ROYALTIES FOR REGIONS
EXPLORATION INCENTIVE SCHEME

The geological history and gold prospectivity of the West Arunta Orogen, Western Australia

by

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Located in remote east-central Western Australia, the West Arunta Orogen (WAO) is one of the least-studied and least-understood areas in the State. Using regional geophysical, geological, and geochemical datasets acquired by GSWA, the interpreted bedrock geology map in Geological Survey of Western Australia (2009) has been modified to create a new geological map of the WAO to use as the basis for prospectivity analysis of the terrain. Here we concentrate on prospectivity for gold, although other commodities have also been studied. This work was funded by the Western Australian Government's Exploration Incentive Scheme (EIS) with the WAO the first of several terrains to be analysed in this fashion by the Centre for Exploration Targeting (CET) at The University of Western Australia.

Geological setting

The WAO is the westward continuation of the Arunta Orogen, which outcrops predominantly in the Northern Territory. It comprises two distinct provinces with different protolith ages and histories (Scrimgeour, 2004; Scrimgeour et al., 2005): the 1870–1710 Ma Aileron Province to the north, and the exotic 1690–1600 Ma Warumpi Province to the south. Both provinces are separated by the north-dipping crustal-scale Central Australian Suture (Shaw and Black, 1991; Close et al., 2004; Scrimgeour et al., 2005). The WAO is unconformably overlain by the Neoproterozoic Murraba Basin in the north and by the stratigraphically equivalent Neoproterozoic to Devonian Amadeus Basin to the south (Zhao et al., 1992; Maidment et al., 2007). The Early Ordovician to Early Cretaceous Canning Basin overlies the Amadeus Basin. Based on data from the Northern Territory, the WAO is interpreted to record multiple Proterozoic crustal processes over a 1500 million-year period from before 1800 Ma through to the Paleozoic (Collins and Shaw, 1995; Scrimgeour et al., 2005).

Datasets

Two regional government geophysical datasets were used as the principal basis for the geological interpretation of the WAO: aeromagnetic and gravity data. The aeromagnetic data were acquired with a 400-m flight-line spacing and 60- to 80-m flight height. The average station spacing for the gravity data is about 2.5 km.

Interpreted geology from potential field data

A series of interpretation products were created, primarily from the potential field data, but with reference to the known geology and the small amount of petrophysical data that are available (Schroder and Gorter, 1984; Lambeck et al., 1988). The resulting geological map is shown in Figure 1.

Areas of shallow or exposed WAO have short wavelength magnetic anomalies due to changes in magnetism within the basement rocks. The oldest known basement in the region, the Lander Rock Formation, has a characteristic magnetic response comprising a modest level of total magnetic intensity (TMI), but linear anomalies are evident.

Areas of basin-fill are generally magnetically subdued, although basement-sourced variations are sometimes evident and clear linear anomalies due to mafic rocks within the Amadeus Basin sequence occur locally. Subtle anomalies allow bedding within basin-fill to be mapped in places. There is commonly a lack of correspondence between gravity and magnetic responses. In areas of basin-fill, the major causes of gravity variations are basement depth and the presence of salt within the Amadeus Basin sequence. Surprisingly, significant variations in gravity also occur in areas of outcropping basement, specifically regions with distinct negative anomalies.

Linear features, mostly defined by magnetic data, are interpreted as: (i) two sets of faults (based primarily on differences in orientation) identified from offsets and truncations of adjacent anomalies; (ii) trend lines — probably representing stratigraphic and metamorphic layering; (iii) banded iron-formation (BIF) — a special case of the trend lines identified from their high amplitude TMI response; (iv) fold axes — based on closures and veeing of the trend lines; (v) mafic dykes — identified from cross-cutting relationships with trend lines representing lithological layering.

