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Western Tasmanian Regional Minerals Program
Devonian Granite Aureoles Project

Tungsten prospectivity, King Island

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Summary

- Mining of scheelite from skarns in the Grassy district of southeastern King Island ceased in 1990. By the close of operations a total pre-mining resource of about 17 Mt at 0.85% WO_3 had been identified, thus placing the King Island skarn deposits amongst the major tungsten resources in the world.
- Mining was initially from the Grassy open-cut workings, which were developed in the No. 1 orebody. Subsequently, the Dolphin underground mine was developed in deeper extensions of the No. 1 orebody that are known as the Dolphin orebody. Another underground mine was developed in the Bold Head orebody some three kilometres north of the No. 1/Dolphin orebody. Mining from the Bold Head and Dolphin mines ceased in 1983 and 1990 respectively.
- In the difficult economic period from 1983 to 1990 the focus of operations was the C lens in the Dolphin mine. Cut-off grade was raised from a previous figure of 0.3% WO_3 to 1% WO_3 (upper C lens) and 0.7% WO_3 (lower C lens).
- At cut-off grades of 0.7% and 1% WO_3 there is a mining reserve of 1.097 Mt at 1.22% WO_3 remaining in the C lens of the Dolphin mine. In addition, the Dolphin mine contains substantial mineral resources calculated at the previous cut-off grade of 0.3% WO_3. The measured and indicated mineral resources include 1.35 Mt at 0.67% WO_3 in the C lens and 0.98 Mt at 0.64% WO_3 in the B lens. Inferred mineral resources comprise 1.3 Mt in the C lens, while the pyroxene-garnet hornfels horizon contains an informal resource that is unquantified, but probably substantial. Unquantified resources are also present in the banded footwall beds. Altogether, there may be in excess of 4.73 Mt of reserves and resources remaining in the Dolphin mine.
- The sum of all remaining, formally defined reserves and resources for the Grassy open-cut mine, the Dolphin underground mine and the Bold Head underground mine is 7.16 Mt, mostly at the cut-off grade of 0.3% WO_3.
- There is excellent potential for the delineation of new tungsten resources on King Island. Promising prospects that had been identified at the time of mine closure remain untested, or not fully tested, by drilling to the present day.
- In the longer term, improvement in the general market conditions for tungsten is likely to encourage renewed exploration and redevelopment of King Island's scheelite deposits. More immediate activity could be driven by corporations seeking to diversify their existing sources of the metal, or by the strategic importance of tungsten in a national context.

Introduction

In the period 2000 to 2002 Mineral Resources Tasmania (MRT) acquired a substantial body of new aerial geophysical data as part of the Western Tasmanian Regional Minerals Program (WTRMP). Together with MRT's existing databases, these new data have been utilised in several thematic projects that aim to highlight mineral exploration opportunities in western Tasmania. Both MRT personnel and independent geologists and geophysicists have participated in the generation and execution of the projects.

This report is part of a series of reports relating to a thematic project that deals with the prospectivity of the Devonian granite aureoles in western Tasmania, which are widely recognised for world-class tin and tungsten deposits and which also contain significant occurrences of other metallic and industrial commodities. The work that has been carried out illustrates the regional setting of known granite-related mineralisation against the backdrop of MRT's new and existing data. It also illustrates the setting, geophysical features and prospectivity of selected occurrences of granite-related mineralisation at a more local scale.

The results of the December 2002 to April 2003 round of work on the Devonian Granite Aureoles Project are presented in four reports. This report is an account of the tungsten prospectivity of King Island.

King Island's tungsten reserves and resources

The principal mineral deposits on King Island are scheelite-bearing skarns in the contact zones of granitoids that intrude the Neoproterozoic Grassy Group, which crops out in the southeastern part of the island (fig. 1). Skarns are associated with two intrusions, the Grassy Granodiorite and the Bold Head Adamellite, both of which are of Early Carboniferous age. Mining and exploration in the period from 1917 to the cessation of mining in 1990 identified a pre-mining resource of about 17 Mt at 0.85% WO_3 (Brown, 1990), ranking the deposits amongst the major tungsten resources in the world. Molybdenum was produced as a byproduct from the scheelite concentrates.

Production was initially from open-cut workings at Grassy (No. 1 orebody), and subsequently from underground workings at Grassy (Dolphin orebody) and at Bold Head (Bold Head orebody). Poor tungsten prices forced the closure of the Bold Head mine in December 1983, and the Dolphin mine in November 1990. Each mine contained substantial identified reserves and resources at the time of its closure (Table 1). There were also blocks contiguous with each of the mine workings that had untested potential for further resources. At the close of mining the Dolphin orebody remained open to the southeast.

Prior to 1982 there was considerable mineral exploration in the Grassy district. Diamond drilling was carried out at a number of prospects around the northern and western margins of the Grassy Granodiorite, and a small resource was identified at the partially tested Investigator 21 prospect (Table 1; fig. 2). Exploration virtually ceased after 1982 because of financial constraints, and consequently there was no further drilling around the northern and western margins of the Grassy Granodiorite. Promising ground with advanced surface exploration to the south of the Bold Head mine remained substantially untested by diamond drilling in 1990. Less accessible offshore prospects to the east and southeast of the Grassy Granodiorite also remained untested.

Prospective targets

Deakin and Richardson (1977) and Brown (1982*b*, 1984, 1987) provide discussions of the tungsten potential of King Island that remain current in most respects to the present day. The prospects identified by these workers are shown in Figures 2, 3*a* and 3*b*. These figures also show the simplified geology of the Grassy district while Figure 4 illustrates the stratigraphy in the mines. The portion of the mine stratigraphy between the basal quartzite and the mafic, upper metavolcanic rocks is termed the Mine Series.

There is extensive hornfelsing near the Grassy and Bold Head intrusions and the carbonate rocks in the Mine Series are selectively metasomatised and mineralised (Wesolowski *et al*., 1985; Williams *et al*., 1989; Brown, 1990). The main ore horizons are the C and B lenses, but substantial mineralisation is also present in the pyroxene-garnet hornfels (Pgh) horizon and in the banded footwall beds. Although formal resource figures were not determined for the Pgh horizon (Table 1) because of the erratic nature of the mineralisation, it contributed up to 10% of the annual production from the Dolphin mine (Fudge, 1990*b*). Faults disrupt the continuity of the Mine Series and grade control work in the mines showed enrichment of the mineralised horizons in the vicinity of many of these, indicating that the faults had acted as conduits for the mineralising fluids.

Much of the Mine Series in the district is covered by the upper metavolcanic rocks, which can reach thicknesses of over 200 metres. The upper metavolcanic rocks are down-faulted against the Dolphin and Bold Head orebodies by the Grassy River Fault and the Grahams Road Fault respectively. Much of the potential of the district, outside of the mines, lies in exploring for new occurrences of mineralised Mine Series beneath the upper metavolcanic rocks cover and for repetitions of the known orebodies across the Grassy River Fault and the Grahams Road Fault.

Table 1

Identified reserves and resources at January 1991 (Fudge, 1991a). The proved/probable components of the Dolphin mining reserve are undocumented (Fudge, pers. comm.). At July 1990, the Dolphin reserves were: proven reserves 1.119 Mt at 1.2% WO_3; probable reserves 0.031 Mt at 1.5% WO_3, cut-off grades as below for each (Fudge, 1990a; 1990b). Note that the mineral resources are additional to the reserves. Investigator 21 resource from Deakin and Richardson (1977).

Category	Status	Million Tonnes	Grade WO_3 (%)	Ore Horizon	Cut off WO_3 (%)
Dolphin underground mine					
Reserves	Mining	1.097	1.22	Lower C	0.7
				Upper C	1.0
Mineral resources	Measured	0.773	0.5	Lower C	0.3
				Upper C	0.3
Mineral resources	Indicated	0.575	0.9	Lower C	0.3
				Upper C	0.3
Mineral resources	Indicated	0.982	0.64	B	0.3
Mineral resources	Inferred	1.3	-		0.3
Informal	See Text	Unquantified (substantial)	-	Px-Ga Hornfels	
Grassy open cut mine/No. 1 orebody					
Mineral resources	Indicated	0.616	0.55		0.3
Bold Head underground mine					
Mineral resources	Measured	0.893	0.9		0.3
Mineral resources	Indicated	0.5	0.8		0.3
Mineral resources	Inferred	0.411	-		0.3
Investigator 21 prospect					
Unspecified		0.25	WO_3 0.47 Mo 0.12	B	

Grassy Granodiorite — northern and western contact zones

Previous exploration in the northern and western contact zones of the Grassy Granodiorite identified seven prospects that were assigned ore potential rankings ranging from 1 to 5 (fig. 2; Deakin and Richardson, 1977). Investigator 21 was assigned a ranking of 1 while Investigator 18 (West) and Investigator 2 were each assigned a ranking of 2. Brown (1984) estimated a potential 0.3 Mt of ore at Investigator 21, occurring in B lens skarn of three metres thickness. He regarded the prospect as defined and envisaged no further work despite the fact that the C horizon was intersected by only one drill hole. It also appears that no further work was done on any of the other prospects although several are of interest, for example:

- Investigator 18 (West): 8 m at 0.56% WO_3 at 200 m depth.
- Investigator 23: Mine Series untested.
- Investigator 2: C horizon untested.

