

# CSA Cu-Zn-Pb DEPOSIT, COBAR DISTRICT, NEW SOUTH WALES

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## LOCATION

The CSA Cu-Zn-Pb deposit is approximately 10 km N of Cobar (Figure 1) at 31°24'38"S, 145°48'04" E; Cobar 1:250 000 sheet (SH55-14).

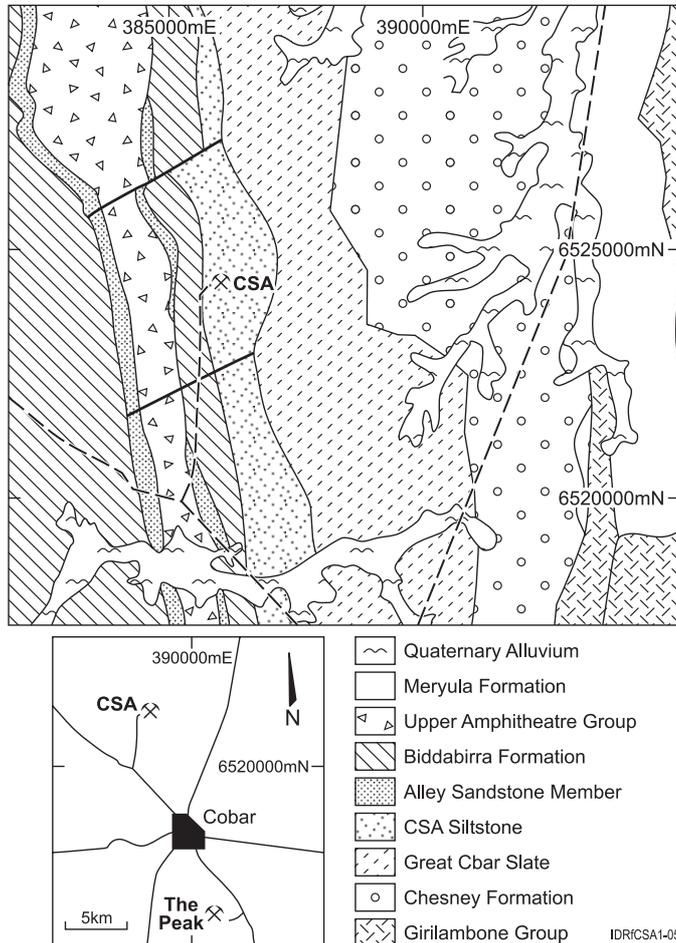


Figure 1. Regional geology and location of the CSA deposit in the Cobar Basin, western NSW (Grid is GDA94).

## DISCOVERY HISTORY

The CSA deposit was discovered as an outcropping gossan with Cu carbonate staining in 1871 by prospector Tom O'Brien, a year after the discovery of Cu in the Cobar district (Andrews, 1913). Major production did not commence until 1905 (Andrews, 1913; Kappelle, 1970). The deposit was mined intermittently until 1920 when production ceased after a major underground fire; 117 000 t of ore had been mined, at an average grade of 3.78% Cu, 2.76% Pb, 25.1 g/t Ag and 0.383 g/t Au (Kappelle, 1970).

Drilling to 500 m in the late 1940s by Enterprise Exploration Co Pty Ltd detected upper Cu and Zn lodes of the Western System (Figure 2) and a Cu lode at depth (Eastern System). Between 1957 and 1960 the deposit and surrounding leases were acquired by Cobar Mines Pty Ltd and a second production phase commenced in 1964. Exploratory drilling of a gravity trend in the early 1970s discovered the QTS North and South systems, which lie approximately 100 m E and 250 m SE of the Eastern System respectively (McDermott *et al.*, 1996; Figure 2). CRA Ltd acquired the deposit in 1980 and carried out extensive near-mine exploration. In February 1993, a consortium led by Golden Shamrock Mines Ltd purchased the deposit from CRA and continued mining until the deposit was taken over by Ashanti Goldfields. The mine was closed in 1997 due to low Cu prices and purchased by the present owners, Cobar Management Pty Ltd (a subsidiary of Glencore International),

