SWORDFISH Cu-Au PROSPECT, NORSEMAN, WA

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LOCATION

The Swordfish prospect is located beneath Lake Cowan, about 4 km W of the North Royal mine and about 7.5 km NNW of Norseman at 32º07'19"S 121º45'50"E; Norseman 1:250 000 sheet SI51-02.

DISCOVERY HISTORY

The discovery air-core drilling intersected weathered and altered basalt at 85-90 m vertical depth below Tertiary to Quaternary sediments during reconnaissance drilling of a magnetic high in late 1991. The bottom sample (89-90 m vertical depth) yielded 1.98 ppm Au, 92 ppm Bi, 16.7 ppm Ag, 760 ppm Zn and 7000 ppm Cu.

GEOLOGICAL SETTING

The mineralization is hosted by greenschist metamorphosed basalts and interflow sediments of the Chinamans Well Basalt, the uppermost unit of the Archaean Woolyeenyer Formation (Figure 1). Quartz-muscovite schists within the sequence are deformed and altered felsic porphyry intrusions.

REGOLITH

Mineralized Archaean lithologies at Swordfish have a thin (<15 m) and variably stripped regolith of saprolite and saprock (Figure 3). The base of weathering is deeper over the main mineralization. This residual regolith is covered by Tertiary and Quaternary sediments, varying from less than 20 m to over 90 m thick (Figure 2C). The Tertiary sediments consist of a thin (<5 m) basal unit of colluvial gravel of mafic and felsic clasts, pyrite nodules and glauconitic clays (Figure 3), overlain by about 40 m of lignite and carbonaceous clays, some with pyrite nodules. This is overlain by about 20 m of mottled cream, olive-green and grey lacustrine clays, locally with thin lenses of carbonaceous clay. Above this is a 2-3 m marker horizon of white clay at a depth of 21-22 m below the present surface of Lake Cowan. About 20 m of mottled brown and olive-green lacustrine clays overlie the marker horizon. The uppermost unit consists of up to 4 m of Quaternary gypsiferous lacustrine and aeolian sands and clays. Kopi (gypsum) dunes and islands occur locally. The water table is about 0.3-0.5 m below the lake surface.

MINERALIZATION

The principal mineralized zones occur between two NE-trending faults (Figure 1), both to the W (dominantly auriferous) and to the E (dominantly cupriferous) of the deformed porphyry and locally within it (auriferous). Although the main auriferous and cupriferous zones do not appear to be coincident, the principal auriferous zone contains anomalous Cu (up to 1.2%), and the principal Cu-rich zones contain anomalous Au (typically 0.5-1.5 ppm).

In fresh bedrock, the mineralized zones have relatively abundant sul-

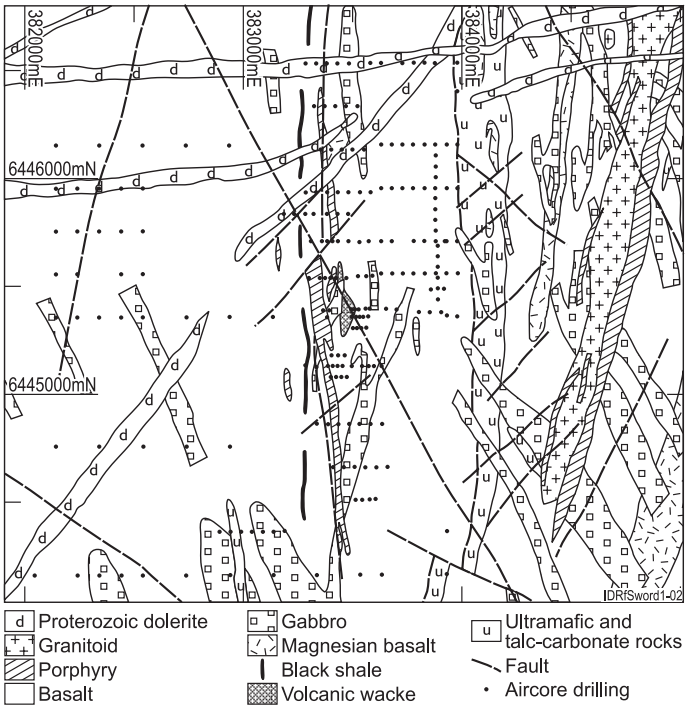

Figure 1. Geological map of the Swordfish prospect showing the aircore drilling. Figure 2 covers the western two thirds of Figure 1.