Grassy Granodiorite — eastern and southeastern contacts

There may be continuity of ore southwards from the Southern ore zone in the Dolphin mine, through a potential ore zone called the Window to the southeastern contact of the Grassy Granodiorite (fig. 5; Brown, 1984). The strong aeromagnetic signature of the latter area suggests that there is a 3000 m strike interval of upper volcanic rocks extending along the southeastern contact of the granodiorite (fig. 3*a*, 3*b*, 6). If the Mine Series is present beneath the upper volcanic rocks, this area offers potential for a major new ore body comparable with the No. 1/Dolphin orebody (Brown, 1984). Ore potential is likely to be highest in the vicinity of the Grassy River Fault (Teredo prospect), which acted as one of the conduits for the mineralising fluids that produced the Dolphin orebody. Drill testing of the Window and Teredo prospects from the Grassy breakwater may be possible.

Bold Head mine and Power House areas

In contrast to the contact zones of the granitoid intrusions, little metamorphism or metasomatism is evident in the rocks that form the coastal exposures to the east and northeast of the Bold Head mine (Brown, 1989; Waldron *et al*., 1993; Calver and Walter, 2000). On the coast, 2.5 km north of the Bold Head promontory (fig. 2), the upper volcanic unit is downthrown against an unmetamorphosed and unaltered succession that is apparently equivalent to the Mine Series. Mineral Resources Tasmania's aeromagnetics (fig. 6) strongly suggest that this faulted contact extends inland to become the Grahams Road Fault (fig. 7), which downthrows the upper metavolcanic rocks against the section of Mine Series that contains the Bold Head orebody.

Prospectivity beneath the upper volcanic rocks in the block of country bounded by the Grahams Road Fault, the coast and the Grassy River Fault is likely to be highest in the west (Power House area), closer to the Grassy River Fault where Brown (1984) envisaged a number of possible settings for new mineralisation including those illustrated in Figure 8. He also considered that previous drilling on the south side of the Grahams Road Fault had not exhausted the possibility of a repetition of the Bold Head orebody closer to the Grassy River Fault (fig. 7).

The Power House area was covered by detailed, grid-based gravity, ground magnetics and a VLF survey (fig. 3*b*; Brown, 1983), but restrictions on exploration expenditure resulted in the data not being processed to the stage of defining drill targets. Granitoid depth contours (Leaman, 2003; fig. 12) derived from a combination of the grid-based gravity data and regional gravity data support the view that granitoid is present at shallow depth through the Power House block of country, but that it dips steeply east nearer the coast.

The Dolphin East prospect (fig. 9) lies east of the Dolphin orebody, on the eastern side of the Grassy River Fault, and presents essentially the same opportunities as the Power House block of country. A diamond-drill hole collared in the Dolphin mine workings passed east of the Grassy River Fault, but was terminated at -500 m RL while still in upper volcanic rocks (Brown, 1984).

Prospects elsewhere on King Island

Integrated MRT/AGSO aeromagnetics (fig. 10) provide a strong indication that the magnetically distinctive, upper volcanic rocks strike NNE, extending offshore of King Island's east coast. The aeromagnetic pattern further suggests that Mine Series equivalents may be present adjacent to the offshore, eastern contact of the Sea Elephant Adamellite. Mineralised skarns may therefore be developed in this currently inaccessible location.

At Reekara, to the west of the Sea Elephant Adamellite, there are quartz-tourmaline veins that carry tungsten mineralisation and subordinate tin mineralisation (fig. 1, 10, 11; Hughes, 1955). Little modern work has been done in the area. Brown (1984) highlighted a possible relationship between the veins, an inferred extension of the Grassy River Fault, and a possible subsurface ridge extending west from the Sea Elephant Adamellite. He canvassed the possibility of a Mt Carbine-style, vein stockwork being present in the Reekara area. The gravity-derived, granitoid depth contours (fig. 12) substantiate the view that there is a shallow, subsurface ridge of granitoid in the Reekara area.

Thorium radiometrics

There is clearly a range of geological materials in eastern and southeastern King Island that have high thorium (fig. 14) and uranium radiometric signatures, including the heavy mineral sands at Naracoopa and Cowper Point. The correspondence, and near correspondence, of high thorium radiometric values with the Bold Head deposit, the Dolphin deposit and Grassy Open Cut, the tailings dam (just northeast of the Dolphin deposit), and the northwest and western margins of the Grassy Granodiorite (fig. 13) suggest that high thorium radiometric values may also be an indicator of scheelite mineralisation. On this basis, the areas of high thorium radiometric values north of the Bold Head Adamellite, in the Power House block of country, at Reekara and possibly elsewhere warrant further investigation.

Tenement and environmental situations

Following closure of the Dolphin workings in 1990 the plant, power house and other mine structures were dismantled and removed. The various sites were rehabilitated (Miedecke and Partners, 1991) and the open pit and underground workings were allowed to flood. A plan of procedures for the reopening of the Dolphin mine has been prepared by Fudge (1991*b*).

King Island Scheelite Ltd had become part of the North Group by 1990 and was subsequently acquired by CRA/Rio Tinto when that company took over the North Group. In 1998 most of the previous mining lease in the Grassy district was converted to a retention licence (RL2/1998) and in 2002 ownership of this licence was transferred to Australian Tungsten Pty Ltd of PO Box 617, Applecross, WA 6953. By virtue of its *King Island Scheelite Agreement* of 2002, North Mining Ltd continues to claim a right/interest in the tenement and has lodged a caveat to this effect with the Registrar of Mines, Mineral Resources Tasmania.

Conclusions

The Dolphin orebody has the potential for 4.73 Mt of remaining reserves and resources and has the attraction of possible continuity through the Window prospect to the potentially large Teredo prospect. The Grassy open cut/No. 1 orebody contains 0.62 Mt of remaining resources, and another 1.8 Mt of resources may remain in the Bold Head orebody with the potential for some additional resources in untested blocks adjacent to the mine workings. There is excellent potential for new tungsten resources to be delineated in the Power House block of country south of the Bold Head mine, and also in the northern and western contact zones of the Grassy Granodiorite and elsewhere on King Island.

The existence of substantial known tungsten reserves and resources, together with the potential for new tungsten resources, make King Island an attractive target for further exploration and redevelopment. Such activity would be encouraged by future improvement in the general market conditions for tungsten. More immediate encouragement may derive from the metal's strategic importance, either in the case of corporations that may wish to diversify their sources of tungsten, or in a national context. These latter possibilities provide promotional opportunities for investigation by Mineral Resources Tasmania.

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[19 March 2003]

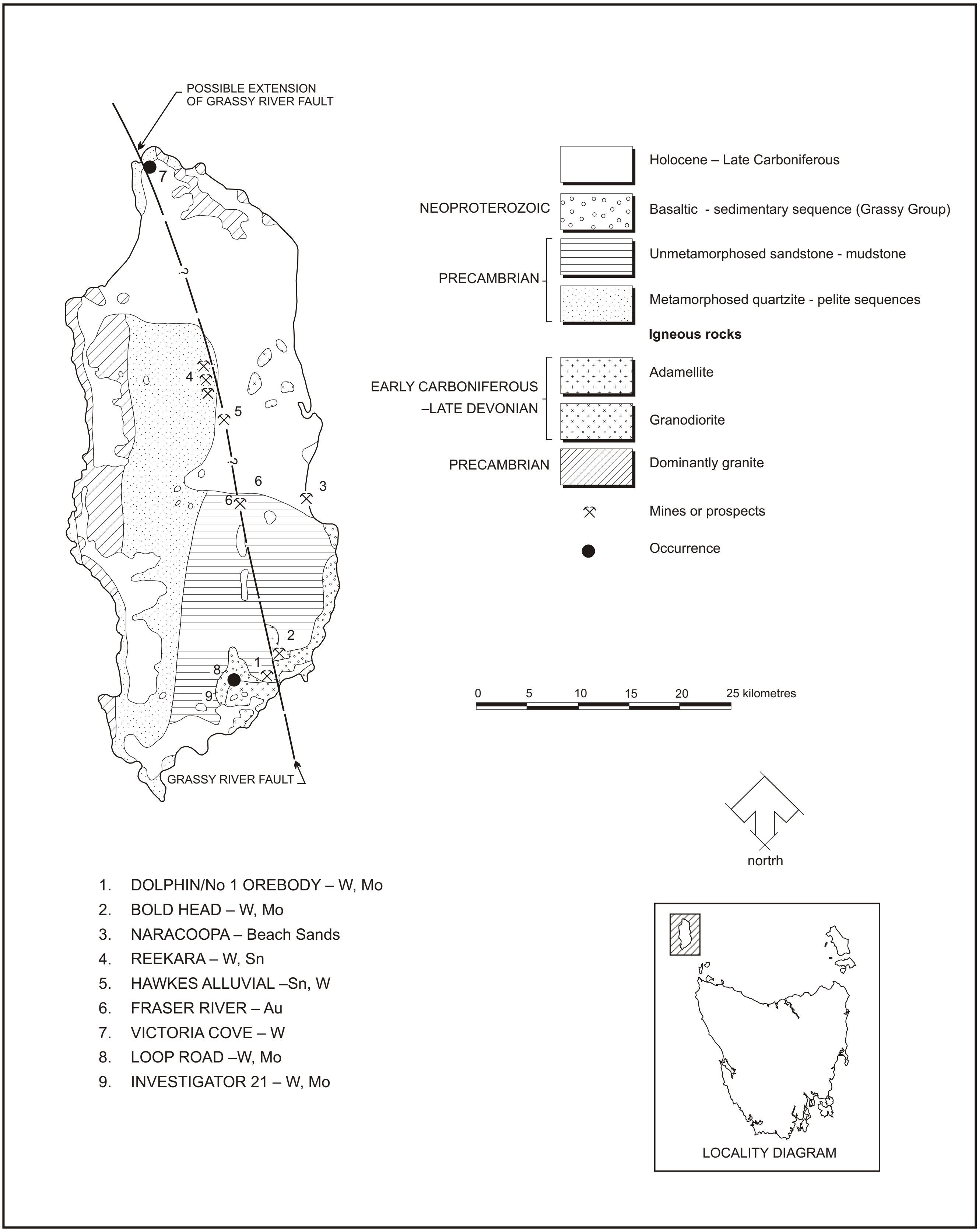


Figure 1

King Island geology and mineral deposits
Source: Brown, 1982b (TCR 93-3454)

