The Kauring airborne geophysical test range, Western Australia

A non-technical overview by
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Introduction

A detailed ground gravity survey and a detailed airborne LiDAR topographic survey (surveying technology that measures distance by illuminating a target with a laser light) in the Kauring area near York, was carried out in 2009 by the Geological Survey of Western Australia (GSWA) and its collaborators. The survey provides a 'benchmark' dataset for the comparison and calibration of airborne gravity and other airborne geophysical sensing systems.

This document gives a brief, non-technical overview of the project, and of the gravity survey method and its uses.

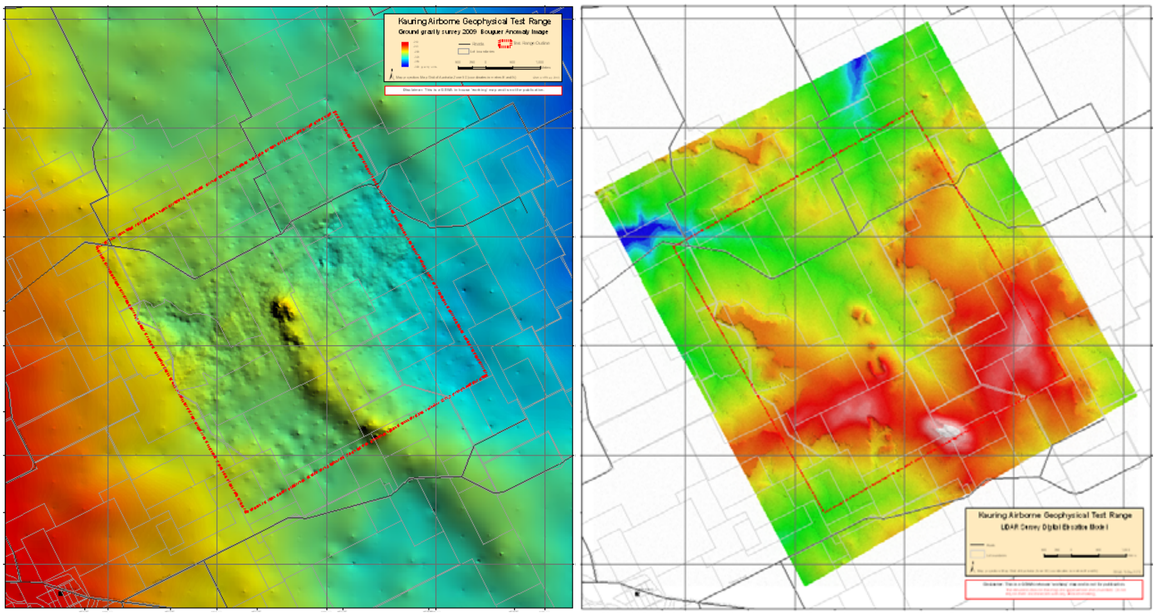

Figure 1: *The Kauring Test Range Gravity Bouguer Anomaly image (left) and LiDAR topography (right). In both images, red indicates high values and blue indicates low values. Gravity values range from -210 to -380 gravity units (gu); elevation from 240 to 360 m. Grid lines are 2 km apart.*

Figure 1 shows the gravity response and the topography in the area of the lozenge-shaped test range (outlined in red). The main feature of interest on the gravity map is a small but intense central anomaly that occurs at the northern end of a weaker, sinuous gravity 'ridge' that extends to the southeast. This gravity ridge is situated along the broader change from high gravity values in the southwest to lower values in the northeast of the map, reflecting a change in underlying rock densities in the area.

The central gravity anomaly is almost certainly caused by iron-rich rocks forming the small topographic rise in the centre of the map; however, it is not yet known if the linear gravity ridge is caused by similar rocks hidden beneath the soil cover. Other airborne geophysical surveys confirm that the gravity anomaly has a coincident magnetic anomaly and an electrical conductivity anomaly.

The well-defined gravity anomaly, and its location in gently undulating farming land, is an ideal site for testing and comparing the responses of different airborne geophysical systems, particularly gravity systems.

Gravity basics

The vertical gravitational field of the Earth has an average value of approximately 9.8 m/s^2 (metres per second per second) — the acceleration of a body falling to the Earth under the effect of gravity. Because gravity varies with mass, lateral changes in the density of the Earth mean that the Earth's gravitational field also varies from place to place.

These variations are very small: there is a difference of only 0.04 m/s^2 (less than half of one percent of the average field) between the lowest value in Mexico City (9.779 m/s^2) and the highest in Oslo, Norway (9.819 m/s^2). The variation over areas of lesser extent would tend to be very much smaller than this.

To make it easier to describe these tiny variations, gravity anomalies are measured in units of micrometres (one-millionth of a metre) per second per second (µm/s^2). This reference measurement unit of 1 µm/s^2 is referred to as a 'gravity unit' — about one ten-millionth of the Earth's average field. On this scale, the 'strong' anomaly in the Kauring test range is less than 100 gravity units (gu) in amplitude. Clearly, measurements of gravity need to be made with a very high degree of precision, and this is particularly true when measurements are taken on a moving platform, such as an aircraft.

