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COMPANY: ACH Minerals Pty Ltd  
ATTENTION: Paul Bennett  
FROM: Graeme Campbell  
SUBJECT: Ravensthorpe Gold Project: Appraisal of Mercury Status of Waste-Rock Streams within **Kundip Deposits** (Kaolin, Harbour View and Flag)  
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Paul,

The following is intended to show that, in terms of Hg occurrences, the environmental geochemistry of the waste-rock streams associated with the **Kundip Deposits** (Kaolin, Harbour View and Flag) are:

- (a) consistent with the **extremely weak – almost non-existent – Hg-enrichment** characteristic of gold deposits located on the Yilgarn block (Campbell, unpublished results since the late-1980s)
- (b) fundamentally distinct from the significant Hg enrichment within the **Trilogy Deposit**

Supporting information on geology, assaying from drilling programmes, and testwork programmes on environmental geochemistry, are outlined below.

### **1.0 GEOLOGY**

The distinction between time of inception, geology and mineralisation styles within the Kundip and Trilogy Deposits is shown in **Attachment I**.

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In essence, [the geology, mineralogy and composition – including Hg status – of the ores and country rocks for the Kundip and Trilogy Deposits are fundamentally different.](#)

## 2.0 DRILLING ASSAYS

A review of assays of waste rock from drilling programmes for the Kundip Deposits is the subject of the GCA (2018) report:

- Graeme Campbell & Associates Pty Ltd, 2018, "Ravensthorpe Gold Project: Review of Assays from Geological Database in Conjunction with Historic GCA-Reports – Geochemical Character of Mining / Processing Streams and Implications for Mine-Waste, LG-Ore and Tailings Management (Harbour View, Flag, and Kaolin Deposits)", unpublished report prepared for ACH Minerals Pty Ltd

[Across all Deposits \(Kaolin, Harbour View and Flag\), the Hg content was less than the detection-limit of 1 mg/kg for 222 assayed samples](#) comprising:

- 91 samples from the Oxide-Waste-Zone
- 35 samples from the Transition-Waste-Zone
- 83 samples from the Fresh-Waste-Zone
- 2 samples of LG-Oxide-Ore
- 4 samples of LG-Transition-Ore
- 7 samples of LG-Fresh-Ore

Although S and multi-element assays for 1,073 samples were reviewed in the GCA (2018) investigation, only 222 were assayed for Hg, since Hg is not a feature of Kundip geochemistry for exploration and ore-delineation purposes.

Typically, Hg contents within, and often well within, the [sub-mg/kg range](#) are recorded for mine-waste streams produced at local gold mines – [the above Hg assays for the Kundip Deposits are, in this regard, simply "more of the same" for a typical WA gold-mine.](#)

## 3.0 ENVIRONMENTAL GEOCHEMISTRY INVESTIGATIONS

### 3.1 Waste Rock & LG-Ores

Earlier geochemical testing of mine-waste and LG-ore samples from the [Harbour View Deposit](#) forms the subject of the GCA (2004) report:

- Graeme Campbell & Associates Pty Ltd, 2004, "Kundip & Trilogy Projects: Geochemical Characterisation of Mine-Waste Samples – Implications for Mine-Waste Management", unpublished report prepared for Tectonic Resources NL

Of the 3 samples of mine-waste and 3 samples of LG-ores tested, all samples, but one, had Hg contents less than 0.1 mg/kg; for two samples, the Hg contents were less than the detection-limit of 0.01 mg/kg. The LG-Transition-Ore sample had a Hg content of 0.18 mg/kg.

The results from the GCA (2004) study are therefore [below, or close to, the Hg contents typically recorded for soils, regoliths and bedrocks derived from unmineralised terrain](#)

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(Bowen 1979).<sup>1</sup>

## 3.2 Tailings

### 3.2.1 Historical Testing

Earlier geochemical testing of process-tailings samples forms the subject of the GCA (2005) report:

- Graeme Campbell & Associates Pty Ltd, 2005, "Phillips River Project: Geochemical Characterisation of Process-Tailings-Slurry Samples – Implications for Process-Tailings Management", unpublished report prepared for Tectonic Resources NL

The Oxide-Ore-Tailings-Solids sample had a Hg content of 0.82 mg/kg, and the Primary-Ore-Tailings-Solids sample had a Hg content of 0.09 mg/kg.

