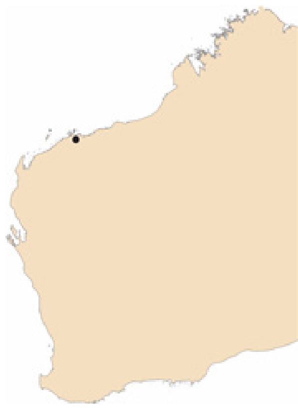
201972: gold-bearing calcrete, Nickol River prospect

(Ruth Well Formation, Karratha Terrane)

Sample type	Gold-bearing calcrete
Total weight	25.7 g
Sample location	Nickol River prospect, about 13 km east of Karratha
Coordinates	MGA zone 50, 496108E 7705957N
Datum	GDA94
1:250 000 map sheet	DAMPIER (SF 50-2)
1:100 000 map sheet	DAMPIER (2256)
Tenement	E 47/2716
Collector	Artemis Resources



Location and sampling

The sample was provided by Artemis Resources in January 2019. It was collected at the Nickol River prospect in the northwest Pilbara, near the Nickol River plant (Artemis Resources, 2019, written comm., 11 January).

Geological context

The Nickol River prospect is located in the Roebourne greenstone belt of the Karratha Terrane, in the northwest Pilbara Craton, about 1.1 km south-southeast of the northern segment of the Regal Thrust. This is a regionally significant thrust fault that has been associated with regional Cu–Au mineralization (Hickman, 2016; GSWA, 2020). The gold-bearing calcrete was recovered above sheared ultramafic rocks and a quartz vein (Artemis Resources Ltd, 2019, written comm., 11 January). The local bedrock includes metamorphosed serpentinized peridotite, locally olivine–spinifex-textured, and minor serpentine–chlorite schist of the 3280–3261 Ma Ruth Well Formation of the Roebourne Group (Hickman, 2022; GSWA, 2020).

The Nickol River prospect is located immediately west of the Nickol River historical gold mining area, which has produced alluvial gold since 1889 to the present day, and has the potential to represent a deeper primary gold system, as indicated by outcropping hard rock gold occurrences (Cyclone Metals Ltd, 2022).

The nearest regolith landform is an alluvial–fluvial unit comprising unconsolidated clay, silt, sand, and basaltic or doleritic gravel on a floodplain. Locally expanding clays form a gilgai surface (GSWA, 2020).

Methodology

The sample was photographed and weighed, its overall morphology and external features, such as colour, roundness, surface relief, coatings, mineral inclusions and mineralogical assemblages, were recorded using visual morphometry. A subsample containing the gold grain was cut from the main specimen and analysed by scanning electron microscopy with the energy dispersive X-ray system (SEM-EDS). The subsample was mounted in epoxy resin, cut and polished, and the gold grain microstructure and inclusions were analysed using optical and SEM-EDS analyses. Gold microchemistry was determined by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analysis, 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. Gold surfaces were repolished after laser ablation, etched with aqua regia, and internal structures examined using reflected light microscopy and SEM-EDS. Details of this method are described in Hancock and Beardsmore (2020).

Morphology

The sample is a rock fragment with dimensions 40 × 35 × 15 mm (Fig. 1). It comprises ferruginous calcrete, which cements together vein quartz, mafic rock pebbles, and a 7 × 5 × 5 mm, well-rounded, irregular gold grain.

SEM-EDS analysis of raw surfaces

The surface of the gold grain is rounded and strongly pitted, with Fe-oxide minerals, calcite grains, and Al–Mg–Ca-rich clays in voids and cavities (Fig. 2a). There is no detectable Ag on the gold surface. Micro- and nano-crystals and particles of gold are disseminated in carbonate-rich clays, and possibly also in organic phases and amorphous silica within microcavities on the honeycomb-like surface of massive gold (Fig. 2b, c).

Figure 1. **Sample 201972: gold-bearing calcrete, Nickol River prospect**

Optical microscopy of polished surfaces

The gold grain contains several voids or cavities open to the grain surface, filled by ferruginous clays, Fe-oxide minerals and calcite grains (Fig. 3a), minor rounded quartz grains and disseminated gold micro- and nanoparticles (Fig. 3b). The interior of the gold grain contains partly altered mineral inclusions, up to 200 µm in size (Fig. 3c).

