Integrated interpretation and modelling of Tellus Aeromagnetic, Gravity, Radiometric and Multispectral Analysis of the Satellite Imagery datasets for the exploration and identification of deep geothermal target areas in the Midlands Valley Terrane.

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ABSTRACT

The DeepGeo project is assessing the setting of potential deep geothermal reservoir targets in the Midland Valley Terrane (MVT) by modelling and integration of aeromagnetic, gravity and radiometric data acquired as part of the Tellus Survey. These data are combined with processed satellite imagery data, in order to further characterise and delineate potential geothermal targets associated with the documented buried intrusions of the MVT. The outcome of this research will generate new geophysical and geological models integrated with historical datasets and provide conceptual exploration model of potential deep geothermal targets in areas where potential there is a potential for high heat usage or, subject to the suitability of the targets where electricity

1. INTRODUCTION

The Midlands Valley Terraine of Ireland is well established as a mineral exploration area for Zinc (Zn) and Lead (Pb). Extensive exploration data is available for interpretation purposes in order to develop detailed subsurface geological models and potentially identify geothermal targets. The identification of these new geothermal targets is proposed by the project through the integration of new Tellus geophysical datasets, satellite imagery data and existing geological data available.

The project has selected a study area of approximately 250km^2 to the East of the town of Athlone, County Westmeath (figure 1) based on strong magnetic anomalies identified by the Tellus airborne data.

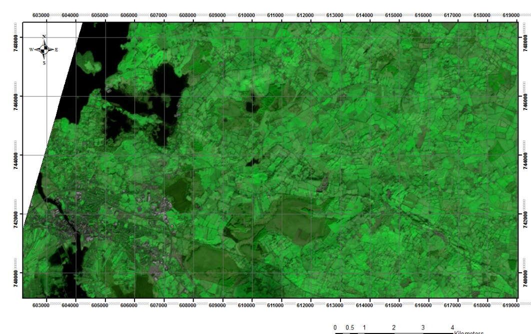

Figure 1 Athlone, County Westmeath

2. GEOLOGICAL SETTING

The bedrock geology of the study area broadly comprised Carboniferous shallow marine sequences of limestones and shales. historical mineral exploration borehole records and maps of the area, Ryan (1991) show a maximum exploration depth of 635 m at well 98-1228-37. The stratigraphic units consist of Argillaceous Bioclastic Limestones (ABL) at the base of the sequence, with Complex faulting throughout the area is characterised by large scale faulting down throwing and offsetting the geological units to the NE-SW direction.

3. GEOPHYSICAL DATA

The Tellus geophysical data shows a total magnetic intensity anomaly that ranges from-30 (nT) to a proximally1000 (nT) in a NE-SW direction with a large amplitude. The anomalies are aligned with the main trend Irish Iapetus Suture Zone. The Tellus EM data shows high values of apparent conductivity between 400 (mS) and 1200 (mS)at 50 (m) depth map, in the study area. Both anomalies are observed to have the same orientation. However the EM anomaly is more constrained by NW faulting.

Historical gravimetric maps show, a broad 50 (km) structure trending in a NE-SW direction with Bouguer Anomaly values ranging from 0 to 10 mGal in the study area. In addition, filtered frequency domain gravity maps by Williams and Brown (1986) exhibit similar trend toward to the South of this structure with parallel orientation, Bouguer gravity anomalies that vary from -10 to 0 mGal.

Interpretation of equivalent Uranium (eU) and equivalent Thorium (eTh) concentrations from the Tellus radiometric data highlight areas with low concentration eU (figure 2) and high concentrations of eTh (figure 3) and Carboniferous, Argillaceous Bioclastic Limestone. The map below figure 2, shows equivalent Uranium concentration from the new Tellus data.