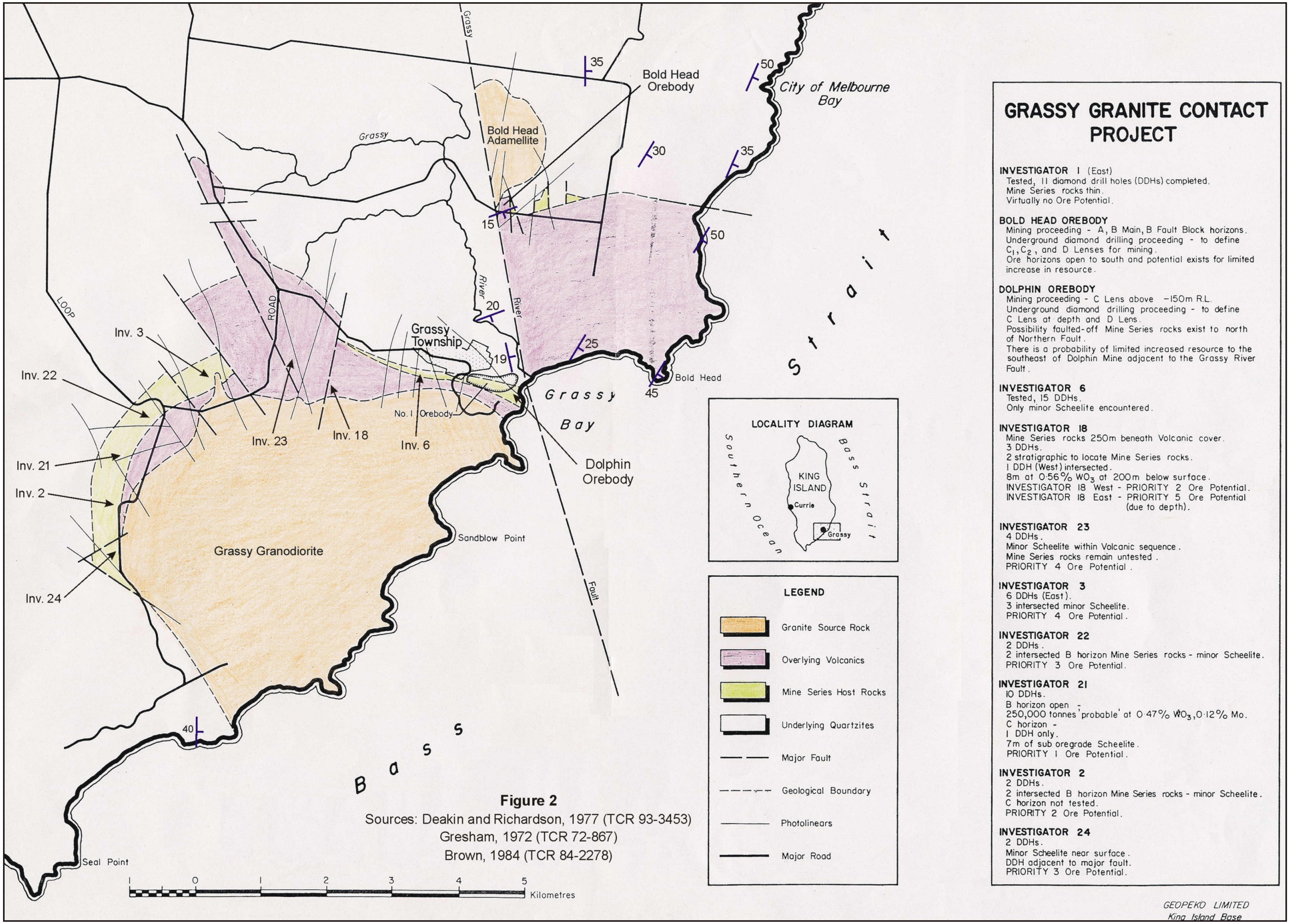


Figure 2

Sources: Deakin and Richardson, 1977 (TCR 93-3453)
Gresham, 1972 (TCR 72-867)
Brown, 1984 (TCR 84-2278)

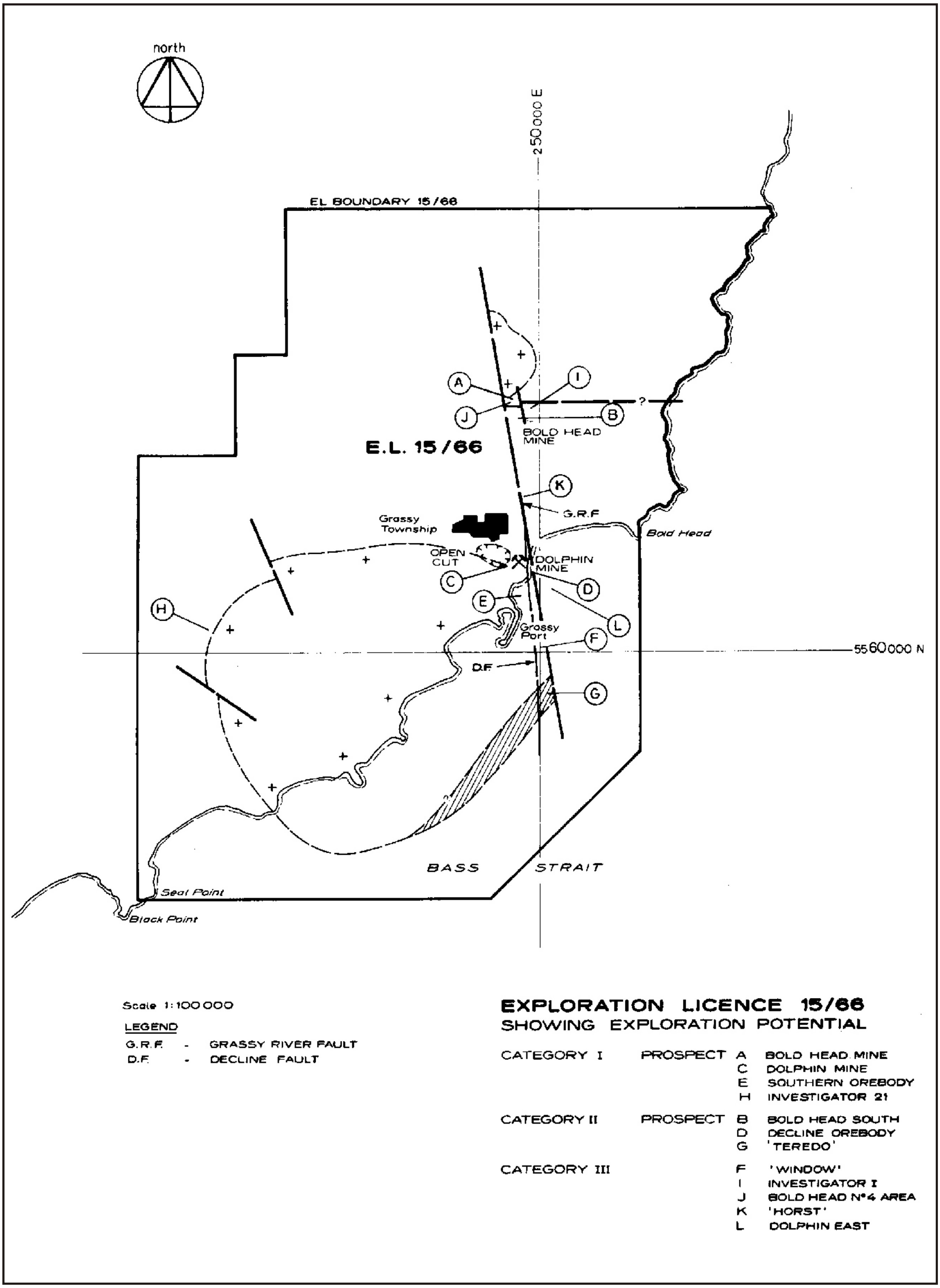


Figure 3*a*

Grassy district — exploration potential
Source: Brown, 1984 (TCR 84-2278)

