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Ferrous archaeometallurgical residues from Woodstown 6

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Abstract

The Woodstown excavations produced 270kg of iron slag, indicative of a high level of activity, both in artefact production and in the production of iron.

Iron smelting slags from Woodstown include well-flown material, both recovered as isolated specimens and from within the base of a small smelting furnace. The assemblage is markedly different from any other Irish early medieval examples of iron smelting, and is interpreted as possibly including tapped slag, although it is clear much of the recovered assemblage never managed to flow from the furnace during its final smelt. The ore smelted in the furnace is not known with certainty, but the slag chemistry would be compatible with a low Mn bog ore.

Chemical arguments are presented that much of the assemblage comprises slags from bloom smithing (bloom refining). Chemical differences between different examples suggest that blooms from different sources were being refined. In contrast to the alien smelting technology, the smithing fits closely with other early medieval assemblages from Ireland. Blacksmithing slags are also abundant indicating the end-use of finished iron, probably for artefact production, although there was no evidence as to what was being produced. A single slag cake has an unusual and distinctive mineralogy and microstructure and may possibly provide evidence for other techniques, possibly steel making.

Contents

1. Methods

All materials were examined visually with a low powered binocular microscope as part of the evaluation (Young 2006a) and a database of all materials produced. The evaluation identified the assemblage as being dominated by residues produced during iron working. A follow-up programme of analysis was designed to investigate the residues in more detail. A particular focus of the campaign of analysis was the investigation of the smithing hearth cakes (SHCs), in order to compare them with other sites of more certainly native Irish origin. A second focus was the investigation of the residues associated with an iron-smelting furnace. A revised catalogue of the archaeometallurgical residues and associated materials 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.

Sample details are given in Table 5, with sampling locations within the smithing slag cakes shown in Figures 1-5. Bulk analytical results are presented in Tables 5-6. Microanalytical results are presented in Table 7. Sample locations for microanalysis are indicated in the relevant BSEM images (Plates 1-16).

2. Results

2.1 Iron-smelting residues

2.1a Distribution

Iron smelting residues were very limited in distribution and quantity, with most of the 9.6kg identified being associated with the base of a furnace, as discussed in further detail later (F2370, 2402, 2406, 2408). Some smelting slag was recovered from the later, post-furnace, fills of ditch F2174 (F2297) and lesser quantities from elsewhere.

2.1b Morphology

The identified smelting slags are all dense, and show good textural evidence for having been very fluid. Most of the isolated pieces in the form of descending or horizontal prilly masses, closely resembling tapped slag. The rough nature of most of the pieces, together with their apparent intimate embedding in ash, suggests that they are flows from the floor of a furnace. At the heart of the smelting complex within context F2330 lies what appears to be the base of a free-standing shaft furnace (see detailed discussion below). The base of this structure is filled with an in-situ mass of slag (context 2406). This mass closely resembles tapped slag in appearance (despite being constrained within the probable furnace base). The total amount of slag from c2406 is approximately 4.5kg. The slag mass shows flows covering an earlier deposit of spheroidal droplets, with flows moving over and against several large stones which apparently form the edges of the base of the furnace. These slag flows show no included moulds of wood or charcoal, and the surface of the flows has a maroon tint, suggestive of some surficial oxidation. In the respects the slags are different from other slag pit furnace slags, and show more similarity with tapped slags. Flows of very similar appearance have also been recorded from the Woodstown SRP excavation (Young 2008e) suggesting that such smelting was not limited to this single location.

2.1c Microstructure and mineralogy

General:
The three investigated samples have broadly similar microstructures, dominated by elongate fayalite crystals of 1-4mm length. In two cases (WTN16 and 17; both from c2406, the main slag mass in the base of the smelting furnace) this is the primary phase, but in the third (WTN21; from c2297) wustite dendrites precede the fayalite. In all cases the fayalite is close to end-member, with just 3% forsterite. Calcium substitution is around 15, with manganese substitution also 1% in WTN16 and 17, but ranging up to 3% in the fayalite from WTN21. WTN17 shows local development of a small quantity of skeletal magnetite.

Details:

WTN16 (Plate 14)
This sample shows multiple sizes of olivine crystals. The largest have lengths of at least 1mm and widths of up to 200µm. They show a rather uniform composition varying from Fa97-98Fo3-2 in the core to Fa99Fo1 with 1% Ca substitution on the margin. A smaller generation is approximately 200µm x 20µm and also appears to be close to end member fayalite. This generation also includes some blocky skeletal morphologies which appear to be associated with wustite dendrites. Fine crystallites in the interstitial glass may be third generation of olivine. Some sparse skeletal magnetite crystals of about 30mm width and with about 20% hercynite are of uncertain relationship to the paragenesis but appear to be early.

WTN17 (Plate 15)
This specimen had a microstructure with sheaves of elongate fayalite crystals, locally up to at least 6mm in length. The central zone of these crystals is solid, but the outer parts show a quench texture with rounded cavities and "cracks". The interstitial area shows the development of delicate wustite dendrites overgrown by blocky late stage olivine, with a final glass. The main olivine grades from Fa97Fo3 with up to 1% Ca substitution in its core to Fa99Fo1 with 1% Ca substitution on its margins. The later blocky olivine is Fa99-100Fo1-0 with 1-2% Ca substitution. Glass compositions range up to about 0.48% P and 0.4% S.

WTN21 (Plate 16)
This sample has sweeping sheaves of elongate fayalite within its flow lobes. Some of fayalite reaches about 4mm in length. The primary phase is formed by wustite dendrites, which are delicate and well formed near the margins, but irregular coarse and blebby in the interior. The fayalite crystals are dominantly Fa98Fo2 with 1%Ca and 3%Mn substitution. Locally they may grade as far as Fa100 with 2%Ca and 3%Mn substitution on their margins. Glass compositions include around 1% P and 0.2% S.

2.1d Chemical composition

The chemical composition of WTN16 and 17 are almost identical, as are those of WTN20 and 21.

The analysed smelting slags of 62-68wt% FeO, 21-28wt% SiO_2 and about 3.3wt%Al_2O_3. The samples from the slag flows inside the smelting furnace show the higher SiO_2 contents (in agreement with their primary fayalite), whereas those from c2297 have a higher iron content (and show primary wustite). The material from the smelting furnace is low in Mn, Ba and P, whereas these elements are slightly more abundant in the slags from other contexts.

The upper crust-normalised REE profiles for the smelting slags (Figure 6) are gently inclined, being depleted in the light REE compared with upper crust. WTN16 and17 shows a slight negative cerium anomaly.

2.1e Structural evidence for iron smelting

The iron-working structures in the butt of the ditch (F2174) are complex and unusual. The unusual nature of the features meant that they were not fully interpretable at the time of investigation, but the following account is based on the serial plans taken during excavation. Since the interpretation is retrospective, there is necessarily some uncertainty. Further detailed examination of the photographic record would be desirable to assist in confirmation of the following interpretation.

The starting point for the following discussion is the *in-situ* slag flow shown on the mid-ex plan 4 of F2330. This flow largely coincides with the later stone feature within a circular area of charcoal and burnt clay.

The structure comprises an oval cut (F2330) approximately 1.4m wide across the ditch and 1.1m along the ditch, with a slight protrusion on its NW side above the centre of the ditch. A furnace appears to have been constructed upon the base of the cut, with a pair of large stones on the NE side of the furnace base with a gap of approximately 120mm between. The slag and charcoal deposit in the base of the furnace (F2406) lies between and to the SW of the stones, but upwards also apparently partially covered the stones and had an extent of 350mm NE-SW by 250mm NW-SE. Slag flows are indicated as extending from the furnace towards the NE (i.e. above and beyond the gap between the stones in the furnace base. The difference in elevation of the base of the cut within the furnace and the base of the cut outside it is unclear from the plans, but seems the cut base seems to dip to the N. It is clear from the plans that the base of the furnace was not cut deeper than the rest of F2330.

At a slightly higher level, burnt clay (part of context F2370) forms a circular structure (interpreted as the base of the furnace shaft), approximately 550mm in external diameter and 300mm internally. The interior of the shaft was tightly sealed by a group of 3 or 4 tightly fitting stones. Deposits immediately over the stone surface appear to have included some charcoal, but rather little slag. The final fill of the complex, F2171, is recorded as being an approximately circular deposit, containing some 20kg of mainly smithing slag, but also a piece of crucible and some copper-alloy dross.

The surface of the stones within the probable shaft lay at 6.2m, the surface of F2406 below the stones at 6.03m, the top of the internal slag flow at 5.97m and the base of the cut in this area at 5.96m.
To the west of the F2330 cut was a cluster of stakeholes, which may have formed a component of the complex. To the north of F2330 a line of stakeholes may suggest some containment of the complex across the line of the ditch.

The interpretation of this structure is crucial to the understanding of the associated residues. The presence of the flows of slag in the base must either indicate a pit for slag-tapping, or slag entrapped in the furnace base. Given the location of the apparent fired clay shaft above, and the geometric position within the overall complex, there seems little doubt that these slags are in the furnace bottom. However, the normal structure for Early Medieval furnaces in Ireland is to have a basal slagpit dug for 200-300mm (and occasionally more) below the shaft (e.g. Young 2003, 2008c, 2008g and references therein). This is not the case here, where the shaft appears to the entirely above ground (although low down in a ditch). The pair of stones near the base and the apparent slag flows outside the fired clay ring to their NE strongly hints at the presence of an arch – either a proper tap arch or an arch for furnace cleaning (cf. those described by Crew 1989, 1998 at Crawcwellt, N, Wales). A clear Irish example of an Iron Age non-slag tapping furnace with an arch was found at Derrinsallagh 3 (Young 2008h), but the slag from such furnaces is quite distinct from that in the present example.

It would be expected that the air supply to the furnace would be through a blowhole 200-300mm above the furnace base (whether a tapping or non-tapping furnace). This would imply blowing at, or just above the level of the later stone filling. Stone or clay fillings such as this have been employed during experimental archaeological investigations to allow the conversion of a smelting furnace into a smithing hearth. Little remains above this level to confirm this interpretation, but it is interesting that the final dump of smithing debris into the complex on its eventual disuse, included large SHCs with unusually polished-appearing bases, which might be taken as indicative of contact with a chilling stone floor to the smithing hearth.

In summary the smelting furnace is unique in the author’s experience in Ireland in being entirely constructed above a basal surface, rather than having a basal pit, and it seems likely that this was allow for the presence of an arch. Some slags may have been tapped, although at least on the final use of the furnace much of the slag appears to have solidified inside the furnace base. The surficial oxidation of the slag may also indicate the use of an open arch. On disuse the lower part of the shaft of the smelting furnace was blocked with large stones to close to the original blowhole level, possibly to allow conversion into a smithing hearth.

2.2 Iron-working residues

2.2a Distribution

The iron-working resides were widely distributed on the site, but the majority were recovered from ditch fills. No primary iron-working contexts were recorded

2.2b Morphology

The majority of the Woodstown collection (181kg out of 272kg) comprised residues from iron-working (smithing). Of this 170kg was material from smithing hearth cakes (SHCs) and 11kg from “pro-tuyère tongues”. A further 63kg of unidentifiable slags was probably dominated by small fragments of smithing hearth cakes, together with a limited quantity of small smithing hearth slag lumps.

The SHCs which were either complete, or sufficiently so that original size could be estimated, number 140, with an estimated original total weight of 148kg.

The weight of SHCs varied from 68g up to 6.31kg. At the lower end of the range certain distinction of SHCs and the masses referred to here as pro-tuyère tongues becomes difficult (see below).

The smithing hearth cakes are very variable in morphology and texture. In general the SHCs are rather conventional in form with moderately dense crusts to the bowls and commonly infills of more charcoal-rich material. There are examples of large bowl-shaped cakes with almost no crust at all, but most do show crust development. The deep cakes of extremely dense, fluid slags recorded in abundance at some other sites (e.g. Clonfad, Young 2009a) do not appear to be common at Woodstown.

The weight distribution of the smithing hearth cakes (Tables 3 and 4) shows a minimum recorded size of 68g, a maximum of 6310g, with a mean for the 140 measurable SHCs of 1060g. The modal 100g class is the 200-300g interval, and 40% of the SHCs are less than 500g, with 71% less than 1000g. 7% of the SHCs weigh over 3000g.

The tuyères from the site have a total weight equivalent to about 7% of the weight of the SHCs. This is comparable with the proportion from the New Graveyard excavations at Clonmacnoise (authors work in progress) and slightly higher than that at Clonfad (Young 2009) or the Clonmacnoise wastewater scheme (Young 2005). Examples with a diameter of approximately 110mm and a bore of 18-26mm are most common, although both larger and smaller examples appear to be present. These dimensions appear similar to the material from Clonfad and Clonmacnoise, although larger examples are also known at Clonfad.

The tuyères are accompanied by a characteristic form of slag cake, to which has here been given the name "pro-tuyère tongue". These cakes appear to extend forwards and possibly slightly downwards from the lower part of tuyère face. They therefore form in a similar position to conventional interpretations of SHCs. They have a distinct morphology however, separating them from the accompanying SHCs. They typically have an elongate shape, typically up to 150x80mm, with a smooth silicate-rich glassy top, a lobate margin, and a prilly, iron rich lower surface. Well-developed examples weigh 160-200g. A total of 10.8kg of this class of slag was recovered, corresponding to 6% of the identifiable smithing slags.

The indeterminate iron slags were generally small pieces likely to have been derived from SHCs but not demonstrably so, together with small pieces of slag that may have formed in the smithing hearth outside the main SHC. It is unlikely, given the distribution of the identifiable slags, that the indeterminate group actually includes a very high proportion of iron smelting slags.

Micro-residue assemblages have not yet been examined in detail, however, several pieces of "smithing floor" were present in the slag collections. "Smithing floor" is a concreted mass of smithing fines, dominantly flake hammerscale, but also including spheroidal hammerscale, other slag fines and charcoal, which has accumulated either on the smithy floor, or within a dump of fines. The Woodstown assemblage includes some rather exceptional pieces of smithing floor that have the form of elongate lengths of irregular "T"-shaped section (up to 40mm deep and 20mm wide). These appear to have accumulated either in a gap in the smithy floor, or most likely (given the overall external similarity of the pieces to wood) by accumulation of hammerscale into the void created by a rotting piece of wood within the floor.

2.2c Microstructure and Mineralogy

General:

The samples examined in detail include SHCs (samples WTN1-11) and pro-tuyère tongues (WTN12-15). The pro-tuyère tongues commonly show an upper layer in which the reaction of ceramic sloughed from the face of the partially-melted tuyère face is in reaction with iron, or iron oxides, lost from the workpiece. These materials now show a diverse range of minerals, frequently including pyroxene-rich assemblages as well as more conventional olivine-rich ones. These silica-rich slags are indicative of the pathway towards the generation of the slags seen in the SHCs.

The SHCs from Woodstown show a variety of microstructures, but the majority show a moderate to strong development of primary wustite, followed by olivines close to end member fayalite. Substitution of Mg, Ca and Mn into the fayalite is generally in very low amounts. Ca may increase in the margins of the main phase olivine, and may be at elevated levels in fine interstitial dendrites (often approaching a kirschsteinite). As well as olivine the interstitial spaces are often dominated by a leucite-wustite symplectite. Leucite and leucite-wustite are seen in several specimens as rims on surviving or former vesicles. Variations on this basic mineralogy include the presence of interstitial apatite (WTN3), the development of a fayalite-hercynite symplectitic intergrowth (WTN8), the development of a symplectic intergrowth of fayalite with a leucite-wustite intergrowth (WTN9, WTN10) and the presence of interstitial rhönite (WTN9). In general the small SHCs show a higher proportion of primary wustite, although the large cake WTN11 with its very high proportion of wustite is the exception to this.

One sample, WTN1, was taken because it was one of the relatively rare fragments of SHCs with evidence for a deep slag puddle. This SHC showed a rather different microstructure from all the others, with abundant primary magnetite, present as both equant grains and plates, and also with the development of a symplectite of fayalite and leucite.

Details:

WTN1 (Plates 1-2)
This sample from part of a "thick-crust" SHC shows a very variable texture, particularly in the form and mineralogy of the iron oxides present.

The basal 6mm (1) comprises a somewhat vesicular slag with magnetite plates and blebs (23% hercynite) that are sparse and possibly resorbed, overgrown by fayalite, then a fayalite plus hercynite symplectite, and then a wustite-leucite symplectite. In a typical area the main olivine phase shows ores of $Fa_{98}Fo_{2}$ with about 1% Ca and 2% Mn substitution. The change to the fayalite-leucite symplectite is abrupt and may be marked by continuous leucite. The leucite may also rarely form dendrites. The olivine of the intergrowth is Fa_{100}, with 6-8% Ca and 1%mn substitution.
Where the leucite-wustite symplectite is absent, there is a very fine grained interstitial groundmass, which probably contains a Ca-rich olivine, probably a kirschsteinite.

Above this is a thin zone (2) up to 1mm thick, with a broadly similar texture, but in which the wustite dendrites become larger and more volumetrically important.

Above this a thin layer (3) of up to 1mm marks the appearance of large equant magnetite grains. Higher still, the equant grains become supplemented with the magnetite plates (4). This thicker zone (4mm) shows enclaves similar to zone 3, and above it lies a further thin zone (1mm) characterised by large equant magnetite crystals (5) and there is a return to dendrites at the top of the sample (6). .

The largest equant magnetite (7-8% hercynite) grains are up to about 100 microns across. The magnetite plates are of uncertain precise mineralogy, and are up to about 1mm long; they occur mainly where magnetite is most abundant.

WTN3 (Plate 3)
The typical texture has a high proportion (around 80%) of primary wustite, in stubby, rounded dendrites. These do not show morphological indication of crystallographic continuity over more than approximately 200µm. Gaps in the wustite coverage sometimes survive as vesicularity, but others are infilled by the continuation of the secondary fayalite. The olivine composition varies little, from Fa97Fo3 with 4% Ca substitution in the cores to Fa98Fo2 with 7% Ca substitution towards the margins. The olivine forms complex elongate crystals of up to 1mm in length and 300µm in width.

Locally, the fayalite shows a thin layer of overgrowth containing a calcium rich olivine, probably a kirschsteinite and apatite. The bulk of the interstitial space is filled, however, by separate kirschsteinite and apatite dendrites (this is the only slag examined to show apatite).

WTN 6 (Plate 4)
This slag shows a very heterogeneous texture. Much of the specimen shows a dominant primary wustite in stubby rounded dendrites, of up to about 1mm across. The secondary fayalite has a narrow range of composition from Fa96Fo4 with 1% Ca and 1% Mn substitution to Fa97Fo3 with 3% Ca and 1% Mn substitution. Interstitial areas are normally filled by dendrites (too small to analyses but probably kirschsteinite). Near some large vesicles there is development of a leucite-wustite symplectite, which occurs in angular areas within the outer part of the fayalite and as more rounded masses within the interstitial areas. In these areas the wustite is reduced or absent. The wustite is also locally absent near the base of the specimen, with areas comprised almost entirely of olivine.

WTN 8 (Plate 5)
The sample shows a patchy development of primary wustite, with typically dendrites of less than 1mm across. The secondary olivine is the dominant phase, with large, complex crystals of up to about 3-4mm in length and 0.5mm width. Some of the olivine is in a symplectitic structure with wustite, the majority is simple. Some olivines late in the development show a symplectite with hercynite (92-97% end member hercynite). The range of olivine composition is limited, with Fa99Fo1 to Fa97Fo3, with 1% Ca and 11-12% Mn substitution in the cores rising to about 4% ca substitution on the margins. The late olivine with hercynite forms the basis for a dense network of interstitial dendrites, forming, locally, skeletal crystal outlines. This late phase is too fine for analysis.

WTN 9
WTN9a (Plate 6): This specimen shows a very low proportion of primary wustite which is present as scattered stubby dendrites – often showing a rather linear distribution. The texture shows large rounded pores, often several mm across. These have leucite and/or leucite-wustite rims (some extremely well-developed) and a frequent development of leucite in the surrounding area. The main phase of olivine is typically Fa97-98Fo3-2, 1-4% Ca substitution and 2-4% Mn substitution. Locally, the olivine shows a complex morphology with an intergrowth with a leucite-wustite symplectite. Here the olivine shows a similar composition. Locally the margins of the olivine increase to around 12% Ca substitution. These margins may then be overgrown by (or altered to) an kirschsteinite (around K80Fa20; 40% ca substitution in Fa). Interstitial areas may contain small equant crystals of Ca-rich olivines and also some dendrites of similar olivines, but the main crystalline phase is of twinned crystals, star-shaped in cross-section, which appears to be rhönite.

WTN9b (Plate 7): this sample shows tubular vesicles in a zone just above the base of the SHC. The primary wustite is fairly sparse and forms well-developed, fairly delicate dendrites of up to about 1mm across. Wustite is absent around the tubular vesicles, suggesting they were initially larger, and forms only a very small proportion of the basal 600µm of the SHC which is almost entirely of olivine. Towards the top of this sample the wustite forms a loose network – possibly indicating much more open early texture. Much of the olivine is in the form of small equant crystals about 400mm across. These grade from Fa93Fo7 with 1% Ca and 4%Mn substitution in the cores through to Fa98Fo2 with 5%Ca and 3%Mn substitution on the margins. The dominant interstitial material is a leucite-wustite symplectite, although there are patches of a very fine material, probably a calcium rich olivine. The margins of the pores are frequently marked by layers of leucite.

WTN10
WTN10a (Plate 8): The sample shows a primary wustite in moderately abundant stout dendrites, There are abundant large pores, which are associated with leucite and leucite-wustite rims, as well as by complex symplectite growths of olivine with leucite-wustite. The olivines involved in the main stage of crystallization appear chemical similar, with cores of Fa96-98Fo4-2 with 1-2% Ca and 7-8% Mn substitution. The margins range up to Fa99Fo1, with 4% Ca and 7% substitution. In some instances continued growth of the complex olivine outside zone of the leucite-wustite intergrowth shows compositions of Fa99Fo1, 11-14% Ca and 7%Mn substitution. Interstitial areas include, dominantly leucite-wustite cotectics, but also lesser areas with dendritic calcic olivine (Fa100 with 18%Ca and 7% Mn substitution).

WTN10b (Plate 9): this sample shows moderately abundant coarse wustite dendrites, which are small and blebby, with little evidence for coherency over more than about 250µm, followed by a rather granular olivine, with equant components up to 300µm across. The vesicles are associated with leucite rims, leucite-wustite and complex olivine plus leucite-wustite crystals. The wustite shows a reticulate distribution in many areas – suggesting former porosity later occluded by the growth of fayalite in these locations. Olivines show cores of Fa99Fo1, with 1% Ca and 9-10% Mn substitution.

The complex olivines show Ca substitution ranging from 3% internally to 13% marginally, both with 7-8% Mn substitution. Some interstitial space shows late-stage olivine dendrites with Ca contents of around 70% kirschsteinite. These calcic olivines are associated with a very fine-grained sodium-rich phase with equal molar proportions of aluminium and silicon, and which is probably nepheline.

WTN11 (Plate 10)
This sample is dominated by stubby, stout, rounded wustite dendrites, of at least 2mm in length. The subsequent olivine is in elongate crystals, up to 3mm in length. The fayalite ranges little in composition internally, from Fa96Fo4 to Fa98Fo2, with just 1% Ca substitution. On the very margins the level of Ca substitution rises to 7%. Mn was below detection in the olivine.

Interstitial areas are largely filled with a leucite-wustite syntectite, although small areas bear a complicated and very fine-grained microstructure, probably dominated by an olivine.

WTN14 (Plates 11 & 12)
This specimen shows two layers – one layer (the lower in the images but the original upper layer?) is formed of quartz and feldspar grains of up to about 3mm in diameter (although most are smaller) in a fine grained matrix dominated by mainly by feathery olivine dendrites. Analyses of these are, with some probable influence from interstitial glass, but they appear to be co-crystallizing ortho- and clinopyroxene. The probable OPX (the brighter phase Plate 12b) shows a ferrosilite composition (Fe:(Fe+Mg) of 0.94-0.97 with Ca substitution of 5-10%. The accompanying phase, probably a CPX (the duller phase on Plate 12b) shows a similar Fe:Mg ratio but has analyses suggesting Ca substitution in the range of 25-40%.

