Distribution of Tellurides and Mercury in Fimiston Open Pit

The Kalgoorlie gold field is characterised by rich gold-telluride lodes and gold quartz stockworks. In the Fimiston lodes gold occurs as free gold, in gold or gold-silver tellurides or locked up with pyrite.

The presence of tellurides in the Golden Mile was first recognised by Holroyd in 1895 (Spencer-Compton, 1966) two years after the first discovery of gold. A number of workers have reviewed telluride mineralogy over the years but mineralogical studies have tended to be descriptive in nature and with the exception of Golding (1978), Clout (1989) and Shackleton *et al* (2003,) no attempt has been made to look at the distribution of the different tellurides laterally or at depth. Historically many of the very gold-rich lodes owed their richness to tellurides and hence much of the massive telluride has been removed. These high grade shoots are now only occasionally encountered and since underground exposures have been lost with the development of the Open Pit, occurrences of visible tellurides are now very rare.

At Kalgoorlie, non-anthropogenic mercury occurs naturally in the mineral coloradoite (HgTe). This mineral is one of 17 telluride minerals identified within the Kalgoorlie Lodes. These can be broadly divided into

Gold Tellurides -	Calaverite ($AuTe_2$) Montbrayite (Au_2Te_3) Nagyagite ($Au(Pb,Sb,Fe)_8 (S, Te)_{11}$)
Gold-Silver Tellurides -	Krennerite (Au_4AgTe_{10}) Sylvanite ($AuAgTe_4$) Petzite (Ag_3AuTe_2)
Silver Tellurides	Hessite(Ag_2Te) Stuetzite ($Ag_{5-x}Te_3$)
Others	Coloradoite (HgTe) Cuprian Coloradoite ((Hg,Cu)Te) Altaite (PbTe) Tellurantimony (Sb_2Te_3) Melonite ($NiTe_2$) Weissite ($C_{2-x}Te$) Tetradymite (Bi_2Te_2S) Frohbergite ($FeTe_2$) Mattagamite ($CoTe_2$)

Native mercury (Hg) has also been recorded at Kalgoorlie (by Rickards, 1900 referenced in Golding 1978) but only in oxidised ore although there is a passing reference in Clout (1989) to the presence of native Hg and amalgam deeper in the mine. The mineral kalgoorliite (sometimes referred to in the early literature as a mercury-gold telluride) was misidentified and is a mixture of coloradoite and petzite. Tellurides are reported to be rare at Mt Charlotte and occur as fine inclusions in pyrite. They are generally Au and Au-Ag varieties and coloradoite has not been noted (Clout 1989).

Tellurides are visible in hand specimens as disseminated masses in siliceous or carbonate-rich lodes, segregations along foliation planes, crosscutting fracture fillings or vugh fillings. They occur as fine-grained composite aggregates, massive segregations, composite grains with native gold, inclusions in and intergrowths with

pyrite and tetrahedrite-group minerals, as well as inclusions in carbonates and various silicates, including quartz and tourmaline. Free gold is frequently associated with these massive tellurides.

Tellurides are best developed at the intersection of lodes or at the intersection between a lode and an unmineralised shear.

Coloradoite has been reported as one of the commonest tellurides in the lodes (Golding, 1978; Clout, 1989). It is frequently associated with petzite and calaverite and native gold. It is associated with all lode types.

Large masses of coloradoite were present in the famous Oroya Shoot which contained extensive green leader mineralisation. This is also the type locality for cuprian coloradoite.

A recent occurrence (late 2004) of telluride veining was observed on the 350 Bench associated with high gold values in X Lode West at the southern end of Stores (Figures 1 and 2)

