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3D geophysical and geological modeling for understanding the gold mineral systems in the Tanami Orogen, Western Australia

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Modern terranes interpretations and the controls on their constituent mineral systems require an understanding of the four-dimensional architecture of the crust. In this study, 3D geological model of the Tanami Orogen (Western Australia) was developed and constrained by geophysical potential field data in order to understand the tectonics and controls over the gold mineral systems of the orogen. This knowledge was used to identify key exploration criteria for gold deposits in the orogen and implement prospectivity mapping for delineating exploration targets.
The Tanami Orogen forms a part of the North Australian Craton and consists of Paleoproterozoic terranes interpreted as being the result of convergent tectonics. All available geophysical, geochemical and geological dataset of the Tanami belt was integrated into a 3D model, which was validated by comparing the theoretical prediction of the 3D geophysical forward modelling with the distribution of the geophysical potential fields measured on the ground. The model reveals the crustal-scale architecture of the Tanami Orogen, and especially the early tectonic framework of the Archean basement. The method helps in building a better understanding of stratigraphic and structural relationships, and adds important insights on critical controls over gold mineralization in the Tanami Orogen.
The enhanced understanding of the tectonic evolution and gold mineralizing systems was used in matrix-based manual and GIS-based automated (fuzzy logic and weight of evidence) prospectivity analyses of the Orogen. The Mineral Systems Approach (MSA) drives both prospectivity analysis methods. In order to implement the MSA, all components of a gold mineral systems were taken into account: (i) source of energy that drives the system; (ii) sources of fluids, metals and ligands; (iii) pathways along which fluids can migrate to (iv) trap zones (i.e., narrow, effective pathways) along which fluid flow becomes focused and fluid composition is modified; and (v) outflow zones for discharge of residual fluids. The manual, fuzzy (knowledge-driven) and empirical (data-driven) prospectivity approaches have never been undertaken in the Tanami region before.
The parallel implementation of the manual, fuzzy and weights-of-evidence prospectivity approaches ensured optimal utilization of all available geological information, both conceptual and empirical, and also helped in validating the conceptual model of the gold mineral systems in the Tanami Orogen that was derived based on the 3D modeling. The output results of the three different prospectivity analysis methods are compared in order to demarcate the most prospective ground for gold exploration in the Tanami region.
A first of its kind for the Tanami Orogen, this study demonstrates that the 3D geological modeling can be effectively used for quantitative simulations of tectonic processes and also for identifying critical inputs for prospectivity analyses.