Towards the upper (?) margin of the band of sand (and locally within it) lies a zone in which primary magnetite (with composition very close to end member) was followed by ferroaugite (clinopyroxene) with Fe:(Fe+Mg) ranging from 0.57 in the cores to 0.69 on the margins, with a narrow range of Ca substitution at around 43-44%. This was followed by a now largely decomposed interstitial glass.

Below (?) the sandy layer was a somewhat more conventional slag. This had elongate fayalite crystals which are marginally associated with small equant crystals of leucite about 10µm across, and are followed by interstitial dendrites of hedenbergite. The distribution of leucite appears to be focused in small patches of slag about 1-2mm across and in some case these also contain small grains of magnetite. The fayalite had compositions of Fa97Fo3 with 1% Ca and 1%Mn substitution. Ca substitution increased towards the margins and rose markedly in the fayalite associated with the leucite, which was Fa100 with up to 14% ca substitution. Mn substitution remained at low levels (1-2%) throughout.

WTN15 (Plate 15)
This sample was a very heterogeneous slag with small rounded fragments of ceramic, partially oxidised lumps of iron and large isolated quartz grains set in a slag with a glassy matrix. The slag shows rapid compositional variation around the various inclusions. One local texture showed elongate olivine followed by both olivine and probably leucite dendrites. Here the olivine core was Fa96Fo4 with 3% Ca and 6% Mn substitution, with the later olivine associated with the leucite being Fa99Fo1, with 11%Ca and 5% Mn substitution.

The area around the altered lump of iron showed very fine olivine in equant to elongate crystals with compositions of Fa89-93Fo11-7 with 3-4% of both Ca and Mn substitution. Similar olivine compositions were also measured in a rather altered area adjacent to a ceramic clast, and again here there were small fayalite-leucite intergrowths.

2.1d Chemical composition

The chemical compositions of the smithing residues (tables 5 and 6) show the SHCs to be mainly iron-rich (whole cake analyses have FeO ranging from 57-72wt% FeO). The non-iron component is mainly silica and alumina with the other major elements present in low concentrations (MnO <1.6%, <MgO <0.6%, CaO <2.6%, K_2O <1.7%, P_2O_5 <0.86%). Exceptions to this are WTN3, which has CaO = 4.1% and P_2O_5 = 3.1% (the apatite in this specimen has been mentioned above), WTN8 with an MnO content of 4.2% and WTN10c with MnO of 2.4%.

The bulk chemical composition of the tongues is very variable, bridging much of the compositional gap between the SHCs and the tuyères.

The tuyères have a silica content of around 75%, with about 10% alumina. Their FeO content is less than 5%, K_2O is about 2%, CaO about 0.1% and P_2O_5 at about 1%.

The REE profiles (upper crust-normalised after Taylor & McLennan 1981) can be divided into three groups:

Group 1 (Figure 7 upper): these show a gently "humped" profile. This group includes profiles from WTN5, WTN9c/d/e and WTN14.

Group 2 (Figure 7 middle): these profiles are gently inclined (Lu_N/Pr_N <1.5). This group includes the profiles of WTN2, WTN3, WTN4, WTN6a/b, WTN12, WTN13, WTN15 and of the tuyère samples WTN24/25. The small pieces of bog iron ore found at Woodstown (WTN19 and WTN22) would also fit in this group.

Group 3 (Figure 7 lower): these profiles are more strongly inclined (Lu_N/Pr_N >1.5). This group includes profiles from WTN1, WTN7, WTN8, WTN10, WTN11. The samples of smelting slags (see above) would also fit within this pattern.

Group 2 can be seen to include all the SHCs with weights below 1kg (except WTN5), together with 3 of the 4 pro-tuyère tongues. Group 3 contains the SHCs above 1kg (except WTN9). Group 1 contains one small SHC, one large SHC and one tongue.

Figure 8 illustrates some of the trends with the chemical compositions using the concentrations of uranium and thorium, together with two measures of REE profile shape. These diagrams show that although there are coherent trends within the composition of the smelting residues, these complicated in detail. Complicating factors might include a variation in the chemical composition of entrained slag in blooms being worked, a variety of chemical compositions for the tuyères (i.e. different clay sources) and possibly a variable degree of interaction between the SHC and hearth floor. These influences will be discussed further below.

3. Interpretation

3.1 Iron smelting

Iron smelting slags will have a chemical composition which is formed from a mixture of the ore, the ceramic if the smelting furnace and a minor contribution from the fuel ash slag (Thomas & Young 1999a and b). The contribution from the ceramic would be expected to have a fairly flat UC-normalised REE profile. Thus the slag should show a profile related to, but of lower amplitude than, that of the originating ore. The actual amounts of each element would be up to 3 times as concentrated in the slag as in the ore-ceramic mixture, In this instance the slag profiles did not correspond with that of any of the investigated possible ores (Figure 6).

In instances where the ore-slag pair is well constrained, the Mn content of the slag is 1-3 of the ore (e.g. Truro; Young 2008b), suggesting that the ore employed during the production of WTN16-17 would have been 0.06-0.20 wt% MnO and for WTN20-21 0.41-1.25 wt% MnO.

Thus, although no ore was recovered from the smelting furnace, the slag composition suggests the use of an ore very low in MnO. Dense flow slags from other sites smelting bog ores have MnO contents in the range of 2-8 wt% MnO. Even the low Mn slags from Ballykilmore (Young 2009b) contain 0.5-3.0 wt% MnO, accentuating the unusually low Mn content of the ore being smelted during the production of WTN 16 and 17. During the production of WTN 20 and 21 the ore would have had an Mn content similar to that of the ores at Ballykilmore. The ores from Adamstown 3 (Young 2009e) do have a suitably low Mn content (even if their REE profiles do not appear to match those of the Woodstown smelting slags). It s possible however, that the same, or a similar ore source yielded the ores smelted at Woodstown.

The smelting furnace at Woodstown remains problematic; it appears to have been a slag-tapping furnace, but the slag in its last use solidified within the furnace base. It is possible that the extremely low Mn content of that final smelt was the reason for this – and the slags were less fluid than from typical ore batches (as suggested by the composition of the other smelting slag finds).

If the furnace is indeed a slag-tapping furnace as it appears, then parallels need to be sought outside Ireland, for in early medieval Ireland the use of the slagpit shaft furnace now appears universal (e.g. Young 2009a,b).

Small slag-tapping shaft furnaces have been proposed from various locations with Viking affinity – including Viking sites in Norway (e.g. Stenvik 1986), Iceland (e.g. Smith 2005) and Canada. Many of these were constructed using an earth bank to surround and protect a thin clay shaft. The geographically closest parallels to the Woodstown furnace are a pair of slag tapping furnaces set at the end of a bow-sided workshop at the South Hook LNG Terminal, Dyfed, Wales (Young 2006c). These appear to date from within the 9th to 11th centuries, and are of uncertain cultural affinity.

3.2 Iron working

The SHC assemblage from Woodstown is compared with those from other early medieval sites in Table 4. The SHC assemblages divide into several groups. The assemblages of smallest SHCs are found on sites such as Coolamurry, Navan, Moneygall, Carrigoran and Parknahown 5. None of these sites has produced evidence for smelting. They all show mean SHC sizes that are small by Irish standards (400-550g typically), with around 10% of SHCs heavier than 1kg, but few, if any, over 3kg. The maximum SHC weight varies, but is often close to 3kg.

These sites can be taken as a baseline for slags produced by the end-user smith. However, although the smith deals primarily with blacksmithing (typically in these assemblages 60-70% of SHCs weigh less than 500g and the modal interval for SHC weights is often 100-200g), some of the cakes are large in comparison with those normally produced by blacksmiths. It has been suggested (Young, forthcoming) that in Ireland there was no tradition of the production of fully refined "trade-iron" as seen, for instance, in Britain, rather there was a trade in partially refined blooms. Pleiner (2000) describes split blooms from Denmark, where the low density bloom fragments ("kloder"; apparently comprising up to 50% slag) were traded for use in rural settlements. Such a practice decentralises bloomsmithing (lessening the local load on forestry resources) and will lead to the occurrence of bloom refining slags even on rural smithy sites.

Only a very few consolidated blooms are known from Ireland, but amongst them three undated split blooms weighing about 5.5kg are known from Dernaglug and Drumaa, Co. Fermanagh (Evans 1948). These closely resemble the Danish split blooms described by Pleiner.

A second group of assemblages includes those from Clonmacnoise, Clonfad, Ballykilmore (which may be a little younger in date) and Woodstown. This group typically only has 30-40% of the SHCs in the assemblage below 500g in weight (i.e. the typical range for end use blacksmithing), but has about 30% of SHCs over 1kg and 10% over 3kg. These sites clearly had a large proportion of bloom refining being undertaken and all show evidence for being part of the chain of iron production. Detailed chemical investigation of the Clonfad assemblage (Young 2009a) has suggested bloom-refining is particularly represented in SHCs over 2kg in weight.

The textural and chemical evidence outlined above suggests a great deal of similarity in the processes generating the various SHCs at Woodstown (with perhaps the exception of WTN1, discussed further below). The variety of chemical composition shows that both blacksmithing and bloomsmithing are important.

The group 2 slags, defined above on the basis of their REE profile, includes the small SHCs, most of the pro-tuyère tongues and the tuyères themselves. In other words these are residues whose REE contents are dominantly controlled by the REE contents of the tuyères. As discussed above, small SHCs are commonly associated with blacksmithing, the end use of iron. The processed iron contains relatively few slag inclusions, so the silicate component of the smithing slag will be derived almost entirely from the tuyère (unless a welding flux is used by the smith, in which case a small contribution from that may be present).

On the other hand, during bloom smithing (or bloom refining) the contribution of slag from the workpiece will be much greater, so the influence of the chemistry of the tuyère on the final slag composition is reduced. In general it has been proposed that the larger slag cakes may be generated during bloom smithing (rather than extended periods of blacksmithing). The Group 3 REE profiles show an inclination of the REE profile greater than that of the tuyères, and so may be providing an indication of an influence from smelting slag. Group 1 REE profiles might either be an indication that there were other tuyère compositions in use (since one of the profiles is from a pro-tuyère tongue), but might alternatively indicate smithing of blooms with a different composition of entrained smelting slag from those in Group 3. Indeed, given that the pro-tuyère tongue in this group is actually the most iron-rich of the analysed tongues, then the origin of the REE signature in the slag from the workpiece is the more likely hypothesis.

One possible origin for slags with a humped profile, such as would be required to generate the Group 1 REE profiles, would be the smelting of ores similar to those from nearby Adamstown 3 (which had a strongly humped profile, similar, but not identical to, the Group 1 profiles).

The Group 3 profiles resemble what little is known of the REE distribution from other sites. Gently inclined profiles have been recorded for smelting slags from Cherryville (Young 2008c) and Ballykilmore (Young 2009b), both of which sites are believed to have been smelting bog iron ores. Inclined profiles have also been recorded from the smelting slags from the furnace excavated at Woodstown (see above). The smelting slags from Woodstown show more steeply inclined profiles than the smithing slags – which would be expected since the inclination will be reduced through the influence of the input from the tuyère.

In summary, the size-frequency distribution of the SHC assemblage resembles that of other sites involved in iron production as well as end-use blacksmithing. Those SHCs interpreted as being from bloomsmithing provide chemical evidence for the smtihing of blooms containing slags with at least two distinct trace element signatures.

One of these has a trace element signature which is compatible with that of a low manganese/low phosphorus bog iron ore, the other more closely resembles ores from Adamstown 3, interpreted as being gossan ores. Neither identification is certain. In addition, there are some SHCs with higher manganese contents which hint at the refining of blooms made from high-Mn bog ore.

There is one exception to the broad similarity of composition of SHCs from the site: WTN1. This sample was from part of a slag cake (whose total original size is unknown), in which the slag had formed a deep fluid puddle. Such cakes are relatively rare at Woodstown, compared, for instance with Clonfad. The microstructure of this cake did not, however, resemble those of the "thick crust" SHCs from Clonfad. Instead it contains abundant primary magnetite in equant crystals and plates, together with equant leucite crystals associated with the later stages of fayalite growth. These features more closely resemble those seen (e.g. Young 2009c) in 19th century puddling slags (a process for oxidising high carbon cast iron to produce low carbon wrought iron). The significance of this is unclear, but it is just possible that this slag might be connected with the process of decarburising high carbon cast iron to produce steel.

4. Discussion

Woodstown has produced a substantial 270kg of iron slags from a relatively small area of excavation. The vast majority of the assemblage is from smithing, although the excavation revealed a small smelting furnace, apparently capable of slag-tapping.

The major research questions surround how that iron working fitted-in to the local and outward-facing aspects of the Woodstown settlement. The implications from the analysis of the iron working residues are not clear-cut, but provide some answers and further questions.

The smelting technology appears to be that of a small slag-tapping shaft furnace; a technology quite alien to early medieval Ireland, but familiar in a general sense at least in other parts of the NW European region. It is tempting to see this as imported Viking technology, but it is possible other factors may (also?) be at play. In Britain, Iron Age usage of non-slag tapping furnaces is closely, but not entirely associated with exploitation of Britain's rather limited bog iron ores. With increased exploitation of rock ores by the late pre-Roman Iron Age a transition to slag tapping furnaces occurs, which is almost universal by the Roman period. In contrast, Ireland has had a much more plentiful supply of bog ores and usage of the Iron Age-style of non-slag tapping furnace appears to have continued, with modification until the 18th century, The presence at Adamstown 3 of large pieces of what appears to be a goethitic rock ore, suggests the possibility that Woodstown might have employed such an ore and the geochemical evidence tentatively supports this; it is just possible that the adoption of a different furnace technology may have been associated with the exploitation of a different resource, rather than simply the cultural background of the smelters.

In contrast, the smithing appears to be well within the native Irish tradition, and the slag assemblage compares closely with sites such as Clonmacnoise and Clonfad outside the geographical and temporal scope of Viking influence.

There is some evidence that either a variety of ores were smelted at Woodstown, or (possibly more likely?) blooms produced elsewhere from a variety of ores were brought to Woodstown for refining and use.

Although the evidence is not quite conclusive, this hints at a lively trade in raw iron from a variety of sources. There is, unfortunately, at present no evidence to what use the finished iron was put, or whether it was simply a trade item.

Finally, the curious slag puddle WTN1 also hints that some more advanced metallurgical activities were practiced at Woodstown, which would be in keeping with the metallurgical sophistication of contemporary artefacts, such as knives and other edge tools.

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Figure Captions

Figure 1. Cross sections of sawn blocks of samples WTN1 – WTN6.
Shows sampling locations. All 1:1 at A4.

Figure 2. Cross sections of sawn blocks of samples WTN7 – WTN8.
Shows sampling locations. All 1:1 at A4.

Figure 3. Cross sections of sawn blocks of samples WTN9 – WTN10.
Shows sampling locations. All 1:1 at A4.

Figure 4. Cross sections of sawn blocks of samples WTN11.
Shows sampling locations. All 1:1 at A4.

Figure 5. Cross sections of sawn blocks of samples WTN12 – WTN15.
Shows sampling locations. All 1:1 at A4.

Figure 6. Rare earth element profiles (normalised to upper crust after Taylor & McLennan 1981) for samples associated with iron smelting.

WTN16, 17 and 20 are flowed iron smelting slags, WTN 19 and 22 are small bog iron ore particles from Woodstown 6, ADN1 and 2 are iron ore samples from nearby Adamstown 3 (Young 2009e).

Figure 7. Rare earth element profiles (normalised to upper crust after Taylor & McLennan 1981) for samples associated with iron working.

Upper diagram *shows samples with a humped profile ($Dy_N > Lu_N$ and $> La_N$).*
Middle diagram *shows samples with only a slight inclination ($Lu_N/Pr_N < 1.5$).*
Lower diagram *shows samples with a stronger inclination ($Lu_N/Pr_N > 1.5$).*

WTN1-11 are examples of smithing hearth cakes, WTN 12-15 are samples of pro-tuyère tongues and WTN 24-25 are samples from tuyères.
WTN16-17 and 20-21 are samples of iron smelting slags for comparison; samples WTN 19, 22-23 are of iron and manganese ores.

Figure 8. Bivariate geochemical plots

Upper diagram*: bivariate plot of the concentration of U v Th in ppm for various residue types. The outlying SHC sample is WTN11. The U/Th ratio is low for the tuyères and high for the smelting slags. The SHCs and tongues have intermediate ratios.*

Middle diagram*: Lu_N/Pr_N v U/Th.*
Lu_N/Pr_N is an indicator of the overall slope of the REE profile. It is low for the tuyères and some SHCs, high for smelting slags, with other SHCs being intermediate. The outlying SHC is WTN11.

Middle diagram*: Lu_N/Pr_N v Lu_N/Gd_N.*
Lu_N/Gd_N gives an indication of whether the REE profile is humped ($Lu_N/Gd_N < 1$) or inclined ($Lu_N/Gd_N > 1$). The two parallel trends suggest that another silicate source, probably a different tuyère ceramic has contributed to some SHCs (WTN5, 9 & tongue 14), whereas most form a trend from the analysed tuyères, WTN24 & 25. The outlying SHC is WTN11.

Plate Captions

Plate 1. Montage of BSEM images of WTN1, areas 3-6. See text for explanation of numbered textures. Scale bar 2mm (total height of image 14.0 mm).

Plate 2. BSEM images of WTN1

a. Area 1. Scale bar 2mm
b. Area 2. Scale bar 600µm
c. Area 7. Scale bar 300µm
d. Area 8. Scale bar 80µm
e. Area 9. Scale bar 100µm

Plate 3. BSEM images of WTN3

a. Area 1. Scale bar 2mm
b. Area 2. Scale bar 1mm
c. Area 3. Scale bar 300µm
d. Area 4. Scale bar 100µm
e. Area 5. Scale bar 80µm

Plate 4. BSEM images of WTN6

a. Area 1. Scale bar 2mm
b. Area 2. Scale bar 2mm
c. Area 20. Scale bar 1mm
d. Area 21. Scale bar 100µm
e. Area 22. Scale bar 3mm
f. Area 23. Scale bar 300µm
g. Area 24. Scale bar 1mm
h. Area 25. Scale bar 100µm

Plate 5. BSEM images of WTN8

a. Area 1. Scale bar 1mm
b. Area 2. Scale bar 400µm
c. Area 3. Scale bar 1mm
d. Area 20. Scale bar 1mm
e. Area 21. Scale bar 300µm
f. Area 22. Scale bar 2mm
g. Area 23. Scale bar 100µm
h. Area 24. Scale bar 100µm

Plate 6. BSEM images of WTN9a

a. Area 1. Scale bar 90µm
b. Area 2. Scale bar 1mm
c. Area 20. Scale bar 600µm
d. Area 21. Scale bar 600µm
e. Area 22. Scale bar 100µm
f. Area 23. Scale bar 100µm
g. Area 24. Scale bar 100µm
h. Area 27. Scale bar 80µm

Plate 7. BSEM images of WTN9b

a. Area 1. Scale bar 2mm
b. Area 2. Scale bar 2mm
c. Area 20. Scale bar 1mm
d. Area 21. Scale bar 4mm
e. Area 22. Scale bar 600µm
f. Area 23. Scale bar 1µm

Plate 8. BSEM images of WTN10a

a. Area 1. Scale bar 300µm
b. Area 2. Scale bar 300µm
c. Area 3. Scale bar 300µm
d. Area 4. Scale bar 300µm
e. Area 5. Scale bar 300µm
f. Area 6. Scale bar 300µm
g. Area 7. Scale bar 600µm
h. Area 8. Scale bar 100µm

Plate 9. BSEM images of WTN10b

a. Area 1. Scale bar 300µm
b. Area 2. Scale bar 300µm
c. Area 3. Scale bar 300µm
d. Area 4. Scale bar 300µm
e. Area 5. Scale bar 900µm
f. Area 6. Scale bar 100µm

Plate 10. BSEM images of WTN11

a. Area 1. Scale bar 1mm
b. Area 2. Scale bar 300µm
c. Area 3. Scale bar 1mm
d. Area 4. Scale bar 500µm
e. Area 5. Scale bar 100µm
f. Area 6. Scale bar 100µm

Plate 11. BSEM images of WTN14

a. Montage of areas 1-3. Scale bar 3mm
b. Area 4. Scale bar 1mm
c. Area 5. Scale bar 300µm
d. Area 6. Scale bar 300µm
e. Area 7. Scale bar 80µm
f. Area 8. Scale bar 80µm

Plate 12. BSEM images of WTN14

a. Area 9. Scale bar 80µm
b. Area 10. Scale bar 200µm
c. Area 11. Scale bar 3mm
d. Area 12. Scale bar 80µm
e. Area 13. Scale bar 100µm
f. Area 14. Scale bar 60µm
g. Area 15. Scale bar 100µm

Plate 13. BSEM images of WTN15

a. Area 1. Scale bar 4mm
b. Area 2. Scale bar 200µm
c. Area 3. Scale bar 80µm
d. Area 4. Scale bar 1mm
e. Area 5. Scale bar 100µm
f. Area 6. Scale bar 1mm
g. Area 7. Scale bar 100µm

Plate 14. BSEM images of WTN16

a. Area 1. Scale bar 1mm
b. Area 2. Scale bar 300µm
c. Area 3. Scale bar 70µm
d. Area 4. Scale bar 70µm
e. Area 5. Scale bar 200µm
f. Area 6. Scale bar 600µm

Plate 15. BSEM images of WTN17

a. Area 1. Scale bar 4mm
b. Area 2. Scale bar 1mm
c. Area 3. Scale bar 300µm
d. Area 4. Scale bar 100µm