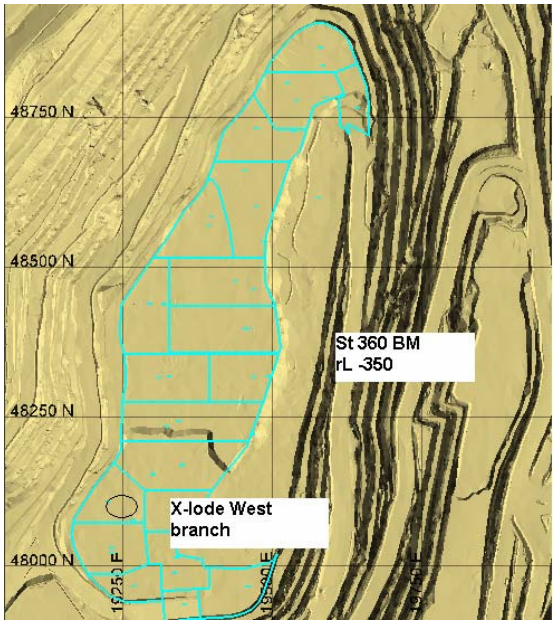

Fig 1. Stores 360 Bench. Telluride occurrence

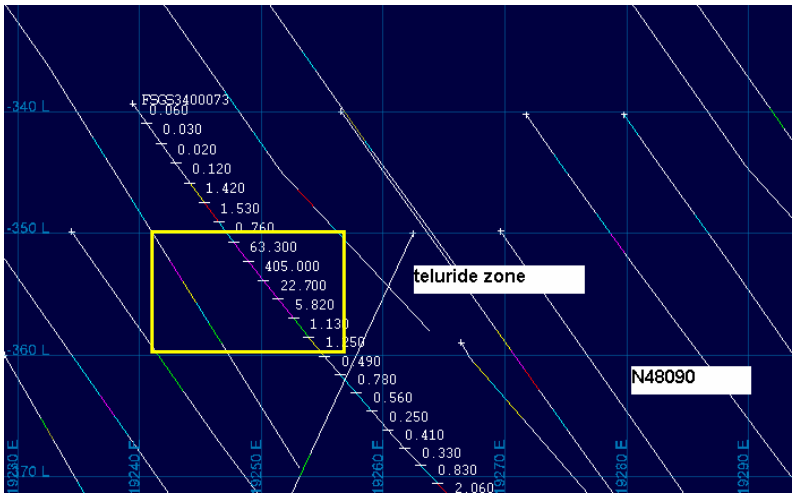

Fig 2. Cross Section showing location of telluride minerals in X Lode West (360mB). Hole shows gold assays

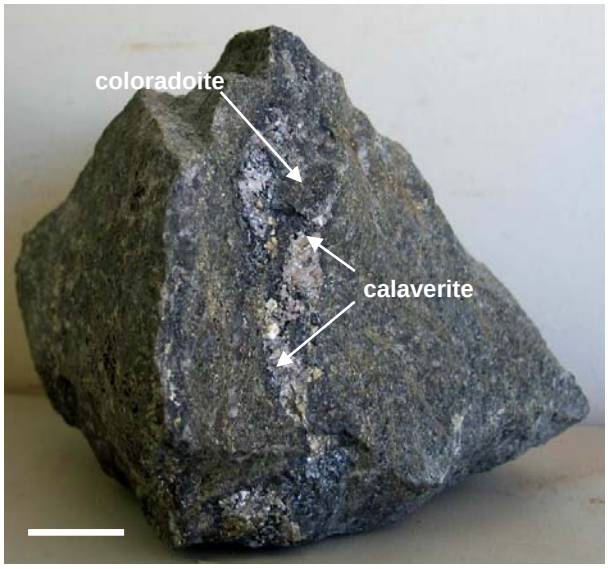

Fig 3. Stores 360 Bench. Hand specimen of Telluride. Scale Bar is approx 2 cm

Mineralogical work was completed on a small suite of samples from this locality (Pontifex and Purvis, 2005). This identified a number of tellurides including calaverite, petzite, sylvanite, hessite and alataite along with coloradoite in all samples. Figure 3 shows a coarse telluride vein from this area and Figures 4 and 5 show photomicrographs of a sample from this study showing the relationship of coloradoite to other phases.

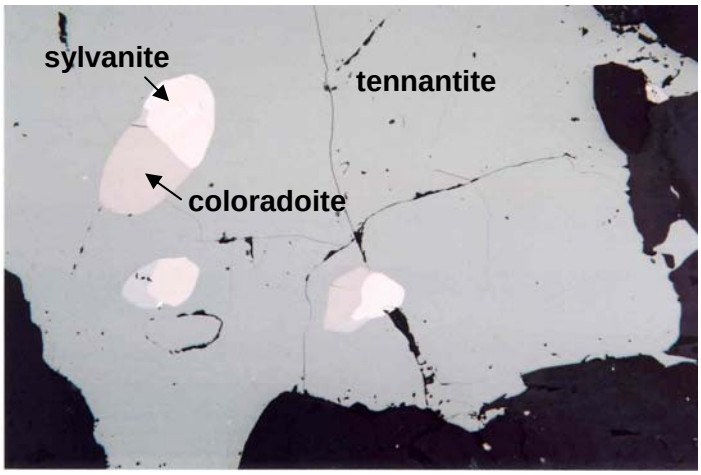

Fig 4 Photomicrograph of telluride sample X Lode (Stores 360mB)

