Preliminary Interpretation of Geology and Geochemical Results for the northern Bougainville Island Tenements of Kalia Limited: 
Implications for Copper and Gold Exploration

Work undertaken for Peter Batten and Terry Larkan

Presentation by Steve Garwin
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Figure 1: Simplified geology for the Kalia Limited tenement area in northern Bougainville Island. The majority of the claims consist of Pliocene to Pleistocene, andesitic to basaltic volcanic rocks of the Emperor Range (Cze - green) which host high K-alkaline, hornblende-bearing diorite to monzonite intrusions (Czd - orange), based on the photogeological interpretation supplied by Kalia. The lineaments (black lines), faults (blue lines) and queried intrusion (?) are summarized from the structural sketch map created from interpretations of radar imagery and aerial photography by the Federal Institute for Geosciences and Natural Resources (BGR) Hanover Federal Republic of Germany and the Geological Survey of Papua New Guinea (GSPNG) in 1990 (Bering et al., 1990). The main prospects of Kalia are indicated for reference.
Figure 2: Summary of diorite to monzonite intrusions (pink polygons), lineaments, faults and hydrothermal alteration (magenta polygons) inferred from radar imagery and aerial photography by the BGR / GSPNG (Bering et al., 1990). The Aita – Baiano clay (argillic) and quartz-alunite (advanced argillic) alteration zones and the main prospects of Kalia are indicated for reference. Note that many of the prospects occur along the margins of mapped or inferred intrusions.
**Figure 3:** Location of rock samples collected by Kalia that are described as intrusions (red squares), K-feldspar (potassic) alteration (magenta), epidote alteration (blue), quartz-alunite (advanced argillic) alteration (green) and porphyritic (black). The main prospects of Kalia are indicated for reference. K-feldspar (orthoclase) alteration typically occurs proximal to porphyry centers; epidote may occur in an intermediate setting (230-280°C); alunite is consistent with the advanced argillic zones that may overly porphyry centers. Aita, Kunai, Kaskuras, Perovasu and Petspets North are characterized by K-feldspar. In contrast the Melilup and Teoveane – Puspa areas lack K-feldspar alteration. Epidote occurs at Teoveane, Puspa, Teosiri and Perovasu. Aita - Baiano contains argillic and advanced argillic alteration, which may represent an epithermal overprint to a porphyry center.

**Summary of Rock Sample Descriptions**

<table>
<thead>
<tr>
<th>Area</th>
<th>Rock Sample Description</th>
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<tbody>
<tr>
<td>Aita</td>
<td>K-feldspar alteration, alunite, intrusions, porphyritic texture</td>
</tr>
<tr>
<td>Kaskuras</td>
<td>K-feldspar alteration and intrusions</td>
</tr>
<tr>
<td>Kunai Hills</td>
<td>K-feldspar alteration, intrusions and porphyritic texture</td>
</tr>
<tr>
<td>Melilup</td>
<td>Intrusions and porphyritic texture</td>
</tr>
<tr>
<td>Perovasu</td>
<td>K-feldspar alteration and intrusions</td>
</tr>
<tr>
<td>Petspets</td>
<td>K-feldspar alteration</td>
</tr>
<tr>
<td>Puspa</td>
<td>Intrusions</td>
</tr>
<tr>
<td>Tai Tai</td>
<td>--</td>
</tr>
<tr>
<td>Teosiri</td>
<td>Intrusions</td>
</tr>
<tr>
<td>Teoveane</td>
<td>Intrusions</td>
</tr>
</tbody>
</table>

**Rock Sample Legend**

- **Red** Intrusion
- **Pink** K-feldspar alteration
- **Blue** Epidote alteration
- **Green** Quartz-alunite alteration
- **Black** Porphyritic texture

