Microgravity surveys on the Nullarbor

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SUMMARY

A series of 15 microgravity surveys were undertaken by the Geological Survey of South Australia to determine if cavities existed underground in specific locations on the Nullarbor Plain, South Australia. Survey spacing ranged from 10 metres to 20 metres in a regular grid pattern. The grids were 200 metres by 200 metres in size, with additional traverses extending from the centre of each grid in the cardinal directions, the total lengths of these lines being 600 metres.

An additional survey undertaken over a small blowhole exhibited a 1.2mGal magnitude anomaly. The remaining sites exhibited a range of magnitudes, peaking at approximately 0.5mGal. The gravity images display areas of high and low density suggesting variation in the density of the limestone consistent with possible cavities.

The microgravity results have been used to aid a scientific drilling programme in the area. The position of the drill rig was moved to areas exhibiting high gravity to reduce the chances of the drilling intersecting caves, and to reduce the chances of heavy trucks potentially breaking the surface and falling into a cavity.

Key words: Microgravity, Potential Fields, Nullarbor, South Australia, Caves

INTRODUCTION

Prior to the commencement of the Geological Survey of South Australia's (GSSA) PACE Copper Coompana Drilling Project, a series of microgravity surveys were conducted in two parts: between 17th of February and 3rd of March 2017, and between the 19th of April and the 3rd of May 2017. They were undertaken on the COOMPANA 1:250k map sheet in South Australia and were designed to explore if any subsurface cavities were present that would hinder drilling. Figure 1 shows the location of the proposed drill sites in South Australia.

Microgravity surveys have been used to detect subsurface cavities successfully in the past (e.g., Rybakov et al 2001) so was an obvious candidate for predrilling geophysics. Microgravity is defined as measuring the acceleration due to gravity to tens of microgals (Sheriff, 1991). Ten microgals is 0.01mGals or 0.1μms-2. A Scintrex CG5 gravity meter records values to 0.001mGals so is the ideal instrument for the task.

The surveys have been collated into a single dataset and this dataset designated the code 2017A2 for incorporation into the SA government geoscience database SA_Geodata. The data can be downloaded through the South Australian Resources Information Gateway (SARIG).

METHOD AND RESULTS

Gravity ties to each site were made via ABABA loops with the Australian Fundamental Gravity Network (AFGN) site at Border Village.

A blowhole at the drillers' campsite (Camp 04/blowhole marked in Figure 1) was used as a test case to test the magnitude of gravity anomaly we should expect from a known underground cavity. The blowhole had approximately a 30cm diameter and extended at least 2.7 metres vertically and an unknown distance laterally through the ground (a light breeze could occasionally be felt from the hole suggesting the lateral extent was significant). Gravity measurements were acquired over a regular grid pattern at 1 metre intervals.

