Australian Government
Geoscience Australia

AEM Go-Map for the Paterson Region, WA and Pine Creek, NT

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Introduction

AEM surveys are becoming a common tool for mineral exploration and groundwater studies. The method can map features such as paleovalleys, subsurface ore deposits, faults and other boundaries between neighbouring rock formations. AEM surveys can penetrate from depths of tens to hundreds of metres, providing a valuable tool in exploring for ore deposits and other resources under cover.

Geoscience Australia (GA) has recently completed two regional scale AEM surveys in the Paterson region, WA and in the Pine Creek region, NT. The surveys were funded by the Australia Government's Onshore Energy Security Program. These surveys provide regional subsurface geological mapping in areas prospective for unconformity-and paleochannel-style uranium deposits. They also reduce exploration risk, by highlighting targets for further exploration in the two regions.

An important risk factor in exploring with AEM is that the depth of penetration of the signal is highly variable, and depends on the conductivity in the area of interest. The depth of investigation of a survey is not known until after the survey has been flown. GA has developed a method of mapping the depth of investigation (DOI) across each survey area (Hutchinson et al, 2010). We present the DOI as a 2D grid across both the Paterson and Pine Creek AEM surveys. Labelled the AEM 'go-map', the DOI grid helps to promote AEM exploration by decreasing risk when industry undertakes tenement-scale surveys within these regions.

Deriving the depth of investigation

The AEM data are inverted to form a conductivity depth model using the GA Layered Earth Inversion (GA-LEI) algorithm of Lane et al. (2004). This algorithm uses an assumed conductivity reference model as a starting point and iteratively adjusts the model until the measured AEM data are fitted. The reference model is also used as a constraint, since the solution is non-unique. Note that the reference model used in this study is a half-space of uniform conductivity. Where the inversion result is unresolved (or ambiguous) the solution will tend toward the reference model.

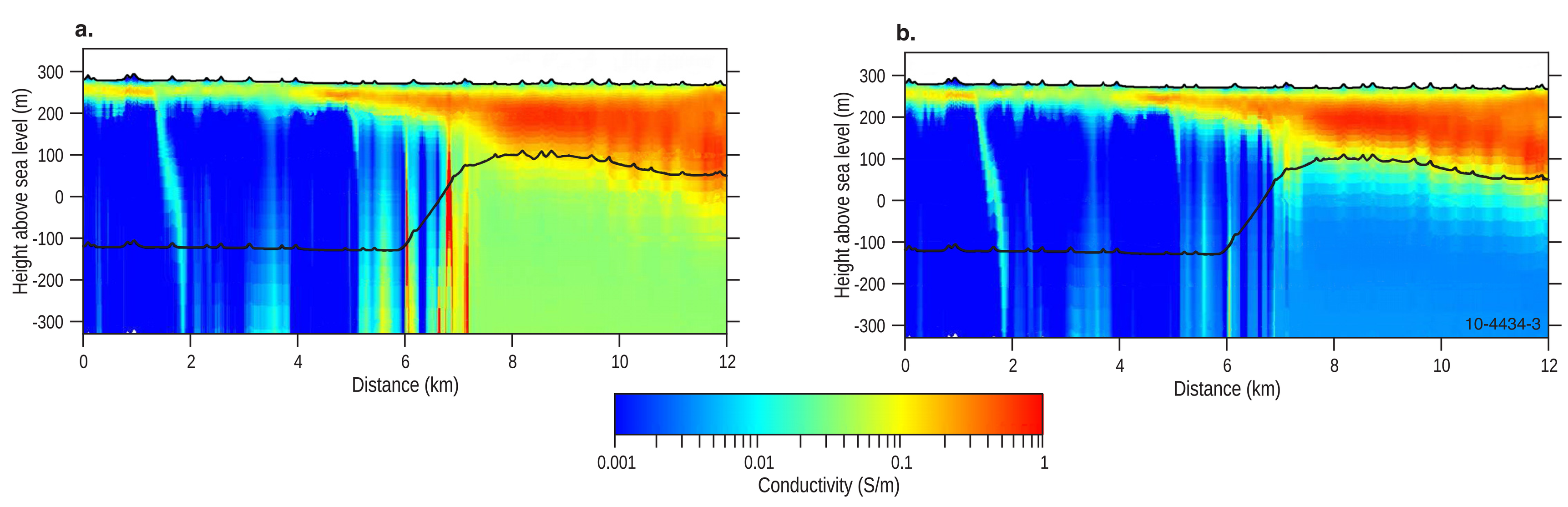

Figure 1. A sample conductivity depth section, comparing the results of inversions using reference models of (a) 0.04 S/m and (b) 0.004 S/m. The black line marks the depth of investigation (DOI) in each case. Above the DOI, the results are similar for both inversions, whereas below the DOI, the conductivity differs according to the reference model value.

