201976: gold grain, Sing Well prospect

(Roebourne Group, Karratha Terrane)

Sample type	Gold grain
Total weight	0.4 g
Sample location	Sing Well prospect, about 18 km southeast of Karratha
Coordinates	MGA zone 50, 497887E 7695314N
Datum	GDA94
1:250 000 map sheet	Dampier (SF 50-2)
1:100 000 map sheet	Dampier (2256)
Tenement	E 47/1746-I
Collector	Artemis Resources

Location and sampling

The sample was provided by Artemis Resources in January 2019. It was collected from the weathering profile above mafic volcanic rocks and a quartz vein, at the Sing Well prospect in the northwest Pilbara region (Artemis Resources, 2019, written comm., 11 January).

Geological context

The Sing Well prospect is located about 0.5 km south-southeast of the southern segment of the Regal Thrust, in the Roebourne greenstone belt of the Karratha Terrane, northwest Pilbara Craton. The thrust is a regionally significant fault spatially associated with Cu–Au mineralization (Hickman, 2016; GSWA, 2020). The local bedrock includes metamorphosed basalt and minor chert of the 3280–3261 Ma Ruth Well Formation, Roebourne Group (Hickman, 2022b; GSWA, 2020). Metamorphosed ferruginous chert and minor banded iron-formation of the 3320–3160 Ma Nickol River Formation are exposed about 0.3 km north of the sample locality. Proterozoic northeast-trending dolerite dykes transect the area (Hickman, 2022a; GSWA, 2020).

The Sing Well prospect is about 10 km southwest of the Carlow Castle gold–copper–cobalt deposit, where mineralization occurs in a primary sulfide zone and an overlying supergene-enriched zone. At the Carlow Castle deposit the primary sulfide mineralization is structurally controlled, occurring in sulfide-rich quartz–carbonate veins within a tectonized zone. On the southern side of the Regal Thrust, within a tectonized zone, there is also extensive chlorite–silica alteration throughout the mafic to ultramafic volcano-sedimentary sequence of the 3280–3261 Ma Ruth Well Formation, Roebourne Group (Fox et al., 2019; Hickman, 2022b, 2016). The Greater Carlow Project has an inferred mineral resource as at 13 October 2022 of 8.74 Mt at 2.5 g/t Au, 0.73% Cu and 0.09% Co (Artemis Resources, 2022).

The nearest regolith landform is a colluvial unit comprising unconsolidated sand, silt, and gravel in outwash fans, scree and talus, and proximal mass-wasting deposits (GSWA, 2020).

Methodology

The gold sample was photographed and weighed, and its overall morphology and external features, such as colour, roundness, surface relief, coatings, mineral inclusions and mineralogical assemblages were recorded using visual morphometry. The raw surface of the sample was analysed using scanning electron microscopy with energy dispersive X-ray system (SEM-EDS). The sample was then mounted in epoxy resin, cut and polished and the gold grain microstructure and inclusions were examined using optical and SEM-EDS analyses. Gold microchemistry was determined by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), calibrated against certified gold reference materials (CRM; Murray, 2009). The sample was ablated in triplicate along 0.5 mm-long traverses and average values calculated for elements present in the CRM. The gold surface was repolished after laser ablation, etched with aqua regia, and its internal structure examined using reflected light microscopy and SEM-EDS. Details of this method are described in Hancock and Beardsmore (2020).

Morphology

The gold grain is moderately to well rounded, lumpy, and slightly flattened, with dimensions 6 × 4 × 1 mm. Its pitted surface is covered by ferruginous clays (Fig. 1).

SEM-EDS analysis of raw surfaces

The surface of the gold grain is pitted and imprinted by regolith material (Fig. 2). There is no detectable Ag on the gold surface and no disseminated gold particles in the ferruginous clays that fill surficial cavities.

