# **URAMET MINERALS LIMITED**

# Processing, Data Enhancement and Interpretation of a Detailed Gravity Survey, Box Hole Project, Northern Territory.

By:

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## Box Hole Gravity Interpretation

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## **Executive Summary**

This report describes the results of data processing, data enhancement, analysis and preliminary interpretation of infill gravity data covering Uramet's Box Hole project. Uramet commissioned Daishat to carry out a series of gravity profiles as infill to a 2006 semi-regional gravity survey.

The detailed gravity survey was carried out by Daishat in August 2007 and consisted of 1041 gravity stations. Gravity stations were located at 50 m intervals along east–west lines, spaced every 250 m, with the lines offset between the semi-regional grid lines. A total of 37 lines were surveyed with line lengths ranging from 1 to 4 km to cover areas of interest. Daishat provided the infill gravity as fully corrected Bouguer anomaly values and also adjusted the 2006 data to match the infill data. Unfortunately, Daishat did not include line numbers in the Excel file and as is common in gravity surveys, lines were surveyed in segments rather than as continuous profiles as in ground magnetics. Line segments were sorted into continuous lines using the northing as a pseudo line number and single point anomalies were removed using a non-linear filter.

Large-scale deep-seated regional effects dominate gravity data and regional /residual separation is an important component of gravity interpretation. Orthogonal polynomial residual filtering removes long-wavelength effectively but does not resolve small anomalies very well. A local residual filter resolves small anomalies but has amplified noise in the Bouguer data. Derivatives are also effective in highlighting local anomalies and attenuating longer wavelength anomalies. Fractional vertical derivatives have been used to optimise enhancement of the shallow field component. High-pass filtering has also been used effectively to highlight local gravity highs.

Bouguer gravity values range from –39 to –32.5 mGgal with the negative Bouguer values reflecting the long-wavelength regional gravity field. Residual filtered images show clearer correlation with surface geology with a clear NNW linear gravity gradient following the contact between Eurowie Sandstone Member and the Upper Arrinthrunga Formation. The residual filtered images show a number of discrete gravity highs varying in size and amplitude. Amplitudes of residual gravity anomalies are in the range +-0.3 mGal which is probably on the low side for lead-zinc mineralisation.

Residual gravity highs with amplitudes greater than 0.05 mGal have been plotted as contours superimposed on the local geology and an image of the aerial photography to aid in target screening. Five priority targets have been selected on the basis of (1) residual gravity highs in proximity to the mapped Eurowie Sandstone Member and the Upper Arrinthrunga Formation contact. (2) Structural targets. Fold hinge/fault related etc. (3) Gravity highs offset from known mineralisation.

The main recommendation is a thorough re-assessment of the detailed structure and stratigraphy of the area so that we can place the gravity in its geological context. It is recommended that the gravity interpretation should be integrated with all available geophysical and geological data including drill logs. Although the focus should be on residual gravity highs, any discrete gravity lows should be checked out as possible sink-holes. More detailed gravity interpretation of target areas is recommended including reconciling with drill hole data. 3D inversion and 3D plotting of drill holes would be ideal.

## 1. Introduction

#### **1.1 Objectives**

The aims of the project were to locate residual gravity highs, which might be due to MVT-type Pb-Zn mineralisation. The infill gravity survey was designed to follow up the 2006 helicopter assisted semiregional gravity survey, which showed a number of interesting gravity highs. Dipole-dipole IP surveys along selected lines and a VTEM HTDEM survey were also carried out

## **1.2 Gravity Survey Data**

The helicopter assisted semi-regional gravity survey was carried out by Daishat in July 2006 and consisted of 203 gravity stations. Gravity stations were located approximately on a 500 m grid, although stations were adjusted where necessary because of unsuitable helicopter landing sites.

The detailed gravity survey was carried out by Daishat in August 2007 and consisted of 1041 gravity stations. Gravity stations were located at 50 m intervals along east–west lines, spaced every 250 m, with the lines offset between the semi-regional grid lines. A total of 37 lines were surveyed with line lengths ranging from 1 to 4 km to cover areas of interest. Figure 1 shows the location of both semi-regional and infill gravity stations.

