

# Comments on Geothermal Exploration

## In Northeast Tasmania

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### Summary

#### **Possible geothermal areas**

An initial glance over the Geopower lease area brought up four initial geothermal possibilities at relatively shallow depths.

1. Great Forrester River
2. Middle Great Musselroe River
3. Great Northern Plains – Boobyalla Sub-basin
4. Mathinna sediments area to north-east of Gladstone

The first two of these were quickly ruled out by existing drill hole data. In both cases the underlying granite was covered only by shallow recent alluvium and had been previously exposed for a significant portion of its geological existence.

The Boobyalla Sub-basin is a Cretaceous trough, with granite (under Boobyalla) at depths of probably between one and two Km. There appears to be current hydrothermal activity along the eastern fault of the basin carrying considerable radiation and implying continuing radiation heating at depth. However, the granite may have been temporarily unroofed during Carboniferous times very soon after its intrusion, before being covered again by Permian sediments. There would be a possibility of a naturally fractured hot rocks situation on the eastern side of this basin similar to (but more restricted than) that described by Kuth from their Midlands exploration.

An E-W strip of Mathinna sediments, extending N-S from about the Grande Flaneur mine in the north to half way between the Bluebell and Portland mines in the south appears to lie above the highly radioactive granites to the north. There is some evidence from magnetics that temperatures in the overlying Mathinna have been, and may even still remain, above the Curie point for ferromagnetism in whatever forms the N-S magnetic anomalies in the area. This area would, at this stage, rate as the most promising for an initial geothermal investigation, with easy access across fairly flat privately-owned farmland and open bushland. Diamond drilling in this area could also have the useful side-effect of helping to sort out where the local gold went to.

## **A comment on exploration methods**

Seismic methods may not produce useful data. Dr Bob Richardson (pers. comm.) has attempted seismic in the Boobyalla area, and comments that the highly weathered surface of the granite produces a gradation in wave velocity rather than any definite reflective or refractive surface. My own attempts at reflection seismic NE of Pioneer also ran into confusion due to shallow “greybilly” produced by silica-rich hydrothermal fluids above greisens and granite fractures. However, while such difficulties exist above the Poimena granites, and may be reasonably assumed to exist elsewhere, it is not certain. A trial seismic may be worth attempting south of the “Grande Flaneur granites”, but perhaps not with great hopes of success. Yet, if it does work, it could produce some very useful data.

Obtaining more detailed gravity data should, I think, be held back from until the new MRT data is published in July (hopefully), otherwise all that may be achieved could be to duplicate data already obtained by MRT.

The use of fairly small (NQ-size?) drill holes to depths of 100 to 200 m to obtain geothermal gradients, followed later by magnetotellurics if justified, would seem to be the main methods. Some remote heat-sensing could be looked into for the fairly open and sparsely vegetated Mathinna sediments area N of Gladstone, but probably would not work well for the swampy Boobyalla Sub-basin area.

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## Looking at available data for NE Tas.

### A Radiometrics

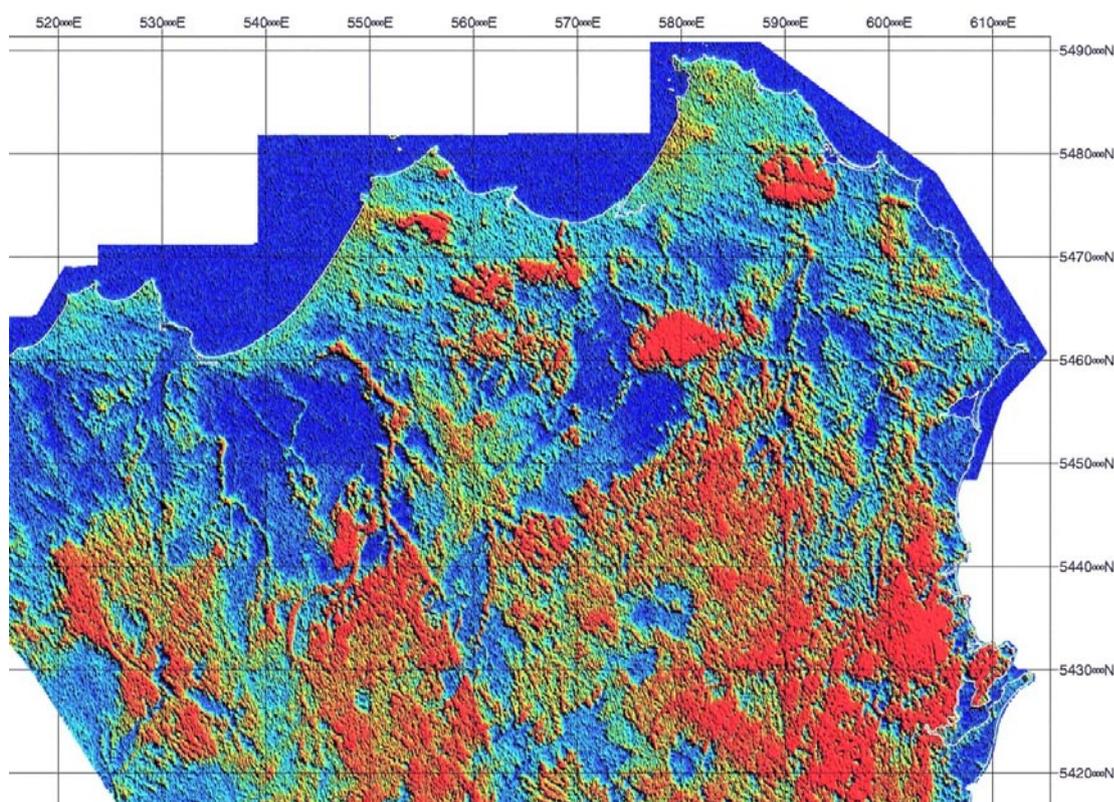
(The following useful summary is taken from Victorian Primary Industries website)

**Potassium** measures the part of energy spectrum which relates to the decay of K40 isotopes. It is usually presented in units of equivalent percent (%). The potassium response varies with the mineralogy of the soils and rocks at the Earth's surface. Potassic minerals include some feldspars (especially orthoclase), muscovite mica, illite and some montmorillonite clays.

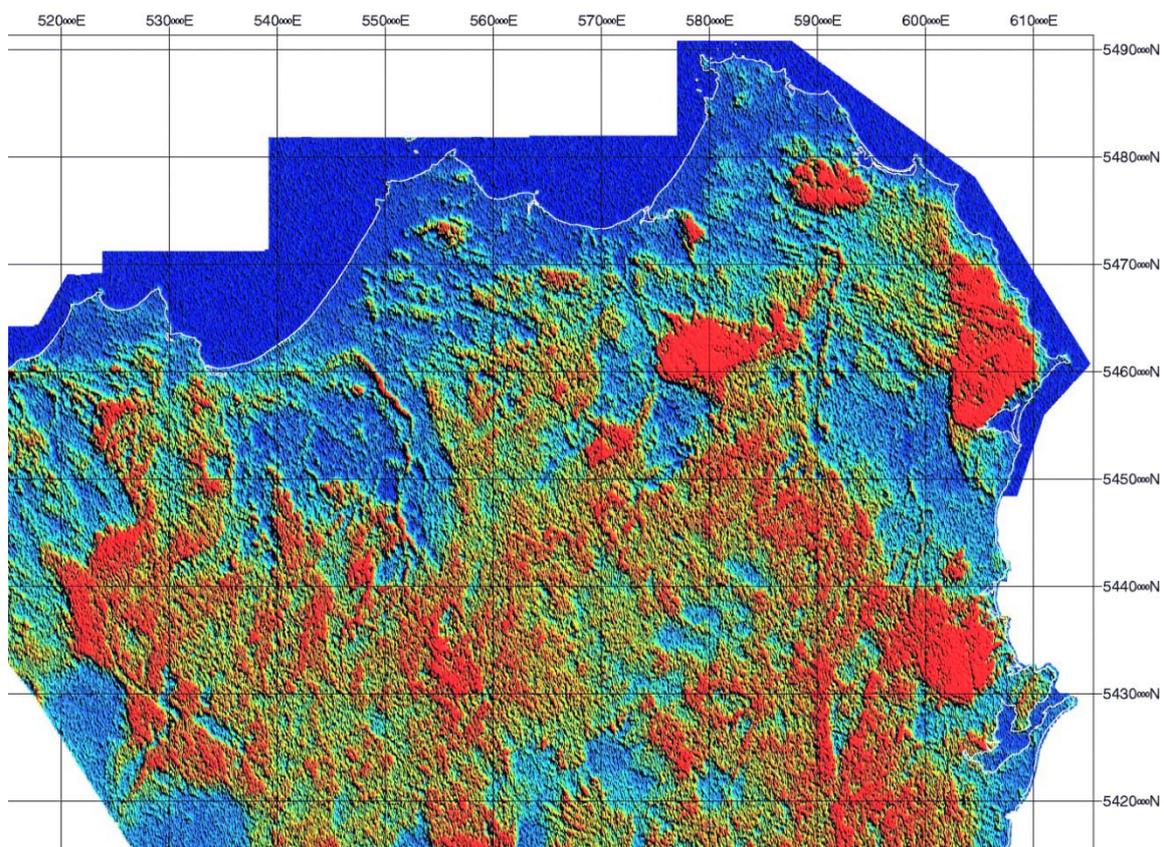
**Thorium** measures the component of the energy spectrum which relates to the decay of Th232 isotopes, and is usually presented in units of equivalent parts per million (ppm). Monazite, thorianite, thorite and xenotime are among the thorium-rich minerals usually present in granites.