Figure 1. Sample 201976: gold grain, Sing Well prospect

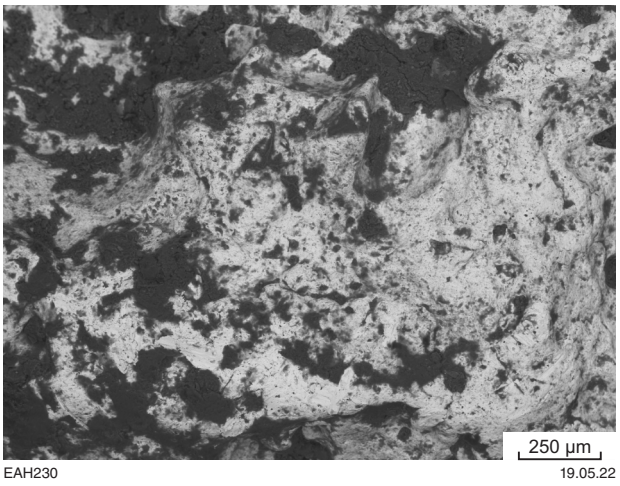

Figure 2. Backscattered image of surface of sample 201976: gold grain, Sing Well prospect

Optical microscopy of polished surfaces

Voids in the gold grain are partly to completely filled with a mix of angular quartz grains and lesser clays and goethite (Fig. 3a). There are several greenish, irregular and rounded inclusions of chalcopyrite and quartz (Fig. 3b), and light grey blocky to rounded inclusions of pyrite ranging from 50 µm to less than 10 µm in diameter (Fig. 3c).

SEM-EDS analysis of polished surfaces

The gold grain contains 2.5% Ag. There are several semirounded chalcopyrite and pyrite inclusions, some of which are brecciated, with gold filling the fractures (Fig. 4). Chalcopyrite grains sporadically occur in Si–Fe–Ca–Mg clays in voids, and one small hole containing a remnant crust of Fe oxide minerals preserves the imprint of an original euhedral pyrite crystal.

