High resolution resistivity: a new opal exploration tool

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Introduction

A new high-resolution resistivity instrument, developed by Jingping Zhe, was tested within the Coober Pedy Precious Stones Field, 900 km NW of Adelaide, to determine its suitability for opal exploration.

The new technique records the electrical resistivity from the surface to a depth of investigation of around 35 m, and results from three test sites show that:

- there is a good correlation between resistivity and lithology
- the technique appears to distinguish between areas of low and high opal prospectivity
- sub-surface geological features important for opal exploration can be delineated.

The technique may provide a quick, cost-effective method for assessing the opal potential of an opal claim, as well as locating specific prospecting targets.

Resistivity method

Resistivity is a popular geophysical method used in mineral and environmental exploration (Telford et al., 1990). With the development of advanced electronics and data processing techniques, resistivity can work more efficiently and deliver more accurate results than previously (Stummer, 2003). The new resistivity acquisition system developed by ZZ Resistivity Imaging Pty Ltd is an example of this technological advancement and differs from traditional instruments in three significant ways:

- It acquires data from a continuous spread of electrodes, avoiding traditional acquisition pattern limitations. This enables collection of considerably more data and produces more accurate results.
- It acquires 26 sets of data simultaneously, compared to current instruments that acquire one set of data at a time. Thus the acquisition of data is more efficient and cost effective.
- The final result is a true resistivity distribution map rather than the traditional apparent resistivity map or curve. This allows easier and more accurate interpretation.

Geology

The geology of the Coober Pedy Precious Stones Field has been described in detail by Robertson and Scott (1990). Opal is found in Early Cretaceous marine Bulldog Shale which, when fresh, is a dark grey, silty and sandy, smectite-rich claystone. Intense weathering has produced a well developed weathered profile comprising up to 50 m of white to mauve, bleached, leached, porous, kaolinitic claystone, locally referred to as ‘sandstone’. Opal is found as veins in horizontal ‘levels’ or in steeply dipping ‘verticals’, infilling fractures and joints in the bleached claystone down to 25 m below the surface and, generally, from 5 m above to 1–2 m below the transition to fresher, denser and darker claystone. Gypsum, alunite, iron oxides and tubules are commonly associated with the levels and verticals. The bleached claystone can be variably silicified to ‘blue ground’.

The Bulldog Shale is commonly overlain by 4–8 m of Tertiary to Quaternary Russo Beds of variable composition, but usually comprising:

- A lower gypsum unit of red-brown, gypsiferous clay-silt with angular to rounded claystone and silcrete rock fragments and gypcrete.
- A middle conglomerate unit of predominantly rounded silcrete cobbles in red-brown, sandy silt-clay matrix. Hard massive silcrete may be present.
- An upper carbonate unit of red-brown, calcareous, sandy clay-silt with rounded silcrete pebbles and platy calcrete development.

Field survey

Three test sites were chosen on the Coober Pedy Precious Stones Field (Fig. 1).

Site 1, located 3 km SW of the Southern Cross Field, is not known to contain opal but 2005 PIRSA-funded PACE initiative opal exploration auger holes, AO3 and AO4, intersected reasonable sandstone and provide geological control for interpretation of the resistivity results.

Site 2, located 3 km SE of the Dead Horse Gully Field, has two Calweld holes, SS94 and SS97, for geological control. These were drilled during the 1981 Department of Mines and Energy funded Subsidised Exploration Programme (Scott and Robertson, 1983). Both holes intersected good sandstone, with SS94 having a trace of colour opal at 12 m depth.

Site 3, located 1.5 km east of the Dead Horse Gully Field, has six auger holes, CO434–35, CO457–59 and CO462, for geological control. These were drilled during the 2005 PIRSA-funded PACE initiative opal exploration program. All holes intersected good sandstone with CO435, CO458 and CO459 having a trace of colour opal, and CO462 having a trace of potch opal.

All three surveys were done with the same field data acquisition configuration, comprising a survey line 162 m long with 28 electrodes each 6 m apart (Fig. 2). From the 28 electrodes, ~5000 readings were collected via the new data acquisition system. In order to increase resolution, another infill line was added by shifting all 28 electrodes along the original line by 3 m (Fig. 3). In total 10 000 data readings were recorded for each line in about half a day.

The efficiency and cost effectiveness of the system has since been improved using 64 electrodes at 3 m intervals.