**Uranium** measures the window of the energy spectrum used to detect the decay of U238 isotopes, and is usually presented in equivalent parts per million (ppm). Typically, the uranium channel is the most 'noisy' as many rocks contain small amounts of uranium minerals such as uraninite and torbernite.

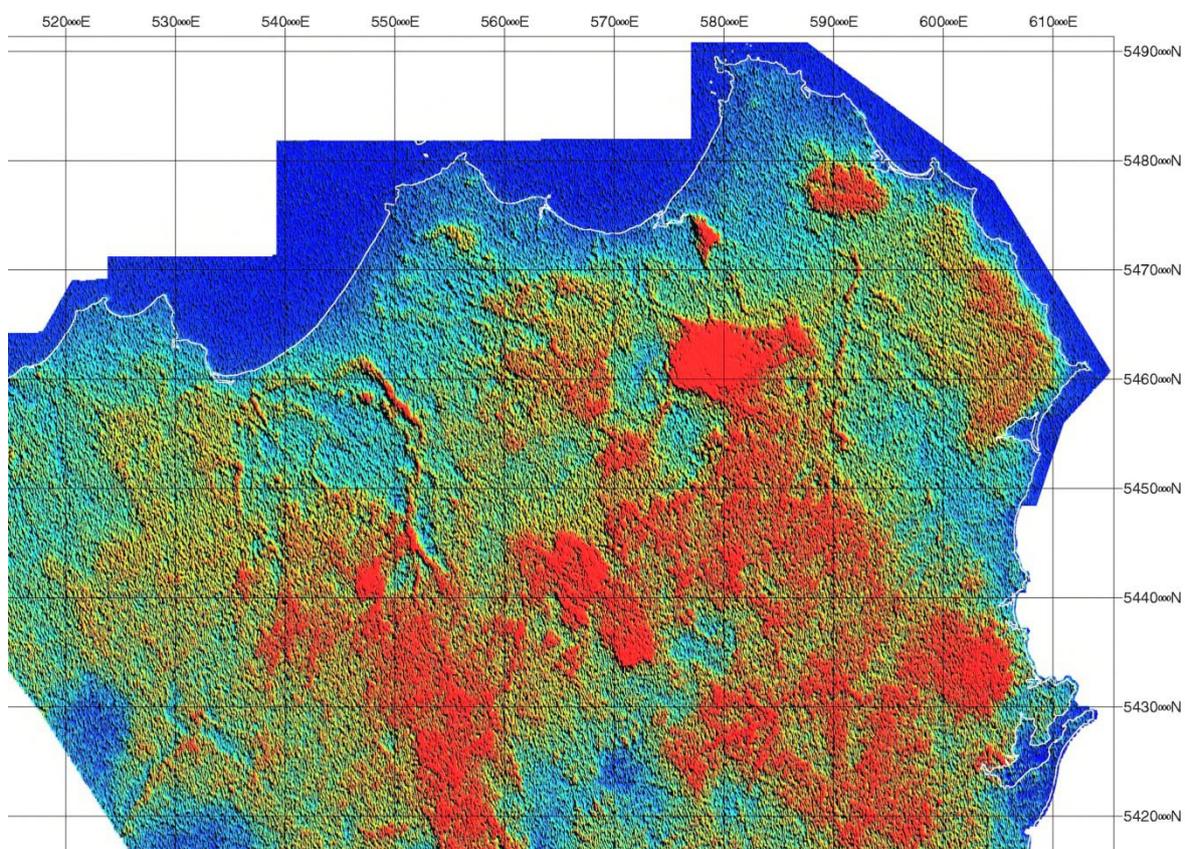
The three radiometric channels covering Geopower's lease are given below.



**Figure 1:** Potassium channel (from Mineral resources Tasmania)



**Figure 2:** Thorium channel (from Mineral resources Tasmania)



**Figure 3:** Uranium channel (from Mineral resources Tasmania)

All the exposed granites are picked out well by both the uranium and thorium channels, with the potassium channel probably picking out clays and micas derived from the granites and ignoring much of the Eddystone batholith.

The elongated roughly N-S traces appear curious at first, but are revealed as following the river system, with the Great Musselroe River and the Forester River featuring prominently. This can be seen in figure 4 (compare with figure 3), where a NE Tas map is superimposed on the uranium channel.



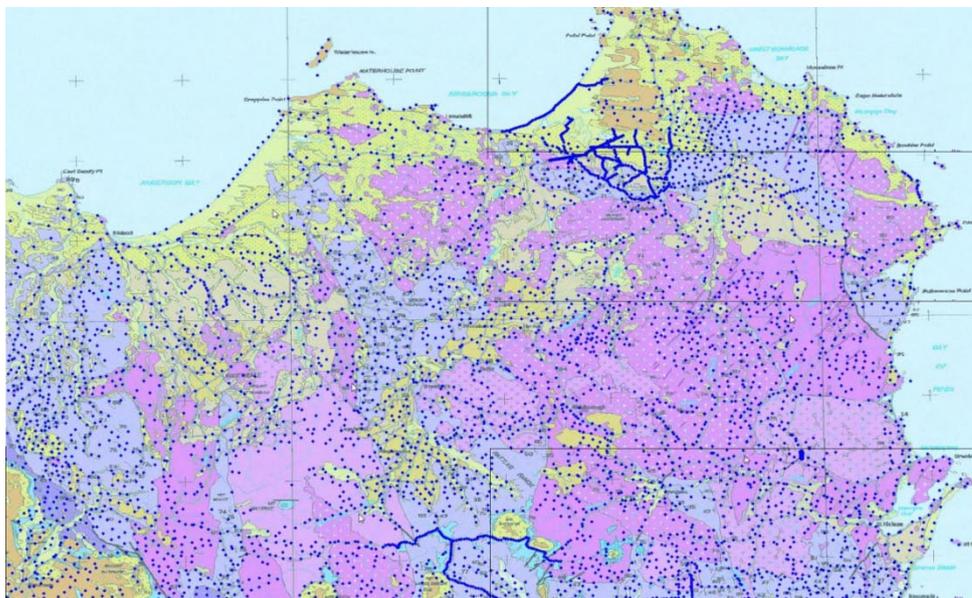
**Figure 4.** NE Tas. Map superimposed on the uranium radiometric channel. The Great Musselroe and Forester rivers show up as radioactive traces.

That rivers draining granite areas should show up as radiometric traces is not very surprising, and nor is the observation that those rivers mainly follow one of the two major fault and fracture directions in the area (either NW to NNW-trending or NNE-trending).

The only curious thing is that the most radioactive sections of these rivers tend to be isolated in horizontal distance from exposed granites, which could indicate a hydrothermal source for the radioactive fluids (through fracture zones) rather than surface drainage.