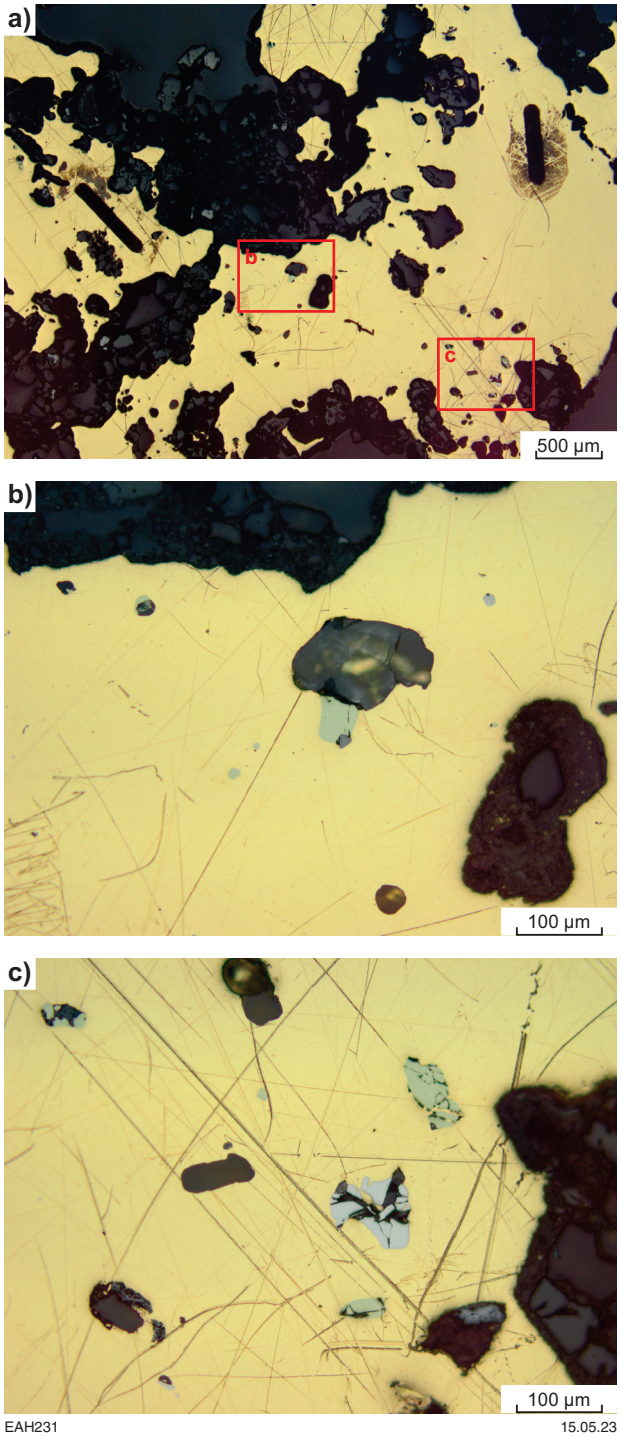

Figure 3. Reflected-light photomicrographs of polished surface of sample 201976: gold grain, Sing Well prospect. Dark, elongate lines are laser ablation tracks produced during LA-ICP-MS analyses

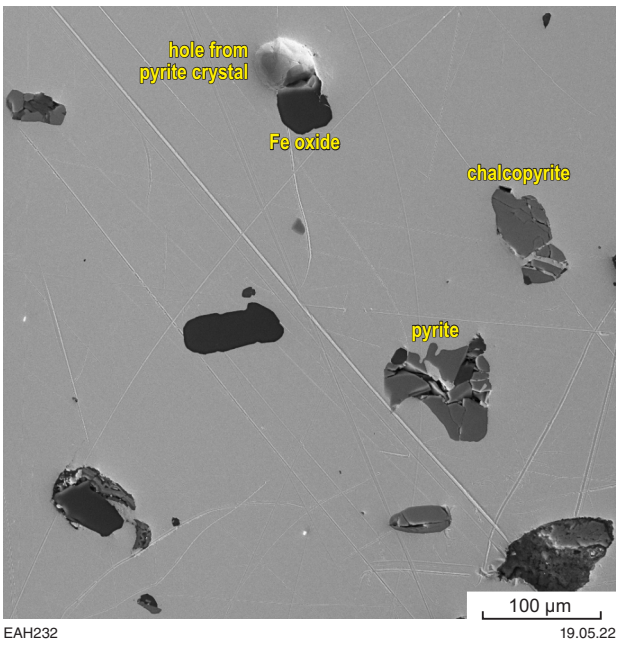

Figure 4. Secondary electron image of micro-inclusions in sample 201976: gold grain, Sing Well prospect

LA-ICP-MS analysis

Analyses consistently detected Ag, Cu and Hg within the gold grain, in concentrations higher than the instrumental detection limit, and probably occurring as limited solid solutions in the gold. Other trace elements were detected only sporadically in low (sub-ppm) concentrations, possibly occurring in micro- and nano-inclusions.

The gold grain has low Ag (2.2 – 2.6%), high Cu (833–946 ppm), and low Hg (22–28 ppm) (Table 1). Pd, Mg, Al, and Cd are also consistently present, in low ppm and high ppb levels (Table 2). Relatively high concentrations of Na and Al detected in tracks 1 and 3, respectively, may reflect ablation of lithophile micro-inclusions. Elevated levels of other elements such as Ti and Ni may also derive from such inclusions.

Table 1. LA-ICP-MS data for selected elements in sample 201976: gold grain, Sing Well prospect

Ag (%)	*Cu (ppm)*	*Hg (ppm)*	*Other (ppm)*
2.2, 2.6, 2.6	833, 920, 946	22, 27, 28	Mg, Pd

Acid etching

The primary gold has a coarsely polycrystalline microstructure with large, coherent twin planes (Fig. 5a), and smaller, curved and incoherent, simple and polysynthetic twinning (Fig. 5b,c). Incipient, fine-grained, polygranular recrystallization of gold occurs locally along the outer grain rim (Fig. 5d), and around some mineral inclusions.

