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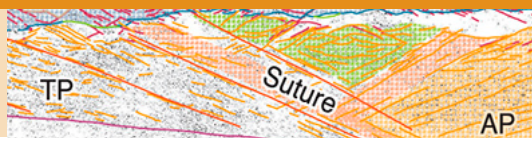
New model for Tanami gold mineralisation

Deep Seismic Survey establishes architecture of major Proterozoic gold province



Bruce Goleby, Patrick Lyons and Dave Huston

Identification of a major suture between the Tanami and Aileron provinces and recognition that mineral deposits in the region are associated with major crustal-penetrating shear zones and/or anticlinal stacks are two fundamental results from the Tanami Seismic research project.

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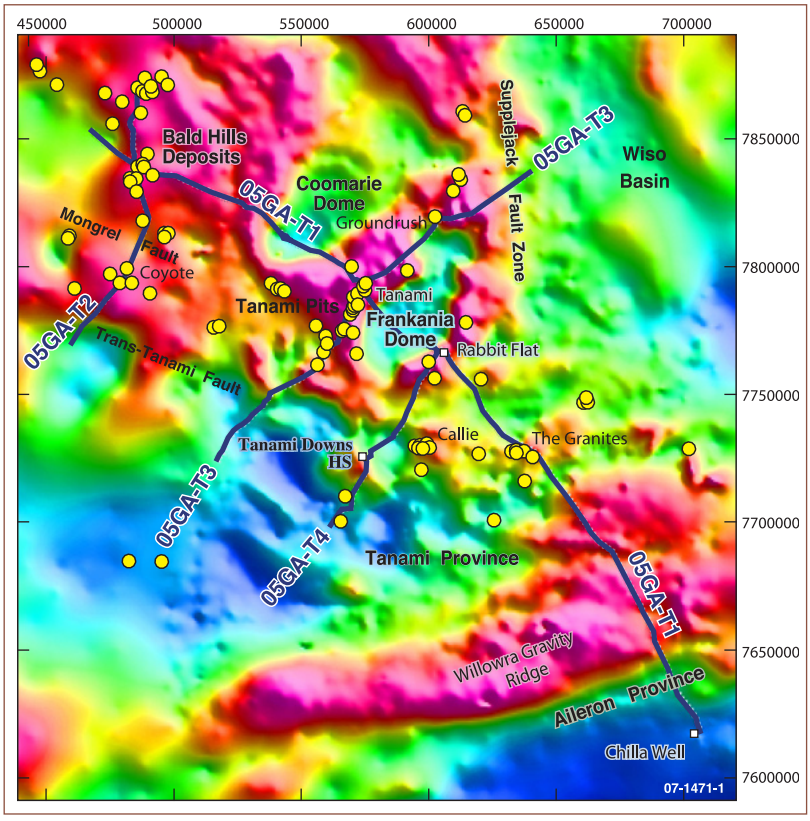

Figure 1. Location of the Tanami region, northern Australia, showing location of the four Tanami traverses (05GA-T1 through to 05GA-T4). Locations of mine sites and deposits are shown as circles.

The suture spatially corresponds to the Willowra gravity ridge (figure 1) and has a classic crocodile form (Meissner 1989). It separates the northwest-dipping structural grain of the Arunta–Aileron province crust in the south from the southeast-dipping structural grain of the Tanami crust in the northwest. The collision between the Tanami and Aileron crusts is interpreted to have occurred prior to ~1840 Ma, as rocks of the overlying ~1700 Ma Tanami–Lander package blanket this suture.

The correlation of the position of known mineral fields with the surface projection of crustal-penetrating shear zones on the seismic section is remarkable (figure 2) and has profound implications for explorers.

Crust-penetrating structures are observed extending from near-surface to the Moho boundary. Where these structures intersect upper crustal Tanami Group rocks, the seismic data shows a dramatic increase in deformation associated with the complexity of secondary structures related to the crustal-scale shear zones (figure 3).

Known ore deposits are all located within the more complexly deformed zones and therefore have a direct association with structural anomalies, including through-going thrust faults, associated pop-up structures and ramp anticlines. The seismic sections show several additional structurally anomalous areas that might be considered to have mineral potential.

Tanami Province crust

The Tanami Group (consisting of the Dead Bullock, Killi Killi and Mt Charles formations) has variable thickness across the province and exhibits dramatic changes in seismic reflectivity. It is thickest in the northwest part of traverse 05GA-T1, between the Bald Hills deposits and the Mt Fredricks region, where it is interpreted to reach a maximum thickness of 10 kilometres (3.5 seconds two-way time (TWT); figure 2). From this area, towards the southeast, there is a gradual, though variable, thinning of the Tanami Group to a point south of 'The Granites' where it thins rapidly to a depth of 3 kilometres (1 second TWT).

