krennerite in the Great Boulder mine. Crystalline rutile is a common oxide phase in mineralized sections of the lodes.

According to Simpson (1912), a large irregular mass of micaceous hematite was associated with Fe-rich carbonate on the No. 12 Level of the Lake View Consols mine. Stillwell (1931) also noted hematite intergrown with magnetite in high grade ore from the 3030 ft. South drive on the No. 4 Lode, Chaffers mine but in general hematite is rare in these ores.

The iron vanadate, nolanite, has been reported from the Middle Lode and is said to be present in other lodes in the Golden Mile (Taylor and Radtke, 1967).

**Gangue Minerals**

**Quartz.** At the edges of the lode, primary quartz makes up a significant part of the lode but in the central portions of the lode, most of the quartz has recrystallized to a bluish-grey microcrystalline material. Occasionally, coarser-grained quartz is present in cross-cutting stringers or veinlets.

**Carbonates.** E.D.A.X. spectra of all lode carbonates examined in this study indicate that they are ankerite (Ca, Fe, Mg carbonate). Siderite (Fe carbonate) has also been reported by Bartram (1969).

**Micas.** Fine-grained sericite is scattered through the lode material. Although more typical of "green leader" ore, V-bearing roscœelite, has been reported from the Golden Horseshoe and Great Boulder mines (Rickards, 1900; Simpson, 1912); 27.11% $V_2O_3$ was recorded in one analysis of green mica from the Great Boulder mine (Simpson, 1912).

**Sulphates.** Minor quantities of sulphates have been recognized in the lodes. Colourless, cleavable gypsum (known as selenite) was associated with quartz, sphalerite and tetrahedrite at the No. 14 Level of the Great Boulder mine (Larcombe, 1911) and has also been reported from the North Kalgurli and Lake View East mines (Simpson, 1912). According to Simpson (1912), small
bladed crystals of barite occurred in veinlets of dolomite and quartz cross-cutting the lodes at the No. 19 Level of the Lake View mine. Very small grains of barite were also observed in the siliceous core of the No. 4 Lode in D.D.H. 5022. Veinlets of purple anhydrite (confirmed by X-ray diffraction) are present in weakly mineralized G.M.D. in D.D.H. 5022.

Tourmaline is another gangue mineral sporadically associated with mineralization. Larcombe (1911) described a specimen from the Perseverance mine in which tellurides have grown along fractures in tourmaline prisms. In a specimen from the No. 22 Level of the Great Boulder mine, small masses of tellurides are penetrated by needles of tourmaline. Development of tourmaline is not confined to high-grade ore but is also found in some weakly mineralized ore. It was frequently observed in the deep drilling of the lodes.

3.2.2 Flatly Dipping Lodes ("Green Leader")

General Statement

The characteristic presence of a green mica gave rise to the name "green leader" for the flatly dipping lodes in the Eastern Lode System. Most of the "green leader" lodes are situated at or close to the boundary of the G.M.D. and Paringa Basalt but the synclinal infold of the B.F.B. in the Lake View mine known as the "Duck Pond" is also regarded as "green leader" by Tomich (1974). According to Tomich (1959) assay values were related to the depth of green, with the deepest green specimens yielding the highest gold values. He suggested that the gold might be locked up in sericite or be present in some colloidal or other form. In 1974, Tomich added the possibility that the high assay values may be due to disseminated fine telluride but still considered the possibility of gold in some unknown form.

A number of polished sections were examined in this study, and all appeared to contain sufficient fine-grained tellurides and free gold to account for their high gold contents. A similar conclusion was reached
independently by Nickel (1977). As a check, some of the green mica from the Emerald Lode (AA40437) was analysed by neutron activation analysis; this contained only 1.3 ppm Au compared with 6.5 ppm Au in the total rock indicating that the mica is not a significant host of the Au. Although a few grains of telluride were associated with the micas, most of the tellurides observed were in small segregations of quartz and carbonate within the foliated rock. It should also be noted that the samples with the most telluride (WM3027, AA40438) contained very little green mica.

Tellurides

Although the tellurides observed in this study and that of Nickel (1977) were all fairly fine-grained, it is of note that in the past, beautiful specimens of telluride were obtained from the Oroya Shoot, the most productive of the "green leader" lodes. One specimen of coloradoite from the Oroya mine measured 125 x 50 x 25 mm (Simpson, 1912). Massive calaverite (Larcombe, 1911; Simpson, 1948) and nagyagite (Simpson, 1912) have also been obtained from the Oroya Shoot.

Larcombe (1911, p. 148) describes a number of modes of occurrence of tellurides in the Oroya Shoot. In one specimen, calaverite and gold coat massive magnetite. In another specimen, tellurides and free gold have grown in a vug of crystalline quartz and dolomite enclosed in pyritic black cherty silica. Tellurides and gold also coat fractures and joints in this ore.

Microscopic grains of telluride are abundant and a number of varieties have been reported in addition to the larger masses of coloradoite, calaverite and nagyagite described above. These include melonite (Stillwell, 1931; Nickel, 1977), petzite (Radtke, 1963; Nickel, 1977), sylvanite (Radtke, 1963) and altaite (Nickel, 1977). In addition, the Oroya Shoot is the type locality for cuprian coloradoite, a Hg telluride with 11.50 to 12.14% Cu, which was found in association with normal coloradoite, calaverite,
petzite, native gold and tetrahedrite (Radtke, 1963).

Analyses of some of the tellurides found in the "green leader" ore during the course of this study are presented in Table 18.

**Antimonian montbrayite?**. Of particular interest is an Sb-bearing Au telluride, probably montbrayite although X-ray diffraction data could not be obtained. This mineral was found both as isolated grains in the gangue and in aggregates associated with petzite, altaite, chalcopyrite and occasionally gold (Fig. 77). Although calaverite was present in the same polished sections as the Au,Sb telluride, the two were not observed in contact.

Montbrayite was first discovered in the Robb-Montbray mine, Montbray Township, Quebec by Peacock and Thompson (1946). After correcting a chemical analysis for the elements contributed by small inclusions of petzite, altaite and bismuth, these authors obtained the composition: 48.50% Au, 0.99% Sb and 50.51% Te and concluded that the mineral was impure $\text{Au}_2\text{Te}_3$ (50.77% Au, 49.23% Te). A more recent probe analysis indicated that 0.3% Sb, 1.3% Pb and 2.9% Bi are incorporated in the structure of montbrayite from the type locality (Rucklidge, 1969). However, Travis (1966) found no trace elements in montbrayite from the Doolittle Lode, New North Boulder mine and recorded a composition almost identical to $\text{Au}_2\text{Te}_3$.

On the basis of 5 atoms per molecule, the composition of the montbrayite from specimen AA40438 can be written: $\text{Au}_{1.90}\text{Sb}_{0.29}\text{Te}_{2.81}$. This indicates that Sb is substituting for both Au and Te and that there is not just a simple solid solution series between montbrayite ($\text{Au}_2\text{Te}_3$) and a triclinic form of $\text{Sb}_2\text{Te}_3$ or hexagonal $\text{Au}_2\text{Te}_3$ and tellurantimony (hexagonal $\text{Sb}_2\text{Te}_3$). Obviously detailed structural work on this Sb,Au telluride is required but for the sake of convenience, it will be referred to as antimonian montbrayite in this thesis.
Table 18.

Telluride analyses - flatly dipping lodes ("green leader")