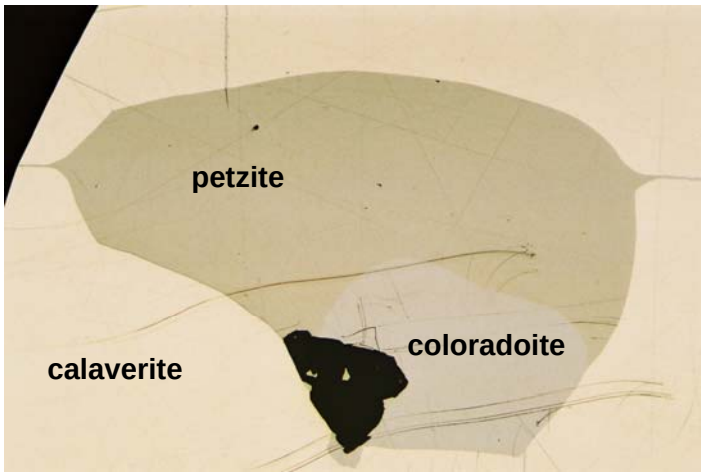

Fig 5 Photomicrograph of telluride sample X Lode (Stores 360mB)

Studies of the distribution of telluride mineralisation in the Kalgoorlie lodes are too limited to make definitive observations. Golding (1978) made some general observations on the distribution of tellurides including coloradoite. She noted a very broad distribution associated with other telluride minerals (notably calaverite and

petzite). It is found in many of the steeply dipping and flat dipping lodes, in the "green leader" ore, at Hidden Secret and in drilling.

Golding (1978) noted its stability along with calaverite over a wide vertical range, having been located in mines from the 200 ft (69 m) level of the Block 45 Mine just below the level of oxidation to as great as 2,500 ft (865 m) in the Phantom Lode. It has also been recorded in drilling to 1,380 m.

Clout (1989) reviewed the distribution of telluride bearing shoots utilising data from Golding and his own study. He identified 71 shoots with over 1 oz/t as being telluride rich and suggested they accounted for over 25% of the total gold production. These high grade shoots are found in all units of the Golden Mile Dolerite as well as in the Paringa Basalt and the Black Flag Beds. Clout (1989) notes that 70% of the historic high grade shoots are above 200 m though the telluride rich shoots occur down to 1,000 m. The paragenesis and relative abundance of tellurides is dependent on the type of alteration in the lode however Clout (1989) notes that coloradoite is "by far the most abundant telluride found through the deposit".

TABLE 2. SUMMARY OF THE RELATIVE ABUNDANCE OF NATIVE GOLD, COMMON TELLURIDES AND NATIVE TELLURIUM IN THE FIMISTON-STYLE GOLDEN MILE ORES*

Mineral		Main Lodes	Caunter Lodes	Cross Lodes
Native gold	Au	XXX	XX	X
Calaverite	$AuTe_2$	XXX	XX	X
Montbrayite	$(Au,Sb)_2Te_3$	T	O	O
Krennerite	$AuTe_2$	T	X	O
Sylvanite	$(Ag,Au)_2Te_4$	T	X	O
Petzite	Ag_3AuTe_2	XXX	XXXX	XXX
Stützite	$Ag_{5-x}Te_3$	T	T	O
Hessite	Ag_2Te	X	X	T
Coloradoite	HgTe	XXX	XX	X
Altaite	PbTe	XX	XXXX	XX
Tellurantimony	Sb_2Te_3	T	X	O
Melonite	$NiTe_2$	X	T	O
Native tellurium	Te	O	O	T

XXXX: abundant, XXX: relatively common, XX: common, X: rare, T: trace, O: absent. * Modified after Stokes (1989).

Table 1 Summary of relative abundance of tellurides (from Shackleton et al, 2003)

Table 1 (From Shackleton *et al*, 2003) summarises the observed relative abundances of the various tellurides. This confirms that coloradoite is observed in all lode styles but is most abundant (with petzite and calaverite) in the Main and Caunter lodes.

Work by Shackleton *et al* (2003) strongly suggested that there is no lateral or vertical variation in the distribution of any tellurides. Refer Figure 6.