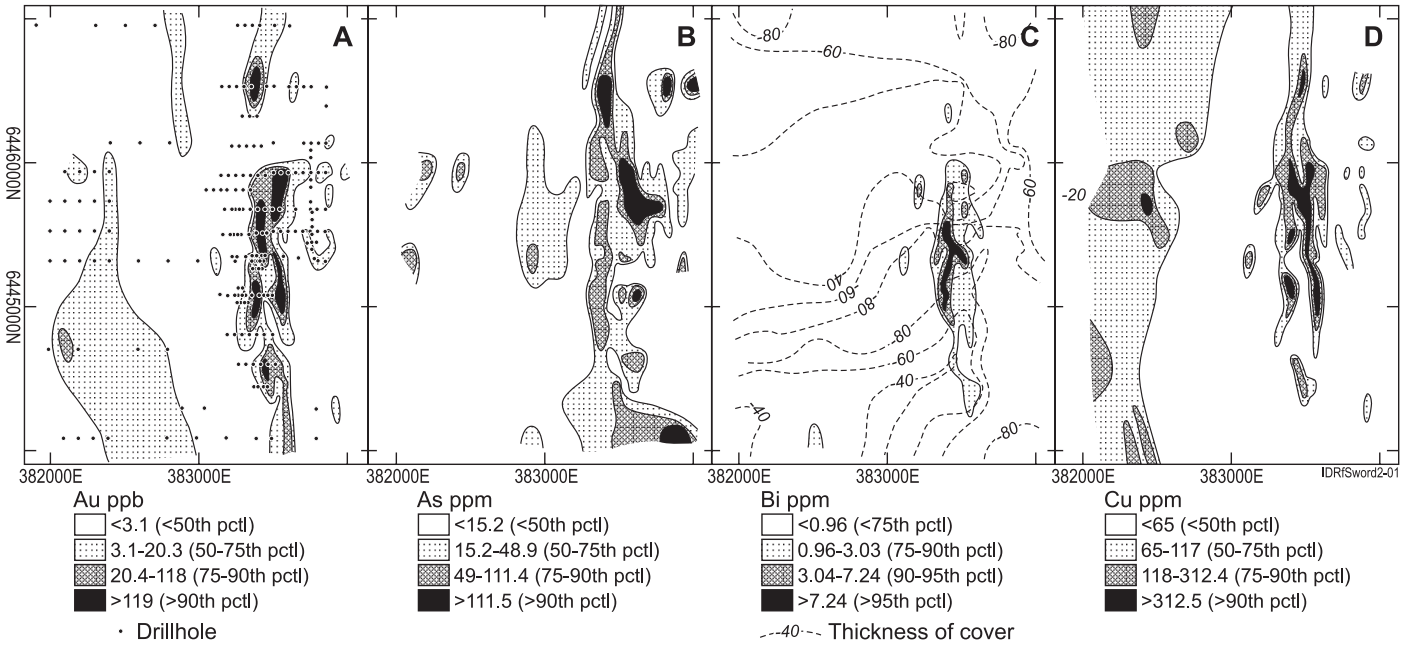

Figure 2. Element distributions at the base of weathering of Archaean lithologies, Swordfish prospect. A. Distribution of Au and drill sites. B. Distribution of As. C. Distribution of Bi with isopachs (m) of thickness of Tertiary sediments. D. Distribution of Cu.