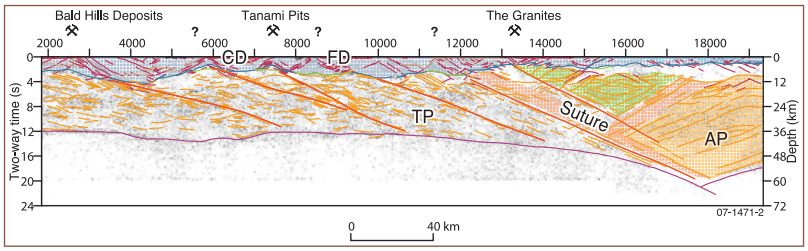

Figure 2. Schematic diagram showing main features of the Tanami traverse 05GA-T1. CD—Coomarie granite, FD—Frankenia granite, TP—Tanami Province, AP—Aileron Province.

Farther south, the structural style changes from one dominated by antiformal stacking to another dominated by 'thin-skinned' thrusting. At this point it becomes difficult to distinguish the Killi Killi and Dead Bullock formations, thus, only the base of the Tanami Group is delineated here. This change also corresponds to the change from mapped outcrop of Killi Killi Formation to mapped outcrop of the Lander Rock package.

The Tanami Group supercrustals are characterised by domains of less complex reflectivity patterns, juxtaposed against areas of complex deformation showing southeast, northeast and northwest dipping thrust faults with associated hanging wall anticlines. Several of these thrust faults appear to link with crustal-penetrating structures. Along-profile variations within the seismic character of the lower parts of the inferred Dead Bullock Formation suggest the possibility of the existence of discrete depocentres into which early sediments of the Dead Bullock Formation were deposited.

There is a marked change in structural character near or below the base of the Tanami Group. This change is inferred to represent a décollement surface that corresponds in places to the unconformity between the Tanami Group and its Proterozoic–Archaean basement, and elsewhere to a surface that runs within the basement material.

The seismic data indicate that Frankenia granite attains a maximum thickness of just over a kilometre. The seismic image indicates that the Coomarie and Frankenia Domes are not domes, as previously thought, but are underlain by inward-dipping reflections. This suggests that the granites are flanked by antiformal thrust stacks. Although this was investigated, it was extremely difficult to identify additional buried granite bodies of cross-sectional area and seismic character similar to those imaged at the surface.

The Supplejack Fault Zone, the inferred eastern boundary to the Tanami Province (Crispe et al, in press), is imaged as a zone of linked structures that extend to the mid-crust. The character of seismic reflectivity on both sides of this zone are not significantly different, suggesting that the Tanami region extends farther east, under the Wiso Basin.

The youngest deformation structures—such as the 'Trans-Tanami Structure' (Tanami Fault) and the Mongrel Fault—are not imaged as major structures on the seismic profile, but as uppermost crustal structures that link to deeper structures. The three-dimensional seismic grid provides a well-constrained geometry to the late structures

and suggests a change in this deformation style within the upper crust, north and south of the Trans-Tanami Structure.

The regional seismic section 05GA-T1 (figure 2) shows the presence of a series of crustal-penetrating structures that extend from the surface to the Moho boundary. Several of these structures are interpreted as fundamental to the evolution of the Tanami Province and the establishment of the current architecture of the region. All link the mid-crust to 'thin-skinned' structures within the uppermost crust.

One of the major crustal-penetrating structures separates the Tanami Province from the Aileron Province. This suture corresponds with a marked thickening of the crust of the Tanami Province, from approximately 42 kilometres near 'The Granites' mine, to over 60 kilometres in the southeastern part of the traverse. This thickening of the crust in the southeast coincides with changes in the regional gravity field that define the east-northeast-trending Willowra gravity ridge (figure 1).

Mineralisation constraints

The onset of the Halls Creek–Tanami orogeny was important for ground preparation within the Tanami Province. It produced thrusts that contributed to the plumbing system of the ~1800 Ma Tanami gold event and might have been associated with lode-gold systems. At about 1800 Ma, convergence from the northwest switched to convergence from the south, and brought about the formation of the giant Callie deposit. The northward convergence opened older meridional structures, particularly in between the Coomarie and Frankenia granites. The major mineralising event occurred at the end of the Stafford event at 1803–1791 Ma and is currently interpreted to relate to the shift from convergence on the northwest margin of the North Australian Craton to convergence along its southern margin (Huston 2006).