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Description</th>
<th>Te</th>
<th>Sb</th>
<th>Au</th>
<th>Ag</th>
<th>Co</th>
<th>Fe</th>
<th>Cu</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA 40435</td>
<td>Isolated grain of antimonian montbrayite?</td>
<td>45.2</td>
<td>4.9</td>
<td>47.7</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>97.8</td>
</tr>
<tr>
<td></td>
<td>Antimonian montbrayite? associated with altaite</td>
<td>44.7</td>
<td>5.0</td>
<td>47.9</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>97.9</td>
</tr>
<tr>
<td></td>
<td>and petzite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA 40438</td>
<td>Isolated grain of antimonian montbrayite?</td>
<td>46.4</td>
<td>4.6</td>
<td>48.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>99.3</td>
</tr>
<tr>
<td></td>
<td>Isolated grain of calaverite</td>
<td>54.1</td>
<td>2.5</td>
<td>41.4</td>
<td>1.1</td>
<td>0.0</td>
<td>0.1</td>
<td>99.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calaverite associated with petzite</td>
<td>53.8</td>
<td>2.7</td>
<td>42.1</td>
<td>1.1</td>
<td>0.0</td>
<td>0.1</td>
<td>99.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isolated grain of calaverite</td>
<td>53.6</td>
<td>2.4</td>
<td>42.8</td>
<td>0.7</td>
<td>0.0</td>
<td>0.2</td>
<td>99.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isolated grain of calaverite with silicate</td>
<td>53.5</td>
<td>2.5</td>
<td>42.3</td>
<td>1.2</td>
<td>0.0</td>
<td>0.1</td>
<td>99.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>inclusions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isolated grain of calaverite</td>
<td>54.4</td>
<td>2.8</td>
<td>40.8</td>
<td>2.1</td>
<td>0.0</td>
<td>0.1</td>
<td>100.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calaverite associated with pyrite along planes</td>
<td>53.2</td>
<td>2.7</td>
<td>41.6</td>
<td>1.3</td>
<td>0.0</td>
<td>0.1</td>
<td>99.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of foliation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isolated grain of calaverite</td>
<td>53.4</td>
<td>2.3</td>
<td>42.9</td>
<td>0.8</td>
<td>0.0</td>
<td>0.2</td>
<td>99.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hessite associated with petzite</td>
<td>38.7</td>
<td>0.0</td>
<td>0.4</td>
<td>60.5</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>99.7</td>
</tr>
<tr>
<td>WM 3027</td>
<td>Isolated grain of calaverite</td>
<td>56.0</td>
<td>0.4</td>
<td>41.3</td>
<td>0.8</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>98.7</td>
</tr>
<tr>
<td></td>
<td>Calaverite associated with petzite</td>
<td>55.3</td>
<td>0.6</td>
<td>42.2</td>
<td>0.7</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>98.8</td>
</tr>
<tr>
<td></td>
<td>Calaverite moulded onto pyrite grains</td>
<td>55.7</td>
<td>0.5</td>
<td>41.3</td>
<td>0.8</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>98.4</td>
</tr>
<tr>
<td></td>
<td>Isolated calaverite grain</td>
<td>55.4</td>
<td>0.5</td>
<td>42.1</td>
<td>0.5</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>98.7</td>
</tr>
</tbody>
</table>
Fig. 77. Tellurides in the "green leader" ore. Antimonian montbrayite (m) is associated with petzite (p) and altaite (a) in the central aggregate. Both petzite and altaite show signs of alteration about the grain boundaries. Some tellurides are molded onto the edges of pyrite (py) and chalcopyrite (c) grains. (AA 40435). Magnification 210X.

Fig. 78. Replacement and alteration of a telluride grain in the "green leader" ore. Calaverite (c) is altering to native tellurium (t) along fractures and grain boundaries. It should also be noted that calaverite has been partially replaced by petzite (p) and gold (g). (AA 40438). Magnification 210X.
Calaverite. The more common Au telluride, calaverite, is also abundant in the "green leader" ore. It is noteworthy that calaverite in the same section as the antimonial montbrayite also contained an unusually high Sb content (Table 18). The Ag content of these calaverites is extremely low despite Cabri and Rucklidges' (1968) conclusion that calaverite can tolerate more Ag in its structure in the presence of Sb and Cu. The calaverite from the Ley Lode, New North Boulder mine (WM 3027) contained a considerably smaller (although still significant) amount of Sb; no antimonial montbrayite was found in this specimen. Calaverite is the only gold telluride reported by Nickel (1977) from a suite of "green leader" samples. Although Nickel states that the tellurides were identified primarily by microprobe analyses, the actual analyses are not published and Nickel makes no mention of Sb or other trace elements in these tellurides.

Other tellurides. A single grain of hessite with uniform anisotropism (analysis in Table 18) and a number of grains of petzite were also observed in the "green leader" ore examined. No tellurantimony was found in these ores despite the high Sb content of the Au tellurides.

Some tellurides in the "green leader" ore show signs of decomposition. A specimen of calaverite which has been partially replaced by "brown gold" is illustrated by Nickel (1977). Nickel confirmed the identity of this mineral by electron probe analysis and concluded that the colour was due to submicroscopic porosity; all transitions between brown gold and normal gold were observed in a single polished section. Not all the brown material replacing calaverite is gold however; some of this material in specimen AA 40438 (Fig. 78) consists predominantly of Te with only traces of Au although crystalline gold and petzite are replacing the calaverite as well. In the sections studied, altaite and petzite also showed signs of alteration along the borders (Fig. 77).
Gold

Gold is present in a number of forms in the "green leader" ore. Although Nickel (1977) suggested that most of the gold in the lodes has formed by oxidation of tellurides, there are numerous examples of gold in contact with unaltered tellurides (Fig. 79) and this gold has obviously not formed by oxidation of tellurides. Gold is also associated with pyrite, and occasionally chalcopyrite and sphalerite where it shows smooth boundaries suggesting contemporaneous deposition (Fig. 80). In addition, gold is frequently present as isolated blebs in the gangue in the vicinity of fine-grained tellurides and has also been observed along foliation planes.

Analyses of gold grains from the "green leader" ore are presented in Table 19. The moderate Ag content of these grains is further evidence that they did not result from decomposition of calaverite since gold formed by oxidation of tellurides is extremely pure: one sample of sponge gold analysed by Simpson (1912) contained only 0.09% Ag.

Sulphides

As in the steeply dipping lodes, pyrite is the most common sulphide in the "green leader" ore. Some pyrite is closely associated with tellurides and contains inclusions of telluride and gold but generally, pyrite is more abundant in telluride-free areas of the ore. The pyrite is frequently partially replaced by chalcopyrite and occasionally other minerals (Fig. 81).

In telluride-rich patches, chalcopyrite and sphalerite become important sulphide-bearing minerals. The sphalerite generally contains exsolved chalcopyrite and has pale yellow internal reflections indicating a low iron content.

Members of the tetrahedrite series were only observed in one specimen of "green leader" ore in this study (MU 5854) where the mineral was present as very small irregular grains intergrown with pyrite. Stillwell (1931), however, reported an occurrence of massive tetrahedrite in the Associated mine
Fig. 79. Gold (g) in contact with unaltered calaverite (c) in the "green leader" ore. Petzite (p) and altaite (a) are also present. (AA 40438). Magnification 530X.

Fig. 80. Gold (g) which appears to have been deposited contemporaneously with chalcopyrite (c), sphalerite (s) and pyrite (py) in the "green leader" ore. The sphalerite contains small blebs of chalcopyrite. (AA 40435). Magnification 210X.
Table 19.

Gold analyses - flatly dipping lodes ("green leader")

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Description</th>
<th>Au</th>
<th>Ag</th>
<th>Fe</th>
<th>Te</th>
<th>Cu</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA40438</td>
<td>Gold associated with petzite</td>
<td>94.8</td>
<td>4.8</td>
<td>0.0</td>
<td>0.2</td>
<td>0.0</td>
<td>99.8</td>
</tr>
<tr>
<td></td>
<td>Gold associated with calaverite</td>
<td>94.3</td>
<td>5.3</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>100.1</td>
</tr>
<tr>
<td></td>
<td>Gold associated with altaite and petzite</td>
<td>93.2</td>
<td>5.8</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>99.3</td>
</tr>
<tr>
<td>AA40435</td>
<td>Gold associated with sphalerite, chalcopyrite and pyrite</td>
<td>91.9</td>
<td>7.2</td>
<td>0.3</td>
<td>0.1</td>
<td>0.1</td>
<td>99.6</td>
</tr>
<tr>
<td>WM3027</td>
<td>Isolated gold bleb in the gangue</td>
<td>92.0</td>
<td>5.8</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>98.1</td>
</tr>
</tbody>
</table>
Fig. 81. Chalcopyrite (c) and ullmanite (u) replacing pyrite (py) in the "green leader" ore. (AA 40435). Magnification 530X.
and chemical analysis of this mineral indicated that it was rich in both As and Sb (11.0% As; 14.6% Sb). Radtke (1963) also reported tetrahedrite in the Oroya Shoot.

A few small grains of pyrrhotite were identified in specimen AA 40436 from the Associated mine.

The only other sulphide phase observed was a bluish mineral which together with chalcopyrite is replacing pyrite in specimen AA 40435 (Fig.81). The E.D.A.X. spectrum of this mineral indicates that it consists of Ni, Sb and S and this together with its optical properties suggests that the mineral is ullmannite (NiSbS). No other occurrences of ullmannite have been reported from Kalgoorlie but the mineral could readily have been mistaken for chalco-cite by previous workers.

Other Minerals of Interest

Large masses of scheelite have been reported from the Oroya Shoot in the Brownhill Extended mine (Simpson, 1912) but no scheelite was recognized in the "green leader" samples studied. Tourmaline is another mineral which was apparently abundant in the Oroya Shoot (Larcombe, 1911) but which was not observed in the samples available.

According to Nickel (1977), the green mica which characterizes the "green leader" ore is not roscoelite, but a V-bearing sericite muscovite as it contains less than the 11.5% V required to change the structure from the 2M to the 1M structural type. The maximum V content found by Nickel was 8.1%. V values obtained in this study (1.4 to 5.9%) support Nickel's conclusions concerning the nomenclature of the mica.

