Government geological surveys across Australia acquire a range of geoscientific data to support minerals exploration. This presentation will look at some of those data types and assess their suitability for opal exploration.
The Gawler Craton Airborne Survey was one of the world’s largest airborne magnetic and radiometric acquisitions. The acquisition program ran from 2017 to 2019 and the final data products were released earlier this year. Magnetic surveys image the magnetic response of iron contained in rocks in the earth’s crust and are sensitive to minute variations of iron. This results in images that can tell us a lot about fault structures in the earth’s crust.
This is the vertical gradient of the magnetic intensity and when we zoom into the Coober Pedy Region we can begin to see what appear to be de-magnetised zones that could be interpreted to be paleo-channels and fault structures. I found it interesting that almost all of the Coober Pedy diggings are situated on the north-eastern side of a north-west trending structure, suggesting that this feature may have been related to the formation of the Coober Pedy Mesa. One aspect of the magnetic data is that it is difficult to confidently infer the actual depth of the features we are interpreting, so any working theories about the relationship between magnetics and opal formation may be difficult to validate. Still, there are some features that may be worth following up with drilling.
Here is the Andamooka Precious Stones Field shown at the same scale as the Coober Pedy image from the previous slide. Magnetically, the two areas are very different and this reflects differing underlying geologies, remembering that the magnetic response we see in these images is the sum of all of the rocks to 1000s of metres, while for opal we are really only interested in the top few 10s of metres!
It is interesting to note that almost all of the Andamooka diggings are in a demagnetised zone and we may be able to infer some structural information through the Andamooka PSF.
Radiometric data was acquired during the GCAS. Radiometric surveys capture surface concentrations of Uranium, Thorium and Potassium. It is a very good tool for understanding how landscapes evolve, because we can infer the movement of uranium across the landscape. How does this relate to opal formation or opal deposits? A number of studies have confirmed that opal and opal bearing levels around Australia have elevated uranium concentrations when compared with the general background uranium levels found in the earth, and although these elevated concentrations are not dangerous this type of mapping can provide useful information if used as a proxy in regional opal exploration. The blue colours in the figure on screen show where uranium concentrations are elevated in comparison with other surrounding areas. This is indicative of potential opal bearing levels and could be an indicator of entirely new opal bearing areas.
This figure shows the same radiometric image normalised to better show the contrast between the three radioelements and we can more clearly see the elevated uranium at and around Coober Pedy.
This figure shows the elevated surface uranium concentrations at Andamooka.
Digital elevation models (DEMs) have been around for decades. The most popular open source global DEM is currently NASA's Shuttle Radar Topography Mission (SRTM) DEM, a global 30 metre cell size coverage providing very good elevation data. The image shows the elevation in metres above the Australian Height Datum (AHD), equivalent to metres above sea level. We can clearly see the Coober Pedy Mesa, with drainage channels running to the south/southwest.
It turns out that if we combine the DEM with current knowledge of the depth of opal bearing levels (OBLs) in Coober Pedy, we can start to infer the lateral extent of Coober Pedy’s opal bearing levels! The Department for Energy and Mining have produced publications over the years that state the depth to various opal bearing levels across Coober Pedy. I have taken that information and converted the depth to OBL level to elevation height. The list in the above map shows the OBLs expressed in metres above sea level, the same units as the elevation model. I then set the lower limit to 201m, which correlates with the set of diggings shown with the red outline on the list. This information suggests that the deepest level of all of those diggings could be the same opal bearing level and the extent of that level is the coloured area on the DEM. This assumes that by-and-large, opal bearing levels are horizontal (a reasonable assumption). We now have a way for opal explorers to plan a prospecting campaign into areas adjacent to known diggings with some knowledge of where they would need to drill in order to catch the same levels of the known areas. This methodology can be fine tuned to limit the extents even further or project OBLs from an individual digging. I have taken a more holistic approach to provide the example you see in the above image.
This figure presents the same data in a slightly different way, this map is trying to capture the edges of a 10 metre thick layer of ground that is likely to have opal bearing levels at or near the surface. It is where those OBLs break the surface and is another way to view areas that would benefit from further drilling. A map like this could be easily rejigged to target a particular OBL associated with any of the know opal diggings in Coober Pedy.
Resistivity is a geophysical, electrical method for measuring the resistivity/conductivity of the sub-surface. An electric current is fed into the ground via an electrode and the electric potential is measured between the electrical source and the surrounding area to capture the conductivity of the ground around the current source. Unlike magnetic data, resistivity surveys are able to be processed in a way that provides resistivity information in the 3rd dimension. This gives us a good handle on the depth of the resistive rocks. The figures in this slide are from surveys carried out in 2006. Areas shown in blue are more conductive, while warmer colours are more resistive. We can immediately see that the areas of the blue sections that pinch upward (some of these are shown in the red circles) are likely to line up with fault structures. Blue ground appears to be more conductive, while good sandstone is more conductive than the surface rocks. This technique has potential for mapping sub-surface units and possibly enabling us to map areas of good sandstone and its proximity to slips that are known to be good indicators within opal bearing ground. Performing these surveys at high resolution on a large scale is cost prohibitive, but this technique should not be ignored because there are likely to be cost effective small-scale surveys possible from contractors who provide these services. (Galvanic resistivity methods are thought to be appropriate for Coober Pedy).
South Australia have a spectral scanning instrument called the HyLogger™. Its purpose is to scan drill core and rock chips to obtain the mineralogy of the samples based on the rocks absorption and reflection characteristics across a range of frequencies. Core scanning has been performed on a number of Coober Pedy Opal Field rock samples obtained during department funded drilling programs. Four minerals, including clay minerals thought to be linked with opal formation and deposition are recognised by the scanner: Gypsum, Kaolin, Alunite, and Montmorillonite. Mineral abundances can be derived from the processing of HyLogger data. Although further work would be required to determine whether these minerals can be used as a vector to opal deposits, I can see potential for this technique, because it provides accurate mineralogy with good control of depth, enabling us to map clay mineral abundances underground. With sufficient mineralogy information at opal bearing levels in both productive and unproductive ground we may see markers that would provide better targeting for productive areas.


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“The Department for Energy and Mining acknowledges Aboriginal People as the First Peoples of South Australia.
We recognise and respect the cultural connections as the Traditional Owners and occupants of the land and waters of South Australia, and that they continue to make a unique and irreplaceable contribution to the State.”
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