The Hillgrove Gold-Antimony-Tungsten District, NSW, Australia

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Abstract

Mineral occurrences of the Hillgrove Au-Sb-W district are hosted in late Palaeozoic polydeformed, hornfelsed metasediments and Permo-Carboniferous granitoids of the New England Orogen. In excess of 204 individual occurrences have been identified to date with the mineralisation developed as strike extensive (>20km's of known veining) and potentially depth extensive steeply dipping fissures. These are contained within an elongate area measuring some 9km by 6km in surface dimensions. Recorded gold production of 720,000 ounces along with current resources in the order of 1.3 Million ounces of gold equivalent highlight the significance of this district. Historical antimony production is estimated at in excess of 50,000 metric tonnes. Significant tungsten of over 2000 t in the form of scheelite has also been produced from the field.

Mineralisation is developed in veins, vein breccias, sheeted veins, network stockworks and as alteration sulphide haloes to the main structures. The vast majority of fissures are sub-vertical and vary in widths of up to 20m in places. Paragenetic studies have previously indicated that the earliest mineralising event was a scheelite-bearing phase of quartz veining. Subsequent phases of arsenopyrite–pyrite–quartz–carbonate veining were accompanied by gold and minor base metal sulphides. Alteration is typically sericite–ankerite–quartz. Overprinting stibnite–quartz veining with gold-electrum, aurostibite and arsenopyrite form an important subsequent phase. Veining can be inferred from historical records to extend for vertical depths of over 1 km.

Preliminary structural studies highlight the potential transpressional nature of the orogenic event associated with the Hillgrove mineralisation. Significant north-south oriented shear and fracture zones occur in the deeper exposed regions of field. Large north-east oriented faults with both ductile and brittle characteristics also crosscut the district. The vast majority of mineralised veining has a distinct north-west oriented strike. Ore shoots are typically sub-vertical with internal movement indicators suggesting a component of left lateral movement associated with the latest stibnite–quartz–gold vein and breccia stage. Fibre lineations and slickensides in the plane of the vein are horizontal in the most intense vein zones, and appear to steepen to plunges of >20° where the mineralisation is erratic suggesting an increased component of strain.

Syn-mineralisation lamprophyre dykes have an age range of 247-255 Ma (late Permian-early Triassic) and have temporal and geochemical affinities to the voluminous Moonbi Suite of high-K granitoids. Fluid inclusion studies have indicated homogenisation temperatures in gangue quartz in the range 100°-250°C and that fluids were of low salinity. Metal zonation within the field is variable between the lode systems.

The Hillgrove gold–antimony–tungsten occurrences have strong affinities to many other orogenic gold-antimony deposits elsewhere, particularly in New Zealand, except that the ore mineral assemblage is telescoped, with earlier deeper level mineralisation overprinted at the same structural level by later, shallower mineralisation.

Introduction

The Hillgrove Mineral Field lies in north-eastern NSW, Australia about 20 kilometres east of Armidale (Boyle, 1990; Gilligan et al., 1992). The field covers 9 by 6 kilometres and is dissected by a deep gorge system of up to 500m depth. The field has been mined since the

1870's and produced over 720,000 ounces of gold with current resources in the order of 1.3 million ounces equivalent. Historical antimony production is estimated at in excess of 50,000 metric tonnes. Over 2000 t of scheelite concentrates have been produced from the field. The Hillgrove mine ceased production in 2002 and went into receivership.

Mineral occurrences of Au-Sb-W are hosted in late Palaeozoic polydeformed, hornfelsed metasedimentary rocks and Permo-Carboniferous granitoids of the New England Orogen (Boyle, 1990; Gilligan et al., 1992). In excess of 204 individual occurrences have been identified to date with the mineralisation developed as strike extensive (>20km's of known veining) and potentially depth extensive steeply dipping fissures. Mineralisation is focussed in a north-west striking belt between the Chandler and Hillgrove faults (Fig 1.)

Straits Resources purchased the deposit in 2004 and now controls 100% of the mining leases and surrounding exploration tenements. An active exploration program has been ongoing for a couple of years defining resources to re-start the mining operation. Previous exploration has only involved very minor drilling from either underground or on surface and the potential of the field is considered untapped by modern methods. A systematic exploration program with assessment of current underground and surface infrastructure, metallurgical testwork and the development of plans for future mining operations

Exploration has involved an extensive underground and surface exploration campaign of the Hillgrove Mining and surrounding exploration tenements. Drilling to date has been targeted at the Eleanora/Garibaldi, Metz mines and at the Clarkes Gully prospect with significant success leading to infill resource drill outs.

