201977: gold grain, Sing Well prospect

(Roebourne Group, Karratha Terrane)

Sample type	Gold grain
Total weight	0.8 g
Sample location	Sing Well prospect, about 18 km southeast of Karratha
Coordinates	MGA zone 50, 497889E 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, northern 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 (GSWA, 2020; Hickman, 2022a).

The Sing Well prospect is about 10 km southwest of the Carlow Castle gold–copper–cobalt deposit, where mineralization occurs as 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 Thrus, 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, 2016, 2022b). The Greater Carlow Project has an inferred mineral resource as of 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 has a well-rounded and flattened, boomerang-like shape with dimensions 12 × 4 × 1 mm. There are two relatively large holes through the nugget, and a crack across its centre — an unusual feature for malleable gold. The dark-brown colour of the surface is due to ferruginous clays (Fig. 1).

Figure 1. Sample 201977: gold grain, Sing Well prospect

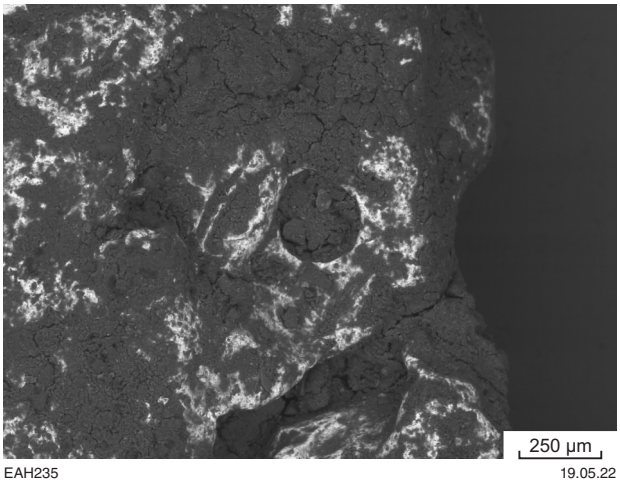

Figure 2. Backscattered image of surface of sample 201977: gold grain, Sing Well prospect

SEM-EDS analysis of raw surfaces

The voids in the flattened surface of the gold grain are filled with Mg–Si–Fe–Al–Ti–Ca (smectite and titanite) and lesser K (illite) clays (Fig. 2). There is no finely disseminated gold in regolith material.

Optical microscopy of polished surfaces

The grain margin is irregular and scalloped, due to dissolution of gold (Fig. 3a). There are several rounded inclusions of pyrite and chalcopyrite, the latter ranging from >200 to <50 µm in diameter and sporadically showing zoning (Fig. 3b).

SEM-EDS analysis of polished surfaces

The gold grain contains 9.5% Ag. The rounded chalcopyrite inclusions have varying Cu contents. One inclusion (Fig. 3b) consists of chalcopyrite (36% S, 35% Fe, 29% Cu) and pyrrhotite (40% S, 59% Fe, 0.7% Ni, 0.6% Cu). One chalcopyrite grain encloses a small calcite crystal.

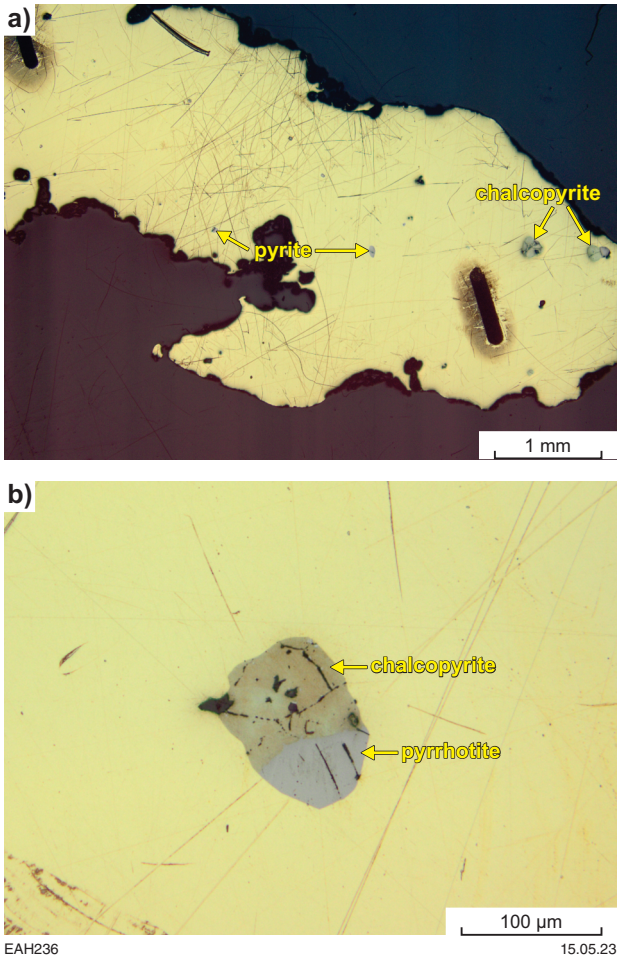

Figure 3. Reflected-light photomicrographs of polished surface of sample 201977: gold grain, Sing Well prospect. Dark, elongate lines are laser ablation tracks produced during LA-ICP-MS analyses

LA-ICP-MS analysis

Analyses consistently detected Ag, Cu and Hg within the gold grains, 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 contains 7.6% Ag, somewhat lower than the c. 9.5% Ag detected using SEM-EDS, and moderate amounts of Cu (220–262 ppm) and Hg (150–181 ppm) (Table 1). Mg, Sb and Sn are also consistently present in the gold grain in low ppm and high ppb levels (Table 2). The high Na concentration in track 3 may reflect ablation of lithophile micro-inclusion. Elevated levels of other elements, such as Al and Zn, may also derive from such inclusions.

