Comparison between the Magma vein – Resolution porphyry and Stavely

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The Resolution porphyry lies in a most prospective terrain, 13 km NNW-N of the Ray porphyry Cu mine (historic production + Reserves ~1.2Bt at 0.6-0.8% Cu) and 4.7 km SW of the Superior East Cu deposit (~1Bt at 0.5% Cu) in southern Arizona, USA (figure 1). EW orthogonal compression provided a dilatant structural environment for the formation of many EW trending veins as well as an EW trending 2.25 km wide and > 4 km long clastic sediment filled graben into which the Resolution wallrock porphyry has been emplaced (Figures 1-3).

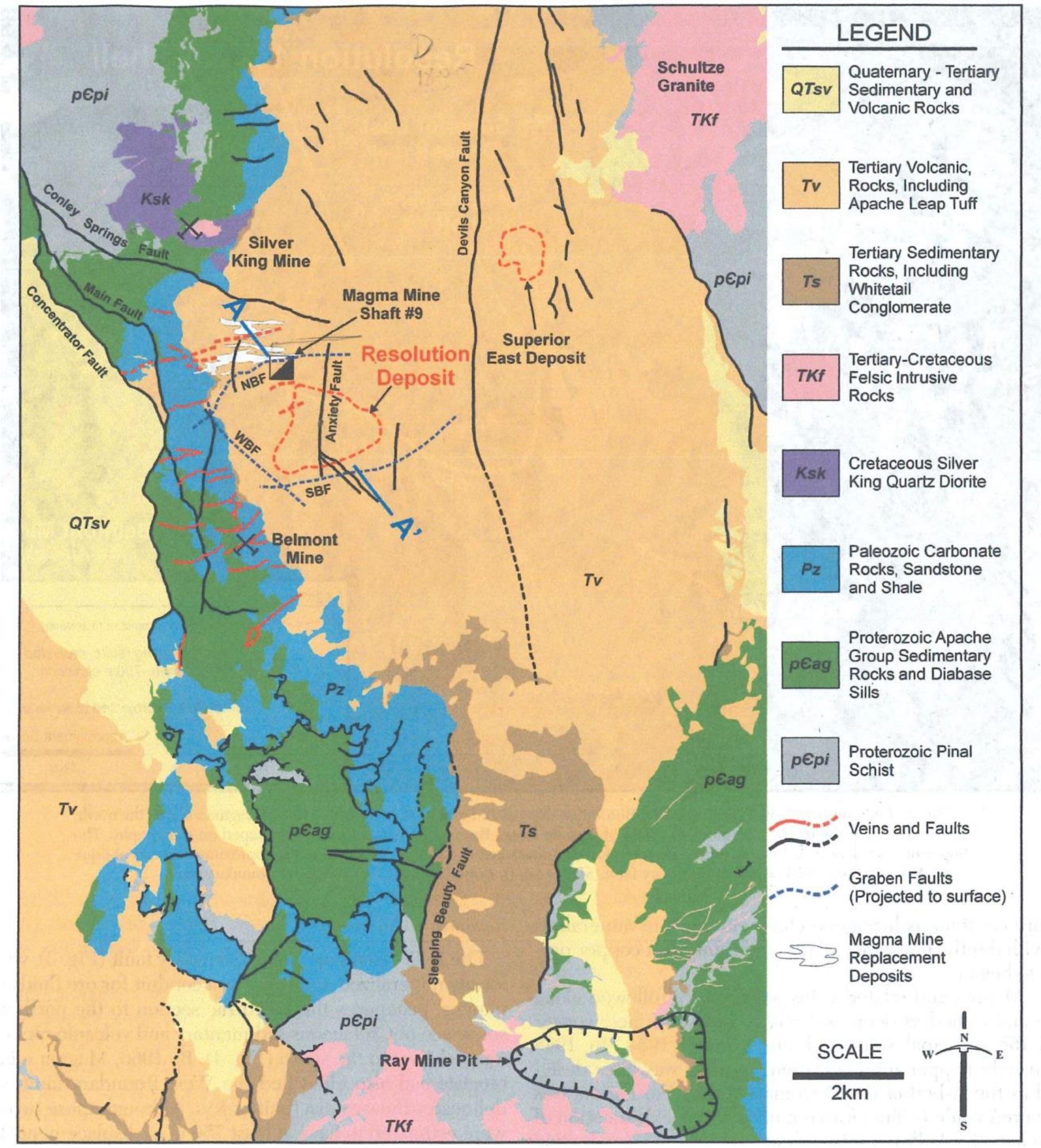

Figure 1 Geological setting of Magma Vein and Resolution porphyry, from Hehnke et al. (2012).