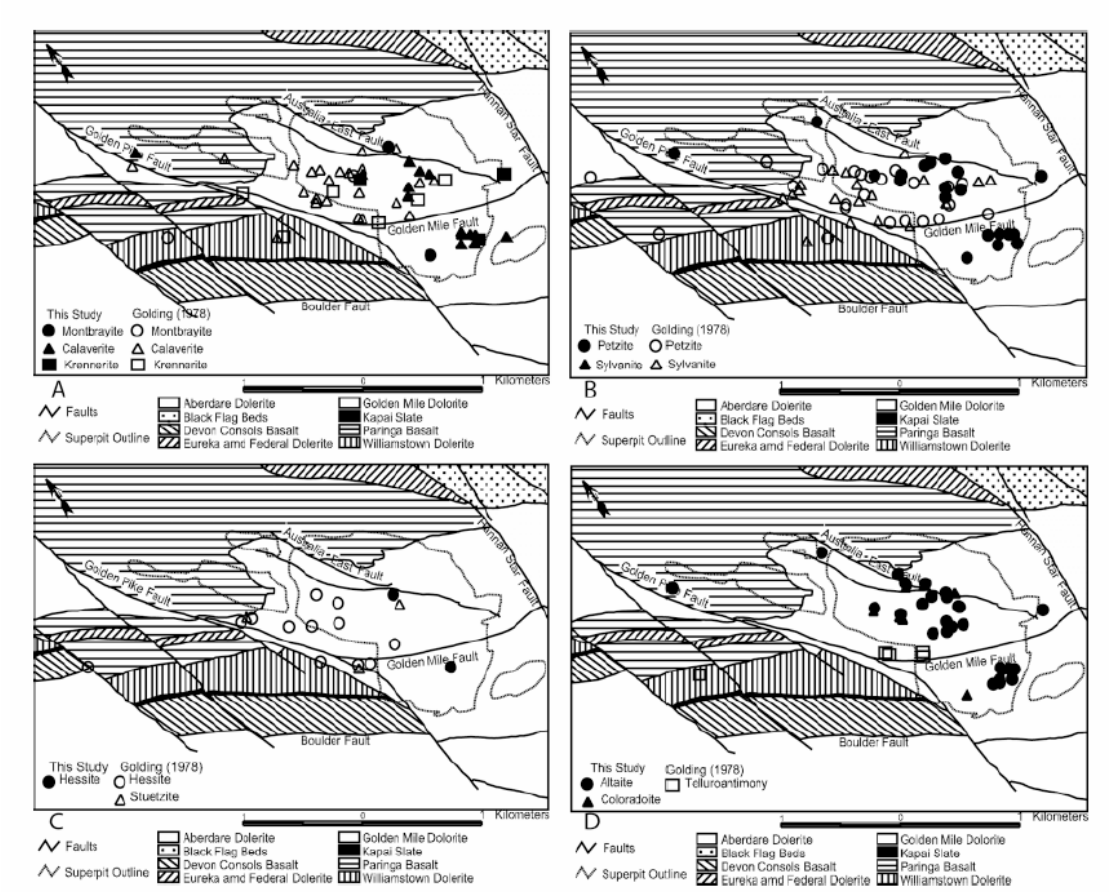

FIG. 10. Maps of the Golden Mile deposit illustrating the location of: (A) calaverite, montbrayite and krennerite, (B) petzite and sylvanite, (C) hessite and stützite, (D) altaite, coloradoite and tellurantimony. Data are from Golding (1978) and this study.

Fig 6 Plans showing the distribution of various telluride minerals in the Golden Mile

Geochemistry

Only very limited analytical data is available concerning the distribution of mercury in the Golden Mile. Mercury is not routinely assayed and has not been analysed for in exploration drilling.

A single analysis of coloradoite in the Golden Mile has been reported in Shackleton et al, (2003) from the Furness Lode, and this contained 60.8% Hg with the remainder being Te.

Geochemical variation related to alteration has been investigated by Clout (1989). His study involved extensive underground mapping, interpretation of historic sampling and collection of 500 lode samples. Many of these samples were analysed for trace elements including mercury and tellurium.

Clout (1989) identified seven different alteration zones with distinctive mineral associations. Of these zones two (zones 1 and 5) were identified as being characterised by abundant tellurides including coloradoite.

Type 1 Alteration is the most common and probably accounts for over 50% of the ore mined. It is characterised by quartz-carbonate-sericite-pyrite along with tellurides, arsenopyrite, and various other minor sulphides, selenides and sulphosalts.

Type 5 Alteration (Vanadian Sericite) contains the classic “green leader” and is similar to type 1 with the presence of a suite of vanadium minerals. This alteration is far more restricted in its distribution.

Geochemically, Clout (1989) notes that all alteration zones with the exception of Type 2 (anhydrite) and Type 7 (ankerite-dolomite) are enriched (relative to unaltered dolerite) in Hg. Figure 7 shows a subset of the geochemical dataset (n=128) for which alteration type is recorded. This confirms that high mercury is associated predominantly with Types 1 and 5 Alterations though types 3 and 4 can have significant Hg.