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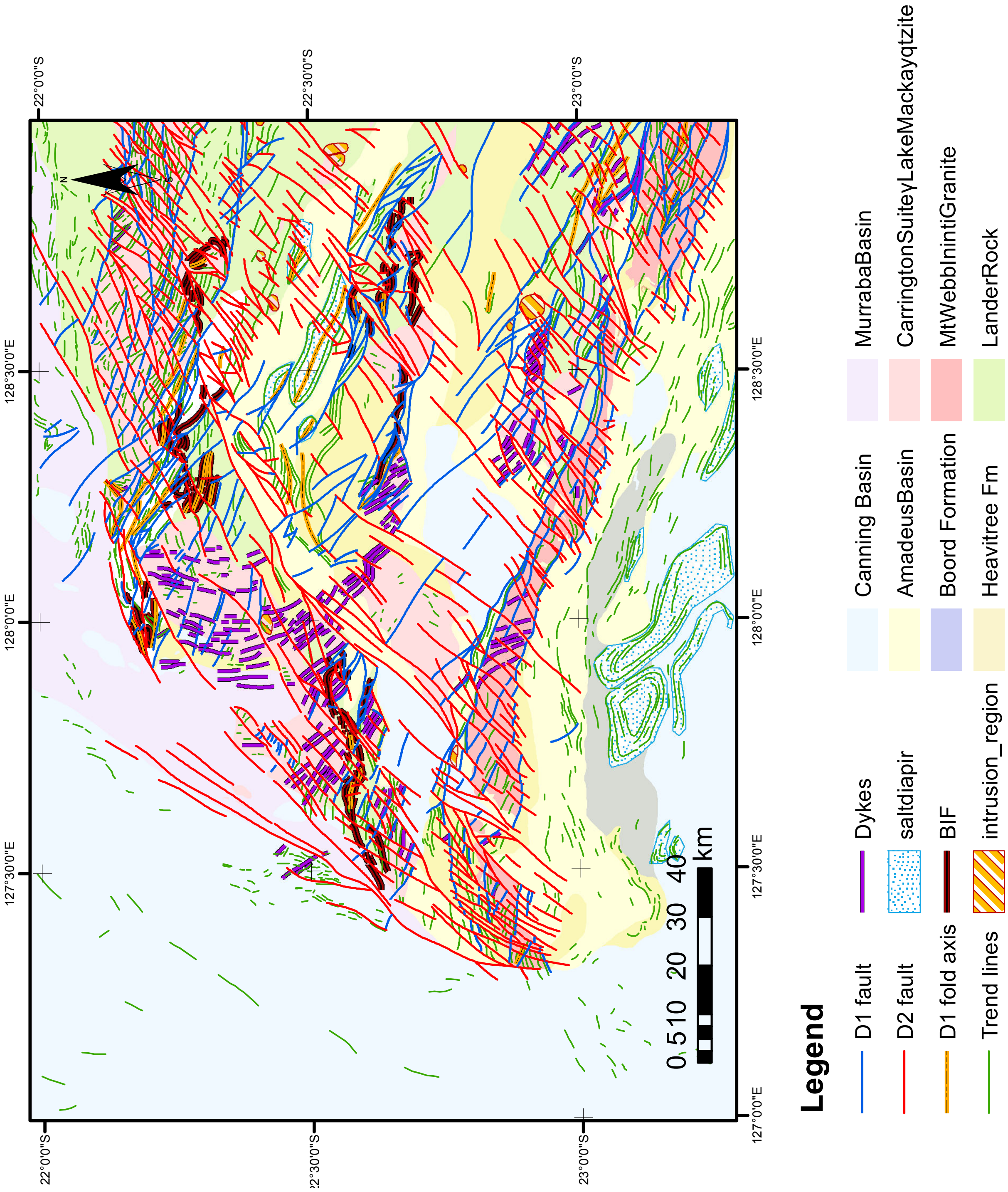

Figure1. Interpretative structural map highlighting the Proterozoic architecture of the West Arunta Orogen

