REPORTS

EXPLORATION LICENCES 1801, 1802, 1956

NORTHERN TERRITORY OF AUSTRALIA

OPEN FILE

NORTHERN TERRITORY
GEOLICAL SURVEY

CR 81/060

Hillrise Properties Pty Ltd.
285 Victoria Street,
Abbotsford Vic. 3067.
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INTRODUCTION

This report has been prepared by T. Sloggett A.F. AUST. I.M.M. and is supported by reports and field work by expert consultants and by qualified officers of major mining companies invited to inspect and assess various finds.

Exploration licence 1801 of 226.23 square miles was granted to Hillrise Properties Pty. Ltd. on the 27th July, 1978. Within E.L. 1801 Hillrise Properties Pty. Ltd. has been granted eight mining tenements 1744H to 1751H inclusive. Exploration licence 1802 of 153.34 square miles was granted to Hillrise Properties Pty. Ltd. on the 27th July, 1978.

Exploration licence 1956 of 401 square miles was granted to Hillrise Properties Pty. Ltd. on 23rd January, 1979.

The three exploration licences in question are located in the Hartz Range area north-east of Alice Springs, Northern Territory.

For most of 1980 Hillrise was assisted in exploration by C.R.A. Exploration Pty. Ltd. which resulted in a farm-out arrangement under which that company will carry out future exploration in E.L.'s 1801, 1802 and 1956. Hillrise therefore concentrated mainly on exploration for ruby and garnet (with Mistral Mines N.L. it is operating a ruby mine in the Hartz Range). However other mineralisation was also examined namely copper, uranium and silver-lead prospects (earlier reported) and a reef in E.L. 1801 which showed tantalite.

Flying and mapping ruby prospects in E.L. 1801, stream sampling in the three E.L.'s for industrial and gem garnet and further work on the silver/lead prospect in E.L.'s 1801 and 1956 were the most important activities undertaken by Hillrise Properties in 1980. A considerable number of consulting geologists were brought to the area and an independent report was obtained on the silver/lead prospect and on radioactivity near the Spriggs Creek Bore (previously reported). In the main exploration for industrial minerals was left to C.R.A. Exploration Pty. Ltd.

Hillrise Properties will virtually withdraw from exploration as C.R.A. Exploration have now been involved in the exploration licence areas for nearly 12 months. Mistral Mines N.L. will operate mining activities and assist in further exploration for gemstones (other than diamonds - included in the C.R.A. Exploration farm-out). It is expected that exploration activity will be sustained at a high level as adequate technical and financial resources are available to C.R.A. and Mistral.
REVIEW OF GEOLOGICAL AND PROSPECTING WORK - EXPLORATION LICENCE 1801

Geological Mapping

In considering our mining operation, it was decided to re-fly and photo-map the mine working areas and to extend the aerial photo mapping programme to include extensive areas of para-amphibolite previously outlined within the exploration licence, outside the mining leases.

Adverse weather conditions delayed the re-flying of the areas until late in July, 1980. At this stage the air photos have been processed and detailed contour maps have been prepared. A graduate geologist has been engaged recently to map the ruby prospect in detail on the ground.

On a regional basis, Associated Aerial Surveys Pty. Ltd. were contracted to utilise existing colour photography (flown by the B.M.R. 1972) to provide 1:2500 scale maps with 5 m contour interval.

Gemstone Exploration
Ruby Corundum, Stream Sediment Sampling

Under the direction of our consultant Mr. Colin Brooks a stream sediment sampling programme is being undertaken. Sediment samples were taken at 100 metre intervals along creeks shedding directly from ruby bearing para-amphibolite bands.

Ruby Corundum Exploration

Exploration of areas of para-amphibolite within the exploration licence has successfully located additional areas of ruby corundum. During the period the area was visited by our consulting geologist Mr. C.C. Brooks and his technical reports are appended. The prospective area of para-amphibolite outlined to date is large and exploration of the area and quantity and quality assessment of the ruby corundum material is continuing under the direction of Colin Brooks. Mr. Fander of Central Mineralogical Services Pty. Ltd. is undertaking a comparative petrographic data assessment of selective rock units within the para-amphibolite. Mr. Michael Katz, geologist of N.S.W. University visited the area in October, 1980, in the company of Messrs. Brooks and Fander (reports are attached.)
A deposit of garnet was found 4 kilometres north of ruby mine. This deposit contains gem quality garnet as well as having industrial potential.

Stream samples were taken in Entire and Spriggs Creek to ascertain the potential for industrial garnet (report attached).

Limited occurrences of silver/lead ore have been discovered in the southwest corner of the E.L. extending at length south east in E.L. 1956 where they are being assessed and evaluated (see E.L. 1956 report).

An occurrence of tantalite has been discovered recently in this E.L. about 10 km east of Spriggs Creek Bore. This was examined by our geologist and Messrs. Brooks and Fander and although the local geology could be compatible with significant occurrences, it appears to have only limited potential.

An extensive area of radioactivity in the northwest corner of the E.L. (previously reported in some detail) was further examined by Mr. D. Zimmerman, geologist. Despite extensive and high counts Zimmerman confirmed earlier opinion that the geology of the area was not likely to support a commercial deposit.

Forty-five kilometres of track have been bull-dozed between Spriggs Creek Bore and Buckitta Bore to facilitate access and exploration. This also would be particularly helpful for tourists as other roads built in the E.L.'s would be.
REVIEW OF GEOLOGICAL AND PROSPECTING WORK-EXPLORATION LICENCE 1956

Silver Lead Occurrence (Galena)

Occurrences of galena were observed running south east through the E.L. within the Irindina Gneiss. Initial samples of the material assayed up to 3% lead and up to 1 oz. silver. The galena occurs in a quartz feldspar carbonate rock unit (meta quartzite with re-crystalised galena?). The galena bearing rock occurs as sporadic but mapable outcrops extending southerly from E.L. 1801 into E.L. 1956 in vicinity of the Harding Springs Well. At this stage the evident paucity of total sulphides, within the unit and the lack of oxidised products (gossans) suggests that no local enrichment zones will occur. Exploration work to date has not fully outlined the extent or nature of this deposit and to this end exploration work is continuing. During the period Mr. I.P. Roark of Electrolytic Zinc Coy. Australia visited the area and his report is appended.

