3D architecture and mineral prospectivity of the Gascoyne Province

by

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The Capricorn Orogen records the Paleoproterozoic assembly of the West Australian Craton, and over one billion years of subsequent intraplate reworking (Cawood and Tyler, 2004; Johnson et al., 2011b; Sheppard et al., 2010). The core of the orogen is occupied by granitic and medium- to high-grade metamorphic rocks of the Gascoyne Province, and these are overlain by variably deformed low-grade metasedimentary rocks. Over the past decade and a half, ongoing field mapping, combined with whole rock and accessory phase geochemical, geochronological and isotope analyses, (Johnson et al., 2011a; Johnson et al., 2011c; Sheppard et al., 2007) have provided a rigorous temporal tectonomagmatic evolution for the Gascoyne Province. The results of a recent vibroseis-source, deep crustal seismic transect through the Capricorn Orogen, provide a detailed view of the deep crustal structure of the orogen (Johnson et al., 2011c). These datasets, combined with high-resolution aeromagnetic and gravity data, allow an opportunity to assess the prospectivity of the Gascoyne Province within a robust architectural framework.

Funded by the Western Australian Government's Exploration Incentive Scheme (EIS), the Centre for Exploration Targeting (<http://www.cet.uwa.edu.au>) at The University of Western Australia has undertaken a study of the crustal structure and prospectivity of the Gascoyne Province. In this work, new understanding of the structural evolution of the province and the geometry of major features is developed. From this new interpretation, and using extensive GSWA databases, a GIS-based prospectivity analysis is undertaken using a mineral systems approach.

In each tectonic zone of the Gascoyne Province (Fig. 1), structural fabrics, folds and faults were interpreted from geophysical datasets and grouped into discrete events. These were then assigned to one of eight province-wide tectonic events based on their overprinting relationships with the main lithologies. Each zone within the Gascoyne Province has a different evolution, but a regionally consistent pattern of events can be derived (Fig. 1).

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Suturing of the West Australian Craton took place during two events — the Ophthalmian and Glenburgh Orogenies. The Ophthalmian Orogeny is not recognized in this study as it is centred further north, and any far-field effects have been overprinted. The Glenburgh Orogeny is, however, very significant and quite well preserved in the southern part of the Gascoyne Province (Fig. 1). Following the Glenburgh Orogeny, the evolution of the province is dominated by a number of intraplate reactivation events. Each has affected several zones, and most have re-utilized the pre-existing east-west structural architecture (Fig. 1). The major fault zones show the greatest tendency to be reactivated, leaving fragments of undeformed crust in-between. However, there is a general propensity for the events to have become geographically narrower, from the province-wide 1820–1770 Ma Capricorn Orogeny to the c. 570 Ma Mulka Tectonic Event, which is restricted to the central part of the province (Fig. 1).

Gravity and magnetic modelling indicates that the large-scale crustal structure defined from seismic studies (Johnson et al., 2011c; Kennett et al., 2011; Reading et al., 2012) is acceptable, given the available petrophysical constraints. However, sensitivity to the finer details of crustal structure is limited by generally low petrophysical contrast between the various granitic supersuites. This study does highlight diversity in the mid- and lower-crust, including an extremely dense layer at the base of the Glenburgh Terrane in the southern part of the Gascoyne Province (the MacAdam Seismic Province), and the high-density Bandee Seismic Province — the southern part of the Pilbara Craton — that underlies the northern part of the province.

A multi-commodity regional prospectivity analysis was undertaken. This involved the translation of inferred 4D controls on mineralization into a mineral system framework (Hronsky and Groves, 2008; Knox-Robinson and Wyborn, 1997; McCuaig and Hronsky, 2000) and implementing GIS-based prospectivity modelling. Five broad types of commodities were analysed: rare earth element (REE); orogenic and intrusive gold; surficial uranium; porphyry-base metal (PBM); and granite-hosted tin-tungsten.

The prospectivity analysis used a mineral system approach that considered, potential fluid-pathways for the transport