Gravity readings are very sensitive to height changes. Because of the variation of gravity with distance between masses, topographic variations have a pronounced gravitational effect and have to be taken into account in determining the gravitational response of the subsurface.

Although the effect is less pronounced for topography further away from the measurement point, nevertheless, a detailed knowledge of the topography is a critical aspect in gravity surveying. For this reason, gravity surveys are accompanied by detailed topographic surveys. In the past this was a painstaking process but today, with precise GPS measurements and accurate airborne LiDAR surveys, it is a much simpler procedure.

Gravity surveys

Geophysical surveys in general are used to make inferences about the composition and structure of the Earth by making measurements that respond to subsurface changes in the physical properties of the Earth.

The purpose of a gravity survey is to infer how the subsurface density changes within an area by measuring the variation in the gravitational field of the Earth over that area. Gravity surveys are used to make inferences about the shape and structure of the Earth; vertical and horizontal variations of rock type, structure and mineral concentrations; variations in the depth to bedrock; and to detect natural and man-made voids.

Until relatively recently, gravity surveys for mineral and petroleum exploration have been ground or marine based, with measurements being taken from an instrument placed on the surface of the Earth or carried on a ship. Such surveys take a long time to complete, even for land-based surveys where a helicopter is used to transport the instrument from one place to another. It also means that some places cannot be surveyed; for example, lakes, rivers, swamps, and thick forests are largely inaccessible.

Airborne gravity surveys

Developments over the past decade or so have seen gravity meters being put into aircraft; and airborne gravity and gradiometry surveys (the measurement of how gravity changes vertically or horizontally in a particular place) are becoming viable survey methods that can be applied more rapidly in appropriate conditions.

However, developments are still at a relatively early stage and there are a number of competing systems being used, each with its own methods of making measurements and its own operating characteristics. From the perspective of instrument developers and of mapping and exploration companies wanting to use airborne gravity surveys, it is important to be able to see how different systems respond in a known area. Developers can be certain that their systems are producing correct results while mapping organizations and explorers will be better able to interpret the results of airborne surveys conducted elsewhere.

It is for this reason that GSWA in collaboration with its federal counterpart, Geoscience Australia (GA), and with Rio Tinto Exploration, who is presently also developing an airborne gravity measuring system, were keen to see the establishment of an accessible site of a known gravity response that could be used for such a purpose.

Establishment of the Kauring test range

A distinct, strong gravity anomaly was identified near Kauring that met these requirements and, in early 2009, a detailed gravity survey was made of the anomaly as part of a GSWA regional gravity survey over an area of about 150 kilometres square approximately centred on Cunderdin.

The Kauring test range consists of two concentric areas: an inner detailed survey area of about 5 x 6 km centred on the Kauring anomaly shown in Figure 1, with readings made at points that varied between 50 m and 250 m apart; and an outer area of 20 x 20 km surveyed in less detail with gravity measurement points 500 m apart that can be used for lower resolution airborne systems (Figure 2). The regional survey consisted of reading points 2 km apart and provides a 'gravity context' for measurements in the test range areas.

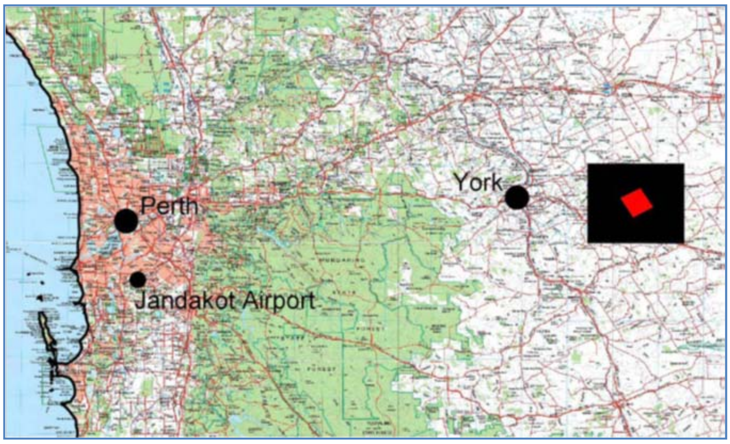

Figure 2. Location map of the low-resolution gravity test area (black) and the inner high-resolution test area (red) in relation to the city of Perth, the township of York, and Jandakot Airport

The inner area is suitable for higher resolution airborne systems that are able to detect relatively small geological features (with dimensions as little as 20–100 m, say) while the outer area is primarily for the use of systems that are designed for the detection of larger features of 2–3 km in extent or more.

Because the accuracy of gravity surveys is so dependent on a good knowledge of the surface topography particularly in the area of more detailed surveys, Fugro Spatial Solutions contributed a 1-metre resolution topographic map of the inner area from an airborne laser scanning (LiDAR) survey; the mapped topography is shown in Figure 1.

Further information

GA has set up a website for access to the various gravity and topography datasets from the test range and for the dissemination of results from future tests.
http://www.ga.gov.au/minerals/kauring

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