A key step is to estimate how much the inversion is influenced by the assumptions fed into it. To do this we compare two inversions with a difference in their reference models and measure how much the inversion changes as a result. This measure is known as the percent data influence (PDI), defined by Oldenburg and Li (1999) and adapted by Lane et al. (2004):

$$PDI = 100\left(1 - \frac{\log(\sigma_{i1}) - \log(\sigma_{i2})}{\log(\sigma_{r1}) - \log(\sigma_{r2})}\right)$$

where σ_{i1} and σ_{i2} are the two inverted conductivities at a given point, and σ_{r1} and σ_{r2} are the corresponding reference model conductivities. We define the PDI using the logarithm of conductivity, since this is the quantity used in the inversion process.

The depth of investigation (DOI) is defined as the maximum depth to which the PDI is greater than 50%. Above the DOI, the inversion is deemed to be more influenced by the AEM data than the reference model, whereas below the DOI the reference model is deemed to be dominant. Note that the 50% PDI threshold is somewhat arbitrary, and a different threshold could be chosen.

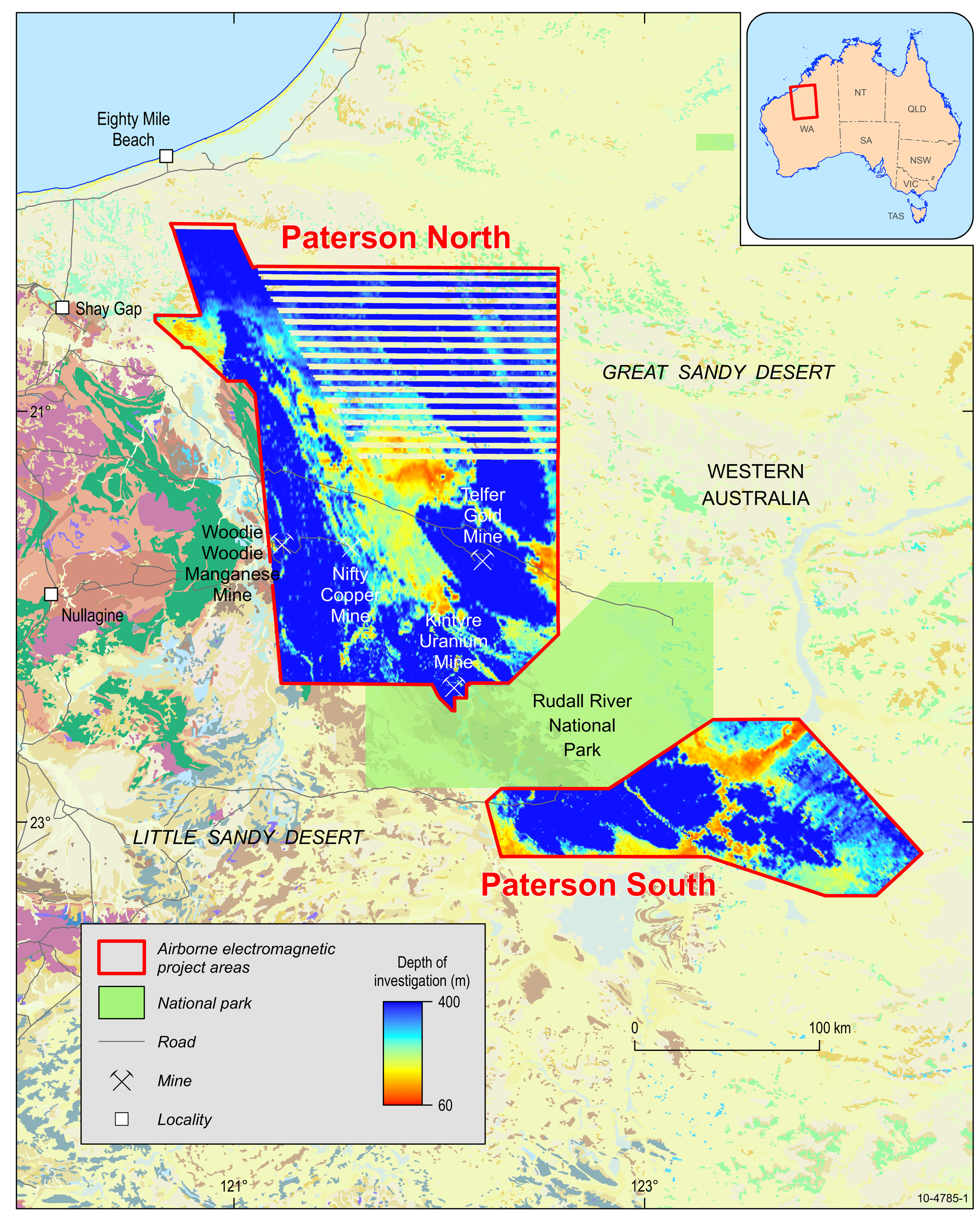

Figure 2. Depth of investigation grid for the Paterson survey, labelled the AEM 'go-map'. We have chosen not to interpolate between the lines of 6 km spacing (the venetian blind effect in the Paterson North data), since this may create misleading results.