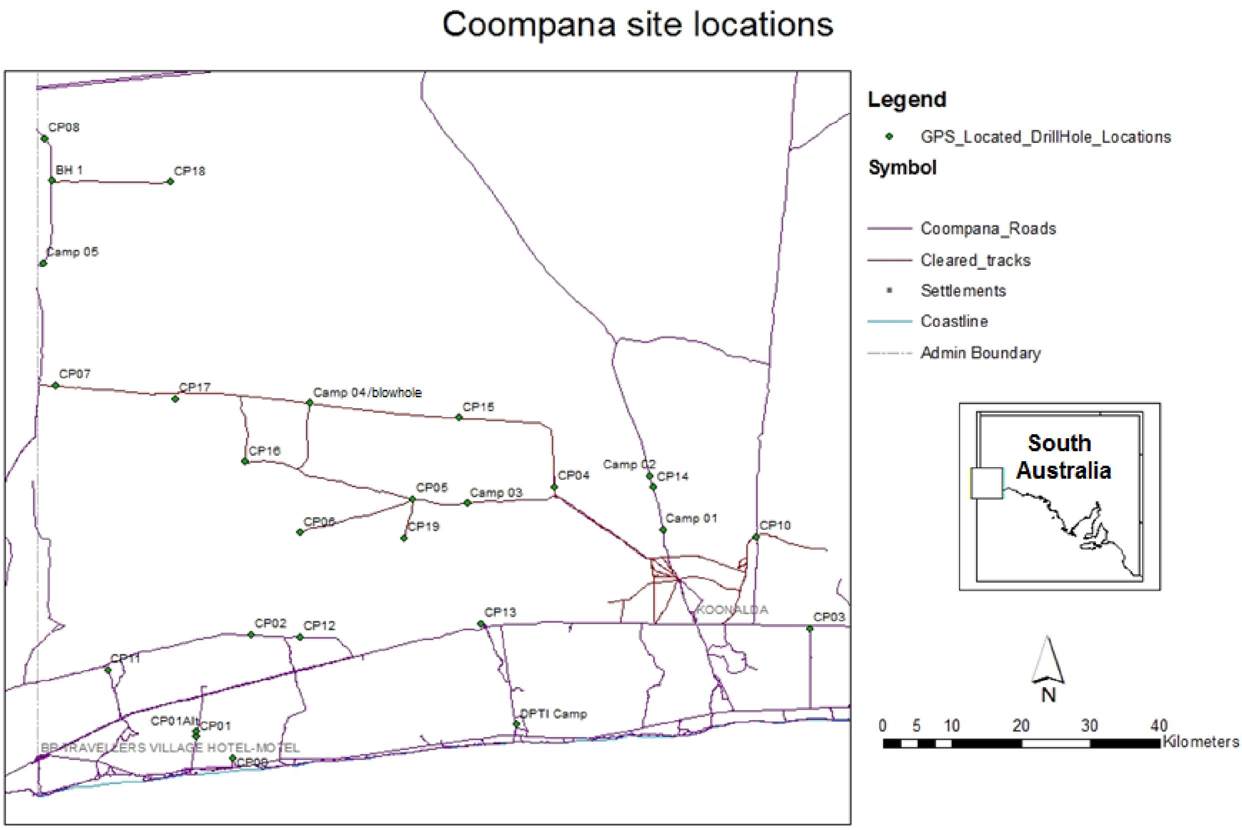

Figure 1: The proposed drill sites are adjacent to established roads and tracks in the Coompana area.

Raw gravity and elevation data were processed using GSSA in-house software (Heath, 2016). Gravity measurements were reduced to the AAGD07 gravity datum, and ellipsoidal heights were used (not Orthometric) as per Hackney and Featherstone (2003). Bouguer reduction using a spherical cap model of the Earth was undertaken using equations from Geoscience Australia (GA). Data was gridded and regional trends removed to best visualise the subsurface density distribution. Areas coloured blue are most likely to correspond to potential underground cavities.

Microgravity data were overlaid on regional gravity data to assess whether the microgravity data for each site was level with the regional data. Microgravity data exhibiting lower gravity values may indicate the presence of a large scale cavity. No large scale cavities (larger than the size of the microgravity surveys) were detected in this manner.

The results of the initial survey over the blowhole (shown in figure 2) clearly show a cave network. The magnitude of this anomaly is 0.26mGal.

As the nature of potential subsurface cavities is ultimately unknown a survey design utilising a regular grid pattern was used at each potential drill site. Each survey was a regular grid, 200 by 200 metres, with traverses extending in the cardinal directions from the centre of the grid. The length of these lines was 600m. This design was created to capture small cave systems (similar to the blowhole example), larger cave systems (say tens of metres across) and potentially deeper, larger lens-shaped cavities.

The station spacing was 20 metres (10 metres in some areas) making quadbike and 4WD assisted gravity unnecessary. A Toyota Landcruiser Wagon was used as transport to each site; however the surveys themselves were undertaken by foot. The topography on the Nullarbor is generally flat with abundant bluebush and saltbush present.

Gravity reading duration was 90 seconds. If the Standard Deviation (SD) on a reading was sufficiently low the operator was permitted to cut a reading short. Any reading with a SD over 0.05mGal was discarded and a repeat measurement taken. The sensor height of each reading was recorded in a field notebook, and a leg of the gravity meter tripod was fixed in place to ensure measurements at the base stations were of constant height.

The survey was conducted by GSSA staff: Philip Heath, Jonathan Irvine, George Gouthas and Carmen Krapf. Two Scintrex CG5 Autograv instruments (Serial numbers 050800135 and 150641354) were used for the duration of the survey, and position information was obtained using a Sokkia GRX1 Real Time Kinematic system. Results for selected sites are shown in figures 3 to 9.

The gravity at each site was acquired in a day. No accidents or incidents occurred during the survey.