Geology and Structure

Mineralised vein and breccia systems at Hillgrove are hosted in biotite-grade metamorphosed sedimentary rocks of the late Palaeozoic Girrakool Beds (originally shale, siltstone, argillite, greywacke), biotite monzogranite (S-type) of the ~300 Ma Hillgrove Adamellite and granodioritic-dioritic rocks of the early Permian Bakers Creek Diorite Complex. The structures and mineralisation post-date, and are unrelated to any of the host rocks. Syn-mineralisation lamprophyre dykes that are both cut by mineralisation as well as having intruded mineralised structures, are dated at 247-255 Ma (Ashley et al., 1994), thus bracketing the potential age of mineralisation to approximately the Permian-Triassic boundary. The dykes are closely related spatially to mineralised structures, are up to a few metres wide and include minette and vogesite types. Geochemically, the lamprophyres are related to the high-K I-type granitoids of the Permo-Triassic Moonbi Plutonic Suite (Ashley et al., 1994).

Nearly all of the mineralised structures of the Hillgrove region lie between two major east-northeast striking regional structures, the Hillgrove and Chandler Faults (Fig. 1). These structures are largely ductile and mylonitic in character, cutting the granitoids and metasedimentary rocks. Metamorphic grade changes across the Chandler Fault imply significant asymmetric uplift along the northern side of the fault, occurring between 266-256 Ma (Landenberger et al., 1995, Ashley and Craw, 2004). Structural studies highlight the potential transpressional nature of the orogenic event associated with the Hillgrove mineralisation. Significant north-south oriented shear and fracture zones are exposed in the deeper gorges of the region and may have a controlling role in the subsequent development of the mineralised veining that is hosted in brittle structures (Ashley and Craw, 2004). The majority of mineralised veining has a north-west oriented strike, with dips commonly 70° to vertical. Mineralised structures commonly pinch and swell, according to the presence of local dilatational sites (Fig. 2), leading to large variation in widths of mineralised veins and breccias (from < 1cm to several metres). Ore shoots are typically sub-vertical with internal movement indicators suggesting a component of left lateral movement associated with the latest stibnite – quartz – gold vein breccia stage. Fibre lineations and slickensides in the plane of the vein are horizontal in the most intense vein zones, and appear to steepen to moderate plunges of >20 degrees where the mineralisation is erratic suggesting an increased component of strain. Veining can be inferred from historical records to extend for vertical depths approaching 1 km (Fig. 3).

Mineralisation

Mineralisation is developed in veins, vein breccias, sheeted veins, network stockworks and as alteration selvages of disseminated and veinlet arsenopyrite and pyrite adjacent to the main structures. Although mineralised structures are commonly <1 m wide, zones of stockworking and brecciation, plus their accompanying sulphidic halo zone may attain widths of up to 20m in places. Paragenetic studies (Boyle, 1990; Ashley and Craw, 2004) have previously indicated that the earliest mineralising event was a scheelite-bearing phase of quartz veining. Subsequent phases of arsenopyrite–pyrite–quartz–carbonate veining were accompanied by gold and minor base metal sulphides. Alteration is typically sericite–ankerite–quartz and this accompanies the disseminated and veinlet arsenopyrite and pyrite zones. Overprinting stibnite–quartz veining with gold-electrum, aurostibite and arsenopyrite form an important subsequent phase. The sulphidic haloes about the mineralised structures vary from being narrow and tight, to up to 20 m wide. In these zones, it has been shown that gold grades (with little or no accompanying Sb) can be significant, with gold hosted “invisibly” in the sulphides. Arsenopyrite is the main host to invisible gold, although a smaller proportion is also hosted in pyrite that tends to be of arsenical composition (Ashley et al., 2000). The disseminated gold halo about mineralised structures is being sampled and drilled in detail to define the grade. Mineral concentrates derived from the sulphidic halo material have proven to yield good gold recoveries from pressure oxidation treatment, followed by conventional cyanidation.

The presence of the sulphidic halo about mineralised structures and the other changes to wallrock mineralogy have led to the development of geochemical alteration haloes that can extend for up to tens of metres. The alteration-mineralisation process has led to addition of Au, Sb, As, S, CO2, K and Rb, with depletion of Na and Sr (Ashley and Craw, 2004). Fluid inclusion studies have indicated homogenisation temperatures in gangue quartz in the range 100°-250°C and that fluids were of low salinity (Comsti and Taylor, 1984). Metal zonation within the field can be inferred on the basis of past production to be from Au-As at depth to Sb-Au-As at shallower levels, with minor scheelite occurring throughout the production interval. Structural, alteration and mineralisation characteristics of Hillgrove accord with many other orogenic gold deposits, although Hillgrove is unusual in potentially having formed progressively during orogenic uplift leading to a telescoped array of vein systems with overprinting of earlier mineralisation by later (e.g. W by As-Au by Sb-Au).

A detailed three dimensional model of the previous mining and sampling has been developed that is assisting in understanding of the various mineralised systems. The veins cross cut lithology but can vary markedly in their nature, vein styles, alteration, width and grades of Au, Sb, As and W (Fig. 4).