The Resolution porphyry Cu deposit is regarded in the terminology used herein (Corbett, 2017) as a wallrock porphyry Cu deposit in which a strongly dilatant structural setting has facilitated the development hydrothermal alteration and mineralised veins within wall rocks outside a blind magmatic source, which need not represent a porphyry Cu intrusion. Hehnke et al. (2012), describe the Schultze Granite as underlying the ore systems described above as a possible magma source for mineralisation, although noting the more felsic composition than expected for porphyry Cu development. Some felsic intrusions of the appropriate Laramide age are recognised cutting the Proterozoic host rock sequence. There are similarities between the setting of the Resolution and Cadia Valley (NSW, Australia) wallrock porphyry deposits, Australia, provided by the setting of orthogonal compression, growth faults reactivated during mineralisation, an underlying magmatic source (monzonite at Cadia) and wall rock hosted veins (Figure 4).

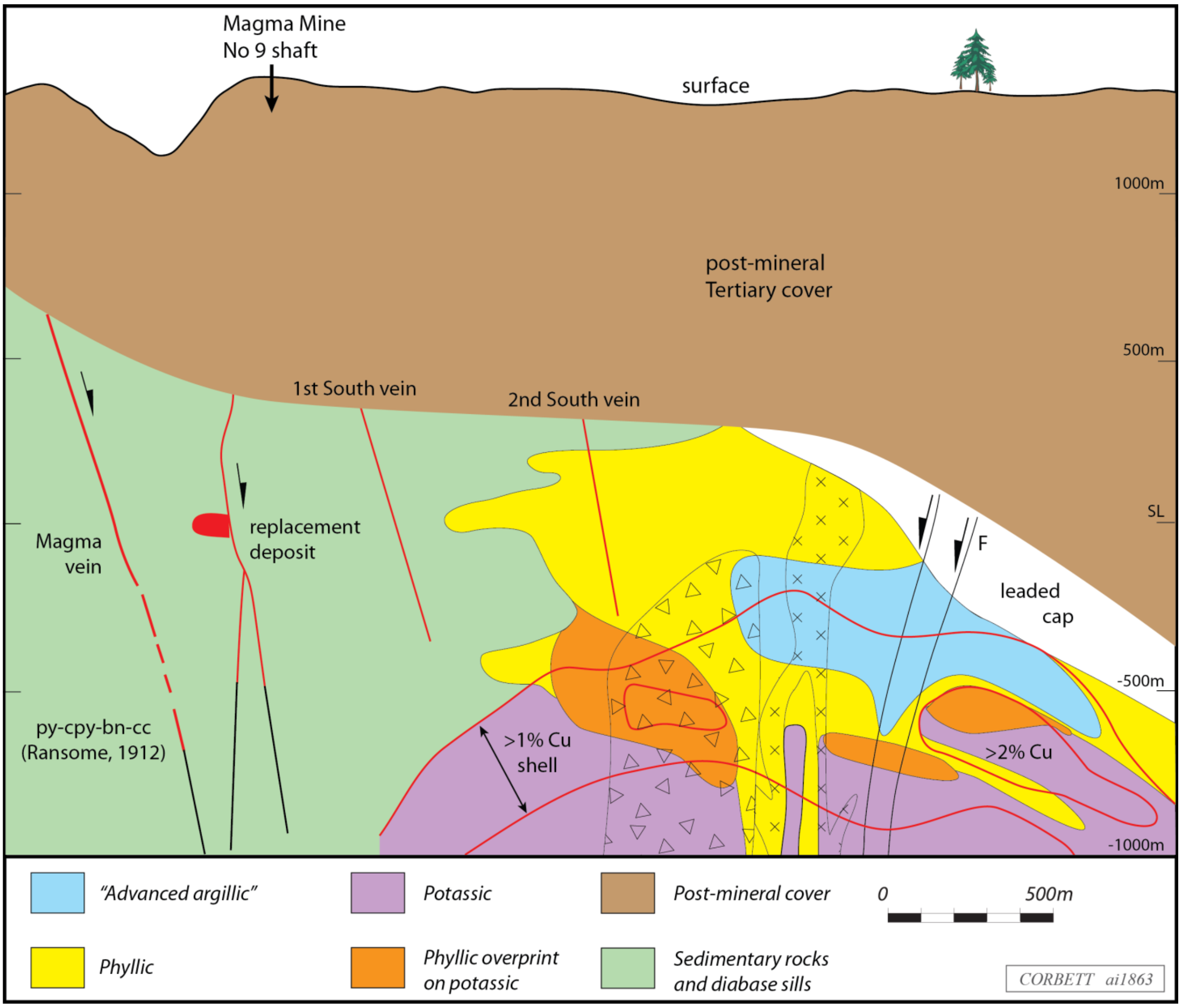

Figure 2. Cross section, along the line A-A' in figure 1, through the Magma Vein and Resolution porphyry, which is not directly across the strike direction of the Magma vein. Pre-mineral breccias and intrusions are overprinted by Laramide alteration and mineralisation. Modified from Hehnke et al. (2012).

The top of the 1% Cu shell at the Resolution porphyry lies some 1500 m below the surface and is buried by 1000 m of post-mineral cover, and would have been exposed by erosion at one end prior to burial by post-mineral cover (Figure 2). A halo of wall rock hosted propylitic alteration characterised by chlorite-epidote grades inwards to less continuous actinolite and magnetite as replacement of mafic minerals and veins. Deeper level Cu mineralisation partly lies within relict potassic alteration, defined by K-feldspar, biotite, anhydrite and magnetite. The upper portion of the potassic alteration is variably overprinted by quartz-sericite-pyrite phyllic alteration, with an uppermost core described (Hehnke et al., 2012) as advanced argillic alteration characterised by increased presence of dickite with topaz, alunite, zunyite, pyrophyllite, with up to 20% pyrite and rare enargite (figure 2). Those workers base the advanced argillic alteration classified at Resolution upon the presence of dickite which could also occur in phyllic and argillic alteration, whereas only alunite places this alteration in the advanced argillic class.

