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Abstract

This analytical investigation focused on the possible evidence for slag-tapping bloomery iron smelting slags amongst the material assessed. The analysed material was al from a single context and included fired clay, a smithing hearth cake, and three examples of flowed slags, two of which have the maroon surface colour that is often an indicator of a tapped slag.

The analyses group the slags into two:

- the first group includes a sample of a smithing hearth cake, a separate sample of a descending prill detached from the base of the cake and one of the samples of a dense horizontal prill with a maroon surface tint (one of the specimens tentatively assessed as a bloomery slag). This group is characterised by an elevated magnesium content, leading to a mineralogy rich in spinels and moderately magnesian olivines. This composition is currently within any comparators in Irish slags, but possible interpretations are discussed

- the second group includes two flowed slags; one with a smooth maroon surface, the other browner, with flow between the moulds of fuel particles. This group is rich in manganese and many trace elements including the rare earth elements (REE) and uranium. This composition is interpreted as indicating the smelting of a local bog iron ore, with the local granite a strong influence on the smelting system chemistry.

Thus of the two potential tapped slag pieces analysed, one is apparently associated with the smithing residues, whereas the other is a smelting slag. The degree of oxidation of this piece, suggested by the superficial colour and as observed in section, suggests that the slag cooled in contact with air and is therefore likely to have been tapped from the furnace. It shares its chemical composition with the browner flow slag, which cooled within the fuel bed and might be from either a slag-tapping furnace or a non-tapping furnace. Whether the furnace concerned was a fully tapping furnace or whether oxidation of liquid slag occurred during a clearance of an intermediate style of furnace, is unknown.

Contents

Methods

From the materials examined for the evaluation report (Young 2006), a selection of seven samples (Table 1) was taken forward for detailed analysis. The materials were all taken from a single sample (s524, c922 from f518, area 18b). The purpose of the project was to determine whether any of the dense lobate, flowed slags with oxide-rich, often reddened, surfaces might be slags tapped from a slag-tapping bloomery furnace.

Electron microscopy was undertaken on the LEO S360 analytical electron microscope in the School of Earth and Ocean Sciences, Cardiff University. Microanalysis was undertaken using the system's Oxford Instruments INCA ENERGY energy-dispersive x-ray analysis system (EDX). All petrographic images presented in this report are backscattered electron 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 Wavelength-Dispersive X-Ray Fluorescence (WD-XRF) system in the department of Geology, Leicester University (this also generated analyses for S, V, Cr, Sr, Zr, Ba, Ni Cu, Zn, Pb and Hf). Whole-specimen chemical analysis for minor and trace elements was undertaken using samples in solution on the ThermoElemental X-series Inductively-Coupled Plasma Mass Spectrometer (ICP-MS) in the School of Earth and Ocean Sciences, Cardiff University.

Throughout this report standard mineral terminology is applied to both natural and anthropogenic materials – although artificial phases are no longer strictly considered to be minerals.

The convention adopted in this report is to describe olivine bearing Fe, Mg, Ca and Mn in terms of an olivine on the forsterite-fayalite join (using the notation for instance of Fa95Fo5 for an olivine that is 95% fayalite and 5% forsterite; where Fe/(Fe+Mg) = 0.95) plus figures for the overall percentage replacement by calcium and manganese.

Results

Description of analysed material

CMS-1 (ceramic sample – chemical analysis only)

CMS-2 (ceramic sample – chemical analysis only)

CMS-3: small SHC
Plate 1 a-g

This (and the following) sample were taken from a small slag cake with the morphology of a small smithing hearth cake (SHC), having a smooth, dished top, and a prilly base. The cake was approximately 90mm in diameter and 40mm thick. Sample CMS-3 was taken from the main body of the SHC, a dense, but vesicular grey slag.

In polished section the slag showed a rather heterogeneous texture, in part associated with chilled internal lobe margins which are assumed to correspond to the upper parts of the prills observed in hand specimen.

The texture exhibited by the slag had two main components – firstly zones with euhedral magnesium-rich spinels, sometimes cored on blebs of wustite, followed by coarse-grained, subhedral olivine (locally containing droplets of iron), and secondly zones with elongate olivines intergrown with hercynite and with interstitial spaces filled by fine olivine in glass.

Inclusions up to several millimetres across, rich in wustite occur and probably present oxidised iron or hammerscale. The wustite is in the form of study pseudodendrites. The interstitial areas of these clasts are filled with the same slag as the surrounding areas. In the case of the area in Plate 1b this includes an olivine (Fa63Fo37 with 1% manganese substitution) intergrown with a spinel mineral (approximately a hercynite with 10% magnetite and 20% spinel *sensu stricto*).

CMS-4: pendent prill removed from base of SHC
Plate 2 a-d, Plate 3 a,b.

In order to examine the possible relationship of the isolated flow slags to the probable SHC (CMS-3) an individual pendent prill was removed from the base of the cake for separate analysis.

In polished section the prill shows a dominantly coarsely crystalline structure, similar to that observed in CMS-3. The crystalline zones were linked to a charcoal particle (with possible weathered secondary iron rim) by a more glass-rich material with a meniscate surface (Plate 2a).

The crystalline zones were formed of a primary wustite (more abundant than in the sample from the main body of the slag cake) in the form of moderately well-developed dendrites with a rather patchy distribution and in small areas as a cotectic with the earliest olivine.

The olivine grades outwards from cores of around Fa60Fo40 with up to 1% calcium substitution. The cores (with or without a cotectic wustite) appear to be overlain rather abruptly by a zone with a strong gradation from Fa70 to Fa90. The olivine in this zone is usually accompanied by a spinel which grades outwards from hercynite with 10% magnetite and 30% spinel *sensu stricto.*

Within the slag there are a few internal lobe margins. One of these was examined in detail (Plate 2d; Plate 3a,b) and consisted of a line along which the nucleation of the magnesian olivine had occurred. There was no specific mineral growth forming a boundary and no directly associated iron oxides.

CMS-5: dense horizontally flowed lobe with maroon surface
Plate 4 a-h, Plate 5 a-b.

This piece is a tabular, dense slag lobe (Plate 8). The upper surface shows possibly deflated raised lobes. The lower surface shows shallow smooth depressions, possibly dimples from fuel contact. The specimen does not obviously comprise multiple flow lobes.

Internally, the polished section did show flow lobes. The external and internal lobe margins seen in the polished section were marked by thin zones of iron oxides. These were fine grained <10µm, but were mainly wustite.

On the observed internal lobe margin, one side of the oxide line was overlain by what was probably a magnesian spinel. On the opposite side the oxide boundary showed skeletal outgrowth of (possibly) magnetite intergrown with a magnesian spinal.

The main slag comprised a primary wustite in delicate dendrites. The wustite is followed by a strongly zoned olivine, ranging from Fa54 with no calcium or manganese, out to Fa95 with 2% calcium substitution.

CMS-6: dense flowed slag
Plate 6 a-f

This sample was a lobe of dense flowed slag, very similar in general appearance to CMS-5, but comprising a very definite prilly morphology (Plate 8).

In polished section the main prill shows a void at its core (Plate 6a), with the body of the prill formed of

primary wustite dendrites, followed by elongate olivine (up to 3mm in length) with interstitial glass.

The outer surface of the prill shows a thin layer of probable magnetite (Plate 6c) with short inward-facing growths. An internal lobe contact (Plate 6d) shows a similar morphology, but the crust appears to be wustite, although it still shows inward-growing magnetite (Plate 6e).

The olivine locally shows a cotectic with wustite at its core. The olivine grades outwards from cores of Fa98Fo2 with 1% calcium and 17 to 20% manganese substitution to Fa100 with 3% calcium and 14% manganese substitution at the margins.

CMS-7: slag flowed between charcoal pieces
Plate 7 a-h

The specimen was a dull, pale brown, flowed slag, formed by a horizontal prill penetrating between pieces of charcoal – now represented by moulds.

In polished section the different lobes have a rather different microstructure. Some primary dendritic wustite, followed by equant olivine with a wustite cotectic (Plate 7b), others show elongate olivine with the wustite confined to blebs along the olivine margins (Plate 7d). The outer margins of the olivine tend to show small intergrowths of hercynite.

The olivine is rather variable from area to area within the section. The cores are typical Fa98Fo2 with 2% calcium substitution, but variably show 26-37% manganese substitution. Near the margins and in interstitial areas the calcium substitution may rise to 12 or even 20%.

Much of the material is marked by fine minerals swept to the olivine grain boundaries (Plate 7h). These include an abundant alkali feldspar (with Na/(Na+K) = 0.62), a titanium-bearing spinel and a calcium phosphate (apatite) with abundant rare earth elements.

Where the interstitial areas are more open, they may either show an intergrowth of calcic olivine and leucite(?) (e.g. Plate 7f) or be occupied by glass with fine grained moderately calcic olivine (e.g. Plate 7g) The lobe margins show little development of primary iron oxides.

Chemical composition of analysed material

The hearth ceramics (CMS-1, CMS-2) were rather aluminous materials, with moderate iron, low levels of manganese, magnesium and calcium. There were moderately high contents of sodium and potassium.

The upper crust-normalised REE profile of the ceramics is very close to horizontal, with just a slight relative depletion at the light REE and a central 'hump' of middle REE.

The SHC (CMS-3 and CMS-4) was moderately iron-rich, strongly aluminous (the wt% Al_2O_3 varies from 6.9 to 8.8, compared with SiO_2 varying from 15.9 to 21.2 wt%) and also very rich in magnesium (4.4 to 5.5 wt% MgO). These materials showed low contents of sodium and potassium, as well as of manganese. Calcium was also relatively low at 0.6 to 1.6 wt% as CaO.

The REE profiles for these three specimens are very similar, with a progressive depletion towards the light REE and a marked negative hafnium anomaly.

The other trace elements of this group are interesting – for they show slightly elevated levels of vanadium and tin. The presence of tungsten was commonly noted in the EDS analyses of their interstitial glasses.

The two smelting slags showed a moderately high iron content, accompanied by high levels of manganese (90 and 17.2 wt% as Mn_3O_4). These slags were much more siliceous than the SHC and associated materials.

The REE profiles of these two samples are elevated, with a slight central hump and deletion towards either end. The high REE contents of the materials are probably associated with the presence of the REE-bearing phosphates seen in the polished section. Other incompatible elements (yttrium and uranium) are also enriched.

Interpretation

The project was undertaken to attempt to recognise if the dense lobate slags from this assemblage (Plate 8) were slags tapped from an iron smelting furnace. The descriptions above demonstrate that the collection includes material of two quite separate origins. One is chemically related to the smithing hearth cake samples, the other is related to a flow slag interpretable as a smelting slag.

Those materials with a dense, glossy appearance with a reddish surface tint can be seen to have iron oxide-rich flow lobe margins – so whether smelting slags or smithing slags, a mechanism for that oxidation must be sought. The flow slag penetrating between the fuel (CMS-7) did not show strongly oxidised flow lobe margins, entirely in keeping with its proposed origin within the fuel bed, which would be expected to have a reducing atmosphere.

The dense slag now identifiable as being a smelting slag and having oxidised flow lobes, and hence potentially a tapped slag, shows a more prilly morphology than some of the other dense, glossy, reddish pieces - so it may be that the unanalysed examples of rounded, but not prilly, dense slags may also have been related to the smithing system.

The two groups of slags described here both have very unusual chemical compositions.

The smithing hearth cake (CMS-3) and its associated materials have an unusual magnesium- and aluminium-rich composition, which gives rise to both unusual (for iron slags) olivine and spinel compositions. The comparison between these minerals in the two slag groups is presented in Figure 2 (for the olivines) and Figure 3 (for the spinels).

The two smelting slag samples (CMS6 and 7) have a very different composition: poor in magnesium, relatively siliceous and unusually rich in the REE, yttrium and uranium.

It is therefore possible that the analysed specimen CMS-6 may indeed be a tapped slag, but it is clear from the analysis of CMS-5, that not all the slags of similar appearance are from this origin – but many are actually from smthing.

Discussion

The interpretation described above raises three main questions:

1. what was the nature of the iron ore smelted to produce CMS6 and CMS7?

2. what was the source of the aluminous and magnesian material in CMS3-5?

and, relatedly

3. was the smithing hearth cake and its associated dense lobes produced during 'normal' smithing?

The answer to question 1 is almost certainly that the ore was a bog iron ore. It is unlikely, although not impossible, that such a manganese ore had a different origin. It is worth noting, perhaps, that the barium content of the smelting slags was very low – and barium is a common element in manganese-rich bog iron ores.

The unusual trace element chemistry of CMS 6 and CMS7, together with the unusual minor mineralogy of CMS7 may be due to incorporation of materials rich in the incompatible elements (Y, U the REE) derived from the local granite. That influence may not have been through the ore however – the subsoil at Carrickmines is rich in degraded granitic material, so these materials may have entered the smelting system through incorporation in furnace lining.

The source of the unusual chemical composition of the SHC, CMS3-4 and the lobe CMS5 is much more difficult to determine. Slags rich in magnesium and aluminium may sometimes be derived from the use of coal fuel – and coal was certainly employed at Carrickmines. However, there is usually also a significant content of calcium in coal ash – which is not evident here. In addition, the actual analysed specimens included clasts of charcoal – so unless both fuels were used together (as sometimes happened), coal seems an unlikely source.

A second possibility might be that the smithing operation was actually one of refining an impure bloom – and that these elements entered the system as slag entrained in the raw iron. A possible source system for this is suggested by the recent work by Dungworth (2010) on late medieval/early post medieval bloomery iron smelting of Coal Measures sideritic ore. The examples he examined had the siderite substituted by both calcium and magnesium, but other sources might just have a magnesian siderite, or, as demonstrated on a small scale by Young (2011) loss of the calcium from a concretionary siderite might preferentially occur during weathering. In this case smelting of weathered ore might produce slag rich in magnesium and aluminium. If this model for the chemical composition of the smithing slags was correct, then it would imply the import to Carrickmines of unrefined iron blooms from a bloomery in either one of the British coalfields, or perhaps one of the Irish coalfields.

The final question revolves around the interpretation of the oxidised-surfaced slag lobes that are not tap slags. How were they formed? The iron content of these slags is sufficiently high that they would have had fairly low viscosity at high temperature, despite the high aluminium content. The slightly raised viscosity may be why the lobes are broad, rounded and deflated – all arguably features of a rather viscous slag (Young 2011). It is unclear whether the oxidation of the lobes would be possible if they flowed down within the fuel of a normal smithing hearth. To become so oxidised an origin near the tuyère might be important . The problem of what these materials actually represent is beyond the scope of the present study. They remain highly unusual materials, but further investigations of late medieval/early post medieval slags in Ireland may eventually provide some clues.

References

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Figure Captions

Figure 1.
Upper crust-normalised REE profiles (normalisation after Taylor & McLennan 1981).

Figure 2.
Percentage substitution of manganese and calcium in in olivines plotted against Fe/(Fe+Mg). Upper diagram is material from the SHC and related material (CMS3-5), the lower diagram shows the flowed smelting slags (CMS6-7).

Figure 3
Variation of spinel chemistry on a Fe-Al-Mg ternary diagram. Open diamonds show the various end member spinel group minerals, the red crosses show the spinels from the smelting slags (CMS6-7) and the thin black crosses those from the SHC and related material (CMS3-5).

Plate Captions

All images backscattered electron photomicrographs except Plate 8.

Plate 1. CMS-3
a. CMS-3. SOI1. Scale bar 2mm.
b. CMS-3. SOI2. Scale bar 200 µm.
c. CMS-3. SOI3. Scale bar 200 µm.
d. CMS-3. SOI4. Scale bar 200 µm.
e. CMS-3. SOI5. Scale bar 30 µm.
f. CMS-3. SOI6. Scale bar 1mm
g. CMS-3. SOI7. Scale bar 200 µm.

Plate 2. CMS-4
a. CMS-4 SOI2. Scale bar 100 µm.
b. CMS-4 SOI3-7. Scale bar 100 µm.
c. CMS-4 SOI8. Scale bar 300 µm.
d. CMS-4 SOI9. Scale bar 2mm

Plate 3. CMS-4
a. CMS-4 SOI10. Scale bar 300 µm.
b. CMS-4 SOI11. Scale bar 100 µm.

Plate 4. CMS-5
a.CMS-5 SOI1. Scale bar 1mm
b. CMS-5 SOI2. Scale bar 1mm
c. CMS-5 SOI3. Scale bar 100 µm.
d. CMS-5 SOI4. Scale bar 1mm
e. CMS-5 SOI5 Scale bar 100 µm.
f. CMS-5 SOI6. Scale bar 100 µm.
g. CMS-5 SOI7 Scale bar 100 µm.
h. CMS-5 SOI8. Scale bar 70 µm.

Plate 5. CMS-5
a. CMS-5 SOI9. Scale bar 70 µm.
b. CMS-5 SOI10. Scale bar 60 µm.

Plate 6. CMS-6
a.CMS-6 SOI1-3. Scale bar 1mm
b. CMS-6 SOI4. Scale bar 100 µm.
c. CMS-6 SOI5. Scale bar 100 µm.
d. CMS-6 SOI6. Scale bar 70 µm.
e. CMS-6 SOI7 Scale bar 40 µm.
f. CMS-6 SOI8. Scale bar 70 µm.