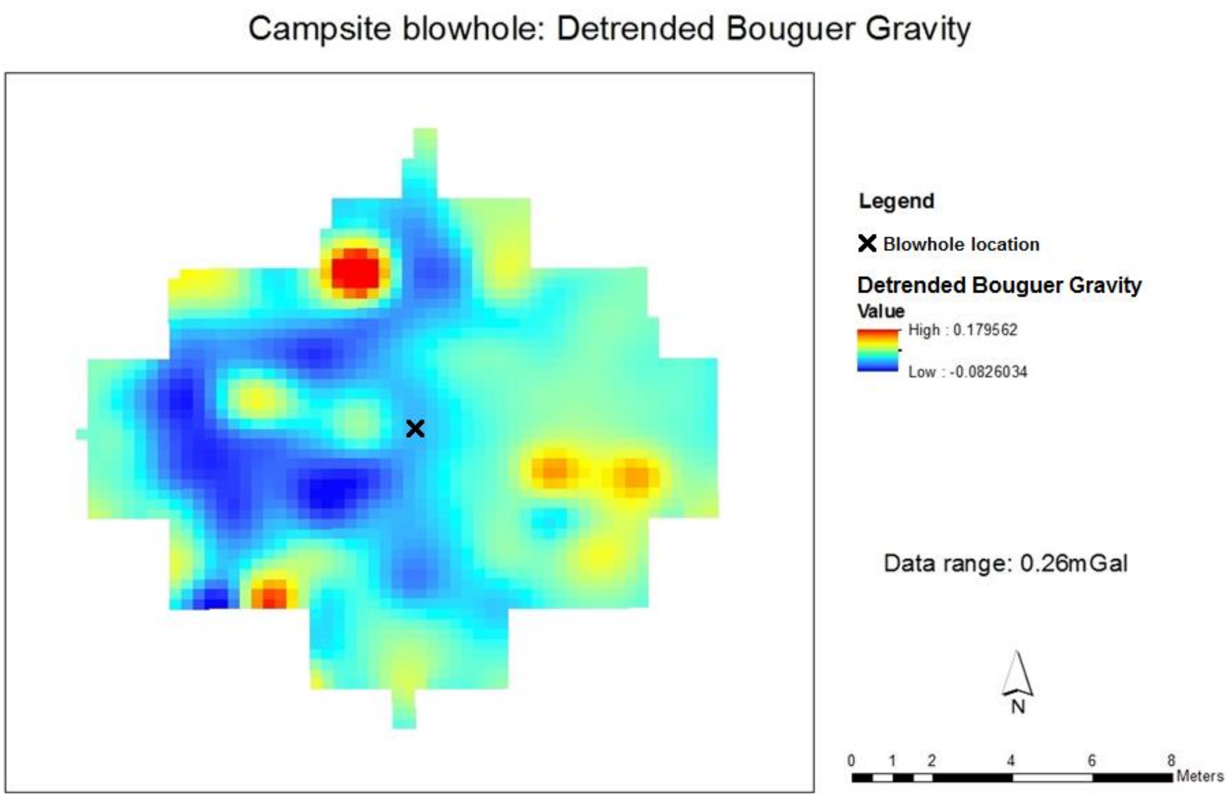

Figure 2: The gravity image over and around a blowhole shows a clear network of caves represented by the blue colour.