Interpretation

The primary, coarsely crystalline gold has very low Ag, elevated Cu and Pd, and rounded inclusions of pyrite and chalcopyrite, suggesting probable crystallization from hydrothermal fluids that have interacted with ultramafic rocks, and a genetic relationship with local Cu mineralization. The gold grain subsequently experienced partial recrystallization during post-primary deformation and metamorphism, and during erosion and transportation into the regolith, when voids were formed by gold dissolution, and subsequently filled with fragmental quartz and clays.

References

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Fox, DCM, Spinks, SC, Pearce, MA, Barham, M, LeVaillant, M, Thorne, RL, Aspandiar, M and Verrall, M 2019, Plundering Carlow Castle: first look at a unique Mesoarchean-hosted Cu-Co-Au deposit: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 114, no. 6, p. 1021–1031, doi.org/10.5382/econgeo.4672.

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Murray, S 2009, LBMA certified reference materials. Gold project final update: The London Bullion Market Association, Alchemist, no. 55, p. 11–12.

Table 2. LA-ICP-MS compositional data for sample 201976: gold grain, Sing Well prospect

Laser ablation track	Unit	^{7}Li	^{9}Be	^{11}B	^{23}Na	^{25}Mg	^{27}Al	^{29}Si	^{44}Ca	^{45}Sc	^{49}Ti	^{51}V	^{53}Cr	^{55}Mn	^{57}Fe	^{59}Co	^{60}Ni	^{65}Cu
1	cps	142			18569	189	314				10						34	117092
2	cps					87	156											103133
3	cps		1			193	4865			22	13	12	25	65	554	6	15	113853
1	ppm					2.3					0.21						0.34	946
2	ppm					1.0												833
3	ppm					2.3					0.28						0.15	920

Laser ablation track	Unit	^{66}Zn	^{69}Ga	^{72}Ge	^{75}As	^{82}Se	^{85}Rb	^{88}Sr	^{89}Y	^{90}Zr	^{93}Nb	^{98}Mo	^{101}Ru	^{103}Rh	^{108}Pd	^{109}Ag	^{111}Cd	^{115}In
1	cps		1					6					1	8	208	5274814	35	
2	cps		3								5			3	179	4455315	28	2
3	cps		2	1	4		4	4	1	3		1		7	197	5373651	36	2
1	ppm													0.02	1.6	25593		
2	ppm													0.01	1.4	21617		0.003
3	ppm				0.05									0.02	1.5	26073		0.004

Laser ablation track	Unit	^{120}Sn	^{121}Sb	^{126}Te	^{133}Cs	^{138}Ba	^{139}La	^{140}Ce	^{141}Pr	^{145}Nd	^{151}Eu	^{157}Gd	^{159}Tb	^{162}Dy	^{165}Ho	^{167}Er	^{169}Tm	^{172}Yb
1	cps	21	6		3	5		2	2	1		2						
2	cps	7	2		3	2			1			1						
3	cps	7		6	5	6	2		2	1		1						
1	ppm	0.09	0.02															
2	ppm	0.03	0.01															
3	ppm	0.03		0.11														

Laser ablation track	Unit	^{175}Lu	^{178}Hf	^{181}Ta	^{182}W	^{185}Re	^{189}Os	^{193}Ir	^{195}Pt	^{202}Hg	^{205}Tl	^{208}Pb	^{209}Bi	^{232}Th	^{238}U
1	cps	2		2	2				2	7797			7		
2	cps	1								6295		9	15		
3	cps		1		2			1		8163	2	25	29		3
1	ppm								0.02	27			0.01		
2	ppm									22		0.03	0.03		
3	ppm									28		0.08	0.06		