The Fe-vanadate, Nolanite, and an unidentified Ti-rich vanadate with the composition: $V_{4.47}^{\text{Ti}}_{3.56}Fe_{0.14}^{\text{O}}_{18}$ are also present in the ore (Nickel, 1977).
3.2.3 Mt. Charlotte

A detailed study of the mineralogy of the Mt. Charlotte ore-body has previously been undertaken by the author (Golding, 1973) and this section is based largely upon the results of that study although some new work has been incorporated.

The Veins

In general, the veins which make up the stockwork ore show sharp contacts to the surrounding wall rocks. Quartz is by far the most abundant of the vein minerals and some veins are composed entirely of this mineral. In many veins, the quartz shows strong undulose extinction and has well developed sutured and serrated boundaries while in others, the quartz is coarse-grained and shows no sign of deformation suggesting a change in stress conditions during vein formation. Calcite is another common constituent of the veins and is usually found in association with quartz, though there are some pure carbonate veins. The calcite frequently shows complex curved twinning which has probably developed as a result of stress. Clear fresh albite, muscovite and pale green chlorite with a strong anomalous blue interference colour are minor constituents of some of the veins and carbonate stringers. Scheelite is occasionally present along the edges of the veins. Although most veins are barren of sulphides, pyrite and pyrrhotite show local concentrations in some veins, especially those which are carbonate-rich.

Up to seven generations of fluid inclusions were recognized in the quartz of a single section of a quartz-carbonate vein. These range in size from less than a micron to about 20 microns. Most inclusions appear to be secondary as they are related to numerous microfractures in the quartz. Some of the larger inclusions show a variation in percentage fill and may be evidence of boiling. A few of the inclusions contain liquid CO$_2$ as well as a vapour phase but no daughter minerals were observed.
Fig. 82. Altaite (a), gold (g) and silicates infilling a fracture in pyrite from the Mt. Charlotte ore. (2094/MCS2A). Magnification 530X.

Fig. 83. Pale yellow electrum (e) moulded onto pyrite containing a dark yellow gold bleb (g) with low Ag content. (7/MC90). Magnification 530X.
Table 20.
Ag content of Mt. Charlotte gold*

<table>
<thead>
<tr>
<th>Type</th>
<th>% Ag</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Average</td>
<td>Median</td>
<td>No. of Grains</td>
</tr>
<tr>
<td>Small blebs in pyrite</td>
<td>3.1-8.4</td>
<td>6.2</td>
<td>5.8</td>
<td>8</td>
</tr>
<tr>
<td>Fracture fillings in pyrite</td>
<td>7.8-10.0</td>
<td>8.7</td>
<td>8.6</td>
<td>8</td>
</tr>
<tr>
<td>Gold moulded onto pyrite in the bleached zones</td>
<td>11.8-26.1</td>
<td>17.0</td>
<td>13.1</td>
<td>3</td>
</tr>
<tr>
<td>Gold associated with pyrrhotite and zoned pyrite</td>
<td>-</td>
<td>9.9</td>
<td>9.9</td>
<td>1</td>
</tr>
<tr>
<td>Free gold in the quartz veins</td>
<td>4.9-5.9</td>
<td>5.4</td>
<td>5.4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Analyses were corrected to 100%.

Table 21.
Analysis of a tetrahedrite grain from the Mt. Charlotte ore

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>Fe</th>
<th>Cu</th>
<th>Zn</th>
<th>As</th>
<th>Ag</th>
<th>Sb</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25.1</td>
<td>4.0</td>
<td>37.3</td>
<td>3.7</td>
<td>0.2</td>
<td>0.3</td>
<td>30.6</td>
<td>101.2</td>
</tr>
</tbody>
</table>
associated with Co-rich zoned pyrite at the edge of a quartz vein.

There is a large range in the Ag content of these different generations of gold (Table 20). Gold grains of more than one generation are frequently observed within the one section and it is interesting to note that the gold (or electrum) grain with the maximum Ag content measured (26.1%) and with the minimum Ag content (3.1%) were associated with the same pyrite grain (Fig. 83).

Sulphides

Pyrite is the dominant sulphide in both the bleached envelopes and veins whilst pyrrhotite and chalcopyrite are the main sulphides in the chloritic host rock. Minor pyrrhotite is found in some of the quartz veins. At the edge of the bleached zone, pyrite sometimes replaces the pyrrhotite in the chloritic host G.M.D. (Fig. 84).

Pyrite. The most common type of pyrite in the ore is anhedral to subhedral and has formed by replacement of titanomagnetite in the wall rock. In the preliminary stage, the pyrite preferentially replaces the magnetite leaving behind the exsolved lamellae of ilmenite (Fig. 85) but in highly mineralized zones, replacement has gone almost to completion and only remnants of titanomagnetite are left. This pyrite is the most common host sulphide for gold and is characterized by very low Co (less than 0.01%) and As (0.03 to 0.13) content. Inclusion-free brassy euhedral pyrite crystals up to 1 cm across are also commonly found in the sericitic ore adjacent to these veins. Gold is rarely seen in this coarse-grained euhedral pyrite which is also low in Co (0.04%) and As (0.13%). However, coarse brassy pyrite within the quartz and carbonate veins is frequently gold-bearing. It also contains small inclusions of chalcopyrite and pyrrhotite but is even lower in As (0.01-0.02%) than the other types of pyrite. In addition to these trace-element deficient pyrites, there are some less common pyrite
Fig. 84. Pyrite (py) replacing pyrrhotite (po) at boundary between bleached and chloritic G.M.D. (2269/MCS2A). 10° off crossed nicols to show island texture. Magnification 530X.

Fig. 85. Preferential replacement of magnetite in titanomagnetite by pyrite. A relatively inclusion-free border of pyrite surrounds the titanomagnetite. (2134/MCS2A). Magnification 210X.
types with significant Co and As contents. These include anhedral zoned pyrite with up to 0.9% Co and 0.25% As found associated with pyrrhotite in some quartz veins and anhedral reaction pyrite with 2.04% Co and 1.89% As enclosed in pyrrhotite in a quartz stringer.

**Chalcopyrite.** This was rarely observed in the Mt. Charlotte ore except as small inclusions in pyrite.

**Tetrahedrite.** Only one grain of tetrahedrite was observed in the many sections studied. This grain was enclosed in a rare isolated grain of chalcopyrite near the edge of a quartz vein and was extremely rich in Sb (see Table 21).

**Other sulphides.** A specimen containing a segregation of sphalerite and galena said to have come from the Mt. Charlotte mine is housed in the Kalgoorlie School of Mines collection. Galena and sphalerite also occur in sediments in the Boulder Dyke at the No. 14 Level of the Mt. Charlotte mine. The only other sulphide noted in this study was a Co-rich gersdorffite associated with pyrite in mineralized G.M.D. from D.D.H. MCS2A.

**Other Minerals of Interest**

Masses of scheelite are occasionally found at the edges of quartz veins.

V-bearing micas are not found in the normal Mt. Charlotte ores but Cr-mica (fuchsite) with a little V is common in the Boulder Dyke in the Mt. Charlotte mine.

### 3.2.4 Golden Pike

The Golden Pike is a small quartz stockwork ore-body developed in unit 8 of the G.M.D. close to the Boulder Dyke at the northern end of the Golden Mile.

The veins resemble those of the Mt. Charlotte ore-body; they consist predominantly of coarse, granular quartz and have sharp boundaries with the surrounding host rocks. In the samples studied however (from D.D.H. G.P.8),
the bleached zone differs from that of the Mt. Charlotte ore in having a
bright pink colour (the bleached zone of the Mt. Charlotte veins is generally
pale green). The pink colour appears to be due to incipient alteration in
the albites. Carbonate (ankerite) is the dominant alteration product in the
bleached ore with minor development of sericite. Some chlorite was present,
even in highly pyritic samples.

Pyrite is abundant in the altered rock adjacent to the veins and is also
present as coarse-grained aggregates in some of the quartz veins.

Gold was observed in both coarse-grained, inclusion-free pyrite in the
quartz veins and in anhedral pyrite which has replaced titanomagnetite in the
bleached G.M.D. around the veins. In one sample, gold also appears to be
replacing titanomagnetite (Fig. 86). Much of the pyrite has been tectonically
shattered and the fractures filled with gold (Fig. 64, p.102). As in
the Mt. Charlotte and lode samples, some gold is also present as small blebs
in the pyrite.

Unlike the Mt. Charlotte ore, there is very little variation in the com-
position of the gold grains analysed, all containing low to moderate Ag con-
centrations (Table 22).

The only other ore minerals noted were chalcopyrite, galena and sphalerite
as very small inclusions enclosed in the pyrite.