C.R.A. Exploration Pty. Ltd. have paid particular attention to this prospect and have reported separately on progress to date. The prospect was examined by geologists Brooks, Fander and Katz who agreed with I.P. Roark's conclusions.

Copper Carbonate and Sulphide

North of Illogwa Shear

Cupiferous deposits extend along the northern boundary of the Illogwa Shear. The copper deposits are chiefly represented by weak and sporadic sulphide replacement zones concentrated along bedding planes and joint openings within epidote, actinolite, meta, quartzites, containing associated hematite. This prospect was also examined by Messrs. Brooks, Fander and Katz who consider the geology of the area unlikely to support a deposit of commercial magnitude.

Industrial Garnet Exploration

The present major source of supply for industrial garnet is Barton Mines of New York, U.S.A. Recent enquiries as to availability indicate that demand and price for industrial garnet is rising. The latest price quoted being 86 cents per kilo for graded industrial ex New York. Stream samples have been taken from Lizzie Creek to ascertain the quality, size and percentage of garnet in stream sands and gravels.

Ultra Basic Rock

Two known areas of ultra-basic rock have been inspected by field parties. These will be subject to further exploration in future.
This area is on the northern boundary of the Alice Springs 1:250,000 geological map area, but is not shown in detail. It contains sections of the graded Plenty River Highway along its northern boundary, the Mount Riddock homestead in its north-eastern corner, and an array of earth station tracks which make most portions fairly accessible to four wheel drive vehicles.

General Geology

The area is part of the Arunta precambrian complex and is so mapped. Later authors, however, have subdivided this, and it is now described as containing the units known as the Irindina Gneiss and Riddock Amphibolite. (Shaw and Langworthy, BMR report in preparation).

The west and central regions of the licence consist principally of low relief areas, with more rugged regions in the east around Mt. Riddock and Mt. Campbell and to the south fringing Mt. Johnstone. The rock types are mainly intensely metamorphosed sediments and volcanics, now represented by gneisses, amphibolites and schists, which are generally folded and sheared along east-west trending lineaments. Later retrogressive alteration is common and there are abundant transgressive low temperature veins of pegmatite and quartz, which frequently carry tourmaline, epidote and mica.

Garnet, Vicinity of Mt. Riddock

As prophyroblasts (up to 100 millimetres in diameter) the garnets are intensely fractured. Fe minerals coating fracture plains gives the garnet a dark non-translucent appearance. Samples of the garnet sent to Bangkok for trial cutting returned a small quantity of good stone. The cut stone is valued at $10 to $12 per carat.

The garnet was examined by Dr. Ralph Segnitt of C.S.I.R.O. who reported on its unusual crystal structure (samples forwarded to your museum). Commercial prospects for both gem and industrial garnet are promising. Good gems have been cut from the stone and commercial negotiations have begun for industrial garnet. This deposit could well be supplemented by alluvial garnet which occurs abundantly in stream sands in E.L. 1956 (in places up to and exceeding 50%).

Stream sampling for alluvial garnet, suitable for industrial use, was undertaken near Mt. Riddock homestead.
Molybdenum was encountered disseminated in schist in the north of the E.L. Costeanning revealed this to be extensive. However assays indicated the mineral was not present in sufficient quantity to give commercial prospects.

A sizeable deposit of Allanite containing a relatively high percentage of cerium has been discovered in the south east of the E.L. Dr. Ralph Segnitt of C.S.I.R.O. again has tested and examined samples and reports that it is a complex ore not yet viable for commercial treatment, but it would most likely have specimen value. However this will be further examined as deposits of the more readily treated and richer monazite are being rapidly depleted as a source of cerium and lanthanum oxides.

Known Mica deposits have been studied and tested and some are believed to be viable on an open-cut basis. Commercial negotiations have been begun to supply mica.

Carbonitite

A possibly significant deposit of carbonitite in the south west of the E.L. is being prospected. It is believed other occurrences are likely to the east of this deposit and further exploration will give particular attention to these.

General

The summary of equipment given in the previous report has been little changed and the list of consultants is the same.

Major reductions in areas of the three E.L.'s will permit concentration on prospects which show promise for development.
### EXPENDITURE - 1980

**HILLRISE PROPERTIES PTY. LTD.**

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**C.R.A. EXPLORATION PTY. LTD.**

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PLATE I

LOOKING NORTH-EAST FROM SECTION E TO SECTION 'A-B' (IN SHADOW). NOTE PARTICULARLY THE APPARENT GENTLE DIP SLOPE EXTENDING FROM JUST ABOVE AND LEFT OF CENTRE OUT TO THE RIGHT HAND EDGE OF THE PHOTOGRAPH. NOTE PARTICULARLY THAT WORKINGS 'A-B' ARE ROUGHLY PARALLEL WITH THIS, BUT OBVIOUSLY NOT EXACTLY CO PLANAR WITH WORKINGS NORTH OF THEM (I.E. TO THE LEFT AND UP IN THE PHOTOGRAPH).

THE WORKINGS ALL YIELDED RUBY AND SLOGGETT'S GEOLOGICAL MAPPING SHOWS WORKINGS A-B OFFSET BY MINOR FAULTS FROM THE OTHERS.
PLATE II

LOOKING NORTH WEST AT A VERTICAL CUT, SECTION 'E'.
NOTE GEOLOGICAL PICK JUST RIGHT OF CENTRE SHOWING SCALE. THE PICK IS 32 CM LONG.
DARK GREEN ROCK LOWER LEFT IS META AMPHIBOLITE, PALE ROCK IS BASIC FELDSPAR, BROWN ROCK UPPER LEFT IS PHLOGOPITE-RICH. NOTE ALMOST PTYGMATIC DISTORTIONS IN FELDSPAR RICH BANDS 1 METRE RIGHT OF THE PICK. RELATIVE MOVEMENT IS TOP BLOCK RIGHT IN ALMOST AN IMBRICATE ZONE.
PLATE III

VIEW LOOKING NORTH EAST INTO SIDE OF ROAD CUT BETWEEN SECTION 'I' AND SECTION 'J'.
NOTE "BOUDINAGE" STYLE OF STRUCTURE IN ISOCLINALLY FOLDED GNEISS. GEOLOGICAL PICK IS 32 CM LONG. NOTE GNEISSOSITY - VERY STRONGLY DEVELOPED FOLIATION. ORIGINAL BEDDING, SEDIMENTARY LAYERING AND SEDIMENTARY STRUCTURES ARE MOST UNLIKELY TO SURVIVE IN SUCH A REGIME.
PLATE IV

VIEW LOOKING SOUTH EAST INTO VERTICAL WALL IN SECTION 'F'. ROCK TO LEFT IS LEUCOCRATIC LABRADORITE ROCK OR ANORTHITE ROCK WITH A REACTION RIM (?) AGAINST AMPHIBOLITE. BOTH ROCKS HOST RUBY.