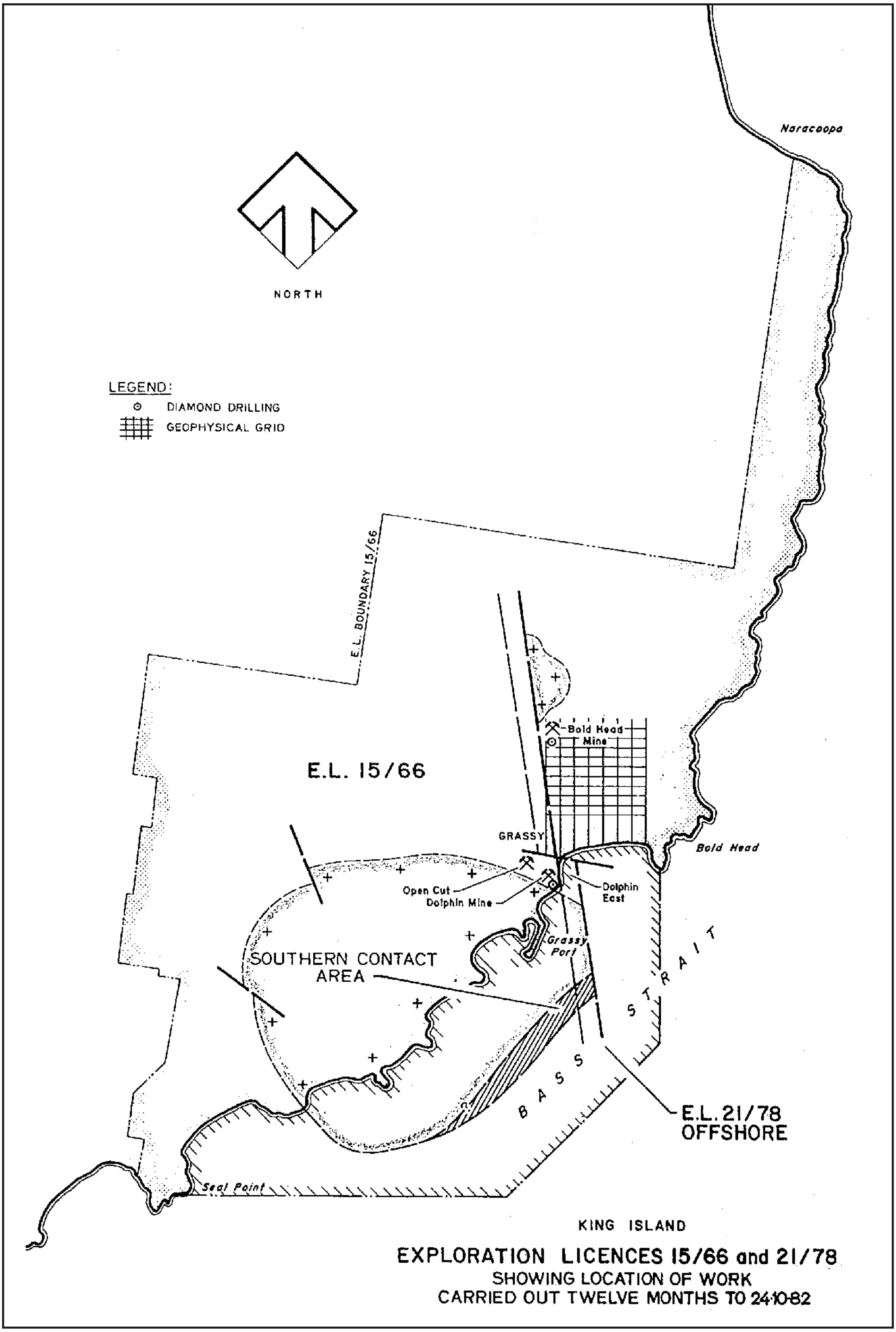


Figure 3*b*

Grassy district — Power House area grid. Source: Brown, 1982b (TCR 93-3454)

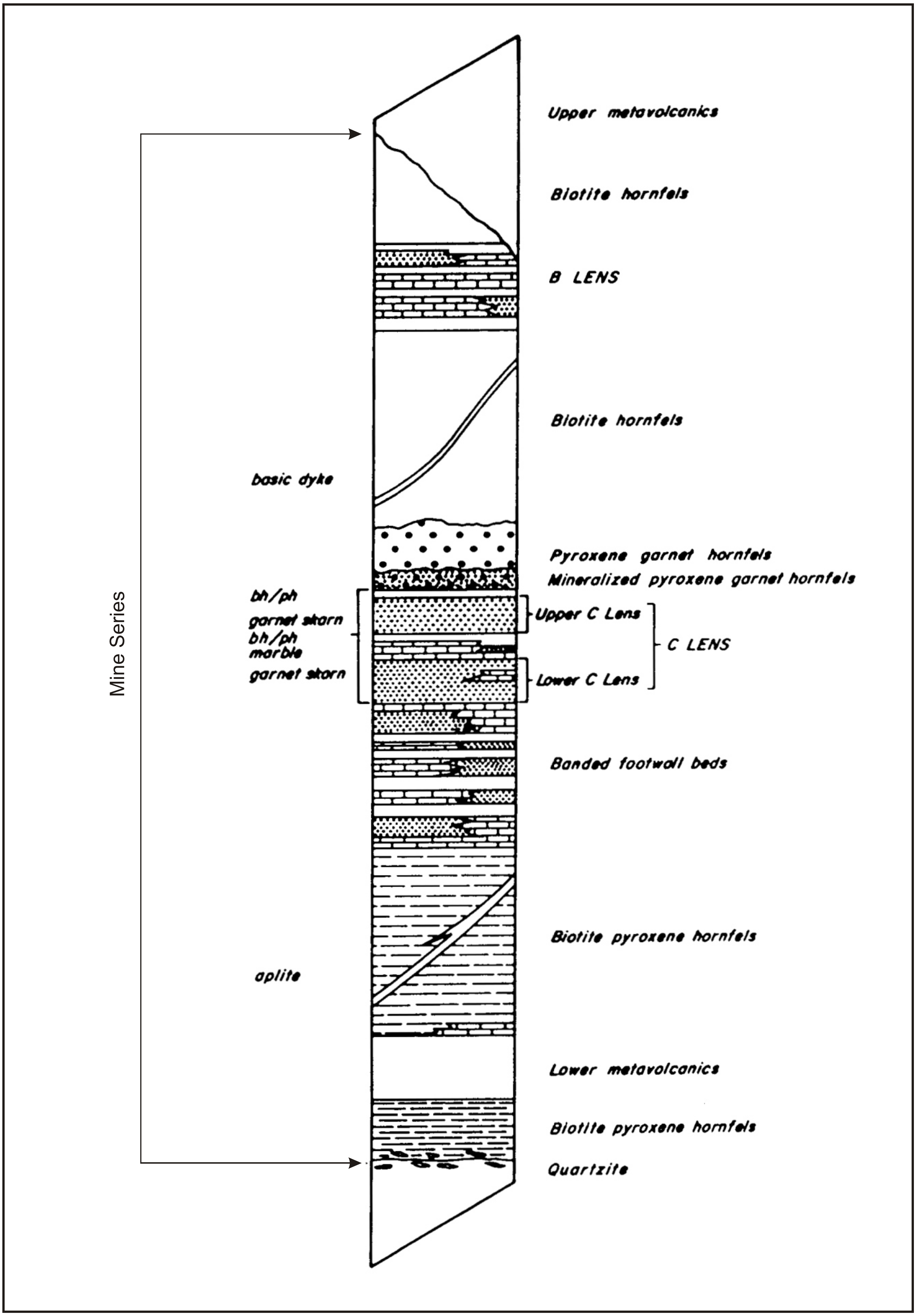


Figure 4

Stratigraphic succession, Open Cut and Dolphin Mine
Source: Brown, 1987 (TCR 87-2746)