Conclusions

The Hillgrove gold–antimony–tungsten occurrences have strong affinities to other orogenic gold-antimony deposits except that the ore mineral assemblage is telescoped, with earlier deeper level mineralisation overprinted at the same structural level by later, shallower mineralisation. The mineralised vein systems have a strong structural control and there is considerable potential for (a) extension at depth, (b) extension along strike of known structures and (c) discovery of new blind systems at depth or under regolith cover. There is also considerable opportunity to develop significant gold production from the arsenopyrite-pyrite halo about mineralised structures and to investigate production of antimony (stibnite) concentrates again to take advantage of currently buoyant world antimony prices. Straits Resources will for the first time attempt to unlock the big picture of the Hillgrove mineralised system and its potential to be a multi-million ounce gold district.

Detailed plans, including costings, for the refurbishment of existing plant and infrastructure are being finalised for potential start up in 2007.

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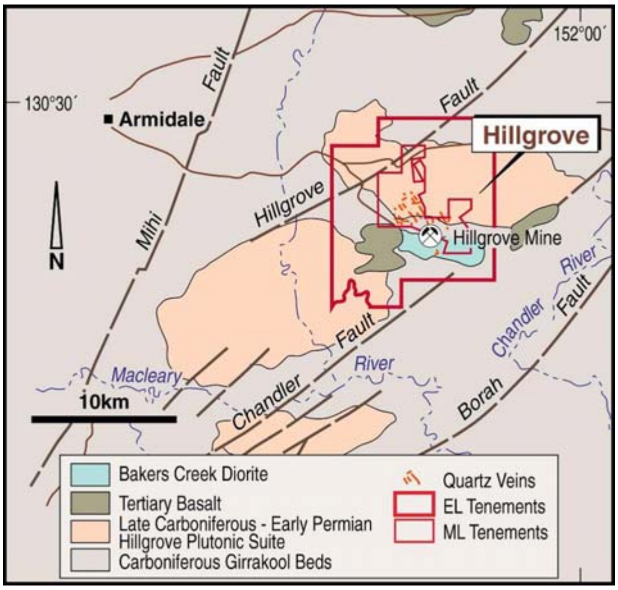

Figure 1: Location and geology of the Hillgrove region.

Figure 2: Mineralised structure hosted in dilatational jog, with quartz-stibnite-gold vein infill and adjacent vein breccia zone. Width of image is approximately 1 m.

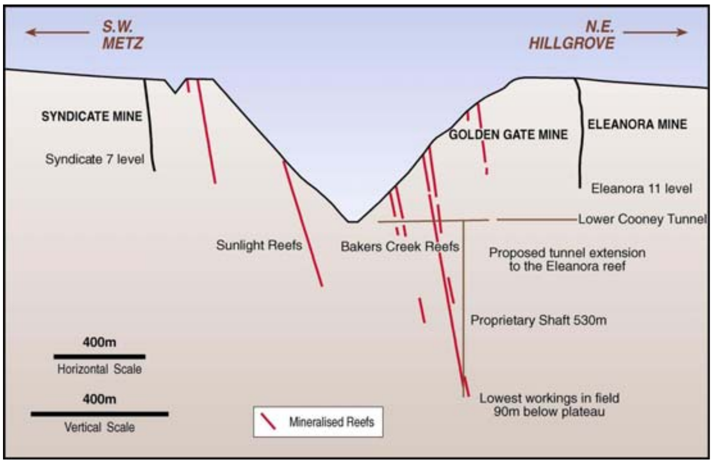

Figure 3: Schematic cross-section from SW-NE across the Bakers Creek gorge at Hillgrove. The main structures are steeply dipping and extend to depths of several hundred metres to 1 km.

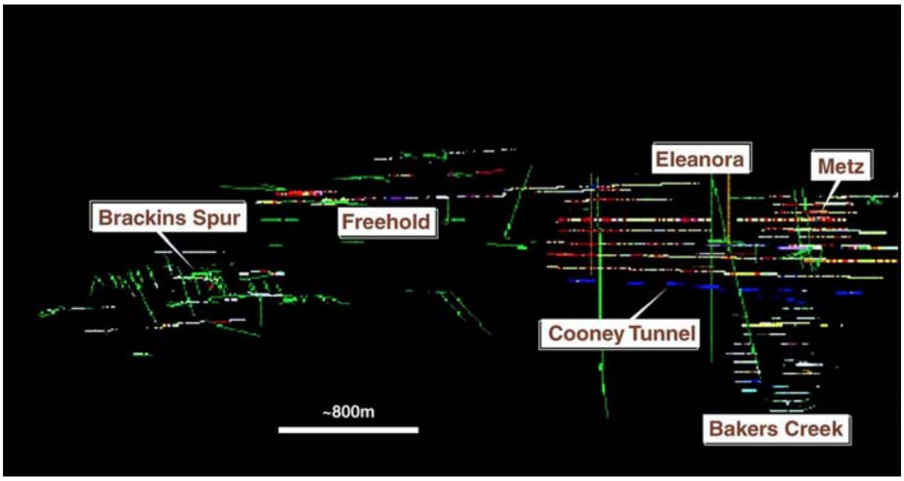

Fig.4. Three-dimensional image of underground workings and drillholes at Hillgrove, colour coded with Gold.