Mapping depth to basalt using magnetic spectra

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SUMMARY

Between 30 and 40% of the Northern Territory is underlain by basalts, mainly the late early Cambrian Kalkarindji Large Igneous Province. These basalts provide a solid floor to mining activities in the overlying strata. They might also provide a buffer of alkalinity and reduction during ore genesis, and should therefore be included in modelling by mineral explorers. A key parameter in the modelling of prospective mineralised zones is the depth to the basalts.

Using the power spectra of open file airborne magnetic data, depths to subsurface basalts can be mapped. A point-and-click package was developed for this purpose, is currently being used to map the depths to the basalts of the Kalkarindji LIP in the Northern Territory.

Open file surveys of magnetic data have varying quality, affecting the ease of extraction of magnetic depths. Although successful depth results can be expected from modern 10 Hz aeromagnetic surveys, the older, 1 Hz proton procession magnetometer data, is more problematic. However some good depth results have been obtained.

Key words: magnetic depths, flood basalts, power spectra.

INTRODUCTION

Boreholes that intersect the extensive subsurface basalts of the Northern Territory are uncommon. Consequently depths are often extrapolated uncertainly across hundreds of kilometres between boreholes. Other considerations reduce certainty further. The largest area of NT basalts are those of the Kalkarindji LIP, dated at ca 508 Ma. In the intervening time since emplacement, one can expect that the excess weight of the basalts has depressed the surface where they overlie sediments. In other areas the basalt surface may have risen. Although a basalt's horizontal extent is readily seen in magnetic images, its identity and depth are not apparent from the images. In the absence of boreholes or detailed gravity profiles, depths can at least be estimated from the extensive open file airborne magnetic data available in the NT.

The underlying theory for a method of getting depths to dipole-resembling bodies was established by Clifton (2007), and software for applying the method has been prepared and demonstrated by Clifton (2010). By making the assumption that irregularities in the basalt surface and edge do resemble dipoles, the same method can be applied to obtain magnetic depths, at least to the irregularities, and by inference to the surface of the basalt itself. However the original software produced animations that were too cumbersome for interpretation. Accordingly, a point-and-click package has been developed.

METHOD

A body of interest is identified on a magnetic image and then the nearest point on a flight line identified. A gate of one, two or four kilometres length is drawn across the location, the power spectrum is obtained, and a transformation is applied to give a depth spectrum. The software used is interactive, allowing the user to select and study depth spectra around locations of interest.

The method suffers from signal interference when more than one body is in the gate. Since surface magnetisation is common in inland Australia, depth spectra are typically very noisy. Consequently, acceptable depth picks are occasional rather than routine.

Ambiguity arises from the cylindrical symmetry due to modelling around a flight line of TMI anomalies. When a "depth" is picked, it is more accurately a slant range at an unknown roll angle from the flight line. In displays, the assigned range has been reduced by the ground clearance measured by the aircraft to give an apparent depth. It is thus a maximum depth.

RESULTS AND DISCUSSION

Nilly borehole (Kruse, 1996) on the Helen Springs 1:250k mapsheet penetrated Cambrian units then intersected basalt at 235 m. Drilling ended 7 m into the basalt. Prior to that time, basalt visible on magnetic images of the area was ascribed to a Proterozoic unit at approximately 400 m, as extrapolated from intersections in boreholes 200 km to the east. The question arose whether the intersected Cambrian basalt overlies the Proterozoic basalt, or whether the whole area of visible basalt is Cambrian.

On Figure 1, a tie line in the NTGS Helen Springs airborne survey of 1993 passes within eight hundred metres of the borehole. Depths of 224 and 218 m are picked nearby. To south and north along the line, depths picked range between 310 and 406 m depth. It would therefore appear that the basalt intersected by the borehole has a patchy distribution and is underlain by a deeper Proterozoic basalt, which dominates the background in Figure 1.

Further south, on the Tennant Creek 1:250k mapsheet, is a similar basalt, also believed to be Proterozoic, at approximately 400 m depth. Because it has been covered with a closely spaced, north-south flown survey, the potentially greater number of depth picks increases the certainty of the average depth. See Figure 2.

The depth picks in Figure 2 vary. However much of that variation is a reflection on the skill of the author, based on limited experience with the new depth tool. Away from the edges of the basalt, picks seem to be more consistently deep, possibly reflecting a balancing out of magnetic influences from the north and south. Picks on the periphery of the basalt seem to be shallower, particularly on the north edge of the basalt. It is not presently clear how much of this is due to the main body of the basalts in the south imposing a background spectral slope into spectra of the magnetically quieter north.