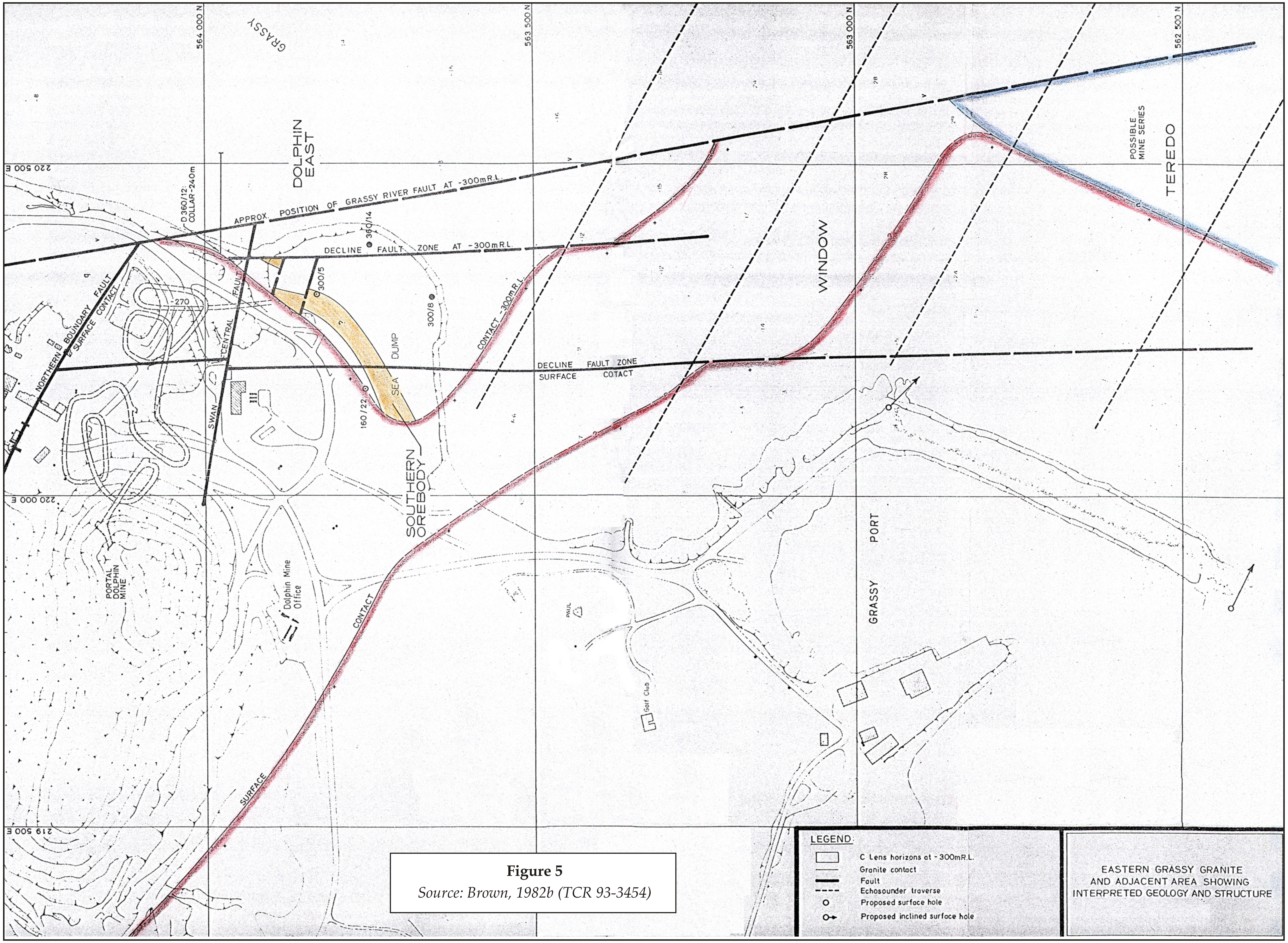
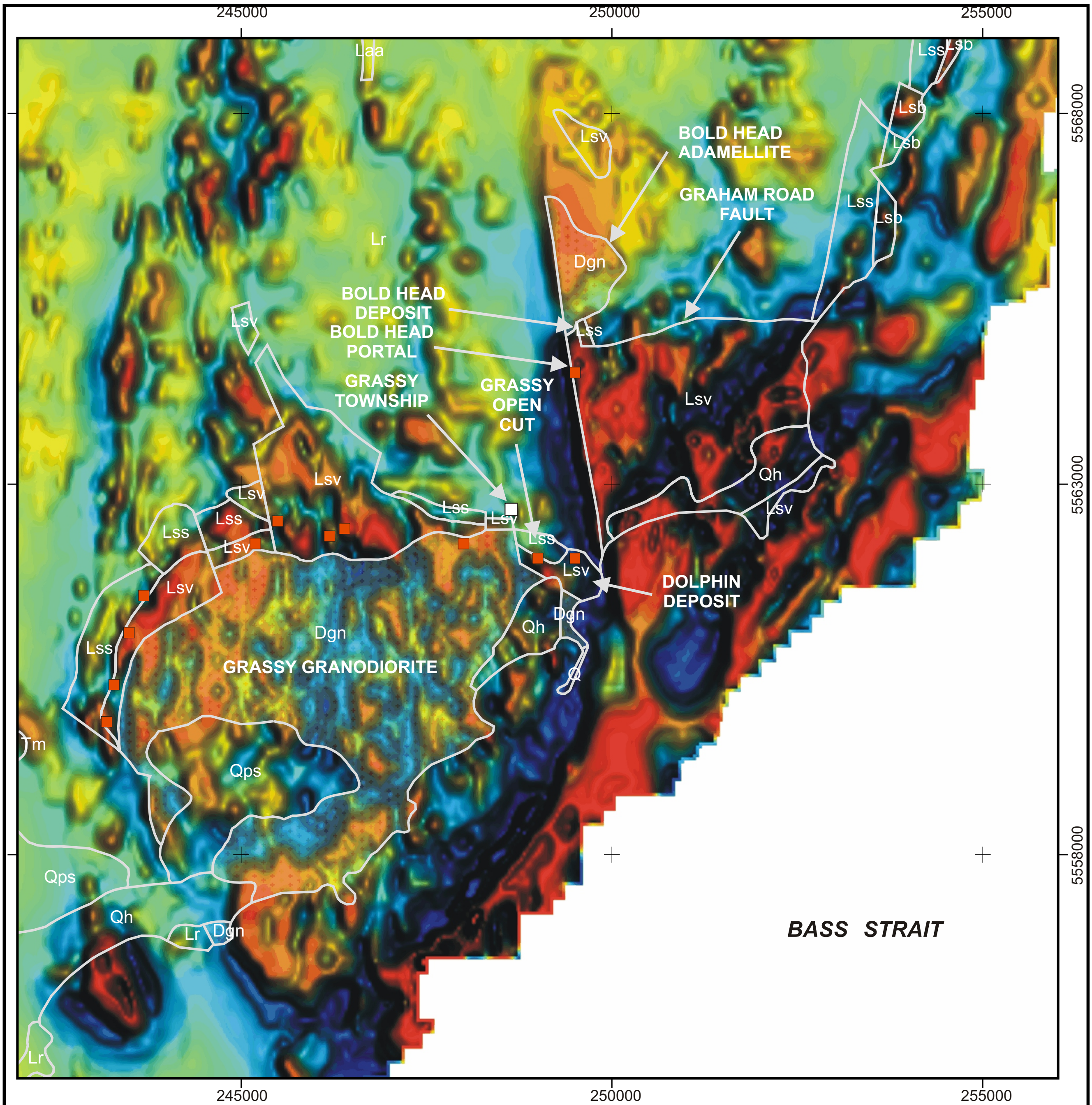


Figure 5

Source: Brown, 1982b (TCR 93-3454)



Legend

Devonian granitoid

Tungsten deposits and prospects

Magnetic HIGH

Magnetic LOW

Geological boundaries and descriptive symbols are derived from MRT 1:250 000 'Geology of NW Tasmania'. Positions of the boundaries are approximate and do not appear to exactly match the geophysical data north and west of the Grassy Granodiorite. Grid shown is the Australian Map Grid, AGD66, Zone 55.

N

S

1 0.5 0 1 2 3 Kilometres

Figure 6

Grassy district, King island, 1st vertical derivative of total magnetic intensity, with overhead illumination. WTRMP survey, 200 m spaced E-W flightlines, mean terrain clearance 82 metres.

Image processing and map production by: Alistair Reed, EarthSearch, in consulatation with Ken Morrison and Nic Turner.

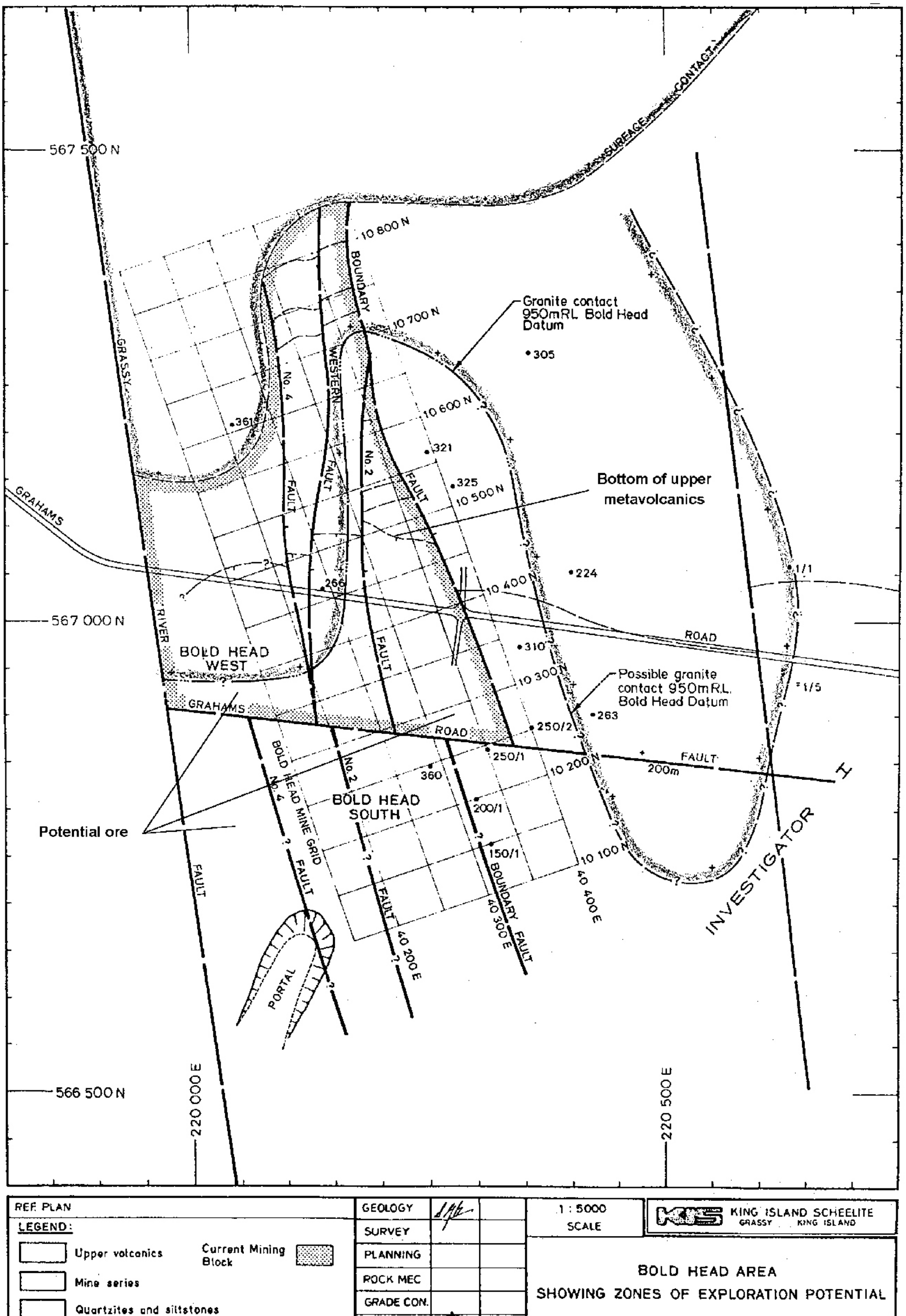


Figure 7

Source: Brown, 1982b (TCR 93-3454)