NOTES ON TERMINOLOGY:
SOME WORKERS INSIST THAT THE TERM "ANORTHOSITE" IMPLIES IGNEOUS ORIGIN, OTHERS NOW DO NOT. BUT I ADHERE TO THE A.G.I. DEFINITION OF "A PLUTONIC ROCK COMPOSED ALMOST ENTIRELY OF PLAGIOCLASE" WHICH CANNOT BE USED (AT LEAST NOT YET) IN THIS CONTEXT.

THE AMPHIBOLITE CAN BE TERMED A PARA AMPHIBOLITE IF IT CAN BE SHOWN TO BE DERIVED FROM A SEDIMENT, AS McCOLL & WARREN PROPOSE.
HARTZ RANGE RUBY DEPOSIT OF MISTRAL MINES N.L.

ADDITIONAL GEOLOGICAL DETAILS

C.C. Brooks
26 July 1980

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SUMMARY

Reports to Bancorp Holdings Pty Ltd and Mistral Mines N.L. of 9 July 1980 recapitulated the geologic and economic status of the deposit in a general sense.

This technical report reviews the geology in more detail and indicates trends of geological investigation that warrant pursuit.

The origin of the deposit may differ slightly from that postulated by McColl and Warren in 1979. This may affect detailed mapping but is unlikely to influence the immediate exploration programme.

Various hypotheses are discussed and the resultant plan of action is outlined.

This is believed to be the quickest and cheapest way to evaluate the deposit, and to set the stage for intelligently evaluating the surrounding region.
PREAMBLE

This report is written as an appendix to the report of 9th July to Mistral Mines N.L., therefore details of location, access, climate, title, markets, references etc. are omitted except to restate the location as 23°05'S: 135°02'E in the northeastern Hartz Ranges of Central Australia and to add new references.

FURTHER WORK

At the writer's request and cost Mr H.W. Fander examined some of the material and discussed the nature of the deposit. His report CMS 80/7/2 is appended.

The deposit was also discussed with Dr R.L. Oliver, a petrologist and Senior Lecturer in Geology at Adelaide University. Dr Oliver, a New Zealand graduate, with a Cambridge Ph.D., some 55-60 years old, has had extensive experience in the petrology of "red corundum"-bearing rocks in Norway and Ceylon. His interest has been held for several years by charnockites and granulites, particularly in Australia and Antarctica.

While the following comments reflect these discussions, full responsibility is accepted by the writer for any views or conclusions given.

No attention is paid to lesser semi-precious stones of the area as brief consideration of the economics of such stones as tourmaline, garnet, iolite etc. indicate that they belong in the amateur fields of prospecting rather than professional - for example, synthetic stones cut to rigorous dimensions can be produced in adequate quantities to meet demand more cheaply than these lesser semi-precious stones. The total market, for example, for iolite I believe to be too small to warrant serious consideration. Naturally these stones will be useful in the tourist and rock hound parts of the planned operation but they do not warrant serious expenditure of professional time.

FIELD OBSERVATIONS

STRUCTURE

The rubies seem to lie in a specific horizon which has been only gently folded, and later offset by very minor faults - see PLATE I.

This appears to be simple folding but the petrography of the rock denies such an interpretation (see below). Therefore I conclude that at the discovery area the rubies have been found in a relatively planar feature reflecting the axial plane of a major recumbent fold. This is in accord with earlier published B.M.R. work.

In detail the rubies lie in a leucocratic and a melanocratic host rock. These have been gently thrust in the area seen. Imbricate-like structures are seen in Plate II and small scale normal faults have been mapped by Mr Sloggett showing offsetting of the host horizons by a few metres.

Nearby structures show major mimetic recrystallization and a very high probability of isoclinal folding - see PLATE III.
PETROGRAPHY

McColl and Warren in their 1979 paper discussed the high calcium content of the ruby bearing layer and observed that the aluminium content is high for a normal clay.

They noted a para amphibolite containing greenish gneiss ruby host rocks. The greenish gneiss consists of magnesian common hornblende, anorthite (Au95) chlorite (clinochlore?) magnesian chrome spinel and ruby corundum, with minor mica (phlogopite?) and pods of massive tourmaline. They noted retrogressive alteration of all of the rocks in the region.

Fander, in his 1980 report CMS 80/7/2 attached as appendix I, identified a labradorite rock containing minor phlogopite and pale actinolite with traces of chromian spinel which he calls "a type of granulite". He also identified the amphibolite as a hornblende granulite.

Despite the strong deformation shown in plates II and II the host rocks show little sign of either a high stress environment or severe mimetic recrystallization.

STRUCTURAL INTERPRETATION

This is very preliminary, to be used as a working guide, and I am confident that field observations will allow a much clearer picture to emerge quite quickly.

Regional

The area has been mapped by the B.M.R. geologists. They show a series of isoclinal folds about north-south axes, tightly refolded about steeply dipping east-west axes so that present attitudes range from steep to recumbent (Wells, 1969).

Plate III shows a reflection of this style of structure, in an outcrop. Plate I shows a gentle north-east dipping planar feature that can be interpreted as reflecting a flat-lying axial plane surface. Any original bedding plane features would have been destroyed. Lithological differences, while reflecting original beds, flows or sills, may be overturned or right way up. Hence a karst limestone sink hole lithology or a residual lateritic bauxite deposit - since metamorphosed into a ruby-bearing target horizon may lie on top of, or underneath the metamorphosed equivalent of its original source rock.

Detail

Plate II shows "imbricate" thrusting on a scale of a few metres. When viewed with plate I this indicates that the axial plane structures in this area dip at low angles and that there has been minor structural adjustment after the last phase of regional metamorphism.