3.2.5 Kalgoorlie Enterprise

Although the Kalgoorlie Enterprise drilling passes close to the Golden
Pike mine (see Fig. 3), the ore from the three diamond drill holes studied
(K.E. 53, 54, 55) bears a closer resemblance to the low grade telluride lode
material than to the gold-quartz stockwork mineralization in both physical
appearance and mineralogy. The highest gold values are associated with strongly
sheared G.M.D. containing abundant fine-grained pyrite. Most of the pyrite
appears to be replacing titanomagnetite.
Fig. 86. Altered titanomagnetite (grey) from the Golden Pike ore-body, replaced by pyrite (cream) and gold (yellow). (3/GF8). Magnification 530X.

Fig. 87. Small grains of gold (g), altaite (a), tellurantimony (t) and antimonian montbrayite (m) in bleached zone about quartz vein in Kalgoorlie Enterprise ore. (84/55). Oil immersion. Magnification 1320X.
<table>
<thead>
<tr>
<th>Specimen</th>
<th>Description</th>
<th>Au</th>
<th>Ag</th>
<th>Te</th>
<th>Fe*</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/GP8</td>
<td>Fracture filling in pyrite</td>
<td>94.8</td>
<td>4.7</td>
<td>0.1</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>&quot;</td>
<td>Gold associated with titanomagnetite</td>
<td>95.1</td>
<td>4.8</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>&quot;</td>
<td>Small bleb in pyrite</td>
<td>94.8</td>
<td>4.4</td>
<td>0.0</td>
<td>0.7</td>
<td>0.1</td>
</tr>
<tr>
<td>&quot;</td>
<td>Fracture filling in pyrite</td>
<td>95.0</td>
<td>4.7</td>
<td>0.1</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>20/GP8</td>
<td>Fracture filling in pyrite</td>
<td>94.1</td>
<td>5.4</td>
<td>0.0</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>20/GP8</td>
<td>Fracture filling in pyrite</td>
<td>94.7</td>
<td>5.1</td>
<td>0.0</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>20/GP8</td>
<td>Fracture filling in pyrite</td>
<td>94.5</td>
<td>5.2</td>
<td>0.0</td>
<td>0.2</td>
<td>0.1</td>
</tr>
</tbody>
</table>

*Fe remaining after subtraction of Fe contributed by surrounding pyrite. See Appendix 3.
Unlike most of the mineralization at Kalgoorlie, the Kalgoorlie Enterprise ore has generally not been bleached by conversion of chlorite to sericite. Dark green chlorite with anomalous Berlin blue interference colours defines the foliation even in highly pyritic samples.

The quartz veins with bleached pyritic envelopes which characterize the Mt. Charlotte and Golden Pike ore-bodies are generally absent in the Kalgoorlie Enterprise drilling — only three mineralized quartz veins and a few quartz-albite-carbonate stringers were found in 290 m of core. One of the veins observed (84/55) consists of an inner part of coarsely crystalline quartz and an outer margin of fine-medium-grained carbonate (ankerite). This vein is surrounded by a narrow bleached halo (approximately 1 cm wide) resulting from sericitization of the chlorite. Some of the pyrite grains in the bleached zone have a pressure fringe of quartz and sericite suggesting post mineralization deformation. The stringers which traverse the ore consist of quartz and feldspar with an envelope of carbonate. Evidence of post-ore deformation can be seen in some of these; in specimen 201/55, the quartz has strong undulose extinction whilst the plagioclase shows bent and displaced albite twins. There has been some development of sericite about the stringers but carbonate and chlorite are the dominant alteration products.

In the sheared chloritic ore, tellurides were observed in a number of sections. Petzite appears to be the dominant telluride and was found both as isolated inclusions in pyrite and in small aggregates associated with gold, chalcopyrite and other tellurides. Coloradoite and a silver telluride are also present as minute inclusions in pyrite.

Gold occurs as tiny blebs and irregular grains, many of which are less than two microns in diameter. Some of these blebs are isolated in the gangue but most are enclosed in pyrite where they are often associated with inclusions of gangue minerals, chalcopyrite and tellurides. The gold contains a
low to medium Ag content and unlike most gold analysed from Kalgoorlie, these grains contain a significant concentration of Fe in solid solution (Table 23).

A section through the narrow bleached zone of one of the quartz veins (84/55) shows abundant gold isolated in the gangue minerals of the bleached zone. One of the gold grains is associated with tellurantimony and an Sb-bearing gold telluride (Fig. 87). Analyses of this Au telluride (Table 24), indicate that it contains slightly more Sb than the antimonian montbrayite in the "green leader" ore but it is probably the same mineral. Tellurantimony and altaite were also observed as small, irregular grains in the gangue.

Although the pyrite in the Kalgoorlie Enterprise ore contains numerous small inclusions of chalcopyrite and occasionally pyrrhotite, no tetrahedrite was observed in this ore.

3.2.6 Hannans North Lode and Related Deposits

The Hannans North Lode is a siliceous, pyritic shear zone in the G.M.D. at the northern end of the field. It has some associated flatly dipping quartz veins. Chlorite and ankerite are the dominant alteration products according to Bartram and McCall (1971). Unfortunately, the only samples of this ore available to the author had already been crushed too fine for mineragraphic examination. However, according to Utting (1953), the gold is associated with pyrite and is also found free in the lode material. No tellurides have been reported from this deposit. There are a number of other mineralized shear zones closely related to the Hannans North Lode but only the Hannans North Lode contained payable gold.

3.2.7 Other Deposits in the Northern Part of the Field

There are numerous small workings in the northern part of the field. These have been described by Simpson and Gibson (1912), Feldtmann and
Table 23.
Corrected gold analyses - Kalgoorlie Enterprise

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Description</th>
<th>Au</th>
<th>Ag</th>
<th>Fe*</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>127/53</td>
<td>Irregular grain in pyrite</td>
<td>94.8</td>
<td>4.4</td>
<td>0.8</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>94.9</td>
<td>3.4</td>
<td>1.7</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>94.9</td>
<td>3.7</td>
<td>1.4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>95.3</td>
<td>2.7</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td>102/53</td>
<td>Isolated grain in gangue</td>
<td>91.5</td>
<td>7.7</td>
<td>1.8</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>90.6</td>
<td>7.4</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>92.3</td>
<td>7.2</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>91.2</td>
<td>7.2</td>
<td>1.6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>92.2</td>
<td>7.6</td>
<td>0.6</td>
<td>-</td>
</tr>
<tr>
<td>201/55</td>
<td>Tiny bleb in pyrite</td>
<td>96.7</td>
<td>2.3</td>
<td>1.0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>95.3</td>
<td>2.6</td>
<td>2.1</td>
<td>-</td>
</tr>
<tr>
<td>84/55</td>
<td>Gold associated with tellurantimony and an antimony-bearing gold telluride in the gangue</td>
<td>95.3</td>
<td>4.4</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>95.2</td>
<td>4.2</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>95.5</td>
<td>3.9</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>95.5</td>
<td>3.9</td>
<td>0.4</td>
<td>0.1</td>
</tr>
</tbody>
</table>

*Fe remaining after subtraction of Fe contributed by surrounding pyrite. See Appendix 3.
Table 24.

Analyses of Sb-bearing Au-telluride in the Kalgoorlie Enterprise ore

<table>
<thead>
<tr>
<th>Te</th>
<th>Sb</th>
<th>Au</th>
<th>Ag</th>
<th>Co</th>
<th>Fe</th>
<th>Cu</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.2</td>
<td>6.1</td>
<td>45.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>96.5</td>
</tr>
<tr>
<td>43.4</td>
<td>6.1</td>
<td>46.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>95.9</td>
</tr>
</tbody>
</table>
Farquharson (1913), Feldtmann (1916) and Haycraft (1965). Many of these mines are in oxidized interflow sediments (see Fig. 2) whilst others are related to fault zones.

The most important mines in the Kapai slate are the Devons Consols, Kapai, Sir John and Sons of Gwalia; in these, free gold appears to have occurred mainly at the junction of cross quartz veins with the oxidized sediments.

Interflow sediments near the base of the Paringa Basalt also contain small deposits, the most important of which is the North Collier. According to Feldtmann and Farquharson (1913, p.49), the richest gold in this mine occurs where pale, banded slaty material representing a line of movement was met by graphitic "indicators" (i.e. black shales). Feldtmann and Farquharson reported that the gold in the "ironstone" (oxidized shales) was very pure and it had probably been recrystallized.

Mineralogically, and genetically, the most interesting mine in the northern part of the field is the Hidden Secret mine. From the map of Feldtmann (1916), this mine appears to be situated in the Paringa Basalt, close to its contact with the Williamstown Dolerite in the region of the Golden Pike Fault (see Fig. 2).

Like the "green leader" ore, the Hidden Secret ore is characterized by an abundance of green mica; Simpson (1912) reports 1.21% $V_2O_3$ and 0.50% $Cr_2O_3$ in a bulk rock analysis of an ore sample from this mine and as only one mica species was visible in thin section, Simpson concluded that it was a mixed V-Cr mica.