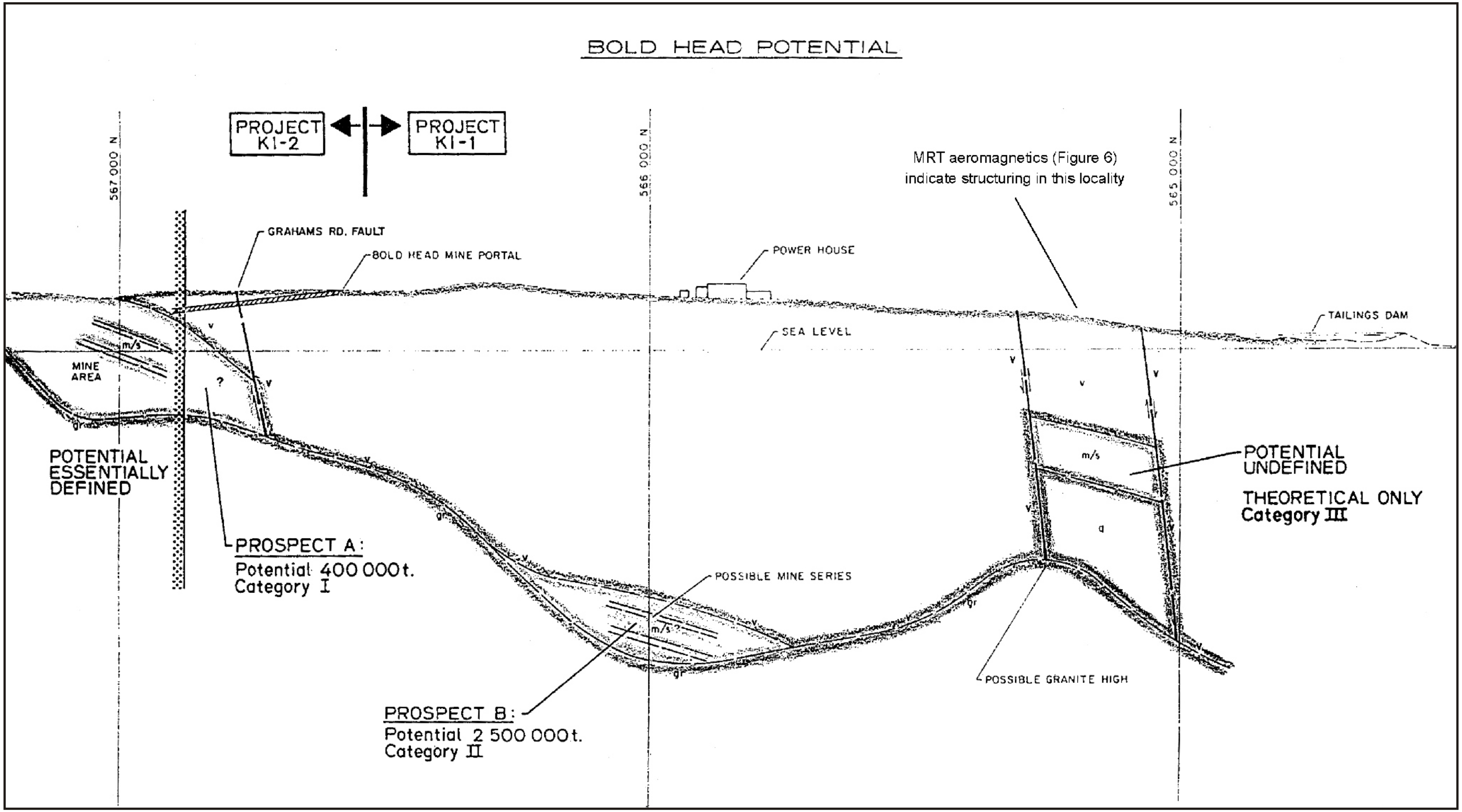


Figure 8

Bold Head schematic section showing possible situations with ore potential

Source: Brown, 1982b (TCR 93-3454)

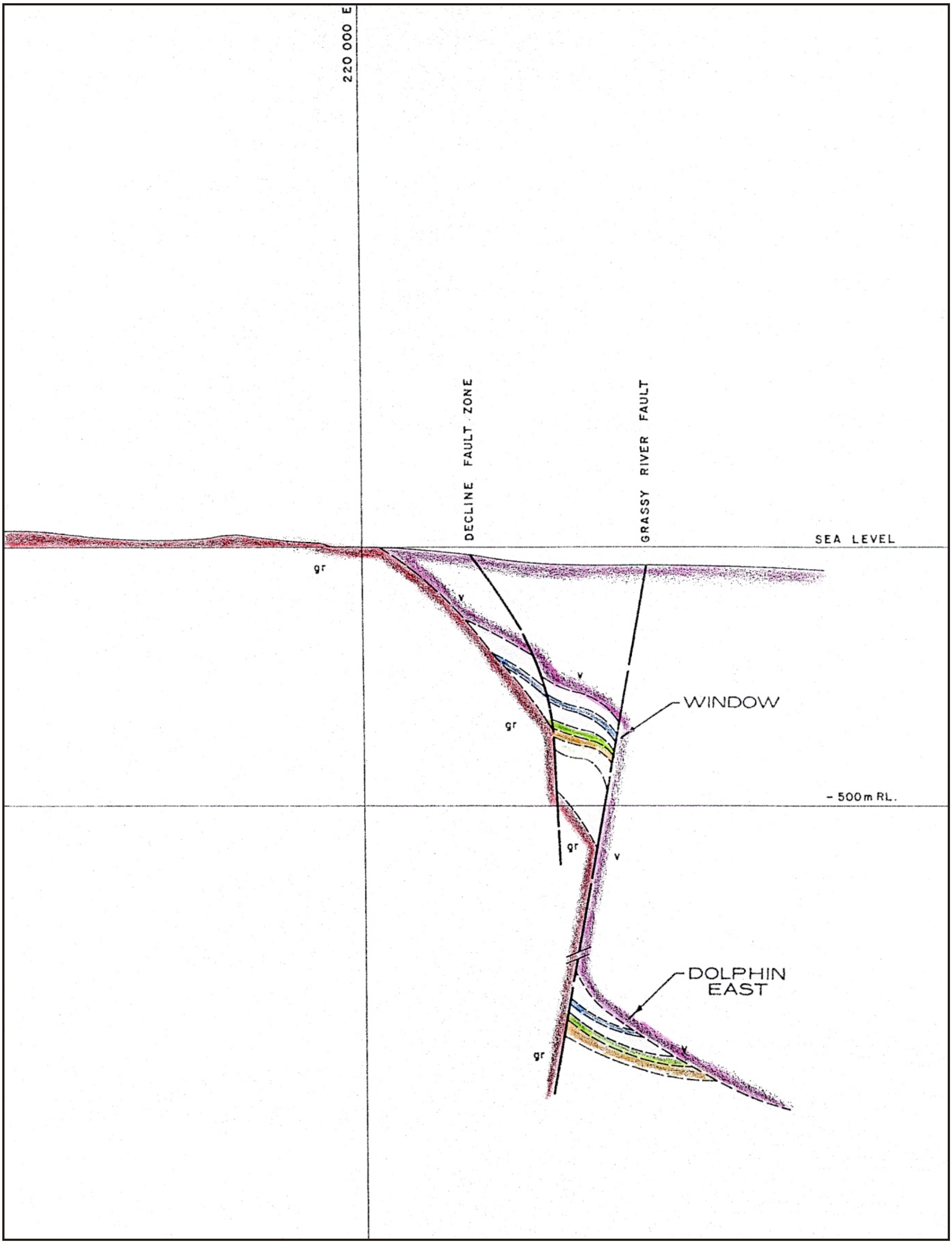


Figure 9

Dolphin East prospect — Schematic longitudinal section, 563 500 N
Source: Brown, 1982b (TCR 93-3454)