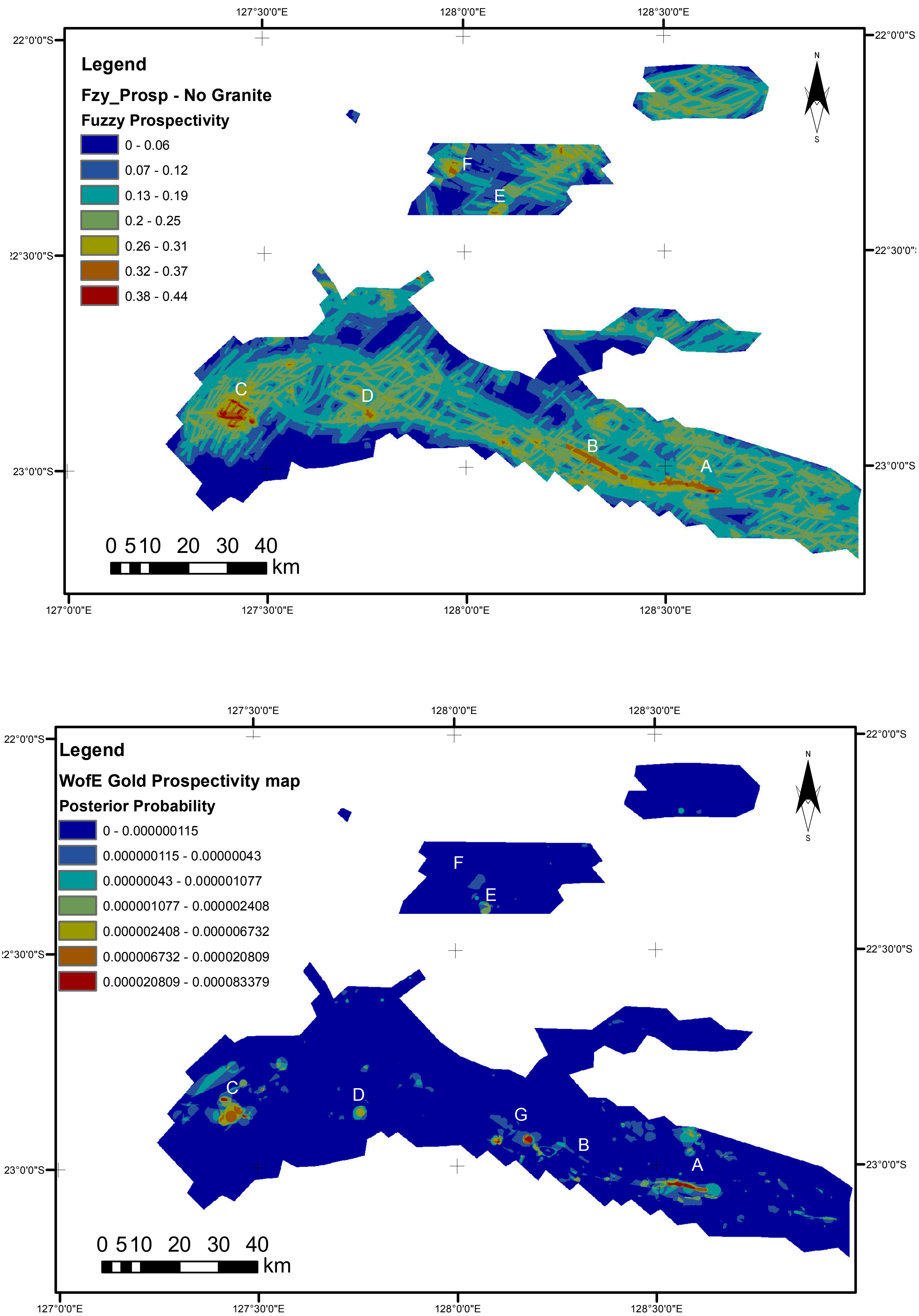

Figure 2. Fuzzy (top) vs WofE (bottom) prospectivity models for gold in the West Arunta Oorogen