**Geology**

- **Intrusion**
- **Hydrothermal alteration**

**Figure 3:** Location of rock samples collected by Kalia that are described as intrusions (red squares), K-feldspar (potassic) alteration (magenta), epidote alteration (blue), quartz-alunite (advanced argillic) alteration (green) and porphyritic (black). The main prospects of Kalia are indicated for reference. K-feldspar (orthoclase) alteration typically occurs proximal to porphyry centers; epidote may occur in an intermediate setting (230-280°C); alunite is consistent with the advanced argillic zones that may overly porphyry centers. Aita, Kunai, Kaskuras, Perovasu and Petspets North are characterized by K-feldspar. In contrast the Melilup and Teoveane – Puspa areas lack K-feldspar alteration. Epidote occurs at Teoveane, Puspa, Teosiri and Perovasu. Aita - Baiano contains argillic and advanced argillic alteration, which may represent an epithermal overprint to a porphyry center.
Figure 4: Geophysical lineament interpretation of Fathom Geophysics (Buckingham, 2019), shown with interpreted diorite to monzonite intrusions (pink polygons) and hydrothermal alteration (magenta polygons), and the Aita hydrothermal alteration zones of Kalia. The main prospects of Kalia are indicated for reference.
Figure 5: Shuttle Radar Topographic Mission (SRTM) image, showing interpreted diorite to monzonite intrusions, lineaments, faults and hydrothermal alteration zones. The Aita – Baiano clay (argillic) and quartz-alunite (advanced argillic) alteration zones and the main prospects of Kalia are indicated for reference. Note that many of the prospects occur along the flanks of the central topographic highs that comprise the Emperor Range. The central portion of this range is inferred to be hydrothermally altered by the BGR / GSPNG (Bering et al., 1990) and has yet to be accessed by Kalia. This area of interest represents a target for future exploration (dark red outline).
Figure 6: Reduced-to-the-pole magnetics pseudo-gravity image (100 – 1600m residual) and medium- to high-level, elliptical magnetic highs (grey and black polygons, respectively – after Fathom Geophysics, 2019), shown with interpreted diorite to monzonite intrusions, lineaments, faults and hydrothermal alteration zones. The Aita – Baiano clay (argillic) and quartz-alunite (advanced argillic) alteration zones and the main prospects of Kalia are indicated for reference. Many of the prospects form a cluster that lie above a major magnetic high in the eastern part of the area (see dashed red outline in overlay). Aita, Kaskuras, Kunai Hills and Petspets North are associated with discrete magnetic highs. Several of the interpreted intrusions and hydrothermal alteration zones lie near the margins or apices of magnetic highs.
Figure 7: Reduced-to-the-pole magnetics edge-enhancement image (400m – 10km residual) and medium- to high-level magnetic highs (grey and black polygons, respectively), shown with interpreted diorite to monzonite intrusions, lineaments, faults and hydrothermal alteration zones. The Aita – Baiano clay (argillic) and quartz-alunite (advanced argillic) alteration zones and the main prospects of Kalia are indicated for reference. The image enhances magnetic gradients and the edge of the inferred batholith complex (red dashed outline in overlay). Aita, Teoveane, Puspa, Kaskuras, Tai Tai and Melilup lie in prospective settings along the margin of the inferred batholith, near elliptical magnetic highs that have the potential to represent mineralized cupolas.
Figure 8: Diagram showing V/Sc vs SiO₂ in whole-rock analyses of least-altered Cu-Au mineralized vs barren magmatic systems (after Loucks, 2014). The whole-rock geochemical results for the Kalia claim area (Rogerson et al., 1989) indicate a common range of 55 to 61% SiO₂. The assays from Kalia rock-chips typically show V/Sc of 10 to 40. This indicates that the parent magmas for the hornblende-bearing intrusions and volcanic rocks in the Kalia tenements are hydrous and potentially fertile for the production of copper-gold-bearing deposits.

Trend to high V/Sc related to elevated H₂O in the melt and/or elevated pressure. This facilitates the advance of hornblende crystallization relative to titanomagnetite, which favours the incorporation of V in the residual melt (rather than in titanomagnetite) with Sc extracted from the melt into hornblende.
Figure 9: Vertical hydrothermal alteration and mineralization model in porphyry Cu-(Mo-Au) systems as summarized by the MDRU-study, which is based on more than 12 porphyry deposits in North and South America, including the vertical reconstruction of the Yerington porphyry copper deposit in southeastern Nevada, USA (Cohen, 2011 and Halley et al., 2015). There is a common zoning in the hydrothermal alteration to porphyry systems, characterized by a core of biotite + K-feldspar (potassic, > 300°C), proximal actinolite- through epidote-propylitic (300 to 230°C) to distal chlorite-calcite propylitic (< 230°C) alteration. In many systems, these early-stage alteration zones are overprinted by transitional-stage chlorite-sericite-clay (intermediate argillic); and late-stage quartz-sericite (sericitic-phyllic) and quartz-alunite-pyrophyllite-dickite (advanced argillic) alteration. A similar zoning in sulphide minerals occurs, characterized by central, higher-temperature bornite-chalcopyrite, proximal chalcopyrite-pyrite and distal, lower-temperature pyrite-chalcopyrite-sphalerite-galena. This last assemblage is common in the late-stage, intermediate-sulfidation epithermal veins that locally flank porphyry systems.
There is a consistent element distribution in global porphyry systems. Local discrepancies in metal sequence may reflect late argillic overprints or varying $\text{H}_2\text{O}:\text{CO}_2:S$ proportions of the ore fluid. Distribution of Au-Ag varies and is partially controlled by oxidation / sulfidation state, temperature and metal-complex speciation.

