compiled by R. Grasso, M.Sc.
STREAM SEDIMENT SAMPLE........... H2

SCALE

METRES 1000 0 1 2 3 4 KILOMETERS

Base map compiled from 1:100,000 map sheets of RIDDoch and QUARTZ prepared by Division of National Mapping.

GEMSTONE CORPORATION OF AUSTRALIA LTD.

STREAM SEDIMENT SAMPLE LOCATIONS
EL 5683
HARTS RANGE, NORTHERN TERRITORY
JANUARY 1989

PLAN 5683-2
REFERENCES


APPENDIX 1

BY PROF. A.F. WILSON

MINERALOGICAL DETAILS OF SAMPLES FROM SPRIGGS CREEK

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.
(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</th>
</tr>
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<tbody>
<tr>
<td>Alm</td>
<td>almandine</td>
</tr>
<tr>
<td>Bl</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>
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</tr>
<tr>
<td>Phi</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>

(2) Clear red Alm commonly 3mm diam. Mag, Ilm, dark green Hb. Py, Cor not found. Spriggs Creek, about 1.5 km W. of Spriggs Bore.
(3) Abundant clear dark red Alm commonly greater than 4mm diam. Mag, Ilm, khaki-green Hb. Py, Cor not found. Source near-by garnet amphibolites. Collected 2.3km upstream from sample 2 in major tributary from left of Spriggs Creek.

(4) Abundant clear gem quality red to pink Alm up to 4 or 5mm diam. Weathered from coarse garnet and amphibolites and gneisses.

Other minerals black Hb and some dark green Diop, Mag, Ilm, Ep. Py, Cor not found. 3.9km SSW of Spriggs Creek on track from Spriggs Bore to New Lizzie Bore.

(5) Very rusty Qz vein trending 270 degrees (true). 1.6 km beyond sample 4 on same road.