Plate 16. BSEM images of WTN21

a. Area 1. Scale bar 400µm
b. Area 2. Scale bar 4mm
c. Area 3. Scale bar 100µm
d. Area 4. Scale bar 200µm

context	Sample	weight	Material	SHC prop	estimate
479	6 to 8	0.25	chip of lining slag		
	6 to 8		2 pieces of bone		
600	495	174	2 exploding pieces of corroded iron		
		26	not yet exploded iron object		
	496	14.5	shale bearing clinker		
		8.5	lining bleb		
	497	36.1	Coke		
	498	21	lining slag lump		
	499	9.6	dense flowed slag nub		
	500	13.3	lining slag bleb		
	501	13.3	Stone		
		43.8	tiny SHC-like piece 50x45x20, dimpled dense base. Black glassy lining-dominated top		
	502	16	indeterminate iron slag		
	503	910	SHC, broken slightly at proximal end, wide bowl with slightly raised lining slag patch at proximal end, (110)x130x50, base dimpled, top fairly smooth	97	938
	504	2.7	lining slag bleb		
	505	120	exploded slag fragment containing piece of iron		
		106	pro-tuyère tongue		
	506	8.2	Coke		
	507	11.3	shale-bearing clinker		
	508	142	14 pieces of lining slag - 3 of these are probably clinker		
		158	large vitrified stone		
		366	86 tiny pieces of indeterminate slag		
		388	8 larger pieces of iron slag		
		14	3 pieces of iron debris		
		40	possible piece of bog ore		
		186	basal part of porous SHC with lots of stone clasts		
		206	8 pieces of tuyère		
	509	4	Clinker		
		66	3 indeterminate iron slags		
		154	3 iron objects		
	510	1300	complicated compound SHC. Base gravelly, rough, top covered in a gravelly lining slag, 175x140x60	100	1300
		24	3 small pieces of mixed dense and lining slag		
	511	72	small piece of slag starting to explode		
		100	3 small exploding concretions		
		42	concretion exploded to show nail		
		402	dense slag exploded to reveal amorphous iron lump		
		200	possible bog ore lump		
	512	110	concretion - may have iron inside?		
		466	dense lump of iron slag, once contained iron, now exploded into many fragments		
		74	10 pieces of indeterminate fe-slag		
		0.9	coffee bean		
	535	7.5	Clinker		
		12.5	concretion around iron object		
		11.11	bog ore		
	539	1	dense hollow prill		
	540	1.9	dark glass prill - probably not iron slag		
	543	376	38 pieces of indeterminate iron slag		
		3.8	Nail		

context	Sample	weight	Material	SHC prop	estimate
600	543	48	3 pieces of lining-dominated iron slag		
		8	1 stone		
	544	50	small piece of exceptionally dense vesicular fe-slag		
	546	17.2	lining influenced iron slag nub		
	547	76	shale, burnt till vitrified on one end		
		776	44 pieces of indeterminate slag		
		1095	143 indeterminate iron slag fragments		
		36	2 pieces corroded iron		
		88	6 pieces of lining dominated slags		
		104	6 pieces of lining slag		
		388	large rounded pebble of possibly mineralised rock - but if anything looks like Mn mineralisation		
		24	2 stones		
		50	2 stones		
		8	?bog ore?		
		298	3 SHC fragments		
	548	1	burnt coal measures shale		
		20	concretion?		
		8	2 fragments of smithing floor		
		10	2 tiny indeterminate slags		
		76	3 corrosion balls around iron		
		24	bog ore fragment		
		66	pro-tuyère tongue with burnt bone on upper surface		
	549	48	dense iron slag nub		
	550	516	2 possibly burnt sandstone pieces		
	551	1.4	coke		
		322	22 pieces of iron-slag		
		5.6	lining slag		
	553	56	6 pieces of lining slag		
		8	2 stones		
		2	2 bog ore fragments		
	554	0.67	coke		
		656	68 small pieces of slag		
		2.8	iron-slag		
		7	2 pieces of iron		
		428	10 stones		
	1388	276	small SHC with dished blown top, very dense, now exploded, (80)x(80)x35 - probably about 25%???	25	1104
	2085	2.9	oxidised fired clay		
	2212	10.1	rounded crucible base with Cu alloy on inside		
	2501	1.8	2 coke pieces		
	2962	5.67	oxidised fired clay		
	3009	12.1	object?		
	3010	10.3	object?		
	3011	86	object?		
	3020	215	small exploding SHC 80x60x30	100	215
	3045	46	object?		
	3046	50	slag?		
	3063	9.6	indeterminate iron slag		
	3071	13.6	fe object?		
	3072	21.2	slag indeterminate - but very magnetic		
	3073	15.2	slag or object, very magnetic		

context	Sample	weight	material	SHC prop	estimate
600	3077	58	dense slag with exploding iron lump		
	3087	27.3	tuyère		
	3088	29.8	tuyère		
	3090	4.12	oxidised fired clay		
	3191	34	object?		
	3597	26	irregular bleb of dense slag		
	3818	56	concretion around iron object? Might be very dense slag		
	4034	6.55	coal		
	4039	4.2	highly slagged crucible sherd		
	4057	4.28	thick crucible sherd		
	4110	288	burr part of large irregular SHC		
	4164	0.58	sherd of pot or probably crucible		
	4165	1.1	fired clay		
	4173	15	vitrified lining / tuyère		
	4210	1.61	vitrified lining - probably not crucible		
	4214	1.8	lightly vitrified clay - hearth/tuyère?		
	4232	3.6	vitrified lining - probably tuyère		
	4370	682	SHC with some edges knocked off, very dense, 120x(100)x50	70	974
	4479	3	oxidised fired clay		
	4480	8.4	clinker		
	4531	2.3	half reduced half oxidised fired clay		
	4541	21.5	fired clay		
	4552	3.6	fired clay		
	4574	7.4	glazed pebble/lining slag		
	4718	128	c80% of tiny SHC? 65x75x25	80	160
	3155to3157	26.6	3 pieces of coal		
	3309&3310	96	2 pieces of indeterminate dense iron slag		
	4144 to 4146	1.85	possible crucible sherd		
	4144 to 4146	6.5	deeply vitrified pale ceramic		
	4144 to 4146	4.5	coarse vitrified ceramic		
	4505 & 4506	4.3	fired clay		
	4529, 4530	11.2	fired clay		
	4559 to 4564	94	6 pieces of fired clay		
	4601 to 4605	27.61	5 pieces of burnt / fired clay		
	f4225	0.66	slag fragment		
	f4253	6.16	crucible base		
	f4517	4.29	lining slag		
	f4709	1.3	thin rounded crucible		
757	1,2,3	58	three small slag fragments, one dense, other two lining influence - of which one my be slag from a tuyère tip		
	4,5	2.5	rust		
	4,5	4	lining slag		
	4,5	7	slagged lining or tuyère		
798	2	5.5	charcoal rich slag embedded in bright red fired clay		
	4	17.4	rounded flown slag bleb, quite dense		
	8	3.8	bleb of lining slag		
821	1,2,3	6	3 small pieces of lining rich slag		
885	1	1.35	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
	2	1.65	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
	3	1.16	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
	4	1.52	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		

context	Sample	weight	material	SHC prop	estimate
885	5	1.43	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
	6	0.27	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
	7	3.8	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
	8	0.38	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
	9	0.25	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
	10	0.41	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
	11	0.44	crucible - rounded, thin, small, greenish clear external glaze, internal dark deposit		
887	6	0.52	2 pieces of thin crucible rim		
	9	3.32	small piece of vitrified lining		
	10	9.01	well flown maroon slag with some sediment inclusions - might just be clinker		
	11	148	small piece from large thin crust cake		
920	1	2.32	nail		
941	1,2,3	11.2	fragmented corroded iron objects		
999	1	6	flown bleb		
1040	1	1.02	stone		
1083	1	5.06	cupel, low disk like form, reduced to slightly oxidised on base, upper surface dark		
1083	2	0.3	broken hollow slag sphere		
1111	6,7	322	broken contorted piece of thin crust slag, highly deformed on extraction		
1214	7	6	rusted lining influenced slag bleb flowing around small charcoal pieces		
	12	40	small pro tuyère tongue - lining on top rusty below		
1233	12	5.5	8 pieces of irregular slag blebs		
	12	0.08	hollow sphere		
1407	none	3.8	small scrap - probably corroded iron rather than slag		
1464	1,2	116	2 small SHC fragments		
1468	1	84	iron slag lump - charcoal rich		
1488	3	9.2	concretion		
	4	22	lining slag lump		
1499	2,3,4	34	indeterminate iron slags		
	2,3,4	2	stone		
1510	163	9	iron object		
1511	9	376	very dense conventional SHC, 110x75x35	100	376
	10	750	slightly incomplete SHC with a curiously polygonal shape. 145x(95)x45. Slightly dished top with adhering charcoal rich material, bowl, coarse grained thick crust, base gravelly	80	938
	5,6,7,8	232	4 fragments, all probably from very small SHCs		
1999	5	28.8	5 pieces of fired clay, one with dense slag attached - probable tuyère material		
	14	3.18	vitrified lining/tuyère		
	473	96	14 indeterminate slag fragments		
		26	4 lining slag fragments		
2003	545	30.5	indeterminate iron slag		
2006	233	36	5 pieces of lining slag (1 might be clinker)		
		2	bog ore		
	542	14.5	glazed pebble		
		11.8	indeterminate iron slag		
2007	465	2.46	base of crucible		
		42	8 small scraps of iron-slag		
		18	2 concretions around possible nails		
		254	33 other lining slag fragments		
		12	stone		
		276	3 dense SHC fragments		
		106	probable pro-tuyère tongue,		

context	Sample	weight	material	SHC *prop*	*estimate*
2007	465	52	probable pro-tuyère tongue,		
		50	probable pro-tuyère tongue,		
		78	probable pro-tuyère tongue,		
		32	7 fragments of glazed\lining or tuyère		
2019	474	12	blebby piece of iron slag		
2034	469	52	3 indeterminate slag pieces		
		12	2 nails		
		24	Mn coated pebble		
		84	3 pieces of vitrified lining or tuyère		
2036	472	22	Fe object		
2067	475	242	5 pieces of indeterminate iron slag		
		968	well formed SHC, with elliptical bowl and purple bloomed lining slag raised up on one end, overall 140x115x60 of which bowl 35	100	968
		350	distal 30%? of cake as above, fairly thick crust internally with 25mm thickness	30	1167
2095	466	388	9 pieces of misc. slag.		
		640	compact dense SHC with odd shape - deepest part at one end. Flat to very slightly dished top in charcoal-rich but very fine slag, 100mm in diameter, deepest point lies 50mm below one end of this, the cake then extends out 30mm beyond deepest point to give 110 length. base smooth	100	640
		252	irregular mass of slag, charcoal rich, probably very irregular SHC, but very different from others in this context. Base has adhering fired clay, 120x65x40		
		350	small slightly corroded SHC in charcoal bearing vesicular slag. 100x70x35. Base with some prilly extensions around charcoal moulds distally, rough charcoally proximally	100	350
		230	rather like miniature version of 640g cake above. 65x80x40, top 60x70 flat neat subcircular, base with charcoal impressions	100	230
		210	central part of small dense conventional SHC - edges missing all the way round	85%	247
		40	2 pieces of vitrified lining - one certainly tuyère		
2096	467	10	crucible sherd		
		64	small slag mass - just possibly a miniature version of 198g cake above		
		1290	12 pieces of dense worn slag - presumably all SHC material but form not certain. All vesicular		
		20	5 pieces slag debris		
		376	10 worn indeterminate slag pieces		
		1	lining slag bleb		
		198	small irregular charcoal rich low density SHC, 90x70x45 almost perfectly biconvex	95	95
		362	rather wide flat SHC broken in 2. Top very vesicular including large ones at one (proximal?) end, base rough 110x90x25	100	362
		398	probably the major part of a wide flat charcoal rich SHC, but form not certain		
		1475	rather worn slag mass forming part of a very large wide shallow cake. Original cake probably has bowl c65 deep and about 230mm across, with c 25mm upstanding lumps, surviving piece is 150x130x90. Slag quite dense, conventional, uniformly coarsely vesicular to base	c35?	4214
		142	lining slag tongue - extremely gravelly with larger quartz grains than seen in tuyère		
		364	slab with base of tuyère attached to pro-tuyère tongue. tuyère has low curvature across base and may curve in other direction too. Base of b/h only 45mm above base, appears to be c 27mm diameter. Tongue extends 75 and curves up in front of b/h - probably bent during extract. upper smooth lining-dominated layer overlies more iron-rich prills.		
		86	slab of vitrified tuyère face, probably about 120 mm diameter		
		18	2 small vitrified lining / tuyère fragments		
		76	3 pieces of vitrified tuyère		
2100	437	7.7	3 small pieces of indeterminate slag/concretion		
		32	fired clay lump with gravel grade quartz inclusions		
2102	438	50	indeterminate iron slag piece		
		140	piece from small very dense puddle type SHC. Top smooth, but may be interior of large vesicles. Crust to about 22mm	?	
2104	439	10	charcoal dominated slag lump		
2105	440	290	concretionary rusted lump		
		20	indeterminate iron slag		
		34	gravelly lining rich irregular lump		

context	Sample	weight	material	SHC *prop*	*estimate*
2131	441	46	fine charcoal dominated slag attached to sintered sediment		
		30	small blebby slab of lining-dominated material		
2151	442	76	5 pieces of lining-dominated slag, variable colour glass, with superficial purple tint		
2154	443	22	corroded nail		
		6	lining-dominated slag bleb		
		144	5 worn pieces of slag - at least three from dense SHCs		
2165	385	3.48	lining slag with maroonish colour - possibly pale internally		
2165	445	10	3 pieces of concretionary material		
		6	small glazed pebble		
		128	9 pieces of dense prilly slag flowing between charcoal moulds		
		46	14 indeterminate small pieces of generally rather low density slag		
		14	4 pieces of lining slag		
		4	tiny chip of rock from mineral vein with acicular quartz growing into vein with tips overgrown by botryoidal iron oxides. All very small scale, not obvious if this could be an ore		
2166	446	264	24 small pieces of undiagnostic slag, or very small SHC pieces		
		24	corroded iron object		
2168	447	20	corroded iron sheet		
		4	low density slag bleb		
		82	part of small SHC with fluid top with blebs of slag sticking up between deeply impressed charcoal	?	
		16	tuyère sherd		
2170	1	2.82	round-bottomed crucible sherd		
2170	3	11.09	probable tuyère shaft		
2170	448	472	6 concreted pieces, probably cored on slag		
		758	small bits of indeterminate slag and debris c80 pieces		
		484	11 larger pieces of indeterminate slag, probably mainly SHC fragments		
		106	10 pieces of dense slag in prills and blebs with small charcoal moulds		
		26	lining slag ball		
		834	small SHC, but very well formed just like the larger one. Has lower bowl, 130x95x30 overlain and filled by more charcoal rich material then has lining influenced slab (broken?) at top. Overall 65 thick. Top burger slab 85 wide.	100	834
		382	another smaller piece from same type of cake. Large vesicles have an imbricate structure and apparently a smooth blown top. Away from these top is raised much higher in rough piles of material. Base smoothly dimpled		
		84	fine debris, mainly from thin crust material		
		354	irregular dense slag lump. SHC material, possibly one cake compacted during extraction, possibly only a part		
		188	4 dense slag pieces from crusts of SHCs or similar		
		122	90x60 thin slabby tongue of slag with variable pale - purple top, smooth top rough rusty base		
		210	9 pieces of lining-dominated slag, mostly rather blebby textures suggesting these are pro-tuyère tongue fragments		
		120	3 pieces of tuyère , two joining. Not particularly helpful for size - may have low curvature edge.		
		324	15 pieces of vitrified lining/tuyère		
2171	1	4.51	round-bottomed crucible sherd		
2171	4	2.5	cu alloy dross? (put in with crucible material)		
2171	5	56	tuyère		
2171	332	9.62	4 pieces of dense flown slags		
2171	419	0.47	burnt bone chip with slaggy droplet attached		
		2	lining slag		
2171	515	468	highly accretionary piece- probably conceals small SHC		
		156	8 pieces of dense shiny metallic well flowed slag in sheets		
		45	5 pieces of dense metallic slag in prills and blebs		
		296	part of a coarsely prilly mass, appears to be originally 100x100x50, but not clear what it is		
		3680	c100 pieces of indeterminate iron slag		
		610	35 pieces of dense metallic slags as charcoal moulds etc		

context	Sample	weight	material	SHC *prop*	*estimate*
2171	515	21	5 nails		
		580	21 pieces of lining-dominated slags - probably mainly from tongues		
		1300	block of granite		
		738	SHC, 120x115x65. Base microprilly, cavernous, distally digitate, top has charcoal moulds but coated in organic rich concretion	100	738
		420	SHC, 110x100x45, base rough with fine charcoal, top very irregular	85?	494
		366	SHC, 110x100x45, base and top both coated in fine organics,	100	366
		218	elongate SHC, bowl 100x60x25 with raised lump 20 high at one end. Base and top seem quite rough	100	218
		362	small burger style cake sitting on top of prilly mass. Burger 70x80x20, whole piece 110x80x50	100?	362
		972	classic SHC, gently concavo-convex bowl filled distally with charcoal material, proximally open and smooth. Base rough and deepest at proximal end where becomes a little microprilly. 160x130x45	100	972
		822	classic SHC, flat top with small blown hollow, suggesting cake may be transverse. Small pile of slag blebs to one side of the hollow. Base microprilly, with slightly large prills below hollow. 140x110x55 (of which bowl is 45)	100	822
		444	part (or all if one side is simply squashed in) of SHC with open bowl with smooth top, has separate blebby slag collapse onto it at one end - possibly originally a higher pro tuyère piece. Base mainly rather smooth 100x (95)x70	100	444
		266	extremely dense slag cube - probably broken from a burr, but may be from an extremely thick crust cake		
		280	dense arcuate piece of slag - might be burr or a section of a very thick crust cake		
		160	part of small SHC, probably originally about 90x70x35, conventional	40?	400
		138	very rusty small semi-circular mass- probably half of a very dense small SHC but not certain		
		174	basal part of a fairly thin crust cake - but not clear what original size was		
		1445	12 pieces of densish slags from SHCs		
		168	small pro-tuyère tongue in two lobes, upper lining rich, lower more iron rich and slightly more distal		
		84	small pro-tuyère tongue fragment, has particles stuck to upper surface		
		1380	18 pieces of tuyère . Shape mainly unclear but flattish base on at least two		
2172	514	746	9 pieces of smithy floor, forming irregular ridges, possibly as replacement of wood or infill between wood (similar material also in 513)		
		300	nine pieces of dense prilly slags, well flown		
		38	lining-dominated slag, possibly from tuyère tip		
		5200	230x190x100. Very large SHC. Crudely concentrically structured top with slab of lining-dominated material in centre, bearing stone/lining fragments. Lower surface fairly even although rough, with faulted line across centre.	100	5200
		1025	SHC with dish top. 130x160x50 (also has stone stuck to base). Has slight flowage from lip on one side. Top obscure. Base charcoal rich	100	1025
		832	neat, flat topped SHC, with prilly flowage from base 140x100x40 bowl + 25 prills	100	832
		1620	proximal side of large cake with lots of flowage in blown area. Basal part more charcoal rich. Not clear how much is missing, this could be from a very big cake. Top with pillulous lobes and charcoal impressions plus areas without flow just charcoal rich		
		1230	130x110x60 SHC with dense lower and upper layers with more charcoal rich material in between. Base seems rough, top largely obscured by debris in hollow	100	1230
		576	SHC of similar size to many of the others but with main section hollow down to a thin crust. 145x120x55, hollow 70x80x35deep	100	576
		1055	pro-tuyère tongue and tip of tuyère . Has curious lobe of extremely dense slag below in the form of a rounded lobe, almost a biconvex SHC	100	1055
		1220	part of an elongate SHC with some concretion attached (160)x120x85. Basal crust seems quite dense and has prilly base. Top obscured by concretion	60?	2033
		2295	large flat-topped SHC with slightly raised centre and upturned section on one margin - not clear if this is proximal or distal, but may simply be deformed on extraction. It is ignored from measurement 210x160x85 (of which bowl is 70)	100	2295
		2040	slightly irregular SHC with a charcoal rich prilly texture throughout 180x180x110	90	2267
		990	small SHC with deep bowl shape. Has prilly leakage on proximal side, which terminates in well-flown material apparently in contact with a wall dipping at 60 degrees below the cake. Bowl 130x105x80 with hollow 30 deep. whole block 145x115x90	100	990
		1125	elongate cake probably comprising two separate cakes with lateral displacement. 180x110x70. Bases rough, upper cake seems to have smooth top below accretionary material	100	1125
		832	small flat topped SHC with some accretion including stone stuck to top. 130x130x40 . Details obscured	100	832
		396	small dense SHC - or just possibly part of a larger one (75)x(115)x(35)	90?	440
		850	hollow topped SHC 130x140x45base rough, locally charcoal rich. Top smooth especially in hollow. Crust 10-20 thick, thickening proximally, fairly vesicular, conventional looking material, no great internal differentiation	100	850
		716	highly accreted slab - presumably all or part of a standard SHC is enclosed		

context	Sample	weight	material	SHC prop	estimate
2172	514	454	irregular rather worn piece probably representing most of a small SHC. Lots of adhering organics etc		
		2350	slag debris and indeterminate pieces, or pieces not specifically identifiable although generally of SHC origin		
		402	part of a small conventional thick crust dense SHC. Top dished, smooth with lip showing signs of flowage. Base fairly smooth and even. Probably just over half of the cake but difficult to be certain 120x(70)x40, crust 20 fairly uniform	60	670
		348	rubbly block from charcoal rich SHC		
		296	small piece from part of a large thick crust cake. This is the only true piece here. It has several generations of elongate olivines. Slag steely grey with a lustre like galena. Upper couple of millimetres is a sand-rich glass		
		424	2 pieces of SHC with an almost thick crust quality - but more conventional		
		146	tiny dense SHC, has deeply charcoal impressed top and prilly base85x60x35	100	146
		68	possible tiny spoon shaped SHC, 70x50x20. Could be part of something larger	100?	68
		458	4 assorted dense SHC fragments		
		162	lining rich tongue, smooth top with some rusty charcoal rich material centrally		
		154	typical tongue, lining rich, smooth top and lobate base		
		106	mass of moderately dense tongue material - in spheroids and dominated by lining		
		124	low density tongue material, charcoal rich base		
		110	low density tongue material, charcoal rich base		
		74	slag tongue - lining-dominated		
		122	slightly unusual deep tongue - possibly folded. Has purple sheen to top and prilly base		
		72	small blebby tongue		
		68	tongue fragment		
		234	a strange lining-dominated SHC rather than a tongue? (100)x(70)x40. Highly vesicular. Looks like tuyère tip slag, but has bowl shaped back/base with some rusty material attached		
		1060	20 pieces of tuyère		
2173	381	64	6 pieces of lining influenced iron slag		
2173	449	90	concretionary material around animal jaw		
		1176	c150 small slag pieces		
		860	double layer SHC, with upper not above lower component, 130x120x70 overall. All rather charcoal rich	100	860
		124	slag tongue, upper layer of lining rich material, lower material iron rich, some slight explosion suggesting iron present		
		210	4 pieces of vitrified lining- 1 from a 120mm diameter tuyère , others not certainly tuyère		
2173	541	1	indeterminate slag piece		
		12	dense thin sub-tuyère slag flow, or flown smelting slag		
2180	450	17	various indeterminate slag fragments		
		42	two pieces of vitrified lining, not clearly tuyère		
		1160	double layer conventional SHC. Overall 150x110x70, each of two components more like 120x100x40, but offset centres, base concreted but seems rather prilly, top covered in fine charcoal rich material	100	1160
		242	piece from small irregular very dense SHC, top blown smooth with purple sheen, but very "lump", probably a single cooling unit, rather brecciated on extraction		
		90	slab of tongue with smooth top surface, grey, with patches of black glass. This top layer has a lot of glass internally and is about 8mm thick. It rests on top of material mainly comprising vertical prills of slag, weathering khaki		
		66	blebby mass of coarse gravelly lining slag with purple bloom on surface, probably a pro-tuyère mass, top appears blown		
2181	487	6	small concretion - possibly iron inside?		
		102	2 charcoal rich fragments, probably from SHCs, one quite coarse grained		
2182	451	36.5	vitrified tuyère face		
2188	1	39.55	rounded bottom crucible, elliptical in plan, well used with colourful external glaze		
		2	approx quantity of crucible contents		
		1	crucible deposit		
2188	2	4.25	round bottomed crucible base		
2188	452	480	5 pieces of broken SHC or other charcoal-rich material		
		128	strange block - prilly one end and yellow accretionary the other - probably a cake fragment but my be a pro-tuyère piece		
		6	slagged lining, broken from above?		