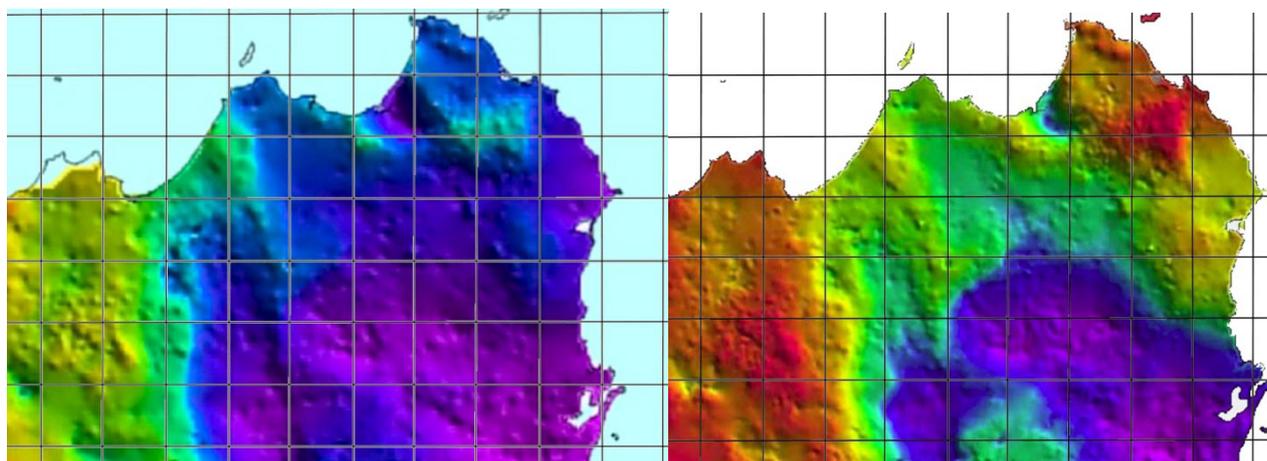
## B. Gravity

Gravity station coverage of the Geopower lease area, as shown in the MRT database is shown in figure 5.



**Figure 5.** Gravity stations coverage of Geopower lease area (from Mineral resources Tasmania). Note: 20 km grid.

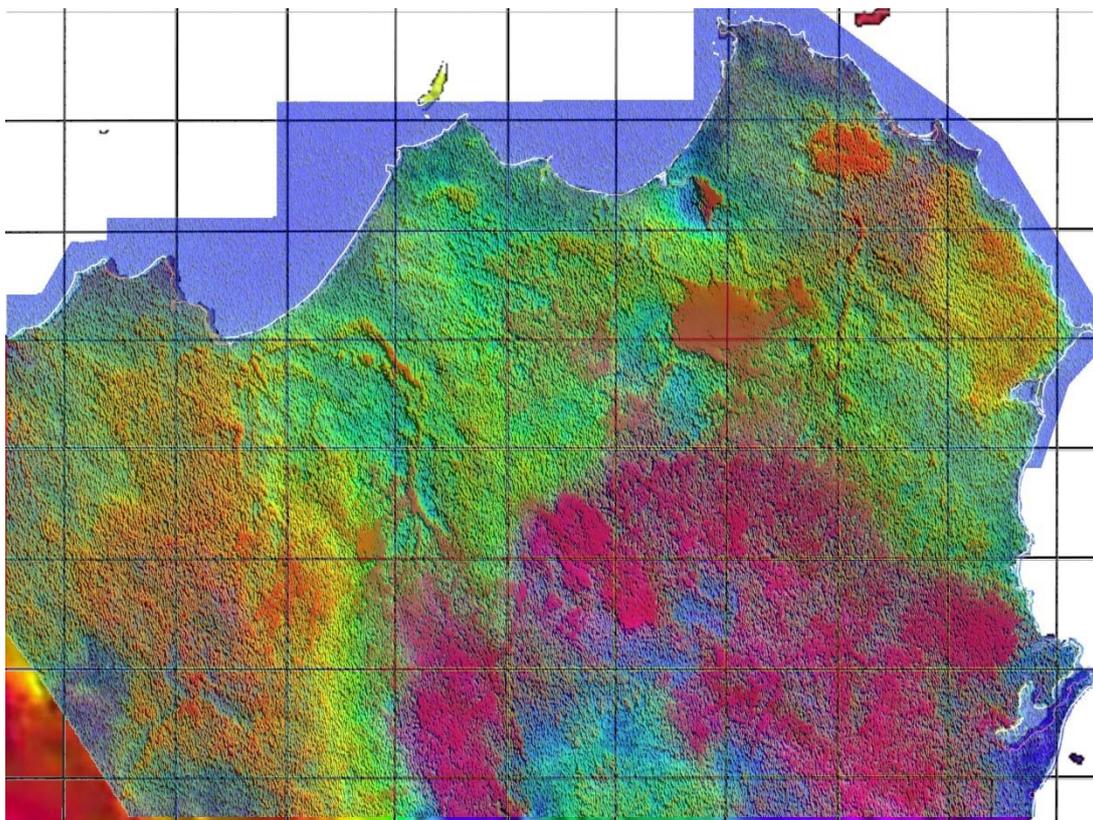
A preliminary residual gravity map produced by MRT (2008) is shown below. A 2003 MRT gravity map merely places the shading at different gravity contours. Both these maps have been used below, depending on the area being examined.



(a)

(b)

**Figure 6.** (a) MRT 2003 residual gravity map of NE Tas. (b) MRT Preliminary 2008 residual gravity map.



**Figure 7.** MRT Residual gravity map (b) overlain on MRT U-radiometric map.

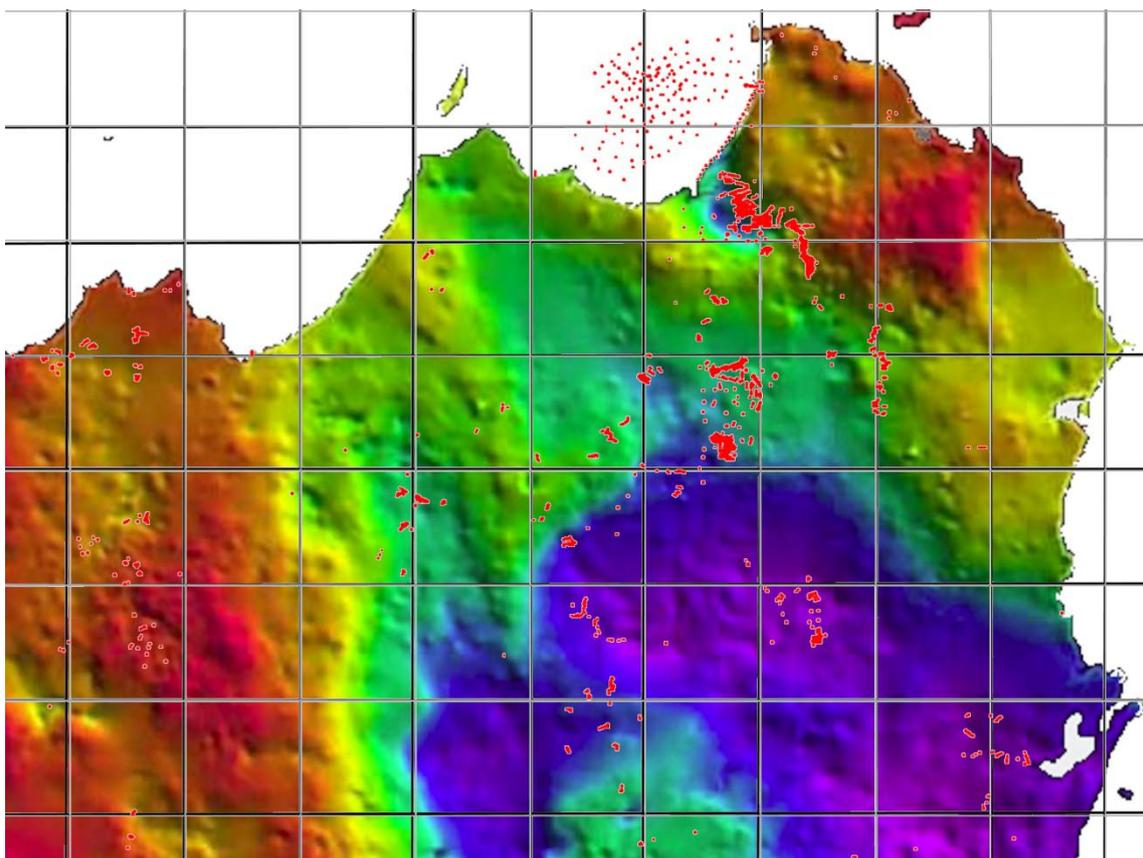
Most of the radiometric signal is associated with the more deep-seated granites that outcrop across the highlands of the NE. The high radiation areas to the N of Pioneer are associated with exposed granites that would appear to be of comparatively shallower depth.

The high radiation area near Boobyalla is interesting in that it is not associated with exposed granite or with nearby radioactive granites, but is associated with a smaller and somewhat isolated low-gravity region. It appears in the thorium and uranium radiometric data, but not in the potassium data.