**Figure 10:** Vertical geochemical dispersion model in porphyry Cu-(Mo-Au) systems as summarized by the MDRU-study, which is based on more than 12 porphyry deposits in North and South America, including the vertical reconstruction of the Yerington porphyry copper deposit in southeastern Nevada, USA (Cohen, 2011 and Halley et al., 2015). The geochemical zoning illustrated in this model forms the basis for the interpretation of the stream-sediment and rock samples in the Kalia tenements of northern Bougainville Island.

**Note:** Absolute elemental values will vary

![Diagram](image)
Figure 11: Zoning of polymetallic replacement deposits in map-view for the Main Tintic district in Utah, USA (Morris, 1986), showing the zoning outwards from a Cu-Au zone proximal to the causal intrusion through an intermediate Pb-Ag zone to a distal zone of Zn-Mn. The metal zoning in this map is consistent with that shown in the cross-section in the previous figure. The ratios of Cu/Zn, Pb/Zn, Au/Ag, Ag/Pb and Mo/Mn increase with proximity to the causal intrusion (i.e., in the direction of increasing temperature of mineralization).
Figure 12: Summary of gold in stream-sediment samples published by the GSPNG (Rogerson et al., 1989), shown with interpreted intrusions and hydrothermal alteration. The Aita – Baiano clay and quartz-alunite alteration zones, outline of the major magnetic high (inferred batholith) and the main prospects of Kalia are indicated for reference. The yellow polygons in the overlay indicate catchments with more than 50 ppb gold (0.05 ppm Au) in stream-sediment. Note that Au > 50 ppb occurs in the vicinity of the Aita, Kaskuras, Perovasu, Tai Tai, Mellilup and Petspets North. No historic stream sediment samples are reported for the Kunai Hills area. Many of the streams that lie west of Aita and Perovasu are anomalous with respect to gold. This area should be investigated by Kalia Limited (see Figures 14 and 16).
Figure 13: Summary of tellurium in stream-sediment samples published by the GSPNG (Rogerson et al., 1989), shown with interpreted intrusions and hydrothermal alteration. The Aita – Baiano clay and quartz-alunite alteration zones, outline of the major magnetic high (inferred batholith) and the main prospects of Kalia are indicated for reference. The yellow polygons in the overlay indicate catchments with more than 0.3 ppm Te in stream-sediment. Note that Te > 0.3 ppm occurs in the vicinity of the Aita, Teoveane, Puspa, Teosiri, Tai Tai, Melilup, Petspets North and some catchments that lie outside the known prospects. No historic stream sediment samples are reported for the Kunai Hills area.
Figure 14: Summary of copper in stream-sediment samples, shown with interpreted intrusions and hydrothermal alteration. The Aita – Baiano clay and quartz-alunite alteration zones, outline of the major magnetic high (inferred batholith) and the main prospects of Kalia are indicated for reference. The green polygons in the overlay indicate catchments with more 125 ppm Cu in stream-sediment. Note that Cu > 125 ppm occurs in the vicinity of the Aita, Perovasu, Teoveane and Teosiri. No historic stream sediment samples are reported for the Kunai Hills area. Many of the streams that lie west of Aita and Perovasu are anomalous with respect to copper (and gold), as indicated by the dashed purple outline in the final overlay. This area should be investigated by Kalia Limited, in addition to the follow-up of the mineralization already discovered in he known prospect areas, as described in Figures 26 to 34.
Figure 15: Summary of zinc in stream-sediment samples, shown with interpreted intrusions and hydrothermal alteration. The Aita – Baiano clay and quartz-alunite alteration zones, outline of the major magnetic high (inferred batholith) and the main prospects of Kalia are indicated for reference. The light blue polygons in the overlay indicate catchments with less than 150 ppm Zn in stream-sediment. Note that Zn < 150 ppm occurs in the vicinity of the Aita, Perovasu, Teosiri and Petspets North. No historic stream sediment samples are reported for the Kunai Hills area. Many of the streams that lie west of Aita and Perovasu are anomalously low with respect to zinc (with high copper and gold). This area should be investigated by Kalia Limited.
Figure 16: Summary of Cu/Zn in stream-sediment samples, shown with interpreted intrusions and hydrothermal alteration. The light green polygons in the overlay indicate catchments with Cu/Zn > 1 in stream-sediment. Note that Cu/Zn > 1 occurs in the vicinity of the Aita, Perovasu and Petspets North. Many of the streams that lie west of Aita and Perovasu and south of Mellilup are anomalously high with respect to Cu/Zn. This same area is flanked by anomalous gold (see overlay), which is consistent with the presence of a porphyry Cu-Au system(s). This prospective region (dashed purple outline in final overlay) should be investigated by Kalia Limited.
Figure 17: Summary of V/Sc in outcrop and rock-float collected by Kalia Limited, shown with interpreted intrusions and hydrothermal alteration. The Aita–Baiano clay and quartz-alunite alteration zones, outline of the major magnetic high (inferred batholith) and the main prospects of Kalia are indicated for reference. As indicated in Figure 8, V/Sc > 10 is characteristic of fertile and hydrous magmas related to global porphyry copper- (gold) systems. The results indicate rocks with V/Sc > 10 for all prospects sampled to date. The highest V/Sc values are from Kunai Hills and Aita.
Figure 18: Summary of gold in outcrop and rock-float collected by Kalia Limited, shown with interpreted intrusions and hydrothermal alteration. The highest gold results are from the Teoveane, Puspa, Perovasu and Melilup areas, with maxima ranging from 1.6 to 10 ppm Au. The overlay shows the anomalous gold catchments from GSPNG work (Rogerson et al., 1989), which indicate that the catchments to the west of Aita and Perovasu may contain greater amounts of gold than the streams already sampled by Kalia Limited.
Figure 19: Summary of molybdenum in outcrop and rock-float collected by Kalia Limited, shown with interpreted intrusions and hydrothermal alteration. The highest molybdenum (Mo) results are from the Perovasu and Aita areas with significant Mo present at Puspa, Teoveane, Teosiri, Petspets North and Kunai Hills. Molybdenum is a good proximity indicator for potential porphyry copper-(gold) systems, as shown in Figure 10.
Figure 20: Summary of copper in outcrop and rock-float collected by Kalia Limited, shown with interpreted intrusions and hydrothermal alteration. The highest copper (Cu) results are from the Aita, Perovasu, Teoveane and Teosiri areas. The overlay shows the anomalous copper catchments, which indicate that the catchments to the west of Aita and Perovasu may contain the same or greater amounts of copper than the streams already sampled by Kalia Limited.
Figure 21: Summary of arsenic in outcrop and rock-float collected by Kalia Limited, shown with interpreted intrusions and hydrothermal alteration. The highest arsenic results (As > 100 ppm) are from Aita, Teoveane and the streams south of Melilup. Anomalous arsenic (As > 50 ppm) occurs at Puspa and Teosiri. The rock samples from Kunai Hills are low in arsenic. Figure 10 indicates that arsenic occurs in the upper-levels or distal portions of porphyry systems. However, telescoping of ore systems will produce an arsenic overprint to Cu-Mo-rich porphyry centers.

