# GRM CRUSTAL MAGNETIC ANOMALIES: SEPARATING THE LORD HOWE RISE AND NORFOLK RIDGE SUBMARINE STRUCTURES

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The high elevation of MAGSAT and POGO data makes difficult the interpretation of observed crustal magnetic anomalies in regions of any geologic complexity. In average scalar maps this is not just a matter of resolution but is also compounded by the overlap of central and flanking anomalies from nearby sources. This overlap is a function of the strength and separation of the sources and the geomagnetic latitude. Even in reduced-to-pole (RTP) maps where geomagnetic latitude effects are minimized and anomalies are located directly over their sources, overlap of anomalies will occur for nearby sources. Given the general complexity of the Earth's crustal geology, multiple source bodies will often lie within the resolution element of the MAGSAT and POGO data. Small weak sources lying near larger stronger sources will tend to be missed, although they do contribute to the total observed anomaly. Lower elevation magnetic anomaly surveys such as GRM will alleviate this problem through the combined effects of significantly greater resolution and stronger signal amplitude. This will permit not only the detection of smaller source bodies, but also analysis of their structure and nature.

The improvement a GRM would provide can be easily demonstrated in the Lord Howe Rise/Norfolk Ridge area east of Australia, between the Tasman Sea and South Fiji Basin. These submarine features are of interest because their origin has important plate tectonic implications. The Lord Howe Rise (LHR) is a continental fragment broken off from Australia by the opening of the Tasman Sea. It is a wide, shallow structure lying between 160 and 165$^{\circ}$E longitude at 23 to 37$^{\circ}$S latitude (Figure 1). Seismic refraction data show the LHR crust extending to depths in excess of 20 km. By contrast the Tasman Sea oceanic crust is only about 6 km thick reaching a depth of less than 11 km below sea level.

The nature of the adjacent Norfolk Ridge (NR) is less certain. This narrow N-S trending feature lies along 168$^{\circ}$E longitude and averages less than 1$^{\circ}$ across (as defined by the 2000 m bathymetric contour). It is separated from the LHR by the New Caledonian Basin which itself is at most 3$^{\circ}$ wide. There are some similarities in the crustal structure of the NR and LHR: both have depth-to-Moho of more than 20 km, and both have a central crustal layer with seismic velocity ($V_p$) of 6.0-6.2 km/sec overlying a 6.7-6.8 km/sec lowest layer.

The narrowness of the NR and its close proximity to the much larger LHR (Figure 1) mean that presently available 2° average scalar magnetic anomaly maps will not be able to separately resolve these two structures. The NR has only 15% the volume of the LHR, so even if they had identical magnetic structure, the Norfolk Ridge would be a minor contribution to the anomalies shown in 2° average maps. This is born out in the observed MAGSAT and POGO data (Figure 2) which show a prominent double-lobed positive anomaly located over the LHR. At MAGSAT elevation (~450 km) under local magnetic field conditions (~54,000 nT at the surface) the peak anomaly is ~9 nT (Figure 2a). The RTP POGO data (Figure 2b) is at an elevation of 500 km and a constant main field of 50,000 nT. The peak anomaly is only 7 nT, but note that the anomaly has shifted to lie (nearly) directly over the LHR. This is the advantage of an RTP representation: the anomaly is located directly over its source. Detailed examination of the POGO data shows that the southern lobe of the LHR anomaly does not lie directly over the topographic peak of the Rise, but is displaced eastward (toward the NR) by about 2°. This is consistent with the presence of a second magnetic anomaly source at the location of the southern NR.

In order to study the effect of elevation on the anomaly signatures over the LHR-NR area, we calculated model signatures at a range of elevations between 550 (representative of POGO data) and 150 (a low GRM elevation) km for a variety of NR models. The LHR model used was a "continental" structure with a high susceptibility lowest crustal layer (Frey, 1984, in press). This model provides good agreement with the observed POGO RTP and MAGSAT average scalar data assuming no contribution from the NR.

FIGURE 1.