Of even greater significance, is the occurrence of massive tellurides in this mine. According to Simpson (1912), these tellurides occur as veins and lenses cross-cutting the foliation of the dark, chloritic country rock and also as fine-grained moss-like masses. No quartz veins are present according
to Simpson. The telluride assemblage is Ag-rich with hessite and petzite as the dominant tellurides. The hessite shows inversion twinning. Altaite is found as small inclusions in the hessite and also as larger masses some of which contain small orientated inclusions of a mineral which Stillwell (1931) concludes is aguilarite. Traces of Ag and Se in altaite analysed by Simpson (1912) support this conclusion but the mineral was not observed in this study. Other tellurides noted in the ore by Simpson (1912) are coloradoite, melonite and tetradymite (or a telluride giving a positive wet chemical test for Bi). Simpson also reports that chalcopyrite, free gold and galena are associated with the tellurides and that the ore as a whole contains a high proportion of pyrite.

Tellurides have also been reported from a cross vein in the Fair Play Extended mine (a small shaft to the north of the Hidden Secret mine) and from sheared Paringa Basalt in the Creswick shaft (Feldtmann, 1916).

3.2.8 Mineralization to the South of the Golden Mile

A few isolated areas of mineralization were intersected in the South End drilling carried out by Western Mining Corporation.

The most significant of these is a small quartz vein with a narrow bleached halo (about 2 cm wide) in sheared unit 8 of the G.M.D. from D.D.H. S.E.15 (3984/15, Fig. 63, p.100).

As usual, the bleaching has resulted from conversion of chlorite to sericite. The chlorite in the surrounding rock, like that from unit 8 in the Mt. Charlotte mine, is Fe-rich and characterized by yellow-green to dark-green pleochroism.

Tellurides

Abundant veinlets and fine-grained patches of tellurides, chiefly calaverite with lesser amounts of petzite and altaite are present in the bleached G.M.D. directly adjacent to the vein whilst further away, tellurides
occur as rounded inclusions in pyrite, moulded onto the edges of pyrite and pyrrhotite grains and were occasionally observed replacing leucoxene. Figures 88-92 illustrate the various modes of occurrence of the tellurides.

In addition to calaverite, altaite and petzite, the mineralized zone about this vein contains some very rare tellurides which have not been previously reported from the Kalgoorlie area; these include the recently discovered Co-telluride, mattagamite (Thorpe and Harris, 1973), the Fe-telluride, frohbergite and an antimonian montbrayite. Mattagamite and frohbergite were observed in contact in one field of view; in this occurrence, the mattagamite is also in contact with free gold and the combined aggregate is moulded onto the edge of a pyrrhotite grain (Fig. 90). In another aggregate bordering pyrrhotite, mattagamite is associated with antimonian montbrayite, gold and calaverite; all minerals except mattagamite and calaverite are in mutual contact in this aggregate (Fig. 91). Elsewhere in the polished section, mattagamite and calaverite were also observed in contact. In all observed occurrences, mattagamite is associated with pyrrhotite. Frohbergite, however, in addition to its association with mattagamite and pyrrhotite, occurs in isolated-telluride aggregates where it rims petzite (Fig. 92).

The composition of some of the telluride grains from this locality are given in Table 25. Because of the small size of these grains (many are less than 5 microns), the analyses are slightly inaccurate but are sufficiently reliable for mineral identification and for determination of trace element contents where these elements are not present in minerals adjacent to the grain being analysed and onto which the electron beam of the probe may have impinged during analysis.

Mattagamite. Although Thorpe and Harris (1973) proposed the name mattagamite for the CoTe₂ end member, the material which they discovered in the Mattagami Lake mine was a ferroan variety with an average Fe content of
Fig. 88. Fine-grained calaverite (c), altaite (a), petzite (p) and gold (g) in bleached zone adjacent to vein in D.D.H. S.E.15. (3984.3/15). Magnification 210X.

Fig. 89. Calaverite blebs (c) in pyrite from bleached zone about vein in D.D.H. S.E.15. (3984.4/15). Magnification 210X.
Fig. 90. Auriferous mattagamite (ma), frohbergite (f), native gold (g), calaverite (c) and petzite (p) bordering pyrrhotite (po) in bleached zone about vein in D.D.H. S.E.15. (3984,4/15). Oil immersion. Magnification 1320X. A. Plane reflected light. B. 10° off crossed nicols. C. Sketch.
Fig. 91. Auriferous mottagamite (ma), antimonian montbrayite (m), calaverite (c) and gold (g) bordering pyrrhotite (po) in D.D.H. S.E.15. (3984.4/15). Oil immersion. Magnification 1320X. A. Plane reflected light. B. Sketch.

Fig. 92. Frohbergite (f) associated with petzite (p), gold (g) and calaverite (c) in telluride aggregate isolated in the gangue adjacent to the vein in D.D.H. S.E.15. (3984.3/15). Oil immersion. Magnification 1320X.
<table>
<thead>
<tr>
<th>Specimen</th>
<th>Description</th>
<th>Te</th>
<th>Sb</th>
<th>Au</th>
<th>Ag</th>
<th>Co</th>
<th>Fe</th>
<th>S</th>
<th>Cu</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3984.4/15</td>
<td>Mattagamite associated with frohbergite, gold and pyrrhotite</td>
<td>76.4</td>
<td>0.6</td>
<td>5.2</td>
<td>0.0</td>
<td>13.9</td>
<td>3.1*</td>
<td>0.2*</td>
<td>-</td>
<td>99.4</td>
</tr>
<tr>
<td></td>
<td>As above</td>
<td>76.9</td>
<td>0.6</td>
<td>5.1</td>
<td>0.0</td>
<td>13.8</td>
<td>2.9*</td>
<td>0.2*</td>
<td>-</td>
<td>99.6</td>
</tr>
<tr>
<td></td>
<td>Frohbergite associated with mattagamite in above</td>
<td>73.0</td>
<td>0.3</td>
<td>0.4</td>
<td>0.0</td>
<td>3.5*</td>
<td>18.3*</td>
<td>0.2*</td>
<td>-</td>
<td>95.7+</td>
</tr>
<tr>
<td></td>
<td>As above</td>
<td>72.9</td>
<td>0.3</td>
<td>0.5</td>
<td>0.0</td>
<td>2.4*</td>
<td>13.7</td>
<td>0.2*</td>
<td>-</td>
<td>90.0+</td>
</tr>
<tr>
<td></td>
<td>Antimonian montbrayite? associated with mattagamite, gold, calaverite and pyrrhotite</td>
<td>45.6</td>
<td>4.6</td>
<td>47.3</td>
<td>0.0</td>
<td>0.0</td>
<td>1.4</td>
<td>0.0</td>
<td>-</td>
<td>99.1</td>
</tr>
<tr>
<td></td>
<td>As above</td>
<td>46.1</td>
<td>4.6</td>
<td>46.2</td>
<td>0.0</td>
<td>0.1*</td>
<td>1.4</td>
<td>0.0</td>
<td>-</td>
<td>98.4</td>
</tr>
<tr>
<td></td>
<td>Calaverite associated with antimonian montbrayite? and gold in above</td>
<td>55.3</td>
<td>1.0</td>
<td>36.7</td>
<td>0.7</td>
<td>0.3*</td>
<td>2.2*</td>
<td>0.6*</td>
<td>-</td>
<td>96.8+</td>
</tr>
<tr>
<td></td>
<td>As above</td>
<td>53.1</td>
<td>1.0</td>
<td>39.8</td>
<td>0.9</td>
<td>0.1*</td>
<td>4.1*</td>
<td>2.2*</td>
<td>-</td>
<td>101.2+</td>
</tr>
<tr>
<td></td>
<td>Calaverite associated with mattagamite, gold and pyrrhotite</td>
<td>54.4</td>
<td>1.2</td>
<td>39.4</td>
<td>0.7</td>
<td>0.1</td>
<td>1.5*</td>
<td>0.2*</td>
<td>-</td>
<td>97.5+</td>
</tr>
<tr>
<td></td>
<td>Calaverite bleb in pyrite</td>
<td>56.2</td>
<td>1.1</td>
<td>42.6</td>
<td>0.5</td>
<td>0.0</td>
<td>0.2*</td>
<td>0.1*</td>
<td>0.0</td>
<td>100.7</td>
</tr>
<tr>
<td></td>
<td>Calaverite veinlet in the gangue</td>
<td>56.1</td>
<td>1.2</td>
<td>42.2</td>
<td>0.7</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>-</td>
<td>100.2</td>
</tr>
<tr>
<td>3984.3/15</td>
<td>Frohbergite associated with petzite</td>
<td>81.8</td>
<td>0.2</td>
<td>0.7*</td>
<td>0.3*</td>
<td>0.0</td>
<td>14.6</td>
<td>0.0</td>
<td>0.0</td>
<td>97.6+</td>
</tr>
<tr>
<td></td>
<td>As above</td>
<td>79.8</td>
<td>0.4</td>
<td>0.9*</td>
<td>0.4*</td>
<td>0.0</td>
<td>16.1</td>
<td>0.0</td>
<td>0.0</td>
<td>97.6+</td>
</tr>
<tr>
<td></td>
<td>Isolated calaverite grain</td>
<td>56.6</td>
<td>0.1</td>
<td>42.2</td>
<td>0.8</td>
<td>0.0</td>
<td>0.2</td>
<td>0.0</td>
<td>-</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>Isolated calaverite grain</td>
<td>57.1</td>
<td>1.0</td>
<td>42.8</td>
<td>0.7</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>101.7</td>
</tr>
<tr>
<td></td>
<td>Calaverite bleb in pyrite</td>
<td>56.3</td>
<td>1.0</td>
<td>41.9</td>
<td>0.7</td>
<td>0.0</td>
<td>0.7*</td>
<td>0.1*</td>
<td>0.0</td>
<td>100.7</td>
</tr>
<tr>
<td></td>
<td>Irregular calaverite grain in pyrite</td>
<td>56.2</td>
<td>1.2</td>
<td>42.8</td>
<td>0.9</td>
<td>0.0</td>
<td>0.2*</td>
<td>0.1*</td>
<td>-</td>
<td>101.2</td>
</tr>
</tbody>
</table>