#### **1.3 Geology and Mineralisation**

At the Box Hole prospect, outcrops of galena occur along 6 km of strike length in dolostones of the Upper Cambrian Arrinthrunga Formation. The Arrinthrunga Formation comprises dolostones and limestones, with minor sandstone, siltstone and shale. The gossanous lead-zinc outcrops occur at the upper contact of the Eurowie Sandstone Member, which separates the Lower and Upper Arrinthrunga Formation. Rock units within the Box Hole prospect have been subjected to localised folding into north– northwest trending synclines. North of Kings workings, there is evidence of later approximately east– west folding. In the central portion of the Box Hole prospect, there are a number of anastomosing and bifurcating north–south trending faults belonging to the Putta Putta Fault System, which are closely associated with the hinge zones of the synclinal folds.

In the 1960's, about 15 t of lead ore averaging 65-70% Pb and 60 g/t Ag was mined from a surface pit known as Kings Workings. The style of mineralisation is classic MVT involving low-temperature replacement and vug-filling components.

Much of the previous exploration within the Box Hole project area has been concentrated in the vicinity of the known gossan outcrops and interpreted strike and depth extensions including the Kings Workings in the centre of the Box Hole prospect area. Although the area has been the subject of base metal exploration by at least nine previous tenement holders, much of the focus has been on a relatively narrow linear corridor and much of the previous drilling has been relatively shallow.

In 2006, a 5 km by 7 km 500 m spaced gravity survey undertaken by Elkedra resulted in the identification of over 15 discrete gravity targets most of which lie outside the galena-barite outcrop in areas that have never been subject to any significant exploration activity. Geophysical modelling of the gravity anomalies indicates they are consistent with sulphide bodies lying at depths of 100-200 m.

The term Mississippi Valley-type (or MVT) Pb-Zn deposit is commonly used to describe the varied family of epigenetic sphalerite-galena ores hosted by carbonate rocks that were precipitated from low temperature (75-200°C) basinal brines. MVT deposits generally seem to be the product of regional to sub-continental-scale fluid flow that led to ore precipitation typically in dolostone and limestone of stable,

only weakly deformed carbonate platforms. MVT deposits are typically small in size but of high grade. Individual deposits are usually 2-10 Mt in size but these typically occur in districts of up to 200 Mt grading around 8% combined Pb and Zn. Uramet's targets are individual deposits with dimensions 250m x250m x50m. Target include stratigraphic, fault zone, breccia zones and palaeo-karst models

## 2. Gravity Processing

#### 2.1 Basic processing

Daishat provided the infill gravity as fully corrected Bouguer anomaly values and also adjusted the 2006 data to match the infill data. Unfortunately, Daishat did not include line numbers in the Excel file and as is common in gravity surveys, lines were surveyed in segments rather than as continuous profiles as in ground magnetics. The first task involved sorting line segments into continuous lines using the northing as a pseudo line number. Next single point anomalies were removed using a non-linear filter. Figure 2 shows the final Bouguer anomaly profiles produced by this processing. The Bouguer anomaly data were gridded using minimum curvature and a mesh spacing of 50 m. Figure 3 shows a colour image of the Bouguer anomaly data with contours superimposed. The combined semi-regional and infill data were gridded using minimum curvature with a mesh spacing of 100 m. Figure 4 shows a colour image of the combined Bouguer anomaly data with contours superimposed.

#### **2.2 Regional-Residual Separation**

Bouguer gravity anomaly data are smoother than the equivalent magnetic data because:

- the gravity field is one order less differentiated than the magnetic field (the gravity field changes less rapidly in space than the dipolar magnetic field)
- > Variations in density are less than variations in magnetic susceptibility.

Large-scale deep-seated regional effects dominate gravity data and it requires careful analysis to recognise the contributions due to shallower structures. Regional /residual separation is an important component of gravity interpretation. The problem can best be considered in terms of digital filtering and spectral analysis. If the spectra of individual components overlap, we cannot separate out the components. We should note that definition of regional and residual is specific to the problem in hand : residual for one problem may be part of the regional for the next problem.