Results

For each line at the three selected sites, ~10 000 data readings were processed into a true resistivity distribution map (Fig. 3). Unlike previous methods the maps show the true resistivity at the true location,

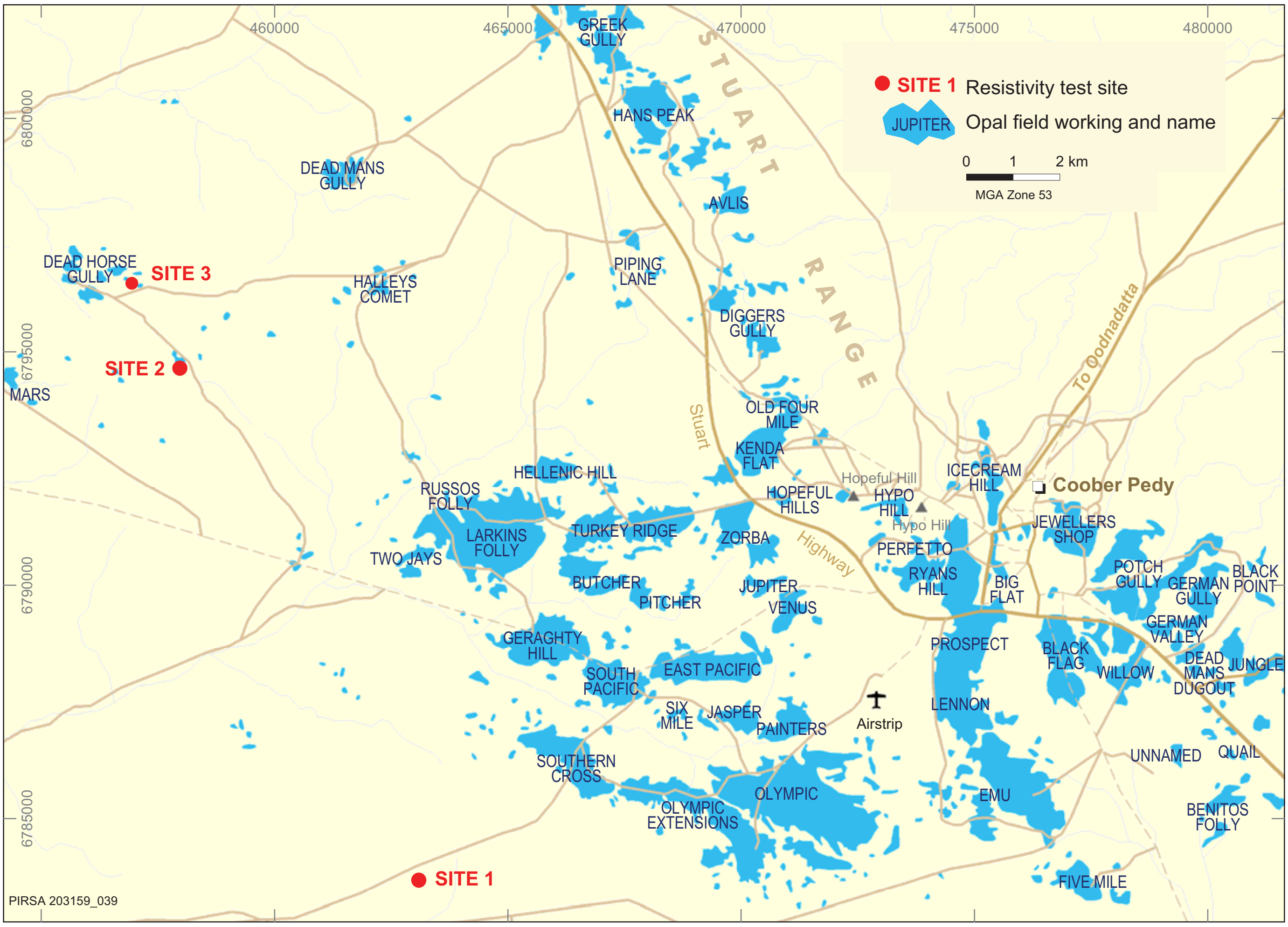

Figure 1 *Locality of resistivity test sites, Coober Pedy Precious Stones Field.*

so that geological features can be seen directly without further interpretation.

Site 1. The profile shows smooth resistivity contours with the Russo Beds being resistive (red, mauve) and the silcrete horizon being most resistive, particularly where it is thickest. Weathered, leached and bleached Bulldog Shale (good sandstone*)* is clearly contained within a moderate to high resistive zone (orange) while the underlying less weathered Bulldog Shale is confined to the low resistivity zone (green and blue).