Veins which might be correlated with prograde A and retrograde D vein styles (Corbett, 2019), are best developed within a competent Fe-rich diabase host rock as well as sedimentary rocks (Hehnke et al., 2012), over a vertical distance of at least 500 metres. Chalcopyrite accounts for about 65% of the Cu content, initially deposited during potassic alteration within early A veins of quartz, anhydrite, chalcopyrite, bornite, pyrite, molybdenite with local magnetite with K-feldspar-biotite selvages which are estimated to have contributed about 0.3-0.7% Cu as roughly 20-45% of the metal budget. Later veins likened to D veins contain progressively higher Cu contents in a chalcopyrite-bornite-pyrite sulphide assemblage with phyllic (sericite-quartz-pyrite) alteration selvages (Hehnke et al., 2012). These veins are in turn overprinted by veins characterised by bornite-chalcocite-digentie-pyrite with advanced argillic alteration topaz-silica alteration selvages while pre-existing sulphides within the alteration halos are replaced by chalcocite-bornite. The majority of the Cu mineralisation has been introduced by veins with retrograde sericite and dickite alteration.

Veins associated with Cu mineralisation grade upwards as:

- At the lower boundary of the 1% Cu shell pyrite-chalcopyrite A veins with prograde alteration selvages dominated by (potassic alteration) biotite within the diabase and (propylitic) chlorite-epidote elsewhere.
- Those veins dominate at the deeper portion of the 1% Cu shell, mineralisation as vein fill of pyrite, chalcopyrite, quartz, anhydrite with local haematite-carbonate.
- D veins, which dominate in the upper portion of the 1% Cu shell contain, pyrite, bornite, chalcocite, and digenite in-fill with sericite selvages.
- In this progression in space (deep to shallow) and time, the sericite includes local advanced argillic alteration recognised as dickite, kaolinite and topaz with sparse covellite and enargite.