context	Sample	weight	material	SHC prop	estimate
2188	452	32	probable slagged tuyère piece		
2191	463	3.5	charcoal in concretion - probably not slag		
2200	453	260	9 varied pieces of charcoal and/or lining rich smithing slags		
		450	slab of curved crust - probably around half an SHC cut on extraction - but details not clear		
		220	top part of a charcoal rich cake with slab of lining material, presumably just the top layer from a large structure		
		176	fragment from a small but rather thick crust type of cake, crust only to 20mm, but very dense		
		362	piece of large tuyère		
2201	325	0.88	double slag bleb - like cottage loaf		
2201	454	48	2 rather weathered fragments of probable SHC material		
2203	527	148	156 small pieces of indeterminate iron slag - at least two possibly from smelting?		
		6	2 pieces of iron - one conjoins with piece in sample 523		
		22	5 pieces of lining slag		
		30	stone		
		42	piece of bog ore like material		
		248	probably most of small SHC, proportion not strictly determinable		
2204	455	14	dense slag indeterminate		
		6	lining slag bleb		
		550	slightly incomplete SHC, 75%, slightly double structured with dense top and base but soft lenticular material between.125x(90)x55	75	733
		48	5 fragments of possible tuyère		
2205	456	74	2 pieces of indeterminate iron-slag		
		144	lining rich, possible pro-tuyère cake - but quite dense for one of those, very strange looking piece		
		6	highly glazed lining		
2210	457	400	24 pieces of indeterminate iron slags		
		32	4 lining fragments		
		370	fragment of small thick crust SHC, crust to 35 thick, probably around 25%, originally 140 diameter, charcoal and possibly raised lobes on top	25	1480
		998	slightly odd cake with conical basal part and elevated upper smooth topped burger. Probably complete. 110x110x90	100	998
		422	probable SHC fragment with deeply prilly base		
		282	crust with slightly lobate top		
		924	elongate SHC, 160x105x40, smooth top with accreted organics, base roughly dimpled, top slightly hollowed at one end	100	924
		1665	c60%? of deep dense SHC. 170x(100)x95, all rather rusty and surfaces not clear	60	2775
		380	3 fragments of small conventional SHCs		
		194	low density pro-tuyère slag mass		
		160	4 large pieces of lining dominated material (pro-tuyère?)		
2225	458	13.4	many pieces of iron-corrosion, 1 possible nail, small fragment of copper corrosion. Not slag		
2244	459	88	part of cake of gravelly lining rich material		
		474	small dense SHC of conventional bun form, 105x90x40, base abraded, top charcoal scatter on hard surface, internally vesicular	100	474
		350	9 pieces, probably all from SHCs		
2246	460	136	broken small highly vesicular SHC - not possible to identify proportion		
2247	461	38	4 amorphous pieces of lining slag		
2248	3	1.9	glazed pebble		
2279	462	102	charcoal rich slag piece broken into 4		
2291	333	8	2 pieces of thin narrow iron strip/blade		
2297	1	30	8 crucible sherds-probably a single round bottomed form with copper alloy evidence		
	6	67	15 crucible sherds, mainly large round bottomed forms (as complete one?), plus a Dunnyneill type cupel		
	8	26	8 crucible sherds, mainly round bottomed		
	341	7	5 small bleb fragments of iron slag		
		6.3	two fragments of glazed ceramic with reddish glaze suggestive of copper oxides		
		56	small fragment from thin crust SHC		
		22	slagged lining/tuyère		

context	Sample	weight	material	SHC prop	estimate
2297	513	4210	21 concretionary masses, most probably slag-cored		
		356	accretionary lump - dense slag core		
		860	smithing floor material with moulds of ?timbers		
		460	16 pieces of dense flowed slags in lobes and sheets		
		38	4 small pieces of dense well flown slag		
		168	5 pieces of probable flow lobes in ashy matrix		
		104	9 dense flow lobes in ashy matrix - may be smelting slags		
		1145	10 slag pieces not certainly SHC		
		666	25 small pieces of slag		
		5675	small slag debris- many hundred pieces		
		296	2 pieces of charcoal rich slag, probably from SHC with attached lining rich slags		
		3195	sub 5cm slag material, either indeterminate or not separated		
		274	chunk of a slag cake made of dense microprills in open texture		
		1265	27 pieces of indeterminate iron slag		
		852	c110 small pieces of indeterminate slag		
		98	17 small indeterminate slag pieces		
		4045	22 lumps of slag with substantial pale accretion such that original slag not determinable		
		718	6 pieces of homogeneous granular dense SHCs, very weathered with onion-skin weathering developing		
		6840	indeterminate slag fragments in several hundred small pieces		
		238	indeterminate slag fragments		
		4	nail shank		
		282	accretionary lump - starting to explode so may have iron inside		
		160	lining-dominated lobe - not clear if pro-tuyère or from top of large SHC		
		76	lining-dominated slag - possibly a tiny SHC		
		810	17 pieces of lining dominated slag - some probable pro-tuyère tongues, others from SHCs		
		290	coarse sandstone - may possibly be quern fragment		
		22	2 stones		
		1255	SHC, flat top with central hollow, 155x130x80	100	1255
		1055	SHC with concretionary overgrowth therefore details uncertain	110?	959
		662	SHC with flat top overlain by pile of blebby slags, either dripped from tuyère or squeezed on extraction, transverse, 80x120x50+40 pile of blebs	100	662
		1740	SHC with lower bowl and upper burger shaped slab, bowl 130x140x50 total height 95, burger 90x80x25.	100	1740
		1070	most of very irregular thin crust type of cake 180x110x80	90?	1189
		330	100x80x55, deep small SHC	100	330
		760	slightly double layer SHC 110x90x55	100	760
		2100	double layer cake with basal bowl supporting upper layer with flat top, overall 125x140x85 of which bowl is 60, top burger 90x75, bowl seems fairly thick crust	95	2211
		1430	deep thick crust bowl with flat top of charcoal-rich material, (100)x140x75, crust to 50 centrally	85?	1682
		510	rather irregular small SHC, 100x110x50	100	510
		154	tiny SHC, 60x70x30	100	154
		250	small SHC with smooth base and lobate top. Internally rather gravelly, (70)x80x45	75	333
		428	small SHC with scalloped lobate edges (90)x90x35	95	451
		236	small SHC with flat top, lobate with smooth deeply impressed charcoal moulds, 90x70x30	100	236
		242	small SHC with internal v coarse sugary texture, (50)x90x440, may just be part of something larger	65	372
		210	small part of SHC with smooth blown, slightly flown top (unusual!). Crust 23 with prominent tubular vesicles, flown layer distinct, lenticular in hollowed top, piece 80x60x40 proportion unknown		
		928	large slice through cake with fairly thick crust bowl overlain by more charcoal-rich material	??40	2320
		2650	10 substantial SHC pieces		
		1580	10 SHC pieces		
		2060	10 SHC pieces		

context	Sample	weight	material	SHC prop	estimate
2297	513	338	probably an irregular small SHC, 105x70x40	100	338
		686	irregular mass of charcoal rich slag - may be SHC, 110x90x70	100	686
		732	concreted SHC, 115x95x50, very dense	100	732
		490	probably a concreted SHC, flat top, 130x125x40, very low density	100	490
		446	3 SHC fragments with lining rich tops		
		760	8 pieces of variably dense lining rich ?SHC with a curious texture of interlocking spheroids		
		3985	240x180x130, large SHC. Base rough distally, microprilly centrally and prilly beneath proximal end. Proximal lip shows some flow. Bowl 70 deep. Top fairly flat in 90 from proximal end, then vertical rise to top. This edge is very sharp and may be a tool cut?. mounded material on top of bowl all very charcoal rich	100	3985
		846	segment (maybe 1/5) of large SHC. Has moderate crust probably (rather obscure) with internal quite dense slags as prills between charcoal moulds.	20	4230
		914	segment of large SHC with smooth blown interior to bowl. Crust only15 thick in bowl up to 80 deep. Piece is probably very deformed on extraction so original dimensions not certain		
		1605	bowl shaped SHC 180x150x70 base obscured by lots of accreted organics, bowl hollow c27 deep.	100	1605
		2185	dense SHC, biconvex, possibly with one edge missing 155x(150)x100 of which 80 is dense bowl	90	2428
		6310	large SHC, almost plano-convex just very slightly mounded top. All coated in fine organics, so no details really visible	100	6310
		1115	odd SHC with slag puddle on top at proximal end, base correspondingly shows multiple prills near proximal end and microprills elsewhere. 140x150x75. A very unusual piece	100	1115
		378	slab of thin crust material coated in fine organics, nature uncertain		
		766	very dense SHC of extremely irregular shape, 155x110x65 of which bowl 35, very elongate, may be two small cakes with lateral displacement	100	766
		302	irregular piece - possibly small SHC with smooth flowed top almost rolled up on extraction	?100	302
		852	v odd SHC in which one end is smooth raised lobe of slag with hollow interior suggesting drainage. Base prilly. 2/3 of top covered by this odd raised lobe, other 1/3 is smooth with deep charcoal dimples, covered in fine organics. 140x100x110 of which bowl 70	100	852
		420	small SHC, 125x105x30, very shallow, top with smooth charcoal impressions, base microprilly	100	420
		392	slab from a shallow SHC, cant be more than 60%	60?	653
		334	very different sort of SHC, small and very dense. Has some gravelly lining blebs around edge of top, purplish surface, microprilly base, a bit rusty.c60%?	60	557
		286	slab of thin crust shallow cake similar to 392 item above		
		332	small dense SHC with raised blebs of lining slag on top, . 80x80x70 of which 35 bowl	100	332
		366	small neat conventional SHC 90x95x30 slightly dished top, smooth with charcoal impressions, base obscured by accreted organics	100	366
		160	probably most of thin low density SHC, 90x60x30 smoothish top, microprilly base		
		1065	7 pieces of dense SHC with smooth maroon tops, no cake sizes indicated, maximum crust is 17mm		
		5680	complete SHC, has several small chisel like tool marks on upper face, seems base may have been hammered. 235x210x110. Top charcoal-rich slightly rusty, small central patch of lining slag dented by one of the toolmarks. Proximal side shows gravelly surface to bowl, extending out about 100mm at half height. central part of base flat with dark shiny slag - either hammered or this may be a stone contact. distal part of bowl is charcoal covered.	100	5680
		664	v badly deformed SHC torn on extraction. May be all of it but not entirely certain. Top hollowed with raised blebs, base charcoal rich, v deformed so figs after deformation 170x100x60	100	664
		244	base of a large SHC with perfectly planar surface in shiny dense slag. Compares with 5680g example above - from same hearth?		
		446	chink of thin crust cake with lots of accreted organics		
		398	slab of thin crust from a large cake, partly microdimpled, cracked, with some flowage		
		1075	probably around 30% of a deep dense cake. (120)x(90)x90. Dense part up to 60 thick, but not typical thick crust, has finely granular olivine with small rounded vesicles abundant throughout	30	3583
		648	small section of very large cake. Cake uniformly microprilly, but has some denser lobes on top, cake 90 thick		
		424	double layer SHC with 2 small cakes, each 70-80 diameter x20thick, with large displacement between	100	424
		542	6 small SHC fragments		
		3710	thin crust SHC, very symmetrical , 195x195x100 of which bowl 70	100	3710
		734	broad SHC with raised slag lobes on upper surface, base fairly smooth, 130x(160)x55	60	1223

context	Sample	weight	material	SHC prop	estimate
2297	513	656	complex SHC with raised upper thick crust type bowl with blown top, sitting on top of more porous material, dimensions of original unknown, very deformed on extraction		
		756	oval conventional SHC, with additional slag to one side, all obscured by organics accretion	100	756
		1705	11 SHC fragments		
		800	substantial chunk of an originally very large thick crust SHC, 90 deep (crust 50) radius 100?		
		794	SHC with charcoal rich slag adhering to base, cake 100x75x30 all 120x110x80	100	794
		268	small SHC with accreted material to side110x70x35	100	268
		446	dense piece of well-flowed slag. Like tap slag with dimpled lower face, but top shows hints of contact with overlying ?wood		
		92	dense shiny crust, with charcoal impressions on one side - probable smelting slag?		
		256	tongue of slag (pro-tuyère tongue or SHC?) with lining rich top and rusty charcoal-rich base		
		264	similar item to above, but slightly more gravelly on top110x90x35		
		244	3 pieces of vitreous to purple low density slag probably pro-tuyère tongues		
		86	pro tuyère tongue - small with lumps of stone on top		
		242	slag tongue from pro-tuyère area. Has lining rich top overlying some rather dense inclined slag prills		
		948	24 pieces of lobate lining slag probably derived from tongues		
		172	3 pieces of slag tongue		
		406	curious tongue of well flown dense slag, in ashy matrix, with lining debris accumulated on upper face		
		132	smaller version of 406 piece - again, has well flow lobe in ash, with one edge bent abruptly upwards		
		166	pro-tuyère tongue		
		450	8 fragments of similar tongues		
		52	pro-tuyère tongue fragment		
		208	very platy form of pro-tuyère tongue		
		440	4 pro-tuyère tongue fragments		
		606	13 pro-tuyère tongue or other lining slag fragments		
		1235	11 pieces of tuyère , shape unclear, one seems 140x180, another seems slightly small, both possibly slightly angular, largest piece has finger hole in side		
		142	low density pro tuyère purple low density slag, which has tracked back up lower side of tuyère		
		62	2 pieces of slagged tuyère side		
		54	dense well flown slag with one planar side - possibly a sub-tuyère slag		
		232	7 pieces of vitrified ceramic, probably tuyère associated		
		490	9 pieces of tuyère - one shows very large radius		
		200	highly slagged tuyère tip		
		52	fragment of tuyère tip with slag		
		446	12 tuyère fragments		
		42	tuyère fragment		
2299	464	30	concretion around possible iron		
		86	corroding iron		
		434	80%? of small SHC, very dense shallow bowl with slab of lining material on top, (85)x(85)x50	80	543
2317	476	24	concretion		
		46	indeterminate iron-slag		
2318	477	556	stone		
		448	small SHC, very rusty with concreted gravel. 100x80x40	100	448
		70	tuyère fragment		
2320	352	60	4 pieces of tap slag like material. Largest one has lobes closely associated with/penetrating fired clay		
2350	350	2.33	9 spheroids/coffee beans		
		22.27	19 pieces of rough or blebby slags (a continuum)		
2353	516	1430	smaller and indeterminate slag pieces, mainly SHC fragments and charcoal rich material		
		522	worn and weathered mass of charcoal rich slag		
		78	just possibly a tiny SHC. 45x70x35, dished slag sheet with slightly prilly base	100%	78
		238	small conventional SHC with a fairly dense crust, probably mainly complete? 90x(60)x30	95?	251

context	Sample	weight	material	SHC prop	estimate
2353	516	500	weathered thin crust cake. Charcoal rich bowl fill, top probably missing 120x100x55 of which bowl 40	100	500
		1330	slightly incomplete thin crust SHC with well developed concentric rings. 160x(115)x100. Largely coated in organics but base is slightly prilly proximally, elsewhere just charcoal rich	100	1330
		910	dense compact SHC, slightly biconvex. Top has raised lumps - though details obscured 130x120x60 of which bowl 50. Some slightly lobed margins. Base prilly to microprilly	100	910
		276	dense fragment of large burr. Has curious horizontal line on rear - does this indicate base of tuyère ??		
		434	charcoal rich SHC, slightly biconvex. 110x80x55 of which bowl 35	100	434
		3610	large charcoal-rich thin crust type cake - well no real crust at all. 240x220x130 of which bowl 100. 1 end is raised up in spike - otherwise top is planar.	100	3610
		290	rather weathered burger type cake sitting on inclined cone of charcoal rich slag. 100x75x60, burger part 75x75x10 at one end of top	100	290
		184	small possible SHC. Flat circular top 50 diameter on prilly spiky mass. Total 75x55x40	100	184
		142	small irregular mass, might just be small SHC, 65x80x40		
		280	slag tongue attached to tuyère tip. Smooth lining rich top, dense prilly base		
		164	3 pieces of lining-dominated slags probably from tongues		
		414	irregular tongue of lining slag on iron rich base. Base has corroded onto accretionary material with burnt bone chips		
		102	lining slag tongue		
		322	tuyère tip attached to tongue, which seems to lie directly on charcoal rich slag. Layered, dipping into SHC. This is a fresh break		
		1850	61 sherds of tuyère		
2355	480	244	5 fragments of charcoal-bearing slag		
		574	9 pieces of vesicular and charcoal-bearing slag, mostly in the form of a basal crust. These are really not determinable to smelting/smithing		
		636	30 pieces of charcoal bearing iron slag, some rich in lining material, probably all smithing debris		
		24	6 pieces of slagged ceramic		
		2725	SHC with curious stepped profile on the proximal side - suggests large stone placed across hearth on this side? 160x175x90. Top dished, fairly smooth some adhering charcoal. Concretion on proximal side probably not slag - so not included in dimensions, base smoothish (but accreted proximally) and probably charcoal -rich distally	100	2725
		544	possibly complete, but very irregular SHC, very charcoal rich, with thick ashy charcoal layer on top, sides and base somewhat microprilly. 110x75x60	100	544
		240	charcoal rich but dense block of slag - probably just less than half of an SHC		
		40	oxidised fired fragment of smallish tuyère		
2356	350	4.54	13 irregular blebby slags		
		3.23	39 spheroids		
2356	483	102	15 small fragments of charcoal rich slags, some with lining dominated lobes, some sintery. Resembles basal smelting material but probably broken and poorly consolidated smithing material, in view of the open nature of the above SHC		
		402	possibly complete SHC. Has thin crust bowl filled with voids, charcoal and raised slag lobes on top. 110x120x40. Because so porous, difficult to determine if complete	100	402
		174	lobate lining slag - presumably a pro-tuyère mass. Very slightly rusty prilly base - all low density		
2357	358	2.65	4 irregular pieces of thin slag sheet		
		20.7	11 irregular blebby pieces of slag		
		0.16	1 hollow coffee bean		
2359	479	26	8 pieces of sinter or concretion?		
		2	2 small burnt stones		
		58	7 pieces of rough flowed material - some quite filmy, not good prills but probably basal smelting slag		
2364	481	80	5 pieces of vesicular and charcoal-bearing slag - presumably smithing debris		
2365	21	3.67	rounded crucible base, very slight red glazing on exterior		
	22	2.04	red glazed cuboid, possibly crucible handle		
	23	0.58	crucible - grey fabric, thin, clear ext glaze		
	25	4	mixture of various iron rich materials - at least one small iron fragment but most are crusts of uncertain origin		
	53	0.71	curved fired clay - piece of tuyère ?		
	418	2.48	2 pieces of slag, originally a single piece of digitate lining slag		
	420	18	4 tiny scraps of iron-slag		

context	Sample	weight	material	SHC prop	estimate
2365	420	36	4 pieces of lining slag		
	482	42	small round cake of curious vesicular cream material - presumably devitrified glass. May be vitrified ash also has vitrified sediment, ash and charcoal and one possible piece of hammerscale		
		1410	17 large lumps of concretion - based on slag, type unknown		
		232	possible concreted SHC with smooth bulbous top, most of rest hidden by concretion		
		732	concreted mass probably enclosing an SHC		
		1545	5 dense concreted slag pieces		
		652	2 very dense pieces of concretion with rust - may be dense slag or may have pieces of iron inside		
		76	3 dense lobes of flowed slag		
		202	small dense mass of flow lobed SHC material resting on grey sediment		
		16	5 pieces of dense material and a thin scale piece. All could be sub tuyère but not certain		
		1765	small slag pieces, mainly concreted and indet. C. 150 pieces		
		156	5 larger slag fragments		
		204	may be small SHC, but may just be charcoal rich slag strengthened around iron inclusion as rather rusty		
		11200	small and indeterminate slag pieces		
		120	small fragments, 6, of dense well flown brittle slag, some thin so may be sub tuyère , but at least one seems to be flown material from cake		
		1965	8 lumps of concretion cored on dense pieces of SHC crust		
		2745	incomplete large thin crust cake, with upper band like a crust at top. Top smooth, fairly well blown, most of material charcoal rich. (210)x(160)x(100), base prilly, one small patch seems to have baked clay, could be 70%, but very uncertain	70?	3921
		1990	hollow-topped SHC with top marked by lobes of fairly fluid slag, base seems fairly smooth. 140x160x70, hollow 90x55x25 deep. Cake deepest on proximal side, where also most obvious flowage on lip	100	1990
		1145	slightly incomplete charcoal rich cake. Has shallow basal bowl, then thick charcoal layer then slight denser upper dish. Overall 135x110x75 of which basal bowl 35	95	1205
		942	dense pear shaped SHC. Slightly concreted hiding the dished top. Seems fairly dense. 150x110x60 of which bowl = 45, only small area upstanding but this is inflated smooth topped lobe	100	942
		792	dense subcircular SHC with slightly dished top 120x110x45. Dish is close to one end. Base microprilly, top texture obscured	100	792
		288	small dished SHC, some low-density concretion. 90x90x30 triangular in plan	105	274
		584	extremely dense small SHC 100x80x50. Rather obscured and may be related to the dense material below. It is possible this is not the entire SHC it seems to be	100	584
		156	fragment of thin dense crust with adhering grey sediment		
		472	fragment of very dense thick crust/burr material with adhering grey sediment		
		628	fragment of very dense thick crust burr material. Crust to 45 thick		
		352	majority of small weathered SHC with dense crust with adhering grey sediment	70?	503
		566	central small part of a thick crust cake with crust to at least 30, proportion of cake unknown but fairly moderate		
		638	strange SHC with basal dense bowl, possibly on sediment, topped with flat surface of lining dominated material (80x110x50)	100	638
		530	(90)x110x55 dense but charcoal rich SHC, fairly conventional, base smooth, top obscure	75	589
		398	probably 25-40% of small dense SHC, encrusted so few details, probably around 45 deep and 100 across	30	1327
		292	small irregular SHC, rather encrusted so not clear, but top appears charcoal rich and base prilly	100	292
		260	irregular small SHC with hollowed top 120x90x40 - but long axis may be stretched out on extraction	100	260
		446	rather worn extremely dense SHC 120x70x35, probably almost complete	95	469
		208	small mass, probably an irregular SHC 110x70x25, top slightly dished, smoothish, base charcoal rich	100	208
		174	probably most of small SHC, but broken so hard to be certain. (60)x80x40, mainly charcoal rich but firm rusty flat top, base slightly prilly, some cracks so probably includes iron	65	268
		3260	12 dense heavily concreted slag fragments, probably bits of thickish crust SHCs?		
		1980	17 pieces of less dense concreted SHC		
		196	rather weathered but probably small dense conventional SHC, 70x60x25	100	196
		430	double layer SHC 100x100x50. Dimpled base on lower burger, then charcoal rich between, then obscure top on upper burger	100	430
		210	small open textured SHC (or just heart of larger thin crust cake, 75x80x30	100	210
		190	small dense SHC, some concretion 80x60x25	100	190
		512	large slab from side of very big SHC		

context	Sample	weight	material	SHC prop	estimate
2365	482	1565	18 assorted slag pieces, probably all SHC fragments		
		260	small SHC, slightly bent on extraction, 95x80x30	100	260
		282	90x70x45 biconvex small SHC, rather similar to bulbous lobe seen below tongue on another example	100	282
		2025	8 pieces of dense slag from SHCs		
		250	small SHC, slightly bent on extraction, 85x85x30	100	250
		128	very small slag disc - presumably a tiny SHC 55x55x25	100	128
		118	fragment from end of cake with charcoal rich slag SHC with lining-dominated smooth top		
		390	5 pieces of lining-dominated SHC tongue - all may essentially be entire pieces		
		152	circular mass, probably a tongue with lining dominated gravelly top with raised spikes on edge and somewhat prilly base		
		436	9 pieces of lining-dominated slag, probably all from tongues		
		242	either tongue or compound cake (fragment?) - has lobe of lining rich material resting on top of dense charcoal rich slags		
		138	typical tongue with smooth upper surface with slightly raised lobes on edges, over prilly, low density base		
		64	three pieces of vitrified lining/tuyère		
		3335	tuyère fragments, 48 large pieces and 86 small fragments		
2367	484	78	10 small slag fragments, mainly thin sheet material, one piece seems to have a small flake adhering		
		4	nail		
		48	stone		
2369	354	0.34	accretion		
		9.73	15 pieces of dense flown slag including 2 spheres		
		34.1	12 pieces of rough dense slag in mainly sheet form		
		0.27	reduced fired clay - 1 piece		
2370	2	34	11 slag fragments of irregular dense flown material, could be smelting material most likely		
	486	48	5 pieces of prill/flow		
		6	film of slag with ashy material adhering, flake like material stuck on but may just be surface from a slag lobe		
		190	smelting slag in lobate accumulation. Appears to be constricted between some fired clay and some other surfaces - so might just be from a basal pit rather than from a tapped flow		
		152	well flown slag overlain by material with charcoal moulds - could be a furnace slag or a basal pit slag		
2373	355	2.08	irregular slags		
		0.52	8 spheroids		
2375	485	90	9 pieces of well-flown slag in prills and very thin sheets. Sheet material could be sub-tuyère, but could equally be basal smelting furnace		
		12	stone		
		86	rough lobe of slag with charcoal ash adhering and some drip like blebs. Probably a basal smelting furnace material		
2402	356	12	7 blebs of lining slag		
	470	1	reduced fired clay		
		24	17 lower density slag fragments		
		14	6 small stones		
		112	24 piece of dense prill - smelting slags		
2403	357	10.14	6 pieces of flown bleb in ashy matrix		
2404	361	13.79	11 pieces of blebby or spiky slag		
		0.25	thin slag sheet		
2406	359	4	reduced fired lining		
		82	10 pieces of dense tap slag like material some with maroon bloom, some multiple fine prills		
2406	468	2340	stones with some iron-coatings - 2 large pieces		
		634	42 pieces - probably originally 2 (1 quite small), of a basal flow, a sheet of well-flown slag diverging into rivulets and horizontal prills. Show well developed lobes with some charcoal contact. Not clear if over-melted smithing slag, but quite possibly from a smelting furnace		
		2920	complex mixture of broad taps slag like flows and narrower prills, and occasional thin sheet (almost like large hammerscale). Clearly a smelting assemblage. All pieces appear coated in ash - so may be basal flows in a pit rather than tapslag. C260 pieces		
		1245	large block of tap slag like flows, apparently dropped over a large vertical surface.		
		224	10 fragments of associated material, including flows passing over spheroid rich accumulation, as seen in sample above. All of this smelting material.		