AEM Go-Map

The DOI was calculated along each of the individual lines of each survey and was combined into a 2D grid. This grid is known as the AEM go-map. It shows where in the survey area an EM survey is likely to penetrate to substantial depths. Thus the AEM go-map can show where further EM surveys are likely to be effective. Figure 2 shows the AEM go map for the Paterson survey, WA, while Figure 3 shows the AEM go-map for the Woolner and Rum Jungle areas of the Pine Creek survey, NT.

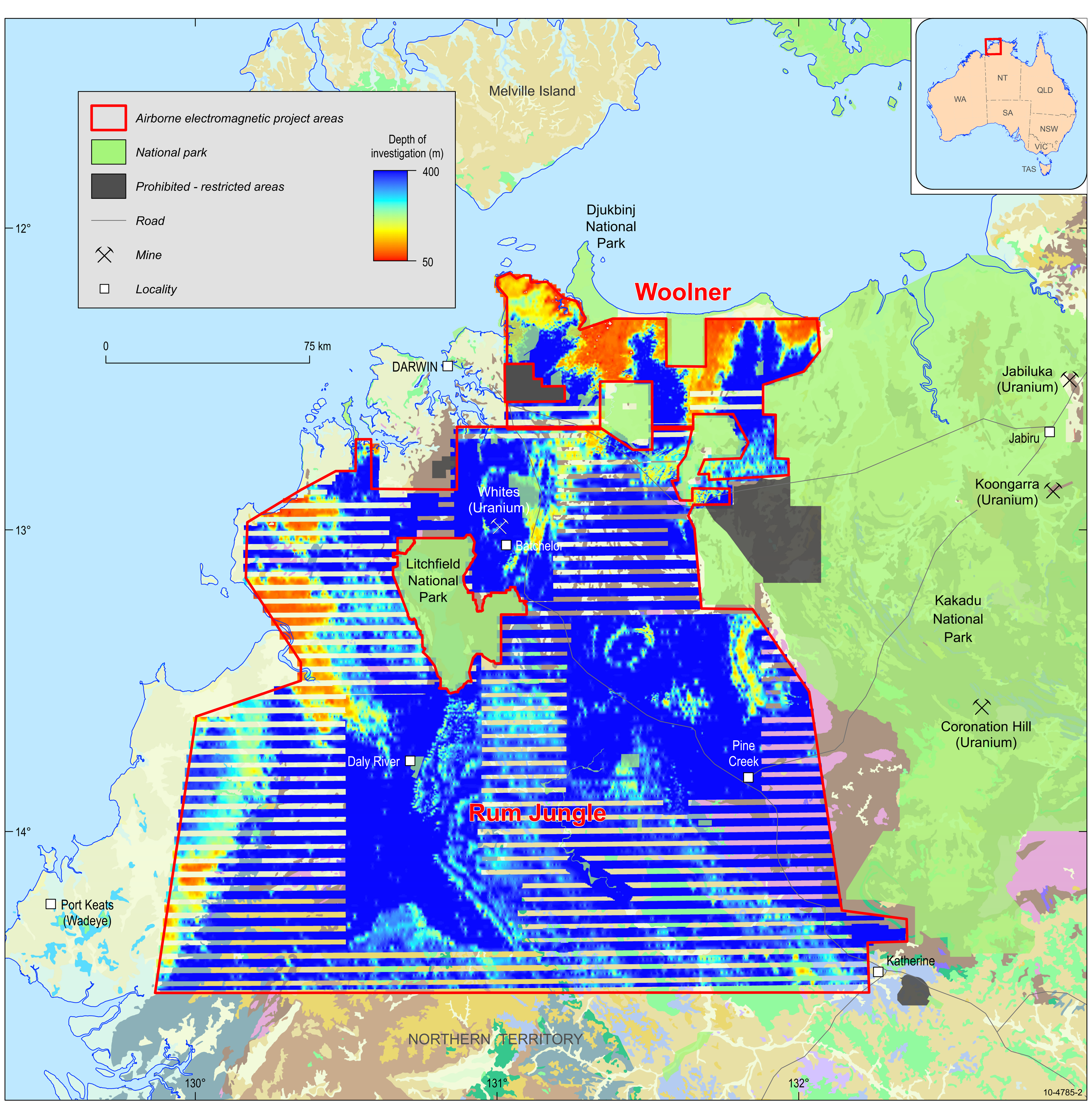

Figure 3. AEM go-map (depth of investigation) for the Woolner and Rum Jungle areas of the Pine Creek survey. We have chosen not to interpolate between the lines of 5 km spacing, creating a 'venetian blind' effect.

Conclusion

The AEM go-map shows how the depth penetration of AEM surveys varies in the Paterson and Pine Creek regions. The depth of investigation is a useful indicator of how effective an EM survey will be, and it is difficult to estimate until after a survey has been flown. The AEM go-map reduces the risk involved in further exploration in these regions, allowing local-scale AEM surveys to be targeted more effectively.

References

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Oldenburg, D. and Li, Y., 1999. Estimating depth of investigation in dc resistivity and IP surveys: Geophysics, 64, 403-416.

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