SEM-EDS analysis of polished surfaces

The main gold mass contains 7.0 – 7.5% Ag, whereas gold in a thin (< 50 µm) external rim and in intergranular veinlets is Ag free (Fig. 4a). Gersdorffite (NiAsS, with 1.5 – 4.0% Co and 1% Fe impurities) is present as rounded inclusions (Fig. 4a). Voids and cavities are partially to completely filled by K–Cr–Ti-rich illitic clays that contain irregular quartz grains, Fe-oxide minerals, and disseminated particles, plates and crystals of pure gold (Fig. 4b).

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 moderate Ag (6%) and Cu (345–373 ppm), and low Hg (40–46 ppm). Except Mg and Sb (sub-ppm), no other elements above ppm level were detected (Table 1), although very low (ppb) traces of Ti, Ni, Zn, As, Se, Pd, Sn and Pb are present (Table 2).

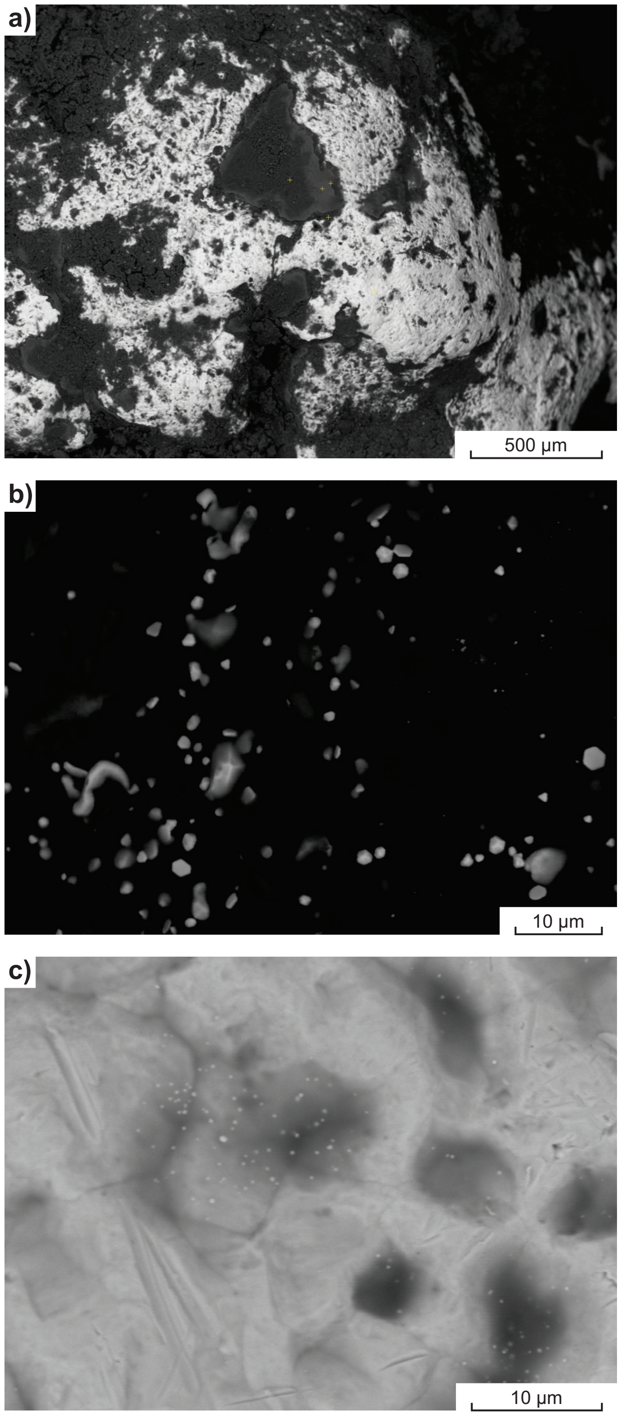
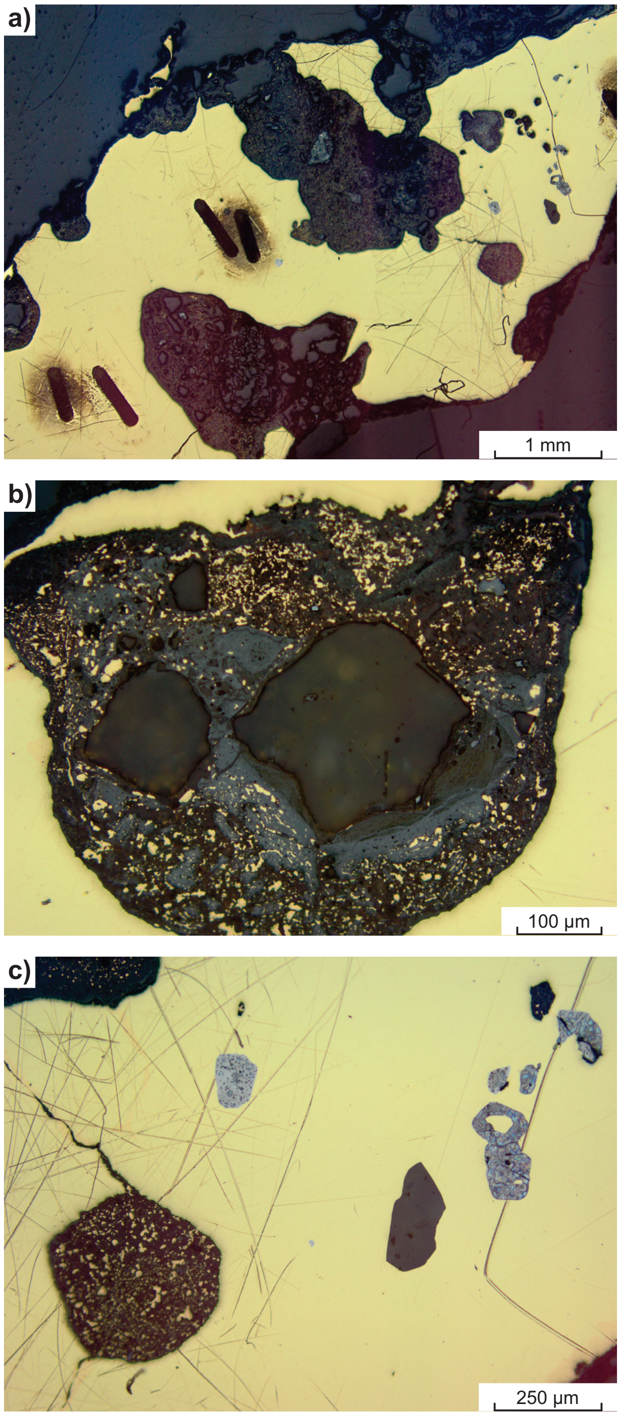