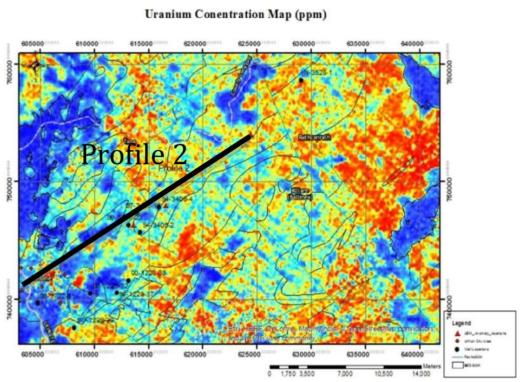

Figure 2Tellus Equivalent Uranium concentration map (ppm)

The radiometric data for the study area is correlated with surface temperature measurements with near and far infrared, thermal bands (Bands 10,11,12,13,14) from LansatOli 8 satellite imagery (figure 5) and with eU eTh concentrations, in order to delineate potential areas with elevated radiogenic heat production. Profile 2 (figure 2) is parallel to the magnetic anomaly as well as to the high values of apparent conductivity. Profile 2 exhibits relatively high Uranium concentration and in less proportion equivalent thorium concentration. Figure 4, shows eU and eTh concentrations trends for profile 2.

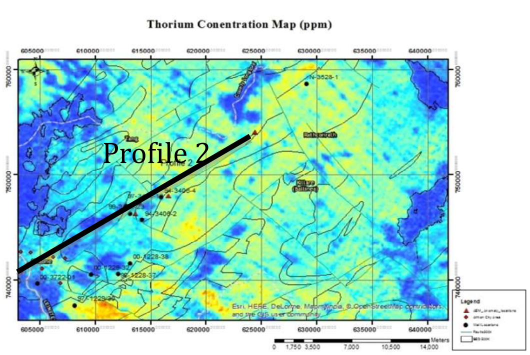

Figure 3Equivalent Thorium concentration map (ppm)

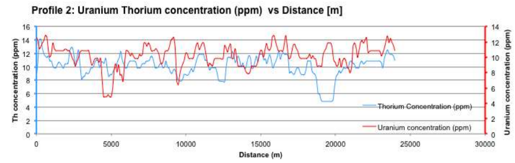

Figure 4 Profile 2 equivalent Uranium and equivalent Thorium concentrations.

3. SATELLITE IMAGERY

Surface temperature maps(figure 4) were produced by using processed images from NASA JPL. (2014). ASTER Global Emissivity Dataset, is being used to delineate and identify potential relationships between heat production due radiogenic decay in the study area and residual surface temperature.

Surface temperatures image was overlaid with geological bedrock map to observe if surface temperature distribution could be associated with lithology and eTh and eU concentration. However, no evident trend can be observed. Highest surface temperatures where observed in ABL (Marine shelf and ramp facies) with values varying from 6.2 °C to 13.8°C as well as high eU concentrations of 15.8 (ppm) and eTh concentrations of 13.8 (ppm).

On the other hand, in the south western part of the study area across the fault the ABL shows a change in temperature reaching a maximum value 11.8°C with eU, eTh highest concentrations 11.8 (ppm) respectively. The relationship that can be initially observed is that surface temperature follows the broad trend on the geological map.

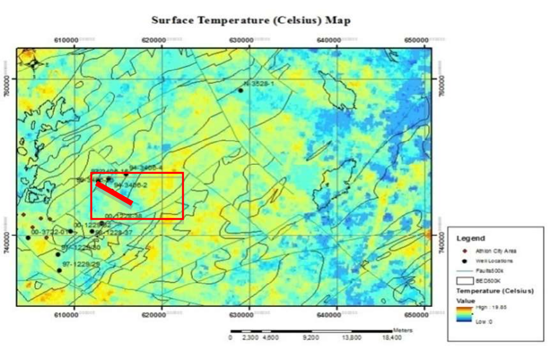

Figure 5Surface temperatures Map (ºC)

The overall surface temperature variations are from 6 ºC to 19 ºC degrees after atmospheric correction. Further work is being undertaken to discriminate soil and anthropogenic temperatures influence (figure 6) and observer residual temperature map.