**Arsenic in Rock Samples**
- > 300 (max = 6630 ppm)
- 100 - 300
- 50 - 100
- 30 - 50
- < 30

Outline of magnetic high – inferred batholith

Aita – Baiano clay alteration

Aita – Baiano quartz-alunite alteration zone

Outcrop As

Kunai Hills

Teosiri

Kaskuras-Pasuna

Perovasu

Kunai Hills

Mellilup

Tai Tai

Teoveane

Puspa

Petspets North

Geology (Photo Geology Interpretation)

- Intrusion
- Hydrothermal alteration

5000 m
Figure 22: Summary of Cu/Zn in outcrop and rock-float collected by Kalia Limited, shown with interpreted intrusions and hydrothermal alteration. The highest Cu/Zn results occur at Aita, Teoveane, Perovasu and Kunai Hills. Aita, Perovasu and Kunai Hills are also characterized by anomalous molybdenum. Hence, all three of these areas show potential for a porphyry center on the basis of rock geochemical results.

Outcrop Cu/Zn
Figure 23: Summary of outcrop and rock-float geochemical results averaged by area in the northern Bougainville tenements of Kalia Limited, shown with interpreted intrusions and hydrothermal alteration. Refer to Table 1 and the accompanying spread-sheet for details and a more comprehensive report of elemental values. On the basis of the average geochemical results, Aita and Kunai show the best potential for porphyry copper-(gold) systems (por); the Teoveane – Perovasu – Puspa – Teosiri region more prospective for epithermal gold mineralization (epi). These three areas are recommended for follow-up exploration by Kalia Limited. An additional target is interpreted on the basis of steam-sediment Cu and Cu/Zn results and magnetics. Refer to Figures 26 to 34 for a more detailed illustration of the three southern targets.