Further gravity measurements were undertaken for various areas across Tasmania in late 2008, including around the NE. These are not yet included in the available MRT data or maps, but are expected to be available in late June to early July 2010.

### C. Drill hole data

Although MRT records many hundreds of drill holes across the lease area, nearly all of these were only to examine the alluvial tin mining prospects and are fairly shallow. Figure 8 shows the MRT-recorded drill hole locations across the lease area.



**Figure 8.** Drill hole locations recorded by MRT across the lease area.

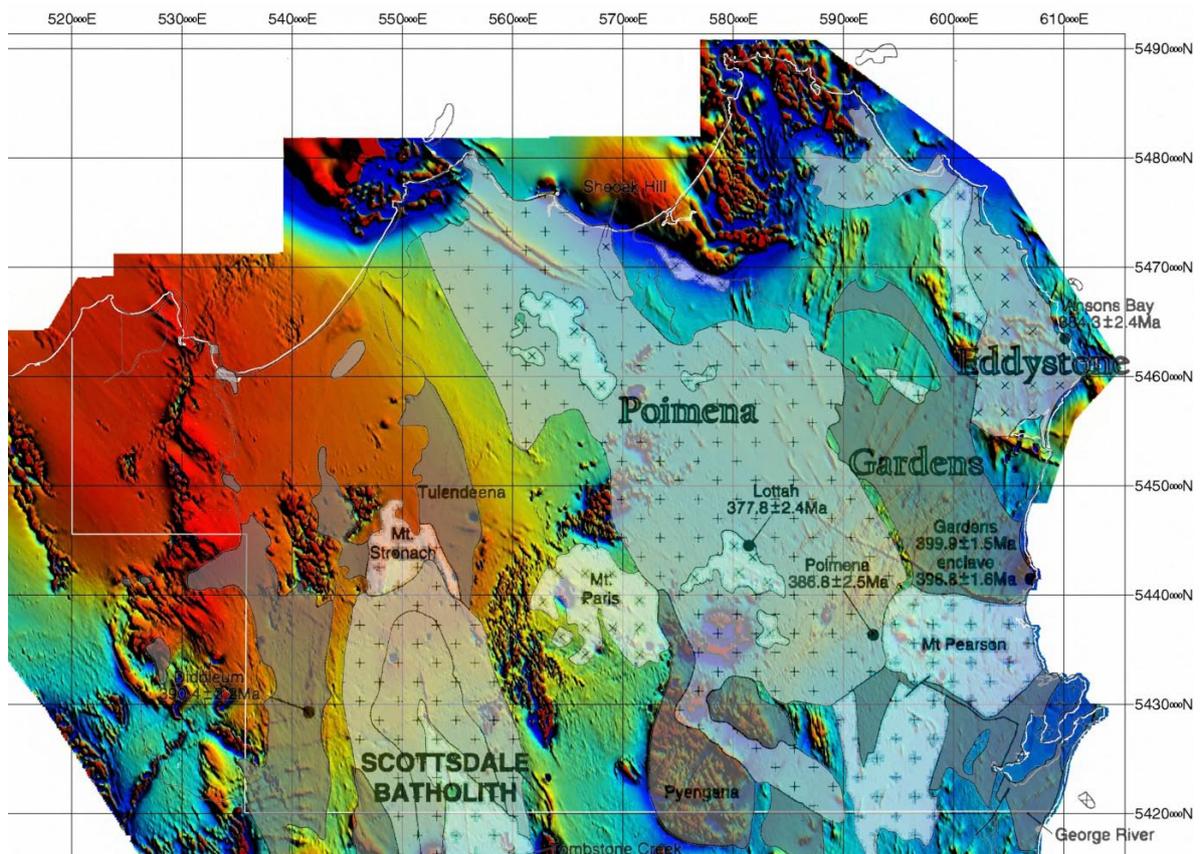
Most of the holes shown in figure 8 have been associated with defining tin resources. The holes to the south of Gladstone have been drilled either into exposed granites (e.g. those on Blue Tier) or into quaternary or late Tertiary sediments above granites that had been exposed for long geological time periods (e.g. holes defining the lead system for tin mining). Although many holes have been drilled over the years for gold exploration, these do not seem to appear in the MRT record, but can often be found in company reports.

However there are drill holes shown for two areas of possible geothermal interest. One of these is the area just to the east of Boobyalla, above the low gravity area, and the other is the line of drill holes along the middle reaches of the Great Musselroe River.



## E. Magnetics

Much of the magnetic pattern in the far NE of Tasmania is related to the granites. For example, the most intense magnetic ridges (not associated with known dolerites or basalts) lie between the Gardens and Eddystone plutons, and the lower intensity NNW-trending traces occur only in the eastern half of the Poimena pluton and to the north of the very low gravity trench. The latter appear to be associated with aplites and greisens, but the former are so far of unknown origin.



**Figure 10.** Magnetics over the lease area, overlain by exposed granites.

## **Some possible areas for geothermal investigation**

The main criteria for consideration here have been;-

- A. A granite, that has never been exposed.
- B. A continuous (over time) insulating cover of more than half a km
- C. Evidence of radiation (keep the granite hot)

Another consideration has been the possible existence of an extensive fracture system adjacent to (or within) the hot granite that may offer something similar to the NFHR (naturally fractured hot rock) option currently being considered by Kuth in the Midlands. In the NE Tas. situation this may well show up at the surface as linear radiation traces, and evidence of current hydrothermal activity.

In NE Tas. perhaps the insulating cover that immediately springs to mind would be Mathinna sediments, but other rocks should also be considered. These would include a granite cover, - particularly if that granite cover was more like a weak nuclear-powered electric blanket.

The latter situation (granite cover) is not considered here. There is some evidence that hydrothermal activity still occurs in the exposed granites of the Poimena pluton, associated with some NNW-trending fractures.

### **Four initially interesting areas present themselves**

- 5. Great Forrester River
- 6. Middle Great Musselroe River
- 7. Great Northern Plains – Boobyalla Sub-basin
- 8. Mathinna sediments area to north-east of Gladstone

#### **1. Great Forester River**

On the basis of criterion C above, this looks interesting, but drill hole data indicates that it is only buried at less than a few hundred metres (maybe around 100m), and was once exposed.

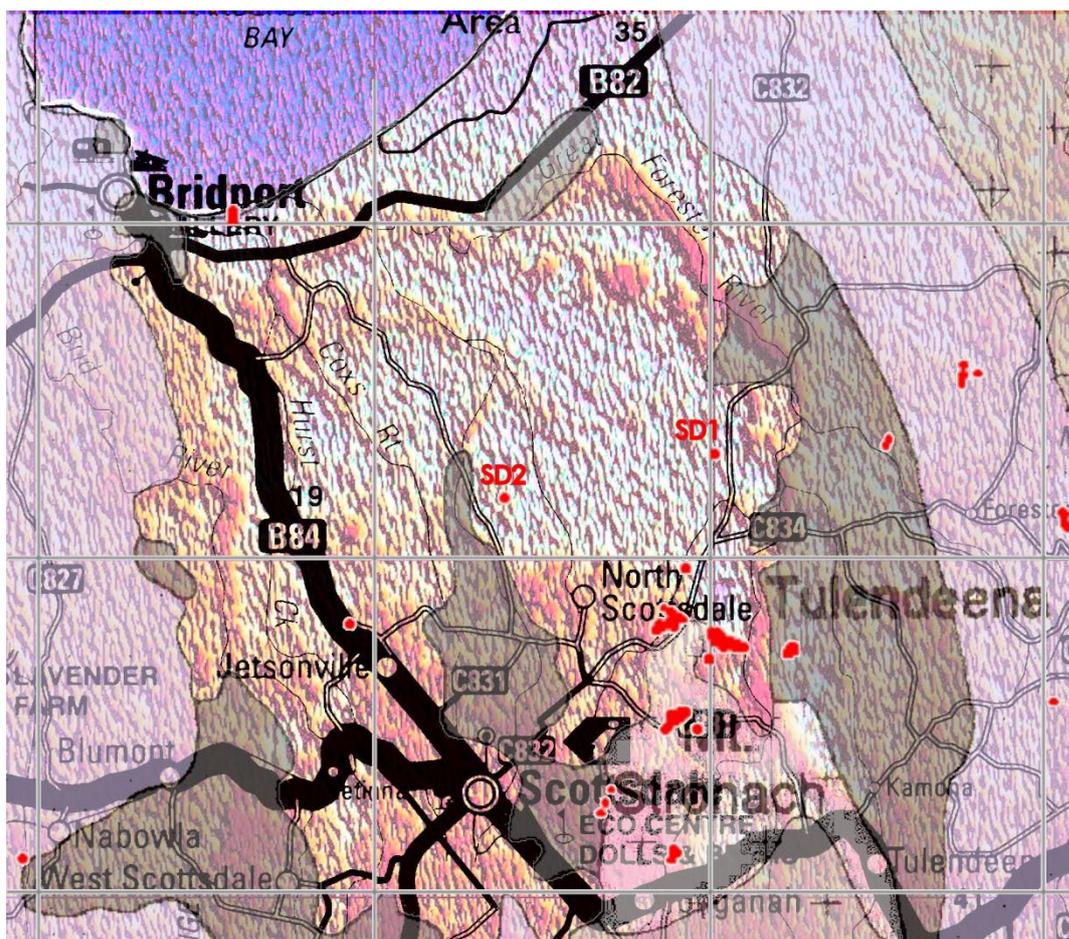
Nevertheless, relevant information is given below.