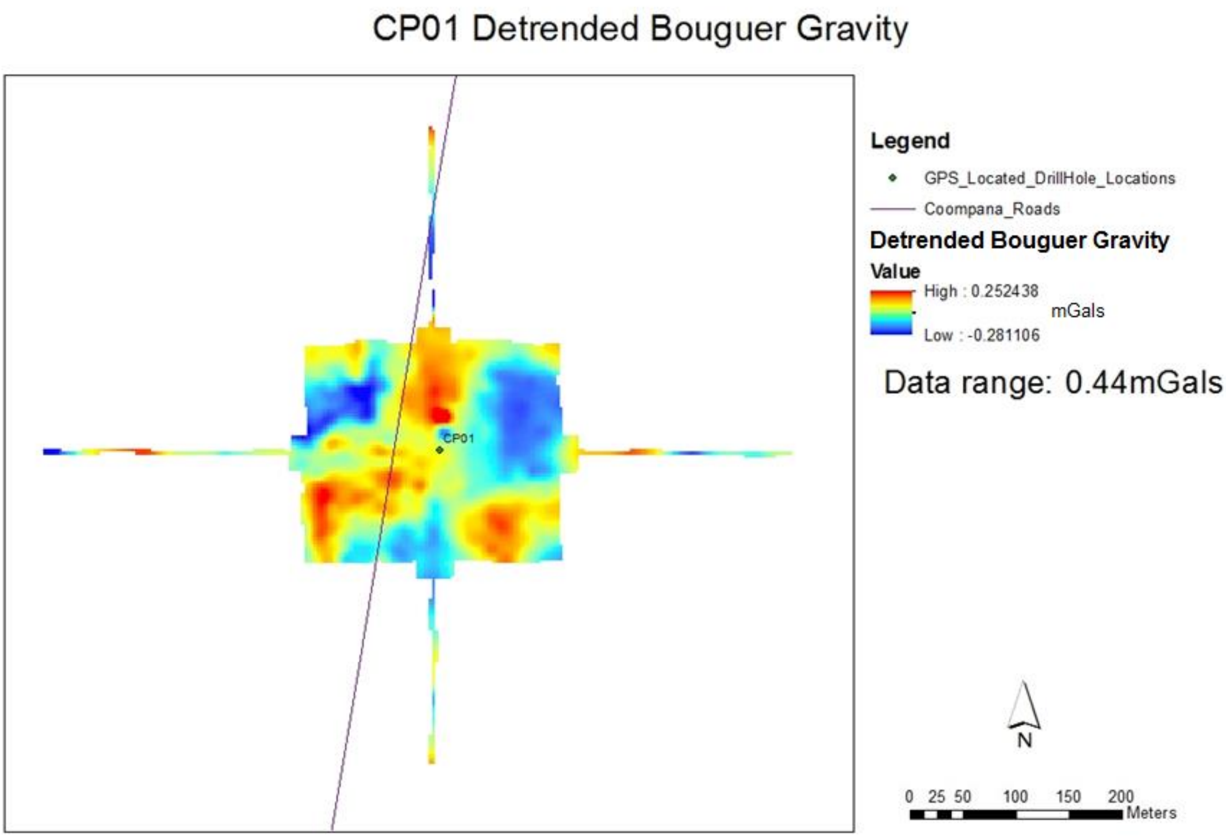

Figure 3: The gravity image over site CP01 shows potential cavities to the east, south, and northwest of the site.

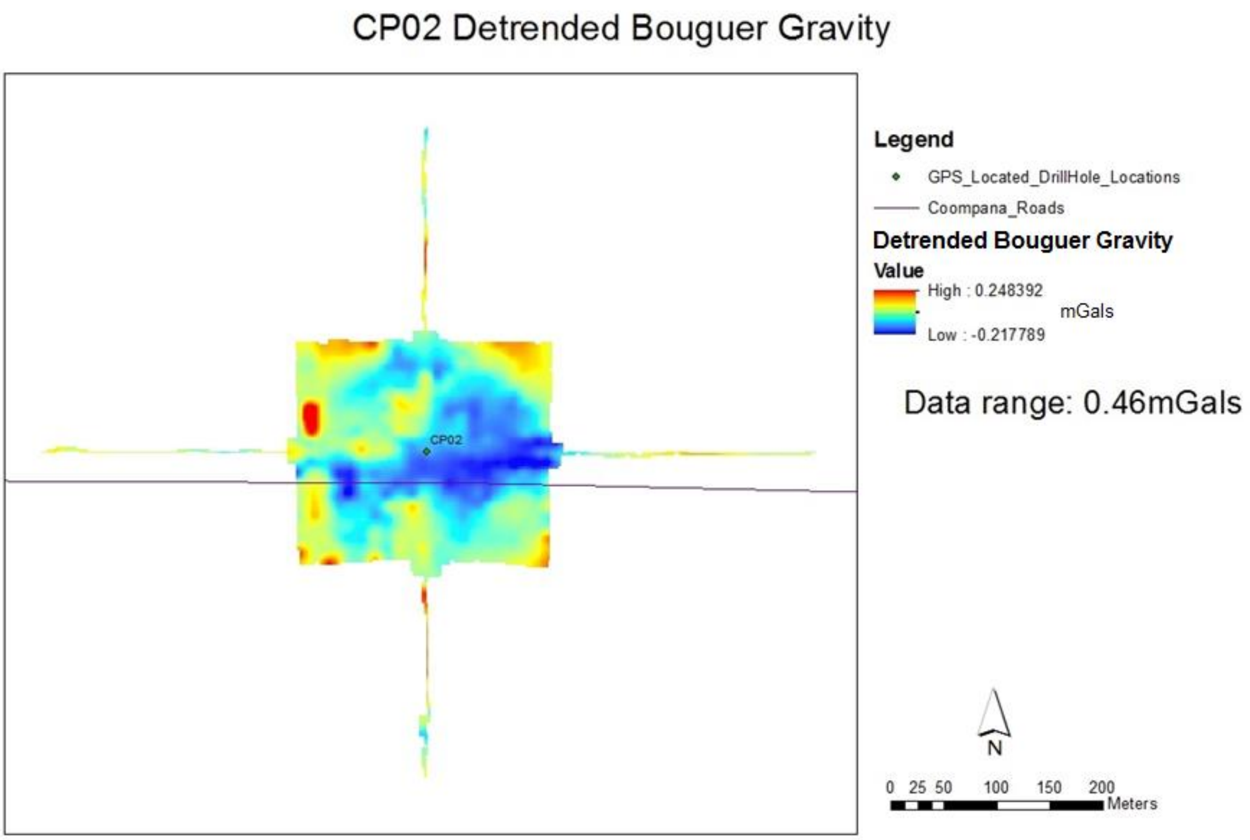

Figure 4: The gravity image over site CP02 shows potential cavities directly under the site.