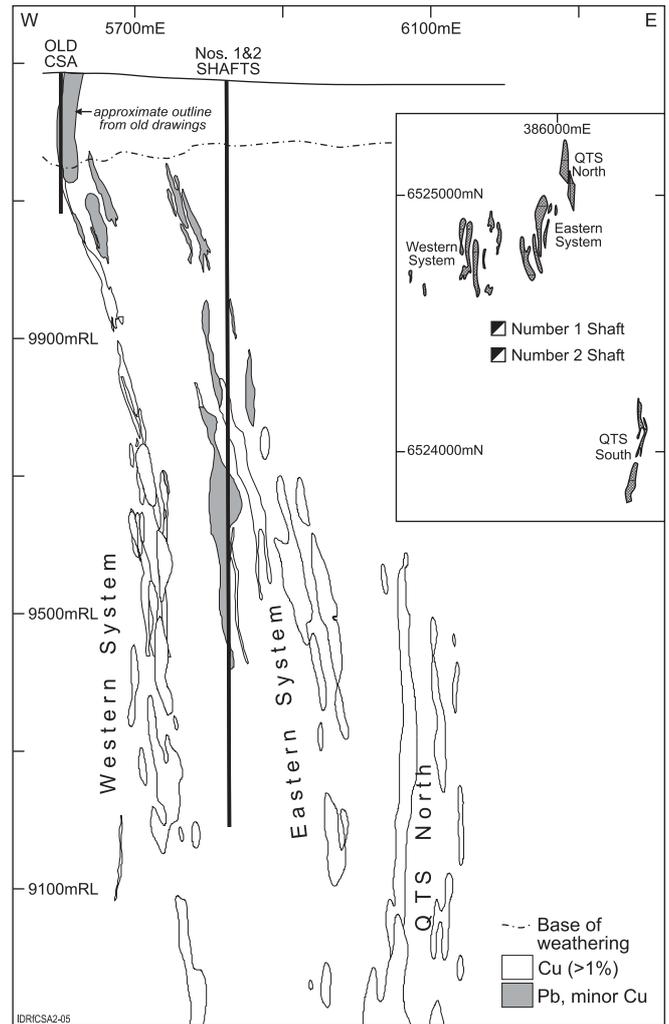


Figure 2. Cross section (6524280 N) and plan view (9300 RL) of the various ore systems (and contained lenses) at the CSA deposit (after Scott and Phillips, 1990).

The mine re-opened in early 1999. From 1964 to December 2004, 24.8 Mt of ore, averaging 2.6% Cu, 22 g/t Ag, 0.62% Pb and 1.98% Zn, were produced from the CSA deposit. Since 1992 production has been focussed on the Cu ores.

## PHYSICAL FEATURES AND ENVIRONMENT

The CSA deposit occurs in an area of low undulating NNW-trending rises and is associated with a broad, prominent hill (Elouera Hill) about 30 m above the surroundings. It lies close to a local drainage divide between the catchments of Sandy Creek to the SW and Yanda Creek to the NE.

The climate is semi-arid, with an average annual rainfall of 403 mm. Mean maximum daily temperatures are 20-34°C (January) and 4-16°C (July). Vegetation close to the deposit has been disturbed by mining and is an open woodland of Bimble Box (*Eucalyptus populnea*), Belah (*Casuarina pauper*), Cypress Pine (*Callitris glaucophylla*), Green Mallee (*Eucalyptus viridis*), Mulga (*Acacia aneura*), shrubs and grasses (Cunningham, 1981).

## GEOLOGICAL SETTING

The CSA deposit (Figure 1) is one of several base metal- and Au-bearing deposits of the Cobar Mineral Field. It occurs on the E margin of the early Devonian Cobar Basin (Central Lachlan Orogen) and is hosted by the CSA Siltstone (turbiditic siltstones and sandstones). The CSA Siltstone (Glen, 1991) is part of the Cobar Supergroup, consisting of

lower syn-rift sediments (Nurri Group) and upper post-rift sag phase sediments (Amphitheatre Group). These rocks have undergone lower-greenschist metamorphism.