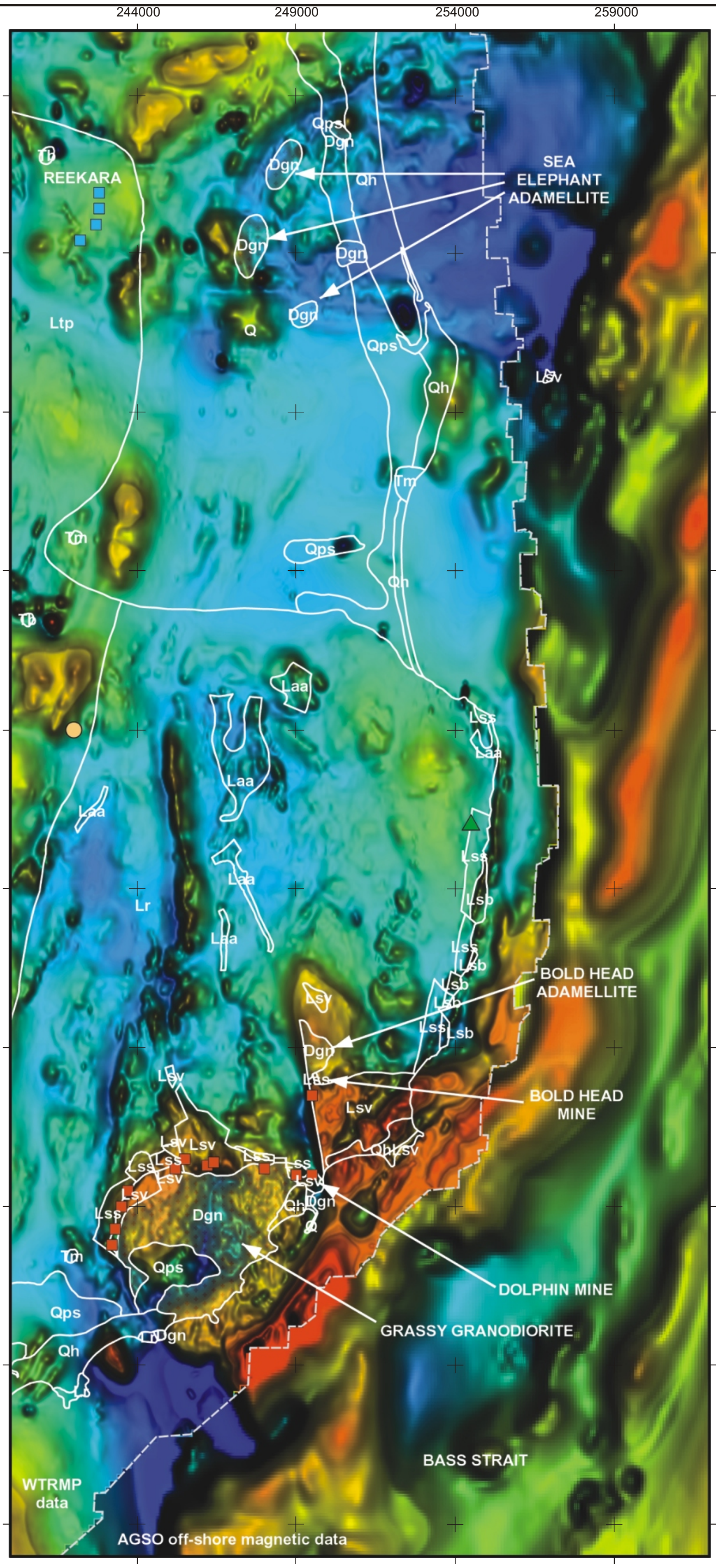


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Image processing and map production by: Alistair Reed, EarthSearch, in consulatation with Ken Morrison and Nic Turner.

Legend

- Silver, lead, zinc deposits and prospects
- Gold deposits and prospects
- Tin deposits and prospects
- Tungsten deposits and prospects
- Devonian granitoid

Magnetic HIGH

Magnetic LOW

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N
S

1 0 2 5 kilometres

Figure 10
East and southeast King Island, total magnetic intensity, with overhead illumination. WTRMP survey, 200 m spaced E-W flight lines, mean terrain clearance 82 metres. AGSO data collected on 400 m spaced, E-W flight lines, with a mean terrain clearance of 135 metres.

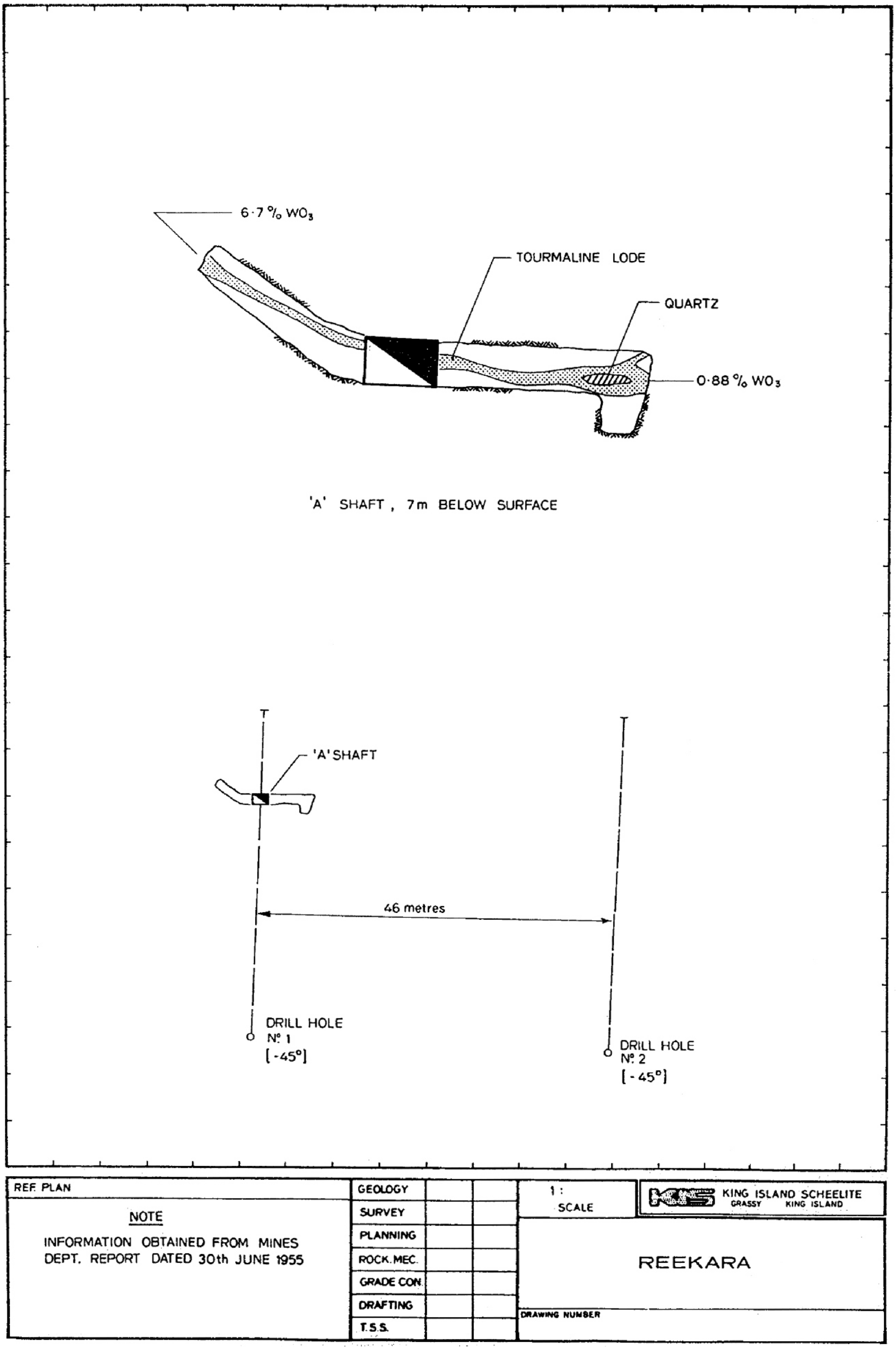


Figure 11

Old prospecting work, Reekara area. Source: Brown, 1982b (TCR 93-3454); see Hughes, 1955