Notes: cps, count per second; ppm, parts per million

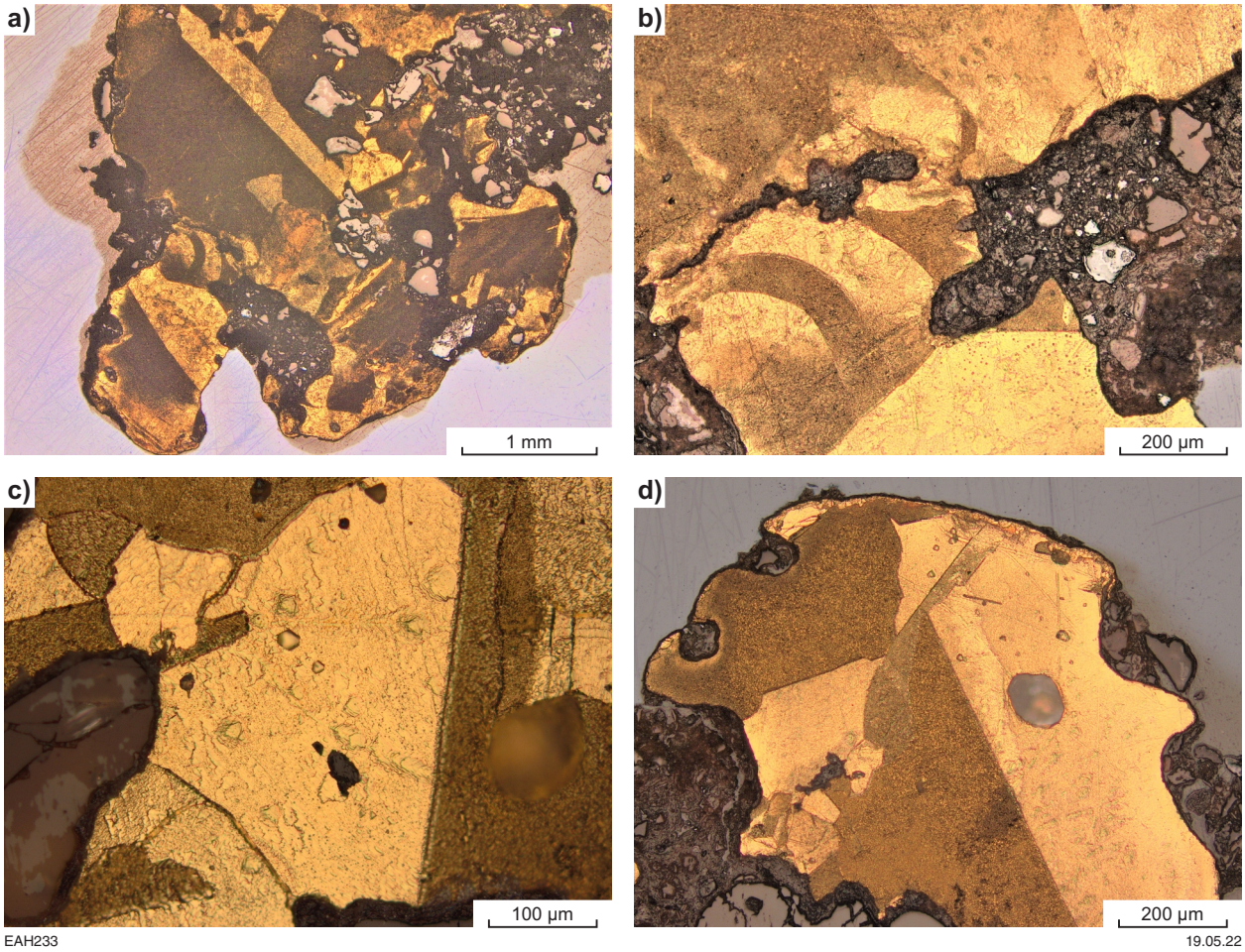

Figure 5. Reflected-light photomicrographs, after repolishing and acid etching, of parts of sample 201976: gold grain, Sing Well prospect

Recommended reference for this publication

Hancock, EA, Blay, OA and Beardsmore, TJ 2023, 201976: gold grain, Sing Well prospect; GSWA Mineralogy Record 10: Geological Survey of Western Australia, 5p.