Plate 7. CMS-7
a. CMS-7 SOI1. Scale bar 1mm
b. CMS-7 SOI2. Scale bar 200 µm.
c. CMS-7 SOI3. Scale bar 200 µm.
d. CMS-7 SOI4. Scale bar 200 µm.
e. CMS-7 SOI5. Scale bar 200 µm.
f. CMS-7 SOI6. Scale bar 200 µm.
g. CMS-7 SOI8. Scale bar 100 µm.
h. CMS-7 SOI9. Scale bar 70 µm.

Plate 8.
Upper and lower surfaces of the dense flowed slags with oxide-rich surfaces from s524, c922. The samples from which CMS-5 and CMS-6 were taken are indicated. Upper image shows upper surfaces, lower image shows lower surfaces.

Table 1: Major and minor elements as wt% oxide. Determined by XRF. LOI = loss on ignition (negative = weight gain)

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	Mn_3O_4	MgO	CaO	Na_2O	K_2O	P_2O_5
CMS1	74.79	0.61	12.12	5.77	0.49	0.80	0.65	1.39	1.96	0.225
CMS2	75.29	0.57	11.56	6.44	0.51	0.78	0.68	1.45	2.21	0.197
CMS3	21.15	0.76	8.82	61.67	0.40	5.47	1.04	0.05	0.21	0.214
CMS4	19.69	0.89	7.18	63.11	0.42	4.38	1.62	0.10	0.28	0.280
CMS5	15.88	1.08	6.92	69.17	0.28	4.56	0.62	0.03	0.22	0.192
CMS6	20.77	0.12	2.44	64.92	8.98	0.25	1.22	0.27	0.50	0.276
CMS7	22.61	0.09	2.73	52.90	17.18	0.34	2.22	0.24	0.49	0.491

	SO_3	V_2O_5	Cr_2O_3	SrO	ZrO_2	BaO	NiO	CuO	ZnO	PbO	HfO_2	LOI	Total
CMS1	<0.003	0.015	0.008	<0.002	0.029	0.032	0.019	0.002	0.067	<0.002	<0.004	1.12	98.95
CMS2	<0.003	0.018	0.007	0.010	0.028	0.038	0.015	0.002	0.014	0.003	<0.004	0.66	99.82
CMS3	0.065	0.086	<0.004	<0.003	0.009	0.012	0.005	<0.003	0.002	0.007	<0.005	-1.33	99.97
CMS4	0.105	0.065	<0.004	<0.003	0.015	0.020	<0.003	<0.003	<0.002	<0.003	<0.005	-4.47	98.15
CMS5	0.007	0.045	<0.004	<0.003	0.013	0.012	0.039	0.003	<0.002	0.005	<0.005	-5.86	99.07
CMS6	0.034	<0.003	<0.005	0.014	0.011	0.067	0.023	<0.003	0.002	0.005	0.006	-5.75	99.92
CMS7	0.020	0.004	<0.005	0.018	0.012	0.120	<0.004	<0.003	0.004	0.005	<0.005	-4.80	99.48

Table 2: Major elements as wt% oxide. Determined by ICP-MS

	MnO	Fe_2O_3	TiO_2	P_2O_5
CMS1	0.35	4.25	0.44	0.17
CMN2	0.40	5.18	0.45	0.16
CMS3	0.32	53.31	0.68	0.18
CMS4	0.27	42.76	0.61	0.21
CMS5	0.23	64.80	1.02	0.19
CMS6	7.22	55.49	0.10	0.26
CMS7	11.85	38.51	0.08	0.41

Table 3: Trace elements in elemental ppm. Determined by ICP-MS.

	Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Rb	Sr	Y	Zr	Nb	Mo	Sn	Cs	Ba
CMS1	8.5	57.2	77.6	11.2	55.4	46.1	255.0	14.6	79.6	68.4	28.9	203.8	7.89	2.07	4.85	7.84	256.2
CMN2	9.1	64.2	59.5	10.6	35.2	26.3	80.4	14.6	105.0	82.5	32.3	168.7	8.02	2.44	7.77	11.42	332.3
CMS-3	23.5	413.2	30.4	1.7	4.8	11.6	26.9	18.8	7.3	41.1	13.1	79.0	6.12	4.24	50.14	0.60	87.2
CMS4	17.9	209.8	15.9	1.5	45.9	39.9	27.1	14.4	6.5	52.0	16.1	95.9	6.75	1.71	36.86	0.39	137.8
CMS-5	19.7	224.2	59.7	6.1	68.1	227.5	45.1	23.7	6.6	21.3	16.4	108.3	7.68	4.34	92.98	0.54	67.6
CMS6	2.0	15.4	63.0	7.4	17.3	11.5	33.2	6.8	19.8	121.5	148.1	100.4	2.18	1.23	1.26	1.12	276.1
CMS7	2.2	17.3	45.1	58.6	15.9	37.0	36.9	7.2	13.6	159.3	233.3	97.9	1.81	1.45	0.96	0.78	484.5

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Pb	Th	U
CMS1	26.99	48.96	6.23	24.04	5.23	1.06	4.86	0.74	4.38	0.80	2.50	0.34	2.44	0.38	5.16	0.83	12.57	6.79	3.91
CMN2	29.99	56.08	7.37	27.23	5.81	1.32	5.54	0.85	4.61	0.87	2.67	0.38	2.42	0.38	4.04	0.82	14.99	7.20	4.88
CMS3	6.14	14.49	1.80	7.47	1.94	0.43	2.02	0.34	2.15	0.41	1.25	0.20	1.39	0.23	1.68	0.38	2.46	2.54	3.27
CMS4	8.93	19.49	2.44	9.96	2.65	0.61	2.90	0.48	2.89	0.53	1.59	0.24	1.61	0.24	2.33	0.50	2.37	3.13	4.22
CMS5	6.07	14.52	1.92	8.17	2.17	0.52	2.36	0.41	2.55	0.51	1.64	0.27	1.74	0.28	2.26	0.49	2.62	2.24	3.58
CMS6	64.41	150.12	20.15	83.42	18.35	3.72	21.18	3.05	16.91	3.31	10.36	1.40	8.29	1.13	2.16	0.21	3.46	2.92	25.78
CMS7	102.31	263.20	31.81	133.59	29.05	6.08	34.10	4.97	26.86	5.36	16.82	2.26	13.02	1.90	2.08	0.41	2.67	3.41	38.02

Table 4: EDS microanalyses as wt% element. All elements analysed.

		O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Co	Cu	As	Zr	Ba	Ce	Nd	W	Total
CMS3	SOI 1	24.98		2.66	3.04	4.30				0.16	0.36	0.45				50.02									85.97
CMS3	SOI 1	25.03		3.00	8.28	6.35				0.19	0.54	0.27				25.49									69.16
CMS3	SOI 1	42.05	0.68	2.87	11.61	12.59	0.15			0.79	1.91	0.68			0.28	45.15									118.75
CMS3	SOI 1	42.38		7.50	4.80	15.24				0.40	1.00	0.38			0.27	44.24									116.21
CMS3	SOI 2	37.47		2.60	26.22	0.34						1.13	0.34			35.42									103.52
CMS3	SOI 2	36.64		10.05		15.48					0.21				0.31	39.32									102.02
CMS3	SOI 2	40.16		3.56	29.20	0.20						0.62	0.37			32.54									106.66
CMS3	SOI 2	24.94		0.76	0.68	0.17						0.69				73.90									101.15
CMS3	SOI 2	36.37		2.76	0.33	14.81					1.00				0.61	52.27									108.15
CMS3	SOI 3	24.51		1.69	0.40							0.86				72.75									100.20
CMS3	SOI 3	35.83	0.66	2.77	3.15	14.85				0.75	2.02	0.39			0.33	40.05									100.80
CMS3	SOI 3	39.69		3.67	29.10	0.19						0.26				30.53									103.43
CMS3	SOI 3	40.65		6.51	30.54							0.35	0.31			24.85									103.20
CMS3	SOI 3	40.34		5.91	30.06							0.39	0.46			26.81									103.97
CMS3	SOI 3	41.14		6.42	30.89	0.21						0.26	0.50			25.01									104.42
CMS3	SOI 3	39.90		4.43	30.48							0.29	0.52			28.69									104.32
CMS3	SOI 3	37.35		8.95		15.67					0.18				0.26	41.46									103.87
CMS3	SOI 3	38.02		10.61	0.23	16.14									0.38	39.79									105.17
CMS3	SOI 3	40.35		13.05	0.24	17.02					0.14				0.38	37.07									108.24
CMS3	SOI 3	35.82		7.63		14.90					0.26				0.31	41.77									100.68
CMS3	SOI 3	33.74		1.58	0.17	13.90					0.49				0.39	50.97									101.24
CMS3	SOI 3	42.32	2.53		9.19	18.20	0.54	0.29		4.54	8.16	0.71				15.11									101.58
CMS3	SOI 3	34.51		7.94	0.20	14.72					0.22				0.29	40.35									98.23
CMS3	SOI 3	32.57		2.46		14.05					0.43				0.42	49.57									99.50
CMS3	SOI 3	33.72		4.68		14.24					0.30				0.33	45.49									98.76
CMS3	SOI 3	45.15	2.57		9.87	18.92	0.53	0.39		4.89	9.05	0.58				18.18									110.12
CMS3	SOI 3	37.15		4.05		15.30					0.37				0.49	51.19									108.56
CMS3	SOI 4	35.07		5.00		14.69					0.21				0.38	46.30									101.65
CMS3	SOI 4	34.16		2.89		14.07					0.38				0.38	49.44									101.33
CMS3	SOI 4	36.75		1.82	25.72	0.21						1.51	0.51			34.37									100.88
CMS3	SOI 4	36.71		1.57	26.54	0.32						1.01	0.36			34.43									100.94
CMS3	SOI 4	34.16		3.99		14.10					0.26				0.48	47.38									100.37
CMS3	SOI 4	33.80		0.42	0.22	13.91					0.97				0.37	53.70									103.38
CMS3	SOI 4	34.57		0.45	2.84	12.36					0.99	0.92			0.38	53.78									106.29

		O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Co	Cu	As	Zr	Ba	Ce	Nd	W	Total
CMS3	SOI 5	36.41			11.68	2.91				0.86	1.30	8.12				42.63									103.91
CMS3	SOI 5	41.92	0.89		9.41	13.57		0.16		0.96	8.44	3.08				29.17									107.59
CMS3	SOI 5	36.26			12.33	3.50				0.72	0.99	6.98				43.17									103.96
CMS3	SOI 5	42.48	1.03		9.37	14.57	0.15	0.13		1.18	8.43	2.69				28.94									108.98
CMS3	SOI 5	42.07	2.53		9.03	18.10	0.35	0.65		3.97	8.20	0.32				17.26									102.50
CMS3	SOI 5	16.45	0.82		5.46	7.50		0.27	0.22	1.08	2.57	0.80				74.91									110.09
CMS3	SOI 5	41.22	0.83		8.74	14.54	0.23	0.21		2.10	8.40	2.42				25.80									104.47
CMS3	SOI 5	42.17	2.01		8.71	17.19	0.29	0.26		3.29	7.74	1.05				22.61									105.33
CMS3	SOI 7	38.73		12.72	0.24	16.41					0.17				0.34	36.49									105.11
CMS3	SOI 7															104.39									104.39
CMS3	SOI 7	38.19		7.30	0.44	15.98					0.24				0.46	46.98									109.59
CMS3	SOI 7	47.13	2.15		10.65	22.45	0.34	0.75		3.63	8.19	0.91				15.76									111.96
CMS3	SOI 7	29.76		0.68	6.75	2.44					0.28	1.28				60.60									101.79
CMS3	SOI 7	32.89	0.72	1.64	4.57	14.25				0.79	1.51	0.28			0.44	40.53									97.62
CMS3	SOI 7	35.92		2.08	19.98	1.64						1.74	0.58			40.50									102.44
CMS4	SOI 2	36.78		6.59	0.61	15.39		0.14			0.97				0.28	44.69									105.44
CMS4	SOI 2	36.85		11.03		16.06					0.20				0.33	38.54									103.02
CMS4	SOI 2	36.37		10.56		15.98					0.23				0.31	40.15									103.60
CMS4	SOI 2	36.17		10.79	0.25	15.71					0.17				0.47	39.53									103.09
CMS4	SOI 2	35.71		9.79	0.28	15.89					0.33				0.27	40.76									103.03
CMS4	SOI 2	36.55		10.05	0.22	15.91					0.26				0.44	41.21									104.64
CMS4	SOI 2	33.16		4.30	0.19	14.62					0.49				0.43	48.85									102.04
CMS4	SOI 2	31.96		1.71		14.01					0.70				0.44	52.73									101.54
CMS4	SOI 2	34.51		0.48	21.89	0.21						3.06				41.85									102.01
CMS4	SOI 2	37.56		4.72	29.16							0.41	0.37			28.84									101.06
CMS4	SOI 2	42.57	3.63		9.83	19.74	0.54	0.40		6.44	5.56	0.32				15.45								2.34	106.83
CMS4	SOI 2	33.53	0.31		0.78	14.67	0.31			0.81	15.12					34.16									99.69
CMS4	SOI 2	34.85		0.21		15.24	0.29				15.95				0.25	39.41									106.19
CMS4	SOI 2	31.66		1.04		14.08					0.98				0.33	53.07									101.16
CMS4	SOI 11	35.66		8.76	0.40	15.21					0.35				0.38	41.88									102.64
CMS4	SOI 11	33.03		2.79		14.37					0.61				0.43	51.03									102.26
CMS4	SOI 11	36.63		3.25	25.85	0.44						1.19	0.52			33.16									101.03
CMS4	SOI 11	35.24		3.25	26.86							0.75	0.34		0.13	32.72									99.28
CMS4	SOI 11	36.11		3.46	25.46	0.48						1.22	0.62			33.11									100.45
CMS4	SOI 11	34.34		8.15	0.33	15.02					0.36				0.47	41.75									100.42
CMS4	SOI 11	34.32		8.90	0.29	14.67					0.31				0.37	39.79									98.65
CMS4	SOI 11	34.93		10.33	0.22	15.04					0.28				0.32	37.87									98.99

		O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Co	Cu	As	Zr	Ba	Ce	Nd	W	Total
CMS4	SOI 11	34.16		7.18	0.23	14.84					0.26				0.43	42.57									99.67
CMS4	SOI 11	35.25		3.26	0.22	14.60					0.54				0.43	48.16									102.46
CMS4	SOI 11	31.15		2.03	0.18	13.51					0.62				0.54	49.32									97.34
CMS4	SOI 11	32.97		0.54	20.30							2.90	0.17			39.21									96.08
CMS4	SOI 11	29.96		1.02	0.16	12.90					0.90	0.14			0.43	49.66									95.16
CMS4	SOI 11	33.62		11.11	0.19	14.69					0.22				0.28	33.23									93.36
CMS4	SOI 11	34.37		4.45	25.28	0.24						0.89	0.46			27.57									93.26
CMS4	SOI 11	34.45		2.11	25.02							0.78	0.29			31.83									94.49
CMS4	SOI 11	42.91	3.04		8.88	15.99	2.77	0.23		5.56	8.94	0.22				9.09								1.98	99.60
CMS4	SOI 11	37.72			11.22	11.76	0.66	0.11			2.02	0.28				14.76								1.47	80.32
CMS4	SOI 11	29.73			4.21	4.61	0.25	11.19			2.00	1.52				50.98								0.77	105.73
CMS4	SOI 11	31.14		1.62		13.56					0.71				0.35	49.85									97.24
CMS4	SOI 11	31.03			7.35							10.37				51.49									100.24
CMS4	SOI 11	40.21	3.68		10.58	19.06	0.53	0.15		7.28	3.90	0.23				9.93								2.97	98.52
CMS4	SOI 11	23.26			0.42	0.37					0.23	1.04			0.21	72.97									98.50
CMS4	SOI 11	16.69	0.38	0.13	9.78	4.16	0.59			2.11	4.29					16.63									54.75
CMS4	SOI 11	32.76		8.12		14.38					0.28				0.35	39.55									95.44
CMS4	SOI 11															95.66									95.66
CMS5	SOI 8	36.10		5.88	28.06	0.23						0.78	0.26			27.14									98.45
CMS5	SOI 8	36.06		5.63	27.97	0.22						0.80	0.17			26.97									97.82
CMS5	SOI 8	33.95		1.74	24.95	0.23						1.56				36.07									98.51
CMS5	SOI 8	30.23		0.90	1.87	12.54	0.15			0.15	0.78	0.38			0.28	51.20									98.48
CMS5	SOI 8	28.11		2.22	1.24	12.48					0.37	0.23			0.38	50.18									95.21
CMS5	SOI 8	31.31		4.51	0.21	14.23					0.31	0.14			0.26	48.00									98.97
CMS5	SOI 8	30.50		1.99	0.20	13.97					0.50	0.15			0.33	51.32									98.96
CMS5	SOI 8	30.64		2.90	0.24	13.91					0.39				0.33	49.50									97.91
CMS5	SOI 8	30.96		3.90		13.99					0.36	0.14			0.34	47.96									97.66
CMS5	SOI 8	34.71		3.76	25.72	0.39						1.32				31.56									97.47
CMS5	SOI 8	33.71		2.17	24.50	0.23						1.73				34.95									97.30
CMS5	SOI 8	31.93		8.20	0.31	14.56					0.15	0.16			0.21	41.33									96.86
CMS5	SOI 8	32.27		2.57	1.48	12.61					0.39	0.45			0.30	50.79									100.85
CMS5	SOI 8	29.68		2.13	5.10	10.62					0.35	0.75			0.22	46.90									95.75
CMS5	SOI 8	33.44		7.58	0.36	14.45					0.16	0.14				40.92									97.06
CMS5	SOI 8	29.65		1.48	0.31	13.35					0.50				0.25	50.31									95.85
CMS5	SOI 8	21.89		0.27	0.72	0.18						1.20	0.17			72.45									96.88
CMS5	SOI 8	21.98			0.72							1.20				72.54									96.44
CMS5	SOI 8	37.22	2.15		9.55	16.62	0.55	0.12		3.66	6.31	0.37			0.23	19.45									96.22
CMS5	SOI 8	30.22		0.47	5.10	10.24					0.94	1.40				49.08									97.45
CMS5	SOI 8	34.74	2.24		9.22	15.70	0.69	0.16		4.18	6.07	0.47				25.58								1.05	100.11