Outline of magnetic high – inferred batholith

<table>
<thead>
<tr>
<th>Area</th>
<th>Anomalous Average Elements in Rock Samples</th>
</tr>
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<tbody>
<tr>
<td>Aita</td>
<td>As, Cu, Mo, low Mn, Fe, S, V/Sc, Cu/Zn, Pb/Zn, Mo/Mn</td>
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<tr>
<td>Kaskuras</td>
<td>Li</td>
</tr>
<tr>
<td>Kunai Hills</td>
<td>Mo, high Mn, Fe, V/Sc, Cu/Zn, Pb/Zn</td>
</tr>
<tr>
<td>Melilup</td>
<td>--</td>
</tr>
<tr>
<td>Perovasu</td>
<td>--</td>
</tr>
<tr>
<td>Petspets</td>
<td>Li, K, Na</td>
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<tr>
<td>Puspa</td>
<td>Li, Mo, Zn, Mo/Mn</td>
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<tr>
<td>Tai Tai</td>
<td>K, Na, Fe, V/Sc</td>
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<tr>
<td>Teosiri</td>
<td>Au, Ag, Cu, Li, Pb, Zn, W, K, Fe, Cu/Zn</td>
</tr>
<tr>
<td>Teoveane</td>
<td>Au, As</td>
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</table>

Geology [Photo Geology Interpretation]

- Intrusion
- Hydrothermal alteration

5000 m

Aita – Baiano clay alteration
Aita – Baiano quartz-alunite alteration zone
**Figure 24:** Summary of outcrop and rock-float geochemical results averaged by area showing rock samples that describe intrusions (red squares), K-feldspar (potassic) alteration (magenta), epidote alteration (blue), quartz-alunite (advanced argillic) alteration (green) and porphyritic texture (black). The integration of the average geochemical results with field observations support the interpretation of potential porphyry centers at Kunai and Aita, and the potential for epithermal gold mineralization at Teoveane and Teosiri. The target south of Melilup is inferred from stream-sediment results and magnetics. The presence of K-feldspar alteration at Perovasu may indicate higher temperatures of hydrothermal alteration than for the nearby prospects and/or a transitional setting for mineralization.
Table 1: Summary of outcrop and rock-float geochemical results averaged by area in the northern Bougainville tenements of Kalia Limited. Refer to figures 23 and 24 for the distribution of the prospect areas. The anomalous threshold values for the Yerington porphyry system, Nevada USA (Halley et al, 2015) are shown for reference. Refer to Figure 10 for the distribution of these elements in a re-constructed cross-section for Yerington. In this table, significantly anomalous results are highlighted by bold text.

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<tr>
<th>Prospect</th>
<th>Sample Type</th>
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<th>Fe_pct</th>
<th>S_pct</th>
<th>V_Sc</th>
<th>Cu_Zn</th>
<th>Pb_Zn</th>
<th>Mo_Mn</th>
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<tr>
<td>Aita</td>
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<td>6.4</td>
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<td>Puspa ¹</td>
<td>Float / OC</td>
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Notes: Significantly anomalous values are indicated by bold text. Below detection limit average values are represented as blank entries

The anomalous thresholds of Halley et al. (2015) are indicated for the zoning about a Yerington-like porphyry system (see figures in presentation for reference)