The overall zonation in vein and wall rock alteration (potassic -> phyllic -> advanced argillic) and vein (chalcopyrite -> bornite-chalcocite -> sparse covellite-enargite) mineralogy in time and space (deep to shallow level) is indicative of fluid evolution from near neutral to low pH conditions in a cooling ore fluid. Vein selvages coalesce to provide more pervasive wall rock alteration.

The Magma Vein was initially worked from 1875 as the Queen or Silver Queen mine for supergene Cu, Ag and Au mineralisation and later reopened as the Magma mine in 1910. Ransome (1912) described the magma vein as developed within an EW trending steep north dipping fault with a reverse dip-slip movement of up to 200 m. A fine grained quartz diorite porphyry pre-mineral dyke has been intruded into the host structure. Two ore shoots are localised at the intersection of the vein and competent quartzite in the sedimentary sequence, although most ore overprints the earlier porphyry. Sulphide ore displays a paragenetic sequence of overprinting pyrite-> chalcopyrite -> bornite -> chalcocite, within a dilatant structure, reflects similar fluid evolution of declining pH with temperature as the Resolution porphyry.

The relationship between the magma vein and Resolution porphyry remains problematic. On one hand the many EW veins which exposed along the western flank of Proterozoic rocks by the erosion of the post-mineral cover, such as in the area of the Belmont mine, could be derived from the underlying Schultze Granite (figure 1). On the other hand the Magma vein is the largest of these EW lodes and displays a strong association with the bounding faults for the graben into which the

Resolution porphyry has been emplaced. It is speculated that the coincidence of an apophysis in a buried magma source, possibly the Schultze Granite, and the dilatant control, evidenced by the graben, links the Magma vein and Resolution porphyry.

At Stavely, a transient component of dextral strike-slip movement on the faulted contact between Stavely volcanics the ultramafic rocks to the east is interpreted to have dilated the Thursdays Gossan Fault and adjacent Copper Splay Fault splay faults which both host copper lode-style mineralisation (figure 5). Other splay faults are expected to be identified by synthesis of the existing data with the results of additional drill holes. Although splay faults represent attractive dilatant settings for linked porphyry-lode mineralisation, the transient strike-slip model at Stavely might not promote ore development as well as the much larger extensional graben at Resolution.

The paragenetic sequence in copper sulphide minerals at the drill intercept DDH SMD044 890-928 m displays the same paragenetic sequence as the Magma vein as: pyrite -> chalcopyrite -> bornite -> chalcocite, as function of similar evolution of the cooling fluid. Furthermore, the approximate spatial zonation in copper mineral zonation which mimics the above temporal zonation, grades away from the vicinity of the junction of the splay fault with the throughgoing Thursdays Gossan Fault as a likely setting for porphyry emplacement.