Site 2. The profile shows the Russo Beds to be highly resistive (red, mauve), while the good sandstone is within the moderate to high resistive zone (orange). Less weathered Bulldog Shale is confined to the low resistivity zone (green and blue). The base of good sandstone is marked by a distinctive scalloped resistivity profile, possibly indicating an irregular weathering profile and/or fault structures with concentrations of moisture producing narrow, near vertical, conductive zones.

Figure 2 *Jingping Zhe conducting a resistivity survey at Site 1.* (Photo 404951)

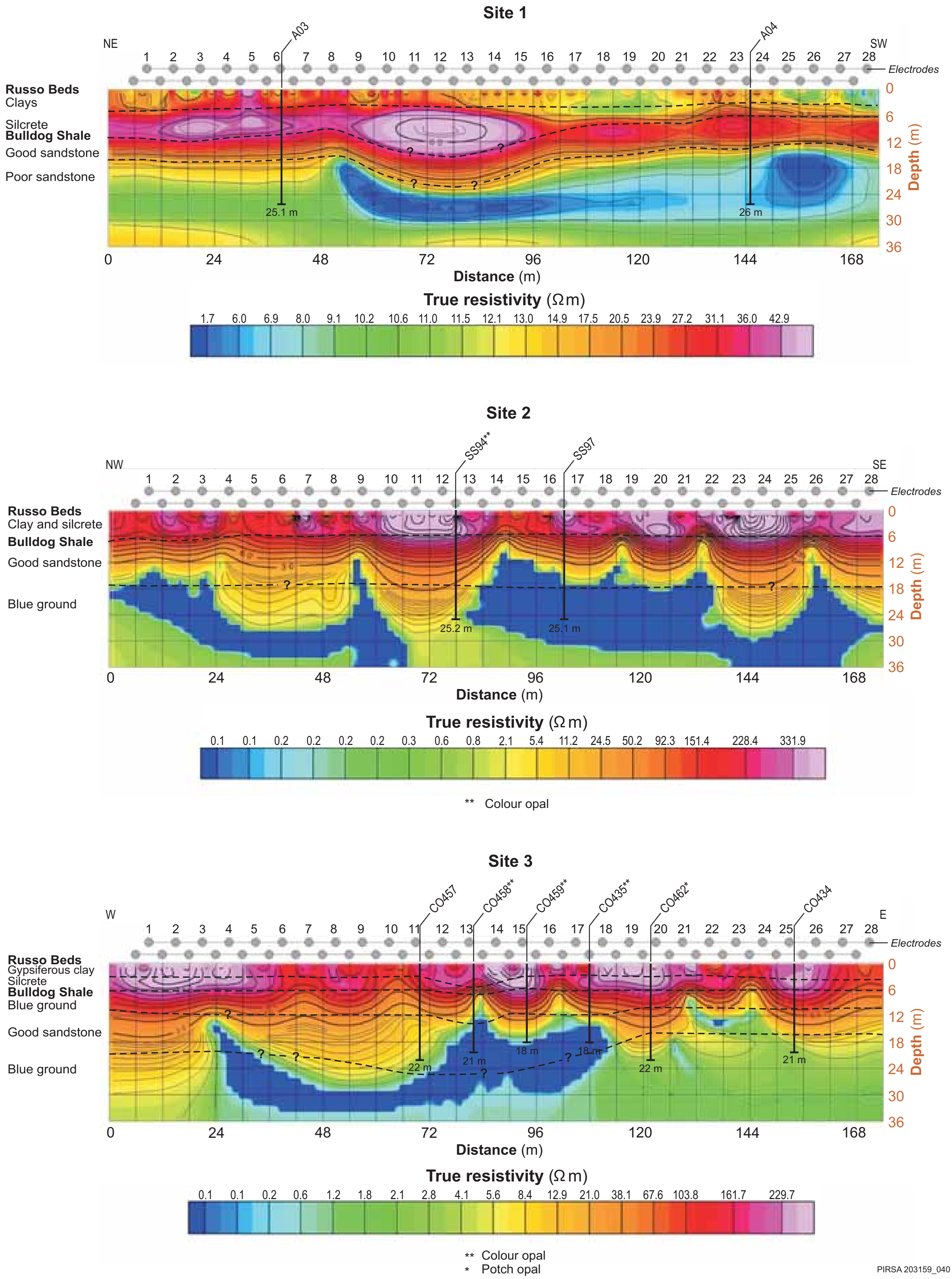

Figure 3 *Resistivity profiles, Sites 1, 2 and 3.*

Site 3. The profile shows Russo Beds to be highly resistive. The top 5 m of Bulldog Shale is silicified and also highly resistive (red), while good sandstone is generally moderately resistive (orange). The less weathered Bulldog Shale approximates the moderate to low resistive zone (yellow and green). The resistivity profile shows a very irregular scalloped boundary between good sandstone to the less weathered Bulldog Shale. Three drillholes that intersected traces of colour opal, at ~14 m depth, are positioned over the most complex part of the profile where two faults are indicated and the depth of weathering, represented by increased thickness of good sandstone, appears to be greatest.

There is a significant difference in the resistivity response between Site 1, which is of low opal prospectivity with smooth resistivity contours, and Sites 2 and 3, which are of high opal prospectivity with low resistivity intrusions giving distinctive scalloped resistivity contours. A test survey at a Lightning Ridge opal-mining site showed similar low resistivity intrusions.

Conclusion

The trial survey of the new high-resolution resistivity method demonstrates its potential to:

- provide basic lithological and structural information of the sub-surface to a depth of investigation of around 35 m
- provide good correlation between resistivity and lithology
- identify the interface between Bulldog Shale and the overlying Russo Beds
- indicate lithological variations of Bulldog Shale due to weathering, silicification and moisture
- locate probable faults, fractures and/or water leakage zones
- distinguish between areas of low and high opal prospectivity
- indicate specific targets for opal prospecting
- be a quick and cost effective opal exploration tool.

Further testing is required to refine the link between resistivity response, lithology and opal prospectivity.

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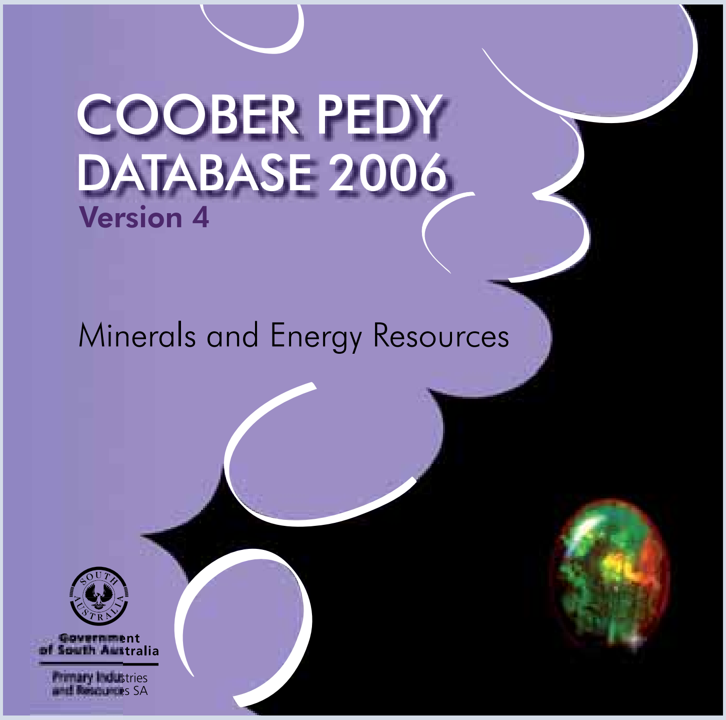
2006 Coober Pedy GIS CD

Version 4 of the Coober Pedy GIS Database CD contains updated data plus new and interactive layers including:

- Year 2000 and 1981 drilling programs with geological logs hyperlinked to drill hole locations
- Coober Pedy Precious Stones Field 1:100 000 geology map with descriptive geological legend and hyperlink to geological cross-section
- Aster mosaic satellite image, an additional layer to the Landsat, digital terrain, radiometrics, gravity and aeromagnetic images
- *Opal in South Australia* (brochure)
- *Geology of the Coober Pedy Precious Stones Field* (Report of Investigations, 56)
- Recent *MESA Journals* including the 2005 Annual Review edition
- *MESA Journal* extracts including articles on Lambina and Mintabie opalfields

The Coober Pedy Database CD is available for $50 from PIRSA Customer Services (Level 7, 101 Grenfell St., Adelaide) and the PIRSA Coober Pedy Area Office.



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