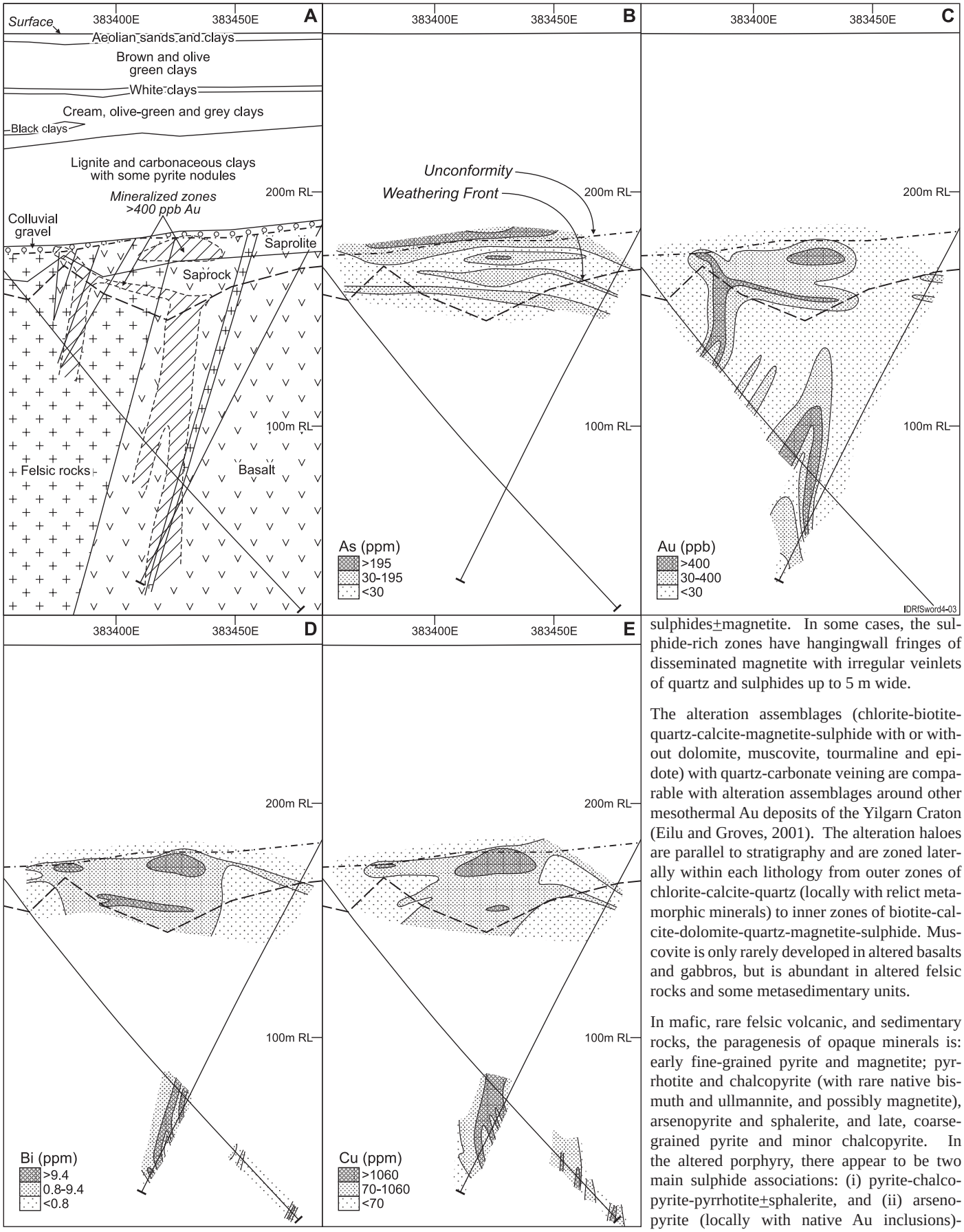

Figure 3. A. Interpreted geological cross-section along 6445400N Interpreted distribution on the same cross-section of As (B), Au (C), Bi (D), and Cu (E). Clear areas indicate no data.

phides (mainly pyrite, pyrrhotite and chalcopyrite) which are disseminated, occur along fractures, or form semi-massive to massive clots and veinlets within zones of silicification and chlorite-biotite±magnetite alteration. Thin (generally <20 mm) quartz±carbonate veinlets are common and some are laminated at their margins. There are several generations of veining, with brecciated veinlets cemented by sulphides±magnetite. In some cases, the sulphide-rich zones have hangingwall fringes of disseminated magnetite with irregular veinlets of quartz and sulphides up to 5 m wide.