### 3.2.2 Testing Currently In-Hand

A programme of geochemical testing is currently in hand for samples of process-tailings to be produced during the Project; testing is well advanced for the Oxide-Ore-Tailings-Solids sample, though yet to commence for the Primary-Ore-Tailings-Solids sample (pending generation from metallurgical investigations).

The Hg content of the Oxide-Ore-Tailings-Solids sample is less than the detection-limit of 0.01 mg/kg.

The Hg concentration in the corresponding Oxide-Ore-Tailings-Slurry-Water sample was less than the detection-limit of 10 µg/L, where the latter reflects reduced assaying sensitivity, due to the TDS (Total-Dissolved-Solids) value of 13,000 mg/L.<sup>2</sup>

Importantly, the process-tailings streams – both Oxide-Ore-Tailings and Primary-Ore-Tailings – to be produced during the Project will be subjected to cyanide destruction prior to discharge to the tailings-storage facility (TSF). In addition to removing soluble cyanide forms *per se*, this detoxification treatment will prevent formation of soluble cyano-metal complexes for Cu, Hg, etc.

## 4.0 CONCLUDING REMARKS

The waste-rock and LG-ore streams to be produced from the **Kundip Deposits** are characterised by a [Hg tenor no different from other local gold mines](#) (i.e. Hg contents within the sub-mg/kg range, and often below the Hg abundance in soils, regoliths, and bedrocks removed from any mineralisation influences).

Regards,

**Dr GD Campbell**  
**Director**

encl. Attachment I

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<sup>1</sup> Reference:

Bowen HJM, 1979, "Environmental Chemistry of the Elements", Academic Press, NY

<sup>2</sup> The TDS value reflects the use of saline groundwater as makeup-water for the mill.

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**ATTACHMENT I**

**GEOLOGY AND MINERALISATION OVERVIEW FOR  
KUNDIP AND TRILOGY DEPOSITS**



**ACH MINERALS PTY LTD**

**REPORT ON THE MINERALISATION STYLES AT THE KUNDIP AND TRILOGY  
DEPOSITS WITHIN THE RAVENSTHORPE GOLD PROJECT (RGP)**

**November 2018**

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## **EXECUTIVE SUMMARY**

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The Ravensthorpe area contains two distinct tectonostratigraphic terranes that are the Archean Ravensthorpe Greenstone Belt and the Proterozoic Mount Barren Group metasediments.

The Archean greenstone belt (c. 2990-2960 Ma) is centred on the town of Ravensthorpe and is further subdivided into the Carlingup, Ravensthorpe and Cocanarup Terranes (Witt, 1998). The three Archean Terranes display a variety of geological units that extend from ultramafic komatiites, basalts and Banded Iron Formation (BIF) of the Carlingup Terrane through to felsic tonalite intrusive and associated extrusive volcanic units of the Ravensthorpe Terrane.

The Mount Barren Group has been dated at c. 1700 Ma (Fitzsimons and Buchan, 2005) and unconformably overlies the Archean basement to the south over a 120km strike length extending from Bremer Bay to Jerdacuttup. The Mount Barren Group has been interpreted as a shallow-marine sequence with stages of anaerobic conditions (Vallini et. al. 2005). During the Albany-Fraser Orogeny the Mount Barren Group was deformed during multiple phases with peak metamorphism at ~1300 Ma and ~1100 Ma (Spaggiari et.al., 2011).

The Archean Ravensthorpe Greenstone Belt has a long history of mining producing a diverse range of mineral commodities from separate mineralising events and systems. These include the epigenetic Cu-Au (Ag) deposits, the largest of which is the historic Elverdton Copper mine, nickel massive sulphides (RAV8) and nickel laterite (RNO), and the pegmatite hosted lithium (Mt. Cattlin). Mineralisation in the Mount Barren Group is restricted to the SEDEX polymetallic (Ag-Pb-Zn, Cu-Au) Trilogy deposit and associated prospects and is contemporaneous with the Albany-Fraser Orogeny. No mining of Proterozoic mineralisation has occurred.

### **Kundip Au-Cu Mineralisation**

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Cu-Au (Ag) mineralization at Kundip is hosted predominantly within the Archean by the Annabelle Volcanics and is mostly within 2 km of the contact with the Manyutup Tonalite. A spatial association between small, medium-grained tonalite plutons and centres of mineralisation has also been recognised with occurrences at Mount Cattlin, Mount McMahon, and micro-tonalitic dykes at Kundip.

Mineralisation at Kundip is hosted in structurally controlled, narrow (~2 m) en-echelon, quartz and massive sulphide veins hosted within shear zones and tensional fractures related to the amalgamation of the Ravensthorpe and Carlingup Terranes.