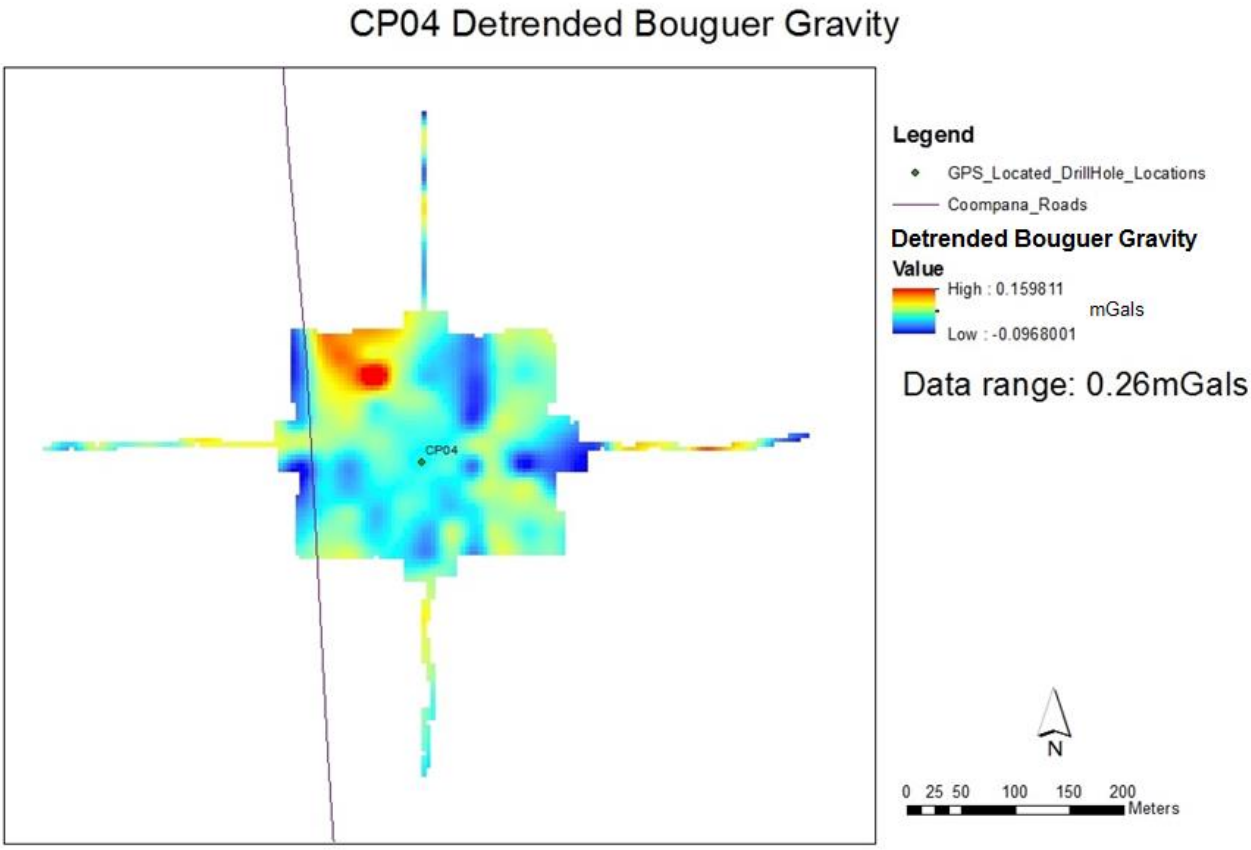

Figure 5: The gravity image over site CP04 shows potential small cavities around the site.