The CSA deposit lies near the stratigraphic top of the CSA Siltstone (Glen, 1994). It is bound to the W by the Footwall Fault (Kappelle, 1970) and located immediately N of the WNW-trending Plug Tank Fault and W of a NNE-trending right lateral fault (Glen, 1988). Between these structures, ore zones occur as a series of N-trending, steeply E-dipping lenses within the W-dipping host sequence. The lenses are parallel to the regional, steeply E-dipping cleavage. Rocks enclosing the mineralization show extensive alteration. Green Fe-rich chlorite and silica are prominent alterations.

### REGOLITH

Elouera hill has been preserved by ferruginization and silicification associated with mineralization and weathering. Colluvium, alluvium (gravel, sand and silt), red silty loams and lithosols, with a significant aeolian component, dominate the surroundings. There is a thin cover of locally derived, gravelly colluvium and red-brown residual soil (<0.5 m thick) on low angle slopes and in gullies. Narrow, incised drainages pass into more gently sloping channels, aggraded by alluvium, and finally into large, low, open drainage depressions. Sediment transport on low-angle slopes and alluvial flats is by sheetwash. Lag accumulations of lithic gravel, quartz fragments and ferruginous pisoliths are extensive around the CSA deposit. A number of well-preserved palaeovalleys are infilled with rounded ferruginous pisoliths and some quartz and lithic clasts (<15 mm) in a silty clay matrix (Munro, 2004).

Minor gossans occur close to the CSA mineralization. Weathering commonly reaches 20-100 m. Strong oxidation reaches 60 m and moderate to weak oxidation penetrates to 100 m. Secondary hematite and goethite mottling extends from surface to 75 m. Deeper oxidation commonly extends to >100 m along faults and shears and to >160 m over the CSA deposit itself. The present regional water table is at about 100 m (150 m below the surface of Elouera Hill).

### MINERALIZATION

Mineralization is as structurally controlled, epigenetic vein-complexes containing semi-massive to massive sulphide bodies. There are four main ore systems striking approximately N and dipping steeply E, sub-parallel to the cleavage. Each system contains many sub-parallel ore lenses that extend along strike for up to 120 m and range to 20 m in thickness. They plunge steeply N for several hundreds of m. In addition to the four main ore zones, a large number of smaller zones of variable size and similar composition occur (Kappelle, 1970). The ore lenses are predominantly chalcopyrite, cubanite ( $\text{CuFe}_2\text{S}_3$ ), pyrrhotite, pyrite and sphalerite with minor galena. Minor and trace ore minerals include arsenopyrite, bismuthinite ( $\text{Bi}_2\text{S}_3$ ), bornite, galenobismutite ( $\text{PbBi}_2\text{S}_4$ ), guanajuatite ( $\text{Bi}_2\text{Se}_3$ ), native Bi, native Ag, stannite ( $\text{Cu}_2\text{FeSnS}_4$ ) and tetrahedrite ( $[\text{Cu},\text{Fe}]_{12}\text{Sb}_4\text{S}_{13}$ ) (McDermott *et al.*, 1996). The ore zones also contain a large number of quartz-sulphide veins subparallel to the crenulation foliation. The sulphides and quartz are hosted in intensely cleaved chloritic siltstones. There are also numerous flat, W-dipping, strike slip faults. Fault zones are generally unmineralized.

Alteration associated with the mineralization includes a broad halo of green, Fe-rich chlorite that surrounds the ore zones and extends outwards for up to 50 m (Scott and Phillips, 1990). Pervasive silicification occurs as a broad zone surrounding the entire mineralized area. Extensive but cryptic Li-depletion haloes (up to 500 m across strike) and less extensive depletions of Na, K, Sr and Ba (up to 100 m) have been documented around the CSA ore zones (Robertson and Taylor, 1987). These are coincident with reduced feldspar and sericite in the rocks. Small areas of intensely siliceous rock known as 'elvan' (Scott and Phillips, 1990) were encountered around the Western System. Black chlorite is developed along late-stage shear zones. Large bodies of talc, commonly containing euhedral pyrite, are associated with most black chloritic shear zones (Scott and Phillips, 1990).