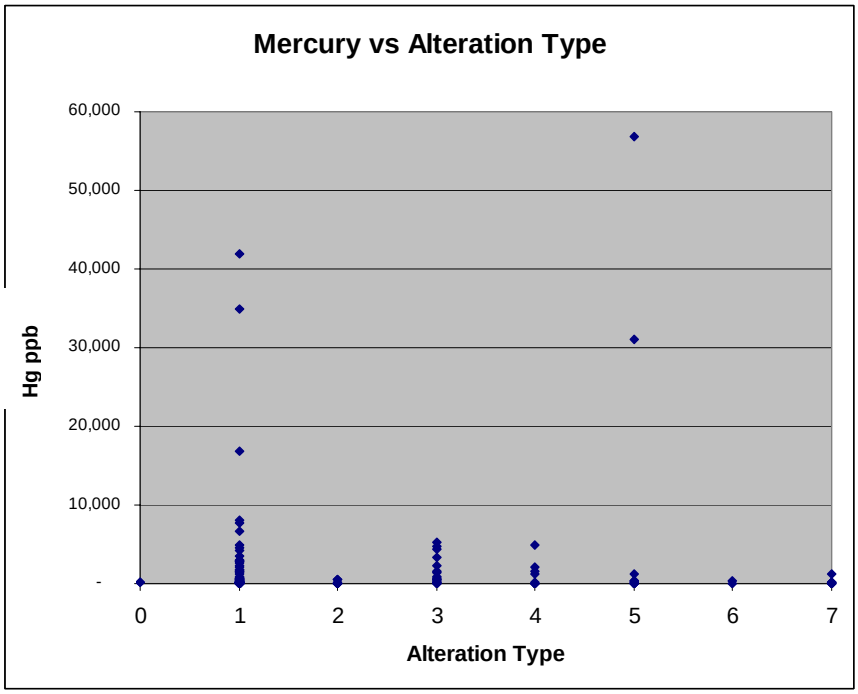

Fig 7 Mercury and Alteration Type

Mercury content recorded from selected underground lode or wall samples (n=433) ranges from 0.01 to 300 ppm Hg. The average of all data is 5.89 ppm Hg. It needs to be remembered that this sampling is weighted to high grade loads and includes samples of material which has been mined out or is a very minor percentage of ore currently mined. The unrepresentativeness of the sampling is confirmed by the average gold grade of all data being 23.9 g/t approximately 10 times the current average grade. If the mercury average is factored by this amount this would suggest an average around 0.6 ppm Hg.

An alternative way to look at it is to remove all samples associated with Alteration Type 5 (or inferred to be associated with it through high Vanadium content) from the database (n=36). If this is done the average of the remainder is 1.73 ppm Hg.

It is likely that the actual mercury content of current ore lies somewhere between these two numbers.

Figures 8 and 9 shows the correlations obtained for mercury data.

There appears to be a relatively poor correlation between mercury and gold. This is not surprising given the variety in gold paragenesis and it is likely that there is a multiple population with only part of the gold related to telluride. As expected however there is a significant correlation between Hg and Te. The line marked on Figure 9 represents the theoretical correlation if all the Te was in coloradoite. Clearly as would be expected the majority of the population lies above this line confirming the presence of many other telluride minerals. Interestingly however there is a small percentage which lies below the line which suggests either analytical error or the presence of mercury in phases other than coloradoite (native Hg or amalgam?).

