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CHARACTERISATION OF GOLD FROM FIJI

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EXECUTIVE SUMMARY

This is a study of the variation in chemistry and inclusion mineralogy of bedrock and placer gold from Fiji. It forms part of a large project, undertaking gold characterisation from a wide range of geological environments in Ecuador, Zimbabwe, Malaysia and Fiji. The work was carried out under the Overseas Development Administration/British Geological Survey Technology Development and Research programme (Project R5549) as part of the British Government's provision of technical assistance to developing countries. For the Fijian component of the project, samples were collected from river gravels, primary ore, and table concentrates.

In total thirty-five samples from five localities were examined. Data collected from these samples are represented by over 100 point analyses of gold, identification of associated minerals, and microgeochemical maps of gold-mineral intergrowths.

A framework for identifying possible sources of alluvial gold is given. This was achieved by characterising bedrock gold mineralisation from a variety of epithermal and porphyry environments. The environments studied included alkali (the Emperor Gold Mine), high-sulphidation (the Mount Kasi prospect) and telescoped (the Tuvatu prospect) systems.

A study of placer gold from the Waimanu alluvial deposit, the only alluvial gold deposit in Fiji, showed two distinct sources of gold: one, a low-silver type, associated with Cu-Fe sulphides, can be related to the nearby Namosi porphyry copper deposit. The other source, a high-silver type with abundant tellurides, indicates an alkali epithermal association, suggesting a source similar in style to the mineralisation observed at Emperor Gold Mine.

The identification of two bedrock sources for the Waimanu alluvials clearly shows that there must be a, yet unknown, alkali epithermal (Emperor) source within the Waimanu catchment. This demonstrates the power of alluvial gold characterisation and its role in gold exploration.

An important implication of these results is that future exploration within the area should be focussed on locating this "Emperor type" source.

1. INTRODUCTION

This report documents the results of work undertaken on ODA/BGS TDR project 92/1 R5549 entitled *Alluvial Gold Characterisation in Exploration Planning*. The project has three main aims. The first is characterisation of primary bedrock gold and associated placer gold from a wide range of geological and geographical settings. The second is to establish whether variations in the bedrock gold are inherited in placer gold. The third is the investigation of how these variations can be used to "fingerprint" primary sources of gold from different geological environments.

The characterisation of bedrock and associated placer gold has two main aspects: the use of scanning electron microscopy to study morphological features (e.g., shape, size and growth patterns) and the application of reflected light microscopy and electron micro-probe analysis to identify of heterogeneities, zoning and inclusions. The latter includes detailed microgeochemical mapping of gold grains on the sub-10μm scale.

This report documents and characterises some of the types of bedrock and alluvial gold mineralisation present in Fiji.

Fiji was chosen as an area suitable for study for the following reasons:

(i) It has a well established operating gold mine (the Emperor Gold Mine), the geology of which is well understood (Denholm, 1967; Forsythe, 1976; Ahmed, 1979; Ahmed *et al.*, 1987; Anderson *et al.*, 1987; Anderson and Eaton, 1990; Kwak, 1990; Setterfield *et al.*, 1989; Setterfield, 1991).

(ii) Several distinct types of gold mineralisation with different mineralogies are present on the islands (Colley, 1976; Colley and Greenbaum, 1980). If the characterisation of alluvial gold allows the differentiation between these styles of mineralisation, then it can be used as an exploration tool in delineating the type of mineralisation responsible for placer gold in stream sediments.

(iii) Possible source regions for alluvial gold and styles of mineralisation for bedrock gold are limited in an island setting. Hence, the likelihood of mixed sources in alluvial samples are reduced compared with very mixed populations in distal samples, that are derived from large catchments with many sources (e.g., Zimbabwe).

2. GOLD MINERALISATION IN FIJI

The Fiji islands are located at a bend in the boundary between the Indo-Australasian and Pacific plates, and occur midway between the west-dipping Tonga-Kermadec subduction zone and the east-dipping Vanuatu subduction zone. The islands are separated from the subduction zones by two discontinuous spreading centres (the Lau and North Fiji basins). Magmatism in Fiji was mainly related, to a now inactive, southwest-dipping subduction zone, which was disrupted in the early Pliocene or late Miocene. The oldest rocks on Fiji are island-arc volcanic and associated sedimentary rocks, which are late Eocene to early Oligocene in age. These rocks were folded and then intruded by the 12-7.5 Ma Colo plutonic suite. Intrusive activity coincided with extensive sedimentation and minor calc-alkaline volcanism, which continued after intrusive activity ceased. Subsequently, several shoshonitic volcanoes were active in northern Viti Levu, the larger of the two main islands. Gold mineralisation on Fiji is commonly associated with this period of magmatism (Setterfield *et al*., 1991).

Several distinct types of gold mineralisation are present on Fiji. These comprise two main styles of bedrock mineralisation, epithermal and porphyry-copper-gold, with subsidiary concentrations of alluvial gold. At least two classes of epithermal mineralisation are present and include high-sulphidation and alkali systems.

2.1. Epithermal gold mineralisation

2.1.1. High-sulphidation systems

Epithermal gold mineralisation that is classified as being High-sulphidation in style is characterised by intense acid-sulphate alteration and is commonly located close to the margin of volcanic craters.

2.1.2. Alkali systems

Alkali epithermal mineralisation has a close association with alkaline magmatism (Bonham, 1988; Richards, 1993) and a distinctive mineralogy, commonly dominated by a suite of telluride minerals. The Emperor Gold Mine, on Fiji, is considered to be a type example of this style of mineralisation (Richards, 1993)

2.2. Porphyry-Cu-Au mineralisation

Porphyry gold mineralisation is not widespread, but a new mine exploiting the Namosi porphyry copper deposit was recently opened and contains minor amounts of gold (≤1ppm). This locality is of particular interest as it lies in the drainage catchment of the Waimanu alluvial gold deposit.

2.3. Alluvial gold

Fiji is not noted for deposits of alluvial gold. The Waimanu gravels are the only known alluvial deposit. Reserves of gold are estimated at 1.53 million m^3. The average grade is 0.03ppm with a maximum value of 10.2ppm (Colley, 1976). Elsewhere, gold is generally very fine grained, but locally abundant (up to 100ppm in pan concentrates).

3. METHODOLOGY

3.1. Sampling

Four areas of gold mineralisation were selected for sampling: Mount Kasi, on Vanua Levu, plus Vatukoula (Emperor mine), Tuvatu-Mount Kingston, and Waimanu on Viti Levu (Figure 1). In each area a suite of samples was collected comprising bedrock ore and its weathered products (e.g., oxidised ore and residual soil) and alluvium. Where possible, the unconsolidated samples were sieved (<2mm) and panned on-site to reduce the amount of material. However, further processing was left until the samples were returned to the laboratory. Thirty-five samples were collected for analysis (see Appendix 1 for details).

3.2. Laboratory studies and sample preparation

3.2.1 Bedrock gold samples

Obtaining samples with visible gold proved extremely difficult. At Mount Kasi, samples were collected from localities at outcrop and drill-core known to have high gold values (>30ppm). At Vatukoula (Emperor mine), a large (10kg) sample of crushed and hand picked ore was collected and at Tuvatu-Mount Kingston samples containing visible gold were provided by Mr. B. Brookes of Geo Pacific Ltd. No bedrock gold was collected that was directly associated with the Waimanu alluvial gold.

Polished thin sections of the high-grade samples from Mount Kasi contained microscopic gold (<40μm) associated with enargite and barite. Processing of the ore sample from Emperor mine (in the manner described below) revealed abundant very fine gold (<100μm).

3.2.2. Placer gold and ore concentrate samples

Placer gold samples were wet sieved into +1000, 1000-500, 500-150, 150-63 and -63 micron fractions. These fractions were then superpanned and the concentrate from each fraction was then magnetically separated using a Frantz magnetic separator into a further five fractions (magnet angle: 10°; magnet current settings: <0.05A, 0.05-0.4A, 0.4-0.8A, 0.8-1.25A and >1.25A). Gold was concentrated in the non-magnetic fraction. Individual gold grains were then hand picked and mounted in resin for subsequent polishing and electron probe micro-analysis.

3.2.3. Electron probe micro-analysis

Polished thin sections of samples were examined using transmitted and reflected light microscopy to identify ore and gangue minerals associated with gold. Samples were then analysed using a Cameca SX50 electron micro-probe. Four approaches were used to provide data for characterising bedrock gold mineralisation:

(i) quantitative analyses of gold; these were used to assess the variation and range in gold composition.

(ii) Microgeochemical maps; these were used to reveal complex intergrowths between gold and opaque minerals plus chemical zoning in gold.

(iii) Associated minerals (e.g., tellurides) were identified using quantitative analyses of inclusions in gold.

(iv) Quantitative analysis of the more common sulphides (e.g., pyrite and galena) was used to ascertain if they contained high amounts of trace elements (e.g., Te, Sb, Ag, Au) that could prove diagnostic for finger printing purposes.

Elements analysed included As, Se, S, Pd, Ag, Sb, Te, Fe, Cu, Au, Hg, Bi and Pb. Although in some analyses values are quoted for a number of trace elements these are very close to the theoretical detection limits (Table 1) and could be unreliable. Of the trace elements analysed, only the concentrations for Cu and Hg are thought to be reliable as these are the only elements that were consistently detected. However, even these are generally below 1 weight percent.

Data are presented as series of tables of analyses for all mineral phases. For gold, 'S'-curves of silver content are used show the range and distribution of data, plus a bivariate plot shows how silver concentration varies with the trace element (Cu and Hg) content.

Microgeochemical maps were acquired by making point analyses on a 256 by 256 grid. The distance between points is dependent on the size of area being analysed but is generally of the order of 1-2μm. Mapping of gold grains was undertaken using an accelerating voltage of 20kV and a beam current of 50nA. The data are collected as uncorrected X-ray counts, but as the matrix is essentially the same in an individual map this causes little error. Data are presented as a series of colour maps, each showing the spatial distribution of a particular element, with red indicating the highest concentration and magenta the lowest.

4. MINERALISED AREAS

4.1. Mount Kasi, Vanua Levu

The Mount Kasi deposit is located at the western end of Savu Savu Bay on the southern coast of Vanua Levu; it operated as a gold mine between 1932 and 1946 producing a limited tonnage of ore (261,000t) at an average grade of 8g/t Au. Mount Kasi has been actively explored by a number of mining companies since 1983, and is now about to be exploited pending a successful application for a mining lease.

The epithermal mineral deposit at Mount Kasi is classified as a high-sulphidation gold-enargite system. It is located on the margin of a volcanic caldera, and is Miocene to Pliocene in age. Mineralisation is hosted in a strongly silicified structure that strikes approximately north-west and dips at 70° to the south; the country rocks comprise a suite of calc-alkaline low-silica andesite flows, basalt dykes, and associated volcaniclastic rocks (Natewa Volcanic Group). These are intruded by hornblende-phyric andesite plugs (Nararo Volcanic Group) of Pliocene age (Turner, 1986) (Figure 1).

Gold grades in the silicified zone are generally less than 10g/t Au. However, there are localised up-flow hydrothermal breccias that host high-grade (bonanza) mineralisation (generally > 20g/t Au) (Taylor, 1987). Within the breccias, gold grade is related to the clast to matrix ratio. Low clast to matrix ratios correlate with high gold grades (G. Taylor pers. comm.). Breccias commonly have a central barite-rich zone and this can also be extremely high-grade (>300g/t Au).

4.1.1. Bedrock gold

Petrographic examination of samples from Mount Kasi reveals a suite of minerals comprising mainly barite, enargite, pyrite and gold telluride. Only microscopic gold was observed in the samples, this occurs both in the native form and as gold tellurides associated with tellurium-rich zones and fractures in enargite (Figures 2 and 3). Analyses of enargite show a wide range in composition (Table 2). The general paragenesis for Mount Kasi (after Turner, 1986) is early quartz, barite, pyrite and Fe-Ti-oxides associated with acid alteration. Main sulphide mineralisation, including gold, comprises enargite-luzonite [$Cu_3(As,Sb)S_4$], goldfieldite [$Cu_{12}(Te,Sb,As)_4S_{13}$] cassiterite [$SnO_2$], tennantite [$Cu_{12}As_4S_{13}$], tellurides, chalcopyrite, sphalerite, galena and bornite [Cu_5FeS_4]. A later suite of sulphides associated with cooling and supergene alteration consists of covellite, neodigenite, chalcocite, hematite, goethite, lepidocrocite and jarosite. Turner (1986) also notes that some gold is associated with supergene alteration. Telluride minerals recorded at Mount Kasi include petzite [Ag_3AuTe_2], calaverite [$AuTe_2$], altaite [PbTe], native tellurium, kostovite [$AuCuTe_4$] and goldfieldite [$Cu_{12}(Te, Sb, As)_4S_{13}$]. Turner (1986) records three types of occurrence for native gold: as irregular grains occurring in voids and cracks in quartz, small (<100μm) grains associated with tellurium-rich fractures in enargite (see Figure 3), and "secondary" gold associated with goethite and hematite.

In all the above cases gold grains were never larger than 100μm. Turner (1986) also analysed a suite of gold grains (Table 3), and found that bedrock gold at Mount Kasi is characterised by very low silver contents (always below the detection limit). In this study no quantitative analyses of bedrock gold were obtained due to the small size of the gold grains (generally <5μm). However, microgeochemical maps (Figure 2) show that qualitatively the gold contains low-silver. This uniformly low-silver gold is unusual for high-level epithermal environments, which commonly have high silver contents (Styles 1995; Henney *et al.*, 1994, 1995a, 1995b). The reason for this could be that the low-silver gold is secondary in origin and that, in the primary ore, gold occurs not in the native state but as various tellurides. The association of native gold with characteristic supergene minerals (e.g. covellite), and gold tellurides with primary (hypogene) ore minerals provide evidence for this hypothesis.

Production records of the mine show that average bullion compositions (calculated from annual production figures) ranged from 890 to 950 fine (approximately 11 to 5 wt% silver). Although these are not direct analyses of gold, and probably include silver-bearing tellurides, the records do indicate that low-silver gold is present through most of the deposit.

4.1.2. Alluvial gold

It was not possible to recover placer gold suitable for analysis from the samples collected within the Mount Kasi drainage catchment. However, this does not preclude applying the information gained from the bedrock gold to other areas. In the case of Mount Kasi, a high-sulphidation epithermal system, which has undergone extensive tropical weathering, associated alluvial gold would have the following characteristics:

(i) its silver content would be very low (<1wt% Ag).

(ii) The inclusion assemblage would be dominated by enargite and gold-silver tellurides.

(iii) The associated heavy mineral suite would include gold and gold-silver tellurides (studies of alluvial deposits associated with Emperor Gold Mine show that these minerals can be found in the alluvial environment).

4.2. Emperor Gold Mine, Viti Levu

4.2.1 Bedrock gold

Emperor Gold Mine is currently Fiji's only operating gold mine and the country's third largest earner of foreign currency. The mine is located on the northern part of Viti Levu, 10 km inland, and has been operating since 1935, producing 121 tons of gold from 11.9m tons of ore; current annual production is approximately 110,000 oz.