		O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Co	Cu	As	Zr	Ba	Ce	Nd	W	Total
CMS5	SOI 9	34.26		3.71	25.61	0.25						1.12	0.18			31.66									96.80
CMS5	SOI 9	31.61		0.84	21.04	0.48						2.84				40.32									97.14
CMS5	SOI 9	32.96		0.84	22.81	0.36						2.45				38.10									97.52
CMS5	SOI 9	33.31		12.40	0.21	15.42									0.24	33.16									94.74
CMS5	SOI 9	31.75		8.43		14.38					0.15				0.29	39.60									94.60
CMS5	SOI 9	29.35		1.72	0.22	13.20					0.44				0.27	49.44									94.64
CMS5	SOI 9	20.96		0.42	0.46	0.15						0.96				71.32									94.28
CMS5	SOI 9	22.67		1.12	4.68	0.43						0.73				60.93									90.55
CMS5	SOI 9	35.99	2.24		8.21	16.49	0.61	0.19		4.45	6.51	0.47				21.08								1.22	97.46
CMS5	SOI 9	29.62		1.18	0.21	13.47					0.65				0.28	51.05									96.46
CMS5	SOI 9	31.02		6.81	0.19	14.30					0.16				0.28	42.89									95.65
CMS5	SOI 9	33.69		11.28	2.34	13.58						0.20				33.33									94.41
CMS5	SOI 9	21.47		0.52	0.39	0.23						0.87				71.10									94.57
CMS5	SOI 9	34.85		5.14	26.04	0.80						0.41				28.43									95.67
CMS5	SOI 9	21.28		0.43	0.45	0.24						0.91				71.41									94.71
CMS5	SOI 9	20.66		0.19	0.47	0.13						1.21			0.26	69.96									92.88
CMS5	SOI 9	21.67		0.49	3.14	0.22						1.27				61.20									87.99
CMS5	SOI 10	35.63		6.29	27.75							0.50	0.29			24.60									95.05
CMS5	SOI 10	34.40		4.95	25.54	0.59	0.13					1.06				27.59									94.25
CMS5	SOI 10	31.15		5.88	1.40	13.16					0.23	0.25				42.98									95.05
CMS5	SOI 10	29.57		2.76	0.23	13.21					0.32					47.29									93.38
CMS5	SOI 10	33.29	2.51		8.26	15.80	0.47	0.18		4.34	6.10	0.39				21.56								1.11	94.01
CMS5	SOI 10	21.79		0.00	0.72	0.59				0.21	0.24	1.23				68.92									93.69
CMS5	SOI 10	31.31		8.59	0.72	13.88					0.13	0.17			0.30	39.23									94.34
CMS5	SOI 10	29.64		3.16	0.24	13.38					0.30				0.29	47.65									94.66
CMS6	SOI 7	24.98			3.95	2.27					0.29	0.14			3.97	57.83									93.44
CMS6	SOI 7	25.31			2.88	3.67					0.59				5.31	54.87									92.62
CMS6	SOI 7	21.58			0.43	0.84					0.15				3.74	66.74									93.48
CMS6	SOI 7	21.41			0.36	0.43									3.47	69.06									94.73
CMS6	SOI 7	24.57			1.42	0.76									1.85	63.67									92.28
CMS6	SOI 7	23.72			2.00	0.52						0.24			1.60	62.48									90.56
CMS6	SOI 7	25.46			1.43	1.32					0.11	0.14			2.64	63.55									94.65
CMS6	SOI 7	28.16			2.02	1.42						0.18			1.94	64.18									97.90
CMS6	SOI 7	22.20			0.37	0.81					0.13				3.62	67.16									94.29
CMS6	SOI 7	21.95			0.54	0.80									3.80	66.19									93.27
CMS6	SOI 7	31.25		0.31	0.24	13.60					0.54				10.21	41.75									97.91
CMS6	SOI 7	32.63	2.89		5.72	14.88	0.52	0.20		4.31	5.08				2.29	17.42						0.68			86.61
CMS6	SOI 7	30.55		0.36	0.22	13.78					0.46				10.23	40.91									96.50

		O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Co	Cu	As	Zr	Ba	Ce	Nd	W	Total
CMS6	SOI 8	30.27		0.33	0.23	13.50					0.35				9.65	45.33									99.66
CMS6	SOI 8	30.45		0.35	0.26	13.60					0.34				9.40	44.89									99.29
CMS6	SOI 8	32.17	0.46		1.12	14.39				0.43	1.25				7.50	44.44									101.76
CMS6	SOI 8	30.45		0.27	0.24	13.69					0.36				9.44	45.42									99.87
CMS6	SOI 8	30.08			0.24	13.69					0.62				8.16	47.10									99.90
CMS6	SOI 8	37.25	3.35		8.56	18.37	0.62	0.25		4.85	6.11				1.75	15.17						0.50			96.78
CMS6	SOI 8	36.04	3.04		8.51	17.49	0.60	0.23		4.52	6.38				1.76	16.04						0.65			95.28
CMS6	SOI 9	30.65		0.49		13.67					0.40				11.29	43.65									100.15
CMS6	SOI 9	30.69		0.56	0.18	13.87					0.43				11.40	42.78									99.91
CMS6	SOI 9	30.49		0.48		13.72					0.36				11.00	43.19									99.25
CMS6	SOI 9	29.55		0.21		13.30					0.57				10.19	43.73									97.56
CMS6	SOI 9	36.39	2.50		9.52	15.81	0.70	0.19		3.61	5.68				3.09	18.02						0.49			95.99
CMS6	SOI 9	22.32			0.68	0.21						0.23			3.27	71.80									98.52
CMS6	SOI 9	21.68			0.49	0.20									3.93	71.49									97.80
CMS7	SOI 7	31.52		0.51		13.89	0.15				1.19				20.91	32.71									100.88
CMS7	SOI 7	30.56		0.32		13.82					1.38				20.26	32.99									99.33
CMS7	SOI 7	32.64				13.97	0.42				4.70				16.60	31.98									100.30
CMS7	SOI 7	34.45			27.66							0.16			6.89	29.95									99.11
CMS7	SOI 7	34.83			27.34	0.19					0.11	0.25			6.69	29.93									99.34
CMS7	SOI 7	22.10			0.27	0.17									8.73	68.40									99.67
CMS7	SOI 7	30.36			0.16	13.32	0.27				3.32				17.23	32.84									97.50
CMS7	SOI 7	36.14			25.21	1.26	0.17			0.37	0.81	0.27			6.76	31.46									102.45
CMS7	SOI 7	34.26	0.22		26.32	0.94	0.13			0.13	0.40	0.26			6.59	29.40									98.65
CMS7	SOI 7	34.52	1.00		1.60	14.22	0.74			1.07	7.70				13.01	27.92									101.77
CMS7	SOI 7	32.64	0.94	0.68	1.79	11.22	0.77	9.30		1.08	4.07	1.07			2.58	29.25					6.14				101.54
CMS7	SOI 7	40.98	7.88		14.60	18.66	0.28			9.05	1.14				0.57	1.84									95.01
CMS7	SOI 7	35.78	1.28		11.75	15.71	0.49			16.07	2.03				1.41	4.11									88.63
CMS7	SOI 7	21.50			0.25							0.36			6.28	67.61									96.01
CMS7	SOI 8	31.64			0.36	13.56	0.35			0.25	3.12				11.99	37.52									98.78
CMS7	SOI 8	30.33		0.40		13.59					0.87				14.45	39.47									99.10
CMS7	SOI 8	30.00		0.31		13.72					0.95				14.69	38.48									98.14
CMS7	SOI 8	30.72		0.29		13.88					0.92				14.41	39.36									99.57
CMS7	SOI 8	30.28		0.33		13.68					0.73				14.43	38.84									98.29
CMS7	SOI 8	29.87			0.20	13.23	0.24				2.02				12.65	38.87									97.08
CMS7	SOI 8	29.84		0.29		13.30					0.77				13.54	39.00									96.75
CMS7	SOI 8	38.29	2.89		12.19	15.81	1.23	0.30		5.65	7.08	0.26			2.11	10.88						0.86			97.55

		O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Co	Cu	As	Zr	Ba	Ce	Nd	W	Total
CMS7	SOI 9	41.84	9.08		17.41	18.47		0.53		9.56	0.78				0.46	2.53					0.50				101.16
CMS7	SOI 9	32.77			24.14	1.50					0.57	0.46			7.59	30.15									97.17
CMS7	SOI 9	34.26			25.54	1.31	0.12			0.43	0.58	0.41			7.09	29.65									99.39
CMS7	SOI 9	39.71	8.76		16.60	18.33				9.41	0.70				0.42	1.78					0.57				96.76
CMS7	SOI 9	30.16		0.41		13.38					1.31				18.58	33.95									97.80
CMS7	SOI 9	29.62		0.45		13.31	0.18				1.19				20.24	31.75									96.74
CMS7	SOI 9	30.22			1.33	13.39	0.22			0.89	3.15				15.81	31.43									96.42
CMS7	SOI 9	29.52		0.34	0.22	13.42					1.50				19.01	31.74									95.76
CMS7	SOI 9	29.60		0.42	0.23	13.34	0.19				1.25				19.91	31.19									96.12
CMS7	SOI 9	28.99		0.34		13.07	0.18				1.21				19.48	31.29									94.57
CMS7	SOI 9	30.97			0.95	5.59	7.39				19.28				4.13	9.40						7.22	1.26		86.19
CMS7	SOI 9	36.15	1.22		28.67	2.54	0.24			0.45	0.59	0.66			5.79	28.84									105.17
CMS7	SOI 9	34.06	2.17		7.96	5.87		0.29		2.35	0.51	8.03			3.39	37.69				0.92					103.24

Table 5: EDS microanalyses as normalised atom%. All elements analysed.

				O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Zr	Ba	Ce	Nd	W
CMS3	SOI 1	#1	area	54.69		3.84	3.94	5.36				0.14	0.32	0.33			31.38					
CMS3	SOI 1	#2	area	57.92		4.56	11.36	8.38				0.18	0.50	0.21			16.90					
CMS3	SOI 1	#3	area	57.70	0.64	2.59	9.45	9.85	0.11			0.44	1.05	0.31		0.11	17.75					
CMS3	SOI 1	#4	area	58.62		6.83	3.94	12.01				0.23	0.55	0.18		0.11	17.53					
CMS3	SOI 2	#1	spinel outer	57.16		2.61	23.71	0.30						0.58	0.16		15.48					
CMS3	SOI 2	#2	olivine	57.68		10.42		13.89					0.13			0.14	17.74					
CMS3	SOI 2	#3	spinel inner	57.72		3.37	24.89	0.16						0.30	0.17		13.40					
CMS3	SOI 2	#4	wustite	52.67		1.06	0.85	0.21						0.49			44.72					
CMS3	SOI 2	#5	i/s/ olivine	58.31		2.91	0.32	13.53					0.64			0.29	24.01					
CMS3	SOI 3	#1	wustite in spinel	52.16		2.37	0.50							0.61			44.36					
CMS3	SOI 3	#2	glass with wustite	58.50	0.75	2.98	3.04	13.81				0.50	1.32	0.21		0.16	18.73					
CMS3	SOI 3	#3	spinel inner	58.12		3.53	25.26	0.16						0.13			12.80					
CMS3	SOI 3	#4	spinel inner+	57.76		6.08	25.73							0.17	0.14		10.12					
CMS3	SOI 3	#5	spinel mid	57.62		5.56	25.46							0.19	0.21		10.97					
CMS3	SOI 3	#6	spinel outer	57.78		5.93	25.72	0.17						0.12	0.22		10.06					
CMS3	SOI 3	#7	spinel margin	57.52		4.21	26.05							0.14	0.23		11.85					
CMS3	SOI 3	#8	olivine (dark)	58.19		9.17		13.90					0.11			0.12	18.50					
CMS3	SOI 3	#9	olivine (dark)	57.74		10.61	0.21	13.97								0.17	17.31					
CMS3	SOI 3	#10	olivine (dark)	58.01		12.35	0.20	13.94					0.08			0.16	15.27					
CMS3	SOI 3	#11	olivine (dark)	58.26		8.16		13.80					0.17			0.15	19.46					
CMS3	SOI 3	#12	olivine (margin)	58.46		1.80	0.18	13.72					0.34			0.20	25.30					
CMS3	SOI 3	#13	glass	60.45	2.52		7.79	14.81	0.40	0.21		2.65	4.65	0.34			6.18					
CMS3	SOI 3	#14	olivine (dark)	57.55		8.71	0.19	13.98					0.15			0.14	19.28					
CMS3	SOI 3	#15	olivine (bright)	57.45		2.86		14.12					0.30			0.22	25.05					
CMS3	SOI 3	#16	olivine - mid	57.98		5.30		13.94					0.21			0.16	22.41					
CMS3	SOI 3	#17	glass	60.16	2.39		7.80	14.36	0.36	0.26		2.66	4.81	0.26			6.94					
CMS3	SOI 3	#18	olivine outer (mid)	58.51		4.20		13.73					0.23			0.23	23.10					
CMS3	SOI 4	#1	main ol	58.27		5.46		13.90					0.14			0.18	22.04					
CMS3	SOI 4	#2	main ol margin	58.39		3.25		13.70					0.26			0.19	24.21					
CMS3	SOI 4	#3	hercynite	57.59		1.87	23.89	0.18						0.79	0.25		15.43					
CMS3	SOI 4	#4	hercynite	57.38		1.61	24.60	0.29						0.53	0.17		15.42					
CMS3	SOI 4	#5	olivine with hercynite	58.26		4.48		13.70					0.18			0.24	23.15					
CMS3	SOI 4	#6	olivine with hercynite marg	58.27		0.47	0.22	13.66					0.67			0.18	26.52					
CMS3	SOI 4	#7	olivine margin (complex)	57.80		0.49	2.81	11.77					0.66	0.52		0.19	25.76					

				O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Zr	Ba	Ce	Nd	W
CMS3	SOI 5	#1	bright o/g on spinel	59.90			11.39	2.73				0.58	0.85	4.46			20.09					
CMS3	SOI 5	#2	rhonite (mixed)	60.69	0.90		8.08	11.19		0.11		0.57	4.88	1.49			12.10					
CMS3	SOI 5	#3	bright o/g on spinel	59.49			12.00	3.27				0.48	0.65	3.82			20.29					
CMS3	SOI 5	#4	rhonite (mixed)	60.48	1.02		7.91	11.82	0.11	0.10		0.69	4.79	1.28			11.80					
CMS3	SOI 5	#5	glass	60.14	2.52		7.66	14.74	0.26	0.46		2.32	4.68	0.15			7.07					
CMS3	SOI 5	#6	iron bleb (mixed)	34.30	1.19		6.75	8.90		0.28	0.21	0.92	2.14	0.56			44.74					
CMS3	SOI 5	#7	rhonite (mixed)	60.72	0.85		7.63	12.20	0.17	0.15		1.26	4.94	1.19			10.88					
CMS3	SOI 5	#8	interstitial bulk	60.18	2.00		7.37	13.97	0.21	0.18		1.92	4.41	0.50			9.24					
CMS3	SOI 7	#1	large olivine on iron core	57.62		12.45	0.22	13.91					0.10			0.15	15.55					
CMS3	SOI 7	#2	iron														100.00					
CMS3	SOI 7	#3	late olivine	57.83		7.27	0.40	13.78					0.14			0.20	20.38					
CMS3	SOI 7	#4	glass	60.53	1.92		8.11	16.43	0.23	0.48		1.91	4.20	0.39			5.80					
CMS3	SOI 7	#5	lobe crust	55.62		0.84	7.49	2.60					0.21	0.80			32.45					
CMS3	SOI 7	#6	olivine with hercynite	56.65	0.87	1.86	4.67	13.98				0.56	1.04	0.16		0.22	20.00					
CMS3	SOI 7	#7	hercynite	57.53		2.19	18.98	1.50						0.93	0.29		18.58					
CMS4	SOI 2	#1	olivine rough core	57.84		6.82	0.57	13.79		0.11			0.61			0.13	20.14					
CMS4	SOI 2	#2	olivine inner	57.15		11.26		14.19					0.13			0.15	17.12					
CMS4	SOI 2	#3	olivine inner	56.73		10.84		14.20					0.14			0.14	17.94					
CMS4	SOI 2	#4	olivine outer	56.61		11.11	0.23	14.00					0.11			0.21	17.72					
CMS4	SOI 2	#5	olivine outer	56.45		10.18	0.27	14.31					0.21			0.13	18.46					
CMS4	SOI 2	#6	olivine outer	56.76		10.27	0.20	14.07					0.16			0.20	18.34					
CMS4	SOI 2	#7	olivine outermost	56.44		4.82	0.19	14.18					0.33			0.21	23.83					
CMS4	SOI 2	#8	olivine margin	56.49		1.98		14.10					0.49			0.22	26.70					
CMS4	SOI 2	#9	outer spinel	56.63		0.51	21.30	0.20						1.68			19.67					
CMS4	SOI 2	#10	inner spinel	56.50		4.68	26.01							0.21	0.17		12.43					
CMS4	SOI 2	#11	glass	58.92	3.50		8.07	15.57	0.38	0.28		3.65	3.07	0.15			6.13					0.28
CMS4	SOI 2	#12	olivine o/g	56.95	0.37		0.79	14.19	0.27			0.57	10.25				16.62					
CMS4	SOI 2	#13	olivine o/g	56.62		0.23		14.10	0.24				10.34			0.12	18.34					
CMS4	SOI 2	#14	bright olivine	56.48		1.22		14.31					0.70			0.17	27.12					
CMS4	SOI 11	#1	med olivine (z3)	56.98		9.22	0.38	13.84					0.23			0.18	19.17					
CMS4	SOI 11	#2	bright olivine (z1)	56.91		3.17		14.10					0.42			0.21	25.19					
CMS4	SOI 11	#3	spinel on Z2-z3 boundary	56.87		3.32	23.80	0.39						0.62	0.25		14.75					
CMS4	SOI 11	#4	spinel on Z2-z3 boundary	55.87		3.40	25.25							0.39	0.17	0.06	14.86					
CMS4	SOI 11	#5	spinel on Z2-z3 boundary	56.56		3.57	23.64	0.43						0.64	0.30		14.86					
CMS4	SOI 11	#6	med olivine (z3)	56.58		8.84	0.32	14.10					0.23			0.22	19.70					
CMS4	SOI 11	#7	med olivine (z3)	56.88		9.70	0.29	13.86					0.20			0.18	18.89					