context	Sample	weight	material	SHC prop	estimate
2406	468	3035	tap slag like flows and prills. Some spheroid accumulation material. All smelting debris. 75 pieces. One important facet of this smelting material is the maroon bloom on surface - suggests cooling on contact with air. One pieces shows stalagmite-like material at foot of convex vertical side - just like vertical side on the large block above		
2408	431	220	55 pieces of dense prilly smelting lags, including some pieces like good tapslag, all very ashy		
2422	533	38	22 indeterminate slag fragments		
2203/2204	523	8	concretion		
		68	2 pieces of iron-slag		
		15	2 pieces of iron		
		94	2 pieces of lining slag balls		
		4	iron rich rock		

Table 1: Woodstown 6 – Catalogue – arranged by context and sample number

Contexts	***Subtotals***							
	Smithing	*Smelting*	*Indet slag*	*Lining*	*Tuyère*	*Crucible*	*smithing pan*	*Tot. res.*
479	0	0	0	0.3	0	0	0	*0*
600	4524	0	5172	560	267	30	8	*11074*
757	0	0	58	4	7	0	0	*69*
798	0	0	23	4	0	0	0	*27*
821	0	0	0	6	0	0	0	*6*
885	0	0	0	0	0	13	0	*13*
887	148	0	0	3	0	1	0	*161*
920	0	0	0	0	0	0	0	*0*
941	0	0	0	0	0	0	0	*0*
999	0	0	6	0	0	0	0	*6*
1040	0	0	0	0	0	0	0	*0*
1083	0	0	0	0	0	5	0	*5*
1111	322	0	0	0	0	0	0	*322*
1214	40	0	6	0	0	0	0	*46*
1233	0	0	6	0	0	0	0	*6*
1407	0	0	0	0	0	0	0	*0*
1464	116	0	0	0	0	0	0	*116*
1468	0	0	84	0	0	0	0	*84*
1488	0	0	0	22	0	0	0	*22*
1499	0	0	34	0	0	0	0	*34*
1510	0	0	0	0	0	0	0	*0*
1511	1358	0	0	0	0	0	0	*1358*
1999	0	0	96	29	29	0	0	*154*
2003	0	0	31	0	0	0	0	*31*
2006	0	0	12	36	0	0	0	*62*
2007	562	0	42	254	32	2	0	*892*
2019	0	0	12	0	0	0	0	*12*
2034	0	0	52	0	84	0	0	*136*
2036	0	0	0	0	0	0	0	*0*
2067	1318	0	242	0	0	0	0	*1560*
2095	1682	0	388	0	40	0	0	*2110*
2096	2939	0	1750	1	180	10	0	*4880*
2100	0	0	8	32	0	0	0	*40*
2102	140	0	50	0	0	0	0	*190*
2104	0	0	10	0	0	0	0	*10*
2105	0	0	20	34	0	0	0	*54*
2131	0	0	46	30	0	0	0	*76*
2151	0	0	0	76	0	0	0	*76*
2154	144	0	0	6	0	0	0	*150*
2163	0	0	40	0	0	0	0	*40*
2165	0	0	174	17	0	0	0	*197*
2166	246	0	264	0	0	0	0	*510*
2168	82	0	0	4	16	0	0	*102*
2170	5749	0	1348	26	455	3	0	*7581*
2171	10427	0	5753	582	1436	7	0	*18205*

Contexts	***Subtotals***							
	Smithing	*Smelting*	*Indet slag*	*Lining*	*Tuyère*	*Crucible*	*smithing pan*	*Tot. res.*
2172	28174	0	300	38	1060	0	746	*30318*
2173	984	0	1177	64	222	0	0	*2447*
2180	1558	0	17	42	0	0	0	*1617*
2181	0	0	102	0	0	0	0	*102*
2182	0	0	0	0	37	0	0	*37*
2188	0	0	608	6	32	47	0	*693*
2191	0	0	0	0	0	0	0	*0*
2200	846	0	260	0	362	0	0	*1468*
2201	48	0	1	0	0	0	0	*49*
2203	248	0	148	22	0	0	0	*418*
2204	550	0	14	6	48	0	0	*618*
2203/2204	0	0	68	94	0	0	0	*162*
2205	0	0	218	6	0	0	0	*224*
2210	5395	0	400	32	0	0	0	*5827*
2225	0	0	0	0	0	0	0	*0*
2244	824	0	0	88	0	0	0	*912*
2246	136	0	0	0	0	0	0	*136*
2247	0	0	0	38	0	0	0	*38*
2248	0	0	0	0	0	0	0	*2*
2279	0	0	102	0	0	0	0	*102*
2291	0	0	0	0	0	0	0	*0*
2297	69987	538	26084	1052	2977	123	860	*101621*
2299	434	0	0	0	0	0	0	*434*
2317	0	0	46	0	0	0	0	*46*
2318	448	0	0	0	70	0	0	*518*
2320	0	60	0	0	0	0	0	*60*
2350	0	0	25	0	0	0	0	*25*
2353	8952	0	1952	0	2172	0	0	*13076*
2355	3509	0	1454	24	40	0	0	*5027*
2356	579	0	107	0	0	0	0	*686*
2357	0	0	23	0	0	0	0	*24*
2359	0	58	0	0	0	0	0	*58*
2364	0	0	80	0	0	0	0	*80*
2365	28335	0	13761	38	3400	6	0	*45582*
2367	0	0	78	0	0	0	0	*78*
2369	0	0	44	0	0	0	0	*44*
2370	0	376	54	0	0	0	0	*430*
2373	1	0	2	0	0	0	0	*3*
2375	0	86	90	0	0	0	0	*176*
2402	0	112	0	37	0	0	0	*149*
2403	0	0	10	0	0	0	0	*10*
2404	0	0	14	0	0	0	0	*14*
2406	0	8140	0	4	0	0	0	*8144*
2408	0	220	0	0	0	0	0	*220*
2422	0	0	38	0	0	0	0	*38*
total	*180805*	*9590*	*63002*	*3320*	*12965*	*247*	*1614*	*272129*

Table 2: Simplified summary of distribution of residue classes by context. All weights in g.

100g class	count	500g class	count	1000g class	count
0-100	3				
100-200	8				
200-300	18				
300-400	12				
400-500	15	*0-500*	56		
500-600	9				
600-700	7				
700-800	9				
800-900	7				
900-1000	11	*500-1000*	43	*0-1000*	99
1000-1100	2				
1100-1200	6				
1200-1300	4				
1300-1400	3				
1400-1500	1	*1000-1500*	16		
1500-1600	0				
1600-1700	2				
1700-1800	1				
1800-1900	0				
1900-2000	1	*1500-2000*	4	*1000-2000*	20
2000-2100	2				
2100-2200	0				
2200-2300	4				
2300-2400	1				
2400-2500	1	*2000-2500*	8		
2500-2600	0				
2600-2700	0				
2700-2800	2				
2800-2900	0				
2900-3000	0	*2500-3000*	2	*2000-3000*	10
				3000-4000	5
				4000-5000	3
				5000-6000	2
				6000-7000	1

Table 3: Woodstown 6 - Summary of distribution of smithing hearth cakes (SHCs) by weight. Each weight class in inclusive of its lower limit and exclusive of its upper limit.

	Coolamurry	Navan	Moneygall	Carrigoran	Parknahown 5	Trumra 4	Clonmacnoise (NG)	Ballykilmore	Woodstown 6	Clonmacnoise (WWS)	Clonfad	Lismore/ Bushfield 1
date	C10-12	E. Med.	E.Med-Med.	C10?	C5-C10?	C5/6	C7-10	C10-15?	C9-10	C10?	C7-9	E. Med?
SHC count	41	17	22	18	89	57	117	30	140	38	381	23
SHC min. wt		60	114		86	92	100	94	68		60	426
SHC max. wt	2588	2990	1800	3866	2898	3163	7815	4033	6310	5540	11000	4390
SHC mean wt	386	507	527	553	567	727	843	1022	1060	1087	1302	1737
% <500g	83%	82%	55%	72%	70%	47%	50%	47%	40%	39%	30%	4%
% <1000g	95%	88%	95%	89%	84%	75%	78%	73%	71%	68%	61%	39%
% >1000g	5%	12%	5%	11%	16%	25%	22%	27%	29%	32%	39%	61%
% >3000g	0%	0%	0%	6%	0%	2%	3%	10%	7%	8%	9%	13%
Modal 100g interval	100-200	100-200	200-300	100-200	400-500	100-300	400-500	200-300	200-300	300-400	300-400	500-600

Table 4. Comparison of the Woodstown SHC assemblage with other Irish smithing assemblages.

Assemblages ordered by mean SHC weight.
Coolamurry from Young, 2008a; Navan Site 1 from Young 2007; Moneygall from Young 2008d; Carrigoran from Young 2006b; Parknahown from Young 2009d; Trumra 4 from Young 2008g, Clonmacnoise New Graveyard site from the author's work in progress; Ballykilmore from Young 2009b; Woodstown this study; Clonmacnoise Waste Water Scheme from Young 2005; Clonfad from Young 2009a; Lismore/Bushfield 1 from Young 2008f.

The assemblages from Coolamurry, Navan, Moneygall, Carrigoran and Parknahown are interpreted as being dominantly blacksmithing residues. The assemblages from Trumra, Clonmacnoise, Ballykilmore, Woodstown, Clonfad, and Lismore/Bushfield are interpreted as including bloomsmithing residues.

Sample		Context	sample	weight	SiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TiO2	P2O5	LOI	LOI	total
WTN1	shc	2172	514	310 part	31.03	3.41	62.86	56.57	0.743	0.32	1.60	0.34	1.44	0.255	0.346	-4.64	1.65	97.70
WTN2	shc	2365	482	282	19.45	2.53	73.91	66.52	0.384	0.24	1.03	0.26	0.69	0.181	0.407	-0.22	7.17	98.86
WTN3	shc	2365	482	290	13.65	2.13	80.18	72.16	0.202	0.38	4.13	0.33	0.56	0.145	3.046	-4.61	3.41	100.15
WTN4	shc	2297	513	366	22.73	1.40	75.18	67.66	0.168	0.12	0.82	0.21	0.52	0.125	0.448	-3.11	4.41	98.61
WTN5	shc	2297	513	416	18.74	1.82	72.38	65.14	1.450	0.26	1.72	0.22	0.66	0.128	0.856	-1.34	5.90	96.89
WTN6A	shc	2170	448	834	15.47	1.42	84.07	75.66	0.422	0.33	1.08	0.19	0.66	0.111	0.248	-4.80	3.61	99.21
WTN6B	shc			834	28.12	5.12	51.87	46.68	0.150	0.28	0.54	0.23	1.70	0.292	0.760	9.62	14.81	98.68
WTN6D	shc			834	17.38	1.82	78.41	70.57	0.392	0.32	1.02	0.19	0.74	0.129	0.340	-2.21	5.63	98.52
WTN7	shc	2353	516	1320	24.23	2.27	70.00	63.00	0.171	0.26	0.69	0.19	0.60	0.175	0.556	-0.15	6.85	99.01
WTN8	shc	2297	513	3715	14.58	3.13	70.02	63.02	4.233	0.20	0.61	0.20	0.43	0.157	0.369	-2.51	4.49	91.43
WTN9C	shc	2170	448	4700	24.82	3.31	67.34	60.61	1.573	0.52	2.31	0.40	1.40	0.190	0.451	-5.07	1.66	97.25
WTN9D	shc			4700	25.11	3.93	64.15	57.74	1.411	0.42	2.47	0.48	1.42	0.207	0.606	-3.30	3.12	96.92
WTN9E	shc			4700	23.82	3.19	67.81	61.02	1.594	0.56	2.26	0.35	1.40	0.180	0.408	-5.37	1.41	96.21
WTN10C	shc	2172	514	5170	19.59	2.79	71.56	64.41	2.428	0.28	1.08	0.19	0.80	0.182	0.342	-3.94	3.22	95.30
WTN11	shc	2297	513	6300	13.99	2.13	84.97	76.48	0.118	0.23	0.60	0.14	0.66	0.137	0.344	-3.86	4.64	99.46
WTN12	tongue	2171	515	189	64.66	7.84	21.82	19.64	0.206	0.45	0.89	0.44	2.57	0.511	0.271	-0.31	1.87	99.35
WTN13	tongue	2171	515	141	54.61	6.44	30.85	27.77	0.740	0.43	1.79	0.47	2.99	0.430	0.522	-0.97	2.12	98.29
WTN14	tongue	2297	513	190	35.38	2.48	57.00	51.30	0.587	0.45	2.39	0.44	1.48	0.170	0.837	-2.81	2.89	98.40
WTN15	tongue	2297	513	161	41.05	4.14	42.13	37.92	1.026	0.45	3.33	0.78	2.80	0.299	1.228	0.79	5.00	98.03
WTN16	tap slag like material	2406	468		28.03	3.36	69.59	62.63	0.200	0.31	1.12	0.24	1.18	0.204	0.589	-5.32	1.64	99.51
WTN17	tap slag like material	2406	468		28.42	3.38	69.51	62.56	0.194	0.31	1.14	0.21	1.24	0.198	0.486	-5.54	1.41	99.55
WTN20	tap slag like material	2406	468		21.01	3.27	75.61	68.05	1.260	0.23	1.24	0.25	0.85	0.178	0.636	-6.55	1.01	97.98
WTN21	tap slag like material	2297	513		21.22	3.20	75.50	67.95	1.254	0.27	1.29	0.27	0.85	0.181	0.555	-6.52	1.03	98.08
WTN19	bog ore	600	511		49.26	7.12	31.23	28.11	0.789	0.37	0.20	0.21	1.47	0.447	0.824	7.60	10.72	99.52
WTN22	bog ore	600	548		40.11	7.97	35.78	32.20	3.574	0.27	0.43	0.21	1.41	0.419	2.309	3.75	7.33	96.24
WTN23	mn ore?	600	547		24.33	13.95	12.32	11.09	19.058	0.25	0.08	0.11	1.88	0.398	0.197	12.38	13.61	84.96
WTN24	tuy1	2171	515		76.82	9.86	4.88	4.40	0.171	0.45	0.09	0.18	2.07	0.635	0.708	1.48	1.97	97.34
WTN25	tuy2	2171	515		74.07	11.43	5.36	4.83	0.142	0.57	0.14	0.21	2.08	0.696	1.128	1.67	2.21	97.50

Table 5: Bulk chemical analyses by XRF on fused beads. Data calculated with iron presented as Fe_2O_3, or alternatively as FeO (grey columns). Values in wt%.

Sample	Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Rb	Sr	Y	Zr	Nb	Mo	Sn	Cs	Ba
WTN1	8.0	25.8	22.9	79.5	146.4	48.4	74.9	5.2	44.8	86.4	15.1	100.4	4.30	16.18	0.56	2.49	218.3
WTN2	3.7	21.2	12.3	164.0	121.5	87.9	78.2	4.9	24.8	43.8	8.8	66.0	3.12	13.20	0.77	1.39	153.6
WTN3	2.2	30.1	2.8	18.1	5.7	186.2	77.8	4.2	11.9	78.7	8.0	54.5	2.38	6.39	99.75	0.41	184.4
WTN4	1.7	13.5	1.2	61.1	16.6	42.2	77.5	4.2	19.8	25.7	6.2	67.9	2.21	5.80	1.19	0.91	103.1
WTN5	10.7	36.5	9.7	38.7	54.9	173.1	82.0	4.6	22.5	48.6	30.6	55.9	2.34	7.49	0.80	1.16	247.5
WTN6A	2.4	12.6	82.1	60.2	161.9	50.1	78.3	4.2	15.3	36.5	6.3	49.1	1.86	3.38	0.48	0.52	155.4
WTN6B	4.7	25.9	22.8	154.5	51.6	101.7	81.7	7.5	85.9	36.1	10.5	99.7	5.16	7.45	0.81	8.92	177.8
WTN6D	2.7	14.0	7.3	85.0	10.2	72.1	78.3	4.2	19.9	40.8	7.1	59.1	2.38	4.40	0.48	0.97	167.3
WTN7	3.5	20.2	17.8	114.2	104.8	174.6	76.9	4.6	23.4	23.6	13.4	76.7	3.06	19.62	0.75	1.65	113.0
WTN8	3.4	33.3	35.7	42.3	18.1	29.5	77.6	4.7	14.7	47.9	12.5	59.2	2.71	1.71	0.63	0.67	507.6
WTN9C	8.3	51.4	47.2	19.3	2.2	38.6	68.6	4.6	39.2	90.1	51.0	80.4	3.20	1.82	0.79	1.38	270.1
WTN9D	7.7	42.4	23.6	40.7	9.0	61.0	73.9	5.5	49.2	96.3	56.7	94.2	3.87	3.17	1.82	2.05	292.5
WTN9E	8.2	55.4	41.1	16.0	6.3	35.5	69.5	4.5	38.2	87.3	50.2	77.3	2.97	1.36	0.72	1.31	265.4
WTN10C	3.1	28.3	20.1	30.8	7.0	72.2	71.7	4.6	26.4	42.0	10.7	78.6	3.30	4.18	2.00	1.27	812.2
WTN11	8.5	109.8	180.7	17.7	29.2	47.9	78.5	3.3	17.4	16.2	60.0	53.6	2.73	27.20	0.78	0.81	103.3
WTN12	8.0	52.1	63.6	34.9	58.0	54.7	54.2	8.0	108.6	52.9	32.0	200.7	8.89	4.51	1.18	8.27	318.2
WTN13	6.2	38.5	44.2	37.6	37.7	56.3	67.9	7.4	105.8	70.3	20.1	168.0	7.49	2.93	0.74	6.27	462.0
WTN14	4.8	32.7	27.2	92.8	62.7	92.6	68.5	4.3	50.2	73.5	37.9	92.8	3.14	4.82	0.64	1.77	255.2
WTN15	4.5	27.2	29.7	78.2	79.6	92.0	63.7	5.6	92.2	99.0	15.3	98.3	4.91	4.53	0.77	3.04	517.3
WTN16	8.4	94.4	155.7	29.3	45.0	47.8	69.3	4.3	43.1	48.1	62.9	95.2	4.33	9.30	0.98	2.30	186.6
WTN17	8.5	92.1	149.3	28.0	41.1	41.4	73.0	4.1	44.6	49.0	62.6	89.9	4.13	8.98	0.76	2.45	185.3
WTN20	5.1	45.6	29.1	24.9	10.0	25.3	74.9	4.9	22.6	60.0	23.4	74.6	3.15	1.22	0.31	0.99	241.9
WTN21	5.3	48.2	31.2	25.9	13.5	34.2	80.2	5.0	24.5	63.0	24.0	77.1	3.24	1.25	0.33	1.15	253.0
WTN19	6.0	87.8	55.6	45.6	5.6	22.8	104.7	9.8	89.3	20.0	15.4	149.1	8.01	0.72	0.99	7.40	292.4
WTN22	7.0	106.8	57.5	164.8	58.7	29.8	284.3	11.5	99.3	68.7	22.4	121.0	7.57	1.04	0.63	8.33	1290.9
WTN23	6.6	79.3	111.5	195.2	634.8	339.9	232.1	15.7	104.0	46.4	104.3	185.5	3.98	6.68	0.96	10.79	7417.7
WTN24	9.1	49.6	68.4	17.3	32.3	42.3	95.2	12.3	110.1	26.6	23.6	219.6	9.66	0.54	0.66	9.47	308.2
WTN25	12.9	53.1	87.7	17.0	56.1	39.1	117.3	14.2	97.5	35.2	37.1	230.6	10.00	0.36	0.67	8.42	432.3

Table 6a. Trace elements from bulk analyses by ICP-MS. Values in ppm

Sample	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Pb	Th	U
WTN1	11.74	23.49	2.87	10.36	2.17	0.48	2.21	0.36	2.16	0.41	1.27	0.21	1.41	0.22	2.39	0.27	1.66	2.65	1.08
WTN2	8.41	18.20	2.06	7.36	1.51	0.32	1.44	0.23	1.37	0.25	0.76	0.12	0.79	0.12	1.61	0.21	2.20	1.99	0.71
WTN3	6.95	14.01	1.74	6.35	1.33	0.29	1.32	0.21	1.23	0.23	0.68	0.11	0.68	0.10	1.40	0.18	1.10	1.56	0.64
WTN4	5.90	11.94	1.42	5.14	1.05	0.21	0.97	0.15	0.90	0.17	0.52	0.08	0.53	0.08	1.59	0.14	3.73	1.23	0.47
WTN5	12.34	17.86	2.85	11.32	2.77	0.73	4.18	0.70	4.34	0.79	2.33	0.36	2.31	0.34	1.32	0.14	4.15	1.44	0.99
WTN6A	4.84	10.49	1.19	4.29	0.92	0.19	0.84	0.14	0.81	0.15	0.48	0.08	0.51	0.08	1.16	0.12	1.60	1.10	0.58
WTN6B	12.80	25.63	3.13	10.76	2.12	0.43	1.75	0.27	1.62	0.30	0.93	0.14	0.95	0.15	2.29	0.26	7.28	3.46	1.31
WTN6D	5.93	12.72	1.46	5.26	1.10	0.23	1.01	0.17	0.98	0.18	0.57	0.09	0.60	0.09	1.40	0.15	0.54	1.39	0.71
WTN7	8.58	15.72	2.05	7.64	1.64	0.35	1.85	0.31	1.88	0.35	1.07	0.16	1.01	0.16	1.82	0.19	4.54	1.91	0.72
WTN8	8.94	27.63	2.38	8.88	1.98	0.42	1.91	0.29	1.76	0.34	1.07	0.17	1.13	0.18	1.45	0.17	1.23	2.28	0.88
WTN9C	23.92	31.81	5.34	21.18	5.17	1.26	7.41	1.17	7.31	1.34	3.73	0.54	3.18	0.47	1.95	0.20	0.66	3.31	1.67
WTN9D	27.89	37.53	6.18	24.31	5.91	1.43	8.40	1.32	8.20	1.50	4.15	0.60	3.43	0.50	2.25	0.23	1.53	3.92	1.97
WTN9E	23.15	30.73	5.14	20.33	4.95	1.21	7.17	1.14	7.16	1.31	3.67	0.53	3.14	0.46	1.89	0.20	0.93	3.18	1.63
WTN10C	7.56	17.68	1.92	7.06	1.59	0.35	1.53	0.24	1.48	0.28	0.89	0.15	0.97	0.16	1.90	0.22	4.07	2.14	1.06
WTN11	12.90	17.62	3.41	13.82	3.47	0.78	4.08	0.68	4.69	1.02	3.37	0.53	3.34	0.52	1.24	0.17	0.61	1.99	4.64
WTN12	28.03	54.98	6.91	25.12	5.25	1.10	5.01	0.77	4.62	0.86	2.59	0.41	2.55	0.39	4.99	0.62	10.77	6.03	2.11
WTN13	19.92	41.67	4.90	17.49	3.64	0.74	3.30	0.51	3.04	0.56	1.71	0.27	1.73	0.27	4.16	0.43	8.85	4.78	1.71
WTN14	18.48	25.74	4.07	15.70	3.67	0.88	5.24	0.87	5.46	1.02	2.82	0.41	2.33	0.34	2.21	0.22	1.71	2.65	1.23
WTN15	13.88	29.50	3.47	12.51	2.61	0.54	2.38	0.36	2.18	0.41	1.27	0.20	1.31	0.21	2.26	0.31	3.44	3.17	1.35
WTN16	20.65	30.95	5.07	19.61	4.47	1.00	4.94	0.79	5.16	1.09	3.48	0.52	3.29	0.49	2.25	0.27	1.16	3.13	4.38
WTN17	20.49	30.64	5.02	19.48	4.49	0.99	4.93	0.79	5.14	1.07	3.40	0.51	3.19	0.48	2.15	0.27	1.39	3.08	4.35
WTN20	9.89	22.31	2.64	10.33	2.63	0.61	3.04	0.48	3.00	0.59	1.89	0.30	1.99	0.32	1.83	0.19	1.84	2.58	3.64
WTN21	10.18	23.01	2.72	10.64	2.70	0.63	3.09	0.50	3.09	0.61	1.93	0.30	2.01	0.33	1.86	0.20	2.85	2.58	3.78
WTN19	17.98	39.88	4.55	16.34	3.33	0.68	2.84	0.43	2.52	0.46	1.42	0.22	1.46	0.22	3.70	0.51	53.74	5.49	1.70
WTN22	22.82	66.55	5.94	21.43	4.44	0.92	4.02	0.60	3.48	0.66	2.05	0.33	2.16	0.34	2.91	0.44	101.24	5.97	2.01
WTN23	29.27	48.30	9.44	38.32	11.04	3.05	12.93	2.37	15.42	3.15	10.46	1.86	13.02	2.11	3.95	0.41	18.12	4.13	6.34
WTN24	30.73	62.18	7.49	26.71	5.43	1.06	4.45	0.66	3.79	0.69	2.10	0.33	2.12	0.33	5.26	0.79	21.11	8.18	2.24
WTN25	35.46	68.82	8.88	31.89	6.71	1.42	6.27	0.98	5.79	1.06	3.25	0.50	3.19	0.49	5.59	0.74	21.92	8.47	2.61

