Geophysical Characteristisation of Crustal Scale Mineral Systems: A Passive Seismic Experiment Across World-Class Orogenic Gold Deposits, Kalgoorlie Area, Western Australia

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A deep crustal passive seismic survey has been completed to the north of Kalgoorlie in the Eastern Goldfields of Western Australia. The survey comprises 22 stations with ~5-10-km station spacing in a linear array deployed for 18 months. The array is coincident with an existing deep reflection profile and new and existing long period magnetotelluric (MT) data have also been acquired and modelled.

The survey area is within granitoid-greenstone rocks of the Archean Yilgarn Craton. The survey traverse extends across the dominant stratigraphic and structural strike and passes close to world-class orogenic gold deposits (Kanowna Belle and Paddington and along strike from the Golden Mile (Kalgoorlie)). According to current understanding of mineral system the processes that create orogenic gold deposits involve 1000 km^3 of rock and extend to mantle depths. A key objective of the seismic and MT surveys was to determine whether components of orogenic gold systems in the deep crust and upper mantle have a geophysical signature and hence could be used as a basis for camp-scale mineral exploration. Mineral systems components anticipated to have detectable responses include: (i) areas of metasomatised mantle indicative of fluid and metal source zones, (ii) 'palaeo-fluid reservoirs' for metal-bearing brines postulated to occur below orogenic gold camps, (iii) large-scale crustal architecture such as indications of major faults/sutures between the various terranes postulated to make up the greenstone successions in the region.

Data quality is excellent and high-quality images of crustal velocity structure have been derived using both teleseismic P-wave receiver function (RF) methods (common-conversion-point and H-*k* stacking) and ambient noise tomography. Nearly 300 teleseismic events (20-120° & Mb > 5.6) were used in the RF stacking. Using a modified Bayesian transdimensional tomographic method, fundamental model Rayleigh wave signals (up to 40 s) extracted from z-component noise cross-correlation functions were inverted for 1D velocity profiles, which are combined to form a 3D crustal shear velocity model.

Comparison of the teleseismically derived velocity contrasts and shear wave-velocity structure from the ambient noise methods, with each other and with the deep seismic reflection data, shows excellent agreement. The Moho is clearly imaged by the teleseismic methods and closely agrees with that interpreted from the reflection data. Structure interpreted in the deep crust from the reflection data closely correlates with variations in shear velocity and also major velocity contrasts. Major faults inferred from surface geology, such as the Ida Fault, coincide with changes in crustal velocity structure suggesting the faults are suture zones between major crustal blocks which penetrate to mantle depths. Such structures are likely conduits for fluid flow. Beneath the gold deposits crustal velocity structure is significantly different from adjacent areas. There is a high velocity zone in the

lower crust and also at the base of the greenstone succession which may be due to a palaeo-fluid reservoir. There is also a high average crust Vp/Vs ratio.

Further data need to be collected adjacent to other gold deposits to confirm the association with mineralization, but the results from the Eastern Goldfields survey are consistent with the orogenic gold mineral systems having a recognizable seismic signature in regional-scale passive seismic data. This suggests that such methods have a role to play in early stage exploration where geology is being defined at the camp- to regional-scale.