Emperor Gold Mine occurs on the western margin of a large caldera (Tavua Caldera). The structural regime of the area is dominated by a complex pattern of N-S steep faults and intersecting low-angle fractures called flatmakes. The location of mineralisation is controlled by these structures and consists of thin, single or multiphase, veins in steep or flat shears. The fracture infilling is typically multistage. Lode widths are typically less than one metre, and throughout the life of the mine the different types of mineralised structure have contributed equally to gold production. Flatmakes are areally extensive and are the largest mineralised structures in the mine, with strike lengths of up to 2km and dip extents of 1km. A wide range of minerals are recorded from the mine; these comprise a suite of tellurides (sylvanite [$AuAgTe_4$], petzite [Ag_3AuTe_2], krennerite [$(Au,Ag)Te_2$], hessite [Ag_2Te], calaverite [$AuTe_2$]), auriferous pyrite and free gold; associated gangue minerals include quartz, adularia, carbonate, sericite/illite and roscoelite [$K(V,Al,Mg)_2(AlSi_3)O_{10}(OH)_2$]. Roscoelite is commonly associated with high-grade telluride mineralisation and is considered an important indicator of high-grade mineralisation. Accessory minerals include arsenopyrite, marcasite, sphalerite, native tellurium, tennantite-tetrahedrite, chalcopyrite and galena. Electron micro-probe analyses of pyrite commonly showed it to be zoned and locally contain up to 8 wt% arsenic (Figure 4 and Table 4). Point analyses across a zoned grain showed that elevated levels of gold are associated with arsenic and antimony-rich zones.

Within the mine, gold-silver ratios show a variation from <1 to about 4 with gold grades ranging between 25 and 1000ppm (Kwak, 1990; Forsythe, 1967). In the polished thin sections examined, no visible or microscopic gold was observed. However, in the sample of ore concentrate, abundant fine grained (<100μm) gold was observed. Here grains varied in composition between 19.16 and 4.38 wt% Ag. The gold grains retrieved from the table concentrate commonly comprised grains intergrown with a variety of minerals such as pyrite, various gold-silver tellurides and coloradoite [Hg_2Te]. The variations in composition of the gold from the table concentrate contrasts with the average bullion fineness of between 700 and 800, which is equivalent to approximately 20-30 wt% silver (Setterfield *et al.*, 1988). If analyses of gold (4 to 20 wt% Ag) from the table concentrate are representative of the compositional variation of gold in the mine, then the concentrated gold ore must either be contaminated by silver-bearing minerals, or significant amounts of gold are present combined with Au-Ag-tellurides. This shows that using production records for estimating the composition of bedrock gold should be treated with caution, as these may be at variance with the 'true' compositional range of native gold.

4.2.2 Alluvial gold

Alluvial samples were collected from four sites surrounding the mine. Placer gold, suitable for analysis, was recovered from one sample (FJ 18). The composition of alluvial gold from around the Emperor Gold Mine varies between 15.38 and 6.15 wt% Ag, this is within the range and matches the distribution found in bedrock gold (Figure 5). A number of telluride minerals were identified in the heavy mineral concentrates and include Au-Ag tellurides, hessite [Ag_2Te], coloradoite and chalcopyrite (Table 1). All of these are recorded from the mine.

The above data not only show that gold composition is strongly correlated between bedrock and alluvial sources, but also the accessory mineralogy of the two environments is almost identical. Importantly, this dual correlation shows that, in Fiji, characterisation of alluvial gold accurately reflects compositional and mineralogical variation in the primary source.

4.3. Tuvatu prospect, Viti Levu

4.3.1. Bedrock gold

The Tuvatu-Kingston area is located on the western side of Viti Levu some 30km to the north-west of Nadi. Mineralisation is hosted in the centre and on the margins of a caldera lying on the Emperor-Mount Kasi trend (Fiji gold trend). The intra-caldera units are shoshonitic in composition and comprise trachyandesitic volcanic rocks intruded by a monzonitic stock with associated late stage dyke swarms of basaltic and andesitic composition (Colley, 1976).

At Kingston, a telescoped multi-phase system of mineralisation occurs in association with a volcanic caldera. It comprises a central Cu-Au porphyry hosted by monzonitic intrusive. High-level (adularia-sericite) epithermal gold mineralisation is developed of the north-eastern margin of the caldera. The porphyry system has best grades of 12m at 1.29g/t Au. The fairly extensive (1400 x 400 x 260m) epithermal vein system (Banana

Creek) is zoned both vertically and horizontally. The lowest part of the system is characterised by low-sulphide veins with a Au-Pb-Zn association, while the higher levels are characterised by a low-quartz/high-sulphide system with a Au-As-Hg-Te association (Meares, 1990).

Samples were provided from the Tuvatu prospect by Mr. Bill Brookes of Geo Pacific Ltd., and consisted of thin microcrystalline quartz veins containing sulphides and visible gold. Minerals identified included arsenopyrite, chalcopyrite, pyrite, enargite [Cu_3AsS_4], sphalerite, native gold and rare altaite [PbTe] (Table 7). Gold compositions are silver-poor and contain between 0.15 and 6.84 wt % silver.

4.3.2. Alluvial gold

It was not possible to recover placer gold suitable for analysis from the samples collected within the Tuvatu prospect drainage catchment. However, this does not preclude applying the information gained from the bedrock gold to other areas. In the case of the Tuvatu prospect, a telescoped porphyry Cu-Au system, associated alluvial gold would comprise low-silver gold (1-7 wt% Ag) with an inclusion assemblage dominated by sulphides rather than tellurides and sulphosalts (e.g. pyrite, chalcopyrite, sphalerite and arsenopyrite).

4.4. Waimanu Alluvial gold, Viti Levu

Alluvial gold was discovered in the Waimanu River about 20km west of Suva in the early part of this century. It occurs in river gravels under river flats and terraces, overlying altered volcanic and sedimentary rocks that have been intruded to the south by a large gabbroic body. Gold occurs in free flakes usually distributed in sinuous stringers in the gravels. The exact bedrock source for the gold is not known, but topographically above the gravels, approximately 15km to the north east, is the recently discovered Namosi porphyry-Cu deposit, which contains a small amount of gold (generally <1ppm) (Colley, 1976).

A sample of alluvial gold was provided by the Mineral Resources Department, Fiji.

The placer gold grains exhibit a variety of textures. Most grains exhibit rims that have high gold contents compared to the cores of grains. These vary from patchy and incomplete to complete mantles. The thickness of the rims is about 5-20μm; commonly the rims are solid but in some cases they contain abundant pores. Also, a number of grains are internally heterogeneous and contain patches and tracks of high-silver gold that is locally replaced by low-silver gold (Figure 6). Within-grain variation in silver content (excluding silver-poor rims) is between 11.30 and 23.79 wt% (Table 8). Overall, the composition of gold from the whole suite of veins varies from below detection to 23.79 wt% silver. Modified 'S'-curves (Figure 7) show two distinct populations: low-silver gold (0 to 15 wt %) and high-silver gold (15 to 25 wt%). However, detailed examination shows several sub-groups which each exhibit fine-scale variation in silver content. This feature of alluvial gold has been observed in the Raub region of Malaysia (Henney *et al*. 1995), where the fine-scale variation observed in the alluvial gold could be directly linked to variation within a single bedrock source.

Other elements analysed were Se, Cu, Pd and Hg. Se and Pd were below detection limits, except for one analysis. Cu concentrations associated with low-silver are up to 1.6 wt%. Hg concentrations are generally less than 0.12 wt%. A bivariate plot of Cu and Hg contents versus silver concentration (Figure 8) shows that there is a weak correlation between Cu and Ag concentrations; elevated Cu concentrations are associated with low-Ag contents in gold.

Inclusions in the alluvial gold were observed in approximately 25% of grains, and show a narrow range of minerals mainly comprising gold-silver tellurides (Table 9). Hessite [Ag_2Te] was the only mineral positively identified, as analyses invariably contain an unknown amount of gold and silver from the host gold grain. The presence of gold from the host grain makes it difficult to correctly assess the stoichiometry of the gold-silver telluride. Other minerals identified include pyrite and a silver-copper sulphide, but these are rare. There is a strong relationship between the composition of the alluvial gold and the type of inclusion. High-silver values in the host mineral grain are associated with tellurium minerals and silver sulphides, whilst pyrite is associated with low-silver gold (Figure 7).

5. DISCUSSION

Paired bedrock and alluvial samples were obtained from one locality (Emperor Gold Mine). Here, an excellent correlation between bedrock and alluvial gold was observed, both in terms of gold composition and accessory mineralogy. This confirms observations made in other areas, which also show a good correlation between bedrock and alluvial gold (Styles, 1995; Henney, 1994, 1995a & 1995b). Thus, the characteristics of bedrock gold throughout Fiji can be used to critically assess possible source regions for the Waimanu alluvials. The three bedrock areas studied have very distinctive characteristics, which should be reflected in alluvial gold derived from that type of deposit. At Mount Kasi, a high-sulphidation epithermal system, native gold is probably of secondary origin and is associated with a suite of distinctive telluride and sulphosalt minerals that might be found as inclusions. At Tuvatu the gold is generally low in silver (~5wt%) and associated with various base metal sulphides; tellurides were only rarely observed. At Emperor Gold Mine, gold shows a wider range of silver values (4 to 17 wt% Ag) and is associated with a range of telluride, sulphide and sulphosalt minerals. The major distinction between the two telluride-bearing deposits is the abundance of certain mineral species. Emperor Gold Mine contains a greater proportion of tellurides compared to Mount Kasi, where the dominant mineral species is enargite and tellurides are minor.

The above types of deposit could be expected to produce the following types of alluvial gold.

(i) *Alkali epithermal*

Moderate to high-silver gold with inclusions mainly of Au-Ag tellurides with rarer sulphides and sulphosalts (Emperor Gold Mine). Data for similar systems elsewhere in the world (e.g. Porgera - Richards *et al.*, 1991) indicate that these characteristics are applicable to deposits other than Emperor Gold Mine.

(ii) *High-sulphidation-epithermal*

No compositional data were obtained on hypogene (primary) gold from this environment. However, data from similar deposits in SE Asia (Styles *et al*. 1995) indicate that it would generally be high in silver, and that expected mineral inclusions in the gold would comprise mainly sulphosalts with minor tellurides.

(iii) *Telescoped porphyry system*

Low silver content, simple mineralogy dominated by sulphides rather than sulphosalts or tellurides (Tuvatu).

(iv) *Secondary gold*

Very low silver content, inclusions of supergene and hypogene minerals (e.g., copper sulphides, enargite) (Mount Kasi).

The Waimanu alluvials, for which there is no known source, show two distinct populations of gold: high-silver gold with common telluride inclusions and rarer sulphosalt inclusions, and low-silver gold with rare pyrite inclusions. This suggests that the Waimanu alluvial gold has two sources: derivation from an alkali epithermal system (medium to high-silver gold); derivation from a porphyry system (low-silver gold).

6. CONCLUSIONS

1. At Emperor mine, where data were obtained on paired bedrock and alluvial gold samples, an excellent correlation between gold composition and accessory minerals was observed. These data, in conjunction with studies by Styles (1995) and Henney (1994, 1995a 1995), show conclusively that many of the compositional and mineralogical features observed in bedrock gold are preserved when gold is mobilised from primary ore to alluvial deposit.

2. In Fiji, an important aspect in establishing the relationship between alluvial and bedrock gold was the analysis of "concentrated" ore from Emperor mine. This type of sample provides far more representative compositional variation and mineralogical associations than single point sampling (hand specimens and thin sections), or bulk assay data obtained during mining operations. This observation reinforces those made elsewhere during the TDR project (e.g., Styles, 1995; and Henney, 1994; 1995a; 1995). It shows that, wherever possible, analysis of "concentrated" ore is the preferred method of characterising bedrock gold, as single point sampling may miss key characteristics of the bedrock gold.

3. In a regional study, it may not always be possible to collect paired alluvial and bedrock gold samples. However, knowing that key identifiable features in bedrock gold are preserved during mobilisation from primary ore to alluvial deposit allows unpaired bedrock and

alluvial samples to be used to characterise variation at a regional scale. In the case of the Fiji studies, data obtained from bedrock gold at Mount Kasi and Tuvatu were used to characterise the types of gold from high-sulphidation epithermal mineralisation and telescoped porphyry systems. These data, coupled with information from Emperor Gold Mine area, were integrated with analyses of gold from the Waimanu alluvial gold deposit and enabled identification of at least two major sources for the Waimanu alluvials. One can be related to the nearby Namosi porphyry copper deposit, and the other has a number of characteristics in common with alkali epithermal (Emperor) style mineralisation; *a source not yet discovered*.

4. This study shows that there is a probable alkali epithermal source of placer gold in the Waimanu alluvial deposit. As Emperor Gold Mine (one of the type localities for alkali epithermal mineralisation) is a world-class ore deposit, exploration efforts should be directed at locating this source. Exploration strategies for locating it should be focussed on identifying key indicators in heavy mineral concentrates collected from first and second order streams within the Waimanu River catchment. Also, as alluvial gold, in Fiji, is commonly fine grained, it is important that sufficient heavy mineral concentrate for analysis (5-10kg of wet concentrate) is collected at each locality. Good indicators for alkali epithermal mineralisation would be moderate- to high-silver placer gold with an inclusion assemblage dominated by tellurides. Heavy mineral concentrates would also be expected to contain significant amounts of tellurides. It is important to stress that these indicators *cannot* be identified by gold and base metal assaying of pan concentrates alone, the individual grains must be examined

5. Future exploration for bedrock gold in Fiji, where minor alluvial occurrences have been identified, should include characterisation of placer gold, as this will be able to identify the type of gold mineralisation that is sourcing the alluvial gold.

6. The data presented in this study are an *excellent demonstration* of the application of alluvial gold characterisation to gold exploration. They also provide very important background information for future studies of alluvial and bedrock gold in Fiji and for studies of gold mineralisation in epithermal environments.

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Figure 1a. Geological map of Fiji (after Colley and Greenbaum, 1980).

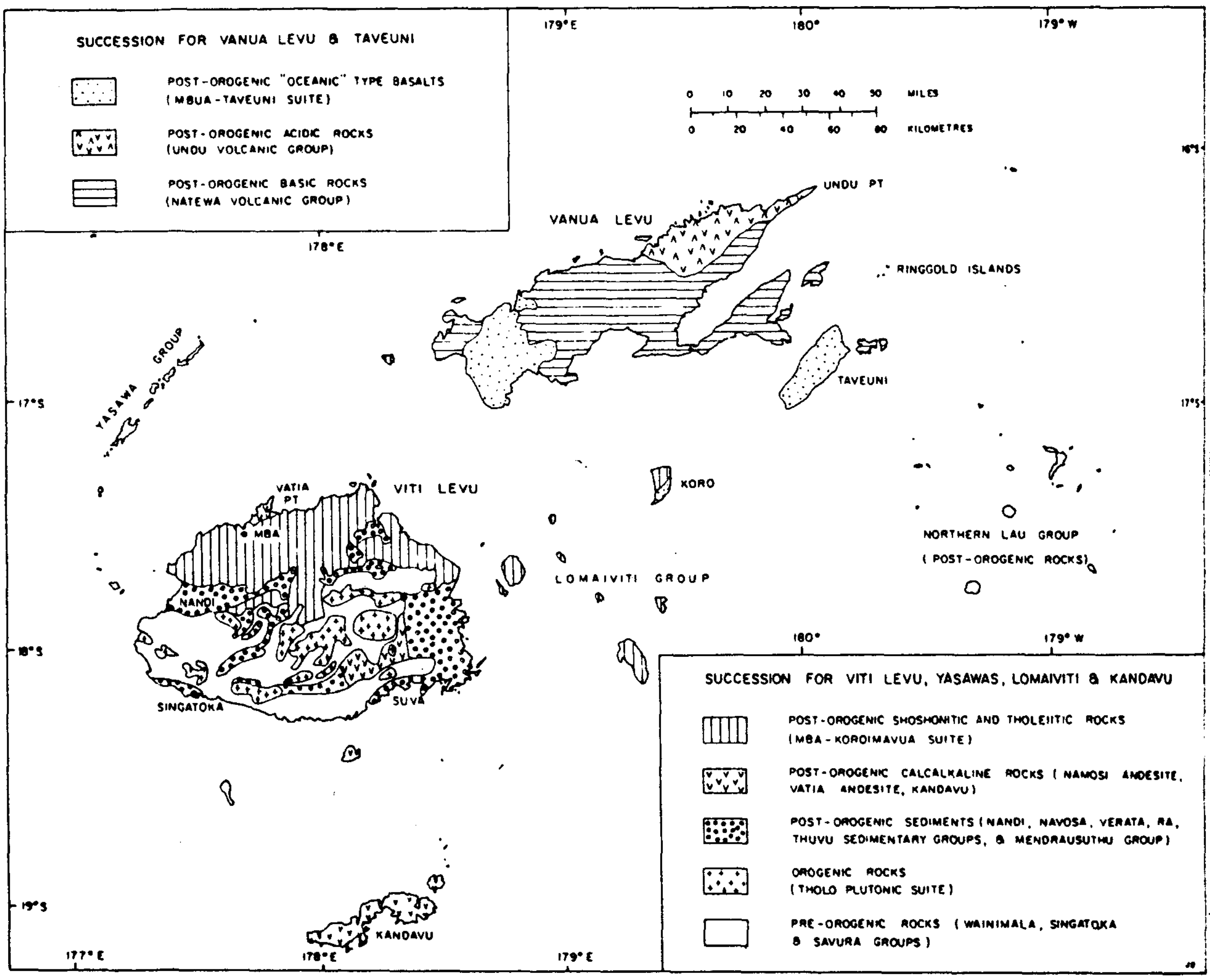


Figure 1b. Map showing the location of mineral deposits in Fiji. The areas studied in this report are: Emperor Gold Mine [47], Mount Kingston [55] and Waimanu [33] on Viti Levu and Mount Kasi [75] on Vanua Levu (after Colley and Greenbaum, 1980).