				O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Zr	Ba	Ce	Nd	W
CMS4	SOI 11	#8	dark olivine (z4)	56.82		11.06	0.21	13.93					0.18			0.15	17.64					
CMS4	SOI 11	#9	dark olivine (z4)	57.03		7.89	0.23	14.11					0.18			0.21	20.36					
CMS4	SOI 11	#10	bright olivine (z5)	58.77		3.58	0.22	13.87					0.36			0.21	23.00					
CMS4	SOI 11	#11	bright olivine (z5)	56.82		2.43	0.19	14.04					0.45			0.28	25.78					
CMS4	SOI 11	#12	hercynite (? Spinel outer)	57.23		0.61	20.89							1.68	0.09		19.50					
CMS4	SOI 11	#13	bright olivine in upper lobe	56.71		1.28	0.18	13.91					0.68	0.09		0.24	26.93					
CMS4	SOI 11	#14	dark olivine in upper lobe	56.88		12.37	0.19	14.16					0.15			0.14	16.11					
CMS4	SOI 11	#15	hercynite (spinel inner)	56.57		4.82	24.66	0.23						0.49	0.24		13.00					
CMS4	SOI 11	#16	hercynite (Spinel outer)	57.28		2.31	24.67							0.43	0.15		15.16					
CMS4	SOI 11	#17	light glass	61.62	3.04		7.56	13.08	2.05	0.16		3.27	5.12	0.10			3.74					0.25
CMS4	SOI 11	#18	dark glass?	66.45			11.72	11.80	0.60	0.10			1.42	0.16			7.45					0.23
CMS4	SOI 11	#19	iron sulphide in glass	52.51			4.41	4.64	0.23	9.86			1.41	0.89			25.80					0.12
CMS4	SOI 11	#20	bright olivine (z1)	57.03		1.95		14.15					0.52			0.19	26.16					
CMS4	SOI 11	#21	bright spinel o/g	57.89			8.13							6.46			27.52					
CMS4	SOI 11	#22	glass	59.16	3.76		9.23	15.98	0.41	0.11		4.38	2.29	0.11			4.18					0.38
CMS4	SOI 11	#23	wustite	51.55			0.55	0.47					0.20	0.77		0.14	46.32					
CMS4	SOI 11	#24	glass in tatty ol void	50.80	0.80	0.27	17.65	7.22	0.93			2.62	5.21				14.50					
CMS4	SOI 11	#25	dark olivine (z2)	56.64		9.24		14.16					0.19			0.18	19.59					
CMS4	SOI 11	#26	iron														100.00					
CMS5	SOI 8	#1	spinel inner	55.67		5.97	25.65	0.20						0.40	0.13		11.99					
CMS5	SOI 8	#2	spinel inner	55.89		5.74	25.70	0.20						0.41	0.08		11.97					
CMS5	SOI 8	#3	spinel outer	55.77		1.88	24.30	0.21						0.86			16.97					
CMS5	SOI 8	#4	ol outer	55.57		1.09	2.04	13.13	0.14			0.12	0.57	0.23		0.15	26.96					
CMS5	SOI 8	#5	ol near spinel contact	53.92		2.81	1.41	13.64					0.28	0.15		0.21	27.58					
CMS5	SOI 8	#6	ol mid	55.41		5.25	0.22	14.34					0.22	0.08		0.14	24.34					
CMS5	SOI 8	#7	ol outer	55.52		2.39	0.21	14.49					0.36	0.09		0.17	26.76					
CMS5	SOI 8	#8	bright olivine	55.66		3.46	0.26	14.40					0.28			0.17	25.76					
CMS5	SOI 8	#9	bright olivine	55.75		4.63		14.35					0.26	0.08		0.18	24.74					
CMS5	SOI 8	#10	spinel	55.85		3.99	24.54	0.36						0.71			14.55					
CMS5	SOI 8	#11	spinel	55.82		2.37	24.06	0.22						0.96			16.58					
CMS5	SOI 8	#12	dark olivine	55.22		9.33	0.32	14.35					0.11	0.09		0.10	20.48					
CMS5	SOI 8	#13	bright olivine	56.65		2.97	1.54	12.61					0.27	0.26		0.15	25.55					
CMS5	SOI 8	#14	bright olivine	54.92		2.60	5.59	11.19					0.26	0.46		0.12	24.86					
CMS5	SOI 8	#15	dark olivine	56.96		8.50	0.37	14.02					0.11	0.08			19.97					
CMS5	SOI 8	#16	bright olivine	55.85		1.84	0.34	14.32					0.37			0.14	27.14					
CMS5	SOI 8	#17	wustite	49.97		0.41	0.97	0.23						0.91	0.12		47.39					
CMS5	SOI 8	#18	wustite	50.42			0.98							0.92			47.67					

				O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Zr	Ba	Ce	Nd	W
CMS5	SOI 8	#19	glass	58.18	2.34		8.85	14.80	0.44	0.10		2.34	3.94	0.19		0.11	8.71					
CMS5	SOI 8	#20	i/s olivine	55.66		0.57	5.57	10.75					0.69	0.86			25.90					
CMS5	SOI 8	#21	glass	55.27	2.48		8.69	14.23	0.57	0.13		2.72	3.85	0.25			11.66					0.15
CMS5	SOI 9	#1	spinel inner	55.68		3.97	24.68	0.23						0.61	0.09		14.74					
CMS5	SOI 9	#2	spinel outer	55.06		0.97	21.73	0.48						1.65			20.12					
CMS5	SOI 9	#3	hercynite on ol marg	55.89		0.94	22.93	0.35						1.39			18.51					
CMS5	SOI 9	#4	dark olivine	55.56		13.61	0.21	14.65								0.12	15.85					
CMS5	SOI 9	#5	mid olivine	55.72		9.74		14.38					0.10			0.15	19.91					
CMS5	SOI 9	#6	bright olivine	55.86		2.16	0.25	14.30					0.34			0.15	26.95					
CMS5	SOI 9	#7	wustite	49.50		0.65	0.64	0.21						0.75			48.25					
CMS5	SOI 9	#8	magnetite?	51.38		1.66	6.29	0.55						0.55			39.56					
CMS5	SOI 9	#9	glass	57.18	2.47		7.74	14.93	0.50	0.15		2.89	4.13	0.25			9.60					0.17
CMS5	SOI 9	#10	olivine outer	55.72		1.46	0.23	14.43					0.49			0.15	27.51					
CMS5	SOI 9	#11	olivine mid	55.20		7.97	0.20	14.50					0.12			0.14	21.87					
CMS5	SOI 9	#12	olivine near rim	56.29		12.41	2.32	12.92						0.11			15.95					
CMS5	SOI 9	#13	wustite	50.13		0.80	0.54	0.30						0.68			47.56					
CMS5	SOI 9	#14	dark spinel on magnetite?	55.83		5.42	24.74	0.73						0.22			13.05					
CMS5	SOI 9	#15	magnetite?	49.80		0.67	0.62	0.32						0.71			47.88					
CMS5	SOI 9	#16	wustite	49.60		0.30	0.66	0.18						0.97		0.18	48.11					
CMS5	SOI 9	#17	magnetite?	51.68		0.77	4.43	0.30						1.01			41.81					
CMS5	SOI 10	#1	spinel inner	56.09		6.51	25.90							0.26	0.14		11.10					
CMS5	SOI 10	#2	spinel outer	55.97		5.30	24.64	0.55	0.11					0.57			12.86					
CMS5	SOI 10	#3	olivine	55.79		6.93	1.49	13.42					0.16	0.15			22.05					
CMS5	SOI 10	#4	olivine outer	56.08		3.44	0.26	14.28					0.24				25.70					
CMS5	SOI 10	#5	glass	55.59	2.92		8.18	15.03	0.41	0.15		2.97	4.07	0.22			10.31					0.16
CMS5	SOI 10	#6	wustite	50.80		0.00	0.99	0.78				0.20	0.22	0.96			46.04					
CMS5	SOI 10	#7	olivine dark	55.18		9.97	0.76	13.94					0.09	0.10		0.15	19.81					
CMS5	SOI 10	#8	olivine bright	55.57		3.89	0.27	14.29					0.23			0.16	25.59					
CMS6	SOI 7	#1	dark oxide line	53.72			5.04	2.78					0.25	0.10		2.49	35.62					
CMS6	SOI 7	#2	dark oxide line	54.31			3.66	4.49					0.50			3.31	33.73					
CMS6	SOI 7	#3	dense crust	50.67			0.60	1.12					0.14			2.56	44.90					
CMS6	SOI 7	#4	dense crust	50.18			0.50	0.57								2.37	46.38					
CMS6	SOI 7	#5	magnetite	55.06			1.89	0.97								1.21	40.87					
CMS6	SOI 7	#6	magnetite	54.35			2.72	0.68						0.18		1.07	41.01					
CMS6	SOI 7	#7	dendrite core	55.19			1.84	1.63					0.10	0.10		1.66	39.47					
CMS6	SOI 7	#8	wustite	57.26			2.44	1.64						0.12		1.15	37.39					
CMS6	SOI 7	#9	dendritic crust	51.36			0.51	1.07					0.12			2.44	44.51					

				O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Zr	Ba	Ce	Nd	W
CMS6	SOI 7	#10	dendritic crust	51.29			0.74	1.06								2.59	44.31					
CMS6	SOI 7	#11	olivine	57.34		0.38	0.26	14.22					0.40			5.46	21.95					
CMS6	SOI 7	#12	glass	57.86	3.57		6.01	15.03	0.48	0.18		3.13	3.59			1.18	8.85			0.14		
CMS6	SOI 7	#13	olivine	56.94		0.44	0.24	14.63					0.35			5.55	21.85					
CMS6	SOI 8	#1	olivine inner	55.80		0.40	0.26	14.17					0.26			5.18	23.93					
CMS6	SOI 8	#2	olivine mid	56.06		0.43	0.28	14.26					0.25			5.04	23.68					
CMS6	SOI 8	#3	olivine margin	56.49	0.56		1.17	14.40				0.31	0.88			3.83	22.36					
CMS6	SOI 8	#4	olivine mid	55.90		0.33	0.26	14.31					0.27			5.04	23.88					
CMS6	SOI 8	#5	olivine outer	55.56			0.27	14.41					0.46			4.39	24.92					
CMS6	SOI 8	#6	glass	57.39	3.60		7.82	16.13	0.49	0.19		3.06	3.76			0.78	6.70			0.09		
CMS6	SOI 8	#7	glass	57.05	3.35		7.99	15.77	0.49	0.18		2.93	4.03			0.81	7.28			0.12		
CMS6	SOI 9	#1	olivine core near W	56.02		0.59		14.23					0.29			6.01	22.86					
CMS6	SOI 9	#2	olivine inner sparse W	55.99		0.67	0.19	14.41					0.31			6.06	22.36					
CMS6	SOI 9	#3	olivine outer	56.10		0.59		14.38					0.27			5.90	22.77					
CMS6	SOI 9	#4	olivine margin	55.76		0.26		14.30					0.43			5.60	23.64					
CMS6	SOI 9	#5	glass	57.68	2.76		8.94	14.27	0.57	0.15		2.34	3.59			1.43	8.18			0.09		
CMS6	SOI 9	#6	wustite	50.22			0.91	0.27						0.17		2.14	46.28					
CMS6	SOI 9	#7	wustite	49.60			0.67	0.25								2.62	46.85					
CMS7	SOI 7	#1	olivine	56.51		0.60		14.19	0.14				0.85			10.91	16.80					
CMS7	SOI 7	#2	olivine	56.03		0.39		14.43					1.01			10.81	17.32					
CMS7	SOI 7	#3	olivine	57.58				14.04	0.38				3.31			8.53	16.16					
CMS7	SOI 7	#4	hercynite	56.02			26.68							0.08		3.26	13.95					
CMS7	SOI 7	#5	hercynite	56.36			26.23	0.18					0.07	0.14		3.15	13.87					
CMS7	SOI 7	#6	wustite	49.67			0.36	0.22								5.71	44.04					
CMS7	SOI 7	#7	olivine	56.29			0.18	14.07	0.26				2.46			9.31	17.44					
CMS7	SOI 7	#8	hercynite	56.97			23.56	1.13	0.14			0.24	0.51	0.14		3.10	14.20					
CMS7	SOI 7	#9	hercynite	55.92	0.25		25.48	0.87	0.11			0.09	0.26	0.14		3.13	13.75					
CMS7	SOI 7	#10	olivine	57.59	1.16		1.58	13.51	0.64			0.73	5.13			6.32	13.34					
CMS7	SOI 7	#11	olivine	55.79	1.12	0.76	1.81	10.92	0.68	7.93		0.76	2.78	0.61		1.28	14.33		1.22			
CMS7	SOI 7	#12	plagioclase	57.92	7.75		12.24	15.03	0.21			5.23	0.64			0.24	0.74					
CMS7	SOI 7	#13	leucite	57.88	1.44		11.27	14.48	0.41			10.64	1.31			0.66	1.90					
CMS7	SOI 7	#14	wustite	50.04			0.34							0.28		4.26	45.08					
CMS7	SOI 8	#1	interstitial olivine	57.17			0.39	13.96	0.33			0.18	2.25			6.31	19.42					
CMS7	SOI 8	#2	ol in w cotectic	55.96		0.49		14.29					0.64			7.76	20.86					
CMS7	SOI 8	#3	ol inner	55.86		0.38		14.56					0.70			7.97	20.53					
CMS7	SOI 8	#4	ol inner	56.21		0.35		14.46					0.67			7.68	20.63					

				O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Zr	Ba	Ce	Nd	W
CMS7	SOI 8	#5	ol outer	56.17		0.40		14.45					0.54			7.80	20.64					
CMS7	SOI 8	#6	ol margin	56.07			0.22	14.15	0.23				1.51			6.91	20.90					
CMS7	SOI 8	#7	ol in w cotectic	56.27		0.36		14.29					0.58			7.44	21.07					
CMS7	SOI 8	#8	glass	57.68	3.03		10.89	13.56	0.96	0.23		3.49	4.26	0.13		0.93	4.70			0.15		
CMS7	SOI 9	#1	feldspar grain	56.23	8.49		13.87	14.14		0.35		5.26	0.42			0.18	0.97		0.08			
CMS7	SOI 9	#2	hercynite in ol	55.38			24.19	1.44					0.38	0.26		3.73	14.60					
CMS7	SOI 9	#3	hercynite in ol	55.88			24.70	1.22	0.10			0.29	0.38	0.22		3.37	13.85					
CMS7	SOI 9	#4	feldspar grain	55.93	8.59		13.86	14.71				5.42	0.39			0.17	0.72		0.09			
CMS7	SOI 9	#5	olivine inner	56.15		0.50		14.19					0.97			10.08	18.11					
CMS7	SOI 9	#6	olivine inner	55.83		0.55		14.29	0.18				0.90			11.11	17.15					
CMS7	SOI 9	#7	olivine outer	55.99			1.46	14.13	0.21			0.67	2.33			8.53	16.68					
CMS7	SOI 9	#8	olivine outer	55.96		0.43	0.25	14.49					1.14			10.49	17.24					
CMS7	SOI 9	#9	olivine inner	55.91		0.52	0.26	14.35	0.19				0.94			10.95	16.88					
CMS7	SOI 9	#10	olivine inner	55.88		0.44		14.35	0.18				0.93			10.94	17.28					
CMS7	SOI 9	#11	phosphate	60.62			1.10	6.23	7.48				15.06			2.35	5.27			1.61	0.27	
CMS7	SOI 9	#12	hercynite in ol	54.63	1.29		25.70	2.19	0.18			0.28	0.36	0.34		2.55	12.49					
CMS7	SOI 9	#13	mixed - Ti spinel?	57.17	2.53		7.92	5.61		0.24		1.61	0.34	4.50		1.66	18.13	0.27				