CONCLUSION

Where lines of magnetic surveys travel north–south across a body of rock with sufficient magnetic contrast to the country rock, depths to the body can be picked from the depth spectra of the magnetic data. Considering that much airborne magnetic data is open file and readily available, such depth estimates can be obtained very cheaply.

ACKNOWLEDGEMENT

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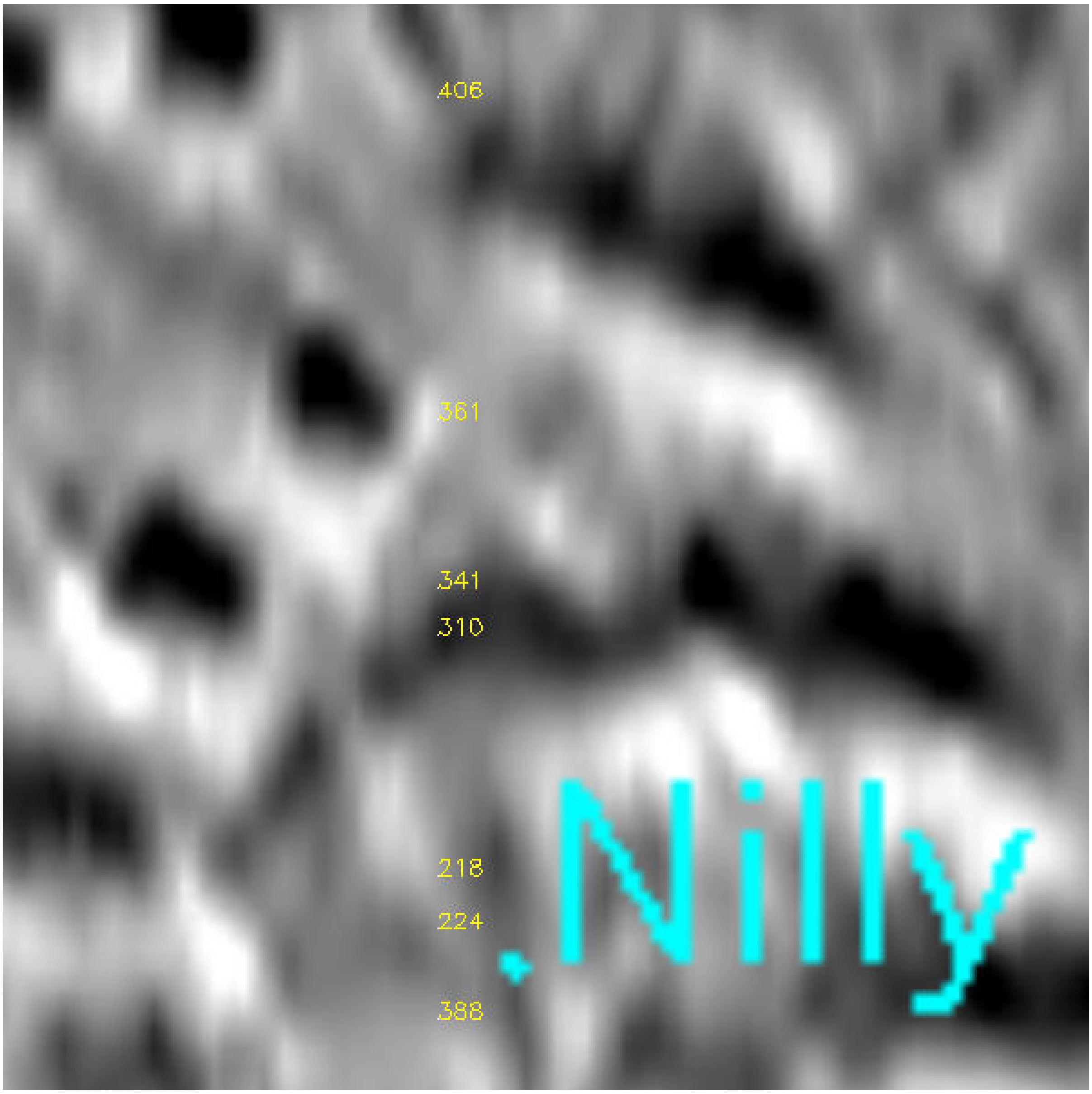

Figure 1. Nilly borehole at 134.256 E -18.412 S, intersected basalt at a depth of 235 m. Depth picks on flightline 67171 verify the existence of a magnetic body at that depth, but confirm an earlier prediction that the more extensive basalts in the magnetic (vertical derivative) image are closer to 400 m in depth. Image is 13 km north to south.