A number of techniques have been applied in regional / residual separation:

- graphical smoothing,
- polynomial filtering
- frequency domain filtering and spectral analysis

It is difficult to generalise on use of the different methods. Orthogonal polynomials and spatial and frequency domain filtering all have their advantages and disadvantages.

Figure 5 shows a colour image of an orthogonal polynomial order 5 residual. The filter has removed long-wavelength effectively but does not resolve small anomalies very well. Figure 6 shows a local residual filter, using an iterative space domain method. This filter resolves small anomalies better than Figure 4, but has amplified noise in the Bouguer data. Figure 7 shows a local residual filter image of the combined survey data.

## **2.3 Derivatives**

Derivatives are used routinely to highlight local anomalies and attenuate longer wavelength anomalies. It is well known that derivatives of potential fields enhance the field component associated with shallow features and de-emphasize the field from deeper sources. The vertical gradient (1st vertical derivative) and second vertical derivative filter enhance near surface anomalies, attenuating deep-seated features to produce a much sharper field than the Bouguer anomaly.

The second vertical derivative provides very clear definition of contacts, faults etc but amplifies noise. Fractional vertical derivatives provide an objective, flexible approach to shallow layer separation filtering as the order of the fractional derivative can be selected to match the data and optimise enhancement of the shallow field component. Resolution of local anomalies increases as the order of the derivative increases at the expense of some noise amplification.

Figures 8 and 9 show vertical derivatives of order 0.5 and 1.5 respectively for the infill data.

## **2.4 Other Filters**

Figure 10 shows high-pass filtered Bouguer anomaly data, using a cut-off wavelength of 500 m

## 3. Gravity Interpretation

## **3.1 Introduction**

Density and magnetization are sources of potential fields, intrinsic to the body possessing the physical property contrast and acting at some distance from it. The strength of the gravitational field of a body is proportional to its density and that of the magnetic field proportional to its magnetization. In exploration, we are concerned with the inverse problem of potential field theory that of deducing the distribution of densities or magnetization's from measurements of gravitational or magnetic fields at or close to the surface. There is no unique solution to the inverse problem, different combinations of geometry and magnetization/density can produce identical results. The anomalous field is a linear function of the mass or magnetization contrast but a non-linear function of the source location and geometry.

The amplitude and resolution of the field decrease as the distance to the source increases. Close to the source, well-defined anomalies are seen and provide good resolution of the causative source. At larger distances from the source, the field is attenuated and recognition of anomalies due to individual sources is no longer possible. The field fall-off rate depends on the source geometry with structural indices ranging from 0-2 for gravity and 0-3 for magnetics. Both gravity and magnetic methods measure anomalies in a **static** natural field and the observer has no control over the field, unlike an artificial field, dynamic method such as seismic or electromagnetics.

The measured magnetic or gravity field is a superposition of effects from sources at different levels in the earth's crust and separation of components is a critical part of the interpretation. In a simple case, this is regional-residual separation, where regional = deep, thick sources and residual = shallow, thin sources.

Gravity anomalies reflect the presence of density variations in the basement, basement topography and the density variations in the sedimentary sequence, which may or may not be isostatically compensated.

## **3.2 Densities and Gravity anomalies**

As can be seen in the table below, lead-zinc ore-bodies are generally denser than the host carbonates but there is considerable overlap in physical property contrasts and highly fractured and porous orebodies may be only slightly denser than the host carbonates. Even where an ore-body produces a positive gravity anomaly, this may be difficult to detect in the presence of larger gravity highs due to faulting, variation in carbonate thickness and local karsting. Ore-deposits associated with sink-holes and other collapse structures may have limited gravity expression as the gravity low associated with the collapse structure masks the gravity high due to the ore-body. The presence of barite-rich zones is an additional complication. Gravity is best used as a follow-up method at prospect scale and residual gravity highs and lows should both be followed up as indicators of possible mineralisation.