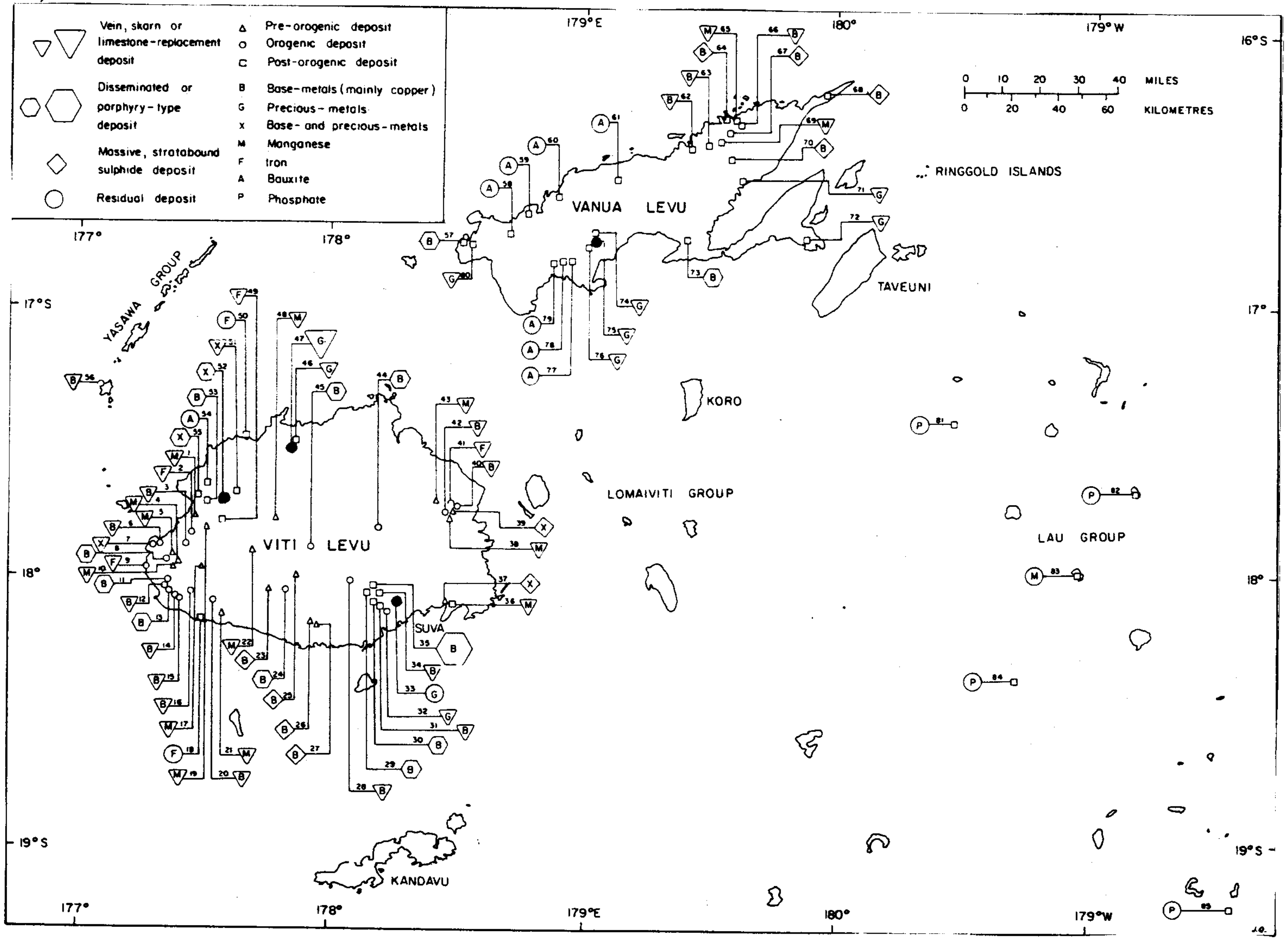


Figure 2. Microgeochemical maps of a a zoned goldfieldite-enargite grain (Area A; Scale bar = 20μm). Note the areas of high gold concentration. These were analysed in detail (Area B; scale bar for the 4 maps is 5μm) and shown to be native gold and gold telluride (calverite $AuTe_2$), arrowed areas have low Te contents and probably correspond to native gold. Area B also shows the fine grained nature of the gold and its relationship to tellurium-bearing minerals.

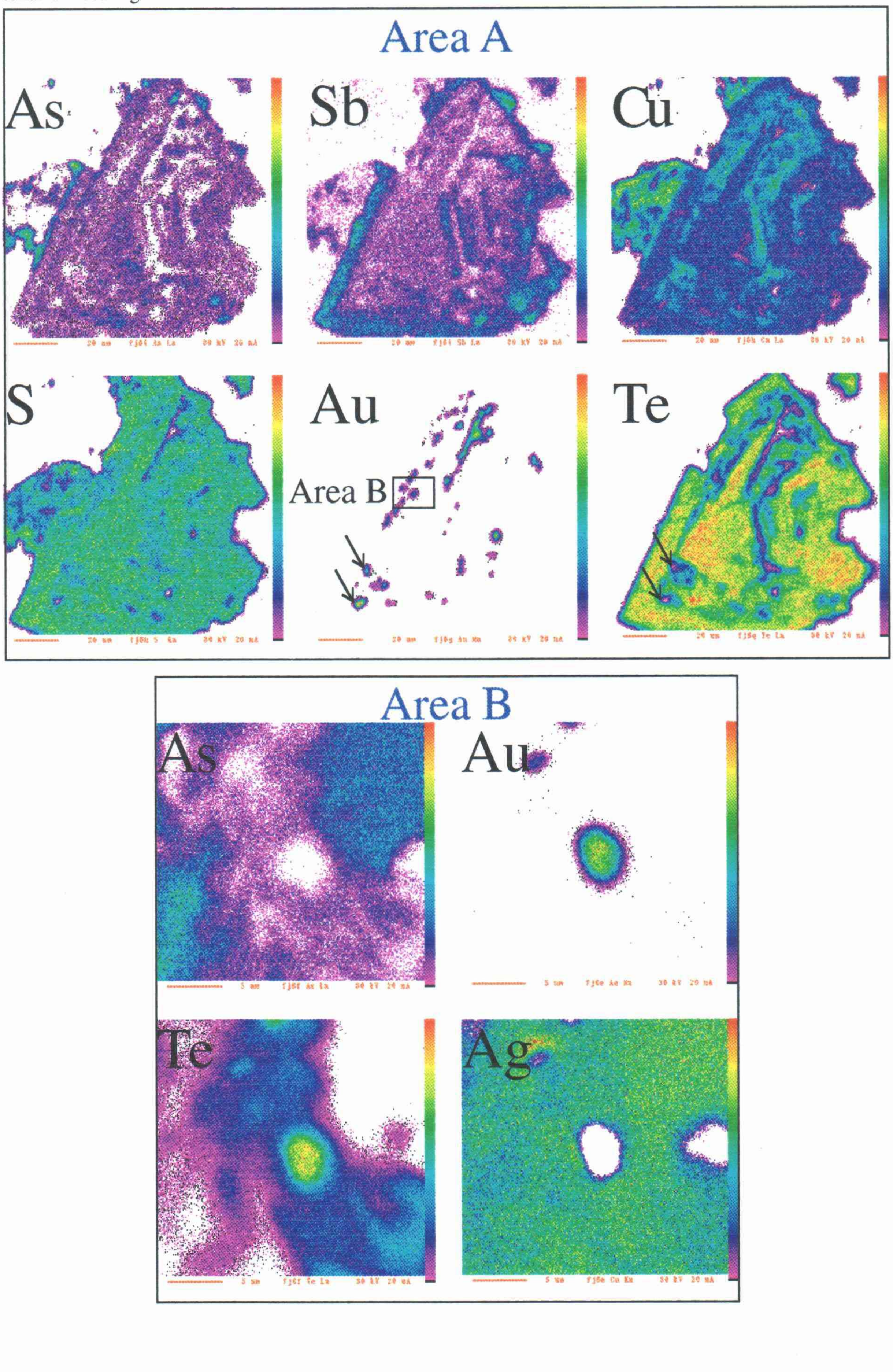


Figure 3. Microgeochemical maps of an enargite-goldfieldite intergrowth (the high barium zone is from an inclusion of barite). The images show how tellurium-rich minerals (mainly goldfieldite) occur along fractures in enargite. Also note the association of small (5μm) specks of gold with the tellurium-rich fracture.

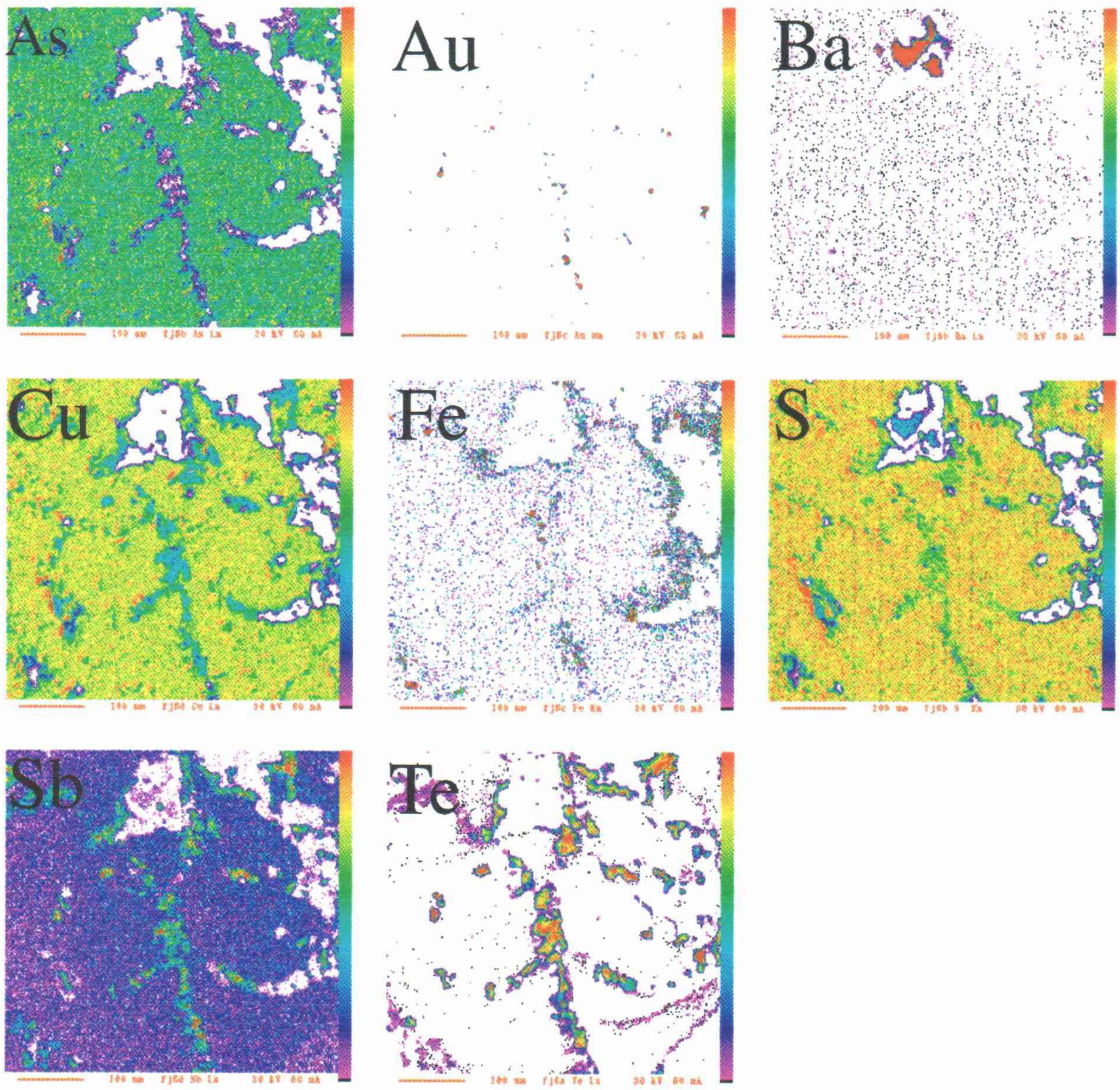


Figure 4. Transect across a zoned pyrite grain. Note that elevated gold levels are associated with high levels of arsenic and antimony.

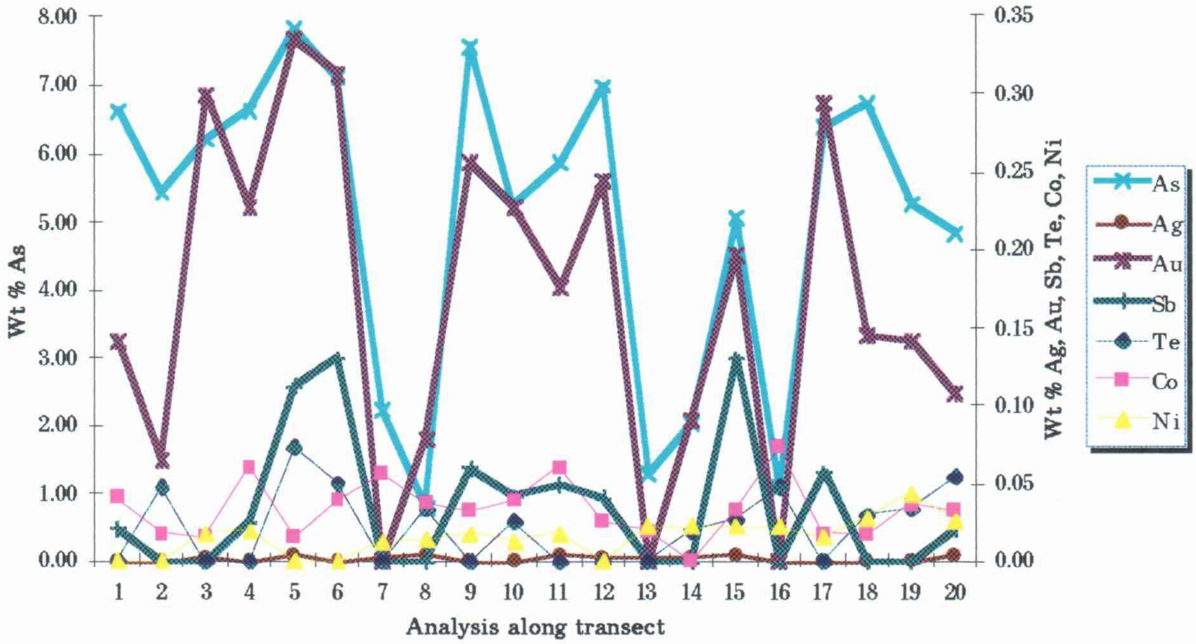


Figure 5. Modified 'S'-curves of alluvial (sample FJ 18) and bedrock (sample FJ 22) gold from Emperor mine and its environs.