The Great Forester River shows up strongly in the radiometrics (figure 11), - just as strongly as the exposed granite in the area. This is the case for all three radiometric channels. All the other rivers and creeks in the area, including the Brid River and Cox Rivulet, also show up as carrying considerable radioactivity.

There is an interesting indication, shown up by the uranium and thorium channels in particular, that the Great Forester River has changed its course northwards at least twice, commencing from a SE extension of Tucker Creek (more prominent in the thorium channel).

If the granite exposures are superimposed, the Great Forester River is seen to roughly follow the western exposures of the Tulendeena pluton (an undifferentiated I-type granite, approx age 390 Ma) and to split up through the Mt Stronach differentiated I-type granites (of approx, age 385 Ma) and around the top of the slightly older and more weakly differentiated Scottsdale I-type granites. The radiation would therefore seem to be associated more with the later more highly differentiated I-type granites, which, from the gravity results, possibly extend below the current surface cover north from Mt Stronach to about half way between North Scottsdale and the Bridport-Gladstone road. Gravity results also suggest that the granite would not be very thick.

Mt Stronach itself was investigated (mainly between 30 and 40 years ago) for the possible mining of molybdenite, but at the time this was considered uneconomic.



**Figure 11.** The most prominent radiation appears to originate from the Mt Stronach I-type highly differentiated granites. Locations of known drill holes are shown in red.

Magnetics over the area are pretty well flat.

The area has been investigated in the past for molybdenite (e.g. Hellyer Mining and Exploration, SPL 772, relinquished Feb 1982), for tin (e.g. BMI Mining, SPL 48 and SPL 55, relinquished Sept 1971), for kaolinite (Ballarat Clay, EL 20/70), and for oil shale (AAR Limited, EL 19/80, relinquished July 1981). Each of the mentioned companies carried out some drilling. Except for two holes drilled by AAR, and two by Hellyer Mining, all the others were shallow auger holes. The Hellyer diamond drill holes were into the already exposed granite of Mt Stronach, but the two AAR diamond drill holes (labelled SD1 and SD2 in figure 12) were within our area of possible interest.

For both SD1 and SD2 drill holes the material overlying the granite consists of Tertiary to Quaternary sands, clays and gravels, with no evidence of any Mathinna sediments. AAR comment that the depositional environment appeared to be “medium to high energy fluvialite”. Depth to granite in SD1 was 52m, and in SD2 was 90m. Needless to say that AAR did not find any oil shale.

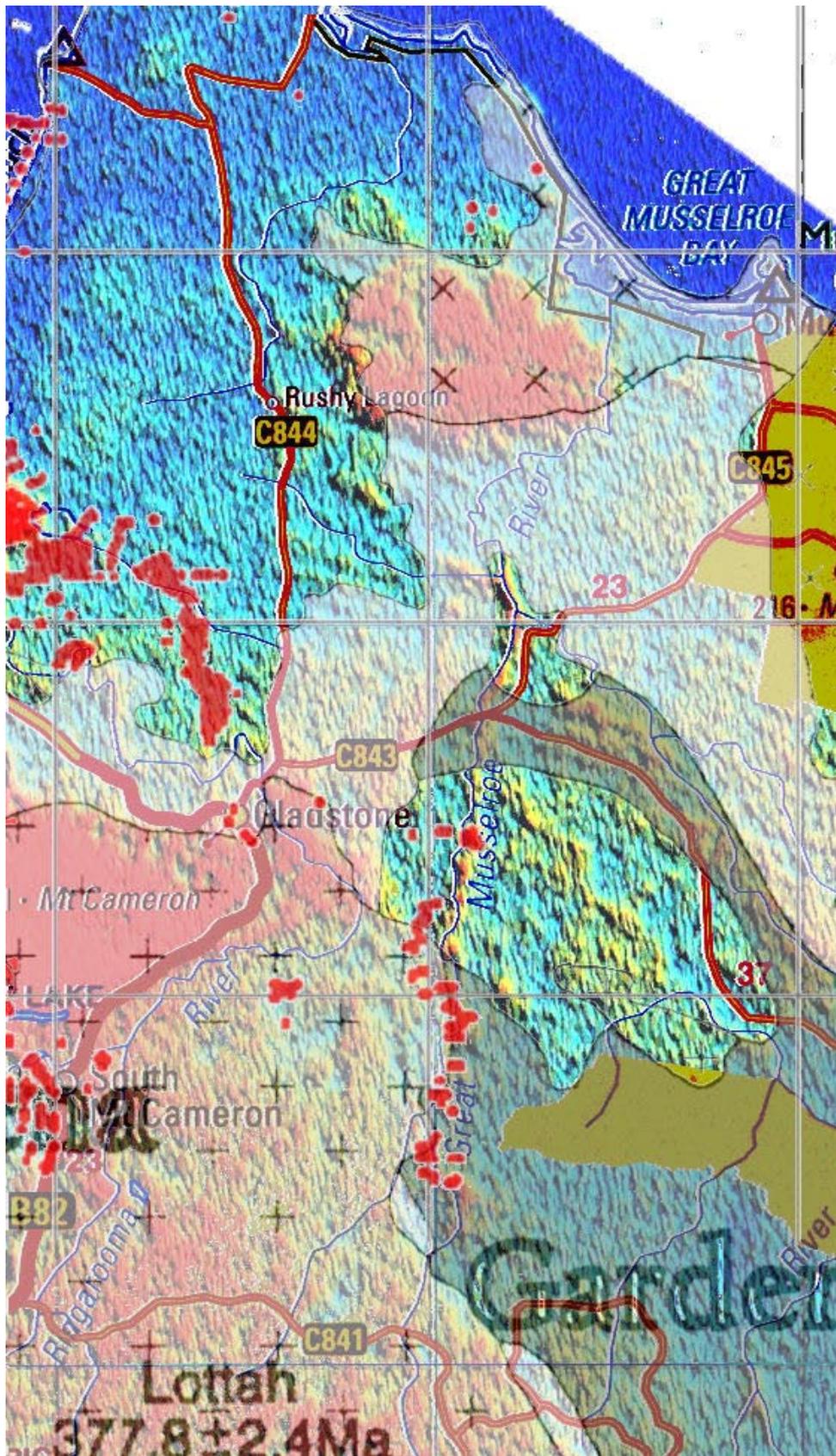
## **2. Middle Great Musselroe River**

As was the case for the Great Forester River, on the basis of criterion C above, this looks interesting, but the somewhat sparse and confusing drill hole data indicates that the granite is only buried under at most 10m of Tertiary clays and gravels, and was once exposed.

Some relevant information is given below.

The area of interest lies about 7 km east of Gladstone (see figure 12), where gravity indicates the continuation of a fair thickness of granite beneath the surface Tertiary sediments. The area is known as the Mussel Roe swamp. BMI Mining carried out a percussion drilling programme in 1971, and these show as the northern-most line of holes across the Mussel Roe River in figure 12. The holes were drilled to what was called “basement”, with no mention of just what this “basement” consisted of (i.e. Mathinna or granite), but some MRT diamond drill holes (drilled in 1937) a little further to the south indicate granite at similar depths, overlain by “drift”, sand and “wash”.

As for the Great Forester and nearby Rivers, the radiation appears to be associated with the more differentiated versions of the I-type granites (of the Poimena pluton here).