*Part of element contributed by surrounding grains.  + Poor analysis due to small size of the analysed grain.
6.7%. In an appendix, these authors reported that an antimonial mattagamite containing as much as 29.5% Sb had also been discovered and stated that Sb varies inversely as Fe. Because of the small size of the mattagamite grains and the close proximity of Fe-bearing minerals, the exact Fe content of the Kalgoorlie mattagamite is uncertain but it is certainly less than 3.1% and probably in the vicinity of 2.5 to 2.7% which is considerably less than that in the ferroan mattagamite from the type locality. Sb is only 0.6% and does not make up for the lack of Fe as in the antimonial mattagamite from the Mattagami Lake mine. Instead, Au is the major trace element in the Kalgoorlie mattagamite and this phase is best described as auriferous mattagamite. It should be noted that this material was analysed well away from the associated gold grains and two analyses from different parts of the grain showed good agreement (Table 25). The optical properties of this auriferous mattagamite are similar to those described by Thorpe and Harris for ferroan mattagamite: it is light violet to bluish grey against pyrrhotite and gold and exhibits weak anisotropism which is best seen on grain boundaries (Fig. 90).

Frohbergite. The Fe-telluride was even more difficult to analyse than mattagamite because of its small grain size and association with other Fe-bearing minerals (pyrrhotite and ankerite). However its composition is consistent with that of frohbergite (FeTe₂). In plane reflected light the Fe-telluride is almost identical in colour to mattagamite but could be distinguished under oil immersion by its slightly higher degree of anisotropism (light to dark purplish grey). However, the orange-red to inky blue anisotropism reported by Thomson (1947) appears to be absent; this is probably a reflection of the small grain size and lack of grain boundaries for comparison.

Antimonian montbrayite. The antimonial montbrayite is similar in composition to that from the "green leader" ore except that in addition to Sb,
the telluride appears to contain a significant Fe concentration; there is some danger that the Fe has been contributed by the surrounding gangue minerals but if this were the case, such good agreement on duplicate analyses would not be expected.

Calaverite. The calaverite at this locality contains a significant but variable amount of Sb and a low Ag content. No Cu or Se were detected in any of the grains for which these elements were analysed.

Gold. Native gold was observed in contact with calaverite, antimonian montbrayite, petzite, mattagamite, frohbergite, pyrite and pyrrhotite and is also present as isolated grains in the gangue (see Figs. 88, 90, 91 and 92). Very little variation in Ag content was found in gold grains from these different associations: thirteen grains yielded an average of 5.6% Ag with a range of 4.4 to 6.9% Ag (Table 26). If grains contaminated by surrounding tellurides are excluded, the range in Ag content is even smaller (5.3 to 6.0% Ag, Table 26).

Sulphides

Although pyrite is the dominant sulphide in the altered rock adjacent to this vein, there is also a significant amount of pyrrhotite which is associated with both the pyrite and the tellurides and in this respect the mineralization differs significantly from other telluride mineralization examined. Pyrrhotite is concentrated in the few mm directly adjacent to the vein whilst pyrite is found throughout the bleached zone. Most of the pyrite in the section is euhedral to subhedral in form (Fig. 89) but directly adjacent to the vein, it has a more irregular form and appears to have been corroded by pyrrhotite and gangue minerals; however it is possible that some of the irregular pyrite has formed by replacement of pyrrhotite. Where pyrite and pyrrhotite are associated at the edge of the vein, the two are always separated by a thin layer of gangue minerals. Both the euhedral to subhedral pyrite and
<table>
<thead>
<tr>
<th>Specimen</th>
<th>Description</th>
<th>Au</th>
<th>Ag</th>
<th>Fe*</th>
<th>Te**</th>
<th>Co***</th>
</tr>
</thead>
<tbody>
<tr>
<td>3984.3/15</td>
<td>Gold enclosed by gangue minerals but in vicinity of tellurides</td>
<td>94.1</td>
<td>5.7</td>
<td>0.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>As above</td>
<td>94.3</td>
<td>5.5</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Gold associated with calaverite</td>
<td>94.2</td>
<td>5.6</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Gold enclosed by gangue minerals (including ankerite)</td>
<td>93.1</td>
<td>5.3</td>
<td>1.5</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Small round bleb of gold enclosed by gangue minerals</td>
<td>93.4</td>
<td>6.0</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Gold associated with frohbergite and petzite</td>
<td>92.4</td>
<td>6.9</td>
<td>0.3</td>
<td>0.4</td>
<td>0.0</td>
</tr>
<tr>
<td>3984.4/15</td>
<td>Gold associated with mattagamite</td>
<td>90.0</td>
<td>5.8</td>
<td>1.5</td>
<td>2.4</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Gold associated with mattagamite and calaverite</td>
<td>92.6</td>
<td>4.4</td>
<td>1.9</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Gold moulded on pyrite</td>
<td>94.0</td>
<td>5.5</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Gold associated with petzite</td>
<td>93.5</td>
<td>6.0</td>
<td>0.2</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Gold bleb enclosed by gangue minerals</td>
<td>93.4</td>
<td>5.4</td>
<td>1.1</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Gold enclosed in gangue</td>
<td>94.6</td>
<td>5.3</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Gold enclosed in gangue</td>
<td>93.8</td>
<td>6.0</td>
<td>0.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Gold bleb enclosed in gangue</td>
<td>94.5</td>
<td>5.4</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Av. 5.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Some Fe may be contributed by surrounding minerals
**Most, if not all Te contributed by surrounding tellurides
***Co probably contributed by surrounding mattagamite
+Some Au from calaverite
xSome Ag from petzite
the irregular pyrite are fractured indicating that both were present at the
time of deformation which caused the fracturing.

A little chalcopyrite is associated with pyrrhotite at the edge of the
quartz vein. No sphalerite or tetrahedrite was seen in this ore.

Beyond the narrow bleached zone, only occasional grains of pyrite are
found and tellurides are absent.

A number of other mineralized veins and shear zones were intersected
by D.D.H. S.E.15. Although these contain abundant pyrite, a little pyrrho-
tite and chalcopyrite and, in some cases, tourmaline, no gold or tellurides
were observed in the sections cut from these indicating that they are con-
siderably lower in grade than specimen 3984/15.

In D.D.H. S.E.13, a quartz vein with gold-bearing pyrite was encountered
in unit 8 of the G.M.D. at 5410 ft. (1972 m). There appears to be two dis-

tinct generations of gold in this vein: one is Ag-rich while the other has
only a moderate Ag content (Table 27); both appear to contain significant
Fe concentrations although the method of analysis for this element is not
very reliable because of the small size of the gold grains and the approxi-
mations involved in correcting for Fe from the surrounding minerals (see
Appendix 3).