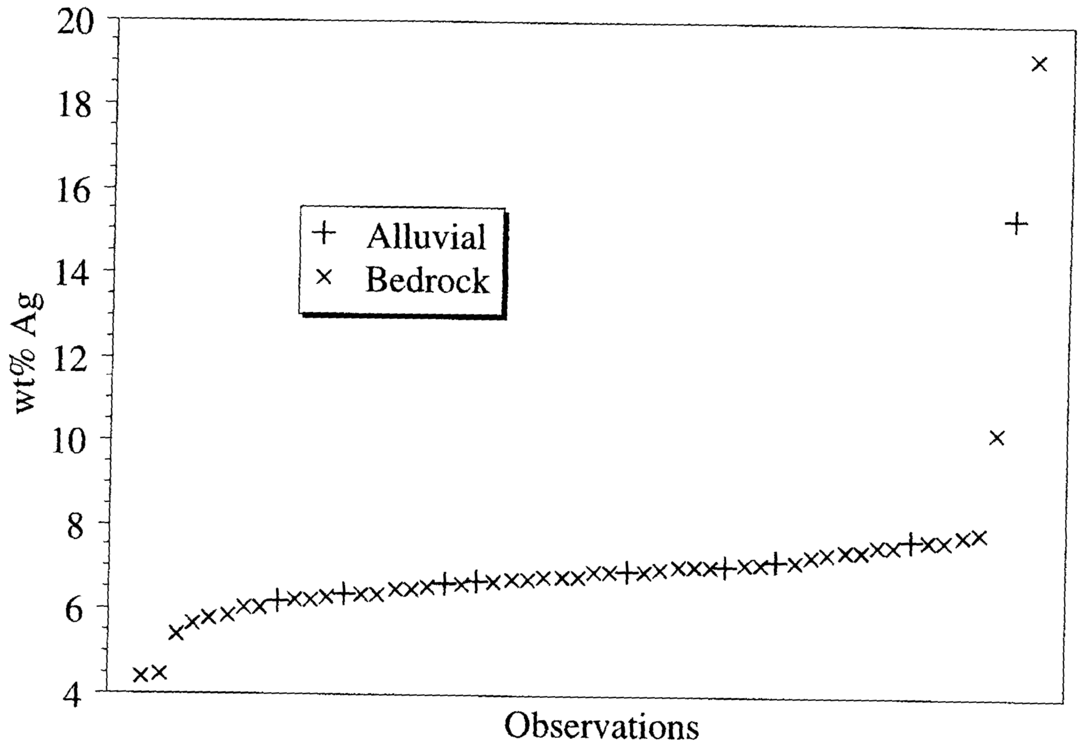


Figure 6. Microgeochemical maps of two placer gold grains from the Waimanu river showing several chemical features. Grain A shows a high-gold rim, and a locally heterogeneous interior with the formation of silver-rich tracks. These tracks are replaced by high-gold tracks. Grain B also shows high-gold rims, and internal silver-rich heterogeneities coupled with high-silver rims. It is thought that the silver-rich features are primary in origin and the high gold rims and tracks are a later secondary feature.

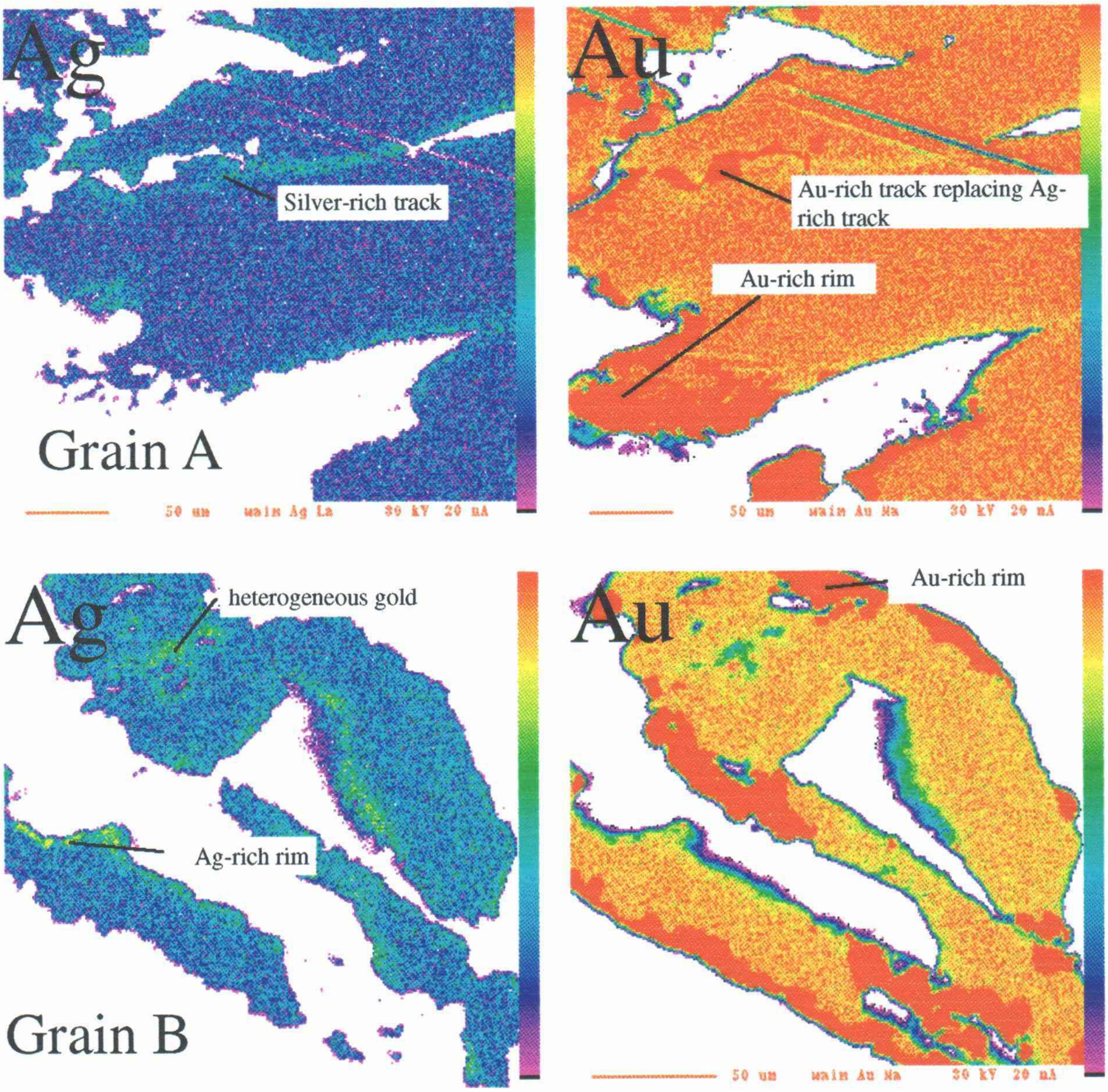


Figure 7. Modified 'S'-curves of silver content for alluvial gold from the Waimanu river. The data show at least two populations of gold: (i) a high silver trend with abundant telluride inclusions, and (ii) a low silver trend with rare base metal sulphide inclusions (the type of inclusions hosted in the alluvial gold grains are indicated as different plot symbols - the blue crosses indicate gold grains where no inclusions were observed).

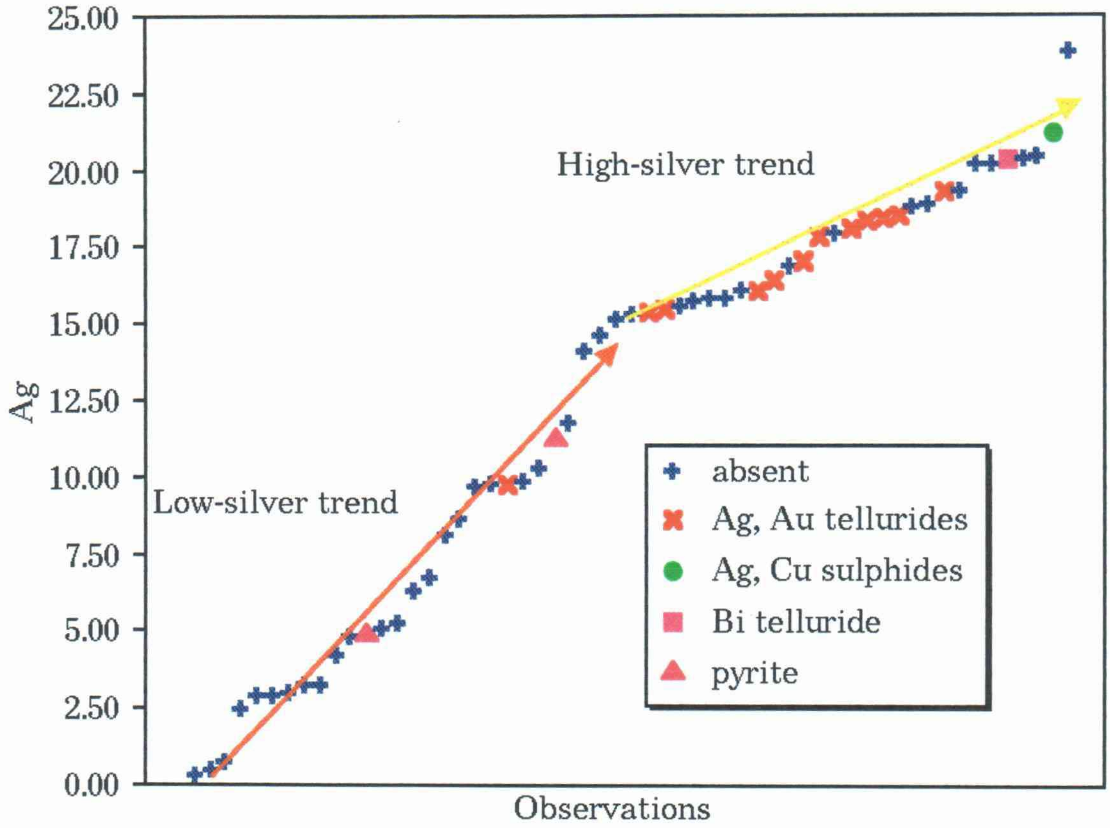
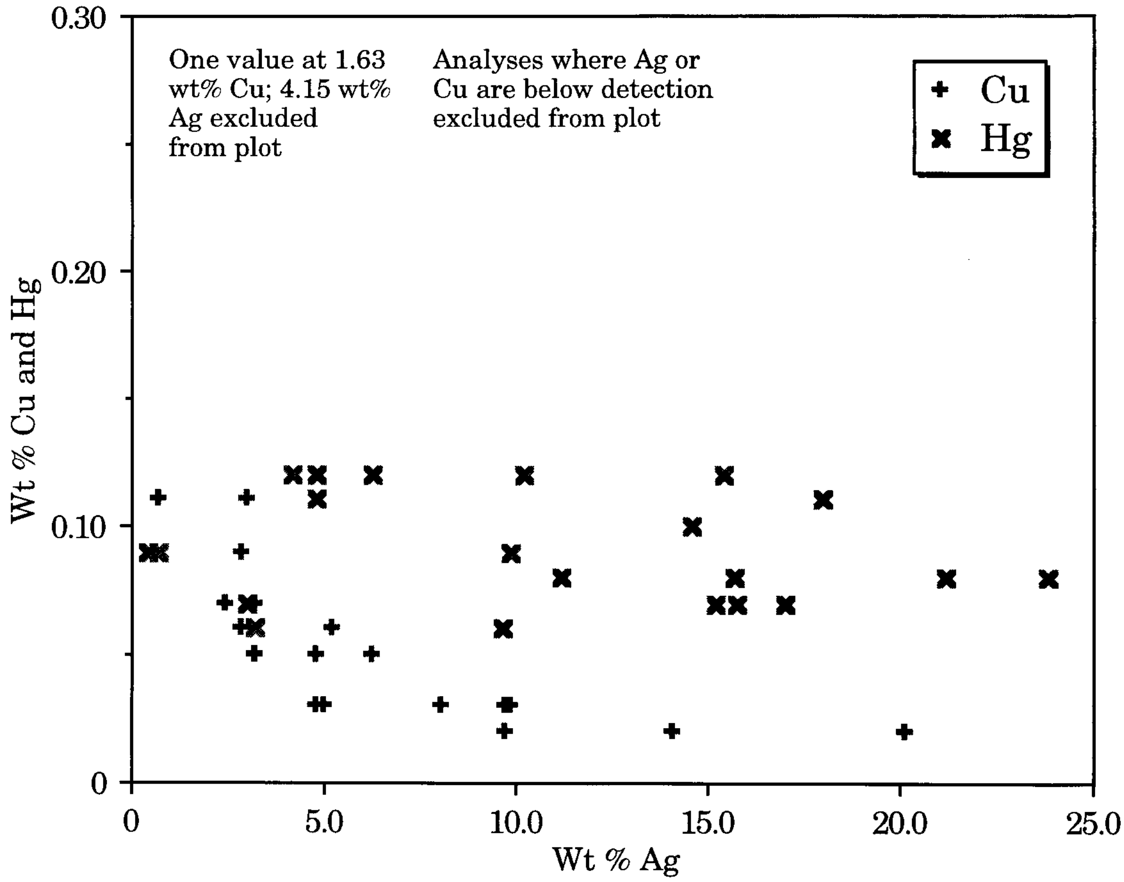


Figure 8. Bi-variate plot of Ag versus Cu and Hg in the Waimanu alluvials. The data show a weak negative correlation between Cu and Ag.



TABLES

Table 1. Analytical conditions and detection limits for electron microprobe analyses. Operating condition of the Cameca SX50 were 30kV high voltage and a beam current of 20nA.

Element	X-ray	Diffracting crystal	Standard	Detection limit (wt%)
As	Ka	TAP	Arsenopyrite	0.06
Se	La	TAP	Se metal	0.11
S	Ka	PET	Pyrite	0.03
Pd	La	PET	Pd metal	0.12
Ag	La	PET	Ag metal	0.13
Sb	La	PET	Sb metal	0.08
Te	La	PET	HgTe	0.08
Fe	Ka	LiF	Arsenopyrite	0.03
Co	Ka	LiF	Co metal	0.03
Ni	Ka	LiF	Ni metal	0.03
Cu	Ka	LiF	Cu metal	0.05
Au	La	LiF	Au metal	0.13
Hg	La	LiF	HgTe	0.04
Bi	La	LiF	Bi metal	0.2
Pb	La	LiF	Galena (PbS)	0.5

Table 2. Electron micro-probe analyses of enargite, goldfieldite, pyrite and calaverite from the Mount Kasi gold deposit.

Mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
	0.36	18.16	-	-	31.18	-	-	1.44	0.00	0.10	-	-	48.13	-	-	-	-	99.37
	0.13	18.09	-	-	30.93	-	-	0.44	0.42	0.02	-	-	50.04	-	-	-	-	100.08
	0.11	17.40	-	-	31.08	-	-	2.82	0.00	-	-	-	49.17	0.04	-	-	-	100.63
	0.23	18.39	-	-	31.14	-	-	0.29	0.63	0.04	-	0.04	50.03	-	-	-	-	100.79
	0.28	18.77	-	-	31.07	-	-	0.45	0.05	-	-	-	48.94	0.04	-	-	-	99.59
	0.39	17.73	-	-	31.02	-	-	0.88	1.48	0.04	-	-	47.46	0.04	-	-	-	99.03
	0.12	18.27	-	-	31.11	0.07	-	0.24	0.54	0.05	-	-	48.03	0.05	-	-	-	98.48
	-	0.25	-	-	51.77	-	0.00	-	0.00	48.14	0.07	-	-	-	-	0.00	-	100.24
	1.24	17.35	-	-	31.16	-	-	1.29	0.66	0.16	-	-	47.61	-	-	-	-	99.47
	0.23	17.92	-	-	31.15	-	-	1.28	-	0.03	-	0.03	49.05	-	-	-	-	99.68
	0.16	18.67	-	-	31.51	-	-	0.43	0.09	0.03	0.03	-	48.08	-	-	-	-	99.01
goldfiledite	0.45	6.26	-	-	24.94	-	-	1.08	19.64	0.04	-	-	46.24	-	-	0.21	-	98.85
	0.93	5.84	-	0.20	24.90	-	-	0.96	21.29	-	-	0.04	45.77	-	-	-	0.42	100.35
	2.03	1.92	-	-	23.52	-	0.12	0.86	27.47	-	-	-	42.72	-	-	-	-	98.63
pyrite	-	0.13	-	-	51.04	-	-	-	0.05	48.28	0.04	-	-	-	-	-	-	99.54
	-	0.26	-	-	51.81	-	0.20	-	0.08	47.92	0.04	-	-	-	-	0.15	-	100.45
	-	0.18	-	-	50.82	-	-	-	-	47.35	-	-	-	-	-	-	-	98.36
	-	0.21	-	-	51.38	-	-	-	-	48.36	0.06	-	-	-	-	-	-	100.00
	-	0.28	-	0.12	51.62	-	-	-	-	47.33	0.08	-	-	0.03	-	-	-	99.46
	-	0.10	-	-	50.60	-	-	-	-	46.81	0.03	-	0.03	-	-	-	-	97.56
	-	0.26	-	-	49.61	-	0.14	-	-	46.07	0.05	-	0.18	-	-	-	-	96.30
	-	0.20	-	-	51.42	-	-	-	-	47.31	0.10	-	-	-	-	-	-	99.01
	-	0.16	-	-	51.55	-	-	-	-	47.95	0.03	-	-	-	-	-	-	99.69
	-	0.20	-	-	51.38	-	-	-	-	47.75	0.03	0.03	-	-	-	-	-	99.38
calaverite intergrown with enargite	0.50	2.98	-	22.86	12.52	-	0.18	1.18	32.03	0.14	-	-	27.69	-	0.22	0.30	-	100.60
	0.63	1.62	-	18.46	16.04	-	0.20	0.61	33.07	0.10	-	-	32.48	-	-	-	-	103.20
	1.15	0.74	-	34.42	4.54	-	0.91	0.44	52.65	0.04	-	-	10.21	-	-	-	-	105.10
	1.61	0.70	-	24.60	12.66	-	0.50	1.11	44.03	0.03	-	-	19.00	-	-	-	-	104.24
	1.62	0.93	-	15.49	18.29	-	0.33	1.71	40.96	-	-	-	25.31	-	-	0.39	-	105.01

Table 3. Electron micro-probe analyses of bedrock gold from Mount Kasi (after Turner 1986). Low totals are due to the small size of the gold grains (hosted in quartz). High iron analyses (1-4, 10) are from hematite and goethite.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cu	-	0.27	-	0.4	0.04	0.22	-	0.02	-	-	0.07	0.13	0.06	-	0.14
As	0.27	0.74	0.29	0.33	0.08	0.02	-	0.45	0.39	0.13	0.4	0.22	0.51	-	-
Sb	-	0.03	0.13	-	-	-	-	-	-	0.16	-	-	-	0.29	-
Te	0.31	0.03	0.44	0.14	-	-	0.1	-	-	-	-	0.11	-	0.36	-
Au	89.83	57.74	89.15	67.6	93.53	88.23	58.84	88.29	93.7	73.2	92.51	91	93.41	91.08	72.88
Ag	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sn	0.03	0.34	0.3	-	0.04	-	-	0.09	0.16	2.13	-	-	-	0.16	-
Fe	1.63	16.54	2.88	15.21	0.21	0.25	0.45	-	0.11	2.41	0.13	0.11	0.28	0.04	0.19
Total	92.07	75.69	93.19	83.68	93.9	88.72	59.39	88.85	94.36	78.03	93.11	91.57	94.26	91.93	73.21

Table 4. Averaged electron micro-probe analyses of pyrite from Emperor Gold Mine. Elevated gold levels measured on the gold M_α confirm other workers observations (e.g., Ahmad *et al.*, 1987) that significant sub-microscopic gold occurs in pyrite.

n = 23	Mean	Minimum	Maximum	Standard Dev.	Det. limit
Se	-	-	-	-	-
As	0.70	0.10	4.94	1.19	0.06
Pt	-	-	-	-	-
Au	0.15	0.14	0.17	0.01	0.08
S	50.75	48.16	52.03	1.04	0.02
Pd	0.08	0.07	0.09	0.01	0.06
Ag	0.18	0.15	0.23	0.03	0.08
Sb	0.05	0.05	0.05	0.00	0.05
Te	0.06	0.05	0.07	0.01	0.05
Fe	47.54	45.98	48.36	0.58	0.03
Co	0.04	0.00	0.06	0.02	0.02
Ni	0.06	0.00	0.19	0.05	0.03
Cu	0.11	0.04	0.21	0.08	0.03
Zn	0.05	0.04	0.06	0.01	0.03
Hg	-	-	-	-	-
Bi	0.17	0.16	0.18	0.01	0.14
Pb	0.35	0.33	0.36	0.02	0.28
Total	99.20			1.22	

Table 5. Electron micro-probe analyses of gold, and other mineral analyses of a table concentrate from Emperor Gold Mine (sample FJ 22). Values for Fe, Co, and Ni are above, but very close to, theoretical detection limits, and hence may not be real.

mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
gold	-	-	-	93.41	-	-	7.70	-	-	-	-	-	-	-	-	-	-	101.11
	-	0.08	-	92.06	-	-	7.02	-	-	0.03	-	0.05	-	-	0.25	-	-	99.49
	-	0.09	-	92.59	-	-	6.66	-	-	-	-	-	-	-	-	-	-	99.33
	-	0.14	-	91.49	-	-	7.33	-	-	0.03	-	0.04	-	-	-	-	-	99.03
	-	0.11	-	93.17	-	-	5.77	-	-	0.06	-	0.04	-	-	-	-	-	99.15
	-	-	-	94.22	-	-	5.38	-	-	-	0.03	0.03	0.04	-	-	-	-	99.70
	-	-	-	88.59	-	-	7.02	-	-	0.04	-	0.03	-	-	-	-	-	95.69
	-	-	-	90.98	-	-	6.28	-	0.10	-	-	0.05	-	-	-	-	-	97.41
	-	-	-	92.11	-	-	7.53	-	0.19	-	-	-	-	-	-	-	-	99.83
	-	0.11	-	91.20	-	-	7.70	-	-	-	-	0.05	-	-	-	-	-	99.07
	-	-	-	95.74	-	-	4.38	-	-	-	-	-	-	-	-	-	-	100.12
	-	-	-	93.16	-	-	7.35	-	-	-	-	-	-	-	-	-	-	100.51
	-	0.17	-	91.12	-	-	7.02	-	-	-	-	0.04	-	-	-	-	-	98.34
	-	-	-	91.21	-	-	7.09	-	-	0.05	-	-	-	-	-	-	-	98.34
	-	-	-	89.19	-	-	10.29	-	-	-	-	0.04	-	-	0.17	-	-	99.69
	-	0.09	-	92.10	-	-	7.44	-	-	-	-	-	-	-	0.31	-	-	99.94
	-	0.10	-	92.25	0.07	-	6.47	-	-	-	-	0.04	-	-	-	-	-	98.91
	-	-	-	92.28	-	-	7.18	-	-	-	-	-	-	-	0.31	-	-	99.77
	-	-	-	92.31	-	-	6.73	-	-	-	-	-	-	-	-	-	-	99.04
	-	-	-	91.59	-	-	7.10	-	-	-	-	-	-	-	0.23	-	-	98.92
	-	-	-	92.16	-	-	6.82	-	-	-	0.03	-	-	-	-	-	-	99.01
	-	-	-	92.45	-	-	6.90	-	-	-	-	-	-	-	-	-	-	99.35
	-	-	-	81.14	-	-	19.16	-	-	0.03	-	-	-	-	-	-	-	100.33
	-	0.10	-	93.40	-	-	5.64	-	-	-	-	-	-	-	-	-	-	99.14
	-	-	-	91.98	-	-	7.01	-	-	0.04		-	-	-	-	-	-	99.03
	-	0.10	-	91.85	-	-	7.86	-	-	-	-	-	-	-	-	-	-	99.81
	-	-	-	94.09	-	-	6.52	-	-	0.06	-	-	-	-	-	-	-	100.66
	-	-	-	91.49	-	-	6.76	-	-	-	-	0.04	-	-	-	-	-	98.29
	-	0.10	-	93.11	-	-	6.03	-	0.10	-	-	-	-	-	-	-	-	99.34
	-	0.13	-	92.75	-	-	6.81	-	0.09	-	-	-	0.05	-	-	-	-	99.83
	-	-	-	92.60	-	-	6.38	-	0.08	-	-	-	-	-	-	-	-	99.06
	-	0.10	-	92.44	-	-	6.20	-	-	-	-	-	-	-	-	-	-	98.74
	-	-	-	93.19	-	-	6.90	-	0.11	0.04	-	-	-	-	-	-	-	100.23
	-	-	-	92.53	-	-	6.03	-	-	-	-	-	-	-	-	-	-	98.56

Table 5. Continued.

mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
gold	-	-	-	94.39	-	-	4.44	-	-	-	-	-	-	-	-	-	-	98.83
	-	-	-	93.00	-	-	6.36	-	-	-	-	0.07		-	-	-	-	99.43
	-	-	-	91.09	-	-	7.79	-	-	-	-	-	-	-	-	-	-	98.88
	-	0.08	-	91.41	-	-	6.78	-	-	-	-	-	-	-	-	-	-	98.27
	-	0.09	-	92.33	-	-	6.62	-	-	-	-	-	-	-	-	-	-	99.04
	-	0.10	-	92.33	-	-	6.94	-	0.11	-	-	0.04	-	-	-	-	-	99.51
	-	-	-	92.21	-	-	7.41	-	-	-	-	-	-	-	-	-	-	99.62
	-	-	-	91.71	-	-	6.45	-	0.10	0.04	-	0.04	-	-	0.20	-	-	98.54
	-	-	-	91.39	-	-	7.53	-	-	-	-	-	-	-	0.16	-	-	99.08
	-	0.09	-	93.21	-	-	5.83	-	0.08	-	-	-	-	-	0.16	-	-	99.38
	-	-	-	93.35	-	-	6.25	-	-	0.04	-	-	-	-	-	-	-	99.63
Au-Ag telluride	0.18	-	-	39.44	-	-	1.87	0.40	59.82	-	-	-	-	-	-	-	-	101.70
	-	-	-	24.57	0.04	-	43.34	0.25	29.64	0.06	-	-	-	-	-	-	-	97.90
	0.15	-	-	30.13	-	-	8.41	0.48	61.68	-	0.07	0.06	0.06	-	-	-	-	101.03
	0.16	-	-	23.31	-	-	8.09	0.40	56.04	-	-	-	0.16	-	-	-	-	88.15
	0.10	-	-	24.88	-	-	12.17	0.40	63.62	-	0.03	-	-	-	0.27	-	-	101.48
	0.11	-	-	33.97	-	-	5.05	0.43	60.44	0.03	-	-	0.22	-	-	-	-	100.25
	-	-	-	28.86	-	-	41.37		21.06	-	-	-	-	-	-	-	-	91.29
	0.21	-	-	29.12	0.73	-	8.16	0.36	60.38	0.49	-	-	0.06	-	-	-	-	99.51
	-	-	-	23.64	-	-	44.81	0.14	32.65	-	0.05	-	-	-	-	0.22	-	101.50
	0.10	-	-	29.09	-	-	9.44	0.45	62.33	-	-	-	0.11	-	-	-	-	101.52
	0.20	-	-	30.25	-	-	8.51	0.39	62.04	-	-	-	0.04	-	-	-	-	101.42
	0.20	-	-	35.85	-	-	5.13	0.36	60.33	-	-	0.03	-	-	-	-	-	101.91
	0.12	-	-	30.23	-	-	7.98	0.47	61.42	-	-	-	-	-	-	-	-	100.21
	0.11	-	-	34.55	-	-	5.43	0.40	60.68	-	0.04	-	-	-	-	-	-	101.20
	0.17	-	-	23.65	-	-	12.14	0.39	63.46	-	-	-	0.05	-	-	-	-	99.86
	0.11	0.14	-	29.34	-	-	8.97	0.49	61.85	-	-	-	0.16	-	-	-	-	101.04
	0.18	-	-	29.81	0.04	-	8.39	0.47	62.15	-	-	-	-	-	-	-	-	101.04
	-	-	-	23.65	-	-	44.37	0.28	32.58	-	-	0.05	-	-	-	-	-	100.92
	0.22	-	-	33.84	-	-	7.05	0.45	61.98	-	-	-	-	-	-	0.23	-	103.76
coloradoite	0.10	-	0.32	-	-	0.23	-	0.35	40.96	-	0.04	0.04		0.05	61.89	-	-	103.98
	-	-	0.47	3.80	0.09	0.19	0.46	0.28	39.82	-	-	-	-	-	53.67	-	-	98.77
	-	-	0.37	-	0.03	0.11	-	0.25	41.22	0.03	0.04	-	-	-	60.91	-	-	102.96
	-	-	0.47	-	0.03	-	-	0.30	40.22	-	0.05	0.03	-	-	61.52	-	-	102.63

Table 5. Continued.

mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
hessite	-	-	-	-	0.02	-	61.89	0.20	37.04	-	-	-	-	-	-	-	0.41	99.57
	-	-	-	-	-	-	62.45	0.21	38.29	0.03	-	0.04	-	-	-	-	-	101.02
	-	-	-	-	-	-	63.18	0.30	38.77	-	-	-	-	-	-	0.26	-	102.51
	-	-	-	-	-	-	61.50	0.21	37.18	-	-	-	-	-	-	-	-	98.88
native copper?	-	0.21	-	-	0.05	-	-	-	-	0.19	0.02	-	98.76	0.09	-	-	-	99.33
pyrite	-	0.29	-	0.21	52.55	-	-	0.07	0.06	47.51	-	0.04	0.04	-	-	-	-	100.76

Table 6. Electron micro-probe analyses of alluvial gold and heavy minerals collected in the Emperor Gold Mine drainage catchment (sample FJ 18).

mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
gold	-	0.09	-	92.04	-	-	6.32	-	-	0.06	-	-	-	-	-	-	-	98.50
	-	0.10	-	90.35	-	-	6.66	-	-	-	-	0.04	-	-	-	-	-	97.16
	-	-	-	90.85	-	-	6.90	-	-	-	0.03	-	-	-	-	-	-	97.78
	-	0.09	-	82.43	-	-	15.38	-	0.09	-	0.03	0.04	-	-	-	-	-	98.07
	-	0.11	-	95.35	-	-	6.58	-	-	4.70	-	0.05	-	-	0.15	-	-	106.94
	-	-	-	92.37	-	-	7.06	-	-	0.04	-	0.05	-	-		-	-	99.52
	-	-	-	93.21	-	-	6.15	-	-	-	-	-	-	-	0.17	-	-	99.54
	-	-	-	92.21	-	-	7.17	-	-	-	-	-	-	-	-	-	-	99.38
	-	0.08	-	91.41	-	-	7.66	-	-	-	-	-	-	-	-	-	-	99.16
Au-Ag telluride	0.15	-		35.58	-	-	3.85	0.35	59.49	-	-	-	-	-	0.19	-	-	99.62
	-	0.14	-	25.64	-	-	43.06	0.15	25.19	0.04	-	-	-	-	0.17	-	-	94.39
chalcopyrite	-	0.09	-	-	30.72	-	-	-	-	27.87	-	-	33.65	0.05	-	-	-	92.38
coloradoite	7.77	-	0.27	0.26	0.22	0.12	-	0.25	31.91	-	-	-	-	-	49.73	-	17.76	108.28
hessite	-	-	-	-	-	-	61.64	0.21	36.96	-	-	-	-	0.04	-	-	-	98.85
magnetite	-	0.31	-	0.16	-	-	-	-	-	54.97	-	-	-	-	-	-	-	55.44
	-	0.41	-	0.19	-	-	-	-	-	61.33	0.08	-	-	-	-	-	-	62.00
	-	0.23	-	-	-	-	-	-	-	54.54	0.07	-	-	-	-	-	-	54.84
	-	0.23	-	0.24	-	-	-	-	-	57.89	0.07	0.05	-	-	-	-	-	58.49
pyrite	-	1.18	-	-	53.37	-	-	-	0.06	46.36	0.05	0.05	-	-	-	-	-	101.07
	-	0.26	-	-	52.47	-	-	-	-	46.84	0.05	0.04	-	-	-	-	-	99.66
	-	0.22	-	-	52.02	-	-	-	-	46.76	0.06	-	-	-	-	0.23	-	99.30
	-	0.22	-	-	51.28	-	-	-	-	47.25	0.04	0.03	-	-	-	-	-	98.83
	-	0.52	-	-	51.16	-	-	-	0.04	47.63	0.03	0.07	-	-	-	-	-	99.46
	-	0.24	-	-	50.87	-	-	-	-	47.30	0.09	0.29	-	-	-	-	-	98.78
	-	0.21	-	-	46.43	-	-	-	-	47.73	-	-	-	-	-	-	-	94.37
	-	0.75	-	0.14	52.52	0.08	-	-	-	45.16	0.05	-	-	-	-	-		98.71
	-	0.20	-	-	52.56	-	-	-	-	47.43	0.04	-	-	-	-	-		100.23
	-	0.14	-	-	55.22	-	-	-	-	45.76	-	0.03	-	-	-	-		101.14
	-	0.20	-	-	51.67	-	-	-	-	47.51	0.05	-	-	-	-	-		99.44
	-	0.18	-	-	52.78	-	-	-	-	46.91	-	0.09	0.58	0.06	-	0.21		100.82
	-	0.17	-	0.19	51.58	-	-	-	-	46.88	0.04	0.05	-	-	-	-		98.91
	-	0.21	-	-	52.47	-	-	-	-	47.45	0.05	-	-	-	-	0.18		100.36
	-	0.69	-	-	51.04	-	-	-	0.06	47.05	0.10	0.04	0.06	-	-	-		99.04
	-	1.29	-	-	51.46	-	0.27	-	0.07	46.72	0.03	-	0.30	-	0.13	-		100.26

Table 6. Continued.

mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
pyrite	-	0.37	-	-	51.66	-	0.13	-	0.05	47.23	0.06	-	0.05	0.04	-	-		99.57
	-	0.12	-	-	52.53	-	-	-	-	47.73	-	-	-	-	-	-		100.38
	-	0.22	-	-	51.30	-	-	-	-	47.04	0.03	-	-	0.05	-	-		98.64
	-	0.22	-	-	51.94	-	-	-	-	47.64	0.07	0.08	-	-	0.11	0.19	0.42	100.67

Table 7. Electron micro-probe analyses of gold and associated minerals from the Tuvatu prospect.

Sample	Mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
DDH9 69.5	gold	-	-		88.46	0.09	-	5.48	-	-	0.05			-		-	-	-	94.08
		-	-		94.60	0.06	-	6.71	-	0.10	-			-		-	-	-	101.48
		-	0.09		93.63	-	-	6.13	-	-	-			-		-	-	-	99.85
		-	-		92.34	-	-	5.80	-	-	-			-		0.21	-	-	98.35
		-	-		94.02	-	-	6.22	-	-	-			-		-	-	-	100.24
		-	-		94.11	-	-	5.45	-	-	-			-		0.17	-	-	99.73
		-	-		94.24	-	-	6.13	-	-	0.04			-		-	-	-	100.41
		-	-	-	92.14	-	-	6.34	-	-	0.03	-	0.05	-	-	0.15	-	0.23	98.95
		-	-	-	94.86	-	-	5.17	-	-	0.05	-	-	-	-	0.18	-	-	100.26
		-	0.15	-	93.63	0.58	-	5.38	-	-	0.08	-	-	0.05	-	0.13	-	-	100.00
		-	0.07	-	89.88	-	-	5.16	-	-	-	-	-	-	-	-	-	-	95.11
		0.11	0.26	-	93.87	5.84	-	5.81	1.15	0.19	0.31	-	-	0.35	-	0.15	0.16	0.98	109.17
		-	-	-	96.03	0.11	-	5.13	-	-	-	-	-	-	-	0.17	-	-	101.43
		-	-	-	92.61	-	-	6.84	-	-	-	0.04	0.08	-	-	-	-	-	99.57
		0.09	-	-	93.30	0.33	-	6.58	0.14	-	0.10	-	-	0.05	-	0.15	-	0.29	101.02
		-	-	-	93.63	-	-	6.75	-	-	0.05	-	-	-	-	-	-	-	100.43
		-	-	-	94.42	-	-	5.77	-	-	-	-	0.06	-	-	0.10	-	-	100.34
		-	0.11	-	90.34	-	-	5.08	-	-	-	-	-	-	-	-	-	-	95.53
		-	-	-	94.25	-	-	4.30	-	-	-	-	0.04	-	-	-	-	-	98.58
		-	0.13	-	92.89	-	-	4.86	-	-	-	-	-	-	-	0.31	-	-	98.19
	pyrite	-	0.19	-	-	53.20	-	-	-	-	48.51	0.05	-	-	-	-	-	-	101.94
		-	0.23	-	-	53.01	-	-	-	-	48.83	0.04	-	-	-	-	-	-	102.11
		0.06	0.16	-	0.13	53.37	-	-	-	0.06	48.61	0.05	-	-	-	-	0.13	-	102.57
		0.11	0.29	-	0.14	52.61	-	-	-	-	48.08	0.03	0.05	0.47	-	-	-	-	101.78
		-	0.34	-	-	52.29	-	-	-	-	48.36	0.04	-	0.35	-	0.13	-	-	101.51
		-	0.21	-	-	52.74	-	-	-	-	48.68	0.04	-	-	-	-	-	-	101.66
		-	0.32	-	-	52.75	-	0.15	-	-	48.25	0.04	-	0.19	0.21	-	-	-	101.92
		-	0.15	-	0.16	52.89	-	-	-	-	48.08	-	-	-	-	-	-	-	101.28
		0.08	0.30	-	-	53.16	-	-	-	-	47.77	0.05	-	0.39	-	-	-	-	101.74
		0.07	0.32	-	-	52.34	-	-	-	-	47.87	0.03	0.04	0.33	-	-	0.11	-	101.12
		-	0.30	-	-	52.62	-	-	-	0.08	47.98	0.07	-	0.10	-	-	-	0.22	101.36
		-	0.14	-	0.20	53.23	-	0.17	-	0.05	48.21	0.06	0.03	-	-	-	-	-	102.08

Table 7. Continued (NB. High Cu and Fe analyses in sphalerite from DDH9 69.5 are probably due to minute chalcopyrite inclusions.

Sample	Mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
DDH9 69.5	chalcopyrite	-	0.25	-	-	52.18	-	-	-	-	48.78	-	-	-	0.06	-	-	-	101.28
		-	0.18	-	0.25	34.71	-	-	-	0.06	30.74	0.05	-	35.72	-	-	-	-	101.70
		-	0.27	-	-	34.37	-	-	-	-	31.40	-	0.03	35.75	0.05	0.07	-	0.18	102.13
		-	0.25	-	-	34.77	-	-	-	-	31.29	0.03	-	35.87	0.04	-	-	0.18	102.44
		-	0.24	-	-	34.61	-	-	-	-	31.23	0.06	0.03	35.84	0.09	-	-	0.40	102.49
		-	0.24	-	-	34.59	-	-	-	-	30.86	-	-	35.70	0.08	-	0.12	-	101.60
		-	0.09	-	-	34.24	-	-	-	-	31.09	0.03	-	35.82	0.07	-	0.09	-	101.42
		-	0.21	-	-	34.29	-	-	-	-	30.93	0.04	-	35.59	0.04	0.09	0.13	-	101.32
	sphalerite	-	0.12	-	-	32.23	-	-	0.15	-	7.66	-	-	6.52	54.46	-	-	-	101.13
		-	0.13	-	-	32.26	-	-	-	-	9.17	-	-	9.93	49.19	-	0.19	0.36	101.22
DDH9 65.75	chalcopyrite	-	0.30	-	-	33.33	-	-	-	0.08	30.31	-	-	35.55	-	-	-	-	99.58
		-	0.24	-	-	33.76	-	0.14	-	-	30.97	-	-	35.56	-	-	-	0.13	100.80
		-	-	-	-	34.97	-	-	-	-	30.65	-	-	35.41	-	-	-	-	101.03
		0.09	0.32	-	-	35.11	-	-	-	-	31.12	-	-	36.01	-	-	-	-	102.64
		-	0.18	-	0.15	36.04	-	-	-	-	30.95	-	-	35.77	-	-	-	-	103.08
	gold	-	-	-	90.33	-	-	3.58	-	-	-	-	-	-	-	-	-	-	93.91
		-	-	-	94.67	-	-	4.36	-	-	-	-	-	0.06	-	-	-	-	99.08
		-	-	-	94.60	-	-	4.45	-	-	0.04	-	-	-	-	-	-	-	99.08
		-	0.12	-	95.78	-	-	3.28	-	-	-	-	-	-	-	-	-	-	99.17
		-	-	-	94.63	-	-	4.52	-	-	0.05	-	-	-	-	-	-	-	99.20
		-	-	-	94.95	-	-	4.21	-	-	-	-	-	0.05	-	-	-	-	99.21
		-	0.08	-	95.51	-	-	3.69	-	-	-	-	-	-	-	-	-	-	99.27
		-	0.09	-	94.71	-	-	4.36	-	0.09	0.03	-	-	-	-	-	-	-	99.28
		-	-	-	95.59	-	-	3.69	-	0.12	-	-	-	-	-	-	-	-	99.39
		-	0.14	-	95.03	-	-	4.35	-	-	0.05	-	-	-	-	-	-	-	99.57
		-	-	-	95.18	-	-	4.29	-	-	0.04	-	-	-	-	0.11	-	-	99.61
		-	-	-	95.05	-	-	4.26	-	0.15	-	-	-	-	-	0.17	-	-	99.63
		-	0.10	-	96.15	-	-	3.52	-	-	-	-	-	-	-	-	-	-	99.76
		-	-	-	95.53	-	-	4.14	-	-	-	-	-	-	-	0.11	-	-	99.78
		-	-	-	95.20	-	-	4.45	-	-	-	-	-	-	-	0.14	-	-	99.79
		-	-	-	94.98	0.06	-	4.61	-	0.14	-	-	-	-	-	-	-	-	99.79

Table 7. Continued.

Sample	Mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
DDH9 65.75	gold	-	0.12	-	95.69	-	-	3.95	-	-	0.08	-	-	-	-	0.12	-	-	99.96
		-	-	-	95.99	-	-	3.64	-	0.12	0.04	-	-	-	-	0.19	-	-	99.97
		-	0.10	-	95.43	-	-	4.47	-	-	-	-	-	-	-	-	-	-	99.99
		-	0.11	-	95.73	-	-	4.15	-	-	0.04	-	-	-	-	-	-	-	100.03
		-	-	-	95.46	-	-	4.36	-	0.16	0.05	-	-	-	-	-	-	-	100.03
		-	0.10	-	95.67	-	-	4.29	-	-	-	-	-	-	-	-	-	-	100.05
		-	-	-	95.61	-	-	4.32	-	0.18	-	-	-	-	-	-	-	-	100.12
		-	-	-	95.61	-	-	4.53	-	-	-	-	-	-	-	-	-	-	100.13
		-	-	-	95.62	-	-	4.40	-	-	-	-	-	-	-	0.12	-	-	100.13
		-	0.07	-	95.57	-	-	4.42	-	0.10	-	-	-	-	-	-	-	-	100.16
		-	0.08	-	95.99	-	-	4.11	-	-	-	-	-	-	-	0.10	-	-	100.27
		-	0.12	-	95.64	-	-	4.41	-	0.10	-	-	-	0.04	-	-	-	-	100.30
		-	-	-	95.94	-	-	4.33	-	-	0.03	-	-	-	-	-	-	-	100.31
		-	-	-	95.82	-	-	4.49	-	-	-	-	-	-	-	-	-	-	100.31
		-	-	-	96.92	-	-	3.49	-	-	-	-	-	-	-	-	-	-	100.41
		-	0.09	-	95.33	-	-	4.90	-	-	-	-	-	-	-	0.10	-	-	100.43
		-	0.12	-	95.70	-	-	4.53	-	0.10	-	-	-	-	-	-	-	-	100.45
		-	-	-	96.31	-	-	4.08	-	-	0.04	-	-	-	-	0.11	-	-	100.53
		-	0.10	-	95.82	0.06	-	4.50	-	0.10	-	-	-	-	-	-	-	-	100.58
		-	-	-	96.06	-	-	4.38	-	-	0.05	-	-	-	-	0.11	-	-	100.59
		-	0.12	-	96.21	-	-	4.27	-	-	-	-	-	-	-	-	-	-	100.60
		-	-	-	95.57	-	-	4.86	-	0.21	-	-	-	-	-	-	-	-	100.65
		-	0.13	-	95.54	-	-	4.83	-	-	0.03	-	-	-	-	0.21	-	-	100.74
		-	0.12	-	96.17	0.11	-	4.29	-	0.15	-	-	-	-	-	-	-	-	100.83
		-	-	-	96.51	-	-	4.89	-	-	0.03	-	-	0.04	-	-	-	-	101.47
	Au+PbTe?	0.08	0.10	-	47.02	1.19	-	2.31	0.25	14.56	0.25	-	-	0.21	-	0.11	-	31.44	97.51
	pyrite	-	2.12	-	-	48.93	-	-	0.11	-	46.04	-	-	1.01	-	-	-	0.23	98.44
		-	0.19	-	0.14	51.17	-	-	-	-	48.54	-	-	0.65	-	-	-	-	100.68
		-	0.31	-	-	52.47	-	-	-	-	47.95	-	-	0.37	-	-	-	-	101.10
		-	0.31	-	-	52.90	-	-	-	-	47.86	-	-	0.35	-	-	-	-	101.43

Table 7. Continued.