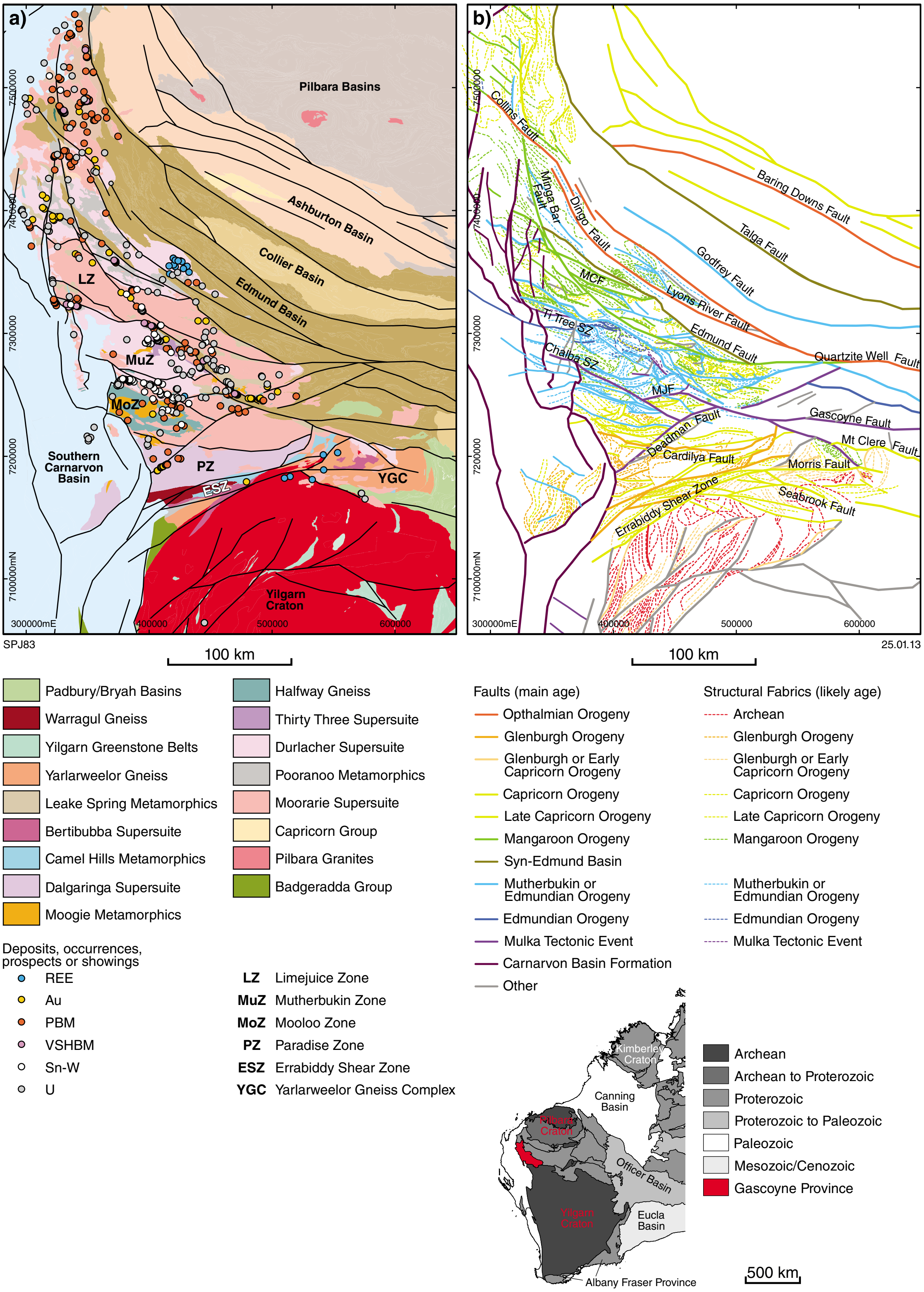

Figure 1. **a) Simplified geological map of the western part of the Capricorn Orogen showing the structural zone divisions and location of mineral deposits in the Gascoyne Province; b) Gascoyne Province-wide distribution of the age of structures, including major faults in the western Capricorn Orogen. For structural fabrics, the age is the likely age inferred from overprinting relationships. As most major faults have a long history involving several activation episodes, we infer the age of the most important movement for faults. Note the narrowing of orogenic footprints through time, from the province-wide Capricorn Orogeny (yellow) to the Mulka Tectonic event (purple).**