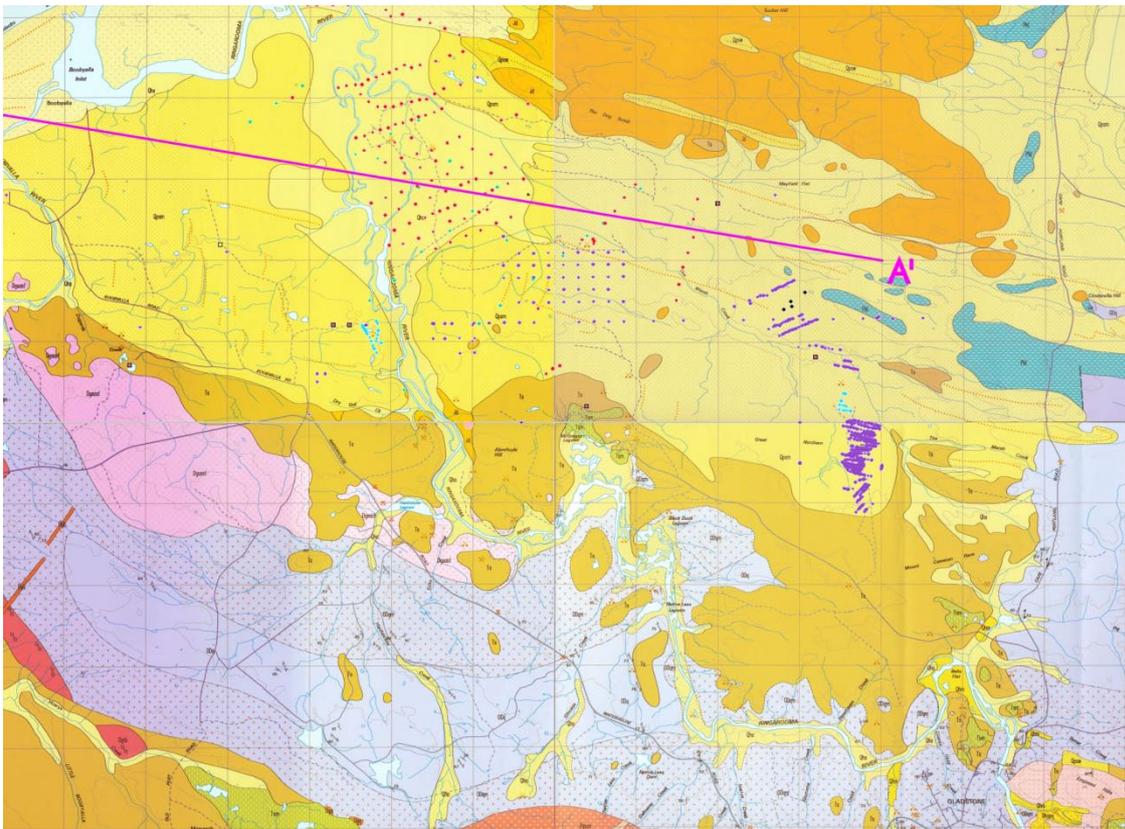
**Figure 12.** A possible area of interest about 5 to 10 km east of Gladstone, beneath surface Tertiary sediments. The locations of surface exposures of granite plutons are indicated, and drill hole locations are shown in red.

### 3. Boobyalla Sub-basin

This is an area that could be interesting to examine in more detail. Although the granite, in a down-faulted Cretaceous trough, is now buried beneath perhaps a Km or more of Permian to recent sediments and dolerites, it may have been unroofed briefly in Carboniferous times. However, the considerable U/Th radioactivity on its eastern side indicates a fairly strong hydrothermal system and suggests some similarity to Kuth's Midlands NFHR situation.

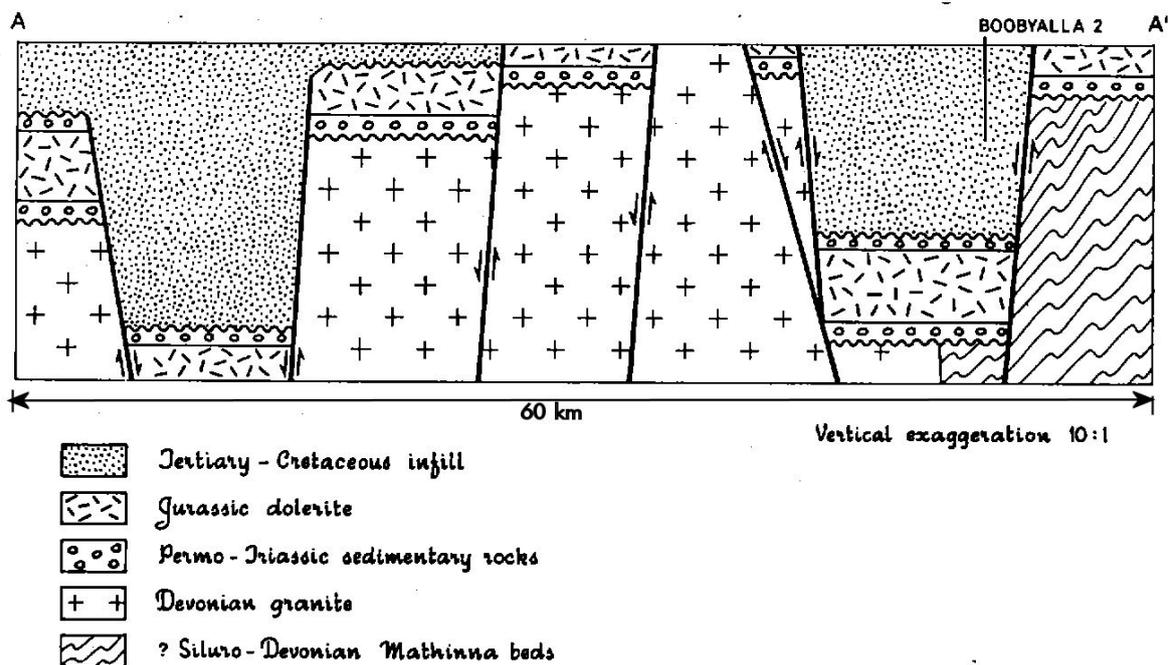
The Boobyalla Sub-basin is the area in the upper left hand quarter of figure 13. To the east it passes into the tin mining area known as the Scotia Lead. The area has been extensively drilled to determine tin grades, and also the likelihood of oil shale. Nearly all the drilling has been very shallow, generally less than 20m, using auger and percussion methods, with none of this reaching any solid basement. The "basement" reported in many of these drill holes seems to merely record the estimated bottom of any tin wash.

Shell drilled several diamond holes looking, unsuccessfully, for oil shale, with the deepest hole, at the junction of Waterhouse and Boobyalla Road, to 265m. This encountered unconsolidated Cretaceous sediments and rubble, but no granite basement.



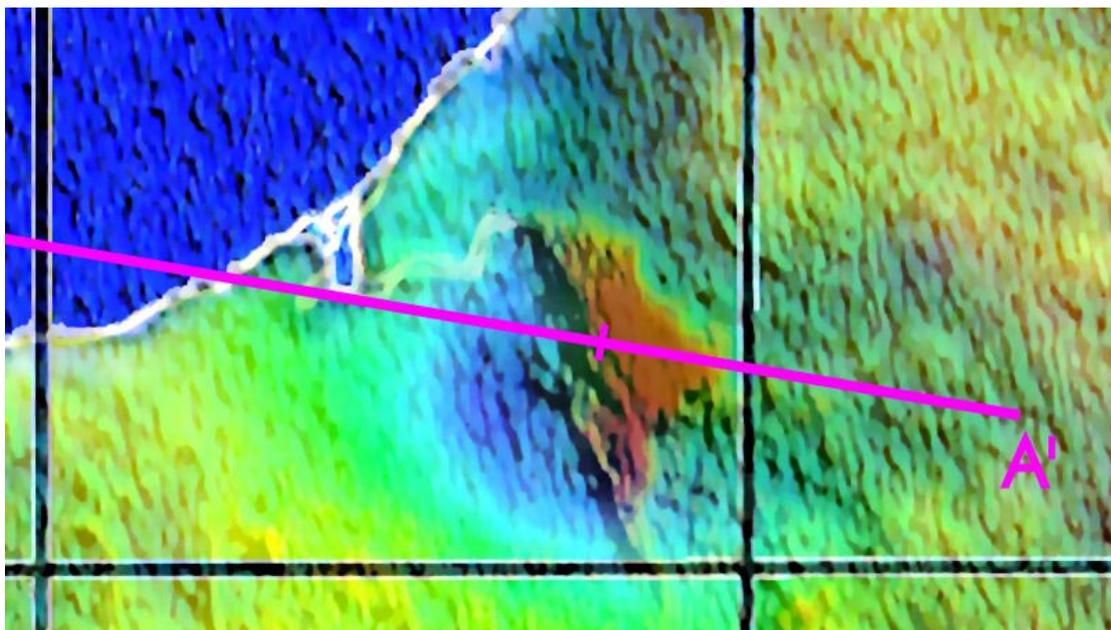
**Figure 13.** Boobyalla Sub-basin, showing drill hole locations and E end of suggested cross-section.