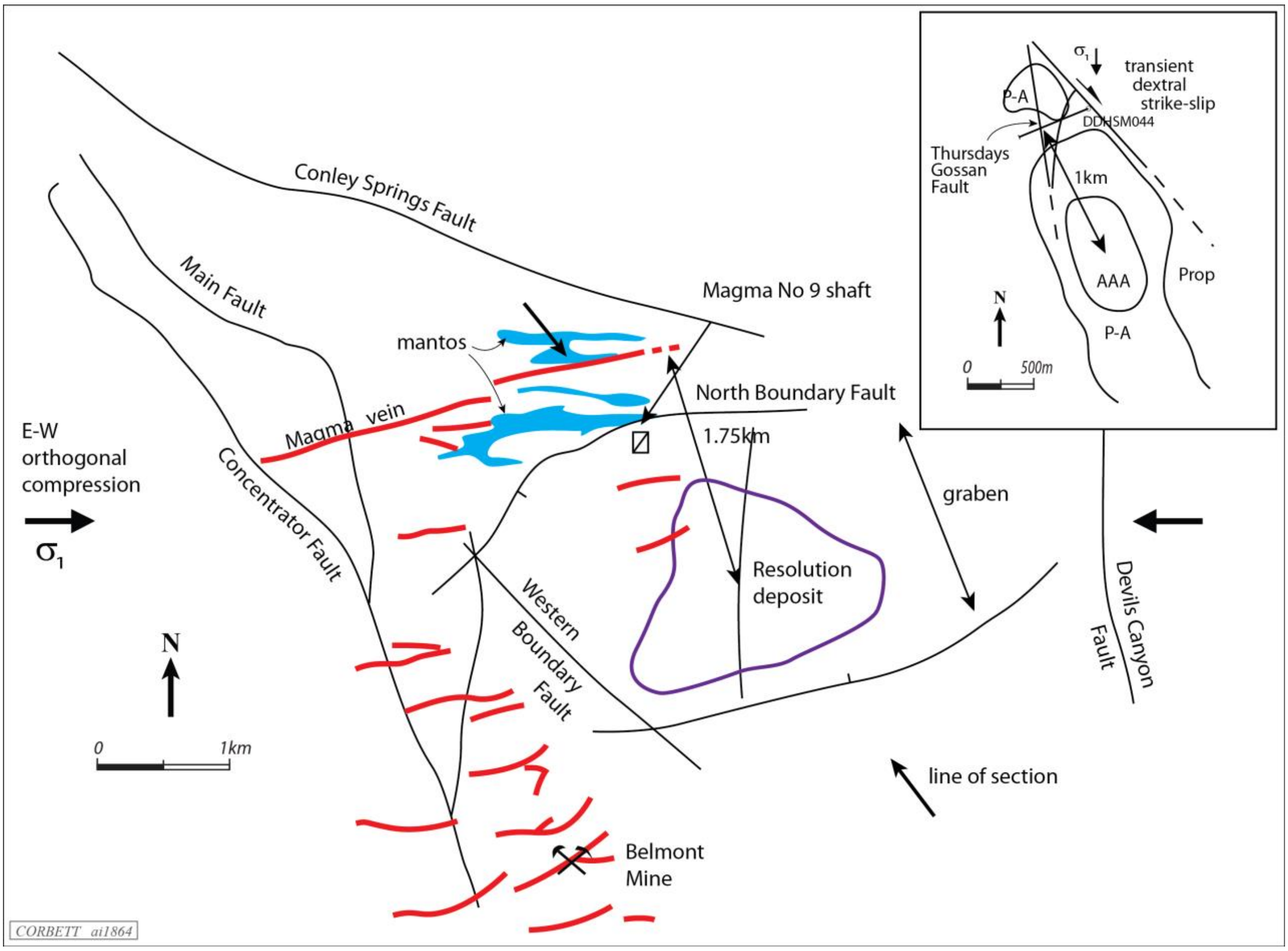

Figure 3 Comparison of the geological settings of the Magma Vein-Resolution wallrock porphyry mineralisation (from Hehnke et al., 2012) and the Thursdays Gossan Copper lode intersected in DDH SMD044 at Stavely with the centre of the advanced argillic alteration described by Spencer (1996).

Consequently, each of the two districts may feature underlying magmatic source rocks, the Schultze Granite, which is open over 20 km strike at Resolution (figure 1) and at Stavely the Victor porphyry is speculated as the source for the 4 km long alteration zone outlined by Spencer (1996). Each district then also features a dilatant setting to localise porphyry and adjacent lode mineralisation, the graben at Resolution and the splay fault at Stavely for a porphyry target. Each district displays the same sulphide mineral paragenetic sequence of pyrite -> chalcopyrite -> bornite -> chalcocite, in the Magma lode and Resolution porphyry veins, although at Stavely exploration to date has only identified lode-style mineralisation such as the Thursdays Gossan Fault copper lode and the Copper Splay Lode. The splay fault intersection with the Thursdays Gossan Fault represents an ideal location for porphyry emplacement at Stavely, although the centre of the Victor advanced argillic alteration also requires more thorough prospecting. A straight line distance of 1.75 km from the Resolution porphyry to the Magma vein is governed by the setting of the Magma vein within the graben bounding fault and compares will with Stavely where there is a distance of 600 m from the DDH SMD044 drill intercept of the Thursdays Gossan Fault copper lode to the convergence with the splay fault as a target and 1 km to the Victor porphyry target (figure 3).

