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Iron ores from Adamstown 3

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Abstract

Two specimens of goethite iron ores were shown to have a primary foliated texture, later fragmented and bound by later iron oxide cements. The goethite bore grains of quartz and feldspar, some large, that showed evidence for aggressive corrosion.

The chemical analyses of the ores confirmed them as iron rich, with very low contents of contaminants (besides the quartz and feldspar). They had very low manganese and phosphorus contents. The Upper crust-normalised REE profiles show a humped form with marked relative depletion of the light REE.

These features suggest that the blocks are not bog iron ore, but derived from a solid rock source. Such a source might be a low-temperature primary goethite deposit or an altered gossan above a sulphide ore vein. The present samples have insufficient features to discriminate between these origins.

The similarity of the REE profile with that of some iron slags from Woodstown is discussed.

Contents

Methods

All materials were examined visually with a low powered binocular microscope as part of the evaluation (Young 2006) and a database of all materials produced. The evaluation identified the materials as goethitic iron ores. A follow-up programme of analysis was designed to investigate the residues in more detail with a view to establishing whether they might be similar to materials employed for smelting iron at Adamstown 1 and Woodstown 6. The catalogue of the ore samples is presented in Table 1.

Electron microscopy was undertaken on the LEO S360 analytical electron microscope in the School of Earth, Ocean and Planetary Sciences, Cardiff University. Microanalysis was undertaken using the system's Oxford Instruments INCA ENERGY energy-dispersive X-ray analysis system (EDX). All images of microstructures presented in this report are backscattered electron (BSEM) photomicrographs. The polished blocks for investigation on the SEM were prepared in the Earth Science Department, The Open University.

Chemical analysis was undertaken using two techniques. The major elements (Si, Al, Fe, Mn, Mg, Ca, Na, K, Ti, and P) were determined by X-Ray Fluorescence using fused beads, on the Open University Earth Science Department's Wavelength-Dispersive X-Ray Fluorescence (WD-XRF) system.

Whole-specimen chemical analysis for minor and trace elements (Sc, Ti, V, Cr, Mn, Fe, Co, Zn, Ga, Rb, Sr, Y, Zr, Nb, Mo, Sn, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, Pb, Th and U) was undertaken using samples in solution on the ThermoElemental X-series Inductively-Coupled Plasma Mass Spectrometer (ICP-MS) in the School of Earth, Ocean and Planetary Sciences, Cardiff University. All sample batches for chemical analysis are run with internationally certified standards. Bulk analytical results are presented in Table 2.

Results

The microscopic investigation of the samples confirmed the hand specimen identification. Both were fragmental goethitic ores. ADN1 shows a texture comprising many small fragments bound by iron oxides, whereas the sample ADN2 appears to have been taken from within a single fragment.

The overall texture of ADN1 is shown by Plate 1. The sample is almost entirely of goethite apart from scattered large (up to 3mm) grains of quartz. The quartz shows evidence for etching and attack prior to, or contemporary with, the precipitation of the iron oxides. The iron oxides are dominantly in the form of grains 1-2mm across, with a slightly foliated texture, picked out by small voids. The grains are bound together with goethite cements.

ADN2 is formed of similar material to ADN1, but is somewhat denser (having fewer voids). The structure is more regular than ADN1, but there are a few areas (see plate 2) where there are areas that are slightly

less iron rich, possibly indicative of remnants of an original host rock.

The chemical compositions of the samples (Table 2) are very similar. Both are very rich in hydrated iron oxide, with ADN1 having a higher level of contamination by silica and alumina than ADN2 (probably reflecting a greater abundance of quartz and feldspar grains). Both have a silica to alumina ratio close to 4.1 by weight. The very low manganese and phosphorus contents of the ores are significant when compared with slags from adjacent sites.

Trace elements are generally in rather low concentrations. The rare earth element (REE) profiles (Figure 1) show a slightly humped form with significant depletion of the light REE compared to upper crust, and with the middle REE slightly more abundant than the heavy REE.

Interpretation

The textures of these samples, taken together with the very low manganese and phosphorus contents, suggest they are not bog iron ores, but are rock ores.

There is little available geological data from the area with which to compare the ores. Goethite ores may be found as minerals deposited in fairly low-temperature systems (for instance in the Bristol Channel Orefield of SW Britain, Young & Thomas 1999), but are also commonly produced by the supergene alteration of sulphide ore to produce gossan. Gossan ores re not well described in the geological literature, but a recent account of an example employed in early smelting was given by Young (2008).

The present examples do not contain diagnostic features which would allow discrimination between these geological origins.