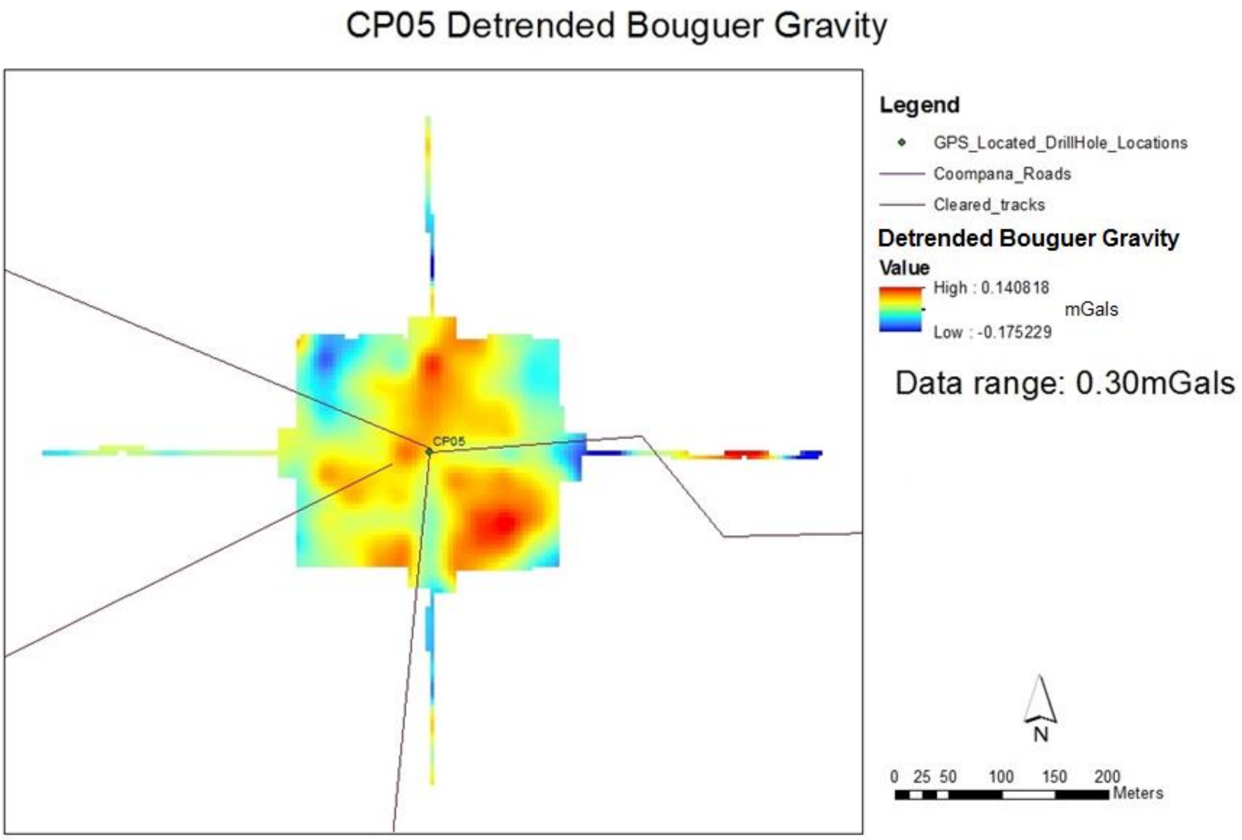

Figure 6: The gravity image over site CP05 shows potential small cavities to the northwest and east of the site.