Inferred geological history of the West Arunta Orogen

Two major deformation events control the current architecture of the WAO, which overprint and reactivate structures produced during earlier Proterozoic events (including the 1810–1800 Ma Stafford Event, 1780–1770 Ma Yambah Event, 1640–1630 Ma Leibig Orogeny, c. 550 Ma Petermann Orogeny). The first is a set of structures that trend west-northwest. Seismic data acquired along strike to the east show that major structures with a similar orientation are north-dipping and extend to the base of the crust (Goleby et al., 1988; Wright et al., 1990). Inconsistent responses in gravity and magnetic data, in particular negative Bouguer anomalies in areas where the magnetic data show that basement is at the surface, are interpreted as indicating that basement outcrops are 'slivers' structurally emplaced within a succession comprising predominantly sedimentary rocks of the Amadeus Basin, with deformation mostly likely associated with the 400–300 Ma Alice Springs Orogeny (Devonian–Carboniferous). This interpretation is consistent with structural studies in the Arunta Orogen outside Western Australia (Flottmann et al., 2004).

To test the idea that the WAO consists of a basement-involved, thick-skinned, thrust terrain, 2D gravity forward modelling was completed on a profile drawn perpendicular to the Central Australian Suture. As with any potential-field modelling, the model is not unique, but it demonstrates that the thick-skinned structural style is consistent with the gravity data.

The second major structural trend is northeast–southwest. Major examples of these D_2 structures comprise basin-bound structures of the Canning and Murraba Basins. These structures were probably much older faults that were reactivated as normal faults during the late Triassic Fitzroy Movement in the Canning Basin, and represent the main control on the thickness of preserved sedimentary rocks.

Older tectonic fabrics created during the long and complex tectonic history of the region are interpreted as having been reactivated during tectonic episodes recorded in the fill in adjacent sedimentary basins. However, the current outcrop pattern in the WAO is probably mostly controlled by the faulting associated with the Alice Springs Orogeny and the Fitzroy Movement.

Gold prospectivity modelling of the West Arunta Orogen

GIS-based prospectivity analysis was used to identify the most prospective ground for gold deposits in the WAO. A knowledge-driven fuzzy model (Porwal et al., 2003) and a data-driven weights-of-evidence (WofE) model (Agterberg et al., 1990) were implemented. These approaches are essentially based on empirical mathematical models which compare the spatial distributions of various targeting criteria (represented by predictor maps). The targeting criteria are based on a mineral systems model for deposit formation and the approach used involves creation of a series of predictor maps based on geological features associated with the relevant model for deposit formation. Both intrusion-related gold systems and the orogenic gold systems were considered in the WAO study, the essential difference being the presence of granitoids.

The fluid-pathway component of the gold mineral system in the WAO was associated with the two main sets of faults, these being potential fluid conduits. Physical traps are locales into which the mineralizing fluids are focused. Fault intersections, closure folds, and unconformities constitute potential trap sites. The final component of the WAO gold mineral model is a chemical scrubber; the presence of a favourable geochemical environment for deposition of metal. The role of iron oxide minerals in desulfidation of fluids makes, for example, the presence of BIF a potential indicator of a chemical trap. Finally, geochemical data were also used to create predictor maps.

Results indicate that the most prospective areas for gold in the WAO are located in the A, C, D, and E regions (Fig. 2). Region C contains known mineralization. This study indicates that regions B, F, and G are also potentially prospective.

Conclusion

The WAO is an area with complex and poorly understood geology. However, high-quality geophysical datasets allow geological entities with significant exploration potential to be identified, and by placing the entire analysis in the mineral systems framework, it is possible to identify and demarcate areas that have the greatest prospectivity.

The WAO study is the first of a series where the integration of multiple geological and geophysical datasets from various terrains in Western Australia, in a mineral systems context, will be used as a basis for regional-scale prospectivity analysis.

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