Although the iron smelting slags at Woodstown 6 (Young 2009) did not show “humped” REE profiles, the site produced several examples of possible bloom-smithing slags (Young 2009, samples WTN5, 9, 14) which did show such a profile. Although it is possible that the REE profile of these examples was inherited from such a pattern in the hearth ceramics, it is also possible that they inherited the REE pattern from smelting slag trapped in the raw bloom.

References

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Figure Captions

Figure 1. Rare earth element profiles, normalised to Upper Crust (after Taylor & McLennan 1981)

Plate Captions

Plate 1. Montage of BSEM images of samples ADN1. Scale bar 2mm.

Plate 2. BSEM images

a. ADN1. Area 5. Scale bar 200µm.

a. ADN2. Area 1. Scale bar 2mm.

a. ADN2. Area 2. Scale bar 2mm.

Adamstown 3

1	f6	434g	block of brecciated yellowish ore cemented and overlain by dark botryoidal goethite, very dense
341	f1	376g	block of fragmental goethite ore

Table 1. Catalogue of material from site Adamstown 3

(a)

Sample	*Context*	*find*	*weight*	*SiO_2*	*Al_2O_3*	*Fe_2O_3*	*FeO*	*MnO*	*MgO*	*CaO*	*Na_2O*	*K_2O*	*TiO_2*	*P_2O_5*	*LOI*	*LOI (FeII)*	*total*
ADN1	f1	341	376g	10.27	2.54	72.55	65.30	0.05	0.18	0.10	0.11	0.44	0.32	0.33	12.06	19.32	98.95
AND2	f6	1	434g	5.21	1.23	80.18	72.16	0.28	0.01	0.04	0.11	0.06	0.03	0.16	11.17	19.19	98.48

(b)

	Sc	*V*	*Cr*	*Co*	*Ni*	*Cu*	*Zn*	*Ga*	*Rb*	*Sr*	*Y*	*Zr*	*Nb*	*Mo*	*Sn*	*Cs*	*Ba*
ADN1	3.12	75.80	66.98	11.71	82.12	42.73	236.37	7.08	23.77	5.17	22.99	88.93	5.46	69.57	0.46	1.12	44.81
AND2	7.21	33.46	40.36	43.21	120.39	78.64	319.20	1.77	3.13	1.36	34.82	7.94	0.55	0.92	0.63	0.20	11.10

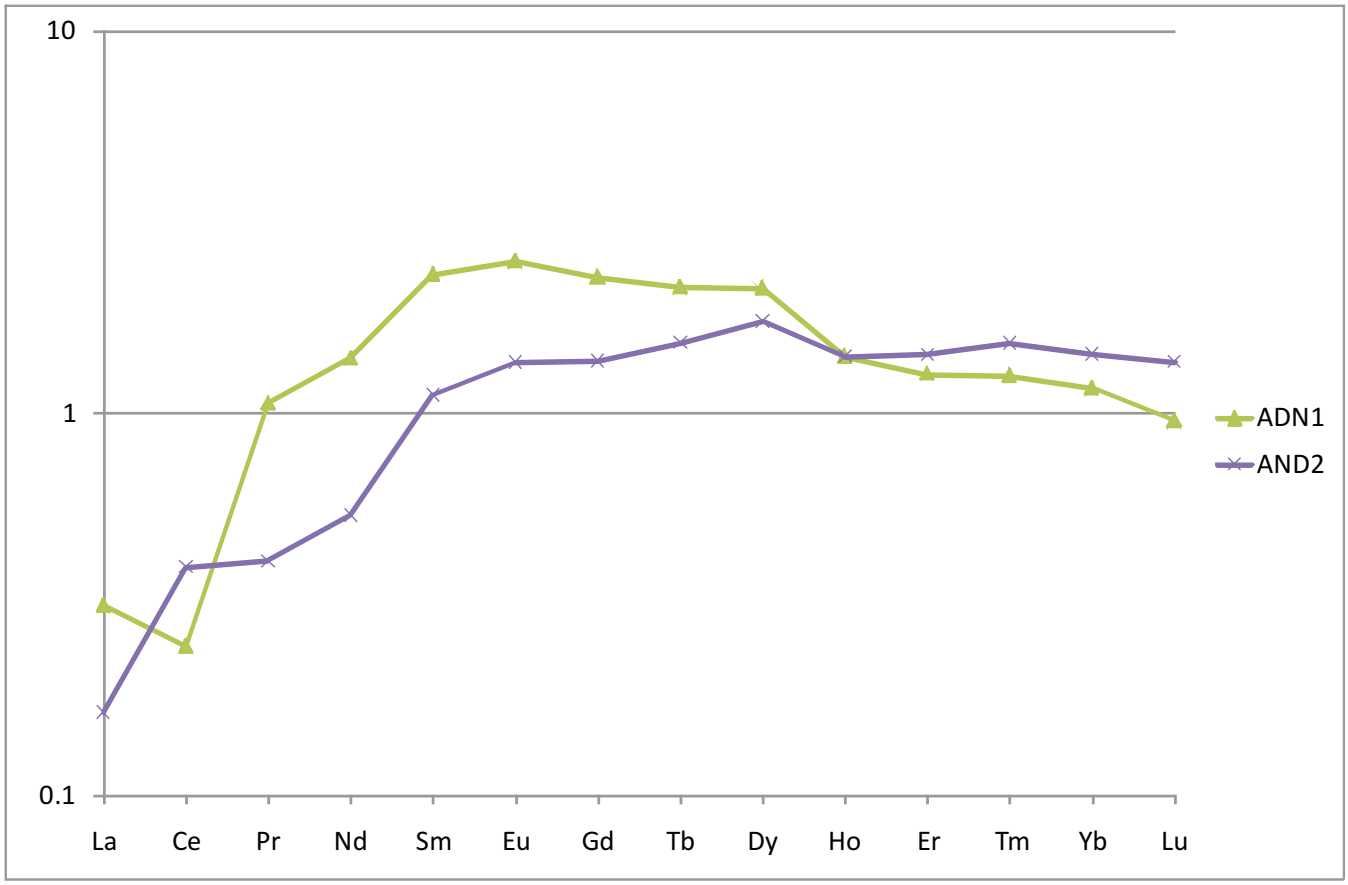
(c)