Table 6: EDS microanalyses. Modelled mineralogical compositions.

					olivine			spinel						
					Fa	Ca	Mn	Al3	Ti	V	Fe3	Fe2	Mn2	Mg2
CMS-3	SOI 1	#1	wusitite clump	area										
CMS-3	SOI 1	#2	spinel + olivine	area										
CMS-3	SOI 1	#3	spinel + olivine (big i/s)	area										
CMS-3	SOI 1	#4	olivine-rich	area										
CMS-3	SOI 2	#1	spinel outer					1.68	0.04	0.01	0.27	0.83	0.00	0.18
CMS-3	SOI 2	#2	olivine		0.63	0%	1%							
CMS-3	SOI 2	#3	spinel inner					1.78	0.02	0.01	0.19	0.77	0.00	0.24
CMS-3	SOI 2	#4	wustite											
CMS-3	SOI 2	#5	i/s/ olivine		0.89	2%	1%							
CMS-3	SOI 3	#1	wustite in spinel											
CMS-3	SOI 3	#2	glass with wustite											
CMS-3	SOI 3	#3	spinel inner					1.82	0.01	0.00	0.17	0.75	0.00	0.25
CMS-3	SOI 3	#4	spinel inner+					1.83	0.01	0.01	0.14	0.58	0.00	0.43
CMS-3	SOI 3	#5	spinel mid					1.81	0.01	0.01	0.16	0.62	0.00	0.40
CMS-3	SOI 3	#6	spinel outer					1.84	0.01	0.02	0.13	0.59	0.00	0.43
CMS-3	SOI 3	#7	spinel margin					1.85	0.01	0.02	0.12	0.72	0.00	0.30
CMS-3	SOI 3	#8	olivine (dark)		0.67	0%	0%							
CMS-3	SOI 3	#9	olivine (dark)		0.62	0%	1%							
CMS-3	SOI 3	#10	olivine (dark)		0.55	0%	1%							
CMS-3	SOI 3	#11	olivine (dark)		0.70	1%	1%							
CMS-3	SOI 3	#12	olivine (margin)		0.93	1%	1%							
CMS-3	SOI 3	#13	glass											
CMS-3	SOI 3	#14	olivine (dark)		0.69	1%	0%							
CMS-3	SOI 3	#15	olivine (bright)		0.90	1%	1%							
CMS-3	SOI 3	#16	olivine - mid		0.81	1%	1%							
CMS-3	SOI 3	#17	glass											
CMS-3	SOI 3	#18	olivine outer (mid)		0.85	1%	1%							
CMS-3	SOI 4	#1	main ol		0.80	0%	1%							
CMS-3	SOI 4	#2	main ol margin		0.88	1%	1%							
CMS-3	SOI 4	#3	hercynite					1.71	0.06	0.02	0.22	0.88	0.00	0.13
CMS-3	SOI 4	#4	hercynite					1.75	0.04	0.01	0.20	0.90	0.00	0.11
CMS-3	SOI 4	#5	olivine with hercynite		0.84	1%	1%							
CMS-3	SOI 4	#6	olivine with hercynite marg		0.98	2%	1%							
CMS-3	SOI 4	#7	olivine margin (complex)		0.98	2%	1%							

					olivine			spinel						
					Fa	Ca	Mn	Al3	Ti	V	Fe3	Fe2	Mn2	Mg2
CMS-3	SOI 5	#1	bright o/g on spinel					0.95	0.37	0.00	0.68	1.00	0.00	0.00
CMS-3	SOI 5	#2	rhonite (mixed)											
CMS-3	SOI 5	#3	bright o/g on spinel					1.00	0.32	0.00	0.69	1.00	0.00	0.00
CMS-3	SOI 5	#4	rhonite (mixed)											
CMS-3	SOI 5	#5	glass											
CMS-3	SOI 5	#6	iron bleb (mixed)											
CMS-3	SOI 5	#7	rhonite (mixed)											
CMS-3	SOI 5	#8	interstitial bulk	area										
CMS-3	SOI 7	#1	large olivine on iron core		0.56	0%	1%							
CMS-3	SOI 7	#2	iron											
CMS-3	SOI 7	#3	late olivine		0.74	1%	1%							
CMS-3	SOI 7	#4	glass											
CMS-3	SOI 7	#5	lobe crust					0.54	0.06	0.00	1.40	0.94	0.00	0.06
CMS-3	SOI 7	#6	olivine with hercynite		0.92	5%	1%							
CMS-3	SOI 7	#7	hercynite					1.40	0.07	0.02	0.51	0.86	0.00	0.16
CMS-4	SOI 2	#1	olivine rough core		0.75	2%	0%							
CMS-4	SOI 2	#2	olivine inner		0.60	0%	1%							
CMS-4	SOI 2	#3	olivine inner		0.62	0%	0%							
CMS-4	SOI 2	#4	olivine outer		0.61	0%	1%							
CMS-4	SOI 2	#5	olivine outer		0.64	1%	0%							
CMS-4	SOI 2	#6	olivine outer		0.64	1%	1%							
CMS-4	SOI 2	#7	olivine outermost		0.83	1%	1%							
CMS-4	SOI 2	#8	olivine margin		0.93	2%	1%							
CMS-4	SOI 2	#9	outer spinel					1.48	0.12	0.00	0.40	0.96	0.00	0.04
CMS-4	SOI 2	#10	inner spinel					1.80	0.01	0.01	0.17	0.69	0.00	0.32
CMS-4	SOI 2	#11	glass											
CMS-4	SOI 2	#12	olivine o/g		1.00	38%	0%							
CMS-4	SOI 2	#13	olivine o/g		0.99	36%	0%							
CMS-4	SOI 2	#14	bright olivine		0.96	2%	1%							
CMS-4	SOI 11	#1	med olivine (z3)		0.68	1%	1%							
CMS-4	SOI 11	#2	bright olivine (z1)		0.89	1%	1%	0.00	0.00	0.00	2.00	0.64	0.02	0.33
CMS-4	SOI 11	#3	spinel on Z2-z3 boundary					1.68	0.04	0.02	0.26	0.78	0.00	0.23
CMS-4	SOI 11	#4	spinel on Z2-z3 boundary					1.72	0.03	0.01	0.24	0.78	0.00	0.23
CMS-4	SOI 11	#5	spinel on Z2-z3 boundary					1.66	0.04	0.02	0.27	0.77	0.00	0.25
CMS-4	SOI 11	#6	med olivine (z3)		0.69	1%	1%							
CMS-4	SOI 11	#7	med olivine (z3)		0.66	1%	1%							

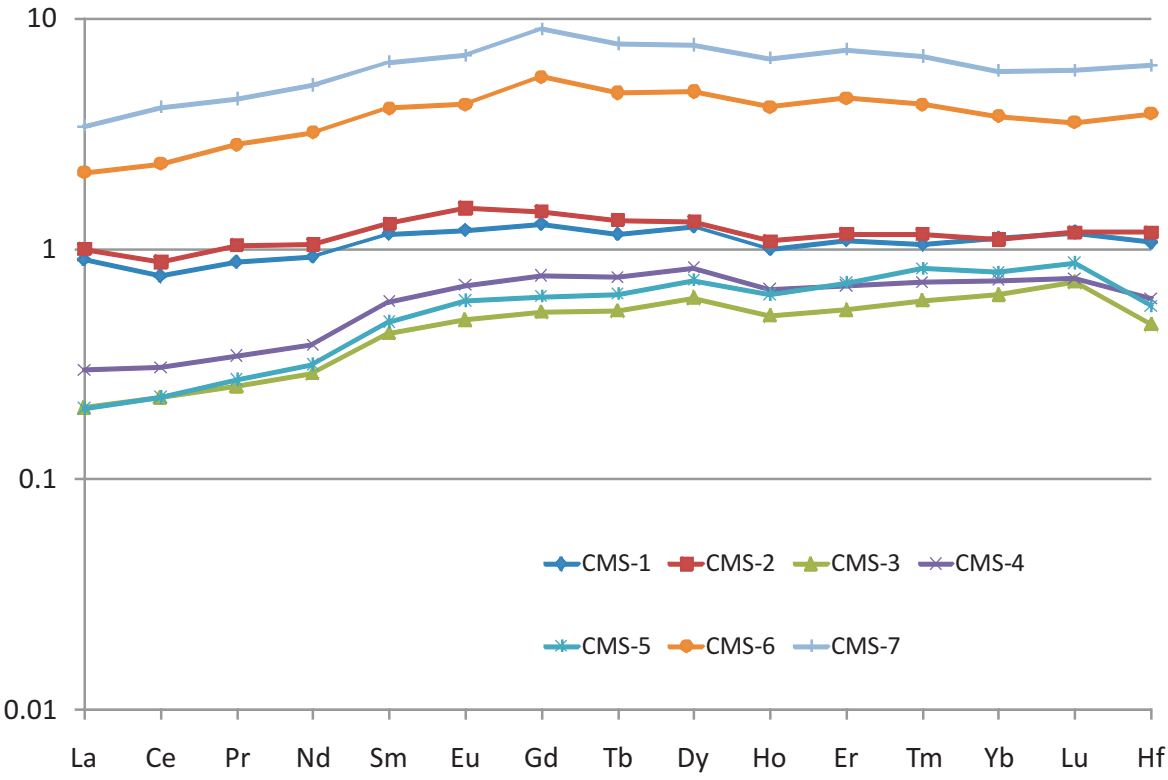
				olivine			spinel						
				Fa	Ca	Mn	Al3	Ti	V	Fe3	Fe2	Mn2	Mg2
CMS-4	SOI 11	#8	dark olivine (z4)	0.61	1%	1%							
CMS-4	SOI 11	#9	dark olivine (z4)	0.72	1%	1%							
CMS-4	SOI 11	#10	bright olivine (z5)	0.87	1%	1%							
CMS-4	SOI 11	#11	bright olivine (z5)	0.91	2%	1%	0.02	0.00	0.00	1.98	0.72	0.03	0.25
CMS-4	SOI 11	#12	hercynite (? Spinel outer)				1.47	0.12	0.01	0.41	0.96	0.00	0.04
CMS-4	SOI 11	#13	bright olivine in upper lobe	0.95	2%	1%							
CMS-4	SOI 11	#14	dark olivine in upper lobe	0.57	1%	0%							
CMS-4	SOI 11	#15	hercynite (spinel inner)				1.72	0.03	0.02	0.23	0.68	0.00	0.34
CMS-4	SOI 11	#16	hercynite (Spinel outer)				1.74	0.03	0.01	0.22	0.85	0.00	0.16
CMS-4	SOI 11	#17	light glass										
CMS-4	SOI 11	#18	dark glass?										
CMS-4	SOI 11	#19	iron sulphide in glass										
CMS-4	SOI 11	#20	bright olivine (z1)	0.93	2%	1%							
CMS-4	SOI 11	#21	bright spinel o/g				0.58	0.46	0.00	0.96	1.00	0.00	0.00
CMS-4	SOI 11	#22	glass										
CMS-4	SOI 11	#23	wustite										
CMS-4	SOI 11	#24	glass in tatty ol void										
CMS-4	SOI 11	#25	dark olivine (z2)	0.68	1%	1%							
CMS-4	SOI 11	#26	iron										
CMS-5	SOI 8	#1	spinel inner				1.75	0.03	0.01	0.22	0.60	0.00	0.41
CMS-5	SOI 8	#2	spinel inner				1.76	0.03	0.01	0.21	0.61	0.00	0.39
CMS-5	SOI 8	#3	spinel outer				1.66	0.06	0.00	0.29	0.87	0.00	0.13
CMS-5	SOI 8	#4	ol outer	0.96	2%	1%							
CMS-5	SOI 8	#5	ol near spinel contact	0.91	1%	1%							
CMS-5	SOI 8	#6	ol mid	0.82	1%	0%							
CMS-5	SOI 8	#7	ol outer	0.92	1%	1%							
CMS-5	SOI 8	#8	bright olivine	0.88	1%	1%							
CMS-5	SOI 8	#9	bright olivine	0.84	1%	1%							
CMS-5	SOI 8	#10	spinel				1.68	0.05	0.00	0.27	0.73	0.00	0.27
CMS-5	SOI 8	#11	spinel				1.64	0.07	0.00	0.29	0.84	0.00	0.16
CMS-5	SOI 8	#12	dark olivine	0.69	0%	0%							
CMS-5	SOI 8	#13	bright olivine	0.90	1%	1%							
CMS-5	SOI 8	#14	bright olivine	0.91	1%	0%							
CMS-5	SOI 8	#15	dark olivine	0.70	0%	0%							
CMS-5	SOI 8	#16	bright olivine	0.94	1%	0%							
CMS-5	SOI 8	#17	wustite										
CMS-5	SOI 8	#18	wustite										
CMS-5	SOI 8	#19	glass										

				olivine			spinel						
				Fa	Ca	Mn	Al3	Ti	V	Fe3	Fe2	Mn2	Mg2
CMS-5	SOI 8	#20	i/s olivine	0.98	3%	0%							
CMS-5	SOI 8	#21	glass										
CMS-5	SOI 9	#1	spinel inner				1.68	0.04	0.01	0.27	0.74	0.00	0.27
CMS-5	SOI 9	#2	spinel outer				1.47	0.11	0.00	0.42	0.93	0.00	0.07
CMS-5	SOI 9	#3	hercynite on ol marg				1.57	0.10	0.00	0.33	0.94	0.00	0.06
CMS-5	SOI 9	#4	dark olivine	0.54	0%	0%							
CMS-5	SOI 9	#5	mid olivine	0.67	0%	0%							
CMS-5	SOI 9	#6	bright olivine	0.93	1%	1%							
CMS-5	SOI 9	#7	wustite										
CMS-5	SOI 9	#8	magnetite?				0.39	0.03	0.00	1.57	0.90	0.00	0.10
CMS-5	SOI 9	#9	glass										
CMS-5	SOI 9	#10	olivine outer	0.95	2%	1%							
CMS-5	SOI 9	#11	olivine mid	0.73	0%	0%							
CMS-5	SOI 9	#12	olivine near rim	0.56	0%	0%							
CMS-5	SOI 9	#13	wustite										
CMS-5	SOI 9	#14	dark spinel on magnetite?				1.71	0.02	0.00	0.28	0.63	0.00	0.37
CMS-5	SOI 9	#15	magnetite?				0.04	0.04	0.00	1.92	0.96	0.00	0.04
CMS-5	SOI 9	#16	wustite										
CMS-5	SOI 9	#17	magnetite?				0.28	0.06	0.00	1.66	0.95	0.00	0.05
CMS-5	SOI 10	#1	spinel inner				1.78	0.02	0.01	0.20	0.56	0.00	0.45
CMS-5	SOI 10	#2	spinel outer				1.70	0.04	0.00	0.26	0.63	0.00	0.37
CMS-5	SOI 10	#3	olivine	0.76	1%	0%							
CMS-5	SOI 10	#4	olivine outer	0.88	1%	0%							
CMS-5	SOI 10	#5	glass										
CMS-5	SOI 10	#6	wustite										
CMS-5	SOI 10	#7	olivine dark	0.67	0%	1%							
CMS-5	SOI 10	#8	olivine bright	0.87	1%	1%							
CMS-6	SOI 7	#1	dark oxide line										
CMS-6	SOI 7	#2	dark oxide line										
CMS-6	SOI 7	#3	dense crust										
CMS-6	SOI 7	#4	dense crust										
CMS-6	SOI 7	#5	magnetite				0.13	0.00	0.00	1.87	0.92	0.08	0.00
CMS-6	SOI 7	#6	magnetite				0.18	0.01	0.00	1.81	0.93	0.07	0.00
CMS-6	SOI 7	#7	dendrite core				0.13	0.01	0.00	1.86	0.88	0.12	0.00
CMS-6	SOI 7	#8	wustite										
CMS-6	SOI 7	#9	dendritic crust										