¹ Puspa average is strongly biased by one sample that contains molybdenite (411 ppm Mo).
² Teosiri average is biased by one sample that contains high Au, Ag, Cu, Pb and Zn.
Oc = outcrop
Figure 25: Targets created by Fathom Geophysics (Buckingham, 2019) shown with interpreted intrusions and hydrothermal alteration (Bering et al., 1990), the Aita – Baiano alteration mapped by Kalia Limited and elliptical magnetic highs. The areas of interest recommended in Figures 23 and 24 are shown for comparison to the Fathom targets. Refer to the subsequent figures for a more detailed illustration of Aita and the Teoveane – Perovasu – Puspa – Teosiri area. Three of the Fathom targets lie within catchments characterized by anomalous copper in stream-sediment, which are recommended for follow-up exploration by Kalia (purple dashed outline in final overlay).
Figure 26: Summary of field-note descriptions of rock samples for the Aita, Teoveane, Puspa, Perovasu, Teosiri and Kaskuras areas, showing interpreted intrusions and hydrothermal alteration, and the elliptical magnetic highs generated by Fathom Geophysics (c.f. Figures 6 and 7). The Aita – Baiano clay and quartz-alunite alteration zones and the outline of the major magnetic high (inferred batholith) are indicated for reference. Aita, Kaskuras and Perovasu are characterized by K-feldspar alteration, which is consistent with proximity to a porphyry center. In contrast the Teosiri, Teoveane and Puspa areas lack K-feldspar alteration. Epidote occurs at Teoveane, Puspa, Teosiri and Perovasu, which suggests a less proximal setting with respect to causal intrusions. Aita - Baiano contains argillic (clay) and advanced argillic (alunite) alteration, which may represent an epithermal overprint to a porphyry center. The final overlay shows prospective Cu-Au areas that are suggested Kalia consider for ridge-and-spur (or grid) soil sampling and geological mapping using the Anaconda method. First priority is given to Aita, Teoveane, Perovasu and the stream that lies south of Melilup (purple outlines) and second priority is accorded to Teosiri (red outline). The following figures illustrate the relationship of rock geochemical results to interpreted geology and the magnetic highs.
Figure 27: Summary of V/Sc in outcrop and rock-float for the Aita, Teoveane, Puspa, Perovasu, Teosiri and Kaskuras areas, showing interpreted intrusions and hydrothermal alteration, and the elliptical magnetic highs generated by Fathom Geophysics (c.f. Figures 6 and 7). The Aita – Baiano clay and quartz-alunite alteration zones and the outline of the major magnetic high (inferred batholith) are indicated for reference. The final overlay shows the suggested areas that Kalia consider for follow-up exploration. First priority is given to Aita, Teoveane, Perovasu and south Melilup (purple outlines) and second priority is accorded to Teosiri (red outline).

Outcrop V/Sc

V/Sc in Rock Samples
- > 20
- 15 - 20
- 10 - 15
- 7 - 10
- 1 - 7

Outline of magnetic high – inferred batholith
- Higher-level magnetic high (MI-mrad 800m diameter)
- Medium-level magnetic high (MI-mrad 1600m diameter)

Legend:
- Intrusion
- Hydrothermal alteration
- Aita – Baiano clay alteration
- Aita – Baiano quartz-alunite alteration zone

2000 m
Figure 28: Summary of gold in outcrop and rock-float for the Aita, Teoveane, Puspa, Perovasu, Teosiri and Kaskuras areas, showing interpreted intrusions and hydrothermal alteration, and the elliptical magnetic highs generated by Fathom Geophysics (c.f. Figures 6 and 7). The Aita–Baiano clay and quartz-alunite alteration zones and the outline of the major magnetic high (inferred batholith) are indicated for reference. All significantly anomalous gold occurs in the Teoveane, Puspa, Perovasu and Teosiri area. The Aita area is low in gold. Gold anomalous catchments (based on data of Rogerson et al., 1989) cover the Kaskuras and Aita prospects and identify several catchments of interest to the west of Perovasu and Aita. The final overlay shows the suggested areas that Kalia consider for follow-up exploration. First priority is given to Aita, Teoveane, Perovasu and south Melilup (purple outlines) and second priority is accorded to Teosiri (red outline).
Figure 29: Summary of molybdenum in outcrop and rock-float for the Aita, Teoveane, Puspa, Perovasu, Teosiri and Kaskuras areas, showing interpreted intrusions and hydrothermal alteration, and the elliptical magnetic highs generated by Fathom Geophysics (c.f. Figures 6 and 7). The Aita – Baiano clay and quartz-alunite alteration zones and the outline of the major magnetic high (inferred batholith) are indicated for reference. The areas of anomalous Mo occur at Teoveane, Perovasu and Aita. The final overlay shows the suggested areas that Kalia consider for follow-up exploration. First priority is given to Aita, Teoveane, Perovasu and south Melilup (purple outlines) and second priority is accorded to Teosiri (red outline).
Figure 30: Summary of copper in outcrop and rock-float for the Aita, Teoveane, Puspa, Perovasu, Teosiri and Kaskuras areas, showing interpreted intrusions and hydrothermal alteration, and the elliptical magnetic highs generated by Fathom Geophysics (c.f. Figures 6 and 7). The Aita – Baiano clay and quartz-alunite alteration zones and the outline of the major magnetic high (inferred batholith) are indicated for reference. Relatively high copper values occur at Teosiri, Teoveane and Aita. Copper anomalous catchments cover the Perovasu and Aita areas and show a large area of interest to the west of Aita. The final overlay shows the suggested areas that Kalia consider for follow-up exploration. First priority is given to Aita, Teoveane, Perovasu and south Melilup (purple outlines) and second priority is accorded to Teosiri (red outline).

