HALLS PEAK MASSIVE SULPHIDE DEPOSITS, NEW ENGLAND, NSW

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LOCATION

Massive sulphide deposits in the Halls Peak area in NE NSW are centred on 30°45'S, 152°02'E, about 45 km SE of Armidale (Figure 1); Dorrigo-Coffs Harbour 1:250 000 map sheet (SH56 10-11).

DISCOVERY HISTORY

Prospectors located gossanous outcrops in the Halls Peak area in 1896. There was limited mining of Cu, Ag, Pb and Zn from the gossans and underlying massive sulphides intermittently from 1916 until the late 1970s. From the 1930s to the mid-1980s there were several exploration campaigns in the region for further massive sulphide lenses and sediment-hosted Ag deposits (Gilligan *et al.,* 1992). Exploration methods used in these programs included stream sediment and soil geochemistry, electrical geophysics, costeaning and drilling (Gilligan *et al.,* 1992), with stream sediment geochemistry leading to the discovery of the gossan zone at Khans Creek (Palethorpe, 1980).

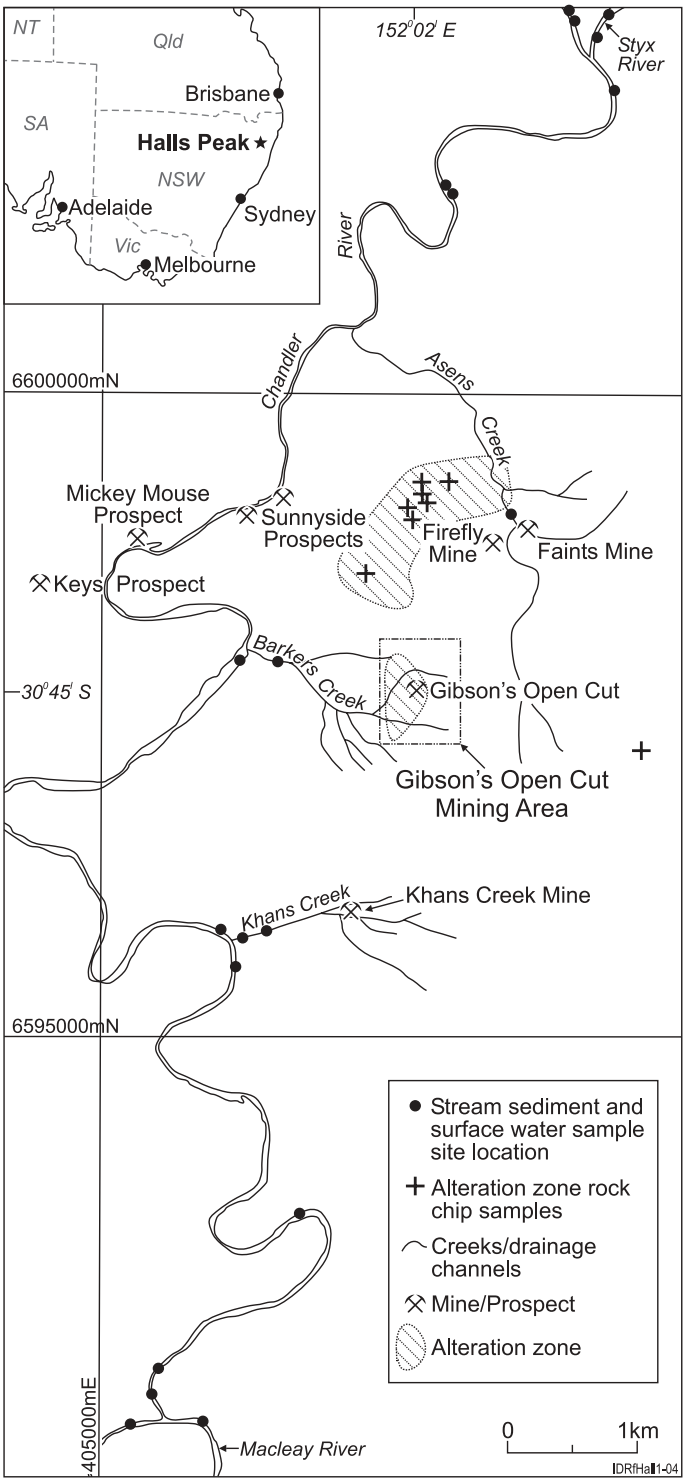

Figure 1. Regional setting of the Halls Peak area, with the location of stream sediment and alteration zone rock chip samples from the Halls Peak Volcanics. The major massive sulphide workings are on the eastern side of the Chandler River gorge, a region of steep slopes, up to 650 m of local relief and dominated by transported regolith.