Sample	Mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
DDH9 65.75	pyrite	0.08	0.88		-	52.56	-	-	-	-	47.95			0.11		-	-	-	101.59
		-	0.17		-	53.43	-	-	-	0.05	48.26			-		-	0.10	-	102.00
		0.12	0.45		-	53.04	-	-	-	-	48.33			0.19		-	-	-	102.13
		-	0.31		-	53.21	-	-	-	-	48.30			0.43		-	-	-	102.24
		-	0.21		-	53.60	-	-	-	-	48.55			0.03		-	-	-	102.39
		-	0.23		-	53.68	-	-	-	0.05	48.74			-		-	-	-	102.70
DDH8 61.45	arsenopyrite	1.50	45.15	-	0.41	17.49	-	0.14	0.69	0.45	30.21	-	-	0.05	-	0.39	-	0.18	96.66
	chalcopyrite	-	0.15	-	-	34.64	-	-	-	-	31.14	0.03	-	35.71	-	-	0.10	-	101.77
		-	0.31	-	-	34.52	-	-	-	0.05	31.13	0.03	-	35.47	0.06	-	-	0.25	101.81
		-	0.17	-	0.27	34.66	-	-	-	-	30.58	0.03	-	35.33	0.04	-	-	-	101.10
		-	0.11	-	-	33.96	-	-	-	0.08	30.62	0.02	-	35.37	0.11	-	-	-	100.28
		-	0.16	-	-	34.99	-	0.16	-	-	31.66	0.04	0.03	35.00	-	-	0.10	0.15	102.29
		-	0.25	-	-	35.28	0.08	-	-	0.06	30.53	0.02	-	35.37	-	-	0.12	-	101.70
	enargite	0.28	19.20	-	-	27.69	-	-	2.25	-	2.83	0.03	-	42.31	7.87	-	-	-	102.44
		-	17.78	-	-	28.24	-	-	4.89	-	2.03	-	0.03	41.12	7.08	-	-	-	101.17
		0.30	19.54	-	-	27.69	-	-	1.47	-	0.85	-	-	42.79	8.04	-	-	-	100.67
	gold	-	0.12	-	90.84	1.25	-	4.69	-	0.10	0.12	-	-	0.34	-	-	-	-	97.47
		0.10	0.09	-	87.69	4.03	-	4.72	0.12	0.26	0.38	0.07	-	0.61	-	-	-	0.98	99.04
		-	-	-	92.34	0.56	-	4.78	-	0.48	0.07	-	-	0.31	-	0.74	-	-	99.27
		-	-	-	95.90	-	-	4.78	-	-	0.06	-	-	-	-	0.35	-	-	101.08
		-	0.14	-	90.97	2.09	-	4.63	-	0.16	0.16	-	-	0.07	-	-	-	0.73	98.96
		-	-	-	94.32	-	-	4.46	-	-	-	-	-	-	-	-	-	-	98.78
		-	0.09	-	95.42	0.10	-	4.85	-	-	-	-	-	-	-	-	-	-	100.44
		-	-	-	76.84	-	-	4.41	-	0.09	0.04	-	-	0.04	-	0.26	-	-	81.67
		0.48	0.72	-	60.49	22.09	-	3.28	1.62	1.54	1.99	0.21	-	2.64	-	0.24	0.15	9.43	104.88
		-	0.07	-	94.70	0.21	-	4.96	-	0.13	0.06	-	-	0.04	-	-	-	-	100.16
		-	0.08	-	91.94	-	-	5.19	-	-	-	-	-	-	-	-	-	-	97.21
		-	-	-	91.57	0.12	-	4.93	-	-	0.07	-	0.05	0.18	-	-	-	-	96.91
	pyrite	-	0.25	-	-	53.25	-	-	-	-	48.06	0.04	0.03	0.37	0.05	-	-	-	102.05
		-	0.15	-	-	53.26	-	0.15	-	-	47.57	1.01	0.05	-	-	0.12	0.14	0.29	102.74
		-	0.21	-	0.13	53.48	-	-	-	-	48.18	0.15	0.06	-	-	-	-	-	102.20
		-	0.27	-	-	53.45	-	-	-	0.05	48.53	0.03	-	-	-	0.14	0.13	-	102.59
		-	0.19	-	-	52.57	-	-	-	-	46.86	-	-	-	0.04	-	0.14	-	99.79

Table 7. Continued.

Sample	Mineral	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
DDH8 61.45	pyrite	-	0.27	-	-	52.83	-	-	-	-	48.59	0.04	-	0.33	0.06	-	-	0.30	102.42
		-	0.25	-	0.18	53.50	-	0.14	-	-	48.43	0.03	-	0.16	0.05	-	-	-	102.74
		-	0.17	-	-	53.15	-	-	-	-	48.77	0.07	0.03	0.04	-	-	0.25	-	102.47
		-	1.26	-	-	51.49	-	-	0.07	-	47.37	0.07	0.03	0.12	-	-	-	-	100.40

Table 8. Electron micro-probe analyses of alluvial gold from the Waimanu river.

grain No.	inclusions	Ag-rich tracks	Se	Pd	Ag	Cu	Au	Hg	Total
1	Ag, Au tellurides	absent	-	-	16.39	-	86.73	-	103.12
			-	-	17.82	-	84.73	-	102.55
2	Ag, Au tellurides	absent	-	-	18.49	-	85.05	-	103.54
3	absent	absent	-	-	6.25	0.05	96.87	0.12	103.29
4	Ag, Au tellurides	absent	-	-	18.43	-	84.13	-	102.56
5	absent	absent	-	-	10.21	-	93.27	0.12	103.60
6	Ag, Au tellurides	absent	-	-	19.29	-	83.92	-	103.21
			-	-	9.70	0.03	93.07	-	102.80
7	absent	present	-	-	23.79	-	79.51	0.08	103.38
			-	-	11.73	-	91.43	-	103.16
			-	-	20.11	0.02	81.68	-	101.81
			-	-	14.60	-	88.11	0.10	102.81
8	Ag, Au tellurides	absent	-	-	15.40	-	87.85	0.12	103.37
9	pyrite	absent	-	-	11.21	-	91.92	0.08	103.21
10	absent	absent	-	-	4.76	0.03	98.26	0.12	103.17
11	absent	absent	-	-	2.99	0.11	99.94	0.07	103.11
12	absent	absent	-	-	8.07	0.03	94.16	-	102.26
13	Ag, Au tellurides	absent	-	-	15.43	-	88.10	-	103.53
14	absent	absent	-	-	3.22	0.07	99.49	-	102.78
15	absent	absent	-	-	18.83	-	83.91	-	102.74
16	absent	absent	-	-	0.00	-	102.80	-	102.80
17	absent	present	-	-	16.82	-	87.06	-	103.88
18	absent	absent	-	-	2.42	0.07	99.77	-	102.26
19	absent	absent	-	-	15.68	-	86.72	0.08	102.48
20	absent	absent	-	-	20.34	-	83.00	-	103.34
21	absent	absent	-	-	19.30	-	84.84	-	104.14
22	absent	absent	-	-	15.14	-	88.18	-	103.32
23	absent	absent	-	-	8.60	-	94.76	-	103.36
24	absent	absent	-	-	20.14	-	82.66	-	102.80
25	Ag, Au tellurides	absent	-	-	15.53	-	87.74	-	103.27
			-	-	17.01	-	86.11	0.07	103.19
26	absent	absent	-	-	0.40	-	103.47	0.09	103.96
27	absent	present	-	-	3.17	0.05	99.28	0.06	102.56
28	absent	absent	-	-	5.21	0.06	97.88	-	103.15
29	absent	absent	-	-	6.65	-	95.86	-	102.51
30	pyrite	absent	-	-	4.82	0.05	97.60	0.11	102.58
31	Bi telluride	absent	-	-	20.27	-	83.16	-	103.43
		absent	-	-	5.01	0.03	97.87	-	102.91
32	Ag, Cu sulphides	absent	-	-	21.21	-	82.80	0.08	104.09
33	absent	absent	-	-	2.88	0.09	102.08	-	105.05
			-	-	2.85	0.06	100.73	-	103.64
34	absent	absent	-	-	9.70	0.02	93.69	-	103.41
35	absent	absent	-	-	17.88	-	84.80	-	102.68
36	absent	absent	-	-	15.77	-	87.13	0.07	102.97
37	absent	absent	-	-	20.43	-	83.69	-	104.12
38	absent	absent	-	-	15.78	-	87.58	-	103.36
			-	-	14.09	0.02	89.77	-	103.88
			-	-	15.24	-	88.73	0.07	104.04

Table 8. Continued.

grain No.	inclusions	Ag-rich tracks	Se	Pd	Ag	Cu	Au	Hg	Total
39	absent	absent	-	-	18.79	-	84.32	-	103.11
40	absent	present	-	-	0.28	-	103.24	-	103.52
41	absent	absent	-	-	9.65	-	94.15	0.06	103.86
42	absent	absent	-	-	0.67	0.11	102.98	0.09	103.85
43	absent	absent	-	-	9.84	0.03	94.02	0.09	103.98
44	absent	absent	-	-	4.15	1.63	98.01	0.12	103.91
45	absent	absent	-	-	16.03	-	86.76	0.00	102.79
46	Ag, Au tellurides	present	-	-	18.02	-	85.39	0.11	103.52
			-	-	18.33	-	85.69	-	104.02
			-	-	16.07	-	88.04	-	104.11

Table 9. Electron micro-probe analyses of inclusions hosted in alluvial gold from the Waimanu River. The grain numbers are the same as shown with analyses of gold grains in Table 8. Analyses are given in weight% (first line in each box) and atomic % (second line in each box).

Grain no.	Mineral	Formula	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
1.1	Au-Ag telluride	-	-	-	-	20.62	-	-	43.87	0.21	31.00	-	-	-	-	-	-	0.21	-	95.91
			-	-	-	13.83	-	-	53.73	0.22	32.09	-	-	-	-	-	-	0.13	-	100.00
1.2	Au-Ag telluride	-	-	-	-	32.86	0.06	-	39.10	0.10	20.96	-	-	-	-	-	-	-	-	93.08
			-	-	-	23.97	0.26	-	52.07	0.11	23.59	-	-	-	-	-	-	-	-	100.00
2.1	hessite	Ag2Te	-	-	-	1.49	0.04	-	52.55	0.19	33.95	0.03	-	-	-	-	-	-	-	88.25
			-	-	-	0.99	0.17	-	63.75	0.20	34.82	0.07	-	-	-	-	-	-	-	100.00
2.2	Au-Ag telluride	-	-	-	-	12.79	-	-	36.54	0.14	20.05	-	-	-	-	-	-	0.25	-	69.77
			-	-	-	11.53	-	-	60.16	0.21	27.90	-	-	-	-	-	-	0.21	-	100.00
2.3	Au-Ag telluride	-	-	-	-	8.98	0.13	-	48.82	0.25	32.62	-	-	-	-	-	0.13	-	-	90.93
			-	-	-	6.00	0.55	-	59.49	0.27	33.61	-	-	-	-	-	0.09	-	-	100.00
2.4	Au-Ag telluride	-	0.12	-	-	10.24	0.09	-	40.34	0.22	24.46	-	-	-	-	-	0.15	-	-	75.62
			0.25	-	-	8.32	0.45	-	59.88	0.28	30.70	-	-	-	-	-	0.12	-	-	100.00
2.5	Au-Ag telluride	-	-	-	-	38.68	-	-	33.76	-	18.82	0.07	0.05	0.07	-	-	-	-	-	91.45
			-	-	-	29.75	-	-	47.41	-	22.34	0.20	0.12	0.19	-	-	-	-	-	100.00
2.6	hessite	Ag2Te	-	-	-	2.52	0.04	-	52.59	0.18	33.21	-	-	-	-	-	-	0.28	-	88.82
			-	-	-	1.68	0.15	-	63.77	0.19	34.04	-	-	-	-	-	-	0.17	-	100.00
2.7	Au-Ag telluride	-	-	-	-	7.18	0.06	-	48.08	0.19	30.59	-	-	-	0.05	-	-	-	-	86.15
			-	-	-	5.02	0.26	-	61.39	0.22	33.01	-	-	-	0.10	-	-	-	-	100.00
2.8	Au-Ag telluride	-	-	-	-	4.23	0.03	-	50.87	0.23	32.28	-	-	-	-	-	-	-	-	87.64
			-	-	-	2.87	0.11	-	62.98	0.25	33.79	-	-	-	-	-	-	-	-	100.00
2.9	Au-Ag telluride	-	-	-	-	57.00	-	-	32.16	-	11.89	-	-	0.04	-	-	-	-	-	101.09
			-	-	-	42.47	-	-	43.76	-	13.68	-	-	0.09	-	-	-	-	-	100.00
2.90	Au-Ag telluride	-	-	-	-	14.58	0.03	-	45.58	0.20	31.11	-	-	0.04	-	-	-	-	-	91.54
			-	-	-	9.95	0.13	-	56.83	0.22	32.79	-	-	0.08	-	-	-	-	-	100.00
2.1	Au-Ag telluride	-	-	-	-	10.38	0.05	-	51.48	0.19	32.27	0.05	-	-	-	-	-	-	-	94.42
			-	-	-	6.70	0.18	-	60.66	0.20	32.15	0.11	-	-	-	-	-	-	-	100.00
2.11	sphalerite	ZnS	-	-	-	54.33	10.53	-	12.45	-	1.18	0.15	-	-	-	16.25	-	-	-	94.89
			-	-	-	28.14	33.51	-	11.78	-	0.94	0.27	-	-	-	25.36	-	-	-	100.00
2.11	sphalerite	ZnS	-	0.11	-	6.85	24.41	-	2.87	-	1.08	0.25	-	-	-	53.10	-	-	-	88.67
			-	0.09	-	2.11	46.15	-	1.61	-	0.51	0.27	-	-	-	49.25	-	-	-	100.00
2.11	sphalerite	ZnS	-	-	-	14.74	7.87	-	30.05	-	16.91	0.10	-	0.03	-	20.78	-	-	-	90.48
			-	-	-	7.12	23.35	-	26.49	-	12.60	0.17	-	0.05	-	30.23	-	-	-	100.00
2.11	sphalerite	ZnS	-	-	-	16.38	15.44	-	3.27	-	0.57	0.18	-	-	0.03	44.24	-	-	-	80.11
			-	-	-	6.50	37.62	-	2.37	-	0.35	0.26	-	-	0.04	52.88	-	-	-	100.00
4.1	calaverite	AuTe2	-	-	-	38.50	-	-	0.62	0.40	56.27	-	0.04	-	-	-	-	0.28	-	96.11
			-	-	-	30.20	-	-	0.88	0.51	68.12	-	0.09	-	-	-	-	0.20	-	100.00

Table 9. Continued.