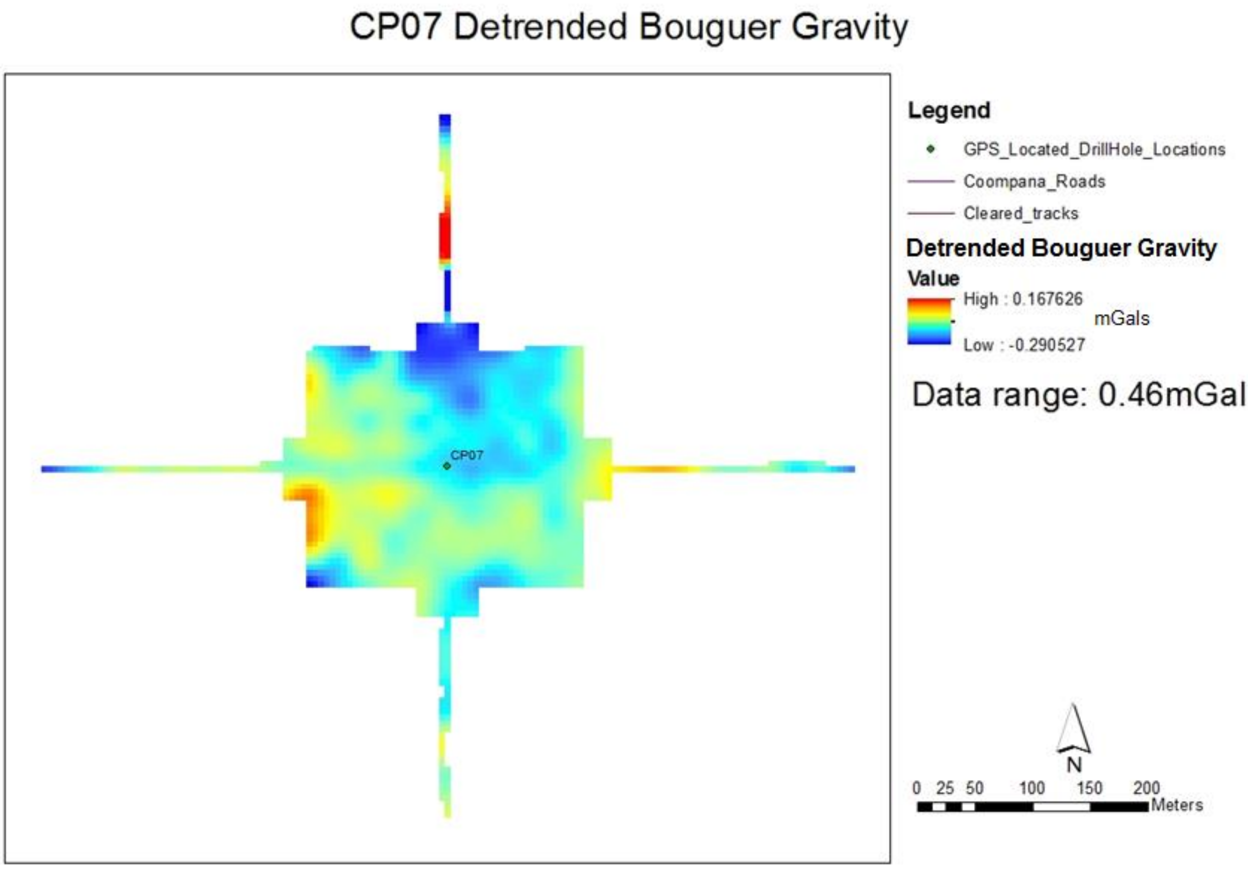

Figure 7: The gravity image over site CP07 shows potential cavities on and to the north of the site.

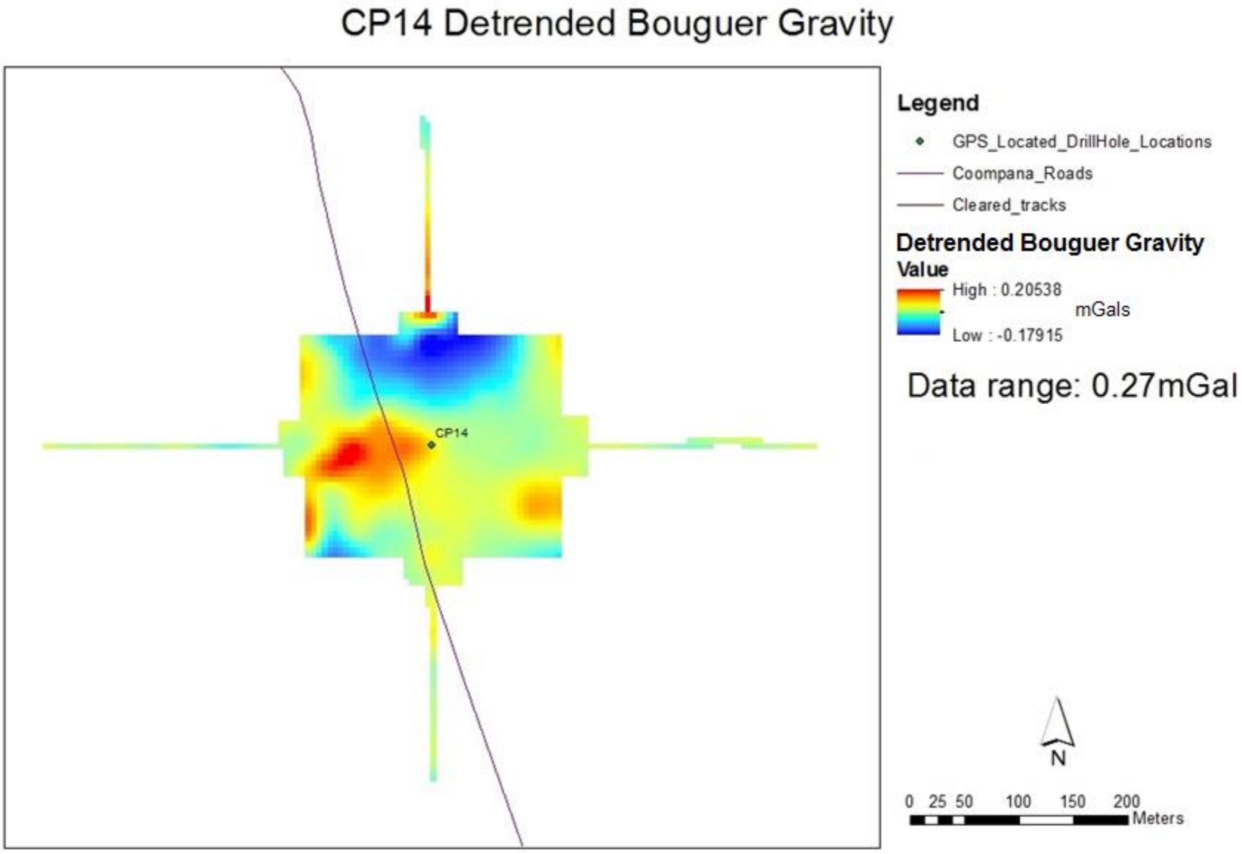

Figure 8: The gravity image over site CP14 shows a potential cavity directly north of the site.