In specimen 2153/9 from the Hannans Lake Serpentinite in D.D.H. S.E.9,
minor quantities of disseminated nickeliferous pyrrhotite (1.0% Ni) and
pentlandite were observed partially replacing serpentinized olivine in the
Hannans Lake Serpentinite. The pyrrhotite contains rounded blebs of niccolite
surrounded by a reaction rim of Ni-rich gersdorffite (Fig. 93). These
sulphides replace serpentine pseudomorphs after olivine and are probably
secondary in origin. Niccolite and gersdorffite have exactly the same mode
of occurrence at Redross, W.A. (K. McQueen, pers. comm.).
Table 27.
Corrected gold analyses - D.D.H. S.E.13

<table>
<thead>
<tr>
<th>Description</th>
<th>Au</th>
<th>Ag</th>
<th>Fe*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold associated with silicates in pyrite</td>
<td>88.0</td>
<td>13.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Gold associated with gangue inclusion in pyrite</td>
<td>86.9</td>
<td>11.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Gold as fracture filling in pyrite</td>
<td>85.2</td>
<td>13.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Small gold bleb in pyrite</td>
<td>87.7</td>
<td>11.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Tiny gold bleb in pyrite</td>
<td>86.2</td>
<td>13.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Tiny gold bleb in pyrite</td>
<td>94.5</td>
<td>4.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Small, irregular gold grain in pyrite</td>
<td>92.7</td>
<td>6.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Small, irregular gold grain in pyrite</td>
<td>92.4</td>
<td>6.4</td>
<td>1.3</td>
</tr>
</tbody>
</table>

*Fe remaining after subtraction of Fe contributed by the surrounding pyrite. See Appendix 3.
Fig. 93. Pyrrhotite (po) containing rounded bleb of niccolite (n) surrounded by a reaction rim of gersdorffite (g) in Hannans Lake Serpentinite. (2153/9). Magnification 530X.
3.3 Discussion on the Distribution and Composition of Mineral Phases

3.3.1 Tellurides

Tellurides, being a characteristic feature of the Kalgoorlie ores, provide a useful starting point from which to compare the different deposits. A list of tellurides noted in this study and those which appear to have been reasonably accurately identified in previous studies is given in Appendix 7. The approximate positions of Au, Ag and Sb tellurides listed in this Appendix have been plotted on a plan of the lodes (Fig. 94).

Although the total number of reliably identified tellurides is too small to enable detailed statistical comparison of the different lodes and ore types, a few general comments can be made on the overall distribution and composition of telluride phases in the field.

Calaverite

Calaverite is found throughout the Golden Mile from the New North Boulder and Bank of England mines in the east to the Middle Lode in the west; from at least as far north as the Block 45 mine (where tellurides were first discovered in the Kalgoorlie ores) to D.D.H. S.E.15 drilled well to the south of the Golden Mile. It appears to be the most common gold telluride in both the steeply dipping and the flatly dipping lodes. It is also the most common telluride in the mineralized vein from S.E.15. It was not, however, observed in the Golden Pike or Kalgoorlie Enterprise drilling. Nor has it been found in the ores of the Hidden Secret mine but is possibly present in other mines from the northern part of the field; Feldtmann (1916) concluded that a light coloured telluride in a specimen from the Reward shaft (Mt. Charlotte ore-body) was calaverite but the identification was based on appearance in hand specimen only.
Fig. 94. Distribution of Au, Ag and Sb tellurides in the Kalgoorlie area.
Calaverite appears to have been stable over the very wide vertical range now represented in the mines having been found from the 200 ft. (69 m) level of the Block 45 mine just below the zone of oxidation to depths as great as the 2,500 ft. (865 m) level in the Phantom lode, Great Boulder mine and 1380 m in D.D.H. S.E.15.

The absence of calaverite in the Ag-rich Hidden Secret ore is probably a reflection of its low Au content but the general absence of calaverite in the Mt. Charlotte and Golden Pike ore-bodies where native gold is abundant is not as readily explained; since these ore-bodies lie well within the depth-range in which calaverite has been observed, physical or chemical conditions not directly related to depth may have been responsible for calaverite deposition.

Although calaverite shows considerable variation in concentration of Ag (0.4-2.1%), Sb (0.0-2.8%) and to a lesser extent Cu (0.0-0.2%), these trace elements do not vary systematically with depth or from one type of deposit to the next; one polished section (AA40438) from the Oroya Shoot contained calaverite with a compositional range in Ag of 0.8 to 2.1%. On the basis of a single grain of calaverite containing 3.5% Ag, 0.77% Sb and 0.3% Cu, Cabri and Ruckledge (1968) concluded that the incorporation of Cu and Sb into the calaverite structure enables it to tolerate more Ag than the Au-Ag-Te system permits (2.8 ± 0.2%). Although the Ag content of the calaverites analysed in this study increases with increasing Sb content, it never becomes anomalous even though Sb reaches higher concentrations in these grains than in the Sb-rich grain analysed by Cabri and Ruckledge. It is possible that the Ag content of calaverite is dependent on the availability of Ag but the association of petzite with some of the Sb-rich calaverites indicates that there was no shortage of Ag in the system. It is thus likely that the composition of calaverite is governed by the amount of Sb and Cu available as well as the amount of Ag.
Krennerite and Sylvanite

Krennerite appears to be restricted to the central portion of the Golden Mile but as no distinction was made between krennerite and sylvanite in the early days, it is possible that its distribution is more widespread than is indicated. There are no confirmed occurrences of krennerite in the "green leader" ore bodies at the folded contact of the G.M.D. and the Paringa Basalt although the krennerite from the 300 ft. (103 m) level of the Lake View mine (Simpson, 1912) was possibly from the Duck Pond Slate which Tomich (1974) also regards as "green leader".

Despite the small number of confirmed occurrences of krennerite, the depth range over which it has been found is as great as it is for calaverite, the deepest known specimen coming from the No. 3 Lode in D.D.H.5028 (1384 m).

Sylvanite has been reported from every locality from which krennerite has been confirmed and has also been found in the "green leader" ore and the Hidden Secret mine in the northern part of the field. However, it was not observed in the South End drilling, Mt. Charlotte, Kalgoorlie Enterprise or Golden Pike ores. The depth range of sylvanite is exactly the same as that of krennerite.

In view of the complete gradation in chemistry between krennerite and sylvanite found in this study, it is not surprising that the two were confused in the past as this would almost certainly result in a gradation in the colour of the two (sylvanite being ideally silvery white; krennerite, brassy yellow). As X.R.D. studies were not possible, it is not certain what affect this variation in composition has on the structure of the two minerals.

Experimentally, the lowest Ag content found by Cabri (1965) on the sylvanite solvus curve was 6.7% Ag at approximately 290°C and the maximum Ag content of krennerite was 6.2 ± 0.2% at 350°C (Fig. 95). However, as
Fig. 95. Phase relations along the AuTe₂-AuAgTe₄ join in equilibrium with vapour. After Cabri (1963).
pointed out by Stumpfl (1970), the Ag content of sylvanite (and krennerite) is probably influenced by the supply of the elements as well as the temperature of formation. The presence of Cu may also have some effect on the Ag content of sylvanite.

The difficulties of applying Cabri's phase diagram for the system Au-Ag-Te to natural assemblages became very apparent in this study. In a specimen from the No. 3 Lode in D.D.H.5028 (674/5028), a krennerite grain with an Ag content of 3.1% (see Table 13, p.115) should have formed near the melting point of $382 \pm 5^\circ C$ according to the diagram of Cabri, whereas a grain from the same polished section with 4.5% Ag should have formed below $290^\circ C$. In addition, this specimen contains sylvanite with an Ag content close to that of ideal $\text{AuAgTe}_4$. This sylvanite is in contact with stuetzite ($\text{Ag}_{5-x}\text{Te}_3$) (Fig. 68) indicating, according to the diagram of Cabri, that the assemblage formed below $220^\circ C$. Furthermore, the krennerite with 3.1% Ag is in contact with stuetzite (Fig. 71), an association impossible according to the phase diagram of Cabri. These facts indicate either that the experimental phase diagram of Cabri is not applicable to the Kalgoorlie ores due to the greater number of variables in the natural system, or that the assemblages observed are in disequilibrium.

Montbrayite and Antimonian Montbrayite

All observed occurrences of montbrayite and antimonian montbrayite have come from the outer fringes of the field: the Doolette Lode, New North Boulder mine; the Oroya Shoot, Associated mine; the Kalgoorlie Enterprise drilling; and the South End drilling. Although it is possible that montbrayite was present but mistaken for calaverite by earlier workers, there is not a single chemical analysis to indicate the presence of montbrayite in the central part of the field. This could be genetically important as Peacock and Thompson (1946), Markham (1960) and Cabri (1965) were all unable to
synthesize montbrayite and Cabri suggested that its field of stability is probably below 320° C. The rarity of montbrayite in natural telluride assemblages led Cabri (1965, p. 1577) to the conclusion that it "formed under unusual physiochemical conditions". The Doolittle Lode montbrayite specimen came from a quartz vein perpendicular to the strike of the lode and Travis (1966) concluded that this vein had formed at a much lower temperature than the main period of mineralization. However, in the "green leader" samples from the Associated mine, there is no evidence that the montbrayite is a late stage mineral. It was observed with smooth boundaries against chalcopyrite and sphalerite as well as petzite, altaite and native gold suggesting that it was deposited contemporaneously with all of these minerals. It is, of course, possible that this whole suite of minerals is a low temperature, late stage deposit. From this point of view, it is important to note that a grain of hessite with uniform anisotropism suggesting a temperature below 145°C was found in one of these specimens. This suite of minerals certainly post-dates most of the pyrite in the ore as pyrite has been partially replaced by chalcopyrite (Fig. 81). In both D.D.H. S.E.15 and D.D.H. K.E.55, montbrayite was present in the bleached halo surrounding a quartz vein. As this style of mineralization is quite different from that of the lodes in the central part of the field, it is likely that it formed under different conditions. It should, however, be noted that the mineralized vein in D.D.H. S.E.15 came from a present depth of 1380 m. It is reasonable to suppose that this specimen was buried to a depth of at least twice its present depth and if the geothermal gradient in the Archean was twice its present crustal average of 25°C/km, then its temperature of formation must have been at least 140°C due to the geothermal gradient alone.