Grain no.	Mineral	Formula	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
4.2	Au-Ag telluride	-	-	-	-	28.18	-	-	40.45	-	24.54	-	-	-	0.05	-	-	-	-	93.22
			-	-	-	20.12	-	-	52.72	-	27.04	-	-	-	0.12	-	-	-	-	100.00
4.3	Cu sulphide		-	-	-	16.36	16.09	-	0.56	-	0.12	0.03	-	-	51.73	-	-	-	0.59	85.48
			-	-	-	5.90	35.63	-	0.37	-	0.07	0.04	-	-	57.80	-	-	-	0.20	100.00
4.5	Au-Ag telluride	-	-	0.10	-	56.07	-	-	1.80	0.23	30.83	-	0.04	-	-	-	-	-	-	89.07
			-	0.25	-	52.05	-	-	3.05	0.35	44.18	-	0.12	-	-	-	-	-	-	100.00
6.1	Au-Ag telluride	-	0.85	-	-	21.25	0.21	-	41.21	0.19	28.29	-	-	-	-	-	-	-	1.49	93.49
			1.46	-	-	14.62	0.90	-	51.78	0.21	30.05	-	-	-	-	-	-	-	0.98	100.00
6.2	Au-Ag telluride	-	-	-	-	22.39	-	-	40.50	0.28	33.00	0.03	-	-	-	-	-	-	-	96.20
			-	-	-	15.14	-	-	50.02	0.30	34.45	0.08	-	-	-	-	-	-	-	100.00
6.3	Au-Ag telluride	-	-	-	-	16.57	-	-	42.52	0.20	25.88	-	0.03	0.04	-	-	-	-	-	85.24
			-	-	-	12.30	-	-	57.64	0.24	29.66	-	0.08	0.09	-	-	-	-	-	100.00
6.4	Au-Ag telluride	-	-	-	-	23.96	0.04	-	33.28	0.13	26.79	-	-	0.05	-	-	-	-	-	84.25
			-	-	-	18.92	0.17	-	47.98	0.17	32.65	-	-	0.12	-	-	-	-	-	100.00
6.6	calaverite	AuTe2	0.09	-	-	41.14	0.09	-	0.81	0.33	49.82	0.03	-	-	-	-	-	-	-	92.31
			0.18	-	-	34.02	0.45	-	1.22	0.44	63.60	0.09	-	-	-	-	-	-	-	100.00
6.8	Au-Ag telluride	-	-	-	-	10.44	-	-	47.82	0.24	31.29	-	-	-	-	-	-	0.19	-	89.98
			-	-	-	7.12	-	-	59.55	0.27	32.94	-	-	-	-	-	-	0.13	-	100.00
6.9	Au-Ag telluride	-	-	-	-	21.32	-	-	33.72	-	20.83	0.02	-	-	0.04	-	-	-	-	75.93
			-	-	-	18.50	-	-	53.43	-	27.90	0.07	-	-	0.10	-	-	-	-	100.00
8.1	pyrite	FeS2	-	0.14	-	2.26	43.41	-	0.38	-	0.09	43.39	0.06	-	-	-	-	-	-	89.73
			-	0.09	-	0.53	62.99	-	0.16	-	0.03	36.15	0.05	-	-	-	-	-	-	100.00
8.2	pyrite	FeS2	-	-	-	52.44	17.94	-	6.37	-	0.13	7.17	-	-	6.03	-	-	-	-	90.08
			-	-	-	24.01	50.45	-	5.32	-	0.09	11.57	-	-	8.56	-	-	-	-	100.00
8.4	pyrite	FeS2	-	0.10	-	9.89	47.60	-	-	-	-	36.82	0.06	-	-	-	-	0.17	-	94.64
			-	0.06	-	2.29	67.56	-	-	-	-	30.01	0.05	-	-	-	-	0.04	-	100.00
8.5	calaverite	AuTe2	0.65	-	-	42.73	0.06	-	1.07	0.24	47.57	-	-	-	-	-	-	-	-	92.32
			1.34	-	-	35.47	0.28	-	1.63	0.32	60.96	-	-	-	-	-	-	-	-	100.00
8.6	Pyrite	FeS2	-	-	-	28.48	39.60	-	6.71	-	1.58	24.13	-	-	0.05	-	-	-	-	100.55
			-	-	-	7.66	65.45	-	3.30	-	0.66	22.90	-	-	0.04	-	-	-	-	100.00
9.1	Pyrite	FeS2	-	0.13	-	14.31	43.17	-	1.56	-	-	33.03	0.06	-	-	-	-	-	-	92.26
			-	0.09	-	3.58	66.40	-	0.71	-	-	29.17	0.05	-	-	-	-	-	-	100.00
9.2	Pyrite	FeS2	-	0.09	-	34.35	36.39	-	4.09	-	0.08	21.08	0.07	0.05	-	-	-	-	-	96.20
			-	0.07	-	10.09	65.66	-	2.20	-	0.03	21.84	0.07	0.05	-	-	-	-	-	100.00
9.3	Pyrite	FeS2	-	0.16	-	27.73	44.74	-	3.08	-	0.10	28.30	0.05	-	-	-	-	0.21	-	104.37
			-	0.11	-	6.78	67.20	-	1.38	-	0.04	24.41	0.04	-	-	-	-	0.05	-	100.00

Table 9. Continued.

Grain no.	Mineral	Formula	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
13.1	Au-Ag telluride	-	-	0.08	-	31.87	0.43	-	34.18	0.18	23.71	-	-	-	0.06	-	-	-	-	90.51
			-	0.16	-	23.75	1.96	-	46.50	0.22	27.27	-	-	-	0.14	-	-	-	-	100.00
13.2	Au-Ag telluride	-	-	0.13	-	68.01	-	-	23.38	0.11	11.97	-	-	-	-	-	-	-	-	103.60
			-	0.26	-	52.44	-	-	32.92	0.13	14.25	-	-	-	-	-	-	-	-	100.00
13.5	Au-Ag telluride	-	-	-	-	24.54	0.10	-	44.21	0.25	31.81	-	-	0.05	-	-	-	-	-	100.96
			-	-	-	15.78	0.38	-	51.90	0.26	31.57	-	-	0.11	-	-	-	-	-	100.00
13.4	Au-Ag telluride	-	-	-	-	34.51	0.10	-	43.54	0.12	25.64	-	0.07	-	-	-	-	-	-	103.98
			-	-	-	22.33	0.38	-	51.42	0.13	25.61	-	0.14	-	-	-	-	-	-	100.00
13.6	Au-Ag telluride	-	0.14	-	-	5.66	0.30	-	59.04	0.21	35.87	-	0.05	-	-	-	-	-	-	101.27
			0.20	-	-	3.30	1.08	-	62.85	0.20	32.28	-	0.10	-	-	-	-	-	-	100.00
13.7	Au-Ag telluride	-	0.19	-	-	23.78	0.24	-	45.79	0.16	31.47	-	-	-	-	-	-	-	-	101.63
			0.30	-	-	15.04	0.94	-	52.86	0.16	30.71	-	-	-	-	-	-	-	-	100.00
13.8	Au-Ag telluride	-	0.28	0.08	-	19.18	0.25	-	51.05	0.16	10.67	0.03	-	-	-	-	-	-	-	81.70
			0.53	0.17	-	14.57	1.18	-	70.78	0.19	12.51	0.08	-	-	-	-	-	-	-	100.00
13.9	Au-Ag telluride	-	-	-	-	46.82	0.09	-	33.01	0.16	16.94	-	-	-	-	-	-	-	-	97.02
			-	-	-	34.94	0.39	-	44.98	0.19	19.51	-	-	-	-	-	-	-	-	100.00
13.10.	Au-Ag telluride	-	0.10	-	-	23.35	0.10	-	28.08	-	18.30	-	-	-	-	-	-	-	-	69.93
			0.25	-	-	22.50	0.62	-	49.42	-	27.22	-	-	-	-	-	-	-	-	100.00
13.11	Au-Ag telluride	-	0.17	-	-	12.77	0.24	-	50.39	0.12	32.01	-	-	0.04	-	-	-	-	-	95.74
			0.28	-	-	8.16	0.95	-	58.81	0.12	31.58	-	-	0.09	-	-	-	-	-	100.00
13.12	Ag-Cu sulphide	-	-	-	-	43.18	8.38	-	37.16	-	2.35	-	-	-	5.71	-	-	-	-	96.78
			-	-	-	23.49	27.99	-	36.92	-	1.97	-	-	-	9.63	-	-	-	-	100.00
13.13	Ag-Cu sulphide	-	-	-	-	45.45	7.99	-	36.60	-	1.91	-	-	-	6.20	-	-	-	-	98.15
			-	-	-	24.76	26.74	-	36.42	-	1.61	-	-	-	10.48	-	-	-	-	100.00
13.14	Au-Cu sulphide	-	-	-	-	38.72	6.10	-	34.79	-	4.81	-	0.06	-	4.61	-	-	-	-	89.09
			-	-	-	23.96	23.17	-	39.31	-	4.60	-	0.12	-	8.85	-	-	-	-	100.00
13.15	Au-Ag telluride	-	-	-	-	49.27	0.06	-	34.16	0.10	21.02	-	-	0.04	-	-	-	-	-	104.65
			-	-	-	34.04	0.26	-	43.09	0.12	22.42	-	-	0.08	-	-	-	-	-	100.00
13.16	Au-Ag telluride	-	-	-	-	39.36	-	-	34.55	0.11	21.75	0.03	0.05	-	-	-	-	-	-	95.85
			-	-	-	28.84	-	-	46.23	0.13	24.61	0.08	0.11	-	-	-	-	-	-	100.00
13.16	Au-Ag telluride	-	-	-	-	48.69	0.19	-	25.34	-	25.81	0.04	-	-	-	-	-	-	-	100.07
			-	-	-	35.78	0.84	-	34.00	-	29.28	0.10	-	-	-	-	-	-	-	100.00
13.17	Au-Ag telluride	-	0.13	-	-	4.80	0.16	-	60.33	0.24	36.74	-	-	-	-	-	-	0.18	-	102.58
			0.19	-	-	2.77	0.55	-	63.49	0.22	32.68	-	-	-	-	-	-	0.10	-	100.00
13.18	Au-Ag telluride	-	0.10	-	-	27.90	0.50	-	34.66	0.11	19.54	-	-	0.03	-	-	-	-	-	82.84
			0.20	-	-	22.33	2.44	-	50.64	0.15	24.14	-	-	0.09	-	-	-	-	-	100.00

Table 9. Continued.

Grain no.	Mineral	Formula	Se	As	Pt	Au	S	Pd	Ag	Sb	Te	Fe	Co	Ni	Cu	Zn	Hg	Bi	Pb	Total
33.1	Ag-Cu sulphide	-	2.59	-	-	25.34	9.31	-	59.69	-	0.55	-	-	-	2.25	-	-	-	-	99.73
			3.14	-	-	12.31	27.79	-	52.95	-	0.41	-	-	-	3.40	-	-	-	-	100.00
33.2	Ag-Cu sulphide	-	2.58	-	-	23.46	8.80	-	58.17	-	0.58	-	-	0.05	4.43	-	-	-	-	98.07
			3.14	-	-	11.44	26.37	-	51.82	-	0.44	-	-	0.09	6.70	-	-	-	-	100.00
33.3	Au-Cu sulphide	-	2.33	-	-	31.60	10.54	-	48.65	-	0.17	-	-	-	6.19	-	-	-	-	99.48
			2.77	-	-	15.02	30.76	-	42.21	-	0.12	-	-	-	9.12	-	-	-	-	100.00
25.1	hessite	Ag2Te	-	-	-	0.37	-	-	61.16	0.25	37.55	-	-	-	-	-	-	-	-	99.33
			-	-	-	0.21	-	-	65.54	0.23	34.01	-	-	-	-	-	-	-	-	100.00
31.1	pyrite	FeS2	-	0.17	-	20.38	47.90	-	-	-	-	32.69	-	0.04	0.09	-	-	-	-	101.27
			-	0.11	-	4.73	68.30	-	-	-	-	26.77	-	0.03	0.06	-	-	-	-	100.00
31.2	pyrite	FeS2	-	0.18	-	23.51	35.78	-	0.28	-	-	26.50	-	-	-	-	-	-	-	86.25
			-	0.14	-	6.96	65.07	-	0.15	-	-	27.67	-	-	-	-	-	-	-	100.00
32.1	tellurbismuth	Bi2Te3	0.89	-	-	0.25	0.04	-	0.52	0.36	47.79	-	-	-	-	-	-	50.36	0.83	101.04
			1.75	-	-	0.20	0.19	-	0.76	0.46	58.42	-	-	-	-	-	-	37.60	0.63	100.00

APPENDIX 1

LIST OF SAMPLES

Sample number	Locality	Sample type	Sample description
FJ 01	Mount Kasi	Pan concentrate	Alluvium/colluvium (assays of colluvium show up to 30g/t gold).
FJ 02	Mount Kasi	Pan concentrate	Alluvium/colluvium (assays of colluvium show up to 30g/t gold).
FJ 03	Mount Kasi	Rock	High-grade barite in core of breccia collected from zone at south eastern end of Mount Kasi open cut.
FJ 04	Mount Kasi	Drill core	DC4 box 25, high-grade enargite ore from Done Creek prospect, adjacent to Mount Kasi Mine.
FJ 05	Mount Kasi	Drill core	R5 47m. High-grade breccia ore.
FJ 06	Mount Kasi	Rock	High-grade breccia material collected from zone at south eastern end of Mount Kasi open cut.
FJ 06	Mount Kasi	Rock	High-grade breccia material collected from zone at south eastern end of Mount Kasi open cut.
FJ 08	Mount Kasi	Pan concentrate	Heavily weathered breccia from the Nanduna Creek prospect. Gold content not known.
FJ 09	Mount Kasi	Pan concentrate	Done Creek immediately below Mt Kasi mine. Rare, small (<100µm) flecks of gold were observed.
FJ 10	Mount Kasi	Pan concentrate	Done Creek 500-1000m below Mt Kasi mine. Rare small (<100µm) flecks of gold were observed.
FJ 11	Vatukoula	Pan concentrate	Nasivi River 3km below main workings; no obvious gold, but much pyrite plus metallic mineral (telluride?).
FJ 12	Vatukoula	Rock	Samples from the 1800' to 1950' levels of the Matanagata workings of Emperor Gold Mine.

Sample number	Locality	Sample type	Sample description
FJ 13	Vatukoula	Rock	Samples from the 1800' to 1950' levels of the Matanagata workings of Emperor Gold Mine.
FJ 14	Vatukoula	Rock	Samples from the 1800' to 1950' levels of the Matanagata workings of Emperor Gold Mine.
FJ 16	Vatukoula	Rock	Samples from the 1800' to 1950' levels of the Matanagata workings of Emperor Gold Mine.
FJ 18	Vatukoula	Pan concentrate	1 km below mine collected from above confluence where a small creek which drains tailings pond meets the Nasivi River. Rare flakes of visible gold, plenty of magnetite.
FJ 19	Vatukoula	Pan concentrate	1km below mine collected from old alluvial terrace. No obvious visible gold, plenty of magnetite.
FJ 20	Vatukoula	Pan concentrate	1 km below mine collected from below confluence where a small creek which drains the tailings pond meets the Nasivi River. Rare flakes of visible gold, plenty of magnetite.
FJ 21	Vatukoula	Pan concentrate	From creek which drains tailings pond 1km below main mine
FJ 22	Vatukoula	Mill concentrate	Mill concentrate from Emperor Gold Mine.
FJ 23	Vuda	Pan concentrate	Collected from unconsolidated river gravels in the Vunda River 1km below main Vunda prospect. 2-4 colours per pan, with fine grained flour gold.
FJ 24	Tuvatu	Drill core	DDH 8 62.7m. Thin veins (1cm) of chalcedonic quartz in altered monzonite. Geo Pacific's Tuvatu prospect
FJ 25	Tuvatu	Drill core	DDH 8 62.4m. Thin veins (1cm) of chalcedonic quartz in altered monzonite. Geo Pacific's Tuvatu prospect

Sample number	Locality	Sample type	Sample description
FJ 26	Tuvatu	Drill core	DDH 8 67.2m. Thin veins (1cm) of chalcedonic quartz in altered monzonite. Geo Pacific's Tuvatu prospect
FJ 27	Tuvatu	Drill core	DDH 8 64.5m. Thin veins (1cm) of chalcedonic quartz in altered monzonite. Geo Pacific's Tuvatu prospect
FJ 29	Tuvatu	Drill core	DDH 8 60.2m. Thin veins (1cm) of chalcedonic quartz in altered monzonite. Geo Pacific's Tuvatu prospect
FJ 30	Tuvatu	Drill core	DDH 9 66.0m. Thin veins (1cm) of chalcedonic quartz in altered monzonite. Geo Pacific's Tuvatu prospect
FJ 31	Tuvatu	Drill core	DDH9 68.7m. Thin veins (1cm) of chalcedonic quartz in altered monzonite. Geo Pacific's Tuvatu prospect
FJ 32	Tuvatu	Pan concentrate	Pan concentrate from western creek; much magnetite with rare grains of gold
FJ 33	Tuvatu	Pan concentrate	Pan concentrate from Tuvatu creek; much magnetite and rare grains of gold.
FJ 34	Vuda	Pan concentrate	Collected upstream from the confluence of a small creek with Vunda River. The confluence is 100m downstream from locality FJ23.
FJ 35	Waimanu	Alluvial gold	Sample of alluvial gold (~30-40 grains) donated by the Mineral Resources Department, Fiji.