### REGOLITH EXPRESION

Only the Western System Cu ore body and the adjacent pyrite-Pb-Zn lodes are exposed at surface (Kappelle, 1970). Here, surface gossans are surrounded by elongate haloes of silicification. The upper parts of the gossans are strongly leached of base metals with only traces of secondary Cu and Pb carbonates (Andrews, 1913). Malachite and azurite veining, native Cu (psudomorphing pyrite and infilling cavities), minor cerussite ( $\text{PbCO}_3$ ) and chlorargyrite ( $\text{AgCl}$ ) occur from 85-115 m. In the original CSA workings, a large mass of supergene cerussite (up to 10 m thick) occurs at the base of oxidation, near the water table (Andrews, 1913). A supergene chalcocite zone also occurred in the northern shoots of the Western System between 140-146 m (Brooke, 1975). Some sulphides, particularly pyrite, occur in the oxidized zone, where they are protected by silica alteration. Iron and Mn oxide staining extends across the surface projection of the blind Eastern System. The other CSA ore bodies are well below the weathering zone and have no weathering expression, although a zone of hematite and goethite above the QTS North lenses occurs at a depth of 1.5 m and probably reflects the near-surface periphery of this system.

Sampling of different regolith materials has shown that Fe oxides and oxyhydroxides are important hosts for base metal and pathfinder elements, including Cu, Pb, Zn, As, Co, Sb and Ag. Although depleted relative to primary concentrations, elements such as Ag, As, Bi, Cd, Co, Cu, Cr, Hg, Mo, Pb, Sb, Se and Zn are sufficiently abundant in the near surface weathered zone to act as pathfinders for CSA style mineralization. Element associations indicative of CSA style mineralization are Ag-Cd-Hg, Cu-Pb-Zn-Fe-Se-Bi-Sb and Cd-Cu-Hg-Zn.

### Saprolite

Ferruginous veins and mottles in the saprolite and saprock are an important sampling medium for CSA style mineralization with contents of Cu >140 ppm, Pb >450 ppm and Zn >600 ppm in near surface saprolite, up to 50 m from mineralization. Around the CSA deposit, mottled saprolite contains numerous well-defined multi-element geochemical anomalies. Copper and Cd anomalies clearly define the main mineralized zones with abundances of up to 265 ppm and 8 ppm respectively. Zinc has been more widely dispersed. These anomalies are short in strike and narrow in width, and are consistent with the N-trending ore structures. Arsenic has a limited distribution over the main mineralized zone, but it is particularly enriched around the Western System. Barium has a patchy distribution over the main ore systems. Lead is particularly enriched (up to 3000 ppm) in the Western System, with a limited distribution over the Eastern System. Bismuth, Sb, Hg and Zn generally show an even distribution over the QTS North mineralization and the surrounding area, with respective maximum concentrations of 1.9, 15, 0.29 and 336 ppm.

### Soil

The regional, red-brown silty loam contains a significant transported component, including wind-blown dust. A number of previous geochemical surveys have used bulk soil sampling. However, these surveys failed to clearly define known mineralized zones, giving very diffuse anomalies. This probably reflects local transport of soil (including contained ferruginous pisoliths) and aeolian dilution. Sharper anomaly definition is obtained by interface sampling the soil-saprolite contact (Figure 3). Important pathfinder elements for soil exploration here include Ag, Ba, Cd, Cu, Pb and Zn, with threshold values of 0.6 ppm, 255 ppm, 0.7 ppm, 75 ppm, 435 ppm and 360 ppm respectively.