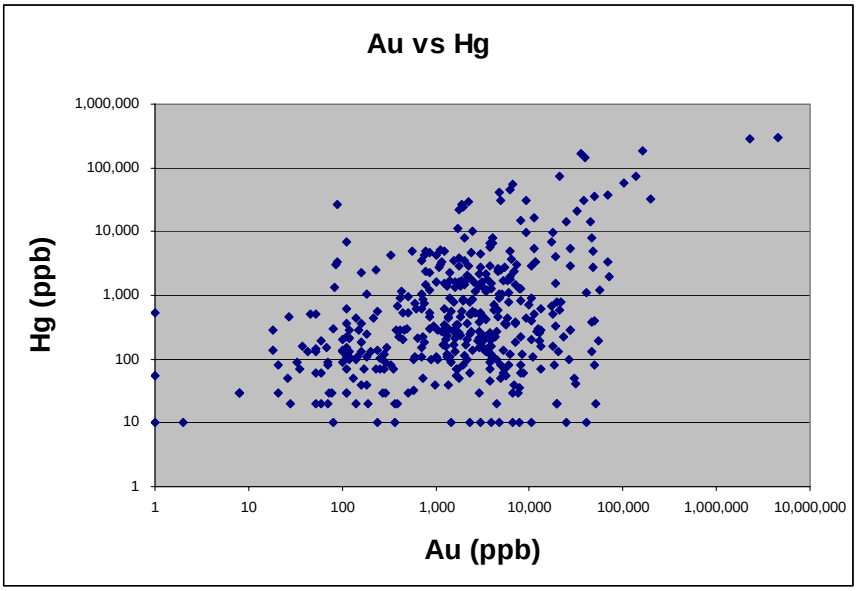

Fig 7 Mercury vs Gold

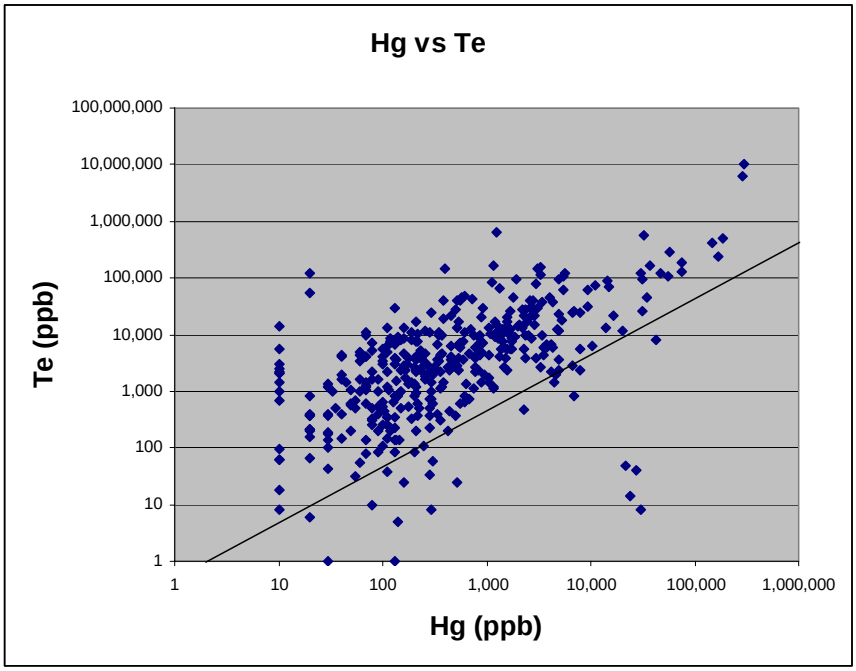

Fig 9 Mercury vs Tellurium

Figure 10 is a similar plot of Hg versus Te utilising only data for which coordinates are available and which lie inside the final pit outline (n=119). This data is coded by

cutback. While data is limited for some cutbacks (such as Golden Pike and Chaffers) the available data support the conclusion that the range of mercury contents is similar across all cutbacks.