6a

6b

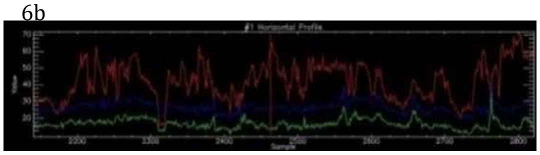

Figure 6a and 6b Anthropogenic and soil vegetation can be capture with the visible bands, below is a wavelength profile extracted from the visible bands healthy vegetation and water are defined responses in terms of wavelength.

Figure 6a and 6b shows surface temperature, wavelength and black body radiation spectral radiance (Wm^{-2} $Sr^{-1}Hz^{-1}$), obtained from the surface temperature data of the satellite image. The plot shows that as temperature of a black body increases the spectral radiance of the same body increases.

The black body spectral radiance graphs were modelled using a constant temperature, and frequency for the near and far infrared using Plank's black body radiation expression [1] for spectral radiance and wien's displacement law [2] to determine the maximum wavelength.

$$I(f,T) = \frac{2hf^3}{c^2}\frac{1}{e^{\frac{hf}{KT}}-1} \qquad [1]$$

$$\lambda_{MAX=}\frac{0.0028976}{T}\,(mK) \qquad [2]$$

The maximum wavelength for a black body at T= 287 (K), with a wavelength 10.10 (μm) will show spectral radiance 2.85E-12 (Wm^{-2} $Sr^{-1}Hz^{-1}$). The same body at T =285 (K) will show 2.71E-12 (Wm^{-2} $Sr^{-1}Hz^{-1}$). The model is built in order to characterise the geology in terms of its spectral firms, measure temperature and predict spectral radiance.

Soil geochemistry data for the area will be used in order to refine and improve the characterisation of the temperature map and observe possible heat production due radiogenic decay.

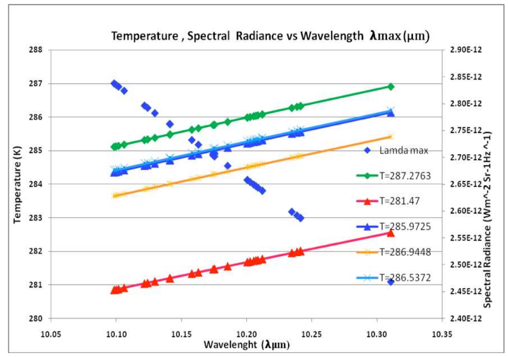

Figure 7Temperature, Spectral Radiance vs. Wavelength

Finally, figure 8 is shows an initial perspective of the complex model built be the project including the Tellus data set in a 3D model layout.

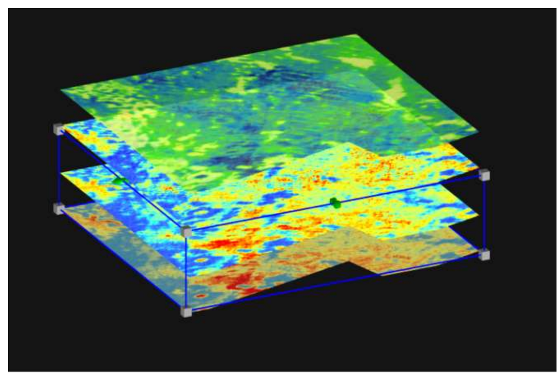

Figure 8Initial 3D perspectives of new data integration

3. CONCLUSIONS

Lansat 8 Thermal bands (10,11,12,13,14) are a valid approach to estimate surface temperature, however soil data in order for further characterization is relevant to develop temperature maps.

The identification of radiogenic heat producing areas as an indicator of potential deep geothermal targets in the Irish midland requires further study. The effect of soil geochemistry on the Tellus data must be integrated with the geological and geophysical data in the area in order to constrain geothermal targets

Deep geothermal exploration in the Irish midland is in its early stage and requires further understanding. However the new Tellus data and integration provides interesting areas that deserve attention.

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Acknowledgements (optional)

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