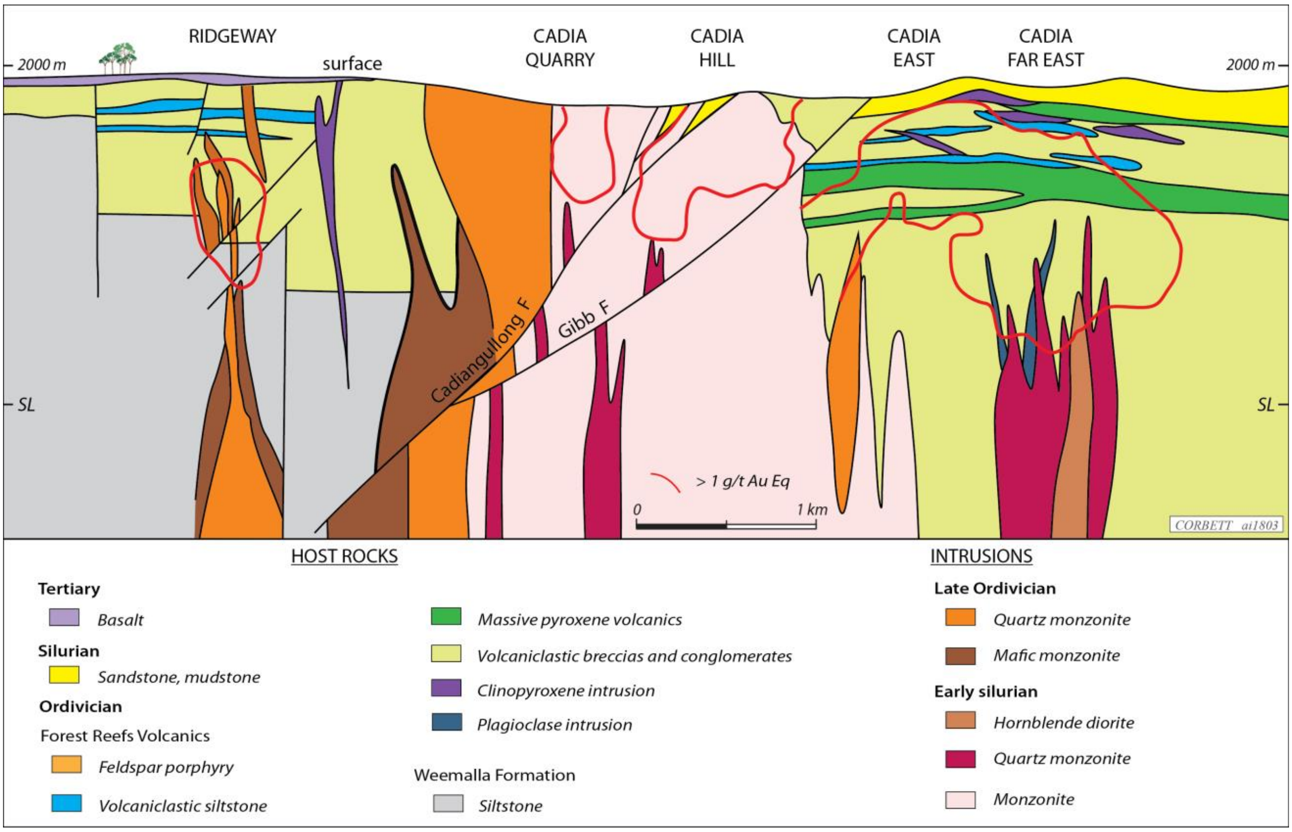

Figure 4 Conceptual long section for the Cadia Valley porphyry Cu-Au deposits modified from Wilson (2003).