The alteration assemblages (chlorite-biotite-quartz-calcite-magnetite-sulphide with or without dolomite, muscovite, tourmaline and epidote) with quartz-carbonate veining are comparable with alteration assemblages around other mesothermal Au deposits of the Yilgarn Craton (Eilu and Groves, 2001). The alteration haloes are parallel to stratigraphy and are zoned laterally within each lithology from outer zones of chlorite-calcite-quartz (locally with relict metamorphic minerals) to inner zones of biotite-calcite-dolomite-quartz-magnetite-sulphide. Muscovite is only rarely developed in altered basalts and gabbros, but is abundant in altered felsic rocks and some metasedimentary units.

In mafic, rare felsic volcanic, and sedimentary rocks, the paragenesis of opaque minerals is: early fine-grained pyrite and magnetite; pyrrhotite and chalcopyrite (with rare native bismuth and ullmannite, and possibly magnetite), arsenopyrite and sphalerite, and late, coarse-grained pyrite and minor chalcopyrite. In the altered porphyry, there appear to be two main sulphide associations: (i) pyrite-chalcopyrite-pyrrhotite±sphalerite, and (ii) arsenopyrite (locally with native Au inclusions)-sphalerite±boulangerite±pyrite±galena±chalcopyrite. Spatial and temporal relationships between these assemblages are unclear.

REGOLITH EXPRESSION

In plan

Due to the palaeotopography (Figure 2C) and the stripped residual regolith developed on the Archaean rocks, geochemical dispersion was investigated at the base of weathering. Dispersion patterns for Au, As, Bi and Cu are illustrated in Figures 2A-D. Other anomalous elements

over the mineralization include Ag, K, Mo, Pb, Sb and Zn (Skwarnecki et al., 1995).

Au
Four main zones of anomalous Au (>20 ppb), up to 700 m long, are related to quartz-muscovite schist and are mainly confined to the zone between the NE faults. Anomalous Au coincides with anomalous Bi, Cu, K, Pb and Si and, locally, with Ag, As, Sb and Zn.

As
The main trend of anomalous As (>50 ppm) is approximately N, parallel to the regional stratigraphy. Zones over 1 km in length are sub-parallel, or oblique, to the quartz-muscovite schist and its country rocks, including one in the SW in mafic rocks. Anomalies occur along the margins of the Talbot Island ultramafic unit, to the E of Swordfish. Arsenic is antipathetic to Cu and Bi, but is generally coincident with Ag, Au and Mo. Along the western margin of the Talbot Island ultramafic unit, As anomalies are associated with Pb and Zn.

Bi
An anomaly of >1 ppm Bi exceeds 1.5 km in length and coincides with anomalous Ag, Au, Cu, K, Mo, Pb, Si, Sb and Zn between the NE faults. There is no correspondence between As and Bi anomalies.

Cu
The principal Cu anomalies (>310 ppm) occur along both margins of the quartz-muscovite schist, particularly between the NE faults, and are coincident with anomalous Ag, Au, Bi, K, Mo (locally), Si and Zn. To the W, a broad zone of weakly anomalous Cu (generally <200 ppm) coincides with weathered basalt.

In section (6445400N)
There are two principal zones of mineralization in bedrock. These are (a) a lesser, upper, western zone of Au mineralization around a lens of sheared and hydrothermally altered basalt within quartz-muscovite schist, where Au is accompanied by anomalous As, Bi and Cu; and (b) a lower, main, eastern zone of Au-Cu mineralization, partly within a thin felsic horizon and partly within sheared and altered basalt, with anomalous Ag, Bi, Co, Mo and Zn.