Table 6b. Trace elements from bulk analyses by ICP-MS. Values in ppm

Sample	Area	Spot	notes	weight oxide% Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Ba	Cu	Sn	As	Total
WTN1	7	1	core of main olivine	0.00	0.43	0.00	28.05	0.00	0.00		0.00	0.88	0.00			1.25	69.02	0.00				99.63
WTN1	7	2	to	0.00	0.61	0.23	27.84	0.00	0.00		0.00	0.56	0.00			1.50	68.23	0.00				98.97
WTN1	7	3	to	0.00	0.62	0.00	28.18	0.00	0.00		0.00	0.44	0.00			1.32	68.32	0.00				98.88
WTN1	7	4	to	0.00	0.52	0.19	27.94	0.26	0.00		0.00	0.54	0.00			1.33	68.78	0.00				99.56
WTN1	7	5	to	0.00	0.48	0.00	28.19	0.26	0.00		0.00	0.55	0.00			1.25	68.66	0.00				99.40
WTN1	7	6	margin of main olivine	0.00	0.30	0.25	28.24	0.00	0.00		0.00	0.61	0.00			1.19	68.96	0.00				99.55
WTN1	7	7	olivine	0.00	0.00	0.22	28.33	0.20	0.00		0.00	3.14	0.00			0.91	66.46	0.00				99.25
WTN1	7	8	olivine	0.00	0.00	0.60	30.27	0.00	0.00		0.13	3.73	0.00			0.82	65.31	0.00				100.87
WTN1	7	9	leucite	1.17	0.00	22.10	53.31	0.20	0.00		18.09	0.00	0.00			0.00	1.77	0.00				96.64
WTN1	7	10	leucite	0.97	0.00	21.22	53.40	0.00	0.00		17.87	0.00	0.00			0.00	2.00	0.00				95.47
WTN1	7	11	interstitial phase	0.00	0.00	3.81	26.04	0.63	0.84		0.19	1.42	0.00			0.19	44.76	0.00				77.88
WTN1	7	12	interstitial phase	1.79	0.00	3.68	41.39	2.10	0.00		0.32	19.64	0.00			0.31	29.91	0.00				99.15
WTN1	7	13	interstitial phase	3.32	0.00	5.56	41.83	3.65	0.39		1.11	17.40	0.00			0.00	23.36	0.47				97.10
WTN1	7	14	magnetite core	0.00	0.00	2.94	0.85	0.00	0.00		0.00	0.00	0.57			0.19	87.73	0.00				92.29
WTN1	7	15	magnetite margin	0.00	0.00	3.31	3.03	0.00	0.00		0.27	1.06	0.55			0.25	82.93	0.00				91.40
WTN1	7	16	magnetite margin	0.00	0.00	3.21	0.71	0.00	0.00		0.00	0.00	0.67			0.19	88.93	0.00				93.70
WTN1	7	17	magnetite core	0.00	0.00	3.15	0.87	0.00	0.00		0.00	0.00	0.37			0.30	88.17	0.00				92.86
WTN1	7	18	magnetite plate	0.00	0.27	1.19	9.05	0.00	0.00		0.00	0.00	0.00			0.52	86.17	0.00				97.20
WTN1	7	19	magnetite plate	0.29	0.00	1.15	9.05	0.00	0.00		0.00	0.54	0.00			0.25	83.32	0.00				94.59
WTN1	7	20	magnetite plate	0.00	0.40	1.11	8.99	0.00	0.00		0.00	0.14	0.00			0.37	85.53	0.00				96.54
WTN1	7	21	olivine	0.00	0.00	0.00	28.53	0.27	0.00		0.00	4.49	0.00			0.74	64.51	0.00				98.54
WTN1	7	22	inclusion in magnetite	1.54	0.00	3.66	37.97	5.76	0.00		0.55	21.75	0.00			0.34	25.02	0.00				96.59
WTN1	7	23	interstitial phase	7.99	0.00	8.47	46.67	0.89	0.55		2.40	8.46	0.00			0.00	22.56	0.99				98.97
WTN1	7	24	leucite?	1.12	0.00	21.65	52.71	0.00	0.00		17.74	0.00	0.00			0.00	2.29	0.00				95.52
WTN1	7	25	interstitial phase	4.30	0.18	5.73	39.06	5.35	0.29		0.88	18.86	0.00			0.17	22.54	0.34				97.71
WTN1	8	1	main olivine outer	0.00	0.30	0.24	28.01	0.00	0.00		0.00	1.32	0.00			1.11	68.27					99.25
WTN1	8	2	olivine	0.00	0.00	0.00	28.44	0.00	0.00		0.22	2.79	0.00			0.94	65.81					98.21
WTN1	8	3	olivine	0.00	0.00	0.19	28.59	0.00	0.00		0.00	4.99	0.00			0.81	64.27					98.84
WTN1	8	4	bright in interstitial	1.33	0.00	4.11	34.12	3.76	0.22		1.57	17.59	0.26			0.17	37.47					100.61
WTN1	8	5	main interstitial	2.55	0.00	3.93	41.52	4.03	0.00		0.40	21.02	0.26			0.00	25.32					99.04
WTN1	8	6	main interstitial	2.16	0.00	3.30	42.36	2.68	0.00		0.26	19.79	0.28			0.18	29.01					100.02
WTN1	8	7	main interstitial	1.89	0.00	3.06	42.55	2.96	0.32		0.23	21.07	0.00			0.00	27.62					99.70
WTN1	8	8	main interstitial	1.39	0.00	2.87	41.34	3.68	0.00		1.03	21.65	0.39			0.00	27.29					99.63
WTN1	8	9	olivine	0.83	0.21	1.39	26.94	2.85	0.00		0.39	8.88	0.00			0.48	56.98					98.95
WTN1	8	10	magnetite plate	0.00	0.00	1.08	8.93	0.00	0.00		0.10	0.00	0.00			0.42	85.71					96.23
WTN1	8	11	magnetite plate	0.00	0.00	1.06	8.87	0.00	0.00		0.00	0.15	0.18			0.32	86.19					96.79
WTN1	8	12	magnetite plate	0.00	0.22	1.23	8.72	0.00	0.00		0.00	0.17	0.00			0.44	85.98					96.76
WTN1	8	13	magnetite plate	0.00	0.00	0.95	10.41	0.00	0.00		0.00	0.12	0.00			0.39	85.44					97.31

WTN1	8	14	main olivine inner	0.00	0.36	0.00	28.40	0.00	0.00		0.00	0.73	0.00	1.20	69.08			99.76
WTN1	8	15	main olivine margin	0.00	0.00	0.00	28.22	0.00	0.00		0.00	1.36	0.00	1.06	67.85			98.48
WTN1	8	16	olivine	0.00	0.00	1.06	29.21	0.55	0.00		2.00	2.59	0.00	0.99	59.53			95.94
WTN1	8	17	olivine	0.00	0.00	0.20	28.22	0.00	0.00		0.00	4.73	0.00	0.64	64.92			98.71
WTN1	8	18	dark interstitial	2.04	0.00	5.12	39.96	3.46	0.44		1.93	18.66	0.22	0.00	23.94			95.78
WTN1	9	1	olivine inner	0.00	0.00	0.23	28.10	0.00	0.00		0.00	1.38	0.00	4.13	65.34			99.18
WTN1	9	2	olivine inner	0.00	0.43	0.28	28.08	0.00	0.00		0.00	1.25	0.00	4.13	65.82			99.99
WTN1	9	3	olivine outer	0.00	0.27	0.00	28.05	0.00	0.00		0.00	1.72	0.00	3.66	65.18			98.87
WTN1	9	4	leucite	1.04	0.00	22.59	52.76	0.00	0.00		18.54	0.00	0.00	0.00	1.51			96.44
WTN1	9	5	interstitial	0.73	0.00	16.71	29.85	3.76	0.00		3.65	13.55	0.65	0.33	30.99			100.22
WTN1	9	6	interstitial	7.90	0.00	18.43	37.31	2.99	0.62		2.13	13.34	0.00	0.57	13.20			96.49
WTN1	9	7	Al, Ti rich magnetite	0.00	0.00	10.55	0.64	0.00	0.00		0.11	0.00	3.52	0.80	78.72			94.34
WTN1	9	8	olivine inner	0.00	0.26	0.35	28.33	0.00	0.00		0.00	1.07	0.00	4.01	65.71			99.72
WTN1	9	9	oxide bleb	0.00	0.00	0.57	0.28	0.00	0.00		0.00	0.00	0.35	0.90	95.94			98.04
WTN1	9	10	olivine	0.00	0.53	0.22	28.55	0.00	0.00		0.00	0.91	0.00	4.18	65.22			99.62
WTN1	9	11	plate	0.00	0.00	0.61	0.34	0.00	0.00		0.00	0.12	0.25	0.90	96.30			98.53
WTN1	9	12	plate	0.00	0.00	0.50	0.81	0.00	0.00		0.00	0.16	0.23	0.87	96.10			98.68
WTN1	9	13	plate	0.00	0.21	0.30	19.44	0.21	0.00		0.14	0.81	0.00	2.77	77.31			101.19
WTN3	2	1	main olivine	0.00	0.99	0.00	28.75	0.37		0.00	0.00	2.21			65.85	0.00		98.17
WTN3	2	2	main olivine	0.00	0.86	0.00	28.68	0.00		0.00	0.00	3.28			64.55	0.00		97.38
WTN3	2	3	wustite	0.00	0.00	0.51	0.00	0.00		0.00	0.00	0.00			91.59	0.00		92.10
WTN3	2	4	wustite	0.00	0.00	0.48	0.21	0.00		0.00	0.00	0.00			93.56	0.00		94.25
WTN3	2	5	interstitial/void	0.71	0.00	9.16	51.55	3.10		0.00	3.40	4.33			11.00	0.00		83.26
WTN3	2	6	interstitial/void	0.00	0.24	10.40	39.44	1.57		0.00	0.00	1.91			35.54	0.45		89.56
WTN3	3	1	phosphate	1.61		5.65	12.90	33.72			2.66	39.86			6.60			103.01
WTN3	3	2	phosphate	2.47		6.98	13.85	29.04	0.53		4.31	35.61			6.69			99.48
WTN3	3	3	phosphate	1.70		4.21	12.58	33.54			2.84	38.85			6.39			100.10
WTN3	3	4	mixed	2.45		10.56	23.27	22.81	0.90		5.07	27.99			7.23			100.27
WTN3	3	5	phosphate	2.32		3.91	8.89	36.62	0.60		2.79	41.47			5.55			102.15
WTN3	3	6	olivine outer		0.59		29.63					3.89			65.52			99.62
WTN3	3	7	olivine inner		1.28		29.52	0.39				2.24			66.58			100.01
WTN3	3	8	olivine inner		0.92		29.26					2.94			66.71			99.83
WTN3	3	9	olivine inner		1.05		28.92	0.69				2.36		0.30	66.55			99.87
WTN3	3	10	olivine margin		0.59		29.24	0.37				4.17		0.33	65.11			99.81
WTN3	3	11	bronze			1.03				0.00					5.57	28.83	88.52	123.94
WTN3	3	12	bronze												4.70	80.53	52.74	137.98
WTN3	3	13	wustite			0.74	0.41					0.19	0.32		96.82			98.48
WTN3	3	14	wustite			0.70									96.74			97.45

WTN3	5	1	olivine inner		1.66		29.45	0.54				2.70		0.42	65.93				100.70
WTN3	5	2	olivine margin		0.79		29.44	0.66				7.50		0.38	62.21				100.97
WTN3	5	3	olivine overgrowth	0.73	0.43	1.34	30.35	1.49			0.55	10.92		0.35	56.98				103.13
WTN3	5	4	apatite	1.56		3.12	11.39	33.29			2.68	40.15			10.11				102.30
WTN3	5	5	apatite	1.25		1.14	7.42	36.05			1.54	45.03			9.32				101.74
WTN3	5	6	apatite	1.48		1.76	7.65	36.88			1.80	44.59			9.12				103.28
WTN3	5	7	apatite	1.18		0.72	4.52	40.48			1.45	48.27			6.50				103.12
WTN3	5	8	apatite	1.34		2.95	12.05	31.55			2.94	38.44			12.59				101.86
WTN3	5	9	glass	2.91		17.09	40.78	2.55	0.84		11.37	6.32	0.27		14.60				96.76
WTN3	5	10	glass	3.02		18.71	42.50	1.94	1.14		12.03	4.54	0.29		14.72				98.88
WTN3	5	11	olivine	1.06		3.42	32.19	1.52			2.13	16.46			44.26				101.05
WTN3	5	12	olivine	0.86		3.27	32.41	1.32			2.20	15.19			46.27				101.51
WTN3	5	13	olivine		0.76		29.79	0.41				6.09		0.38	64.54				101.97
WTN3	5	14	apatite	1.19		1.34	7.46	36.26			1.84	43.84			9.19				101.11
WTN3	5	15	interstitial olivine	1.55		4.56	33.78	1.56	0.34		2.39	17.89			41.79				103.86
WTN3	5	16	olivine overgrowth ?				3.38	0.33	0.43	0.00		0.80			69.01				73.95
WTN3	5	17	interstitial olivine	1.52		8.46	26.45	2.53	0.74		3.47	5.62			40.26	6.53	29.07		124.66
WTN3	5	18	interstitial olivine	0.45		0.86	8.74	1.25	1.13		0.23	2.99			59.49				75.14
WTN3	5	19	glass	3.21		18.48	43.34	1.35	1.04		11.80	4.21	0.33		14.85				98.61
WTN6	23	1	olivine		0.90	0.72	27.97	0.00				0.72		0.83	66.73			0.00	97.87
WTN6	23	2	olivine		1.38	0.28	28.16	0.00				0.58		1.01	66.87			0.00	98.26
WTN6	23	3	olivine		1.32	0.30	28.02	0.00				0.72		1.02	66.98			0.00	98.36
WTN6	23	4	olivine		0.00	1.79	15.51	0.59				0.93		0.33	52.28			6.16	77.59
WTN6	23	5	olivine		1.23	0.34	27.98	0.00				0.64		0.94	66.49			0.00	97.63
WTN6	23	6	olivine		0.41	0.22	27.86	0.00				1.48		0.91	66.76			0.00	97.64
WTN6	23	7	olivine		0.56	0.00	28.07	0.00				0.67		0.91	67.18			0.00	97.38
WTN6	23	8	olivine		1.37	0.00	27.96	0.00				0.58		1.02	66.71			0.00	97.64
WTN6	23	9	olivine		0.56	0.00	27.91	0.00				1.60		0.75	66.74			0.00	97.55
WTN6	23	10	olivine		1.15	0.28	27.80	0.00				0.57		0.82	66.94			0.00	97.56
WTN6	23	11	olivine		1.24	0.28	28.18	0.00				0.53		0.98	66.56			0.00	97.76
WTN6	23	12	olivine		1.14	0.27	28.31	0.00				0.62		0.97	66.63			0.00	97.94
WTN6	25	1	olivine		1.20	0.00	28.20					0.84		0.86	66.05				97.16
WTN6	25	2	olivine		1.24	0.23	27.52					0.71		1.02	65.74				96.47
WTN6	25	3	olivine		1.17	0.28	26.91					0.73		0.72	65.53				95.34
WTN6	25	4	olivine		1.36	0.00	27.51					0.68		1.04	65.22				95.80
WTN6	25	5	olivine		1.23	0.21	27.27					0.75		0.83	66.03				96.31
WTN6	25	6	olivine		0.86	0.23	27.40					1.58		0.79	64.26				95.11
WTN6	25	7	olivine		1.03	0.00	26.88					0.98		0.95	67.22				97.07
WTN6	25	8	olivine		1.21	0.00	27.58					0.70		0.98	65.01				95.48
WTN6	25	9	wustite		0.00	0.41	0.00					0.00		0.24	93.69				94.33

WTN6	25	10	wustite		0.00	0.36	0.24					0.00		0.34	94.18		95.13
WTN6	25	11	wustite		0.00	0.36	0.20					0.00		0.30	94.92		95.78
WTN6	25	12	wustite		0.00	0.38	0.23					0.00		0.28	94.53		95.41
WTN8	23	1	olivine margin	0.00	0.37	0.36	28.63	0.00	0.00	0.00	0.00	0.67	0.00	7.84	60.53	0.00	98.39
WTN8	23	2	to	0.00	0.95	0.39	28.50	0.00	0.00	0.00	0.00	0.32	0.00	8.69	60.04	0.00	98.88
WTN8	23	3	to	0.00	0.81	0.37	28.46	0.00	0.00	0.00	0.00	0.33	0.00	8.67	60.21	0.00	98.85
WTN8	23	4	olivine core	0.00	0.59	0.41	28.56	0.00	0.00	0.00	0.00	0.35	0.00	8.63	60.61	0.00	99.15
WTN8	23	5	to	0.00	0.61	0.23	28.43	0.00	0.00	0.00	0.00	0.36	0.00	8.51	60.57	0.00	98.71
WTN8	23	6	to	0.00	0.33	0.38	28.47	0.00	0.00	0.00	0.00	0.43	0.00	8.14	60.63	0.00	98.39
WTN8	23	7	to	0.00	0.27	0.42	29.01	0.00	0.00	0.00	0.00	0.59	0.00	7.98	60.96	0.00	99.23
WTN8	23	8	olivine margin	0.72	0.00	2.67	31.19	0.43	0.00	0.00	0.56	2.16	0.00	6.73	58.85	0.00	103.32
WTN8	23	9	olivine in symplectite	0.00	0.00	0.35	28.05	0.40	0.00	0.00	0.00	0.95	0.00	7.37	61.22	0.00	98.34
WTN8	23	10	olivine in symplectite	0.00	0.00	0.28	28.44	0.36	0.00	0.00	0.00	0.75	0.00	7.49	61.08	0.00	98.39
WTN8	23	11	olivine in symplectite	0.00	0.00	0.36	28.86	0.42	0.00	0.00	0.00	2.31	0.00	7.61	59.31	0.00	98.88
WTN8	23	12	hercynite	0.00	0.21	57.03	0.26	0.00	0.00	0.00	0.00	0.00	0.56	2.47	44.36	0.00	104.89
WTN8	23	13	hercynite	0.00	0.00	54.15	0.42	0.00	0.00	0.00	0.00	0.00	1.00	2.60	46.10	0.00	104.27
WTN8	23	14	glass?	3.31	0.00	20.83	40.60	3.01	0.70	0.00	8.92	6.12	0.00	1.21	14.80	1.03	100.51
WTN8	23	15	mixed fe-ox	2.33	0.00	13.73	35.66	2.02	0.56	0.00	5.80	5.17	0.00	4.20	34.39	0.33	104.18
WTN8	23	16	wustite	0.00	0.00	0.95	0.48	0.20	0.00	0.00	0.00	0.00	0.33	2.92	92.59	0.00	97.47
WTN8	23	17	wustite	0.00	0.00	0.84	0.27	0.00	0.00	0.00	0.00	0.00	0.59	2.59	93.00	0.00	97.29
WTN8	23	18	olivine with W outer	0.00	0.42	0.32	28.53	0.00	0.00	0.00	0.00	0.47	0.00	8.26	60.78	0.00	98.78
WTN8	23	19	olivine with W outer	0.00	0.29	0.34	28.41	0.24	0.00	0.00	0.00	0.58	0.00	8.26	60.53	0.00	98.65
WTN8	23	20	olivine with W margin	0.00	0.00	2.18	29.05	0.30	0.00	0.00	1.97	1.97	0.00	6.82	53.94	0.00	96.23
WTN8	23	21	olivine with w margin	0.00	0.00	0.26	29.25	0.25	0.00	0.00	0.16	1.58	0.00	7.78	59.55	0.00	98.82
WTN8	23	22	wustite	0.00	0.00	0.93	0.43	0.00	0.00	0.00	0.00	0.00	0.47	2.69	93.40	0.00	97.91
WTN8	23	23	interstitial area	2.77	0.00	19.27	36.81	2.64	1.10	0.00	9.58	6.48	0.00	1.96	20.06	0.90	101.56
WTN8	23	24	glass?	3.35	0.00	21.32	41.22	3.11	1.10	0.00	8.69	6.65	0.29	0.89	12.90	1.20	100.73
WTN8	24	1	olivine core, cotectic with w		0.85	0.22	28.42	0.00	0.00			0.36	0.00	8.24	61.06		99.15
WTN8	24	2	to		0.82	0.41	28.24	0.40	0.00			0.42	0.00	8.54	59.97		98.79
WTN8	24	3	to		0.50	0.00	28.32	0.00	0.00			0.39	0.00	8.23	61.04		98.48
WTN8	24	4	outer before H		0.00	0.00	28.67	0.00	0.00			0.59	0.00	7.61	61.16		98.03
WTN8	24	5	olivine inner part with h		0.00	0.32	28.29	0.00	0.00			0.67	0.00	7.45	61.29		98.02
WTN8	24	6	olivine margin with/post h		0.00	0.37	28.87	0.00	0.14			1.76	0.00	6.69	60.31		98.14
WTN8	24	7	olivine margin with/post h		0.00	0.63	29.80	0.20	0.19			2.29	0.00	6.58	59.74		99.43
WTN8	24	8	hercynite		0.25	53.21	0.46	0.00	0.00			0.00	0.89	2.62	46.59		104.02
WTN8	24	9	hercynite outer		0.00	53.08	0.44	0.00	0.00			0.11	1.07	2.08	47.06		103.85
WTN8	24	10	hercynite inner		0.00	53.53	0.34	0.00	0.00			0.00	0.84	2.35	46.41		103.47
WTN8	24	11	hercynite inner		0.00	48.99	3.88	0.24	0.62			0.65	0.67	2.82	45.20		103.06
WTN8	24	12	hercynite outer		0.00	54.25	0.37	0.00	0.08			0.00	0.63	2.21	46.21		103.75
WTN8	24	13	posth? olivine inner		0.72	0.43	28.36	0.00	0.00			0.45	0.00	8.60	60.23		98.79