PHYSICAL ENVIRONMENT

Sulphide mineralization in the Halls Peak area lies close to the E edge of the Northern Tablelands of NSW, in a heavily dissected region. In the Macleay River catchment, this region forms part of the "gorge country" related to the Great Escarpment of Eastern Australia (Ollier, 1982a). Deposits are located on the E side of the Chandler River valley at between 250 and 900 m. The mineralized zone, containing the main workings (Gibson's, Khans Creek and Faints-Firefly), has slopes ranging from 15-40° and is drained by Asens, Barkers and Khans creeks, tributaries of the Chandler River (Figure 1). Although outcrop is common, the mountainsides are mantled by transported regolith.

The area has a temperate, humid climate. Annual rainfall is approximately 1000 mm, with a summer maximum, and average temperatures range from approximately 13-26°C in January and 2-13°C in July. Most of the region is covered by dry sclerophyll forest although there are significant zones of dry rainforest in sheltered locations. Forestry operations and grazing occur in places on the plateau tops near Halls Peak, but the Chandler River gorge is mostly wilderness. Mining at Halls Peak has resulted in landsliding and physical transport of waste materials into tributaries of the Chandler River and ephemeral acid mine drainage occurs at each of the main workings (Lottermoser *et al.,* 1997).

GEOLOGICAL SETTING

Halls Peak is in the southern part of the New England Orogen. Mineralization is in the early Permian Halls Peak Volcanics, a sequence of moderately deformed, low-grade, metamorphosed, felsic volcanic, volcaniclastic and sedimentary rocks. These unconformably overlie the deformed and metamorphosed Palaeozoic accretionary complex constituting much of central New England (Gilligan *et al.,* 1992). The Halls Peak Volcanics may have been formed in a rift-related setting, partly deposited in marine conditions; evidence of mass flow deposition is prevalent (Moody *et al.,* 1993). Sulphide mineralization is mostly stratiform and constrained by one or more "favourable horizons" containing fine grained sedimentary and felsic volcaniclastic rocks. Several massive sulphide bodies occur and are associated with broad zones of weakly disseminated and stockwork sulphides in hydrothermally altered volcanics and sediments. Characteristics of Halls Peak mineralization are consistent with the Zn-Pb-Cu (Kuroko) type of volcanic-associated massive sulphide deposits.

REGOLITH

Mineralization in the Halls Peak area occurs in steep terrain and regolith profiles are poorly developed. Unlike the western, undissected New England Plateau that retains substantial relicts of Tertiary and earlier lateritic weathering profiles (Ollier, 1982b; Schmidt and Ollier, 1988), erosion related to the development of the gorge country has destroyed any previous land surface. Current regolith development has occurred since the incision of the Chandler River. Residual regolith is preserved on ridge tops (saprolitic material, grading to fresh rock at depths ranging from centimetres to >10 m). Mountainsides are blanketed by transported regolith, including local patches of scree. There is commonly a sharp distinction between *in situ* saprock and overlying transported material comprising a chaotic aggregate of weathered bedrock blocks in a pale sandy to clayey matrix. Soils are generally rocky and skeletal. Streams draining the Halls Peak area are high-energy types, with exposed bedrock and bedload typically ranging from

boulders to sand.

MINERALIZATION

Massive sulphide bodies at Halls Peak are moderately to steeply dipping, and lens-, sheet-, pod- and irregularly-shaped. They are up to several tens of metres across and up to 3 m thick (Gilligan *et al.,* 1992). The bodies are commonly associated with sulphidic shale and siltstone (forming a "favourable horizon" containing anomalous Zn and Pb), diamictite and altered volcaniclastic rocks. Metal grades in massive sulphides are high; averaging 3.5% Cu, 8% Pb, 24% Zn, 260 ppm Ag and 0.42 ppm Au (at Gibson's and Khans Creek). The host rocks are massive to banded and dominated by sphalerite and galena, with lesser amounts of chalcopyrite and pyrite and traces of tetrahedrite. Zones of stockwork and disseminated sulphides in sericite-quartz altered rocks occur at Gibson's and the topographic prominence of Halls Peak. Immature gossans are well developed on massive sulphides.

REGOLITH EXPRESSION

Gossan

Due to the high metal grades of the massive sulphides and the relative immaturity of the regolith at Halls Peak, regolith materials have strong and distinctive geochemical signatures that can be used to target mineralization (see Summary Table). However, due to previous mining, soils, stream sediments and waters have been contaminated by mine waste, and hence metal values are enhanced. Weathering of the alteration zone to form a 'leached capping' and geochemically anomalous saprock (Figures 1 and 2) are dominated by quartz, illite/sericite, goethite and hematite, with local plumbojarosite. Disseminated and vein boxworks after sulphides are recognizable. Patchy, moderately to strongly anomalous values of Au, Ag, As, Sb, Cu, Pb and Zn are typical. Gossans locally preserve relict banded structures and boxworks; they contain dominant goethite and plumbojarosite, with varying amounts of hematite, quartz, clays, malachite, azurite, cerussite, smithsonite, brochantite and aurichalcite. Metal contents are high and average 1.6% Cu, 2.8% Pb, 0.37% Zn, 340 ppm Ag and 0.21 ppm Au. Pathfinder elements As, Sb, Bi and Mo are also strongly anomalous.