Except for Au, only the basal 4 m of the Tertiary, saprolite and saprock derived from the Archaean, and mineralized zones in bedrock were analyzed. For Au, the basal 4 m of the Tertiary, the residual regolith and all bedrock samples were analyzed. Anomalous Ag, As, Bi, Co, Cu, Mo, Pb, Sb and Zn occur in sub-horizontal zones and lenses, separated by zones of apparent depletion, in weathered bedrock. The anomalies extend into the base of the Tertiary, directly above anomalies in weathered Archaean. The extent of dispersion into the Tertiary is unknown.

Within the residual regolith, the broadest parts of the Au (>100 ppb) and Cu (>350 ppm) anomalies lie within the depression in the weathered profile (Figure 3A). The widths of dispersion (up to 50 m) in residual regolith exceed the widths of primary bedrock dispersion (<20 m), and provide larger exploration targets. The dispersion patterns for As, Au, Bi and Cu are shown in Figures 3B-E.

Au
In saprolite, the main Au anomaly (>100 ppb) occurs within the depression in the base of weathering (Figure 3C) above mineralization in bedrock; lateral dispersion is limited. The anomalous Au is coincident with Ag, Bi, Co, Cu, Pb and Sb. There is only very restricted dispersion into basal Tertiary sediments.

As
In bedrock (Figure 3B), As is weakly anomalous (generally <30 ppm), with only minor thin, discontinuous zones of up to 200 ppm. In residual regolith, As anomalies are restricted to narrow sub-horizontal zones and are associated with anomalous Ag, Au, Bi, Co, Cu, Pb, Sb and Zn. Arsenic appears to be principally concentrated at the base of the Tertiary, where it is associated with anomalous Fe, Mn, Mo and Pb.

Bi
Bismuth is associated with Au mineralization in bedrock. In saprolite and saprock (Figure 3D), sub-horizontal Bi anomalies (>3.2 ppm) are associated with anomalous Ag, Au, Cu, Sb and Zn, and occur in the depression in the base of weathering and at the top of the regolith below Tertiary cover. The Bi anomalies are restricted in the basal Tertiary sediments.

Cu
In regolith, a significant Cu anomaly (>350 ppm) is associated with anomalous Ag, Au, As, Bi, Co, Pb, Sb and Zn, and occurs above mineralization in bedrock at the top of the saprolite, beneath Tertiary cover. The Cu anomaly locally extends into basal Tertiary sediments (Figure 3E).

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SUMMARY TABLE

Sample medium	*Indicator elements*	*Analytical methods*	*Detection limits*	*Background (50th percentile)*	*Threshold (90th percentile)*	*Maximum anomaly*	*Lateral dispersion distance (m)*
Primary mineralization	Ag As Au Bi Co Cu Mo Pb Sb Zn	Au: AAS* Other elements: ICP-OES and ICP-MS on mixed acid digests	0.1 5 1 ppb 0.1 5 5 0.5 2 0.5 10	0.5 30 50 ppb 2.2 35 320 0.9 7 0.7 130	3.6 85 640 ppb 19.2 90 2950 3.2 19 2 270	75 9600 31 240 480 6.3% 35 325 26 2.7%	5 2 15 11 6 >15 5 3 2 10
Alteration zone	B, CO_2, K			no data	no data	no data	insufficient data
Saprolite and saprock	Ag As Au Bi Cu Mo Pb Sb Zn	as above	as above	0.5 25 4 ppb 0.1 60 0.9 4 0.5 90	1 125 240 ppb 1.2 165 4.5 19 2 180	86 1.44% 74 92 1.99% 24 1980 16 1800	35/200** 35/400 70/200 70/200 70/400 30/200 40/100 50/150 100/300
Basal Tertiary sediments	As, Au, Bi, Cu, Mo, Pb, Sb, Zn	as above	as above	insufficient data	insufficient data	insufficient data	insufficient data

*Graphite furnace
**In cross section/in plan
All concentrations in ppm unless stated otherwise