WTN8	24	14	posth? olivine inner		0.59	0.49	28.12	0.00	0.00			0.40	0.00	8.29	60.13	98.02
WTN8	24	15	posth? olivine outer		0.24	0.30	28.22	0.00	0.00			0.94	0.00	7.34	61.47	98.51
WTN9a	21	1	large olivine inner		1.10		27.77					1.08		2.60	64.25	97.97
WTN9a	21	2	large olivine inner		1.00		27.46					0.97		2.52	64.02	96.61
WTN9a	21	3	large olivine outer		0.95		27.51					1.09		2.51	64.01	97.32
WTN9a	21	4	large olivine margin		0.23		27.88					2.82		2.19	62.93	96.95
WTN9a	21	5	olivine in pore		0.33		27.86					3.00		2.21	63.42	97.70
WTN9a	21	6	olivine near pore outer		0.30		27.99					3.02		2.13	62.93	97.37
WTN9a	21	7	olivine near pore outer		0.39		27.32					1.80		2.31	63.87	96.66
WTN9a	21	8	olivine near pore inner		0.97		26.81					1.11		2.44	62.63	94.71
WTN9a	21	9	large olivine outer		1.09		27.54					0.90		2.51	64.35	97.47
WTN9a	21	10	olivine in pore		0.52		27.97					1.43		2.54	63.44	96.65
WTN9a	21	11	olivine in pore		0.51		28.02					1.73		2.26	64.45	98.03
WTN9a	22	1	olivine outer	0.29		0.23	27.58	0.53	0.00	0.00	0.00	6.70	0.00	2.10	59.37	96.81
WTN9a	22	2	olivine weathered zone?	0.43		0.20	28.37	1.07	0.00	0.00	0.00	23.62	0.00	1.18	41.49	96.36
WTN9a	22	3	olivine bright in margin	0.00		0.23	28.22	0.70	0.00	0.00	0.00	13.48	0.00	1.53	52.88	97.04
WTN9a	22	4	olivine bright overgrowth	1.08		1.84	28.65	0.84	0.00	0.00	0.10	10.45	0.00	1.48	53.14	97.57
WTN9a	22	5	olivine bright in i/s area	0.30		0.21	28.38	1.26	0.00	0.00	0.09	15.54	0.00	1.37	49.55	96.70
WTN9a	22	6	star crystal	0.73		19.38	24.12	0.53	0.00	0.00	0.18	11.78	4.57	0.32	37.50	99.12
WTN9a	22	7	iron?	1.41		6.48	11.27	2.00	####	0.00	0.63	6.25	0.45	0.20	62.93	144.21
WTN9a	22	8	stat/mixed	1.38		18.98	26.32	1.05	0.46	0.00	0.90	12.12	3.26	0.42	32.75	97.64
WTN9a	22	9	interstitial glass	6.85		18.30	36.55	2.81	0.50	0.00	2.38	11.99	0.00	0.41	18.29	98.09
WTN9a	22	10	star crystal	0.92		20.65	25.59	0.71	1.06	0.00	0.44	11.88	2.74	0.40	35.38	99.77
WTN9a	22	11	star crystal?	1.10		25.72	22.75	0.58	0.41	0.00	0.44	9.39	3.24	0.47	37.53	101.62
WTN9a	23	1	lamellar - rhonite?	0.49	0.00	17.12	24.82	0.80	0.00		0.90	12.37	2.96	0.36	35.22	95.06
WTN9a	23	2	olivine (simple) margin fresh	0.00	0.27	1.57	28.58	0.00	0.00		1.80	3.38	0.00	1.76	54.43	91.79
WTN9a	23	3	olivine simple inner	0.00	0.22	0.00	27.30	0.00	0.00		0.00	2.95	0.00	2.17	62.38	95.02
WTN9a	23	4	olivine (complex) margin	0.40	0.00	0.43	27.32	0.87	0.00		0.00	9.23	0.00	1.66	57.26	97.17
WTN9a	23	5	olivine (complex) inner	0.00	0.26	0.00	27.75	0.00	0.00		0.00	1.97	0.00	2.32	63.93	96.23
WTN9a	23	6	olivine (complex) inner	0.00	0.41	0.00	27.33	0.00	0.00		0.00	1.88	0.00	2.41	64.21	96.24
WTN9a	23	7	olivine (complex) inner	0.00	0.61	0.38	27.31	0.36	0.00		0.00	1.44	0.00	2.67	64.40	97.18
WTN9a	23	8	olivine complex outer	0.00	0.00	0.29	27.18	0.44	0.00		0.00	6.16	0.00	2.02	59.81	95.90
WTN9a	23	9	leucite	0.49	0.00	24.48	51.22	0.00	0.00		18.57	0.00	0.00	0.00	1.39	96.15
WTN9a	23	10	wustite	0.00	0.00	1.11	0.89	0.00	0.00		0.32	0.00	1.08	0.58	91.52	95.50
WTN9a	23	11	wustite?	0.00	0.00	6.72	17.12	0.00	0.00		8.82	0.00	0.00	0.26	40.34	73.27
WTN9a	23	12	wustite	0.00	0.00	0.92	0.99	0.00	0.00		0.28	0.00	0.36	0.60	94.27	97.42
WTN9a	23	13	leucite	1.66	0.00	22.48	42.38	0.00	0.00		12.38	0.22	0.28	0.00	10.07	89.47
WTN9a	23	14	Rhönite?	0.30	0.00	17.41	23.23	0.30	0.00		0.11	11.80	4.23	0.39	37.40	95.17
WTN9a	23	15	Rhönite?	1.34	0.00	4.37	28.05	2.18	0.31		0.40	21.59	0.42	0.92	36.40	95.98

WTN9b	21	1	olivine		1.55	0.58	27.18					0.73			2.43	58.49			90.97
WTN9b	21	2	olivine		1.99	0.28	28.70					0.86			2.65	62.58			97.05
WTN9b	21	3	olivine		2.66	0.23	29.58					0.75			2.78	61.84			97.84
WTN9b	21	4	olivine		2.16	0.31	28.53					0.71			2.67	61.33			95.72
WTN9b	21	5	olivine		1.88	0.00	28.83					0.72			2.71	62.58			96.72
WTN9b	22	1	olivine inner between W		2.70		29.20					0.57			2.72	62.56			97.74
WTN9b	22	2	olivine		2.55		29.43					0.71			2.80	63.30			98.79
WTN9b	22	3	olivine		1.67		29.15					0.86			2.68	63.77			98.13
WTN9b	22	4	olivine margin		0.74		28.44					2.61			2.33	63.63			97.75
WTN9b	22	5	olivine inner		1.65		29.09					0.74			2.75	63.56			97.79
WTN9b	22	6	olivine inner between W		1.38		28.85					0.87			2.55	64.31			97.96
WTN9b	22	7	olivine inner		2.33		29.27					0.63			2.69	63.26			98.19
WTN9b	22	8	olivine margin		0.83		29.04					1.49			2.31	63.40			97.07
WTN10A	2	1	complex olivine inner	0.00	0.28	0.00	14.47	0.00	0.00	0.00	0.00	1.66	0.00		4.52	54.68		0.00	75.61
WTN10A	2	2	complex olivine inner	0.00	0.30	0.00	14.66	0.19	0.00	0.00	0.00	2.50	0.00		4.31	54.54		0.61	77.13
WTN10A	2	3	complex olivine outer	0.00	0.00	0.00	14.32	0.23	0.00	0.00	0.00	4.13	0.00		3.94	51.08		0.85	74.55
WTN10A	2	4	leucite	0.00	0.00	12.14	25.76	0.00	0.00	0.00	10.30	0.23	0.52		0.45	5.84		0.57	55.80
WTN10A	2	5	weathered iron?	0.00	0.00	0.47	6.95	0.00	0.27	0.00	0.00	0.23	0.00		0.00	52.01		0.00	59.93
WTN10A	2	6	weathered iron?	0.00	0.00	3.01	7.82	0.36	1.19	0.00	0.00	0.21	0.00		0.46	45.00		0.00	58.04
WTN10A	2	7	interstitial olivine	0.43	0.00	1.03	14.98	0.87	0.00	0.00	0.21	9.92	0.00		3.01	39.26		0.00	69.70
WTN10A	2	8	weathered iron?	0.27	0.00	2.36	9.76	0.72	0.56	0.00	0.25	1.50	0.00		0.37	41.07		0.00	56.85
WTN10A	2	9	interstitial olivine	0.00	0.00	0.19	14.86	0.46	0.00	0.00	0.00	13.41	0.00		3.01	37.80		0.00	69.73
WTN10A	2	10	weathered iron?	0.00	0.00	0.64	9.80	0.39	0.78	0.00	0.00	0.32	0.00		0.55	47.21		0.00	59.69
WTN10A	2	11	interstitial olivine	0.84	0.00	4.69	15.89	0.97	0.29	0.00	0.68	9.93	0.30		2.22	31.83		0.00	67.64
WTN10A	2	12	complex olivine core	0.00	0.31	0.50	14.43	0.00	0.00	0.00	0.31	1.38	0.00		4.22	53.67		0.00	74.82
WTN10A	2	13	wustite	0.00	0.00	0.26	0.19	0.00	0.00	0.00	0.00	0.00	0.23		1.34	86.42		0.00	88.44
WTN10A	3	1	olivine inner		0.34	0.00	14.15				0.00	0.73			4.44	55.60		0.00	75.26
WTN10A	3	2	to		0.34	0.00	14.17				0.00	0.69			4.50	55.29		0.00	74.99
WTN10A	3	3	to		0.38	0.00	14.38				0.00	0.80			4.59	55.08		0.00	75.23
WTN10A	3	4	olivine margin		0.23	0.00	14.25				0.00	1.97			4.43	53.76		0.00	74.64
WTN10A	3	5	leucite		0.00	12.30	25.87				11.86	0.00			0.00	1.33		0.00	51.36
WTN10A	4	1	olivine inner	0.00	0.14	0.11	14.92	0.27	0.00		0.00	2.26	0.00		4.72	57.05	0.00	0.58	80.05
WTN10A	4	2	olivine margin	0.00	0.14	0.24	14.66	0.24	0.00		0.00	3.69	0.00		3.99	52.97	0.00	0.00	75.94
WTN10A	4	3	olivine inner	0.00	0.21	0.17	14.79	0.25	0.00		0.00	2.66	0.00		4.73	56.26	0.00	0.46	79.54
WTN10A	4	4	interstitial?	0.00	0.14	0.12	15.22	0.26	0.00		0.00	6.65	0.00		4.26	51.05	0.00	0.00	77.69
WTN10A	4	5	interstitial olivine	0.00	0.00	0.20	15.51	0.42	0.00		0.00	8.84	0.00		3.96	48.27	0.00	0.48	77.68
WTN10A	4	6	wustite	0.00	0.00	0.17	0.14	0.00	0.00		0.00	0.00	0.31		1.53	89.89	0.00	0.39	92.43

WTN10A	4	7	interstitial medium	2.77	0.00	11.25	18.07	1.46	0.00		1.66	8.72	0.00	1.25	20.13	0.52	0.42	66.25
WTN10A	4	8	interstitial ?	3.78	0.00	14.53	18.42	1.87	0.00		2.24	8.32	0.00	0.59	8.66	0.00	0.31	59.36
WTN10A	4	9	interstitial dark	4.15	0.00	15.84	19.06	0.86	0.00		2.64	6.28	0.00	0.24	5.18	0.00	0.58	55.39
WTN10A	4	10	leucite	0.13	0.00	13.59	28.30	0.00	0.00		12.32	0.00	0.00	0.00	1.65	0.67	0.35	57.02
WTN10A	4	11	interstitial medium	1.75	0.00	12.32	17.18	1.24	1.52		1.72	9.00	0.00	0.51	14.17	3.29	0.52	64.09
WTN10A	4	12	interstitial medium?	3.10	0.00	11.30	17.32	1.58	0.36		1.29	9.05	0.19	0.89	16.48	0.66	0.37	63.26
WTN10A	5	1	olivine inner		1.01	0.00	28.53	0.00		0.00		0.92	0.00	5.46	62.10		0.40	98.43
WTN10A	5	2	olivine outer		0.50	0.23	28.16	0.00		0.00		4.87	0.00	5.20	58.22		0.41	97.58
WTN10A	5	3	olivine inner		1.08	0.00	28.64	0.00		0.00		0.90	0.00	5.16	62.22		0.36	98.36
WTN10A	5	4	olivine inner		1.09	0.00	28.95	0.00		0.00		0.81	0.00	5.38	62.13		0.00	98.35
WTN10A	5	5	olivine outer		1.15	0.00	28.60	0.00		0.00		0.72	0.00	5.26	61.66		0.44	97.83
WTN10A	5	6	olivine inner		1.06	0.00	27.72	0.00		0.00		0.78	0.00	5.52	60.72		0.44	96.24
WTN10A	5	7	olivine inner		1.28	0.33	28.63	0.00		0.00		0.82	0.00	5.43	62.46		0.56	99.51
WTN10A	5	8	olivine margin		0.53	0.00	28.59	0.30		0.00		2.87	0.00	5.26	60.37		0.30	98.21
WTN10A	5	9	altered olivine		0.49	0.25	29.92	0.41		0.00		1.01	0.00	4.62	53.35		0.35	90.40
WTN10A	5	10	wustite		0.00	0.73	0.35	0.00		0.00		0.00	0.18	1.63	93.57		0.50	96.96
WTN10A	5	11	wustite		0.00	0.59	0.33	0.00		0.00		0.00	0.29	1.57	92.97		0.35	96.10
WTN10A	5	12	wustite		0.00	0.64	0.33	0.00		0.00		0.00	0.32	1.57	93.49		0.47	96.81
WTN10A	6	1	olivine inner		1.28	0.00	28.09					0.72		5.56	61.12		0.33	97.11
WTN10A	6	2	olivine inner		1.31	0.00	28.26					0.66		5.34	61.13		0.55	97.25
WTN10A	6	3	olivine inner		1.35	0.27	29.03					0.70		5.53	61.19		0.32	98.40
WTN10A	6	4	olivine inner		1.14	0.34	28.03					0.89		5.29	61.08		0.00	96.76
WTN10A	6	5	olivine outer		0.77	0.23	28.11					1.03		4.98	61.53		0.35	97.00
WTN10A	6	6	olivine outer		0.47	0.27	28.15					1.86		5.27	60.25		0.52	96.79
WTN10A	6	7	olivine inner		1.29	0.28	28.23					0.79		5.39	61.44		0.49	97.92
WTN10A	6	8	olivine inner		1.06	0.24	27.89					0.75		5.38	61.16		0.38	96.86
WTN10A	8	1	simple olivine inner		0.74	0.00	28.08	0.33	0.00		0.00	1.25	0.00	5.28	60.89		0.42	96.99
WTN10A	8	2	simple olivine inner		0.55	0.33	27.18	0.36	0.30		0.00	3.06	0.00	4.62	58.17		0.44	95.00
WTN10A	8	3	simple olivine margin		0.58	0.25	27.69	0.00	0.00		0.00	1.92	0.00	5.13	60.59		0.00	96.15
WTN10A	8	4	complex olivine outer		0.34	0.39	27.63	0.00	0.00		0.00	2.01	0.00	5.08	60.04		0.43	95.92
WTN10A	8	5	complex olivine inner		0.51	0.43	27.94	0.00	0.00		0.41	1.92	0.00	4.92	59.22		0.34	95.69
WTN10A	8	6	complex olivine inner		0.48	0.27	28.50	0.00	0.00		0.20	1.97	0.00	5.05	60.31		0.33	97.11
WTN10A	8	7	complex olivine inner		0.69	0.97	29.72	0.43	0.00		0.33	1.95	0.00	5.14	59.62		0.48	99.33
WTN10A	8	8	wustite		0.00	0.58	0.30	0.00	0.00		0.00	0.00	0.26	1.67	92.48		0.39	95.68
WTN10A	8	9	complex olivine inner		0.48	0.30	28.89	0.00	0.00		0.00	2.69	0.00	4.95	59.80		0.37	97.49
WTN10A	8	10	complex olivine outer		0.46	1.68	28.73	0.21	0.00		1.01	2.11	0.00	4.92	56.70		0.32	96.15
WTN10A	8	11	simple olivine outer		0.49	0.00	28.01	0.00	0.00		0.00	2.22	0.00	4.99	59.33		0.44	95.48
WTN10A	8	12	simple olivine inner		0.26	0.90	28.86	0.23	0.27		0.00	7.63	0.00	4.51	53.59		0.46	96.70
WTN10A	8	13	simple olivine margin		0.28	0.67	28.94	0.00	0.00		0.00	5.74	0.00	4.60	56.47		0.29	96.98

WTN10B	3	1	main olivine outer		0.28	0.00	12.99	0.00				0.69		5.04	50.34		0.00	69.34
WTN10B	3	2	main olivine inner		0.38	0.00	13.73	0.00				0.50		5.31	50.88		0.00	70.79
WTN10B	3	3	main olivine core		0.75	0.00	14.13	0.00				0.38		5.88	53.55		0.58	75.28
WTN10B	3	4	main olivine core		0.37	1.39	12.94	0.69				3.08		5.25	55.57		0.00	79.29
WTN10B	3	5	main olivine core		0.58	0.00	15.25	0.24				0.63		6.22	58.49		0.80	82.21
WTN10B	3	6	main olivine inner		0.00	0.00	15.81	0.00				1.20		6.09	60.03		0.95	84.08
WTN10B	3	7	main olivine inner		0.28	0.00	16.14	0.20				1.30		5.95	61.35		0.00	85.22
WTN10B	3	8	olivine in pore		0.18	0.00	12.29	0.00				0.65		4.82	46.82		0.00	64.77
WTN10B	3	9	complex olivine		0.17	0.00	13.03	0.00				1.12		5.06	50.45		0.00	69.83
WTN10B	3	10	complex olivine		0.19	0.22	12.27	0.17				1.06		4.75	47.60		0.00	66.26
WTN10B	4	1	ol close to "bubble"		0.72	0.00	28.11	0.34				1.21		5.40	61.47		0.00	97.25
WTN10B	4	2	just inside 1		0.82	0.00	27.80	0.00				1.15		5.25	61.20		0.00	96.22
WTN10B	4	3	complex olivine inner		0.61	0.37	27.91	0.32				1.39		5.33	61.22		0.28	97.42
WTN10B	4	4	complex olivine inner		0.43	0.00	28.20	0.36				1.70		5.18	61.46		0.00	97.32
WTN10B	4	5	complex olivine outer		0.26	0.22	28.43	0.53				4.68		5.03	59.21		0.35	98.71
WTN10B	4	6	olivine		0.31	0.00	27.84	0.37				2.33		4.85	61.49		0.00	97.20
WTN10B	4	7	olivine		0.59	0.29	28.17	0.23				1.71		5.09	62.54		0.00	98.61
WTN10B	4	8	olivine		0.41	0.00	28.07	0.26				3.22		4.95	61.73		0.00	98.64
WTN10B	5	1	granular olivine		1.36	0.23	28.43					0.88		5.36	61.09		0.37	97.71
WTN10B	5	2	granular olivine		1.46	0.00	28.23					0.71		5.51	61.62		0.00	97.52
WTN10B	5	3	granular olivine		1.55	0.00	28.06					0.85		5.52	61.31		0.00	97.29
WTN10B	5	4	granular olivine		0.83	0.25	28.46					0.99		5.46	62.77		0.00	98.74
WTN10B	5	5	granular olivine		1.16	0.00	28.57					0.78		5.46	62.38		0.00	98.35
WTN10B	5	6	granular olivine		1.49	0.37	28.20					0.68		5.33	61.65		0.00	97.72
WTN10B	5	7	granular olivine		1.21	0.00	28.15					0.85		5.58	61.80		0.28	97.87
WTN10B	5	8	granular olivine		1.18	0.26	28.45					0.73		5.60	61.68		0.00	97.91
WTN10B	5	9	granular olivine		1.15	0.00	28.40					0.74		5.36	61.38		0.35	97.38
WTN10B	5	10	granular olivine		1.22	0.00	27.98					0.79		5.60	61.29		0.53	97.40
WTN10B	5	11	granular olivine		1.34	0.22	28.07					0.86		5.45	61.91		0.00	97.85
WTN10B	5	12	granular olivine nearest pore		0.64	0.68	26.73					2.54		4.83	60.02		0.38	95.81
WTN10B	6	1	complex olivine	0.00	0.57	0.37	28.05	0.31	0.00	0.00	0.00	1.62	0.00	6.14	60.53	0.00	0.33	97.92
WTN10B	6	2	complex olivine	0.00	0.61	0.00	28.09	0.26	0.00	0.00	0.00	2.42	0.00	5.75	60.54	0.00	0.00	97.68
WTN10B	6	3	complex olivine	0.00	0.00	0.41	22.02	0.26	0.29	0.00	0.00	2.57	0.00	3.83	61.86	0.00	0.32	91.57
WTN10B	6	4	complex olivine margin	0.00	0.00	0.87	29.34	0.68	0.00	0.00	0.37	6.95	0.00	5.19	55.03	0.00	0.27	98.69
WTN10B	6	5	olive core	0.00	0.24	0.22	28.05	0.00	0.00	0.00	0.00	3.21	0.00	5.69	59.33	0.00	0.34	97.07
WTN10B	6	6	olivine margin	0.00	0.00	0.27	28.43	0.47	0.00	0.00	0.00	6.83	0.00	5.28	55.07	0.00	0.31	96.65
WTN10B	6	7	interstitial olivine	0.00	0.00	0.36	28.85	1.33	0.00	0.00	0.00	18.92	0.00	3.67	43.67	0.00	0.00	96.80
WTN10B	6	8	interstitial olivine	0.53	0.00	1.24	29.01	1.52	0.00	0.00	0.27	17.28	0.00	3.32	42.09	0.00	0.36	95.61

WTN10B	6	9	interstitial olivine	0.00	0.00	34.15	10.72	2.49	0.00	0.00	0.00	7.79	0.70	2.09	46.22	0.00	0.00	104.15
WTN10B	6	10	interstitial olivine	1.35	0.00	2.38	29.11	1.24	0.44	0.00	0.33	17.55	0.00	3.43	43.12	0.00	0.34	99.28
WTN10B	6	11	interstitial olivine	11.69	0.00	31.46	37.29	1.95	0.48	0.00	4.50	7.23	0.00	0.38	6.13	0.57	0.00	101.68
WTN10B	6	12	interstitial olivine	11.74	0.00	33.46	38.38	1.71	0.00	0.00	4.93	6.11	0.00	0.00	3.00	0.00	0.23	99.56
WTN10B	6	13	interstitial olivine	0.76	0.00	16.03	46.73	1.69	0.59	0.00	1.19	2.81	0.00	0.41	12.98	1.39	0.27	84.85
WTN10B	6	14	leucite	0.32	0.00	19.85	44.19	0.00	0.00	0.00	17.57	0.00	0.00	0.00	2.45	0.84	0.00	85.23
WTN10B	6	15	wustite	0.00	0.00	2.46	4.22	0.00	0.00	0.00	1.53	0.00	0.34	0.83	85.90	0.00	0.00	95.28
WTN10B	6	16	wustite	0.00	0.00	0.26	0.50	0.00	0.00	0.00	0.00	0.00	0.33	1.60	93.22	0.00	0.00	95.91
WTN10B	6	17	leucite	0.00	0.00	24.90	52.11	0.00	0.00	0.00	18.75	0.00	0.00	0.00	1.58	0.90	0.35	98.58
WTN10B	6	18	wustite	0.00	0.00	0.42	0.33	0.00	0.00	0.00	0.00	0.00	0.53	1.61	92.85	0.00	0.29	96.03
WTN10B	6	19	interstitial leucite	9.96	0.00	29.24	37.21	2.40	0.61	0.00	6.53	6.81	0.00	0.17	3.60	0.65	0.29	97.46
WTN11	4	1			1.40	0.28	28.70			0.00		0.58			67.74			98.70
WTN11	4	2			1.26	0.60	28.15			0.00		0.70			67.38			98.10
WTN11	4	3	margin		0.66	0.00	29.19			0.00		1.13			69.15			100.13
WTN11	4	4			1.24	0.00	28.62			0.00		0.53			68.42			98.82
WTN11	4	5			1.14	0.28	28.55			0.00		0.70			68.29			98.95
WTN11	4	6	margin		0.56	0.00	28.17			0.00		3.59			64.27			96.60
WTN11	4	7	wustite		0.00	0.77	0.29			0.00		0.00			97.10			98.16
WTN11	4	8	wustite		0.00	0.92	0.31			0.00		0.00			96.63			97.86
WTN11	6	1	olivine inner		1.27	0.30	29.02	0.00	0.00	0.00		0.78			69.06			100.43
WTN11	6	2	olivine margin		1.29	0.00	29.10	0.23	0.00	0.00		0.79			69.20			100.60
WTN11	6	3	bright in weathering		0.00	0.26	2.38	0.00	0.65	0.00		0.00			70.53			73.82
WTN11	6	4	dull in weathering		0.00	13.04	23.16	2.21	4.10	0.00		0.19			40.20			82.89
WTN11	6	5	wustite		0.00	0.90	0.43	0.00	0.00	0.00		0.00			97.37			98.70
WTN14	12	1	core pyroxene dendrite	0.27	8.17	3.00	46.16	1.16		0.00	0.67	20.51	0.00	0.92	19.65	0.00		100.52
WTN14	12	2	mid dendrite	0.28	7.85	2.58	46.52	1.21		0.00	0.62	20.56	0.00	1.01	20.07	0.00		100.69
WTN14	12	3	outer dendrite	0.33	6.94	1.78	45.94	1.27		0.00	0.09	21.02	0.00	1.15	21.96	0.00		100.47
WTN14	12	4	outer solid crystal?	0.26	6.23	1.35	45.56	0.83		0.00	0.00	21.06	0.00	1.28	22.76	0.00		99.33
WTN14	12	5	core solid crystal	0.40	7.65	3.17	46.25	1.07		0.00	0.96	19.86	0.00	0.92	19.02	0.00		99.30
WTN14	12	6	glass?	0.00	0.20	16.84	4.23	25.42		0.00	0.16	2.21	0.00	0.00	20.83	0.32		70.63
WTN14	12	7	glass?	0.00	0.00	12.44	4.13	18.29		0.00	0.12	1.47	0.00	0.00	27.47	0.00		63.93
WTN14	12	8	weathered glass?	0.29	0.31	14.79	9.56	23.35		0.00	0.13	4.85	0.00	0.28	25.96	0.00		79.51
WTN14	12	9	glass?	2.06	0.52	7.45	47.92	1.83		0.00	9.19	3.50	0.00	1.36	23.93	0.54		98.67
WTN14	12	10	glass?	2.30	0.52	7.26	52.03	2.50		0.00	9.51	3.19	0.00	1.71	22.96	0.43		102.94
WTN14	12	11	magnetite?	0.00	0.66	0.90	0.44	0.32		0.00	0.00	0.18	0.00	0.63	88.48	0.00		91.60
WTN14	12	12	magnetite? Outer	0.00	0.78	0.94	0.35	0.00		0.00	0.00	0.25	0.19	0.67	88.62	0.00		91.80
WTN14	12	13	magnetite inner	0.00	1.27	0.71	0.44	0.00		0.00	0.00	0.43	0.20	0.55	88.06	0.00		91.66
WTN14	12	14	magnetite outer	0.00	0.47	0.92	0.48	0.00		0.00	0.00	0.17	0.41	0.46	89.17	0.00		92.08
WTN14	12	15	crystal inner	0.41	7.43	2.63	46.35	1.14		0.00	0.53	20.42	0.00	0.86	20.45	0.00		100.22