				olivine			spinel						
				Fa	Ca	Mn	Al3	Ti	V	Fe3	Fe2	Mn2	Mg2
CMS-6	SOI 7	#10	dendritic crust										
CMS-6	SOI 7	#11	olivine	0.98	1%	19%							
CMS-6	SOI 7	#12	glass										
CMS-6	SOI 7	#13	olivine	0.98	1%	20%							
CMS-6	SOI 8	#1	olivine inner	0.98	1%	17%							
CMS-6	SOI 8	#2	olivine mid	0.98	1%	17%							
CMS-6	SOI 8	#3	olivine margin	1.00	3%	14%							
CMS-6	SOI 8	#4	olivine mid	0.99	1%	17%							
CMS-6	SOI 8	#5	olivine outer	1.00	2%	15%							
CMS-6	SOI 8	#6	glass										
CMS-6	SOI 8	#7	glass										
CMS-6	SOI 9	#1	olivine core near W	0.97	1%	20%							
CMS-6	SOI 9	#2	olivine inner sparse W	0.97	1%	21%							
CMS-6	SOI 9	#3	olivine outer	0.97	1%	20%							
CMS-6	SOI 9	#4	olivine margin	0.99	1%	19%							
CMS-6	SOI 9	#5	glass										
CMS-6	SOI 9	#6	wustite										
CMS-6	SOI 9	#7	wustite										
CMS-7	SOI 7	#1	olivine	0.97	3%	37%							
CMS-7	SOI 7	#2	olivine	0.98	3%	37%							
CMS-7	SOI 7	#3	olivine	1.00	12%	30%							
CMS-7	SOI 7	#4	hercynite				1.82	0.01	0.00	0.17	0.78	0.22	0.00
CMS-7	SOI 7	#5	hercynite				1.81	0.01	0.00	0.18	0.78	0.22	0.00
CMS-7	SOI 7	#6	wustite										
CMS-7	SOI 7	#7	olivine	1.00	8%	32%							
CMS-7	SOI 7	#8	hercynite				1.72	0.01	0.00	0.27	0.77	0.23	0.00
CMS-7	SOI 7	#9	hercynite				1.80	0.01	0.00	0.19	0.78	0.22	0.00
CMS-7	SOI 7	#10	olivine	1.00	21%	25%							
CMS-7	SOI 7	#11	olivine	0.95	14%	7%							
CMS-7	SOI 7	#12	plagioclase										
CMS-7	SOI 7	#13	leucite										
CMS-7	SOI 7	#14	wustite										
CMS-7	SOI 8	#1	interstitial olivine	1.00	8%	23%							
CMS-7	SOI 8	#2	ol in w cotectic	0.98	2%	26%							
CMS-7	SOI 8	#3	ol inner	0.98	2%	27%							

				olivine			spinel						
				Fa	Ca	Mn	Al3	Ti	V	Fe3	Fe2	Mn2	Mg2
CMS-7	SOI 8	#4	ol inner	0.98	2%	26%							
CMS-7	SOI 8	#5	ol outer	0.98	2%	27%							
CMS-7	SOI 8	#6	ol margin	1.00	5%	24%							
CMS-7	SOI 8	#7	ol in w cotectic	0.98	2%	25%							
CMS-7	SOI 8	#8	glass										
CMS-7	SOI 9	#1	feldspar grain										
CMS-7	SOI 9	#2	hercynite in ol				1.70	0.02	0.00	0.29	0.74	0.26	0.00
CMS-7	SOI 9	#3	hercynite in ol				1.76	0.02	0.00	0.23	0.76	0.24	0.00
CMS-7	SOI 9	#4	feldspar grain										
CMS-7	SOI 9	#5	olivine inner	0.97	3%	34%							
CMS-7	SOI 9	#6	olivine inner	0.97	3%	37%							
CMS-7	SOI 9	#7	olivine outer	1.00	8%	31%							
CMS-7	SOI 9	#8	olivine outer	0.98	4%	36%							
CMS-7	SOI 9	#9	olivine inner	0.97	3%	37%							
CMS-7	SOI 9	#10	olivine inner	0.98	3%	37%							
CMS-7	SOI 9	#11	phosphate										
CMS-7	SOI 9	#12	hercynite in ol				1.88	0.02	0.00	0.10	0.81	0.19	0.00
CMS-7	SOI 9	#13	mixed - Ti spinel?				0.74	0.42	0.00	0.84	0.85	0.15	0.00

Figure 1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1
0.1
0.01
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
Hf
CMS-1
CMS-2
CMS-3
CMS-4
CMS-5
CMS-6
CMS-7

Figure 2

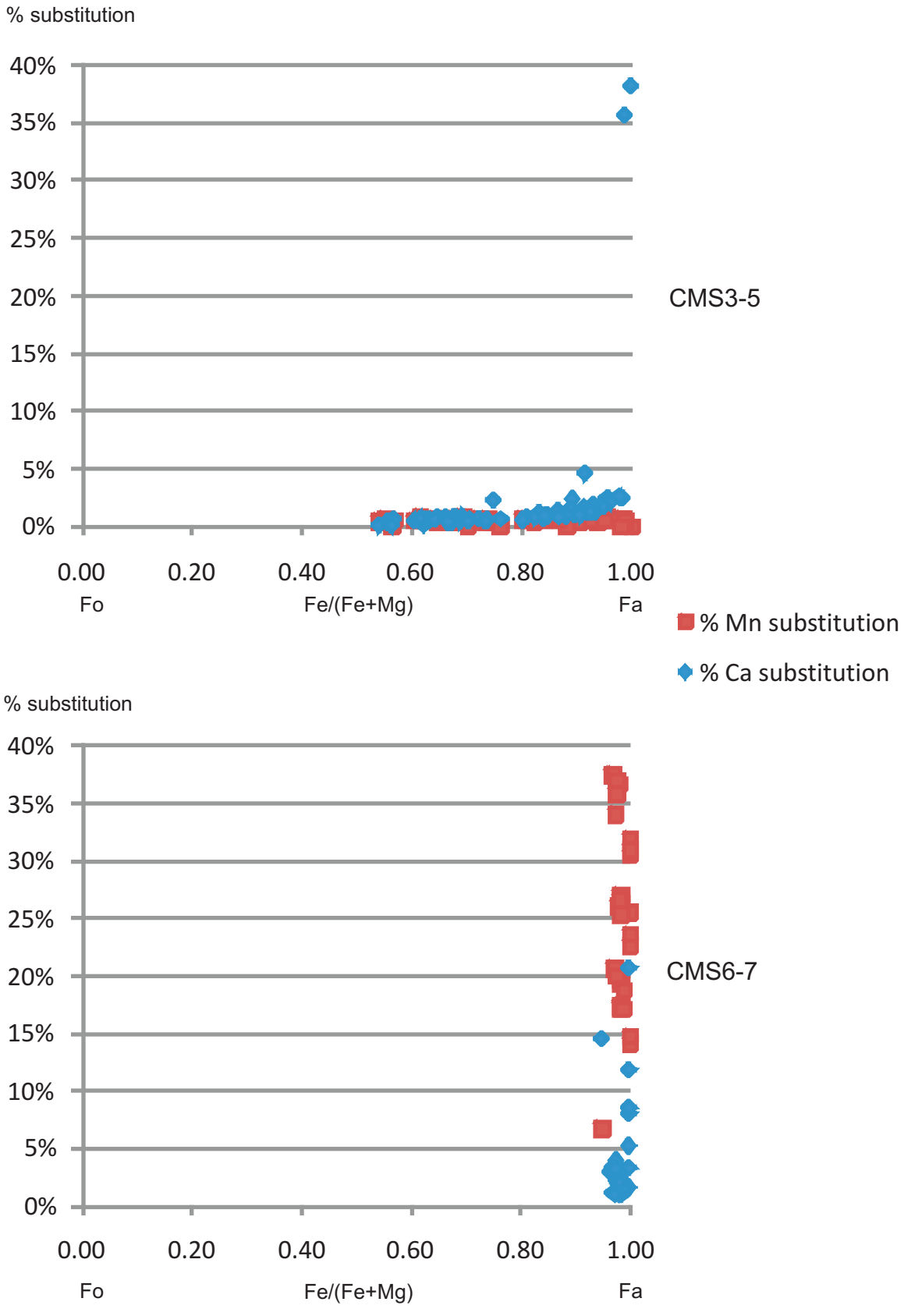
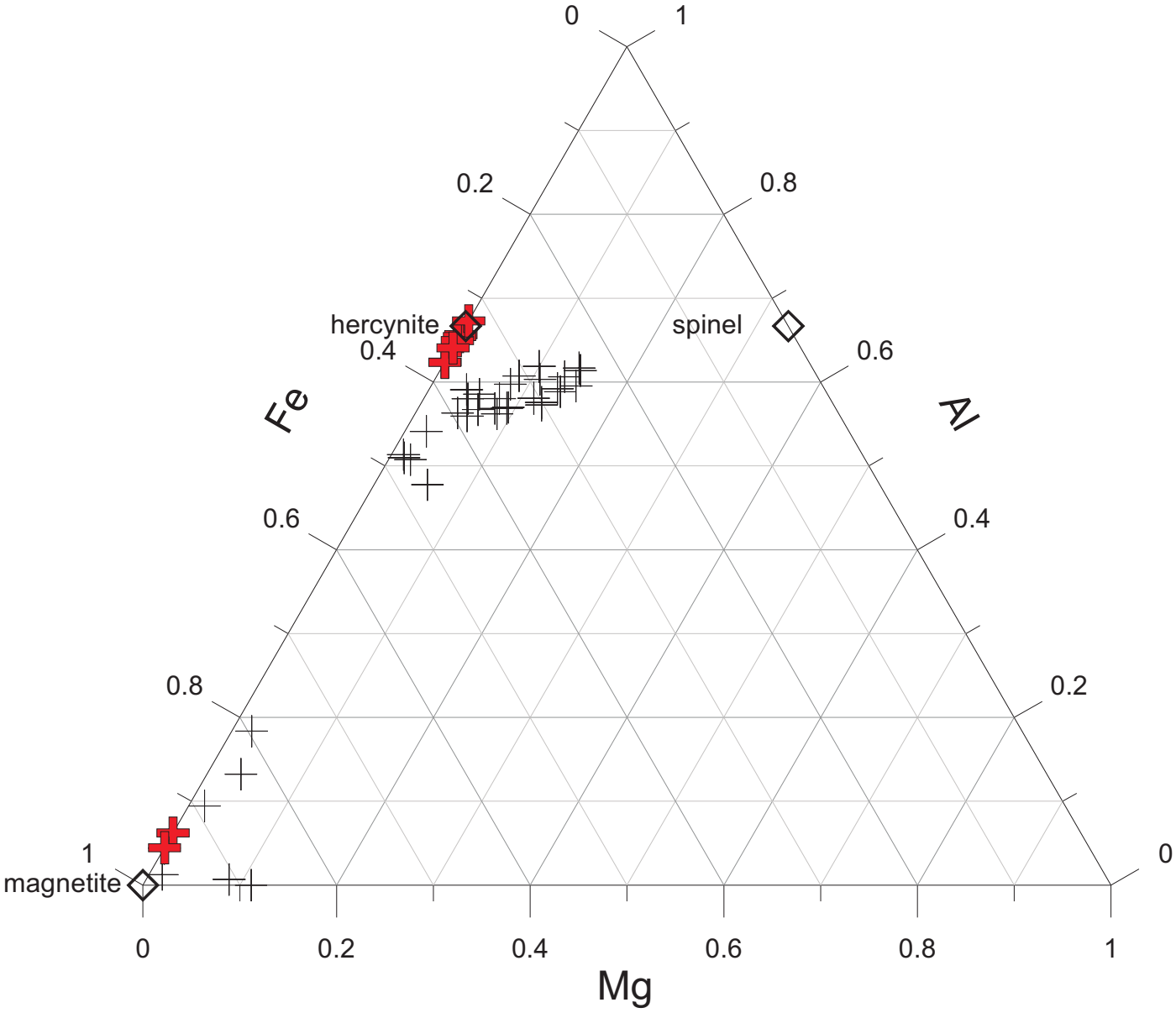

% substitution
40%
35%
30%
25%
20%
15%
10%
5%
0%
0.00
0.20
0.40
0.60
0.80
1.00
Fo
Fe/(Fe+Mg)
Fa
CMS3-5
% Mn substitution
% Ca substitution
% substitution
40%
35%
30%
25%
20%
15%
10%
5%
0%
0.00
0.20
0.40
0.60
0.80
1.00
Fo
Fe/(Fe+Mg)
Fa
CMS6-7

Figure 3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1
0.2
0.8
hercynite
spinel
0.4
0.6
Fe
Al
0.6
0.4
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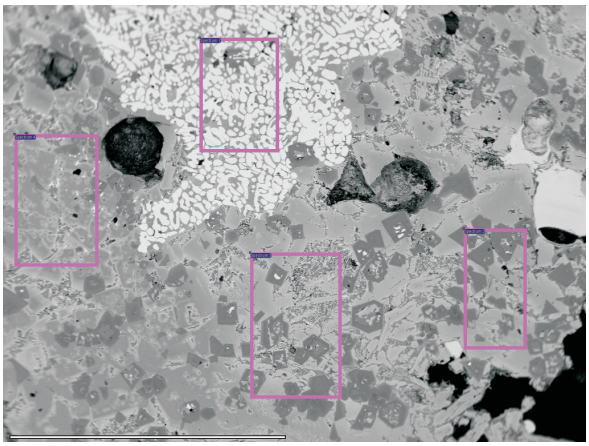
0.2
1
magnetite
0
0
0.2
0.4
0.6
0.8
1
Mg

a



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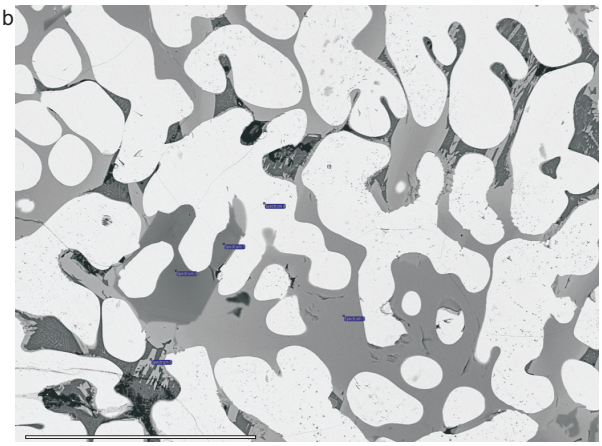

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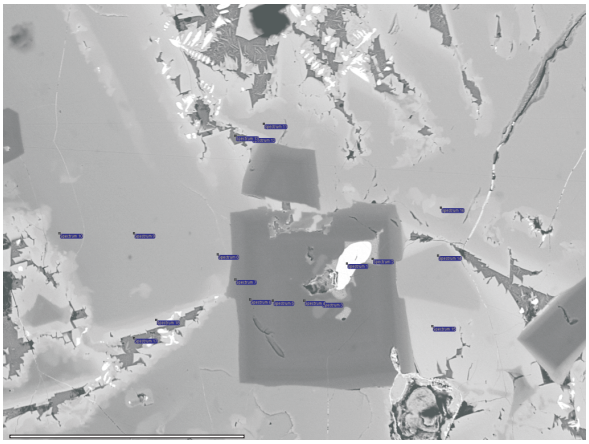

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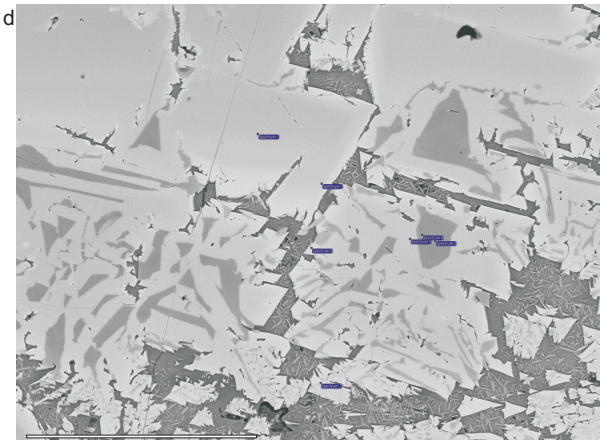

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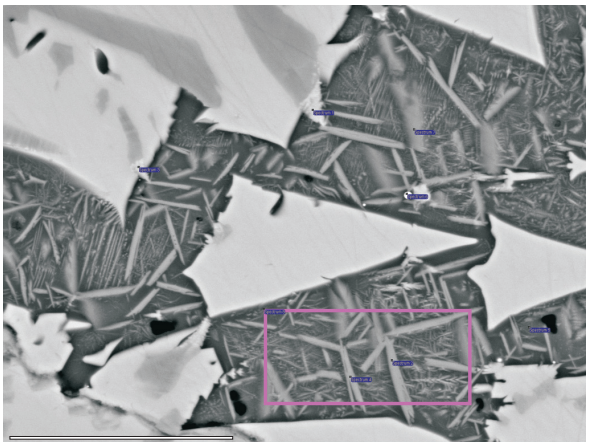

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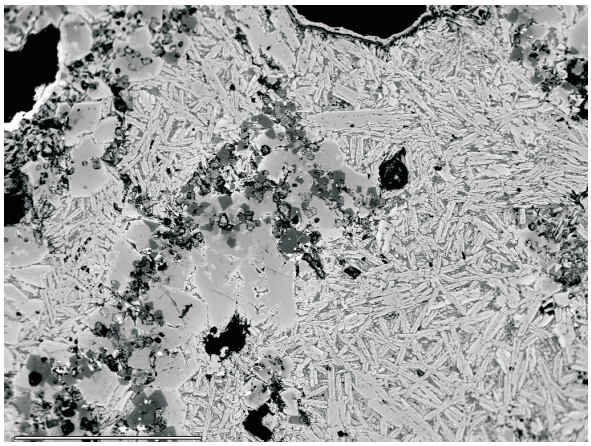