The most common sulphides are pyrite (FeS<sub>2</sub>) followed by chalcopyrite (CuFeS<sub>2</sub>) and pyrrhotite (FeS<sub>x-1</sub>). Sulphides occur as massive to semi-massive and as thin veinlets along fractures. Gold occurs as free gold and as inclusions within the pyrite. Trace element data within the sulphides and gangue minerals is shown below;

- Pyrite: Fe, S (Au, Ag, Co, Bi, Tl, As, Ni)
- Chalcopyrite: Cu, Fe, S (Ag, Se)
- Chlorite: Al, Mg, Fe, Si (Zn, Th, U, Zr, Na, V)

- Muscovite: K (Rb, Ti)
- Ankerite: Ca, Mn (Sr)

The geochemistry element data has identified a depletion of W and Sn characteristically used as pathfinders in Orogenic gold systems in the Yilgarn Craton. Element ratio plots generated from the multi-element data (Co vs Ni, Au vs Te, Au vs Ag) indicate Kundip is more closely correlated to a magmatic hydrothermal setting and not an Orogenic Yilgarn gold system.

Within the oxide zones mineralogy consists of gossanous hematite-goethite-quartz veining replacing pyrite-chalcopyrite, as well as traces of native copper, azurite and malachite. There tends to be copper depletion in the oxide zone with secondary copper hypogene minerals (bornite, digenite, chalcocite and covellite) forming supergene mineralisation at the fresh rock boundary.

## **Trilogy Polymetallic Mineralisation**

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The Trilogy deposit is a polymetallic massive sulphide “SEDEX” deposit hosted within conductive graphitic phyllites of the Proterozoic Mount Barren metasediments. The deposit is situated proximal to the large regional scale Whoogarup Fault which is thought to have a large influence on basin architecture in the Mount Barren Group and thus is an important control for focussing hydrothermal fluids.

The deposit has a strike length of 350 m orientated northeast and dips shallowly at 40° to the southeast, extending down-dip for 320 m. The mineralisation is broadly stratiform to the metasediments with three main sub-parallel ore zones (A, B and C) that vary in width between 10 to 20 m in thickness. The lodes are separated by up to 30m of waste rock. Several secondary, parallel sulphide lodes exist both in the footwall and hangingwall.

There are two different styles of mineralisation present at Trilogy;

1. Ag-Pb-Zn massive-banded style typical of Proterozoic stratiform sediment-hosted Zn-Pb-Ag deposits (SEDEX) as characterised by McGoldrick and Large (1998);
2. Cu-Au stringer-style mineralisation, contained within a silicified envelope that hosts the mineralisation.

The SEDEX lodes at Trilogy (B and C lodes) are comprised of massive and banded sulphides of pyrite, galena/anglesite and sphalerite with minor chalcopyrite. The mineralised lenses typically contain 70% sulphide and vary in thickness from a few centimetres to several metres. Base metal mineralisation at Trilogy is believed to be syngenetic to sedimentation with oxidised metal-charged fluids permeating into the reactive and permeable laminated reduced phyllites. Deformation during the Albany-Fraser Orogeny of the massive-banded sulphides with the sediments corroborates the syngenetic nature of mineralisation.

Analogous to other SEDEX deposits, Trilogy displays a complex geochemical relationship with various deleterious trace metals occurring in concentrations that would result in smelter penalties. These include, As, Cd, In, Hg, Sb and Bi.

Cu-Au mineralisation at Trilogy is hosted within the A lode. It is structurally offset from the base metal lodes by the Trilogy Fault. Mineralisation is hosted within a siliceous alteration halo with minor amounts in the laminated graphitic siltstone. Mineralisation consists of disseminated fine-grained (<0.1mm) chalcopyrite and coarser chalcopyrite with stringer style late stage pyrite-chalcopyrite-quartz veins. There is a gradual decrease in sulphides and width of silica alteration away from the main zone of mineralisation.

The genesis of the Cu-Au mineralisation and associated siliceous alteration is currently not understood but timing relationships have been determined. These include Cu-Au stringer veins overprinting base metal lenses in parts with intensely silicified alteration envelope surrounding the massive style mineralisation destroying original textures.

This implies a mineralisation event that post-dates the base metal mineralisation and theoretically would involve Cu-rich saline fluids focussed by older structures (Trilogy Fault) dissolving, recrystallising and retexturing the pre-existing Pb-Zn mineralisation.