In plate IV what appears to be a reaction rim can be seen on the left hand edge of the meta amphibolite mass. This may reflect an original igneous texture developed on the margin of an ultramafic, or it may be a metasomatic effect of igneous emplacement or even a metamorphic differentiation product formed during regional stressing. The structure of the limits of each mass of amphibolite has yet to be determined. Examination of such rims should restrict the number of possible answers to questions of structural history and original lithology.
There has not been enough field geological mapping done to establish whether it is more likely that the meta amphibolite was a continuous layer, since broken only by minor faulting at a late stage, or whether it was probably a discontinuous series of pods and/or lenses whose continuity has been further disrupted by faulting. If the latter, then the original disposition of the pods may have been stepped up or down through the sequence - or they may have been silled into pre-existing rocks.

Answers to these structural questions may be more important in the initial search phase than the major problem of genesis or association.

PETROLOGY

McColl and Warren put forward the hypothesis that a para amphibolite was heavily contaminated by wind borne pyroclastics or volcanic detritus resulting, after weathering, in an aluminous karst, which then was metamorphosed to form "rock types observed in the greenish gneiss lenses".

This is an ingenious solution to the problem which probably contains some elements of truth. At this time, however, all conceivable hypotheses need to be considered, for two reasons.

Firstly, without some working hypotheses to test, field observation degenerates into bulk fact gathering with the danger that minor but significant observations may be buried in a welter of data. Secondly a prime working hypothesis is needed to guide the broader search.

Therefore two other hypotheses are proposed, based on available petrography, viz.: the host rocks may be the retrograded product of either a metamorphic differentiate or a layered intrusive or extrusive ultramafic basic rock or they may be the retrograded product of a basic lava which had been leached (much as those of Kauai Island in the Hawaiian chain are leached to form bauxite today) then metamorphosed to granulite facies rocks. These ideas conform with views put forward by Fander and Oliver. Oliver, doubts whether the leucocratic and melanocratic phases are metamorphic differentiates based on his experience but agrees with Fander that both rocks may have been derived from basic igneous rocks.

The lack of marble reported from close to the site may reflect only lack of observation. If McColl and Warren's hypothesis is to stand I would expect to find massive marbles or contaminated marbles either immediately below the ruby "horizon" - or, if the sequence has been inverted, immediately above the rubies in places.

GENESIS

McColl and Warren put forward the hypothesis that regional metamorphism of a karst terrain with bauxitic sink hole fillings could give rise to the ruby deposit, but they have to invoke derivation of chromium from volcanics to form ruby - possibly by ionic diffusion or (?) by solution and redeposition. They note the similarity of this deposit to one at Hunza in Kashmir.

Before considering alternatives, I would like to discuss this theory.

If it is correct then field mapping will show the ruby host rocks to be relatively discontinuous with abrupt thickening and thinning of
various lithologies. The host rocks will lie either immediately over (or under, if the sequence is overturned) a massive marble or impure marble bed which will be the metamorphic equivalent of the limestone on which the karst topography developed.

McColl and Warren state on P. 124 that they consider the para amphibolite, about 50 metres thick, exposed as a flat-lying band along a strike of 15 to 20 km all to be prospective for ruby. The scapolitic marbles they mention will need to be carefully mapped. My extensive field experience of karst terrains, particularly in Indonesia (Sulawesi, Irian Jaya) and Papua New Guinea, coupled with studies of the karst and limestone weathering patterns in Yugoslavia, Jamaica and Nauru suggests that there should be much more thickness variation, and much higher marble content in these rocks than I have been to date. This does not deny the hypothesis as so little mapping has been done - rather it sounds a warning.

Careful note should be taken of calcites, marbles and calcretes which are commented on in greater detail in the section on alluvial search.

Re the Hunza deposits: Okrusch et al (1976) state that

This is a calcite-marble mass containing gem-quality ruby in the northwestern part of the Karakoram Mountains. The marble occurs as "massive concordant intercalations of 1-5 m (a few as thick as 10 m) in thickness within garnet-bearing mica schists and biotite-plagioclase gneisses".

"...Plagioclase is not a very common mineral in the marble,..." Tourmaline is said to be rare, rutile...."is a very abundant accessory mineral".

The abundance of carbonate and the great differences between the accessory suites of minerals lead me to believe from what little I've seen and read of the Hartz Range deposit that it does not resemble that of the Hunza. Further fieldwork may change my mind, but at present I do not think that a similar genetic origin is likely for the two deposits. Further, the description of 1-5 m bands of calcite within garnet bearing mica schists and biotite-plagioclase gneisses i.e. the Hunza host, does not read to me as a description of a metamorphosed karst terrain. Another point is that in the Hunza deposits the marbles or calcites are the actual host rocks of the rubies while such is not the case in Central Australia. Two more points are that Okrusch et al published a map showing the marble bands of the Hunza to outcrop continuously over undistorted strike lengths of the order of 15-30 km in terrain intruded by a large granodiorite mass - structurally and genetically different setting from the Arunta occurrence as we know it today.

GENESIS ALTERNATIVES

Fander (op. cit.) states that the mineral assemblages of the host rock suggest a basic ultramafic origin which would explain the silica deficient assemblage, the high alumina content and the presence of chromium in the spinel and the ruby.

He goes on to say that the (labradorite rock may be a metamorphic differentiate and both rocks may have been derived (i.e. formed from by metamorphism C.C.B.) from basic igneous rocks.
Oliver, from his experience thinks metamorphic differentiation is an unlikely mechanism for derivation of leucocratic rock but does feel, quite strongly that both the leucocratic and melanocratic host rocks were probably originally basic volcanics or sills which were regionally metamorphosed to granulite facies and then, by addition of water, retrogressed to amphibolite facies rocks with the pyroxenes retrogressing to amphiboles etc.

This latter explanation, based on a knowledge of Mcoll and Warren's and Fander's work seems, as one would expect, the closest approach to the truth as yet. From this, a major guide to field mapping can be derived. This is not pursued further in this report as Messrs. Fander, Sloggett and the writer intend to visit the field in September, with the topographic map in hand. There various ideas can be discussed and field observations made in sequence to quickly check the ideas and a formal campaign designed.