Figure 2. **Backscattered electron (BSE) images of sample 201972: gold-bearing calcrete, Nickol River prospect. a) Al–Mg–Ca-rich clays in voids and cavities; b,c) amorphous silica within microcavities on the honeycomb-like surface of massive gold**



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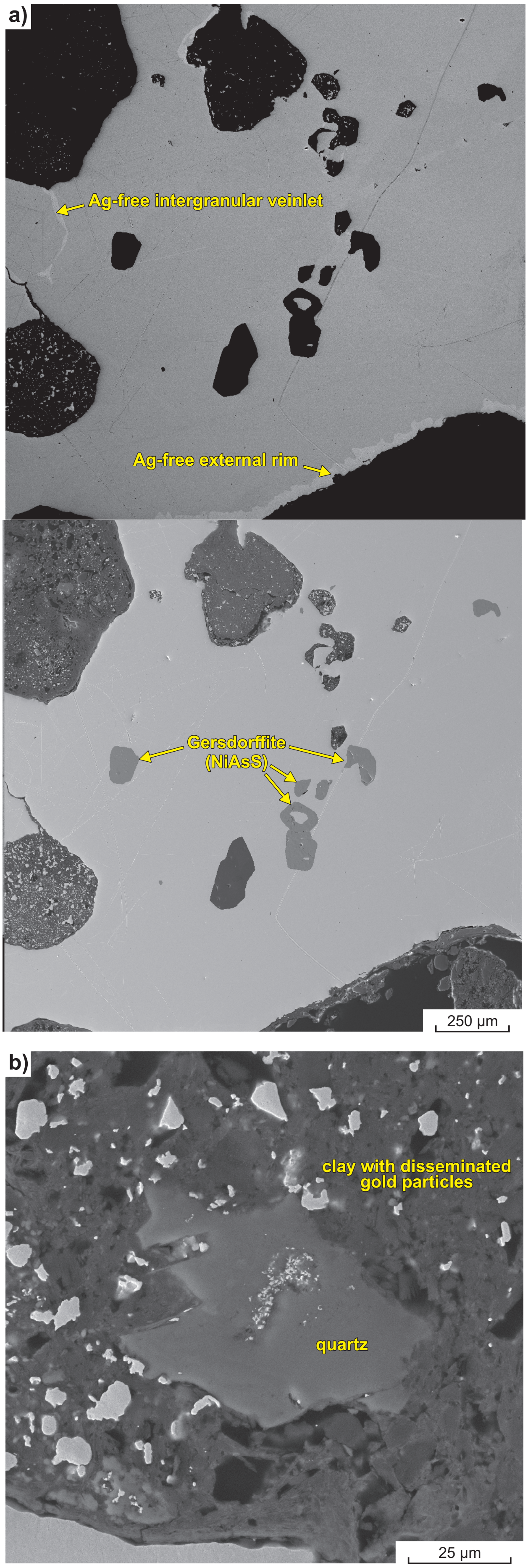