<table>
<thead>
<tr>
<th>Copper in Rock Samples</th>
<th>Value in percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 1000</td>
<td>Rock sample &gt; 1000 ppm Cu,</td>
</tr>
<tr>
<td>500 - 1000</td>
<td>Value in percent</td>
</tr>
<tr>
<td>300 - 500</td>
<td></td>
</tr>
<tr>
<td>100 - 300</td>
<td></td>
</tr>
<tr>
<td>&lt; 100</td>
<td></td>
</tr>
</tbody>
</table>

**Outcrop Cu**

- Teosiri
- Perovasu
- Teoveane
- Puspa
- Kaskuras-Pasuna
- Aita

**Copper in Rock Samples**

- > 1000 ppm Cu
- 500 - 1000 ppm Cu
- 300 - 500 ppm Cu
- 100 - 300 ppm Cu
- < 100 ppm Cu

**Legend**

- Higher-level magnetic high (MI-mrad 800m diameter)
- Medium-level magnetic high (MI-mrad 1600m diameter)
- Intrusion
- Hydrothermal alteration
- Aita – Baiano clay alteration
- Aita – Baiano quartz-alunite alteration zone
- Cu in stream-sediment > 125 ppm

**Orientation**

- North (N)
- Scale: 2000 m
Figure 31: Summary of arsenic in outcrop and rock-float for the Aita, Teoveane, Puspa, Perovasu, Teosiri and Kaskuras areas, showing interpreted intrusions and hydrothermal alteration, and the elliptical magnetic highs generated by Fathom Geophysics (c.f. Figures 6 and 7). The Aita – Baiano clay and quartz-alunite alteration zones and the outline of the major magnetic high (inferred batholith) are indicated for reference. The Teoveane and Aita areas are high in arsenic. The final overlay shows the suggested areas for Kalia to consider follow-up exploration. First priority is given to Aita, Teoveane, Perovasu and south Melilup (purple outlines) and second priority is accorded to Teosiri (red outline).

Outcrop As

![Outcrop As diagram]

Arсенел в образцах горных пород

> 300
100 - 300
50 - 100
30 - 50
< 30

Схема распределения арсенала в образцах горных пород.

Наглядное представление геохимического профиля с использованием геофизических методов.

Гидротермально-метаморфические зоны.

Инфернал батолит.

Верхний геомагнитный аномалии (МИ-мрад 800м диаметра)

Средний геомагнитный аномалии (МИ-мрад 1600м диаметра)

Инфаркт батолит.

Вулканы и складки.

Месторождения арсенала.

Геологические карты с указанием аномалий große.

Возможная зона рудных месторождений.

Перспективные зоны для дальнейших исследований.

Первая приоритетная зона: Aita, Teoveane, Perovasu и южная Melilup (фиолетовые линии).

Вторая приоритетная зона: Teosiri (красные линии).
Figure 32: Summary of V/Sc in outcrop and rock-float for the Aita, Teoveane, Puspa, Perovasu, Teosiri and Kaskuras areas, showing interpreted intrusions and hydrothermal alteration, and the elliptical magnetic highs generated by Fathom Geophysics (c.f. Figures 6 and 7). The Aita – Baiano clay and quartz-alunite alteration zones and the outline of the major magnetic high (inferred batholith) are indicated for reference. The highest Cu/Zn occurs in the Aita, Teoveane and Perovasu areas. The final overlay shows the suggested follow-up exploration areas. First priority is given to Aita, Teoveane, Perovasu and south Melilup (purple outlines) and second priority is accorded to Teosiri (red outline).
Figure 33: Comparison of Cu-Au targets created by Fathom Geophysics (Buckingham, 2019) with those defined on the basis of geology and geochemical results in the present study for the Aita, Teoveane, Puspa, Perovasu, Teosiri and Kaskuras areas. The suggested target areas from this study lie near five of the Fathom targets. Three of the Fathom targets occur within catchments characterized by anomalous copper, gold and Cu/Zn in stream-sediment, which are recommended for follow-up exploration (magenta dashed outline in overlay).
Figure 34: Comparison of Cu-Au targets created by Fathom Geophysics (Buckingham, 2019) with those defined on the basis of geology and geochemical results in the present study for the Aita, Teoveane, Puspa, Perovasu, Teosiri and Kaskuras areas. The suggested target areas from this study (dashed red and purple outlines) lie near five of the Fathom targets. Three of the Fathom targets occur within catchments characterized by anomalous copper, gold and Cu/Zn in stream-sediment, which are recommended for follow-up exploration (magenta dashed outline in overlay). The final two overlays show the approximate location of gold and copper anomalous catchments for reference.