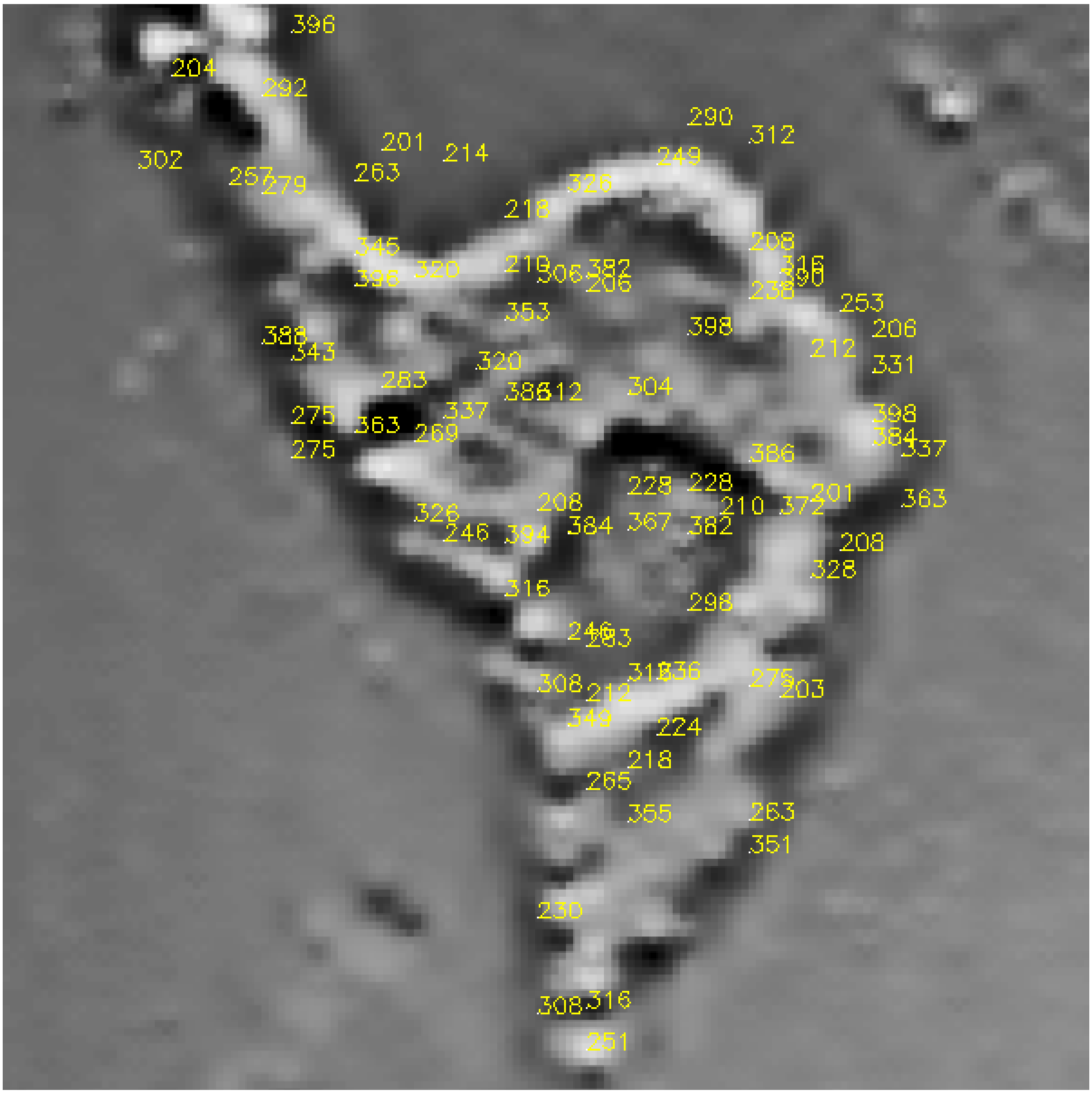

Figure 2. Basalt centred on 133.6 E 19.05 S, approximately 8 km north to south. Depth picks seem to be in two groups, with the shallower picks at the periphery of the basalt. The central hole shows more consistent deeper picks.