### Lag

Lag around the CSA deposit is a mixture of coarse (>2 mm), locally derived bedrock fragments, quartz clasts, gossan fragments and variably transported, highly ferruginous pisoliths. The lithic fragments show variable ferruginization and the ferruginous pisoliths commonly consist of cemented sand and silt, typically with a homogeneous internal structure. The pisoliths commonly have a smooth, varnished surface. A proportion of this ferruginous lag is magnetic (maghemite-bearing). Much is angular, characteristic of *in situ* or locally transported material. Generally, there is little internal evidence of parent rock fabrics.

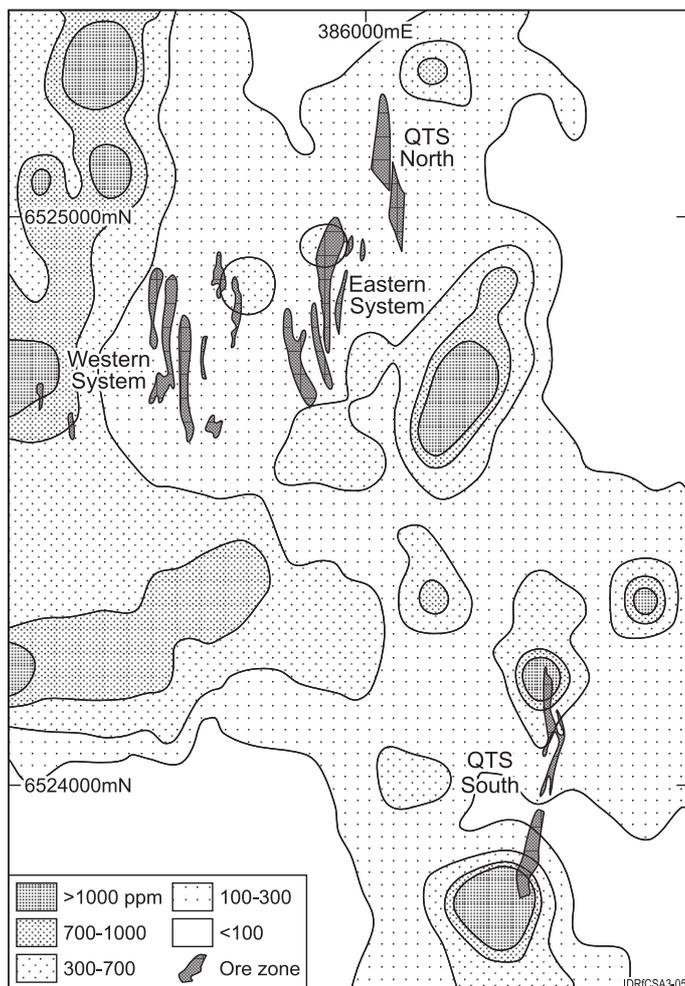


Figure 3. Plan showing Cu+Pb+Zn anomalies around the CSA deposit detected in samples from the soil/saprolite interface (contour interval is 100 ppm, maximum contour 1000 ppm). Ore zones are projected to surface.

The lag from around the CSA deposit generally has elevated Pb, As, Sb and, in some, Ag in the more ferruginous fractions and Cu and Zn typically in the lithic materials relative to regional background. Contents of Pb, As, Sb and Ag are up to 3096 ppm, 509 ppm, 227 ppm and 5 ppm respectively and of Cu and Zn up to 690 ppm and 537 ppm respectively. There is a well-defined positive correlation between the abundance of Fe and hematite with the contents of Pb, As and Sb. This is related to a previously recognized weathering-controlled fractionation of these elements during surface maturation of the lag (McQueen and Munro, 2003). Copper and Zn show a strong negative correlation with Fe and hematite abundance, except in lag derived from gossanous outcrops. A lag sample collected near an outcropping Pb-Zn gossan associated with the Western System has distinctly anomalous concentrations of Pb (330-3100 ppm), As (61-510 ppm), Bi (7-77 ppm), Cu (100-690 ppm), Zn (150-540 ppm) and Ag (0.3-3.1 ppm) in the different lag fractions (lithic and ferruginous).