It is suggested that the Kalia geological team delineate, rate and rank exploration targets based on the results described in this study, the work of Fathom Geophysics (Buckingham, 2019) and Kalia’s understanding of the tenement area, including geological, geochemical, logistical and social aspects. The field-based team has the greatest chance of selecting the targets with the highest potential to lead to the discovery of a copper-gold deposit.
Figure 35: Simplified geological map and summary of copper and gold rock geochemical results for the Baiano area of the Aita prospect of Kalia Limited in the northern portion of Bougainville Island (from page 13 of the AGM report of Kalia Limited, 29 November 2018). The local magnetic high as processed by Fathom Geophysics (Buckingham, 2019) and the mapped quartz-alunite ridge of Kalia are shown for reference in the first overlay. The recommended area for soil sampling and geological mapping (1:2,000-scale) using the Anaconda method is indicated by the dashed purple ellipse in the final overlay. The outcome of this mapping will assist in estimating the depth to a porphyry copper target, which may range from a few hundred meters to one kilometer.
Conclusions and Recommendations

Geological and Geochemical Interpretation of Bougainville Island Tenements of Kalia Limited

- Kalia has compiled and collected geochemical sample data for a total of 429 rocks, 316 stream sediments and 68 panned concentrates.
- The recently completed airborne magnetics-radiometrics survey is a major advancement in the exploration of this under-explored region.
- The field-notes, geochemical results, geological mapping and geophysical signature make for a good foundation of the interpretation for the settings of mineralization and the delineation of copper-gold exploration targets moving forward.
- Significant potential exists for porphyry Cu-Au and epithermal Au deposits given the hydrous and fertile nature of the K-rich magmas that form the Plio-Pleistocene diorite to monzonite intrusions and basaltic to andesitic volcanic rocks in the tenement area.
- The style of hydrothermal alteration and mineralization discovered to date compares favourably to other porphyry-epithermal systems in SE Asia and the SW Pacific, prior to the discovery of major deposits (e.g., Batu Hijau and Elang, Indonesia).
- Geochemical results, consisting of Cu, Mo, Au, Zn, As, Cu/Zn, V/Sc and field-note alteration mineral assemblages, support the interpretation of potential Cu-(Au) porphyry / intrusive centers at Aita, Kunai Hills and possibly Perovasu and south of Melilup.
- Epithermal gold potential exists in the Teoveane, Teosiri and Puspa areas, which are interpreted to represent lower-temperature settings.
- Several target areas have been delineated on the basis of geology, geochemical results and airborne magnetics, which will benefit from follow-up in the field: these include Aita, Perovasu, Teoveane, Melilup South, Teosiri and Kunai Hills, which can be progressed towards the drill-stage by ridge-and-spur- and grid-soil sampling and geological mapping using the Anaconda mapping method.
- Future geological mapping should emphasize the distribution and mineral assemblages of intrusions; presence of ‘quartz-eye’ phenocrysts; abundance of fractures and porphyry-related, granular quartz veins (B-type veins of Gustafson and Hunt, 1975); sulphide and oxide mineral abundances; magnetite veinlets; and hydrothermal alteration zones, including epidote, actinolite, K-feldspar and biotite.
- Consider the use of helicopter-supported, diamond drill rigs capable of drilling NQ- or BQ-diameter core to depths of 1000 m.
- The analysis of geochemical samples should include a four-acid digest with an ICP-MS finish for > 30 elements and low detection-limits for key trace-elements (e.g., 0.1 ppm for Bi, Se and Te); gold should continue to be analysed by fire-assay.
- A 12 km by 5 km area of anomalous Cu-Au in stream sediment samples is located to the west of Perovasu and Aita and should be investigated with the collection of additional stream-sediment, panned mineral concentrate and rock samples.
- It is recommended that the Kalia geological team delineate, rate and rank exploration targets based on the results described in this study, the work of Fathom Geophysics (Buckingham, 2019) and Kalia’s understanding of the tenement area, incorporating geological, geochemical, logistical and social aspects.
- The field-based team has the greatest chance of selecting the targets with the highest potential to lead to the discovery of a copper-gold deposit.
Citation of References

Geological and Geochemical Interpretation of Bougainville Island Tenements of Kalia Limited


Loucks, R., 2014, Distinctive composition of copper-ore-forming arc magmas: Centre for Exploration Targeting, School of Earth and Environment, University of Western Australia, Crawley, WA 6009, Australia, p. 5-16.