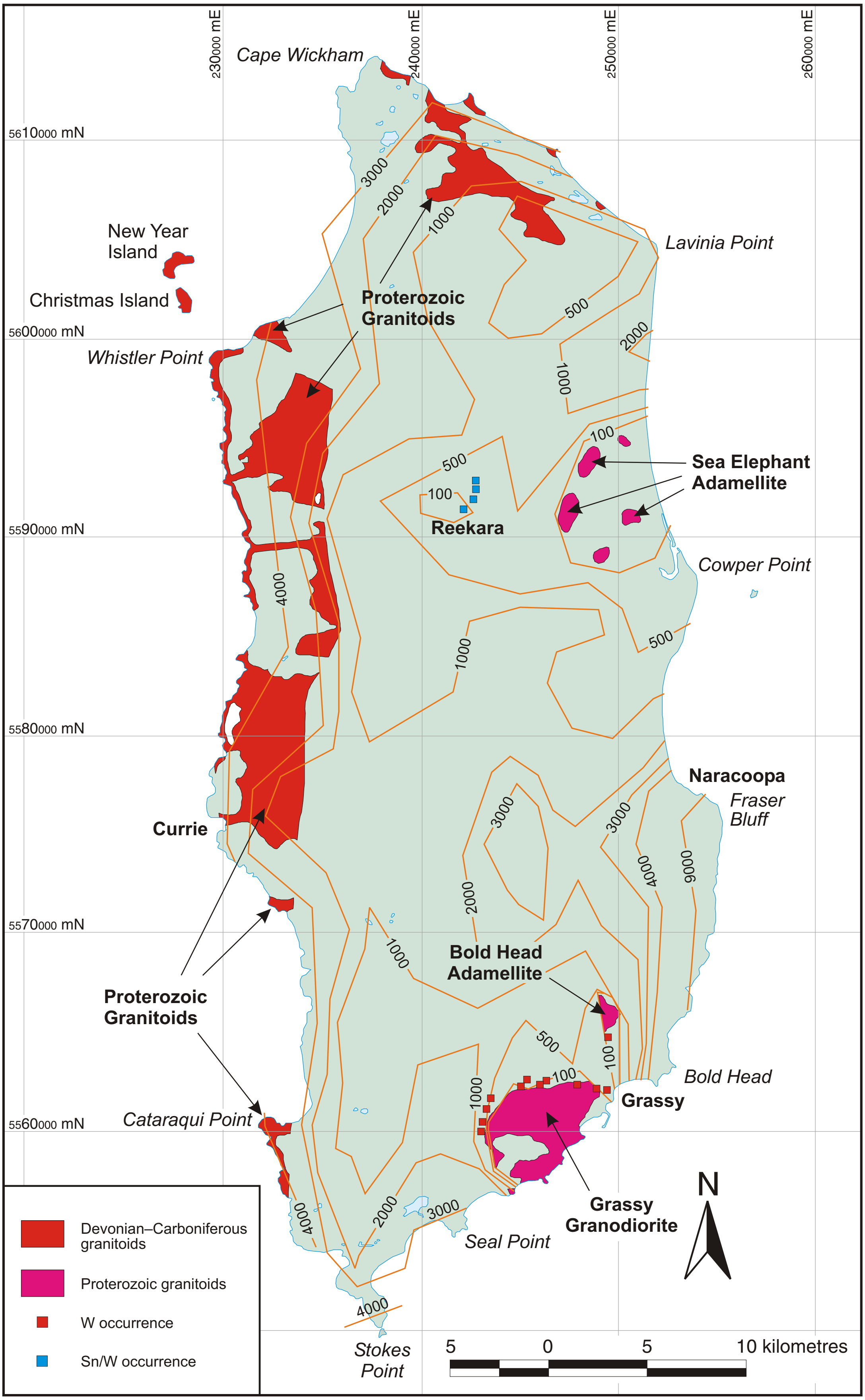
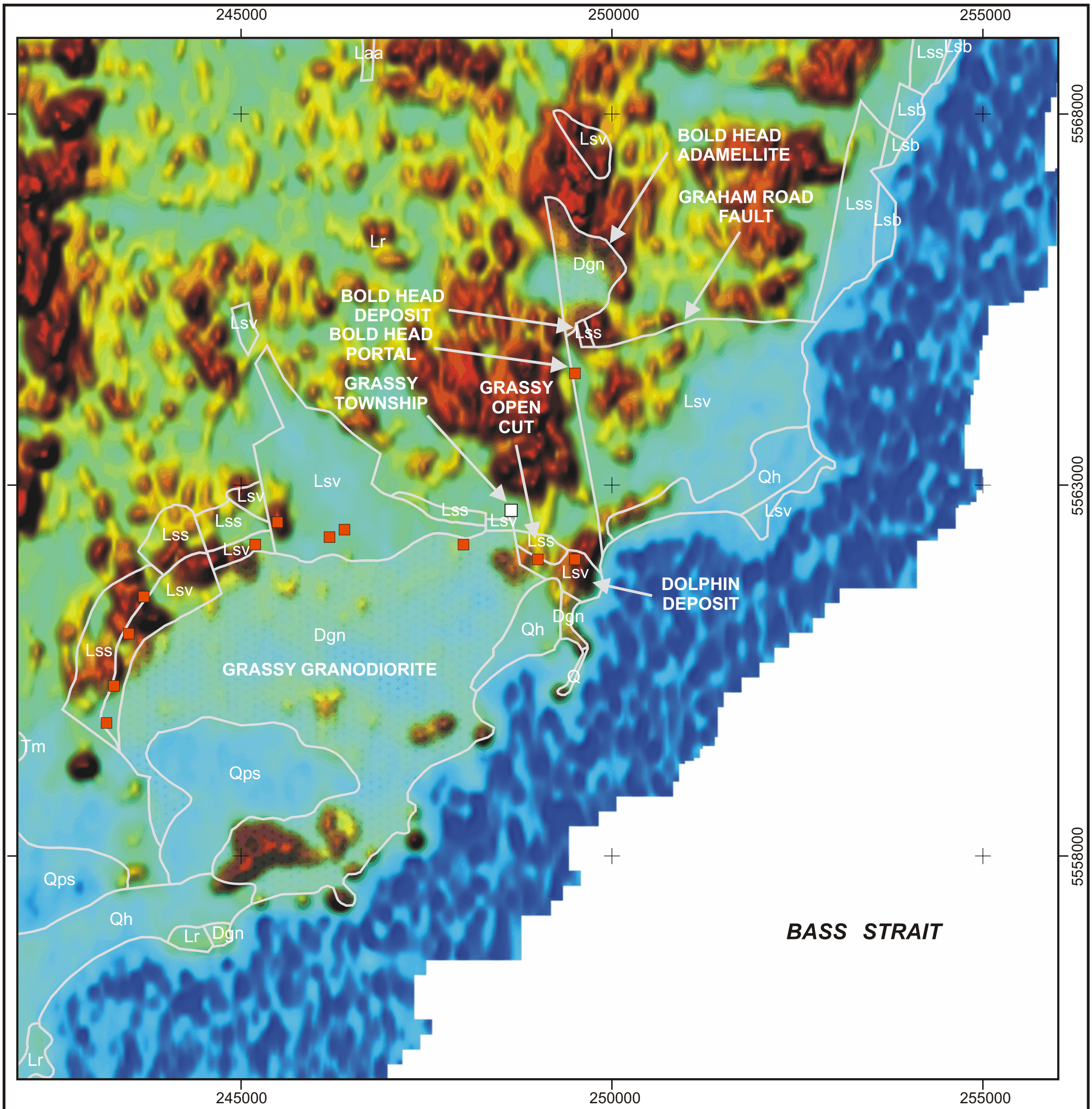


Figure 12

Interpreted granitoid depth contours with depth to top of granitoid shown in metres. Derived from MRT gravity database by Leaman (2003). The pattern is thought to reflect extensive subsurface Devonian–Carboniferous granitoid with little influence from Proterozoic granitoids. Granitoid outcrops are from MRT 1:250 000 scale Geology of Northwest Tasmania *(Calver et al., 1995). W and Sn/W occurrences are from the MRT Mirloch database. Grid is AMG, AGD66, Zone 55.*



Legend

Devonian granitoid

Tungsten deposits and prospects

Radiometric HIGH

Radiometric LOW

N

S

1 0.5 0 1 2 3 Kilometres

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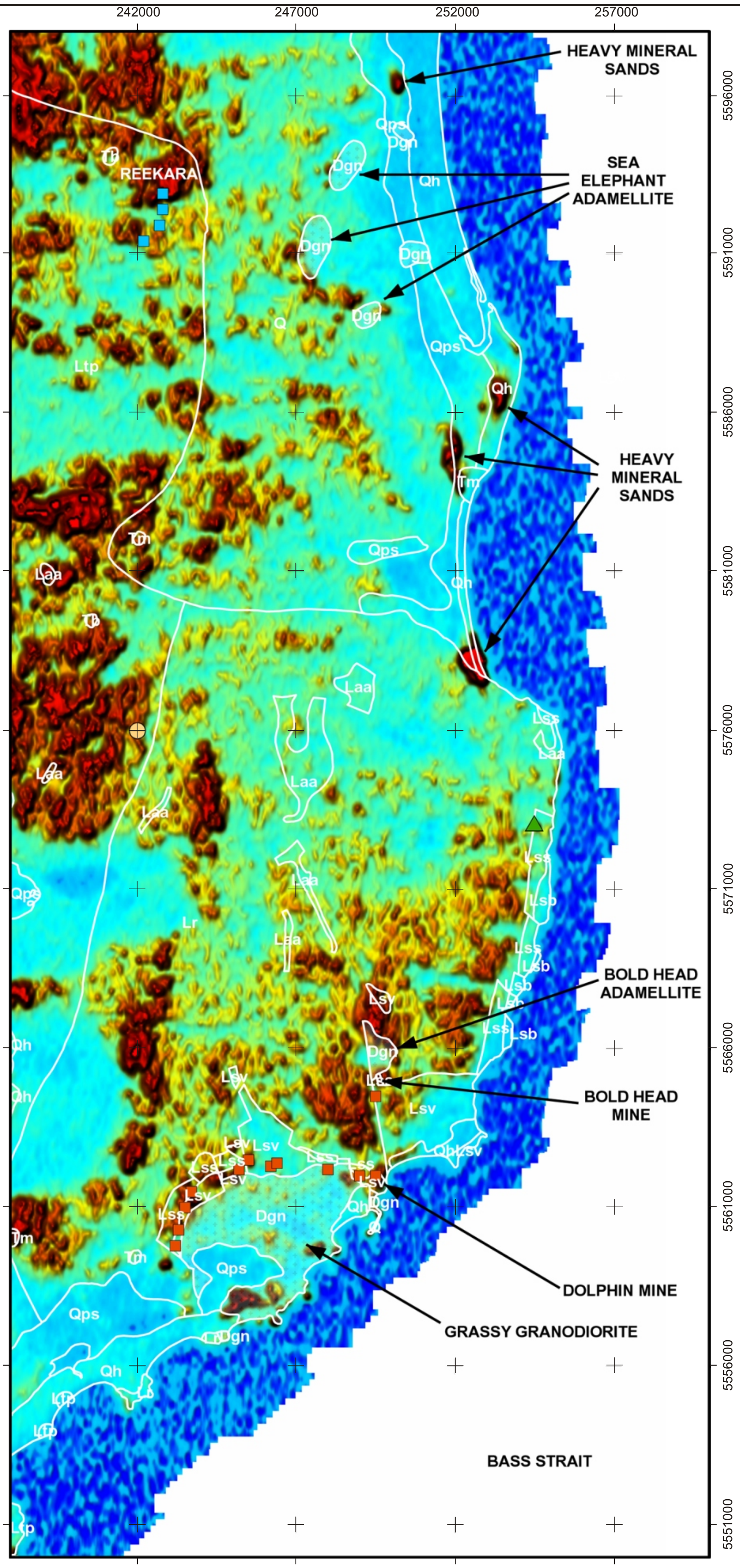
Figure 13

Grassy district, King island, thorium radiometric image, with overhead illumination. WTRMP survey, 200 m spaced E-W flightlines, mean terrain clearance 82 metres.



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Legend

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Radiometric HIGH

Radiometric LOW

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N

S

1 0 2 5 kilometres

Figure 14

East and southeast King Island, thorium radiometric image, with overhead illumination. WTRMP survey, 200 m spaced E-W flight lines, mean terrain clearance 82 metres.