Table 1. LA-ICP-MS data for selected elements in sample 201977: gold grain, Sing Well prospect

Ag (%)	*Cu (ppm)*	*Hg (ppm)*	*Other (ppm)*
7.6, 7.6 7.6	220, 222, 262	150, 180, 181	Mg, Sb

Table 2. LA-ICP-MS compositional data for sample 201977: 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					50	24			7	2		10			2	3	32450
2	cps					183	56		10		5	1	7	7		4		27192
3	cps				8458	157	358		68		8		7		3	2	7	27470
1	ppm					0.60					0.04						0.03	262
2	ppm					2.19					0.11							220
3	ppm					1.88					0.17						0.07	222

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		3		5	3							10	15606271	8	5
2	cps	9	3	3	2			17		1		1	1		10	15616363	6	3
3	cps	23	3		4		7	8		1			2		5	15635389	6	1
1	ppm				0.04										0.08	75722		0.01
2	ppm	0.10			0.02										0.07	75771		0.005
3	ppm	0.26			0.05										0.03	75863		0.002

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	132	415		2	4				1				2		1		1
2	cps	138	393		1	9												
3	cps	207	461		2	7		2									2	
1	ppm	0.59	1.61															
2	ppm	0.62	1.53															
3	ppm	0.93	1.79															

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				1					43618	1	13	32		
2	cps	1	2		2				2	52433		4	24		
3	cps			1						52249	1	13	46		
1	ppm									150		0.04	0.07		
2	ppm								0.021	181		0.01	0.05		
3	ppm									180		0.04	0.10		

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

Acid etching

The primary gold has a coarsely polycrystalline microstructure, with some large, coherent twin planes and irregular crystal margins (Fig. 4a,b). The outer rim of the grain is patchy and consists of two layers: a fine polygranular gold that overlaid coarser recrystallized zones (Fig. 4c); a thin, diffused, paler zone along the edges of the grain is probably a polishing artefact (Fig. 4b).

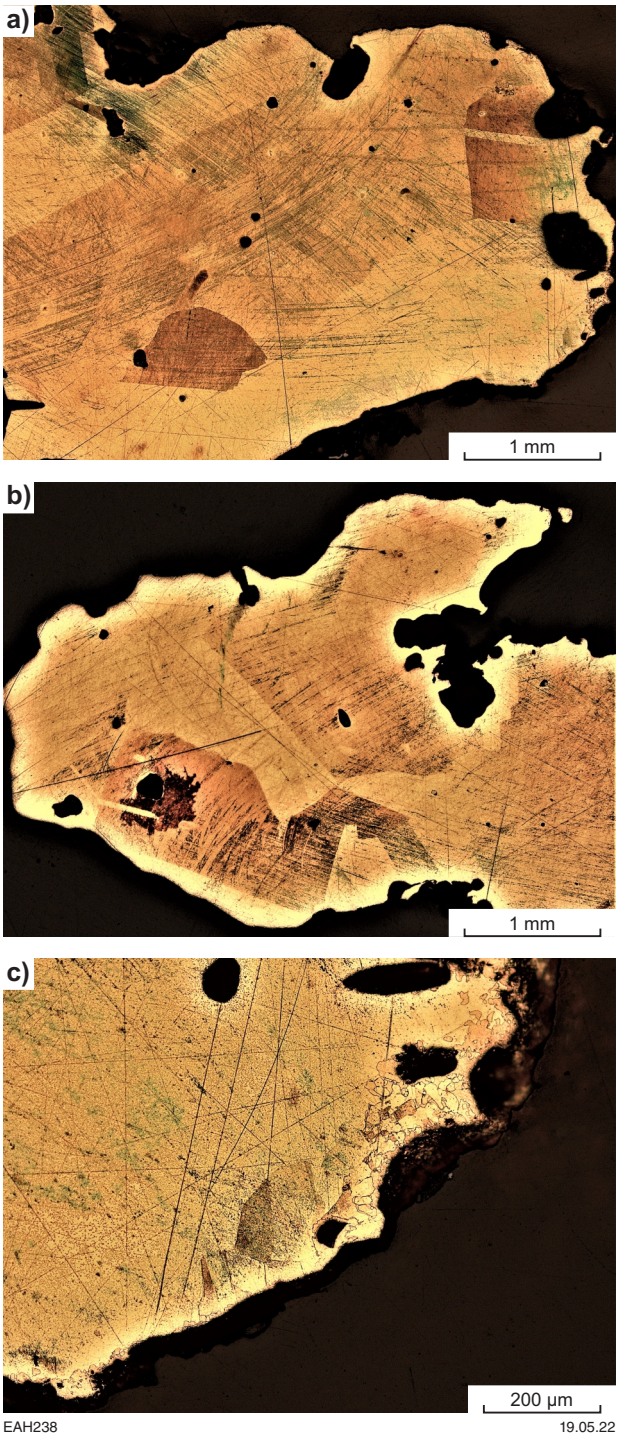

Figure 4. Reflected-light photomicrographs, after repolishing and acid etching, of parts of sample 201977: gold grain, Sing Well prospect

Interpretation

The primary, coarsely crystalline gold with moderate Ag, Cu and Hg, and rounded inclusions of pyrite and chalcopyrite, probably crystallized from hydrothermal fluids. The gold grain subsequently experienced partial recrystallization during post-primary deformations and during erosion and transportation into the regolith, at which time its surface also became well rounded, flattened and irregularly dissolved.

References

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Recommended reference for this publication

Hancock, EA, Blay, OA and Beardsmore, TJ 2023, 201977: gold grain, Sing Well prospect; GSWA Mineralogy Record 11: Geological Survey of Western Australia, 4p.