	La	*Ce*	*Pr*	*Nd*	*Sm*	*Eu*	*Gd*	*Tb*	*Dy*	*Ho*	*Er*	*Tm*	*Yb*	*Lu*	*Hf*	*Ta*	*Pb*	*Th*	*U*
ADN1	9.40	15.72	7.54	36.16	10.39	2.20	8.63	1.37	7.44	1.13	2.92	0.41	2.56	0.31	2.56	0.32	19.95	2.57	4.37
AND2	4.94	25.33	2.92	14.04	5.02	1.20	5.21	0.98	6.10	1.13	3.28	0.50	3.15	0.44	0.18	0.03	25.27	0.52	3.77

Table 2: chemical analyses of iron ore samples from Adamstown 3.

(a) Major elements expressed as wt% oxides, measured by XRF on fused bead. Iron is expressed as Fe_2O_3, with alternative values calculated as FeO and associated LOI shown with grey background. LOI = loss on ignition.

(b) and (c) Trace elements expressed as ppm element, measured by ICP-MS.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1
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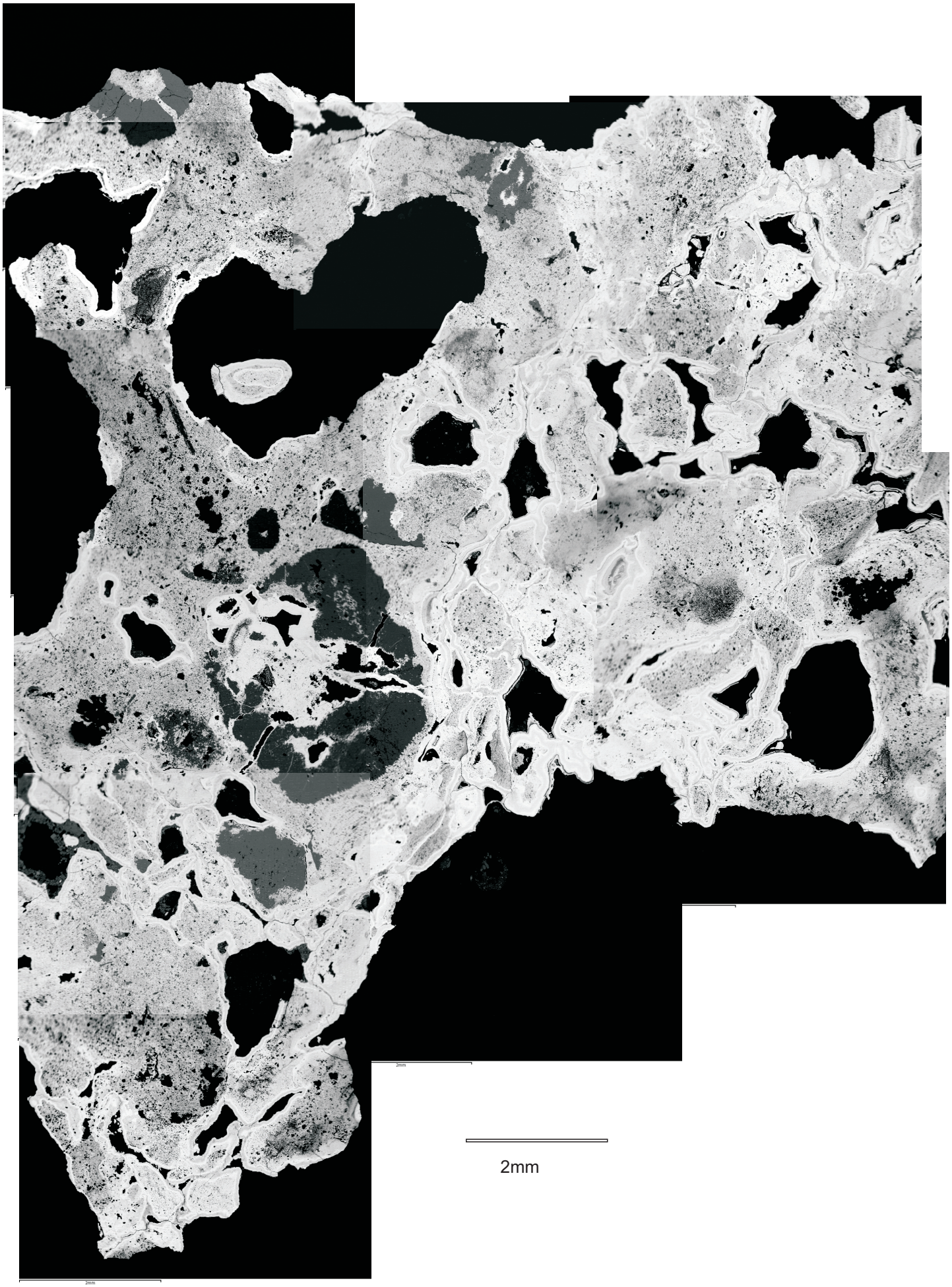
ADN1
AND2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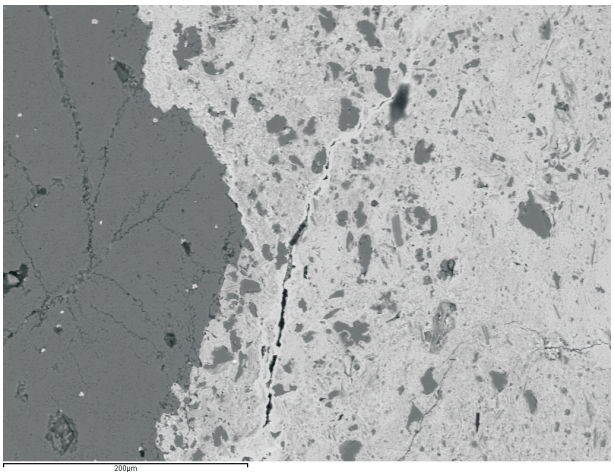
a



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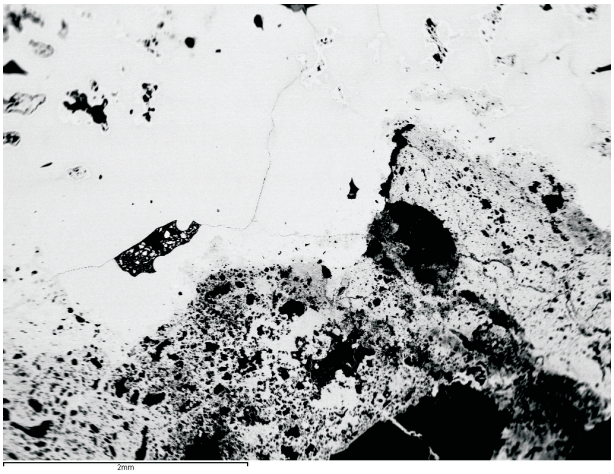

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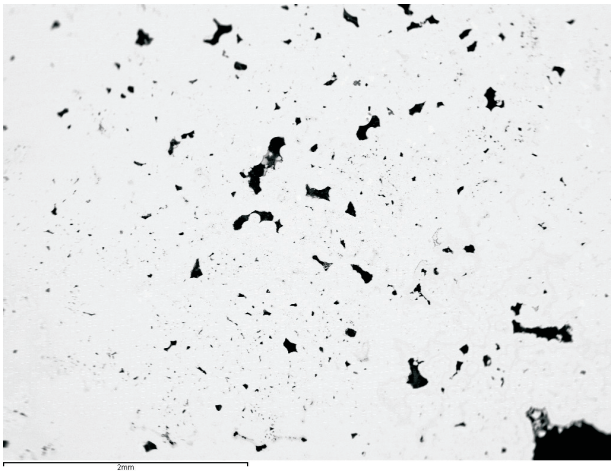

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