GEOLOGY AS A GUIDE

After the genesis hypothesis has been selected, it must be placed in structural context.

Three time frames are possible here, viz.:

1. The host volcanics were lavas or silts interbedded with the regional rocks prior to major folding.

2. The host volcanics were poured onto the area long after the formation of the recumbent folds.

3. The host volcanics were injected into major thrust faults at the close of the dynamic metamorphism.

Preferably, two of these will be negated by simple field observation quite quickly. The third can then be used with geological interpretation of aerial photography - using stereoscopic pairs to allow rapid elimination of enough leased ground so that relinquishment requirements can be met as they fall due.

Preliminary work along these lines can be started by critical examination of the 1:25,000 scale rough drafts of the B.M.R. 1:100,000 scale geologic maps which have been left with Mr. Sloggett.

Questions to be answered include: What is the areal extent of the host rocks? Were they coplanar and only offset by faulting or were they offset prior to faulting? Why are they not stressed? Were they isolated from stress or are they of later origin? Are they lying in old fold axial plane or just parallel to one? If the latter is there a replicate on the other side of the axial plane? Are there other occurrences in the same stratigraphic position in other fold structures? Can non-retrogressed i.e. pyroxene-bearing parts of the host rock be found? What are the relationships between rock-type, structural position and ruby grade?

The late stage thin transgressive quartz and pegmatite veins appear to be of no genetic significance but study of them may isolate areas of late stage stresses which have fractured ruby crystals.
ALLUVIAL SEARCH

The recent (July 1980) report of a good quality alluvial ruby from
the Hartz Range confirms the conclusions of the main report.

An alluvial search programme must be integrated with the hard-rock
work as knowledge from each programme will help the other.

Naturally the alluvial programme should start with photo interpre-
tation of the current drainage patterns and their relationship to known
outcropping deposits.

The next step back in time is to try to identify recent fossil
drainages e.g. as far back as Plio-Pleistocene and try to relate these
to the deposits. In this regard we have a good jumping off point.

A specimen of carbonate rock was taken from 150 m from cut "J" and
submitted to Mr Fander and from him to Drs B. McGowran and B. Daily at
Adelaide University.

This proved to be a laminocalcrete, dominantly composed of acid
soluble carbonate with angular fragments of magnesian hornblende etc.
derived from the subjacent or adjacent granulites. The outcrop is on a
berm which may represent a fossil river or lake terrace. As more
calcrete was noted west of section "E" these two types of data - detailed
land form and calcrete occurrence may allow delineation of fossil
drainages and/or recent river capture which can be used to control the
alluvial ruby search.

Unfortunately there are definitely recent and forming calcretes in
this area, therefore the field data will need to be fully documented to
allow interpretation of any differences between older and younger
calcretes.
REFERENCES


Okrusch, M; T.E. Bunch & H. Bank, 1976, Paragenesis and Petrogenesis of a Corundum -Bearing Marble at Hunza (Kashmir); Mineralium Deposita II(3) 278-297.

Introduction

A two day visit was made to examine mineralised outcrops in parts of the above-mentioned E.L.'s between 10th and 13th June 1980 (fig. 1)

Four surface samples were taken for geochemical assay and results appended with a hand specimen description.

The observations made during this short visit were necessarily cursory and may not reflect the overall regional picture.

Mineralisation

Two types of mineralisation were examined -

(i) Fresh coarse grained galena in a quartz, feldspar garnet + carbonate rock unit.

(ii) Copper carbonates associated with pyrite in quartz veins in a calcareous and mafic sequence.

1. Type (i)

This was visited at localities 2, 3, 4, 5, & 7 (fig. 2) and occurred as a mappable unit about 1m wide containing 3% galena and no other sulphides (E24518). The adjacent rock types were a porphyroblastic garnet (5%) quartz feldspar gneiss (E24517) and a porphyroblastic quartz (5%), feldspar (5%) biotite gneiss - Irindina Gneiss of Joklik (1955). Coarse grained meta-gabbro dykes are abundant and proximal.

2. Type (ii)

This was seen at locality 6, where heavy encrustations of devil's-dice exsolving chalcopyrite were collected and assayed. (E24520). Malachite in quartz veins was also noted in probable meta-pyroxenites and other mafic metamorphosed rocks in the area. A garnet quartz magnetite rock unit, 1-2m wide, was sampled and analysed (E24519).
Summary & Recommendations

In the context of viewing mineralised outcrops in isolation from the regional aspect, both occurrences are uneconomic from a consideration of the secondary nature of the sulphides and the overall paucity of total sulphides in the system.

However, this would not rule out the possibility that these occurrences may have originated from a larger mineralised source.

References:


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I.B. ROARK
Geologist

COSTING:

Geology - 4 days @ $110/day $440
Travel & Meals 400
Geochemical Analyses & Sundries 50

$890

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Central Mineralogical Services

Mr. N. Crowley
Managing Director
Mistral Mines N.L.
285, Victoria Street
ABBOTSFORD / VIC. 3067

17th November, 1980

REPORT CMS 80/10/64

YOUR REFERENCE: Verbal request
DATE RECEIVED: Beginning October
SUBJECT: Visit to Hartz Range
SUBMITTED BY: C.C. Brooks
WORK REQUESTED: Field Study of Ruby Occurrences

Copy to:
Mr. C.C. Brooks
Consulting Geologist
45, High Street
BURNSIDE / S.A. 5066

H.W. Fander, M. Sc.
INTRODUCTION

At the request of Mistral Mines N.L. via Mr. C.C. Brooks (consulting geologist), the writer visited the site of the new ruby discovery in the Hartz Range, N.T.

The primary purpose of this visit was to examine the rocks in which the ruby and pink corundum occurs, and to study these and the adjacent rocks in order to gain an understanding of the rock formations, the nature of the occurrences, and especially the mechanism whereby the corundum (ruby) actually formed. However, this perhaps slightly academic approach was aimed at assisting in finding further potential ruby-bearing rocks.

In addition, other matters of potential economic interest were discussed with members of Mistral Mines, and other localities and specimens were examined.

The basis of this report rests on the examination of rock specimens systematically collected at the locality, studied in conjunction with the first-hand field observations. There is no doubt that this combination of field and laboratory study has achieved faster and more positive results than could ever have been obtained in any other way.