Typical density valu	ues are.
Galena	7.5 g/cm <sup>3</sup>
Sphalerite	4.1 g/cm <sup>3</sup>
Barite	$4.5 \mathrm{g/cm}^3$
Marcasite	$4.9 \mathrm{g/cm}^3$
Dolomite	2.8 g/cm <sup>3</sup>
Limestone	$2.6 \mathrm{g/cm^3}$
Sandstone	2.4 g/cm <sup>3</sup>

## **3.3 Regional Setting**

Figures 11 and 12 show gravity and magnetic intensity images of the regional area.

The southern Georgina Basin region consists of exposed and covered basement of the southern Davenport province and the platform-sediment-covered Aljawarra Domain, bounded to the south by the Arunta Complex. The aeromagnetic data over the Aljawarra craton show a complex picture of magnetic sources at several depths. The data shows that a major NE trending palaeosuture zone together with later major fault systems of NW and NE orientation lie in a broad zone of deformation at the boundary between the Davenport and Aljawarra blocks. The overall magnetic texture of the Aljawarra Domain basement differs from the adjacent Davenport Province. The Aljawarra Domain has very varied magnetic relief and texture with large areas of low amplitude and rugose texture, typical of granitoid - granite gneiss terranes. These areas are separated by narrow, high amplitude (~1000 nT) linear and curvilinear anomalies, interpreted as complexly folded and faulted mafic and ultramafic units. The striking E-W anomaly on the northern edge of the circular Ooratippra anomaly has amplitudes up to 2000 nT. A thick accumulation of Cambro-Ordovician carbonate-dominated sediments, the Dulcie Syncline covers the west of the area.

Apart from the Ooratippra gravity high, the Aljawarra Domain is a region of negative Bouguer gravity values reflecting thick crust. There is a strong gravity gradient over the fault system marking the Aljawarra Domain - Davenport Province boundary and local gravity lows within the Aljawarra Domain can be interpreted as rift basins. Gravity data support lineament interpretation seen in the magnetic imagery.

### 3.4 Interpretation of Infill Survey Gravity Anomalies

Bouguer gravity values range from –39 to –32.5 mGgal. The negative Bouguer values reflect the longwavelength regional gravity field seen in Figure 11. Anomaly trends are approximately NNW with higher values in the northeast and low values in the southwest corner of the prospect and there is little obvious correlation with surface geology. The residual filtered images show clearer correlation with surface geology with a clear NNW linear gravity gradient following the contact between Eurowie Sandstone Member and the Upper Arrinthrunga Formation. The residual filtered images show a number of discrete gravity highs varying in size and amplitude. Amplitudes of residual gravity anomalies are in the range +-0.3 mGal which is probably on the low side for lead-zinc mineralisation.

Residual gravity anomalies are best viewed using high pass filtered stacked profiles and residual filter colour images. Figure 13 shows residual gravity highs with amplitudes greater than 0.05 mGal as contours superimposed on the local geology and an image of the aerial photography. The aerial photograph backdrop is an edge detection version of the image.

#### **3.5 Preliminary Targets**

Selected Box Hole gravity targets are plotted in Figure 13. The priority targets are selected on the basis of:

- 1. Gravity highs close to or offset from the mapped Eurowie Sandstone Member and the Upper Arrinthrunga Formation contact. Targets include A and D.
- 2. Structural targets. Fold hinge/fault related etc. Targets C and E are in this category

3. Gravity highs offset from known mineralisation. Target B is in this category.

Target A is located along the Eurowie Sandstone Member and the Upper Arrinthrunga Formation contact, adjacent to two north–south faults and is close to a chargeability high. The anomaly is the only residual anomaly which has a large excess mass.

#### **3.6 Excess Mass Calculation**

Where residual gravity anomalies are well-defined with no interference from adjacent anomalies, it is possible to make an estimate of the excess mass and inferred ore reserves without making any assumptions about the geometry and depth of the ore-body. The excess mass calculation is based on Gauss' theorem and is relatively simple to implement. The entire anomaly above background is divided into small cells of area  $\Delta$ S (10 x 10 m in this case) and the product of the residual gravity anomaly and cell area summed over the area of the anomaly. Then the total anomalous mass is given by

M = 23.9 x 
$$\Sigma(\Delta g \times \Delta S)$$
 metric tons

To calculate the actual mass requires some knowledge of ore and host rock densities and then multiply the excess mass by  $\rho 2/(\rho 2-\rho 1)$  where  $\rho 2$  is the ore density and  $\rho 1$  the host rock density.