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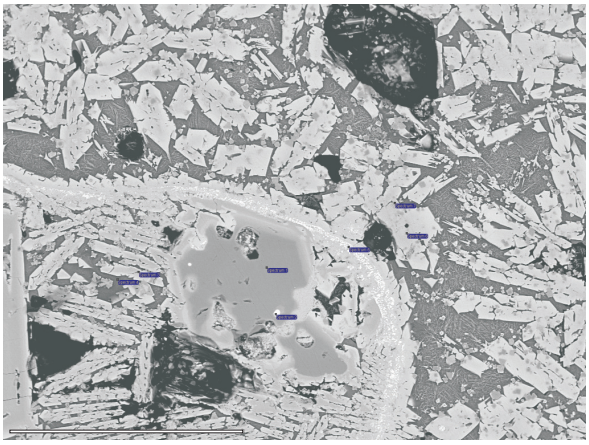

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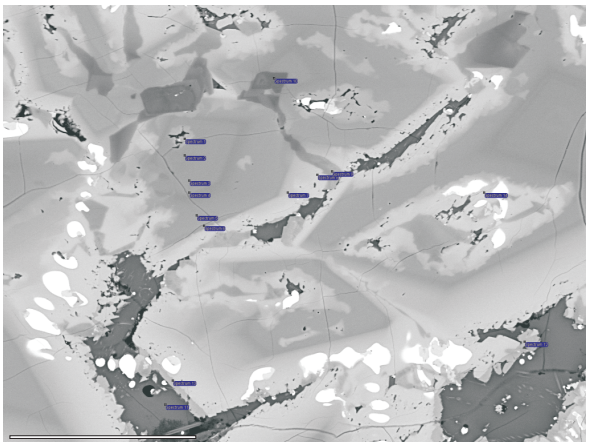

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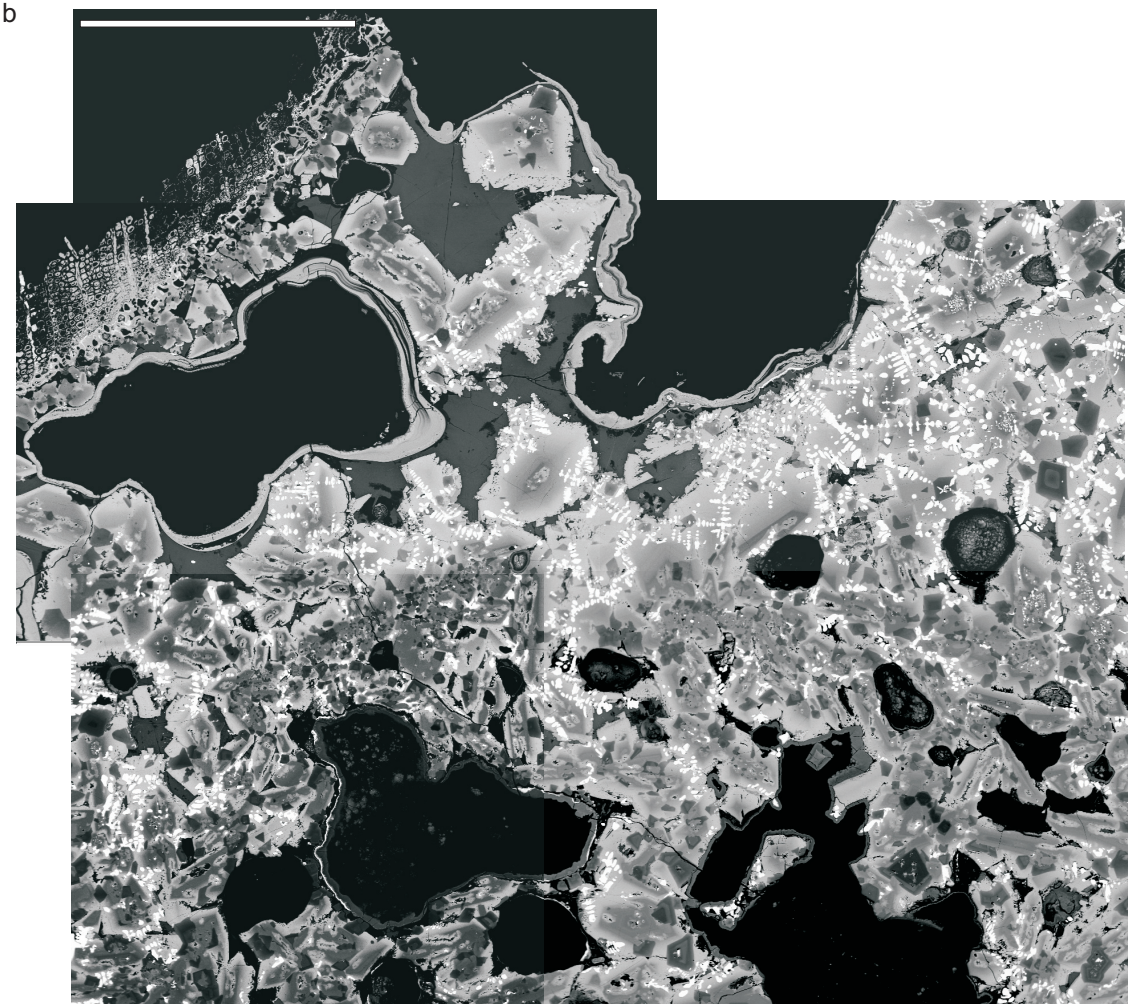

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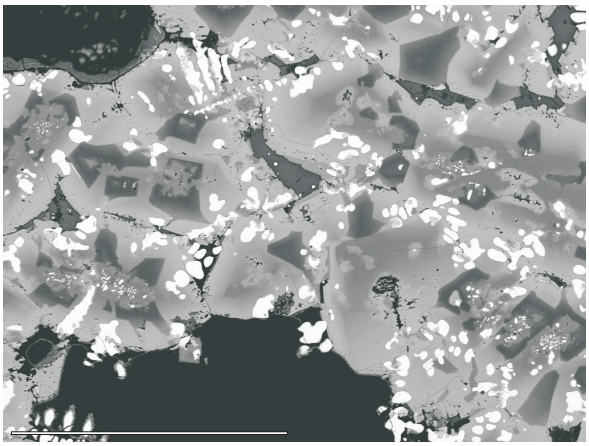

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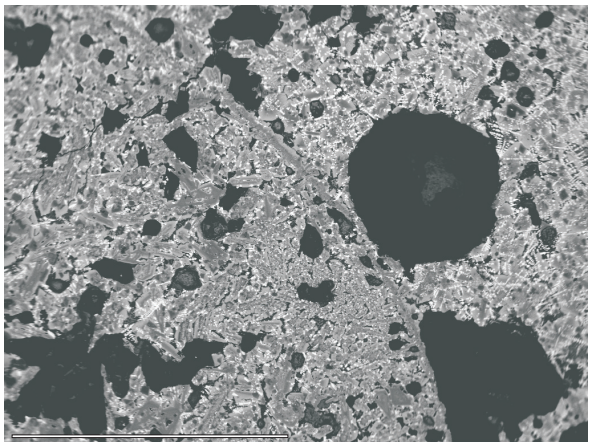

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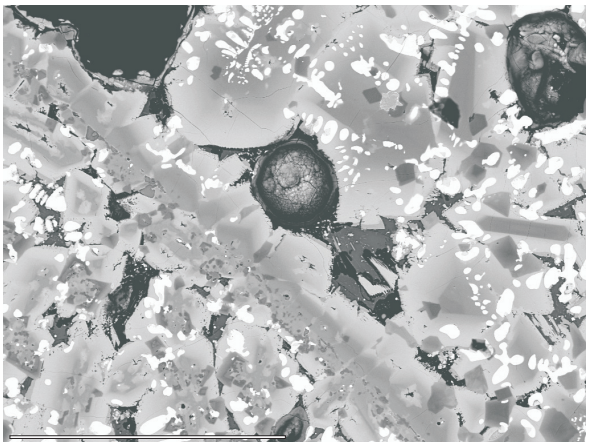

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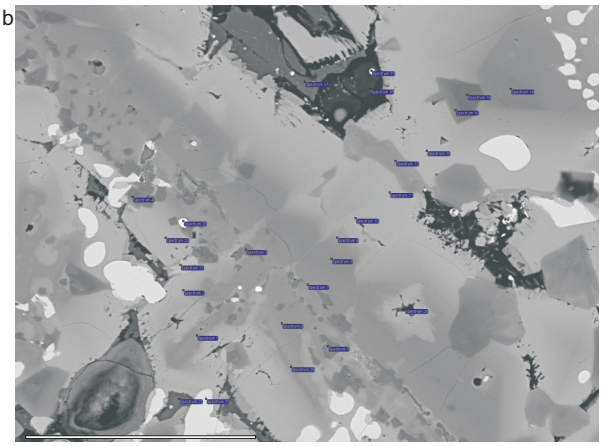

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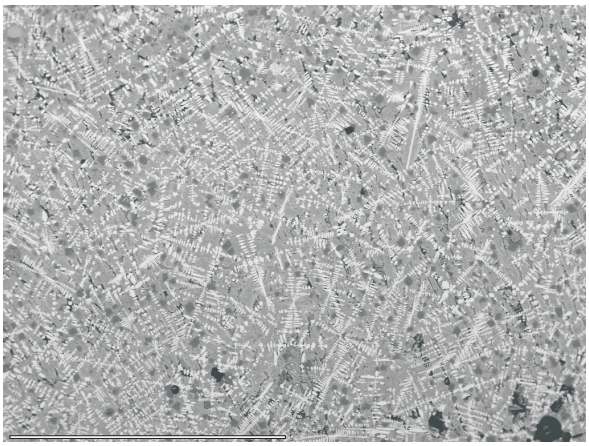

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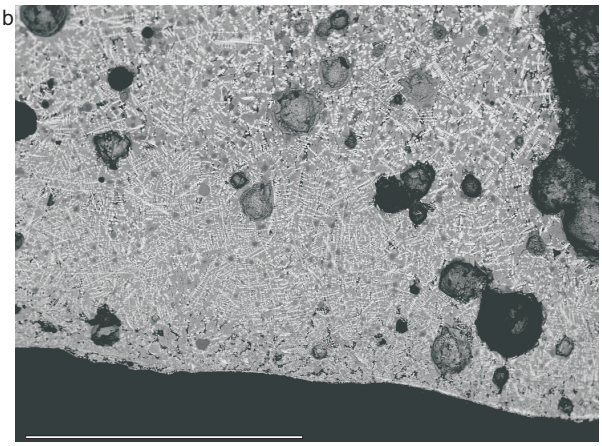

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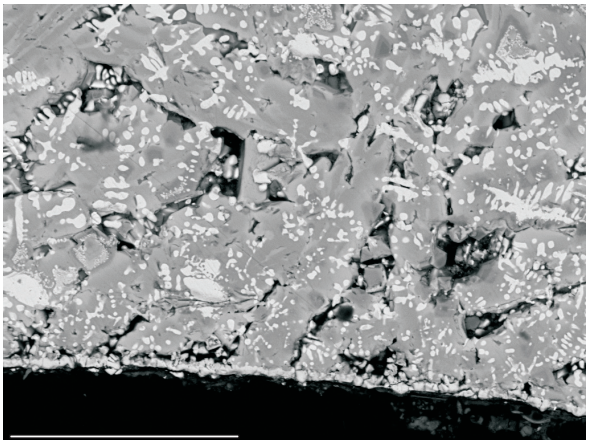

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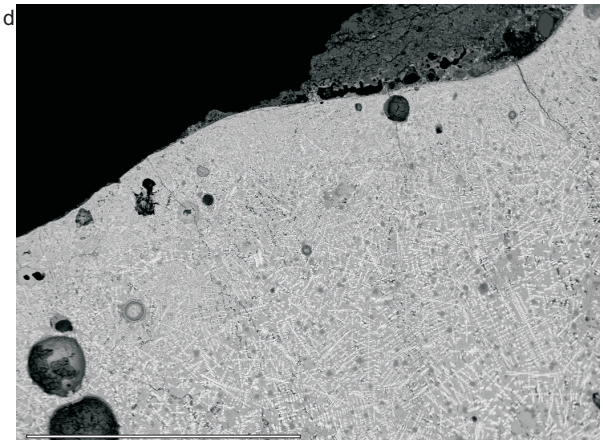

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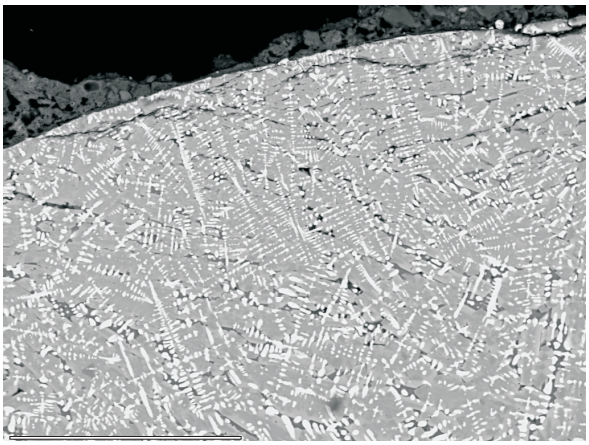

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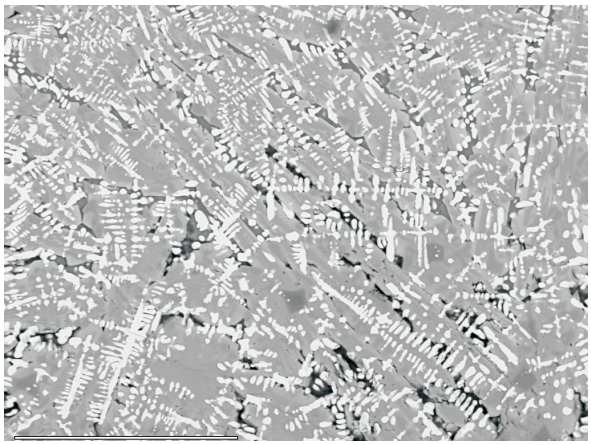

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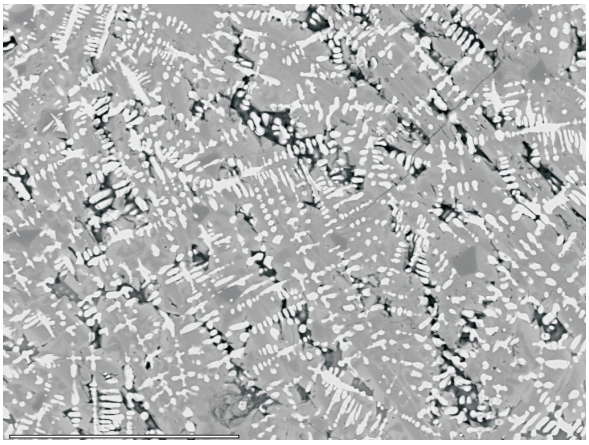

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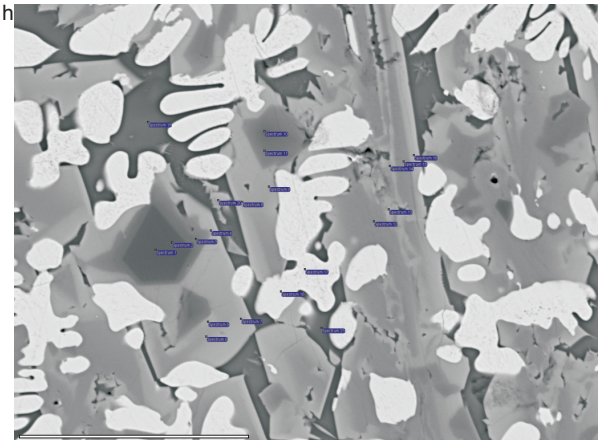

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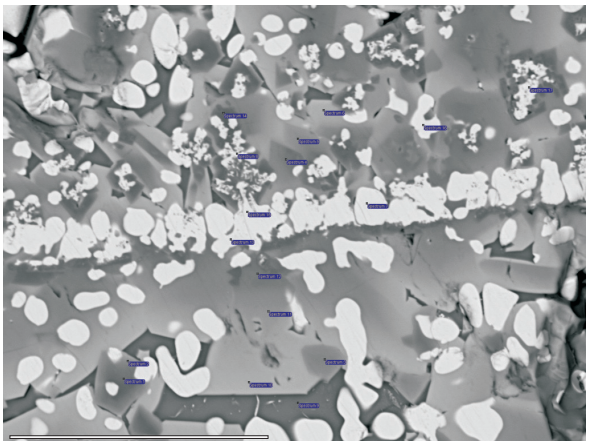

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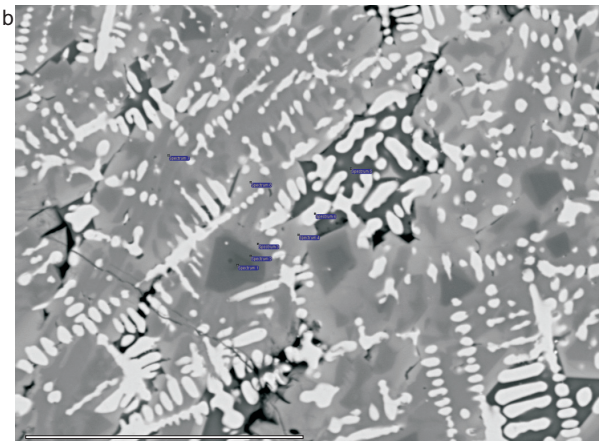