SUMMARY OF RESULTS

This summary has deliberately been placed in the early part of this report, for the convenience of those not wishing to be involved with the more technical aspects of the investigation.

Briefly, corundum (including ruby) has formed at, and very close to, the contact between ultramafic intrusives (generally green-coloured rocks in the field) and quartz-deficient host rocks (labradorite gneisses - white, banded rocks in the field).

The mechanism responsible for the corundum formation is known geologically as "desilication", and it involves the breakdown of aluminosilicates, such as feldspar, to alumina (i.e. corundum); desilication occurs, for instance, when silica-deficient rocks such as ultramafic intrusives are in contact with quartz-poor rocks, and silica is extracted from the silicate minerals. Energy is of course required for this reaction to take place, and this is provided by the molten intrusive.

This mechanism produces corundum under the right conditions; the colour of ruby is due to traces of chromium, and this is provided by the ultramafic intrusive, an entirely logical source for this element. Thus, in a sense, ruby itself provides the key to the understanding of the deposit.
The rock types studied and identified completely supported the mode of formation described above. Furthermore, it is now clear that the contact zone between the ultramafic intrusive and favourable host rocks (poor in silica) is the potential exploration target. The evidence at this stage, with comparatively few rock-exposures, suggests that the intrusive may be sheet-like or channel-like within the host rocks, and could thus be of considerable extent. Thus, the target contact-zone could also be extensive, and is unlikely to be confined to the present locality.

Probably the most positive way to find new ruby occurrences is to carry out UV fluorescence checks on stream sediments, especially those collected from small, steep gullies. Obviously, the more occurrences, the greater the chance of finding high-grade ruby with fewer flaws. Stream sediment sampling and testing would be carried out in conjunction with geological interpretation based on aerial photos, field data and petrological studies.

**PETROLOGY**

Study of the occurrences in the field, and examination of systematically sampled rocks, indicates the following:

1. The host rocks are products of regional metamorphism, of various sediments, assigned to the upper amphibolite to hornblende-granulite facies; the rocks range from quartz-biotite-garnet-sillimanite schists 4-5 m above the ultramafic intrusive, through amphibolites with very minor quartz to labradorite-hornblende gneisses and hornblende-pyroxene granulites immediately above the intrusive. Slabs of these rocks are incorporated as xenoliths in the intrusive.

2. The intrusive rock is also metamorphosed, and now consists of tremolite or pale hornblende and antigorite with accessory chromite; the mineral assemblage clearly indicates an ultramafic derivation, probably a pyroxenite.

3. The various rock types, especially the critical labradorite-hornblende gneiss/amphibolite and the intrusive, are quite consistent throughout all the localities.

4. Post-intrusion metamorphism, clearly involving compression (Schuppen-structures), not stretching (boudinage), affected the intrusive and the host rocks, causing retrograde metamorphism and some mylonitisation/brecciation in all rocks, but especially in the more sensitive intrusive. This accounts for the shape of the intrusive (generally as a bulge or camel's hump). The corundum, already formed at this stage, was also affected by this metamorphic event, causing buckling and fracturing of crystals and the development of smaller flaws generally responsible for the pale colour and opacity of the crystals.
It is likely that this was a regional event, i.e. over a wide area, but may have been less intense in some areas than in others, with correspondingly less effect on the corundum; there is some evidence for this even in the present occurrences, and it is noticeable that smaller corundum crystals are generally less flawed and of better colour than larger ones.

5. A later, metasomatic event has affected the rocks fairly sporadically, and explains the very friable nature of many of the occurrences (not related to weathering). The metasomatism involved the introduction of several minerals, including scapolite (replacing labradorite), tourmaline, zoisite, prehnite, sericite, carbonate, and zeolites into the host rocks and the intrusive.

6. Corundum has developed in host rocks adjacent to the intrusive and in those occurring as xenoliths within the intrusive (perhaps localised in the upper part of the intrusive).

7. Vermiculite/phlogopite, a brown mica formed mainly in the intrusive, occurs as thin, vein-like bodies adjacent to the intrusive and may be a good local indicator of the proximity of an intrusive. The presence of fuchsite (Cr-mica) is also a good indicator, because it is an alteration-product of pink corundum/ruby.

CONCLUSIONS

a. Target zones are defined by rocks adjacent to, and within, the ultramafic intrusive in the proximity of contacts (both upper and lower contacts where exposed), where the intrusive rock is located in favourable host rock; i.e. the correct combination of host rock and intrusive is necessary to the formation of corundum.

b. The prospect for new corundum occurrences is open at present; limits of prospective horizons would be imposed mainly by the geological structures, whereby ruby-bearing rock would be inaccessible due to faulting or folding. A better understanding of the regional/structural geology is therefore essential for exploration planning. The possibility of other gem minerals occurring (e.g. spinel) should not be overlooked.

c. Field and laboratory examination of twenty-one systematically collected rock specimens has established the mode of formation of the corundum, which is well-recognised and clearly documented from other corundum occurrences. Thus, the deposits in the Hartz Range fit in very well with carefully studied deposits.

H.W. Fander, M. Sc.
APPENDIX

Several mineral specimens were examined with "Bluey" Bruce, and some were taken to the laboratory for further testing. They are listed below.

1. Red-green rock with suspected molybdenite.
   This is a skarn, consisting of reddish-brown garnet, green diopside, minor fluorite, and a flaky black mineral which proved to be graphite, not molybdenite.

   This was identified by XRD as tantalite-columbite, a series of related minerals which can contain significant amounts of uranium (up to 1.7 % U has been recorded in references). It is suggested that comprehensive assays, chiefly for Ta, Nb and U, be carried out; however, in view of the apparently sparse occurrence of this mineral in the pegmatites, this further expenditure may not be warranted. The sample will be held at CMS pending instructions.

3. Garnetiferous Creek Sands - Mt. Riddock 6 mile, 7 mile.
   These two samples, collected on the return trip to Alice Springs on 26th October 1980, contain garnet, but the grade is believed to be too low (less than 25 %) to warrant further consideration.