MRT drilled a number of diamond drill holes across the area, with the deepest only a few m from the Shell hole at the junction of the Waterhouse and Boobyalla roads, to 490m. Another, about 2 km NNW of the Shell hole and nicely in the centre of the area, went to just over 400m. Both were still in Cretaceous sediments. The presence of Permian-Triassic sediments and dolerites have been inferred from geophysics, a correlation between the MRT holes, other shallower local geology and a much deeper oil exploration diamond drill hole (to over 3,000m) about 60 km to the NW drilled by Esso Exploration. Thus the deeper stratigraphy under the Boobyalla Sub-basin could be described as reasonably inferred, as illustrated in figure 14, but not proven.



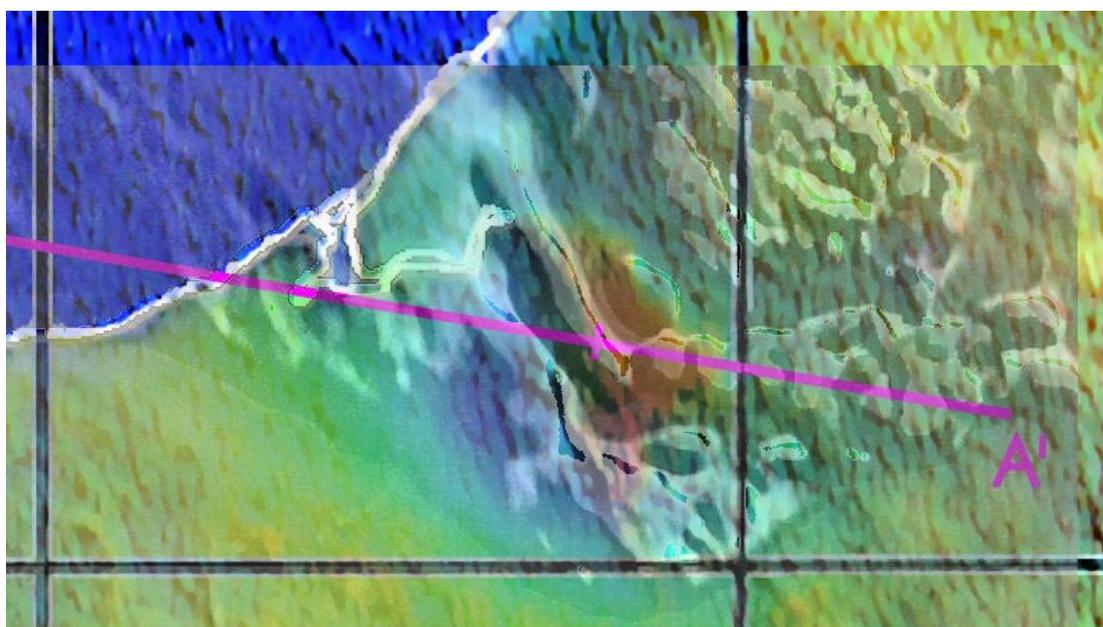
**Figure 14.** Suggested cross-section across Boobyalla Sub-basin (from Moore et al, 1982, MRT drill hole 5366, - also drill holes 5362, 5364 etc).

The edge of the dolerite suggested in figure 14 (near east end A') corresponds approximately to the present position of the Ringarooma River in figure 13. This is interesting, as it explains the apparent off-set between gravity and radiation (see figure 15). It places the high radiation area to the east of this fault and the deep low gravity area to the west. The high radiation area roughly corresponds with the main swamp area.



**Figure 15.** High radiation area overlain on gravity map. Line of cross-section is shown, with the approximate eastern edge of the downfaulted area marked.

The magnetics for the area show the effect of the dolerite (figure 16), but while one ridge of dolerite is implied over the swamp area, where it is quite expected, another parallel magnetic high is also shown over the low gravity area. This may be due to the somewhat thicker dolerite expected on top of the down-faulted block, in which case its decreased intensity westwards needs some explaining.



**Figure 16.** Magnetic high anomalies (shown as white patches here) superimposed on the gravity/radiation map of figure 15.

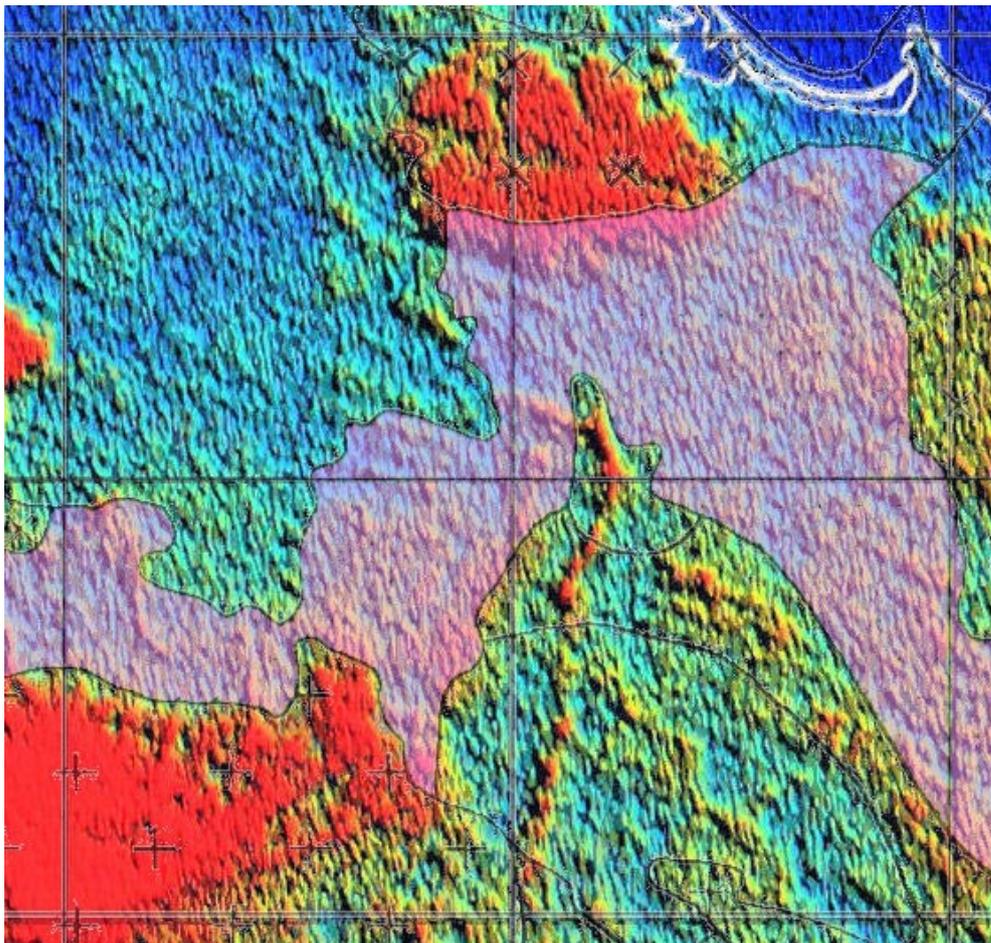
#### 4. Mathinna sediments area to north-east of Gladstone

This is an interesting area, - in particular an E-W strip extending N-S in width from about the Grande Flaneur mine in the north to half way between the Bluebell and Portland mines in the south.

MRT lists no drill holes in the area and no water boreholes. Both of these have of course been drilled in the area, but are either not officially recorded or not open file. So far as I am aware they are all (including those by MHM) relatively shallow and unlikely to record anything of geothermal interest.