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## SAMPLE MEDIA - SUMMARY TABLE

| Sample medium          | Indicator elements | Analytical methods | Detection limits (ppm) | Background (ppm) | Max anomaly (ppm) | Dispersion distance (m)                 |
|------------------------|--------------------|--------------------|------------------------|------------------|-------------------|---|
| Primary mineralization | Ag                 | ICP <sup>2</sup>   | 0.02                   | <0.05            | 3                 | ?                                       |
|                        | As                 | ICP <sup>2</sup>   | 1                      | 9                | 100               | ?                                       |
|                        | Cu                 | ICP <sup>2</sup>   | 1                      | 30               | 2000              | <20                                     |
|                        | K                  | XRF                | 50                     | 41000            | 2700*             | 70-150*                                 |
|                        | Li                 | AAS <sup>2</sup>   | 1                      | 34               | 16*               | >1000*                                  |
|                        | Na                 | AAS <sup>2</sup>   | 25                     | 8800             | 600*              | 100-250*                                |
|                        | Pb                 | ICP <sup>2</sup>   | 1                      | 32               | 500               | <20                                     |
|                        | Sr                 | ICP <sup>2</sup>   | 5                      | 667              | 105*              | 70-150*                                 |
| Saprolite and saprock  | Zn                 | ICP <sup>2</sup>   | 1                      | 115              | 1000              | <20                                     |
|                        | As                 | ICP <sup>1</sup>   | 1                      | 9                | 25                | <100                                    |
|                        | Ba                 | ICP <sup>1</sup>   | 1                      | 1095             | 1840              | <50                                     |
|                        | Bi                 | ICP <sup>1</sup>   | 2                      | <2               | 154               | <20                                     |
|                        | Cd                 | ICP <sup>1</sup>   | 1                      | <1               | 52.2              | <20                                     |
|                        | Cu                 | ICP <sup>1</sup>   | 1                      | 160              | 422               | <100                                    |
|                        | Hg                 | ICP <sup>1</sup>   | 0.1                    | <0.1             | 0.5               | ?                                       |
|                        | Pb                 | ICP <sup>1</sup>   | 1                      | 458              | 2960              | <20                                     |
| Soil                   | Sb                 | ICP <sup>1</sup>   | 2                      | 5.5              | 99                | <50                                     |
|                        | Zn                 | ICP <sup>1</sup>   | 1                      | 388              | 4660              | <100                                    |
|                        | Ag                 | ICP <sup>1</sup>   | 0.01                   | 0.6              | 1.7               | <50                                     |
|                        | Ba                 | ICP <sup>1</sup>   | 1                      | 255              | 833               | <50                                     |
|                        | Cd                 | ICP <sup>1</sup>   | 1                      | <1               | 61.2              | <50                                     |
|                        | Cu                 | ICP <sup>1</sup>   | 1                      | 75               | 550               | 20-200                                  |
| Lag                    | Pb                 | ICP <sup>1</sup>   | 1                      | 435              | 1840              | 10-100                                  |
|                        | Zn                 | ICP <sup>1</sup>   | 1                      | 360              | 4650              | 20-200                                  |
|                        | Ag                 | ICP <sup>2</sup>   | 0.1                    | 0.1              | 3.1               |   |
|                        | As                 | INAA               | 1                      | 65               | 509               |   |
|                        | Bi                 | ICP <sup>2</sup>   | 0.01                   | 12               | 77                | Highly variable typically 100 m to 1 km |
|                        | Cu                 | ICP <sup>2</sup>   | 1                      | 40               | 690               |   |
| Lag                    | Pb                 | ICP <sup>2</sup>   | 2                      | 60               | 3960              |   |
|                        | Sb                 | INNA               | 0.2                    | 20               | 250               |   |
|                        | Zn                 | ICP <sup>2</sup>   | 1                      | 100              | 537               |   |

\* Depletion in primary zone  
<sup>1</sup>After aqua regia digestion  
<sup>2</sup>After HF/HClO<sub>4</sub>/HNO<sub>3</sub>/HCL digestion