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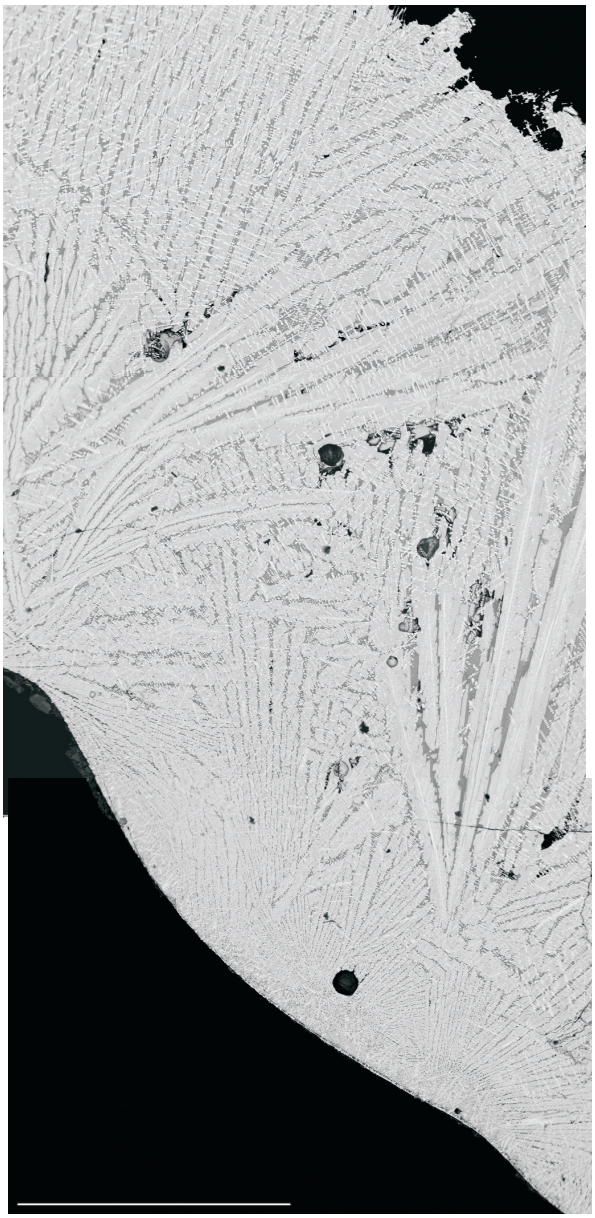

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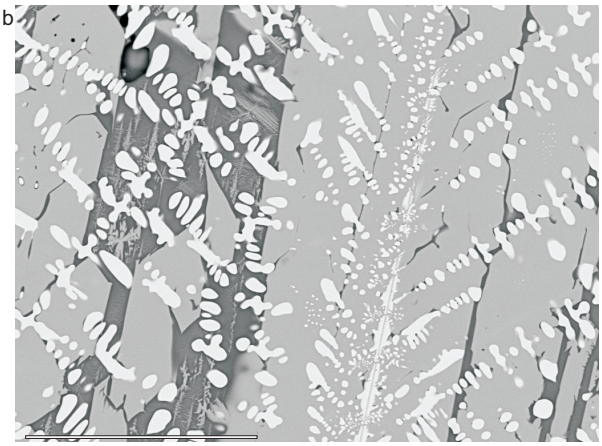

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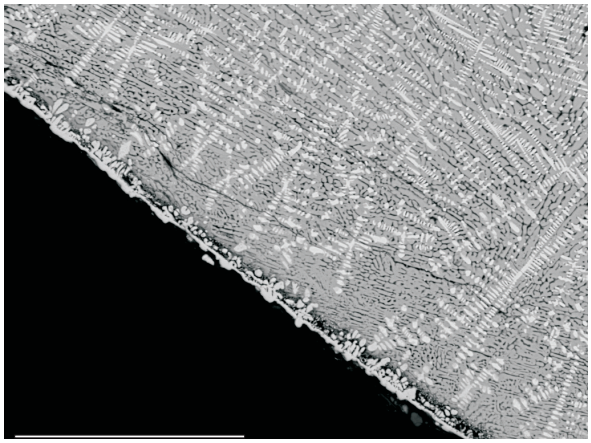

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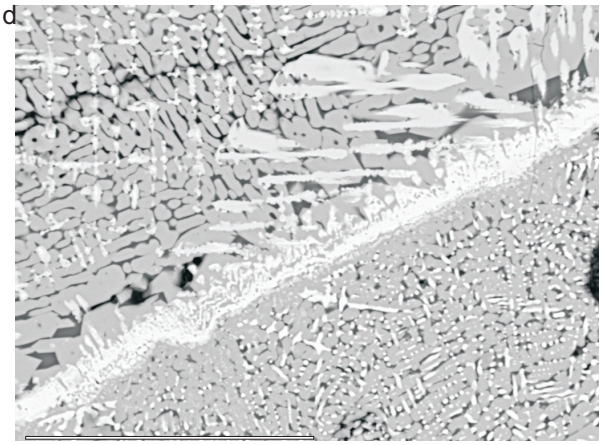

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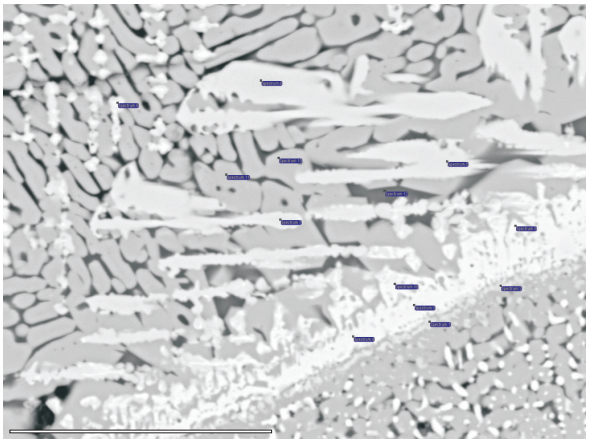

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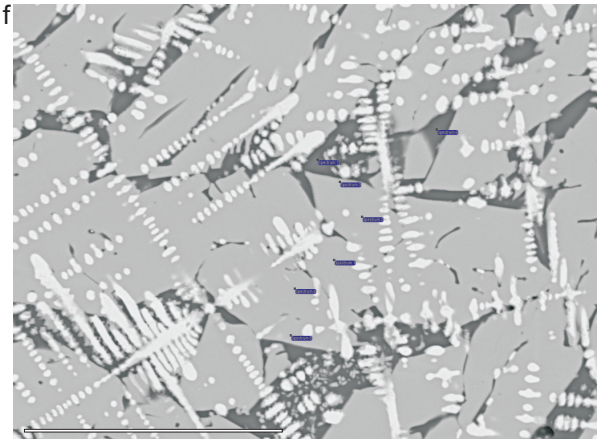

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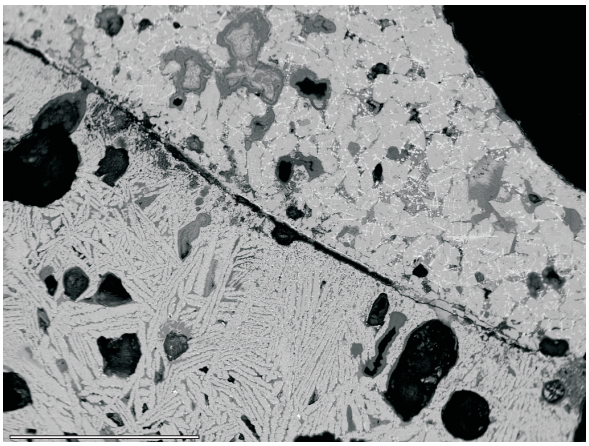

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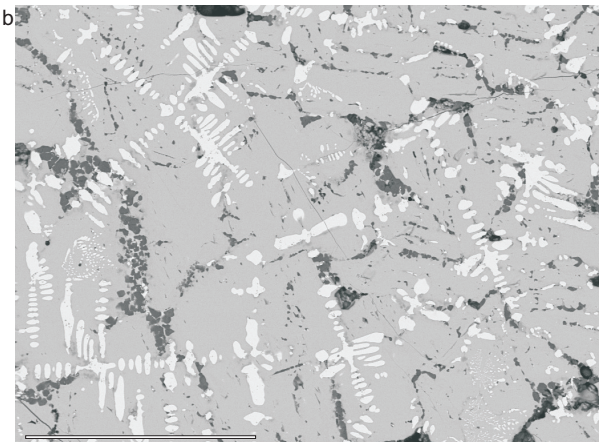

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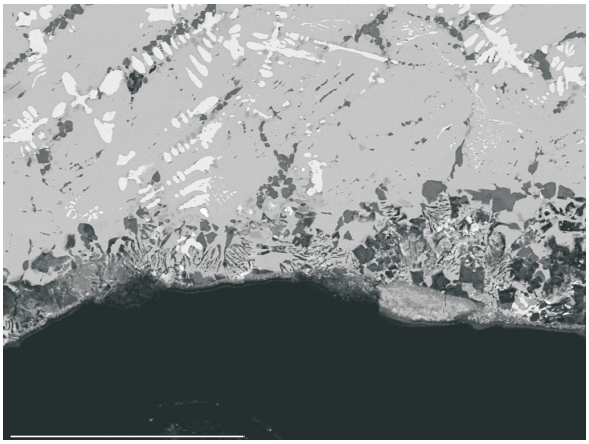

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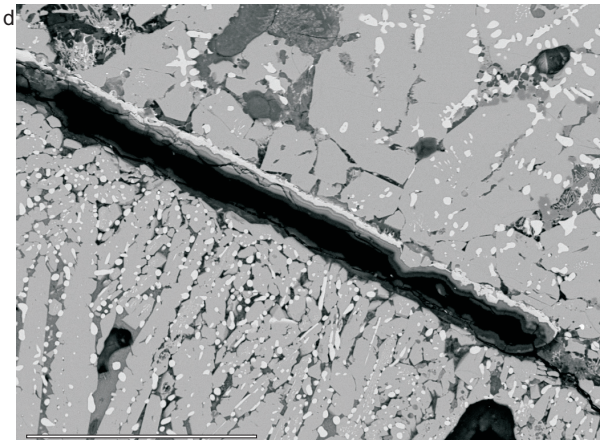

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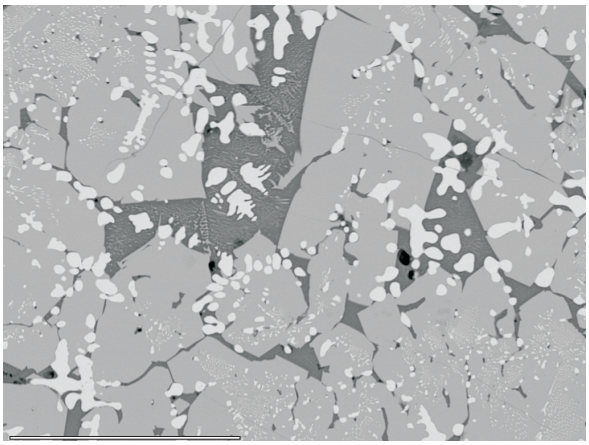

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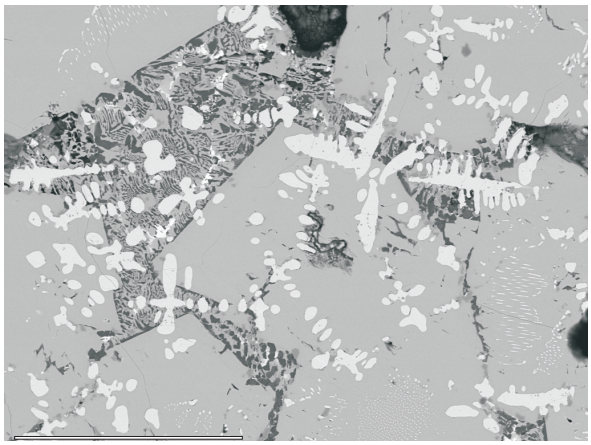

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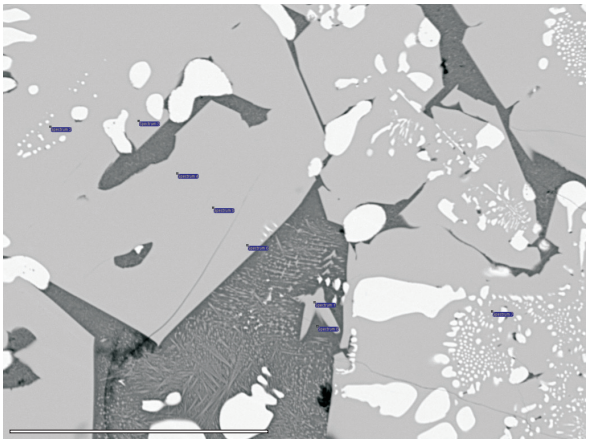

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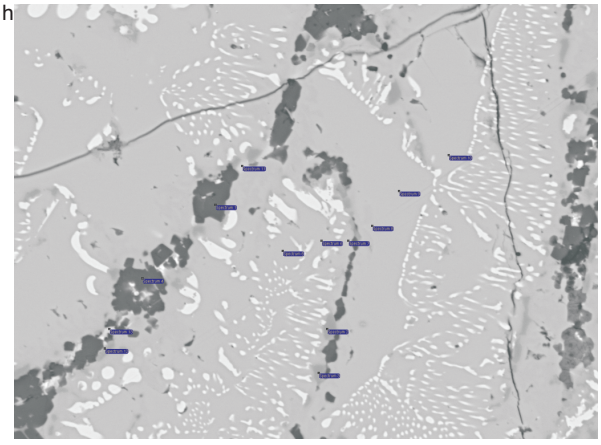

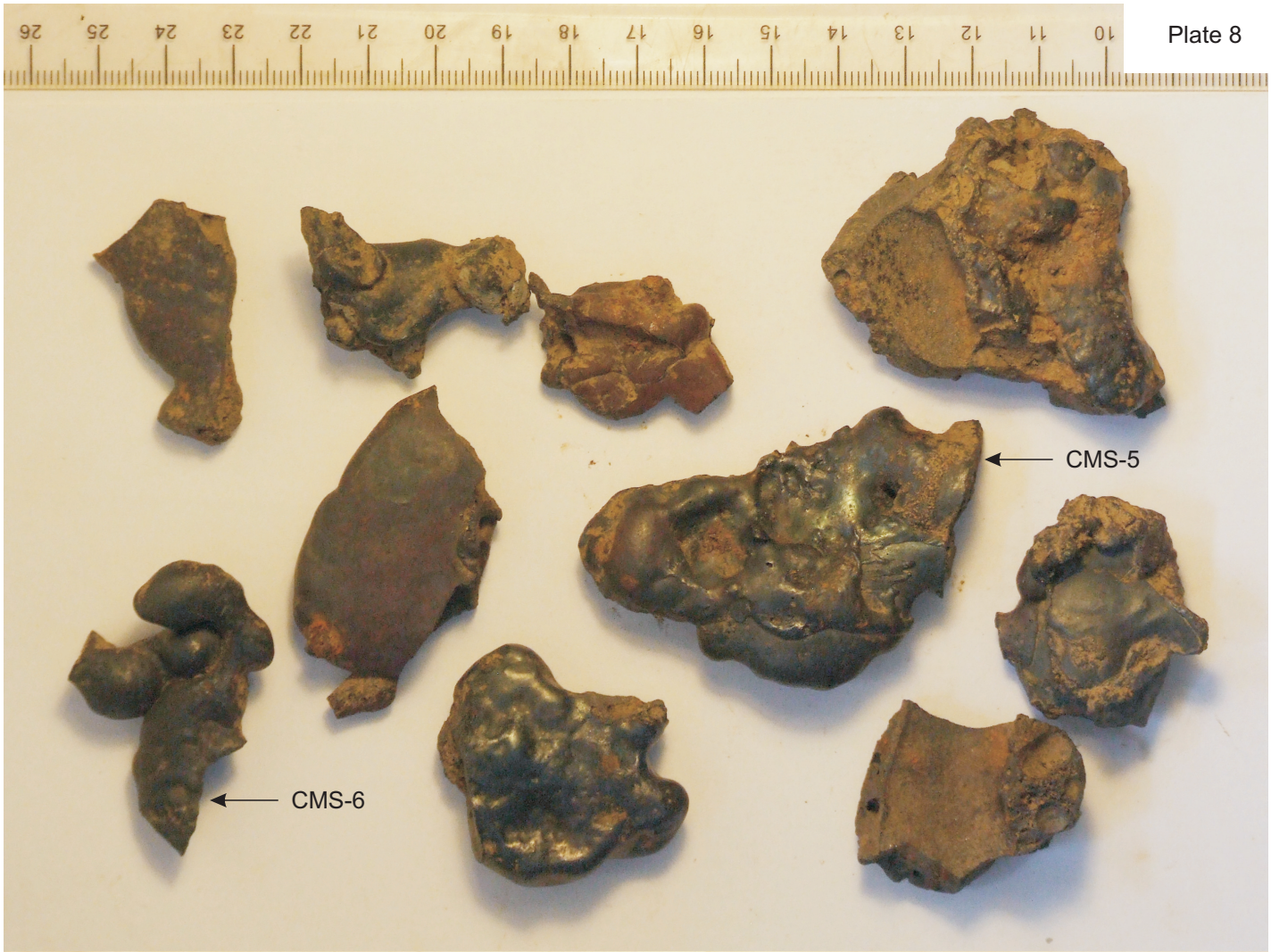
CMS-5
CMS-6


CMS-5
CMS-6

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