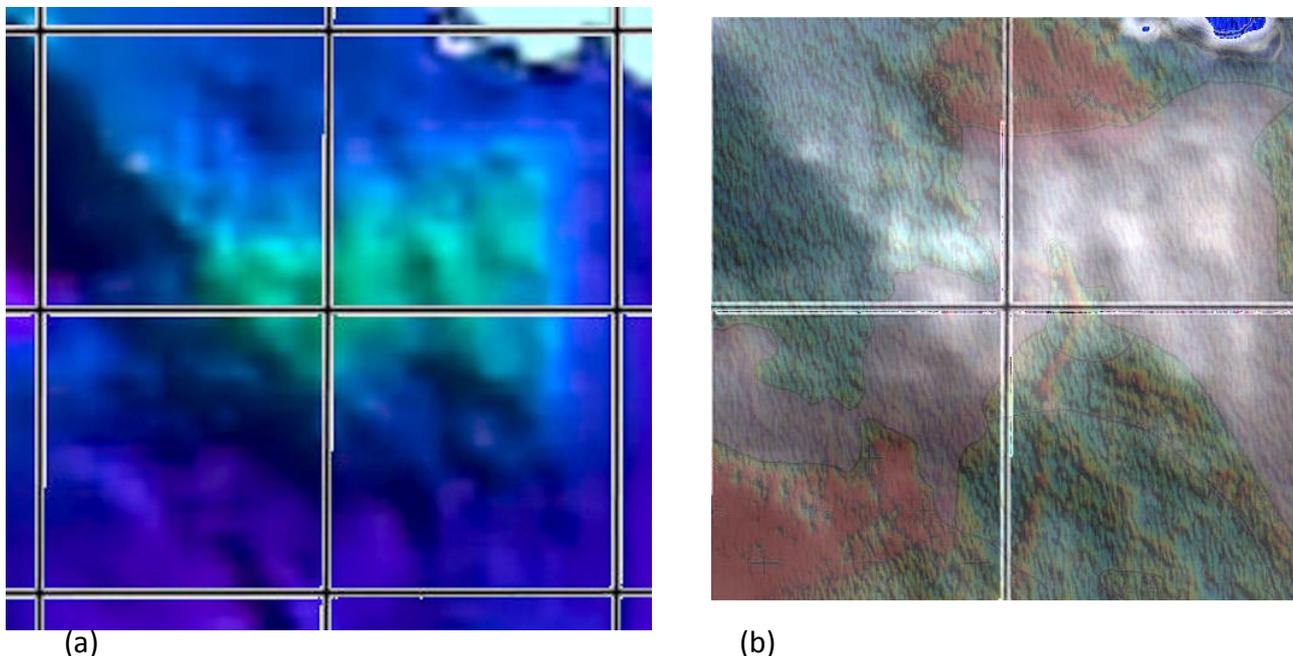
The radiation distribution, viewed in relationship to the Mathinna sediments (figure 17) implies that the Mathinna overlaps the southern edge of the S-type granites of the Eddystone Pluton (the "Grande Flaneur granites"). The overlap area corresponds well with the metamorphosed Mathinna sediments, within which the Grande Flaneur mine occurs.

The WNW- trending radiation lineation across the Mathinna about 5 km NE of Gladstone is interesting (but perhaps not for geothermal reasons) as its western end approximately follows a Tertiary basalt trend that in turn lines up with the Scotia Lead further to the west.



**Figure 17.** Mathinna sediments north of Gladstone superimposed on radiation map.

In figure 18 the gravity map has been superimposed on the Mathinna and radiation map of figure 17, with the Mathinna sediments in the area NE of Gladstone now corresponding to a fairly high gravity area.

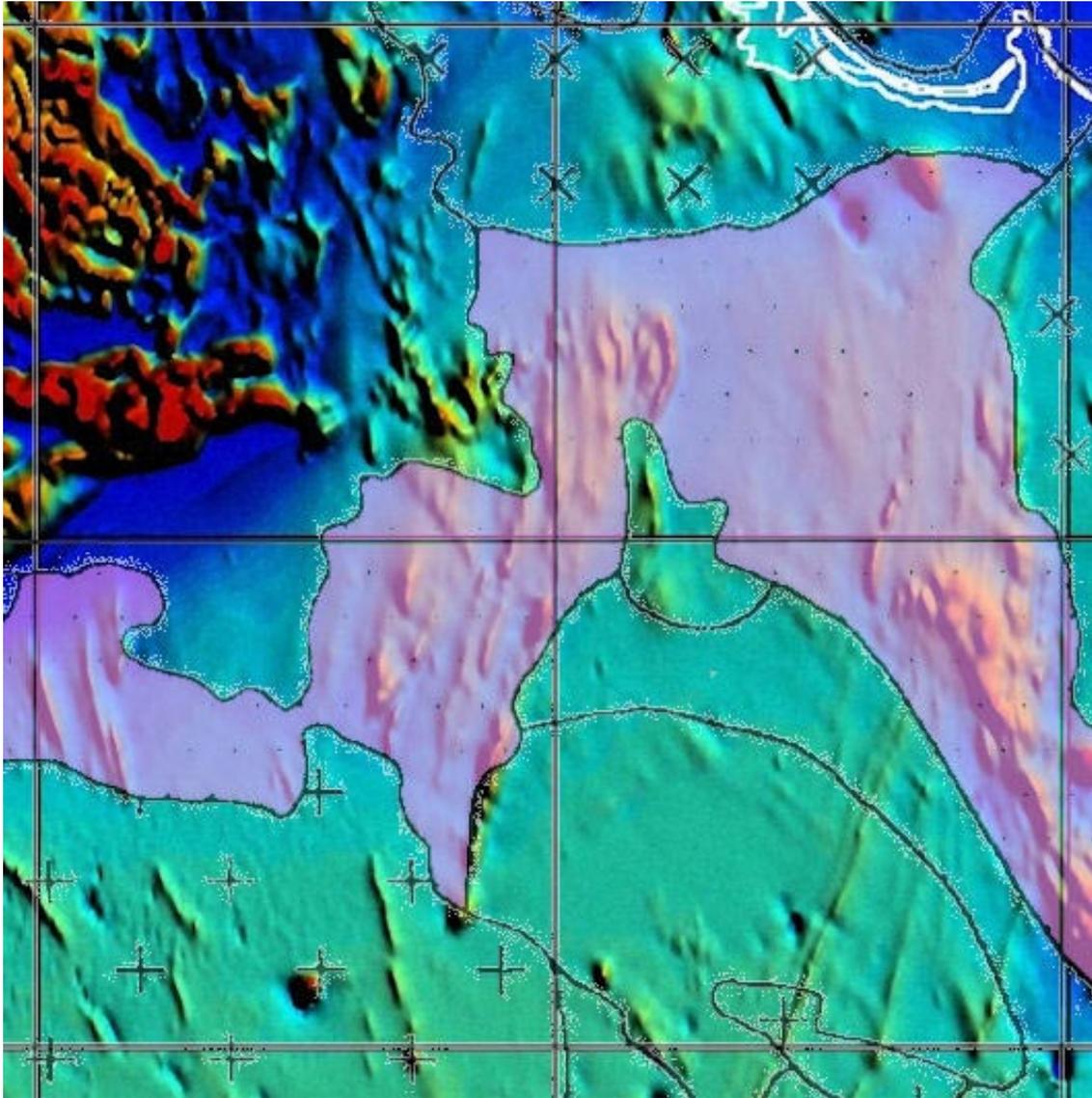


**Figure 18.** (a) Gravity map of the area and (b) gravity superimposed on figure 17, with the high gravity area showing up here as white.

The impression here is of a NW-trending fault, with fairly thick granite extending under the Gladstone Mathinna sediments to the SW of the fault, and an isolated block of Mathinna sediments to the east of the fault, terminated sharply (fault?) by the N-S edge of the Eddystone batholith to the east and by the Gardens pluton to the south.

Of some potential low-temperature geothermal interest however, is the fairly gradual gravity gradient to the north, extending several km south from the old Grande Flaneur mine and past the old Bluebell mine. This may be indicating a fairly deep southern edge to the "Grande Flaneur granite" about half way between the old blue Bell and Portland mines, with the granite rising towards the surface to the north.

The magnetics of the area are shown in figure 19, with the Mathinna sediments shown in purple. The N-S magnetic anomalies are now seen as completely restricted to the Mathinna, but with the interesting effect of their northern extent terminating in a line that, although well within the Mathinna sediment area, very roughly parallels the southern edge of the "Grand Flaneur granite". This suggests a possible destruction or prevention of ferromagnetism due to heating above the Curie temperature.



**Figure 19.** Mathinna sediments superimposed on the magnetics map of the area.

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