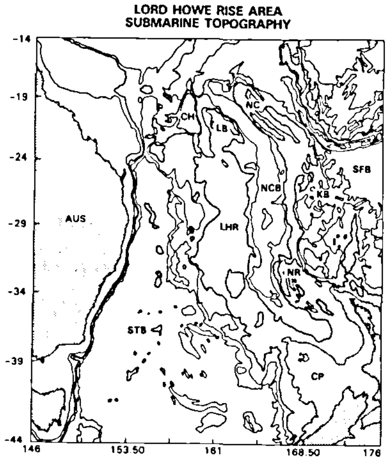
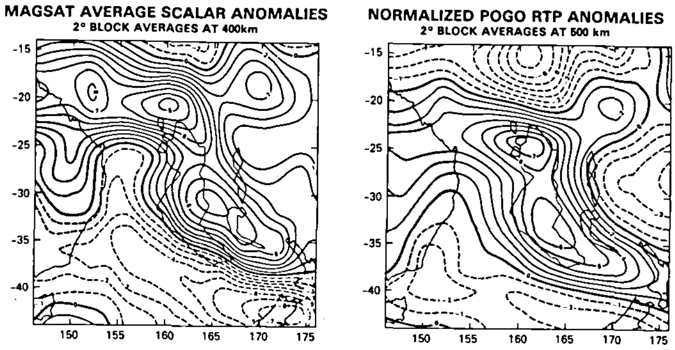


FIGURE 2.



The NR structure which provides the strongest magnetic anomaly contrast with the surrounding oceanic crust is one where the NR is assumed to be thickened oceanic crust. Such a model leads to an average magnetization contrast of 1.4 A/m for the 20 km thick NR. At 550 km this structure alone produces a magnetic anomaly of only 1 nT in a vertical, 50,000 nT main field, assuming the anomaly is an induced + viscous magnetization anomaly and the magnetization contrast used represents both of these effects. By contrast, under the same conditions, theLHR model produces a +6 nT anomaly. The combined structures produce a signature somewhat different from that due to the LHR only: the southern lobe of the anomaly increases from +5 to +6 nT and the 0, 1 and 2 nT contours show a deflection toward the NR which indirectly suggests its presence. These results alone, by comparison with observed POGO RTP data, suggest the model used here for the NR is too strong a source body. The NR probably has a magnetic structure more like the LHR, with an average magnetization contrast for the NR of perhaps only 0.8 A/m with respect to its surroundings. However, it is extremely difficult to correctly infer the relative magnetic structures of the LHR and NR from these high elevation data, as many combinatons of LHR/NR structures would be capable of producing the course anomaly pattern observed.

At 450 km (a high MAGSAT elevation) there is little improvement in the NR anomaly signature. Peak values are still less than 2 nT, while the peak value for the LHR is now up to 9 nT due to the lower elevation. Eastward deflections of the anomaly contours in the combined (Figure 3a) model are again an indirect indication of the contribution of the NR to the total anomaly. These deflections are even more obvious at 350 km elevation, an optimistic best case for a limited portion of the MAGSAT data. The NR model by itself produces a 3 nT anomaly. The LHR model produces +13 and +15 southern and northern lobes, but a weak pair of -1 nT flanking anomalies also appears east and west of the LHR. The overlap of the LHR and NR anomalies pulls the combined model anomaly signature eastward into a pattern which now follows the submarine topography. At 350 km the effect at this too-strong NR structure is such that the NR would probably be recognized as the contributor, a conclusion which might have been tentatively offered based on the higher elevation data <u>only</u> if the NR were as strong as modeled here.

The NR is resolved as a pair of +5 nT and +3 nT anomalies in the combined model signature at 250 km. The NR structure would produce +5 and +6 nT peaks in the northern and southern portions, but overlap with the flanking negative LHR anomalies reduces the NR portion of the combined model anomaly signature.

At GRM elevations (~150 km) the NR structure is clearly resolved (Figure 3b). The LHR and NR are each separately overlain by positive anomaly signatures that are individually closed. A -6 nT anomaly lies over the New Caledonian Basin between the LHR (peak anomaly >63 nT) and the NR (>11 nT). The ratio of peak amplitudes between the NR and LHR is slightly greater than the volume ratios, consistent with the differences in magnetic structure used in the models. The detailed NR structure is also revealed by the anomaly pattern, showing the slight enlargement and westward displacement of the NR at 167°E, 32°S. With data at this elevation it would be possible not only to separately resolve the LHR and NR and to determine their relative magnetic structure, but also to look at variations in that structure throughout the NR or LHR. This would be true not only for this too-strong NR model, but also for the case where the NR had a magnetization contrast with respect to its surroundings equal to or somewhat weaker than that of the LHR.

FIGURE 3. Lord Howe Rise/Norfolk Ridge Model Anomaly Signatures