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Figure 3. (above) Reflected-light photomicrographs of polished surface of sample 201972: gold-bearing calcrete, Nickol River prospect. a) Fe-oxide minerals and calcite grains; b) minor rounded quartz grains and disseminated gold micro- and nanoparticles; c) interior of the gold grain contains partly altered mineral inclusions. Dark elongate lines are laser ablation tracks produced during LA-ICP-MS analyses

Figure 4. (right) BSE and secondary electron (SE) images of polished surface of sample 201972: gold-bearing calcrete, Nickol River prospect: a) BSE and SE; b) SE

Table 1. LA-ICP-MS data for selected elements in sample 201972: gold-bearing calcrete, Nickol River prospect

Ag (%)	*Cu (ppm)*	*Hg (ppm)*	*Minor elements*
5.9, 6.0, 6.4	345, 373, 384	40, 42, 46	

Acid etching

The polished surface of the gold grain exhibits a coarsely crystalline internal fabric with large simple coherent and small incoherent twinning (Fig. 5a). There is a thin (< 50 µm) recrystallized rim, and an incipient, 5–10 µm-thick corrosive rim in contact with Fe-oxide minerals (Fig. 5b, c). Locally curved grain boundaries indicate later deformation (Fig. 5c). A vague circular pattern on the gold surface evident in Figure 5c may be an artefact caused by strong bubbling during dissolution of carbonate inclusions while etching with aqua regia.

Interpretation

Primary gold in this sample has a coarsely crystalline internal texture, 6.0 – 7.5% Ag, and gersdorffite micro-inclusions, implying original hydrothermal formation. The honeycomb nanostructure preserved on local parts of the gold surface may indicate primary growth from colloidal suspensions. The present well-rounded morphology of the gold grain, its outer rim of recrystallization and corrosion, and its occurrence together with quartz, mafic rock pebbles and a loose calcrete cement, indicate some degree of transportation and/or burial alteration prior to its residence in a regolith environment.