REPORT ON HARTS RANGE

RUBY MINE

M. B. Katz

General Geology

The mine site is situated in the Harts Ranges of the Arunta Block (Joklik, 1955) on the northwest corner of the Illogwa Creek 1:250,000 sheet area (Shaw & Milligan, 1969). The rocks of the area are described by Joklik (1955) as the Harts Range Group consisting of the Entia biotite gneiss, the Bruma augen schist, the Irindina gneiss-biotite schist, including the Riddock amphibolite, the Brady paragneiss and the Cadney quartzofeldspathic gneiss. In the vicinity of the mine the Irindina gneiss, and especially the Riddock amphibolite member are the host rocks for the ruby deposits. The Riddock amphibolite is a layered sequence interpreted as a succession of mafic lavas, sills, tuffs and minor sediments. The rubies are found in a light coloured hornblende-plagioclase gneiss interlayered with darker mafic rocks, especially well developed at the gneiss/mafic rock contacts.

Locally the rocks strike northerly and dip at moderate angles to the east, but regionally the mine is situated on the west flank of a major anticline-dome structure comprising the Huckitta Anticline, and the Inkarolla and Huckitta domes which are intruded by granodiorite. The mine is located between two northerly trending, easterly overturned folds; an anticline to the west and a syncline to the east, which seem to be structurally related to the large Huckitta anticline-dome 15km to the east (Fig. 1).

Geology of the Mine

A paper describing the geology and mineralogy of the mine by McColland Warren (1979) considers the deposit as being developed from a terra rosa soil profile formed on a limestone contaminated with pyroclastics and interlaminated lavas and tuffs. According to them the rubies are now located on the bottom of lens-like masses of hornblende-plagioclase and plagioclase gneisses believed to represent the hollows and caves of a partial karst topography. These pockets were infilled by lateritic terra rosa, which were subsequently preserved by transgression, with deposition of further pyroclastics. This account makes the following important assumptions:
(1) That the deposit is stratigraphically right side up

(2) That the deposit is essentially of sedimentary origin with an original limey composition.

(3) That the lenses reflect original karst hollows, caves and basins.

(4) That the deposit has been formed from an unusual composition due to weathering and soil formation.

(5) That the rubies are concentrated at the base of the lenses.

(6) That the chromium was derived from the volcanics (200ppm) and enhanced 10–20 fold in the ruby horizons.

(7) That the deposit has not been penetratively deformed or disrupted.

The following preliminary geological, structural and petrographical evidence suggest that the account is erroneous and a new genetic model is presented. The field and laboratory studies indicate:

(1) That the deposit may not be stratigraphically right side up and may be overturned.

(2) That the deposit is not meta-sedimentary but is a meta-igneous layered anorthosite complex rich in CaO. True meta-limestones are in the vicinity, now represented by marbles.

(3) That the lenses do not reflect karst topography but are excellent examples of 'boudin' structure caused by extensive deformation.

(4) That the deposit has been formed from an original silica deficient, composition rich in Al₂O₃, CaO, (MgO, Fe, Cr) that would be expected from a layered anorthosite complex.

(5) That the rubies are compositionally controlled and can be found not only on the base of 'lenses', but at the top of and within the 'lenses'.

(6) That the chromium is derived from the layered anorthositic complex, which should contain a high chromium content and chromitite horizons could be expected.
(7) That the deposit has been penetratively deformed into large overturned and recumbent isoclinal folds with good axial plane foliation, fold axis lineation, small recumbent isoclinal folds, and boudinage structure and lineation.

**Geological Relationships**

The few sections available for study indicate a local sequence of rocks, which may not be right side up, from apparent top-bottom:

1. dark garnet - biotite - sillimanite augen schist with local quartzite layers and lenses.

2. light coloured foliated, laminated plagioclase-hornblende rock (2-3m) with thin mafic layers (~5cm).

3. dark mafic rock ( ? )

4. plagioclase-hornblende rock

The rocks are prominently, conformably layered, although somewhat disrupted, and they pinch and swell along the strike. The rubies are found in both the light coloured plagioclase-hornblende rock and also in the darker mafic layers,

although there seems to be a concentration of ruby at the plagioclase-hornblende rock/matic rock contacts. The general appearance of the rocks suggest that the garnet-biotite-sillimanite schist is not related to the ruby-bearing sequence, which outwardly resembles a layered anorthositic complex. This complex retains original layering and textures, but has been deformed and recrystallised under, at least, high amphibolite metamorphic facies. The original horizontal layering has been folded into tight, overturned-recumbent folds. In many respects the complex shows great affinity to Archaean layered anorthosites described by Windley (1973) and in particular to the complex visited by the author in 1974 at Sittampundi, S. India (Subramanian, 1956) If these geological relationships are proved to be correct it will be one of the only layered anorthosite complexes described from Australia.

**Structural Geology**

The structural elements recognised in the sections include penetrative planes or S surfaces. The layering is thought to reflect
an original compositional layering and is termed $S_0$, while the regular-irregular, finer foliation, $S_1$, is essentially parallel to $S_0$. $S_0$ is seen to be folded into isoclinal recumbent folds, best seen at the 'Pimple', and the intersection of $S_0$ and $S_1$ at this locality determines a lineation, $L_1$, which is assumed to be parallel to the fold axis. The pinch and swell structures in the sections examined have been interpreted as lenses (McColl & Warren, 1979), however these features are considered boudinage structure, common features found in layered rocks, caused by extension and necking of the more competent units. In three dimensions, these boudins are sausage-shaped and where measured in the 'South Workings' are parallel to $L_1$ and the fold axis.

The $S_0$ and $S_1$ surfaces strike N-NNW and dip at shallow to moderate angles to the east. $L_1$ is a low plunging lineation to the south or north and, in places, is almost horizontal (Fig. 2). All these elements suggest that the rocks are structurally located in a large-nappe-like, isoclinal, easterly overturned-recumbent fold. As way-up indications have not been investigated, the deposit may be right side up or overturned. (Fig. 3).

**Petrography**

About 20 hand specimens and thin sections of the various lithologies were examined. They confirm the field observations that the ruby bearing rocks are part of a layered anorthosite complex.