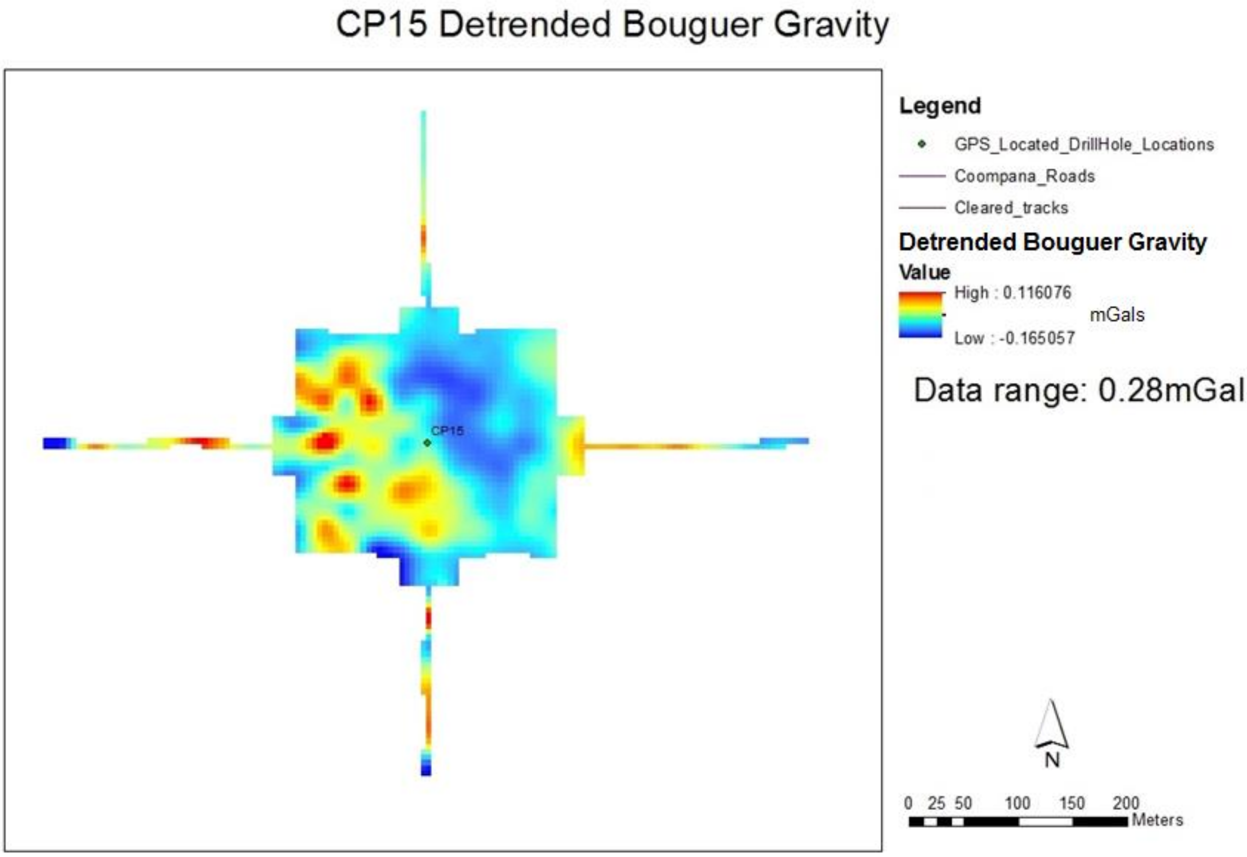

Figure 9: The gravity image over site CP15 shows a potential cavity directly east of the site.

CONCLUSIONS

In figures 2 to 9 areas coloured in blue correspond to areas that could correspond to cavities. The location of the drill sites have been shifted to ensure that drilling does not occur directly over an area of low density. To date no cavities have been intersected as part of the drilling program. While this doesn't prove that the microgravity surveys have located any actual cavities, the drilling results are consistent with the gravity results.

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