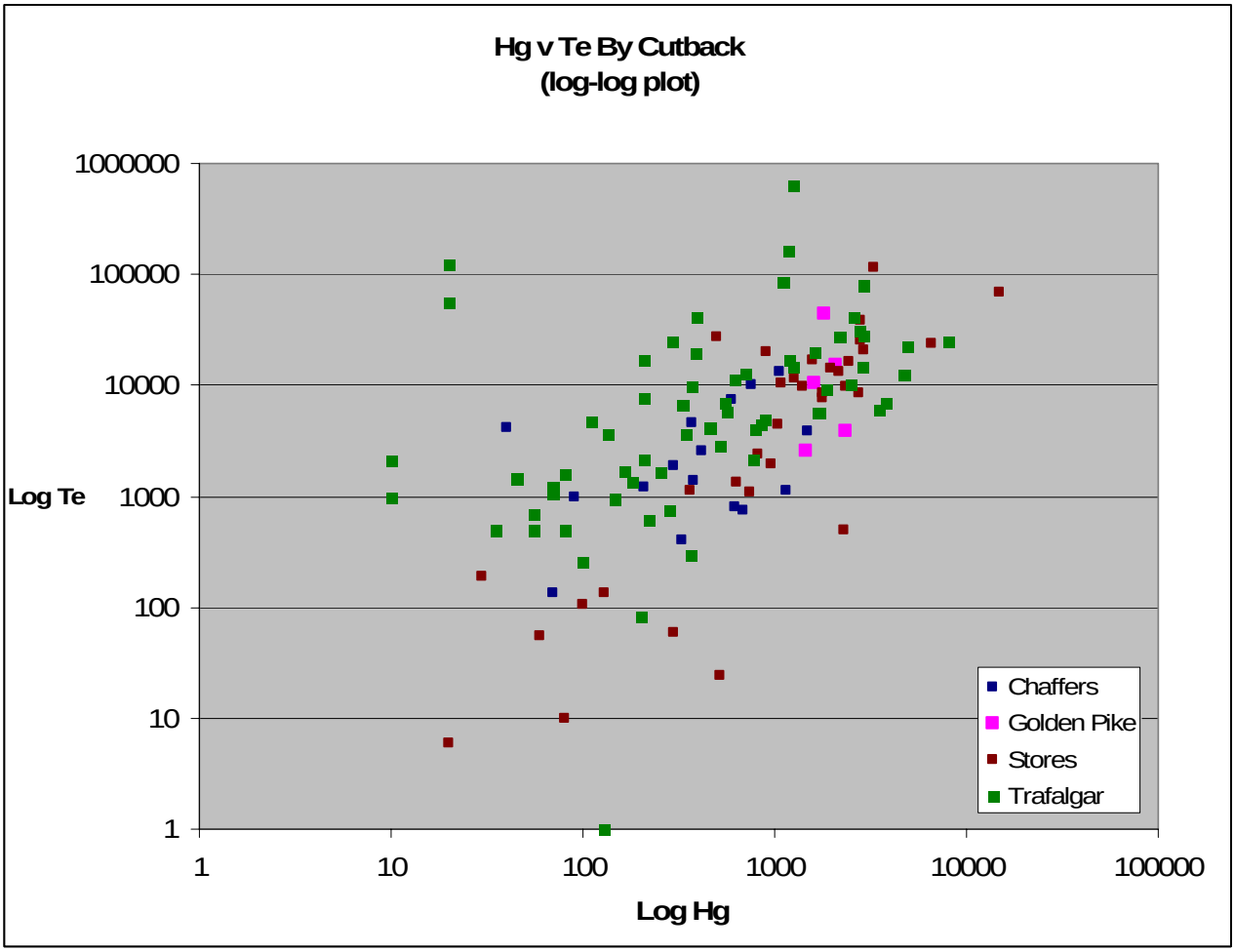

Fig 10 Mercury vs Tellurium (remaining cutbacks)

Figure 11 shows a subset of the total mercury data set for which coordinates are available (n=216) plotted with depth. There is no obvious relationship of Hg with depth, confirming observations made by Shackleton *et a*l (2003) and others.