In all samples where montbrayite was observed, except that from D.D.H. K.E.55, calaverite was also present and calaverite, montbrayite and
native gold were observed in contact in D.D.H. S.E.15 (Fig. 91) and in the
Doolette Lode (Travis, 1966). As there is no evidence of replacement in
these samples, it would appear that calaverite is also a stable phase in
the stability field of montbrayite.

Petzite

Petzite appears to be one of the most widespread of all tellurides at
Kalgoorlie, being found in the Hidden Secret and possibly the Mt. Charlotte
ore in the northern part of the field, in the Kalgoorlie Enterprise drilling,
throughout the Golden Mile in both steeply dipping and flatly dipping lodes
and in D.D.H. S.E.15 to the south of the Golden Mile.

Although Simpson (1912) concluded that petzite was comparatively rare
in deep-seated occurrences, later work has not supported this conclusion;
it has been confirmed at depths of 830 m in the Lake View Lode (Markam, 1960),
865 m in the Phantom Lode (Cabri, 1967), 1384 m in both the No. 3 Lode and
the No. 4 Lode (this study) and 1380 m in D.D.H. S.E.15 (this study).
Petzite thus appears to have been stable over the whole range of conditions
prevalent during mineralization at Kalgoorlie except, perhaps, those of the
gold-quartz mineralization.

Hessite

As hessite has an inversion point at 145 ± 3°C (Kracek et al. 1966),
its distribution and form are of some significance. The largest specimens
of hessite came from the Ag-rich ores of the Hidden Secret mine in the
northern part of the field. This hessite exhibits inversion twinning indic-
ating that it formed above 145 ± 3°C. Some hessite samples from the steeply
dipping lodes also show inversion twinning suggesting that they formed above
this temperature. However, the hessite which veins other tellurides in the
shallow levels is obviously secondary (Stillwell, 1931). Cabri (1965)
points out that the commonly observed intergrowth of hessite-sylvanite and
hessite-petzite in the Kalgoorlie ores (Stillwell, 1931; Markham, 1960) are not consistent with a formation temperature above 120°C. We concluded that either the intergrowths consist of three or four and not two phases with stuetzite and/or petzite formed by breakdown of the gamma phase (Ag₁₀Te) or the gamma phase itself is present. Judging by Stillwell's descriptions however, petzite is frequently present along the edges of the hessite-sylvanite intergrowth and is also illustrated in his Figure 27. Thus all the hessite which shows inversion twinning can be accepted as having a formation temperature above 145°C.

As previously mentioned, however, one of the montbrayite bearing samples from the Associated mine contains hessite with uniform anisotropism. This evidence points to a very low temperature of formation for the tellurides in this "green leader" sample (below 145 ± 3°C). However, as only one small grain of such hessite was observed, there is some danger that the section was cut in such a way that twinning was not displayed and thus the temperature quoted must be regarded as tentative only.

Tellurantimony

The restriction of the observed occurrences of tellurantimony to the deeper levels of the Main lodes (414-1384 m) and the Kalgoorlie Enterprise drilling (714 m) may be genetically significant but as previously mentioned, it may also be a reflection of the lack of recognition of this mineral by earlier workers. The occurrence of tellurantimony in the deeper sections of the lodes may be due to the fact that they are more Sb-rich than the upper part of the lodes. However, this does not explain the apparent absence of tellurantimony in the "green leader" ore from the Associated mine in which antimonian montbrayite and Sb-rich calaverite are abundant. Since tellurantimony is associated with montbrayite (assumed to be a low temperature mineral) and gold in specimen 84/55 from the Kalgoorlie Enterprise drilling,
it would appear that high temperatures are not necessary for its formation. Experimental work on the system Au-Sb-Te would possibly help in the interpretation of this mineralogical data but at the time of writing this thesis, no work had been done on this system to the author's knowledge.

**Coloradoite**

Although the distribution of coloradoite has not been plotted on Figure 94, it can be seen from Appendix 7 that it has a very broad distribution being found in many of the steeply dipping lodes, in the "green leader" ore, the Kalgoorlie Enterprise drilling and the Hidden Secret ore. Like many other tellurides at Kalgoorlie, it has been found from near surface levels to depths as great as 1384 m (in D.D.H. 5028). It was not observed in the mineralized vein encountered in D.D.H. S.E.15 but this is probably of no genetic significance since there are many gold rich assemblages without associated coloradoite, coloradoite being more typically associated with petzite and free gold.

**Altaite**

Although altaite is only an accessory mineral in most of the telluride ore, it has a very widespread distribution: altaite has been confirmed from the Mt. Charlotte and Hidden Secret mines in the northern part of the field, the steeply dipping and flatly dipping lodes in the Golden Mile, the Kalgoorlie Enterprise drilling and the South End drilling. This mineral is also found in the entire range of depth represented in the mines.

**Tetradymite, Melonite and Nagyagite**

Tetradymite, melonite and nagyagite are too rare in occurrence to be able to make any specific comments on their genetic significance.

**Weissite**

Weissite is also rare but its mode of occurrence as veinlets in other
tellurides indicates that is is secondary in most cases (Stillwell, 1931; Markam, 1960).

**Frohbergite and Mattagamite**

Frohbergite and auriferous mattagamite were found only in the bleached halo about the vein in D.D.H. S.E.15 at a depth of 1380 m. On the basis of the relationships of frohbergite with chalcopyrite, pyrrhotite and other tellurides in its type locality (the Robb Montbray mine, Quebec) and in the gold deposits of Sacarambu and Pata Bai, Romania, Ramdohr and Udubasa (1973) concluded that frohbergite formed late in the mineral paragenesis and had probably derived its Fe from the sulphides. As both mattagamite and frohbergite are associated with pyrrhotite in D.D.H. S.E.15, it is quite possible that the pyrrhotite supplied the Fe and possibly the Co required for the formation of these minerals. There is no question of the mattagamite and frohbergite being supergene, however; the great depth from which the core was taken precludes this possibility. If any alteration or mobilization took place, it was hydrothermal. However, the very narrow bleached zone around the vein strongly suggests that only one mineralization event took place and that mattagamite and frohbergite together with antimonian montbrayite, gold and pyrrhotite probably precipitated towards the end of this phase of mineralization.

3.3.2 Gold

Native gold has been found in every mine from the Kalgoorlie district but is especially important in the Mt. Charlotte and Golden Pike ores where it predominates over tellurides as an ore mineral.

Compositionally, the gold shows considerable variation, particularly in its Ag content but the variation within a given deposit tends to be as great as the variation across the field. In the Mt. Charlotte ore-body, there is a definite relationship between the composition of the gold and its
paragenesis; early gold exsolved from pyrite contains much less Ag than later generations of gold present as fracture fillings in pyrite or moulded onto pyrite grains and these in turn differ from the free gold in the quartz veins which has a low to moderate Ag content. Similar differences were noted in the mineralized vein from D.D.H. S.E.13. The gold in D.D.H. S.E.15 showed little variation in composition despite morphological differences suggesting that all of the gold was deposited during a single mineralizing event.

In the Western Lodes, the composition of the gold shows a distinct variation in composition with depth, the deepest samples being the most Ag-rich. The cause of this variation in Ag content is not certain but is possibly connected with the supply of Ag at the time of deposition of the gold; this problem will be discussed further in the concluding chapter of this thesis.

3.3.3 Tetrahedrite Family

Massive tetrahedrite has been reported from both steeply dipping and flatly dipping lodes and is frequently associated with tellurides. Tetrahedrite is also commonly present as small inclusions in pyrite in the steeply dipping lodes. Only one grain of tetrahedrite was observed in the Mt. Charlotte ore, and none was observed in the Golden Pike, Kalgoorlie Enterprise or South End ores. It is probable, however, that a member of the tetrahedrite family was present in the rich ores of the Hidden Secret mine as Simpson (1912) reports that "fahl-ore" or enargite is associated with the tellurides.

The zonation in tetrahedrite composition from Sb-Ag-Zn rich members at depth to As-Fe rich members in the upper levels of the Western Lodes is possibly of genetic significance and will be discussed further in the final chapter.