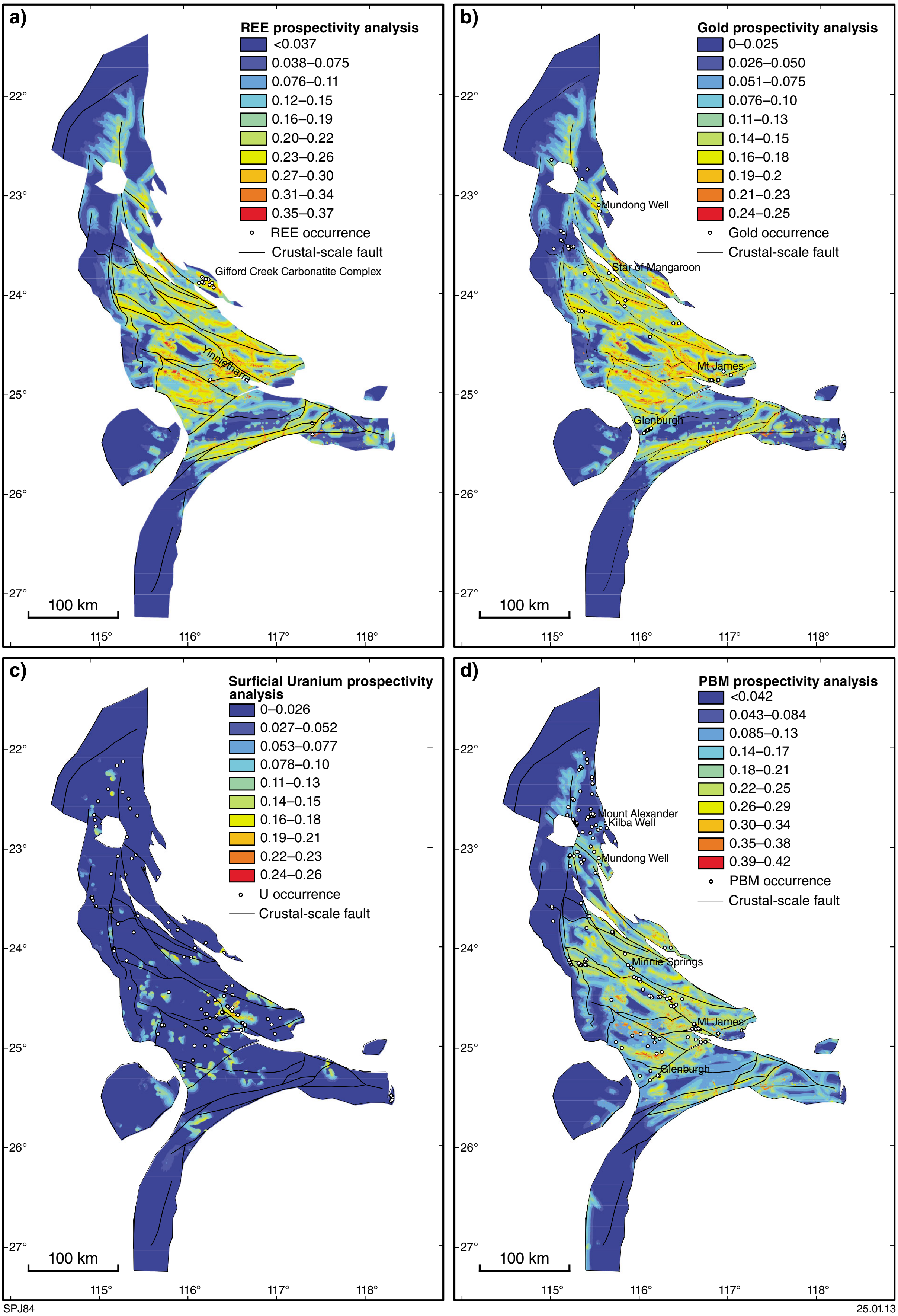

Figure 2. Final prospectivity maps for a) REE; b) orogenic gold; c) surficial uranium; d) porphyry base metals. Note that, for REE and orogenic gold, prospectivity is focused in the central parts of the Gascoyne Province, and show clear links with many, but not all, crustal-scale fault zones.

of metal into the upper crust, and the potential physical and chemical traps in which to precipitate the metals. For each component, a series of predictor maps was generated for favourable criteria, using the newly interpreted structures and other GSWA data. These were combined into a final prospectivity map using a fuzzy inference network. These analyses are not necessarily expected to show the locations of deposits themselves. Rather, they are intended to illustrate spatial variations in geological favourability for a particular type of deposit. The results are influenced by imperfect data distributions, as well as inferences made about the local geology and the way these deposits form. The results indicate the following:

- Analyses for REE indicate much of the province is prospective, with prospectivity concentrated in the central part of the province (Fig. 2a).
- The areas most prospective for gold are concentrated around major crustal boundaries, with the Limejuice Zone ('LZ' in Fig. 1) being particularly prospective (Fig. 2b).
- Surficial uranium shows the highest prospectivity in the central part of the province, but with isolated regions of increased prospectivity across the whole province (Fig. 2c).
- The analysis for porphyry base metals shows broad zones of moderate prospectivity across much of the area, with slight focusing around major crustal structures, but few areas of high prospectivity (Fig. 2d).
- Tin and tungsten occurrences cluster at the margins of the Mutherbukin Zone (Fig. 1), although the analysis suggests that a large part of the province is equally prospective.

In general, these maps showed a strong control on deposit location by crustal structure but this was significantly modified by the presence of acceptable lithological conditions for ore deposition and numerous other controls on prospectivity. Prospectivity for REE, gold and tin-tungsten deposit types is strongest in the central regions of the province, perhaps reflecting the influence of a greater degree of intraplate reworking.

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