The principal member of the complex is a light-coloured plagioclase-hornblende gneiss which is best termed an anorthosite. Where hornblende increases in proportion to the plagioclase the rock varies from anorthosite-gabbroic anorthosite-anorthosite gabbro - gabbro. The rock shows a relict gabbroic-ophetic texture and the fine layering is also thought to be an original feature. The mineralogy of these rocks are also distinctive of an anorthositic complex:

**Major constituents**

- Plagioclase - (An. 94-96; McColl and Warren, 1979) (sometimes sericitized)
- Amphibole-hornblende (Pargasite?) (chrome-rich)
Phlogopite
Epidote-chinozoisite

Minor constituents
Fuchsite - chrome mica
Spinel - (chrome spinel; McColl and Warren, 1979)
Sapphire (rare mineral)

The darker, more mafic units contain the following minerals:
Amphibole - hornblende
Chlorite - (chrome, McColl and Warren, 1979)
Chromite - fine granular layers

Ruby corundum has been found in all these lithologies from anorthosite-mafic units. They often have a preference for the more mafic layers in the anorthosite, but have been found with plagioclase, often coated by a fine rim of sericite (Fig. 4). The rubies are syn-post-tectonic porphyroblasts growing in at least 3 textural-structural states.

(1) basal section parallel to So and S1
(2) basal section normal to So and S1
(3) basal section oblique to So and S1.

Therefore they post-date the development of So and S1 but in case (1) their growth is controlled by these surfaces.

Conclusions
The ruby-bearing rocks are part of a deformed and folded, layered anorthosite complex. The composition of these rocks, which are rich in Al₂O₃, CaO, and SiO₂, deficient, are conducive to form corundum. The rubies must contain chromium and this is derived from the complex, which also contains chromite, chrome spinel, chrome chlorite, and fuchsite. The ruby appears to have grown to sizeable porphyroblasts after the major deformation and this could be due to a later thermal event, possibly related to the intrusion of the Inkamulla and Huckitta granodiorites just to the east. The porphyroblastic crystal growth of ruby corundum is thought to be synchronous with that of the garnet in the surrounding schists.
The general geological history of the area can be summarized:

(1) **Archaean event** - emplacement of a flat lying layered anorthosite complex within a supracrustal sequence of sediments and volcanics.

(2) **Proterozoic event** - Arunta event (1800my) - deformation and metamorphism of the area to form a recumbent folded, meta-anorthosite complex within a meta-sedimentary schist and metavolcanic amphibolite (Riddock amphibolite).

**Recommendations**

This preliminary report highlights the geology, mineralogy and structure of the ruby-bearing rocks. It is evident that this area deserves much more detailed studies from several important aspects.

(1) The anorthositic nature of the host rock
(2) The structural extent and configuration
(3) The possible occurrence of economically important chromitites and chrome garnets
(4) The eluvial and alluvial deposits in the vicinity.

Aspects (1) and (2) should be tackled by a graduate-student who would be able to provide a detailed geological map of the area with structural and petrological information vital for future mining activity. Aspect (3) should be kept in mind in the development of the mine. Aspect (4) requires the services of consultants with experience in placer gem deposits.

I suggest that I recruit an appropriate graduate student to commence an M.Sc. or Ph.D program sometime in 1981 if Mistral Mines is willing to sponsor and support such a student. Colin Brooks should be contacted re: chromite potential of the area and in the case of future alluvial-eluvial mining, a former student of mine from Ceylon, W. Silva, would be interested in a short visit. Personally I think the deposit has much economic and academic interest and I would like to be in contact with you about future developments.
References:


Fig. 2. Stereoplot of Planar Structures $S_0$ and $S_1$ (Solid Great Circles - Actual Readings, Dashed Great Circle - Average Value) and Linear Structures $L_1$ (Bullseye Points) Considered to Be Parallel to the Fold Axis
FIG. 3. STRUCTURAL SECTION THROUGH THE MINE WORKINGS LOOKING NORTH
(GARNET-BIOTITE-SILLIMANITE SCHIST - DARK, LAYERED ANORTHO-
SITE - WAVY PATTERN) ALONG A - B FROM FIG. 1. NOT TO SCALE
TOP - SCHIST AT THE TOP OF THE SEQUENCE - RIGHT SIDE UP
BOTTOM - SCHIST AT THE BOTTOM OF THE SEQUENCE - OVERTURNED
FIG. 4. A C F DIAGRAM SHOWING
ALL POSSIBLE MINERAL ASSEMBLAGES.
SOLID TIE LINES INDICATE RUBY -
BEARING ASSEMBLAGES AND MAJOR
ROCK TYPES. DASHED TIE LINES
INDICATE OTHER ASSEMBLAGES
OBSERVED.
Mr. J. Michie
Mistral Mines N.L.
285 Victoria Street
ABBOTSFORD VIC 3067.

Dear John,

The three samples of garnet-bearing sands from the Northern Territory are similar to those you submitted earlier. The Entire Creek sand contains only about 5-10% garnet; the other samples (Lizzie Creek and Mt. Riddock) may go as high as 20%.

Yours sincerely,

[Signature]

E.R. Segnit.
Dear Mr Crowley,

I can offer the following comments after a brief examination of the samples brought into our laboratory by your Mr Michie:

1. Red brown clay: This appears to be the type of soil clay to be expected in a granitic area. It is composed mainly of mica, poorly ordered kaolinite, quartz and some salt. I could not find anything unusual in it. The techniques I used would not detect small amounts of organic matter, and the sample I received does not contain substantial amounts of the latter.

2. Emerald: These crystals are nice quality specimen material, and would command a useful market, especially if not removed from their original matrix, with collectors. They would, in part at least, cut into pale coloured gemstones.

3. Black glassy mineral: This is allanite, a member of the epidote group of minerals. It is a calcium aluminium silicate containing possibly 15-20% cerium oxide and perhaps 5% lanthanum oxide. It is potentially a source of the valuable commercial oxides, but much overshadowed as such at present by the availability of the much richer and more easily treated monazite. However, in the long term, if there is enough of it, it could become a source of these oxides.

I trust this information will be helpful.

Yours faithfully,

E.R. Segnit
Senior Principal Research Scientist
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Generic FLV unit of Pb DTA
Pb DTA unit
Generic limestone calcite
Pyroclasts inlaid in calcite
Even Cave Sediment

Results in ppm unless otherwise specified
X = element concentration below detection limit

Detection:
- 5 5 5 0.5 5

Standard:
- 15 50 160 15 10

Repeat:
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