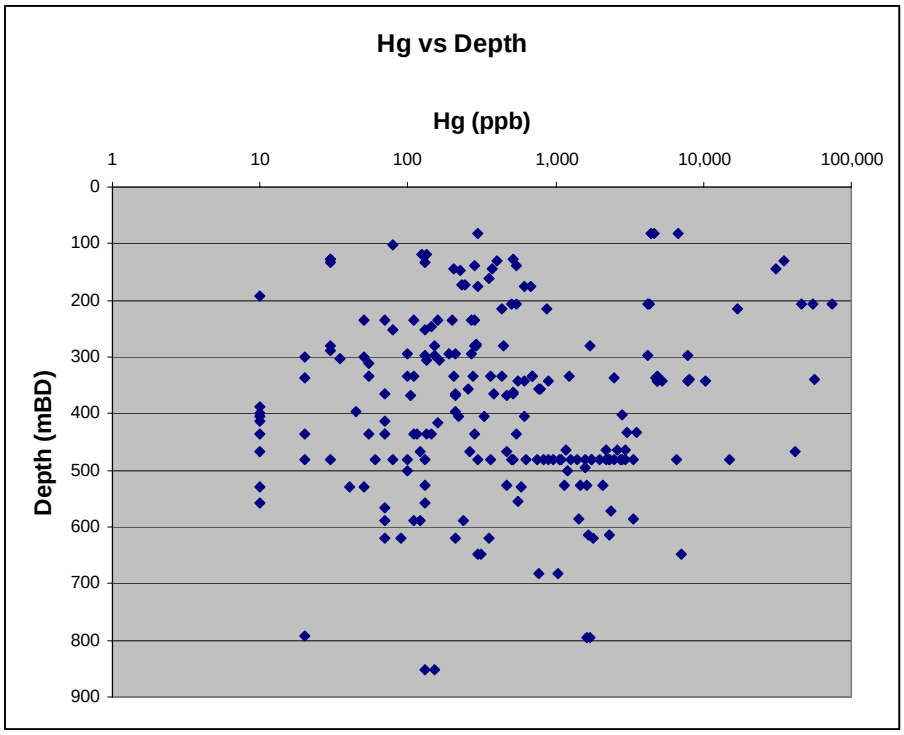

Fig 11 Mercury and Depth

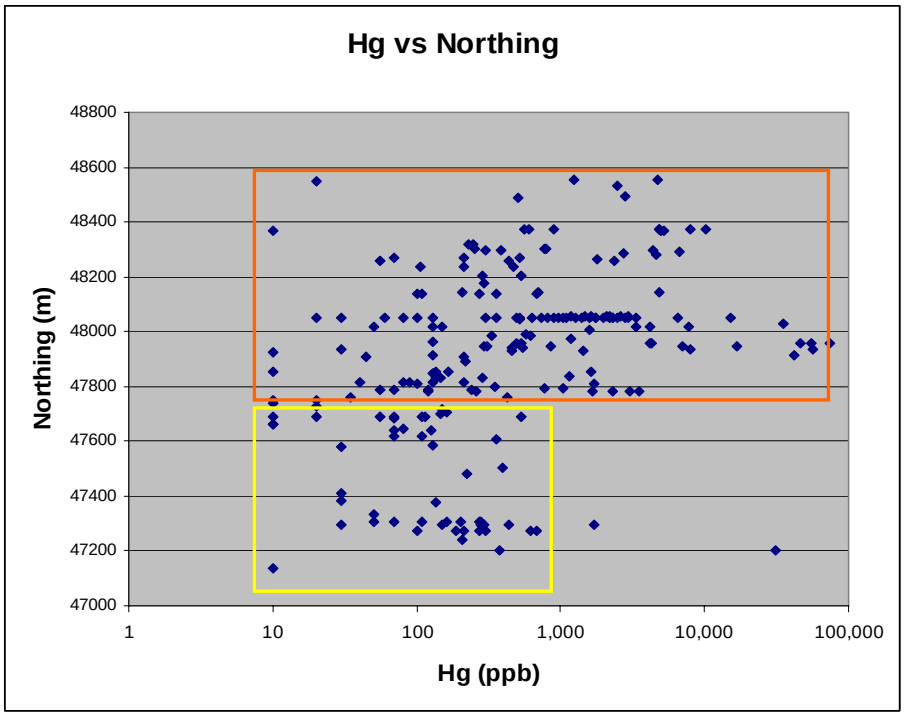

Fig 12 Mercury and Northing

Figure 12 shows available mercury data (n=216) plotted against Northing. This suggests that mercury is generally elevated north of 47800 (most data in the range

0.01 to 100 ppm Hg) whereas south of 47800 most data (with a couple of exceptions) is in the range 0.1 to 1 ppm Hg. Figure 13 demonstrates further that low Hg values are recorded west of the Golden Mile Fault (92000E) shown in red, confirming the Western Lodes as having lower Hg.

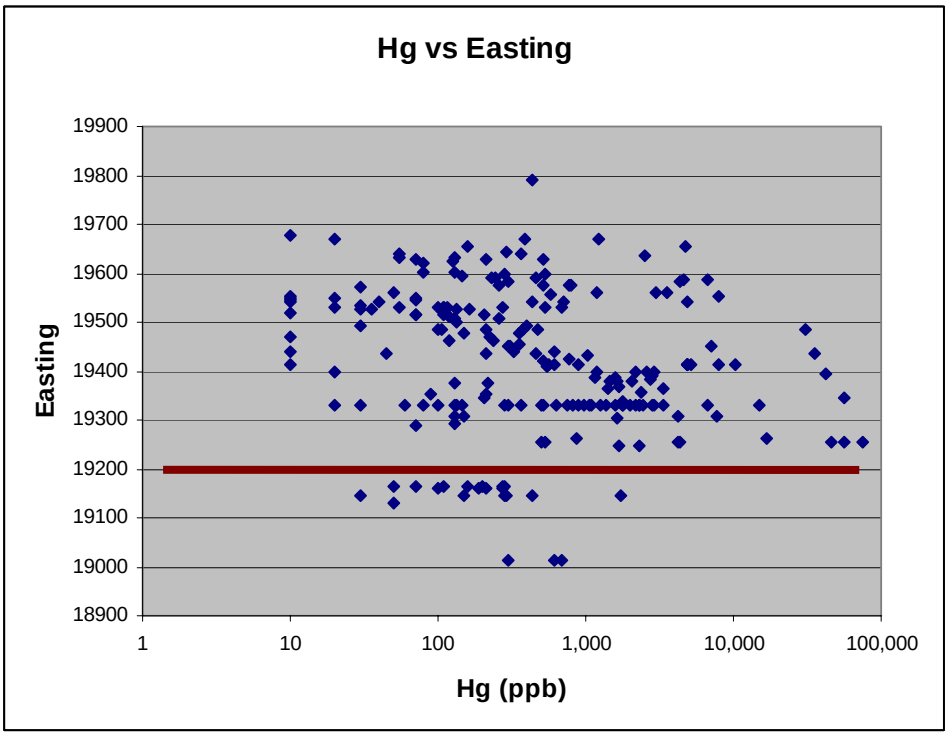

Fig 13 Mercury and Easting

Conclusions

- Mercury is contained within coloradoite, one of a suite of telluride minerals that are rare but widely distributed through the Golden Mile lodes.
- Coloradoite (HgTe) is the most common non-precious metal telluride.
- Other rare mercury minerals may exist (native Hg?).
- Mercury is elevated north of 47800N. Low Hg values are recorded west of the Golden Mile Fault.
- There is no obvious variation with depth and tellurides (including coloradoite) are recorded below 800 m.
- Remaining cutbacks have broadly comparable mercury ranges based on limited data.
- Average mercury content of feed is likely to be in the range of 0.6 - 1.7 ppm Hg.
- There is no suggestion in the data that the tenor of mercury will increase or decrease with depth of mining.

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