"…thickening of the crust in the southeast coincides with changes in the regional gravity field"

At the scale of the seismic data, lode gold deposits are associated with antiformal thrust stacks nested on thrust systems which usually transect the whole of the Tanami Group (figure 3). Some of the thrust systems are, in turn, nested on thrusts transecting the Proterozoic–Archaean basement. The Tanami–Aileron collision is presumed to have been a north–south collision, based on its spatial correspondence with the Willowra gravity ridge, and it may have established a fundamental control on all subsequent deformations.

The Tanami survey

AusGeo News 84 presented a summary of the results from the six-year collaborative study into the Tanami region and its surrounds. It documented some of the major changes the project had made to our understanding of the geological make-up and mineral potential of the North Australia Craton. A key component of the Tanami collaborative project was the acquisition of 720 line-kilometres of deep seismic reflection data (figure 1) to establish the architecture of this major Proterozoic gold province and to define the deep geological structure in regions of known mineral deposits.

Participants in the Tanami deep seismic research project were Geoscience Australia, the Northern Territory Geological Survey, the Geological Survey of Western Australia, Newmont Exploration, and Tanami Gold NL. Results from the Tanami deep seismic research project were presented at the Tanami Seismic Workshop held in June 2006 in Alice Springs.

Details on the acquisition of the Tanami Seismic Survey have been presented previously (see *AusGeo News 79*). Among the

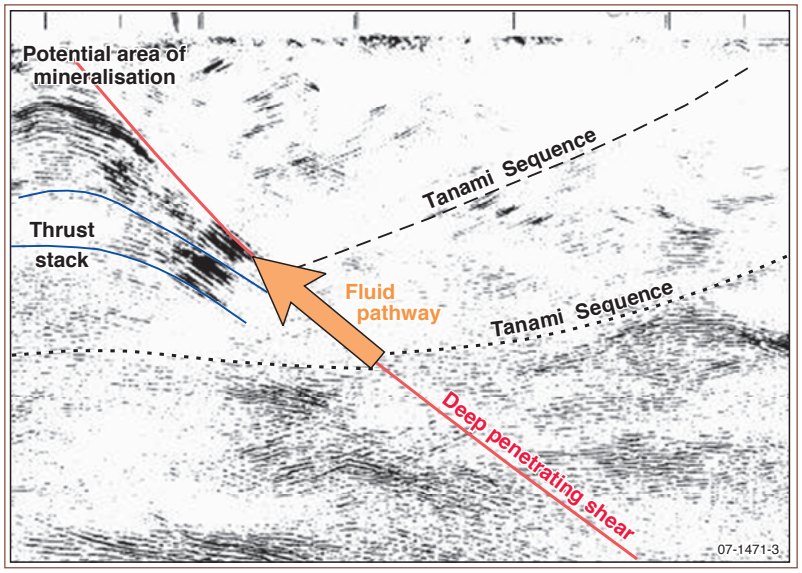

Figure 3. Schematic representation of potential areas selection strategy as indicated by the seismic reflection results. Figure oriented left to northwest.

more significant data obtained during the survey was information on the geometry of faults in the area, the thicknesses of the Tanami Group, the relationships of the various rock layers and mineralisation to crustal-scale structures, and the character of the Tanami–Arunta (Aileron) boundary.

The regional traverse 05GA-T1 (figure 1) from the Bald Hills region in the northwest to the Chilla Well region in the southeast produced excellent images of the crustal architecture along this profile. Traverses 05GA-T2, 05GA-T3, and 05GA-T4 are three cross-traverses that provide three-dimensional control on whole-of-crust architecture within the province.

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ANSIR NATIONAL RESEARCH FACILITY FOR EARTH SOUNDING

ANSIR is seeking comments on its recently released Discussion Paper "**National Planning for a Geotransect Program**". ANSIR is particularly interested in comments from industry and academia geoscientists so if you are interested please visit the ANSIR web site www.rses.anu.edu.au/seismology/ANSIR/geotransect.html for copies of the discussion paper. ANSIR is a National Research Facility operated jointly by Geoscience Australia and The Australian National University.

Acknowledgments

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References

Crispe AJ, Vandenberg LC & Scrimgeour IR. In press. Geological framework of the Archaean and Palaeoproterozoic Tanami region, Northern Territory. Mineralium Deposita.

Goleby B. 2005. Going for gold beneath the Tanami. *AusGeo News 79*.

Huston D. 2006. Tanami—North Australia project wraps up. *AusGeo News 84*.

Meissner R. 1989. Rupture, creep, lamellae, and crocodiles: happenings in the continental crust. Terra Nova 1, 17–28.

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