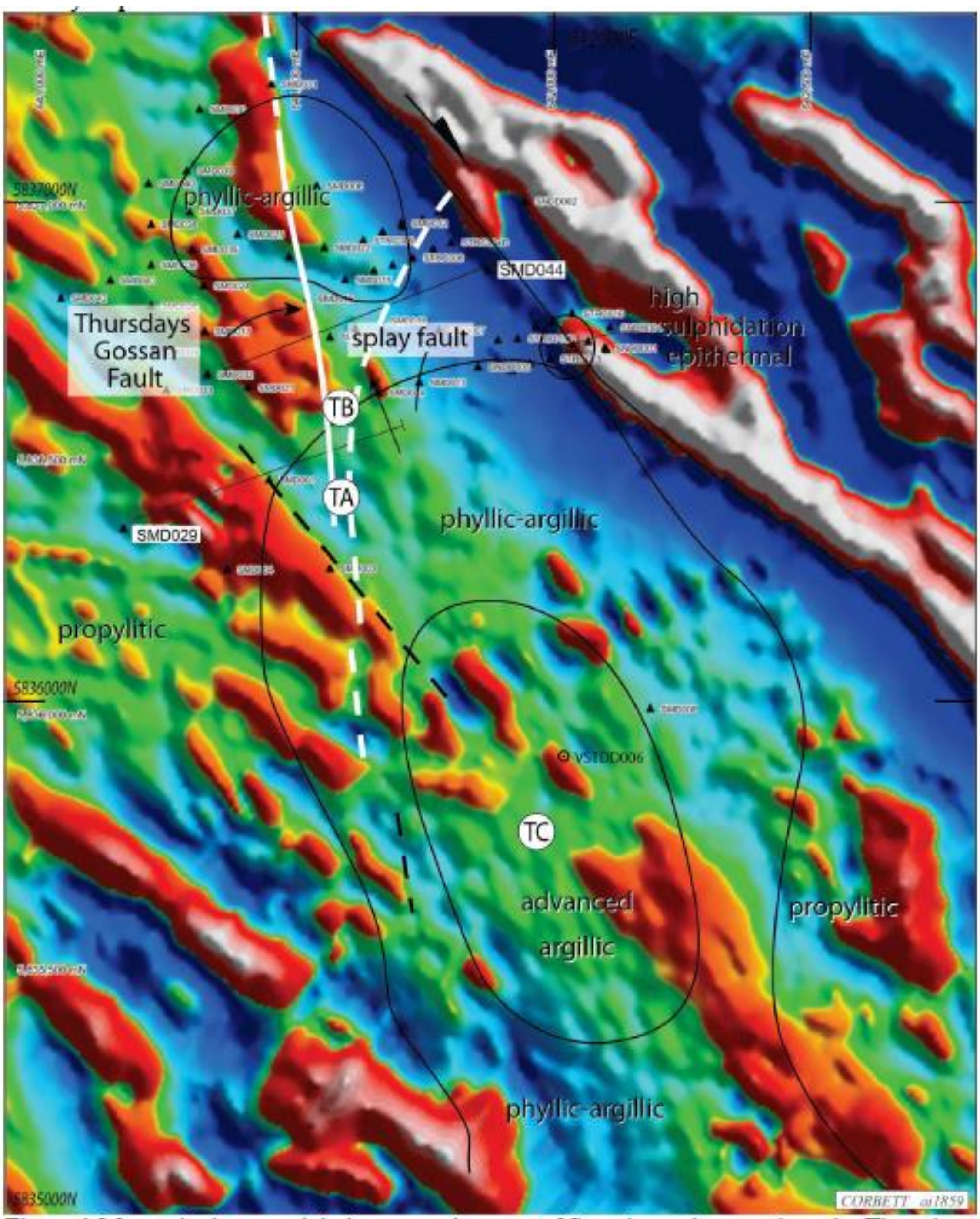

Figure 5. Magnetic data overlain by some elements of Stavely geology such as the Thursday's Gossan Fault and adjacent Copper Splay Fault and also the contact between the Stavely Arc volcanosedimentary sequence and adjacent higly magnetic ultramafic rock to the NE. Hyrdothermal alteration outlines are adapted from Spencer (1996). TA is porphyry target A at the convergence of the Thursday's Gossan Fault and the splay fault, TB is copper lode-style targets on the structures and TC is target C in the core of the Victor advanced argillic alteration.

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