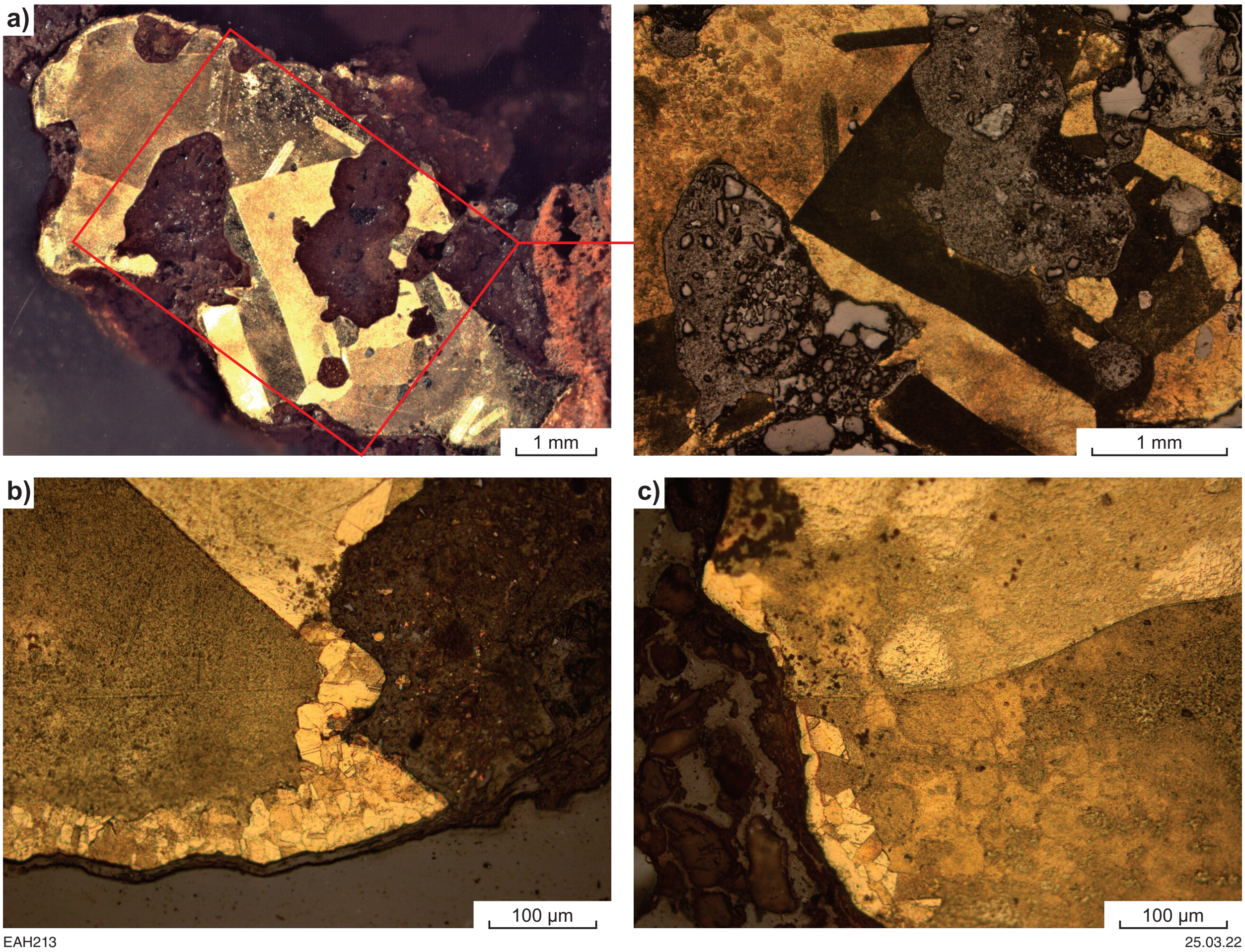

Figure 5. Reflected-light photomicrographs, after repolishing and acid etching, of parts of sample 201972: gold-bearing calcrete, Nickol River prospect

Table 2. LA-ICP-MS compositional data for sample 201972: gold-bearing calcrete, Nickol River 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		3			46	83			1	3		7		16	2	16	47553
2	cps		2			52	5672		29		2	2	2		1	5	10	42665
3	cps			15		82	1381			10		1					6	46145
1	ppm					0.55					0.07						0.16	384
2	ppm					0.62					0.03						0.10	345
3	ppm					0.98											0.06	373

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	8	1		3	7		4		1				5	4	13246961	21	
2	cps	5	3	2	3			6			3			2	3	12116481	20	
3	cps	10				5		3			7			2	4	12408281	20	
1	ppm	0.09			0.03	0.52								0.011	0.03	64274		
2	ppm	0.06			0.04									0.004	0.02	58789		
3	ppm	0.12				0.36								0.005	0.03	60205		

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	17	199			2									1			
2	cps	10	130		3	2												
3	cps	5	160		2	1	3		1		1			2				
1	ppm	0.07	0.77															
2	ppm	0.04	0.51															
3	ppm	0.02	0.62															

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			1				13207		4		2	
2	cps		1		2					11562	1	21	2		
3	cps		1							12231		7	2		
1	ppm									46		0.01			
2	ppm									40		0.06	0.003		
3	ppm									42		0.02	0.004		

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

References

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Recommended reference for this publication

Hancock, EA, Blay, OA and Beardsmore, TJ 2022, 201972: gold-bearing calcrete, Nickol River prospect; GSWA Mineralogy Record 6: Geological Survey of Western Australia, 6p.