Soil, stream sediment and vegetation

Soils from the Gibson's area have numerous Pb, Cu $\pm$ Zn anomalies along strike from known mineralization. Soils with higher metal values locally contain fragments rich in Fe oxides. Stream sediment anomalies have long dispersion trains, with detectable anomalies of Pb, Zn and Cu extending for up to 40 km down the Chandler and Macleay Rivers (Figure 1). Close to mineralization sources, stream sediments contaminated by mine waste commonly contain metal values exceeding the maxima in the Summary Table. In these, metals are largely bonded to Fe oxides and jarosites. Streams draining mineralized areas are locally acidic and waters contain extreme Zn values (with anomalous Cu, Pb and Cd). Riparian vegetation in the Halls Peak area has taken up significant heavy metals, with Zn (Cu, As) being up to 20 times background.

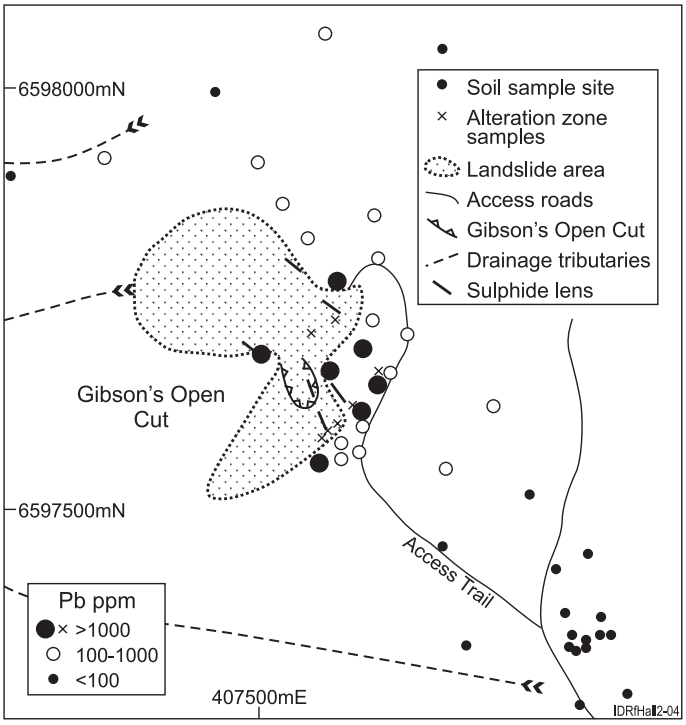

Figure 2. Local setting of the Gibson's Mine area, Halls Peak, showing locations of soil and alteration zone samples, the position of the open cut and massive sulphides lenses, and the area affected by landsliding of sulphidic mine waste.

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Sample medium	Indicator elements	Analytical methods	Detection limits (ppm	Background (ppm)	Threshold (ppm)	Maximum anomaly (ppm)	Dispersion Distance (m)
Primary mineralization	Pb Cu Zn	AAS	5			+10%	
Alteration zone, saprock	Pb	ICP-OES	1	<50	120	1.8%	100s
	Cu	ICP-OES	1	<25	90	4080	
	As	ICP-OES	1	<20	120	1600	
	Ag	ICP-OES	0.2	<0.5	10	162	
Gossan	Cu	AAS	5			37600	limited to
	Pb	AAS	5			47900	gossan
	Zn	AAS	5			8085	
	Ag	AAS	1			800	
Soil, including transported overburden	Cu	ICP-OES	1	13	93	1400	100s
	Pb	ICP-OES	1	40	346	3960	
	Zn	ICP-OES	1	47	167	1260	
	As	ICP-OES	1	3	19	158	
Stream sediments	Cu	ICP-OES	1	18	61	1410	40 000
	Pb	ICP-OES	1	12	249	5940	
	Zn	ICP-OES	1	59	172	3340	
	As	ICP-OES	0.2	8	13	142	
Stream water	Zn	ICP-MS	0.001	0.07	0.1	24	3000
Vegetation (dry)	Zn	ICP-OES	1	12	30	240	6000

Solid samples were analysed after digestion in $HF/HNO_3/HClO_4/HCl$.
Dried vegetation samples were extracted in aqua regia.