Quick calculations on targets A and B gave estimates of 1.5 million tons and 300,000 tons respectively.

For comparison, Pine Point Pyramid 1 ore-body gave an excess mass of 6 million tons using 100 x100 m cells.

## 4. Conclusions and Recommendations

A detailed gravity survey carried out by Daishat in August 2007 has been processed and interpreted to try to locate residual gravity highs which may indicate lead-zinc mineralisation. The survey consisted of 1041 gravity stations at 50 m intervals along east–west lines, spaced every 250 m, with the lines offset between the 2006 semi-regional grid lines. A total of 37 lines were surveyed with line lengths ranging from 1 to 4 km to cover areas of interest. Daishat provided the infill gravity as fully corrected Bouguer anomaly values and also adjusted the 2006 data to match the infill data. Unfortunately, Daishat did not include line numbers in the Excel file and as is common in gravity surveys, lines were surveyed in segments rather than as continuous profiles as in ground magnetics. Line segments were sorted into continuous lines using the northing as a pseudo line number and single point anomalies were removed using a non-linear filter.

Large-scale deep-seated regional effects dominate gravity data and regional /residual separation is an important component of gravity interpretation. Two types of residual filter were used on the Box Hole data. An orthogonal polynomial residual filter has removed long-wavelength effectively but does not resolve small anomalies very well. A local residual filter, using an iterative space domain method resolves small anomalies but has amplified noise in the Bouguer data. Derivatives are also effective in highlighting local anomalies and attenuating longer wavelength anomalies. Fractional vertical derivatives have been used to optimise enhancement of the shallow field component. Resolution of local anomalies increases as the order of the derivative increases at the expense of some noise amplification. High-pass filtering has also been used effectively to highlight local gravity highs.

Bouguer gravity values range from –39 to –32.5 mGgal with the negative Bouguer values reflecting the long-wavelength regional gravity field. Residual filtered images show clearer correlation with surface geology with a clear NNW linear gravity gradient following the contact between Eurowie Sandstone Member and the Upper Arrinthrunga Formation. The residual filtered images show a number of discrete gravity highs varying in size and amplitude. Amplitudes of residual gravity anomalies are in the range +-0.3 mGal which is probably on the low side for lead-zinc mineralisation.

Residual gravity highs with amplitudes greater than 0.05 mGal have been plotted as contours superimposed on the local geology and an image of the aerial photography to aid in target screening. Five priority targets have been selected on the basis of (1) residual gravity highs in proximity to the mapped Eurowie Sandstone Member and the Upper Arrinthrunga Formation contact. (2) Structural targets. Fold hinge/fault related etc. (3) Gravity highs offset from known mineralisation.

The main recommendation is a thorough re-assessment of the detailed structure and stratigraphy of the area so that we can place the gravity in its geological context. It is recommended that the gravity interpretation should be integrated with all available geophysical and geological data including drill logs. Although the focus should be on residual gravity highs, any discrete gravity lows should be checked out as possible sink-holes. More detailed gravity interpretation of target areas is recommended including reconciling with drill hole data. 3D inversion and 3D plotting of drill holes would be ideal.

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7538000 mN       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1	7537000 min	N				
7336000 mN       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1						
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Date:17/12/2007     Uramet Minerals Ltd       Date:17/12/2007     Box Hole Prospect       Author: DRC     Northern Territory					Uramet Minerals I Date: 17/12/2007 Box Hole Prosper Author: DRC Northern Territor	Ltd ct ry
7524000 mN Gravity Interpretation	7524000 mN 별 별			 	Office: Perth Drawing: SC Scale: 1:50000 Prelimite: MOA 7	ion
O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O	276000 J	10000772	1000083	820001	0 0.5 1 kilometres	2