WTN14	12	16	crystal outer	0.34	5.60	3.15	48.15	1.11		0.00	1.92	17.56	0.00	1.17	22.03	0.00	101.03
WTN14	13	1	bright dendrite	0.62	1.46	2.59	45.85	0.27	0.00		3.60	1.87	0.00	0.64	41.29		98.18
WTN14	13	2	bright dendrite	0.82	1.15	2.99	46.31	0.31	0.00		3.47	1.80	0.00	0.62	41.31		98.76
WTN14	13	3	bright dendrite	0.98	0.82	3.10	46.16	0.36	0.00		4.06	3.40	0.18	0.66	38.11		97.82
WTN14	13	4	dull dendrite	0.50	1.18	2.85	50.75	0.28	0.00		2.41	8.02	0.21	0.64	33.43		100.26
WTN14	13	5	dull dendrite	0.67	1.03	2.78	49.79	0.25	0.00		2.41	6.72	0.00	0.61	34.79		99.04
WTN14	13	6	dull dendrite	0.91	0.64	3.40	51.20	0.31	0.00		3.57	7.81	0.18	0.40	29.92		98.34
WTN14	13	7	bright dendrite	0.59	1.02	3.08	44.47	0.48	0.00		3.40	3.20	0.00	0.75	40.31		97.29
WTN14	13	8	bright dendrite	0.62	0.78	3.28	44.88	0.33	0.00		2.96	3.38	0.00	0.62	39.21		96.05
WTN14	13	9	bright dendrite	0.36	1.12	2.84	43.49	0.00	0.00		2.01	3.07	0.00	0.87	44.48		98.24
WTN14	13	10	dull dendrite	0.73	0.54	3.58	51.03	0.45	0.23		2.79	12.51	0.57	0.39	25.99		98.82
WTN14	13	11	dull dendrite	0.71	0.63	2.98	49.83	0.53	0.19		2.19	15.22	0.38	0.51	26.60		99.75
WTN14	13	12	bright dendrite	0.52	0.99	3.17	46.56	0.25	0.19		3.45	2.62	0.00	0.65	38.56		96.97
WTN14	13	13	dark/void	0.00	0.00	4.47	46.11	1.38	0.24		0.23	1.60	1.02	0.19	13.89		69.13
WTN14	13	14	dark alteration?	0.79	0.24	6.26	61.93	0.00	0.27		5.81	1.48	0.22	0.00	15.60		92.60
WTN14	13	15	dull dendrite	0.96	0.40	3.40	51.31	0.61	0.00		2.76	13.66	0.42	0.36	24.73		98.60
WTN14	13	16	medium fine crystals	0.96	0.00	3.44	47.73	0.40	0.00		4.20	2.66	0.19	0.20	39.16		98.93
WTN14	13	17	bright alteration	0.73	0.19	5.59	58.00	0.39	0.27		5.41	2.80	0.36	0.17	19.11		93.00
WTN14	14	1	olivine margin	0.00	0.99	0.00	28.65	0.00	0.00		0.00	1.20	0.00	1.06	67.20		99.09
WTN14	14	2	olivine margin	0.00	0.43	0.55	29.70	0.00	0.00		1.04	2.90	0.00	0.88	61.28		96.78
WTN14	14	3	i/s olivine dendrite	1.08	0.00	6.70	41.87	0.76	0.00		5.18	13.33	0.26	0.24	29.24		98.65
WTN14	14	4	i/s olivine dendrite	1.02	0.00	6.62	42.23	1.19	0.00		5.30	13.76	0.24	0.23	27.44		98.03
WTN14	14	5	i/s olivine dendrite	1.18	0.00	6.54	42.58	1.01	0.00		5.23	14.30	0.31	0.31	28.27		99.74
WTN14	14	6	i/s olivine dendrite	1.16	0.00	7.02	43.49	1.11	0.22		5.73	13.08	0.35	0.35	26.06		98.57
WTN14	14	7	glass?	2.71	0.00	6.99	48.14	1.53	0.99		8.26	8.02	1.19	0.00	21.13		98.95
WTN14	14	8	glass?	2.84	0.00	7.40	49.33	1.41	0.75		9.49	5.28	1.05	0.00	19.65		97.19
WTN14	14	9	i/s bright	1.04	0.00	4.03	16.09	0.24	0.00		2.71	0.74	2.41	0.00	72.25		99.50
WTN14	15	1	olivine core	0.00	0.80	0.25	28.60	0.32	0.00		0.00	1.02	0.00	1.08	66.78	0.00	98.83
WTN14	15	2	olivine core	0.00	0.78	0.00	28.40	0.20	0.00		0.00	1.14	0.00	1.08	67.43	0.00	99.04
WTN14	15	3	olivine outer	0.00	0.47	0.00	28.89	0.00	0.00		0.00	1.52	0.00	1.08	67.35	0.00	99.31
WTN14	15	4	olivine outer assoc leucite	0.00	0.31	0.87	29.67	0.00	0.00		0.77	2.92	0.00	0.81	62.06	0.00	97.42
WTN14	15	5	olivine outer assoc leucite	0.00	0.00	0.30	29.67	0.00	0.00		0.00	4.75	0.00	0.90	63.65	0.00	99.27
WTN14	15	6	olivine outer	0.00	0.46	0.00	28.53	0.00	0.00		0.00	1.89	0.00	1.09	67.04	0.00	99.01
WTN14	15	7	olivine core	0.00	1.07	0.00	28.76	0.00	0.00		0.00	0.83	0.00	1.01	67.62	0.00	99.30
WTN14	15	8	olivine outer	0.00	0.73	0.00	28.70	0.00	0.00		0.00	1.66	0.00	0.94	67.55	0.00	99.58
WTN14	15	9	olivine outer assoc leucite	0.00	0.00	0.00	29.65	0.27	0.00		0.11	3.37	0.00	0.79	66.09	0.00	100.28
WTN14	15	10	olivine outer assoc leucite	0.00	0.00	0.00	28.95	0.50	0.00		0.10	5.29	0.00	0.76	63.79	0.00	99.40
WTN14	15	11	olivine outer assoc leucite	0.79	0.00	0.74	30.63	1.27	0.00		0.66	7.38	0.00	0.70	57.34	0.00	99.51
WTN14	15	12	isolated olivine	0.00	0.00	1.01	0.95	0.00	0.00		0.00	0.30	2.12	0.00	88.52	0.00	92.90

WTN14	15	13	leucite	0.24	0.00	21.18	52.73	0.00	0.00	16.01	0.42	0.00	0.00	6.39	0.00		96.97
WTN14	15	14	leucite	0.00	0.00	23.21	54.57	0.00	0.00	19.07	0.16	0.00	0.00	2.61	0.00		99.62
WTN14	15	15	late dendrite	0.40	0.00	1.69	41.92	1.15	0.00	0.18	20.71	0.61	0.34	32.40	0.00		99.40
WTN14	15	16	late dendrite	0.77	0.00	2.02	43.01	1.34	0.00	0.67	19.43	0.58	0.34	30.61	0.00		98.77
WTN14	15	17	glass	6.33	0.00	4.03	47.65	1.92	2.01	6.89	3.39	0.00	0.40	25.73	0.97		99.33
WTN14	15	18	glass	5.86	0.00	5.08	50.59	1.69	1.55	7.74	2.14	0.00	0.27	23.55	0.54		99.01
WTN14	15	19	glass	5.30	0.00	2.85	45.43	1.80	0.81	5.00	6.98	0.42	0.29	28.33	0.63		97.84
WTN15	2	1	olivine core	0.00	1.53	0.00	29.52	0.00	0.00	0.00	1.74	0.00	4.23	63.69			100.71
WTN15	2	2	olivine margin	0.00	1.04	0.29	30.66	0.00	0.00	0.00	1.99	0.00	4.33	63.69			102.01
WTN15	2	3	late olivine symp with L	0.00	0.43	0.54	28.47	0.58	0.00	0.00	5.89	0.00	3.33	58.82			98.06
WTN15	2	4	olivine	0.00	1.92	0.00	29.55	0.00	0.00	0.00	1.50	0.00	3.96	63.62			100.55
WTN15	2	5	olivine	0.00	0.82	0.00	28.87	0.00	0.00	0.00	2.25	0.00	3.91	63.34			99.19
WTN15	2	6	glass?	3.35	0.00	10.48	52.11	0.85	0.29	7.08	8.33	0.59	0.80	17.74			101.60
WTN15	2	7	glass?	2.33	0.00	11.70	30.49	1.37	0.26	1.47	2.49	0.76	0.22	16.55			67.64
WTN15	3	1	olivine core	0.24	2.84	0.00	30.41	0.00		0.17	1.59	0.00	3.10	62.60		0.00	100.96
WTN15	3	2	olivine margin	0.24	1.82	0.52	31.15	0.00		0.44	2.19	0.00	2.62	61.21		0.00	100.18
WTN15	3	3	olivine margin	0.00	2.40	0.00	30.01	0.00		0.00	2.04	0.00	3.03	62.93		0.00	100.41
WTN15	3	4	olivine core	0.27	2.75	0.00	29.96	0.00		0.00	1.40	0.00	3.00	62.78		0.00	100.17
WTN15	3	5	late olivine	0.00	2.46	0.41	31.82	0.00		0.35	2.10	0.00	2.79	62.44		0.00	102.37
WTN15	3	6	late olivine	0.30	1.89	1.08	32.82	0.30		1.29	2.39	0.20	2.59	55.64		0.00	98.49
WTN15	3	7	olivine	0.32	2.18	0.53	31.00	0.00		0.30	2.31	0.00	2.87	62.42		0.00	101.94
WTN15	3	8	dark dendrite	0.72	0.00	11.52	46.26	0.00		5.81	3.76	0.46	0.36	13.27		0.00	83.47
WTN15	3	9	dark dendrite	0.68	0.00	7.92	51.19	0.27		6.24	2.85	0.56	0.26	9.44		0.00	79.42
WTN15	3	10	dark bleb	0.27	0.17	6.38	48.24	0.00		1.39	3.71	0.97	0.42	5.35		0.00	67.87
WTN15	3	11	glass	2.59	0.20	6.13	52.87	0.44		6.63	9.73	0.57	0.68	20.09		0.00	101.26
WTN15	3	12	glass	2.41	0.00	6.56	55.60	0.47		7.32	7.92	0.56	0.52	17.93		0.00	99.62
WTN15	3	13	glass	2.42	0.00	5.73	52.49	0.48		6.16	10.27	0.74	0.77	20.51		0.00	100.31
WTN15	3	14	alteration?	0.00	0.41	8.33	55.46	0.00		0.39	3.42	0.72	0.72	11.59		0.00	81.62
WTN15	5	1	iron	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	135.17			135.17
WTN15	5	2	magnetite?	0.27	3.44	0.23	30.47	0.00		0.10	2.06	0.00	2.35	61.99			100.92
WTN15	5	3	magnetite?	0.00	2.48	0.38	31.06	0.00		0.11	2.00	0.00	2.16	63.70			101.90
WTN15	5	4	glass	2.81	0.22	6.53	55.94	0.62		8.79	5.17	0.72	0.56	18.90			100.25
WTN15	5	5	glass	2.14	0.37	6.75	55.58	0.62		7.90	7.63	0.70	0.49	18.18			100.35
WTN15	5	6	altered?	0.46	0.23	8.84	55.68	0.00		2.79	3.12	0.97	0.57	17.24			90.40
WTN15	5	7	glass	0.42	0.00	9.26	57.25	0.39		4.11	3.86	0.67	0.32	16.43			93.09
WTN15	5	8	glass/fine dendrite	1.28	0.00	7.49	55.82	0.79		7.08	5.95	0.75	0.51	20.33			99.99
WTN15	5	9	altered iron	0.00	0.00	0.00	6.25	0.45		0.00	0.36	0.00	0.60	71.03			78.68
WTN15	5	10	olivine	0.39	2.88	1.69	34.43	0.00		0.75	1.84	0.00	2.36	58.31			102.64
WTN15	5	11	altered iron	0.00	0.00	0.00	2.03	0.00		0.00	0.41	0.00	1.12	69.14			72.69

WTN15	5	12	olivine	0.00	4.15	0.00	30.47	0.00		0.15	2.26	0.00			2.82	61.17	101.02
WTN15	5	13	glass/fine dendrite	1.60	0.26	7.80	56.85	0.70		7.93	6.35	0.66			0.50	16.86	99.50
WTN15	7	1	area - altered ceramic	2.53	0.99	13.99	63.28	0.24		3.94	0.94	0.59			0.43	12.17	99.10
WTN15	7	2	core olivine	0.00	2.34	0.22	29.44	0.21		0.00	1.57	0.00			3.92	63.49	101.18
WTN15	7	3	core olivine	0.00	2.70	0.00	30.14	0.00		0.00	1.24	0.00			3.70	63.57	101.35
WTN15	7	4	margin olivine	0.00	1.35	0.00	29.94	0.00		0.16	2.42	0.00			3.40	63.27	100.54
WTN15	7	5	olivine margin	0.43	0.96	0.79	32.44	0.00		0.44	2.77	0.00			3.11	61.83	102.76
WTN15	7	6	glass/fine dendrites	1.36	0.00	6.44	49.37	0.74		3.88	17.34	0.47			1.21	18.70	99.51
WTN16	4	1	olivine margin	0.00	0.40	0.29	29.26	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	69.79	100.15
WTN16	4	2	to	0.00	0.78	0.37	28.99	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.28	69.88	100.59
WTN16	4	3	to	0.00	0.90	0.33	28.79	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.33	69.75	100.37
WTN16	4	4	core	0.00	0.96	0.30	28.93	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.31	69.37	100.12
WTN16	4	5	to	0.00	1.00	0.28	29.03	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.28	69.21	99.99
WTN16	4	6	inner quench zone	0.00	0.82	0.23	29.17	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.27	69.03	99.84
WTN16	4	7	middle quench zone	0.00	0.56	0.79	30.36	0.23	0.00	0.19	0.41	0.00	0.00	0.00	0.41	69.65	102.58
WTN16	4	8	outer quench zone	0.00	0.31	0.30	28.76	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.26	69.59	99.55
WTN16	4	9	to margin	0.00	0.00	0.57	29.12	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.20	70.32	100.68
WTN16	4	10	interstitial olivine	0.00	0.00	0.68	29.20	0.00	0.00	0.17	0.80	0.00	0.00	0.00	0.00	69.11	99.96
WTN16	4	11	interstitial olivine	0.00	0.27	0.77	28.66	0.38	0.00	0.63	0.79	0.00	0.00	0.00	0.00	66.75	98.25
WTN16	4	12	quench magnetite	0.00	0.00	7.73	0.86	0.00	0.00	0.00	0.12	2.27	0.24	0.27	0.00	82.59	94.09
WTN16	4	13	quench magnetite	0.00	0.00	9.13	1.34	0.00	0.00	0.00	0.00	2.34	0.29	0.00	0.00	82.25	95.35
WTN16	4	14	wustite dendrite	0.00	0.00	0.54	0.91	0.00	0.00	0.00	0.00	0.18	0.20	0.00	0.00	95.23	97.05
WTN16	4	15	wustite dendrite	0.00	0.00	1.01	1.44	0.00	0.00	0.09	0.27	0.36	0.00	0.00	0.00	94.06	97.24
WTN16	4	16	i/s glass/crystallites	1.08	0.00	15.42	38.73	1.25	1.14	6.41	7.14	0.43	0.00	0.00	0.00	28.82	100.42
WTN16	4	17	i/s glass/crystallites	0.32	0.00	21.62	17.38	0.68	0.48	0.26	1.25	0.00	0.00	0.00	0.00	43.18	85.18
WTN16	4	18	glass?	1.52	0.00	17.17	35.72	0.93	0.56	6.74	5.32	0.36	0.00	0.00	0.00	25.38	93.70
WTN16	6	1	olivine outer		0.57	0.23	28.24				0.26					69.12	98.41
WTN16	6	2	olivine outer		0.89	0.37	28.31				0.20					68.08	98.56
WTN16	6	3	olivine inner		1.01	0.36	28.44				0.21					68.06	98.67
WTN16	6	4	olivine edge of solid		1.22	1.41	28.38				0.24					67.96	99.79
WTN16	6	5	olivine core		1.06	0.44	28.12				0.22					67.63	97.94
WTN16	6	6	olivine inner		0.68	0.37	28.07				0.30					67.64	97.64
WTN16	6	7	olivine margin		0.52	0.00	27.77				0.30					67.49	96.49
WTN17	3	1	olivine outer	0.00	0.00	0.25	26.92	0.00	0.00	0.00	0.35	0.00			0.27	66.12	93.91
WTN17	3	2	olivine inner	0.00	0.76	0.00	26.96	0.00	0.00	0.00	0.27	0.00			0.23	66.20	94.42
WTN17	3	3	olivine core	0.00	0.89	0.22	27.45	0.00	0.00	0.00	0.24	0.00			0.26	66.41	95.47
WTN17	3	4	olivine core	0.00	0.96	0.29	27.49	0.00	0.00	0.00	0.21	0.00			0.29	67.25	96.49
WTN17	3	5	olivine	0.00	0.89	0.00	27.64	0.00	0.00	0.00	0.26	0.00			0.22	67.27	96.27

WTN17	3	6	inner quench zone	0.00	0.96	0.35	27.78	0.00	0.00		0.00	0.26	0.00	0.30	67.43	97.07
WTN17	3	7	to	0.00	0.99	0.00	28.11	0.00	0.00		0.00	0.26	0.00	0.21	67.90	97.47
WTN17	3	8	outer quench zone	0.00	0.55	0.28	28.30	0.00	0.00		0.00	0.32	0.00	0.27	68.58	98.31
WTN17	3	9	to blocky zone	0.00	0.43	0.00	28.24	0.00	0.00		0.00	0.34	0.00	0.24	68.99	98.25
WTN17	3	10	olivine margin	0.00	0.34	0.26	27.97	0.21	0.00		0.00	0.50	0.00	0.36	68.91	98.56
WTN17	3	11	i/s block olivine	0.00	0.00	0.29	27.68	0.21	0.00		0.00	0.78	0.00	0.00	67.86	96.82
WTN17	3	12	i/s blocky olivine	0.00	0.28	0.40	27.84	0.00	0.00		0.21	0.54	0.00	0.29	68.05	97.61
WTN17	3	13	i/d blocky olivine	0.00	0.29	0.36	27.68	0.00	0.00		0.00	0.41	0.00	0.24	68.43	97.41
WTN17	3	14	i/s glass	1.32	0.00	17.07	38.19	1.08	0.64		7.07	6.99	0.48	0.00	25.67	99.31
WTN17	3	15	i/s glass	1.30	0.00	17.52	40.76	1.15	1.07		7.11	8.57	0.39	0.00	21.91	99.78
WTN17	3	16	i/s glass	1.14	0.00	15.67	38.60	1.40	1.26		6.68	8.72	0.33	0.00	24.10	97.90
WTN17	4	1	olivine core	0.00	1.02	0.00	28.03	0.00	0.00		0.00	0.31		0.25	67.52	97.13
WTN17	4	2	olivine quench zone	0.00	0.83	0.00	27.76	0.23	0.20		0.09	0.29		0.23	68.42	98.06
WTN17	4	3	olivine margin	0.00	0.00	0.40	27.64	0.21	0.00		0.00	0.50		0.00	68.29	97.04
WTN17	4	4	late olivine margin	0.24	0.00	0.45	28.67	0.21	0.00		0.14	0.71		0.33	68.06	98.80
WTN17	4	5	late olivine core	0.00	0.38	0.30	28.23	0.00	0.00		0.00	0.29		0.23	68.67	98.11
WTN17	4	6	late olivine core	0.00	0.52	0.31	27.47	0.00	0.00		0.00	0.34		0.32	68.11	97.07
WTN17	4	7	latest skeletal olivine	0.26	0.00	0.91	25.69	0.27	0.00		0.85	0.84		0.19	64.65	93.66
WTN17	4	8	glass with crystallites	1.19	0.00	16.75	40.03	1.33	1.07		7.15	7.68		0.00	22.74	97.94
WTN17	4	9	glass with crystallites	1.29	0.00	15.92	38.81	1.30	0.94		6.85	5.56		0.00	27.30	97.96
WTN17	4	10	late olivine	0.00	0.00	0.85	27.94	0.29	0.00		0.39	0.62		0.00	66.33	96.41
WTN21	3	1	olivine core	0.00	0.57	1.53	26.91	0.42	0.00	0.00	0.00	0.50		1.79	63.56	95.27
WTN21	3	2	olivine outer	0.00	0.67	0.00	27.68	0.28	0.00	0.00	0.00	0.52		1.93	64.52	95.60
WTN21	3	3	glass	0.19	0.22	42.11	6.91	0.54	0.54	0.00	1.21	1.67		0.38	12.59	66.37
WTN21	3	4	glass	5.84	2.23	17.68	30.91	0.93	0.36	0.00	0.31	3.52		0.30	26.06	88.15
WTN21	4	1	wustite	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	129.75	129.75
WTN21	4	2	olivine outer	0.00	0.00	0.00	27.40	0.41	0.00		0.00	0.99	0.00	1.90	64.14	94.84
WTN21	4	3	olivine inner	0.00	0.56	0.00	27.50	0.37	0.00		0.00	0.55	0.00	1.83	64.29	95.09
WTN21	4	4	olivine outer	0.00	0.59	0.00	27.36	0.36	0.00		0.00	0.49	0.00	2.21	64.21	95.22
WTN21	4	5	olivine margin	0.00	0.44	0.00	27.58	0.20	0.00		0.00	0.72	0.00	1.95	64.43	95.32
WTN21	4	6	wustite dendrite	0.00	0.00	0.00	0.30	0.00	0.00		0.00	0.00	0.30	0.58	91.53	92.71
WTN21	4	7	glass with dendrites	1.95	0.00	17.71	34.27	2.08	0.40		6.42	6.37	0.23	0.50	28.13	98.06
WTN21	4	8	glass with dendrites	1.86	0.00	17.90	35.17	2.46	0.54		6.59	7.39	0.22	0.50	22.77	95.42

Table 7: EDS microanalysis data. Values presented as wt% oxide.

Figure 1

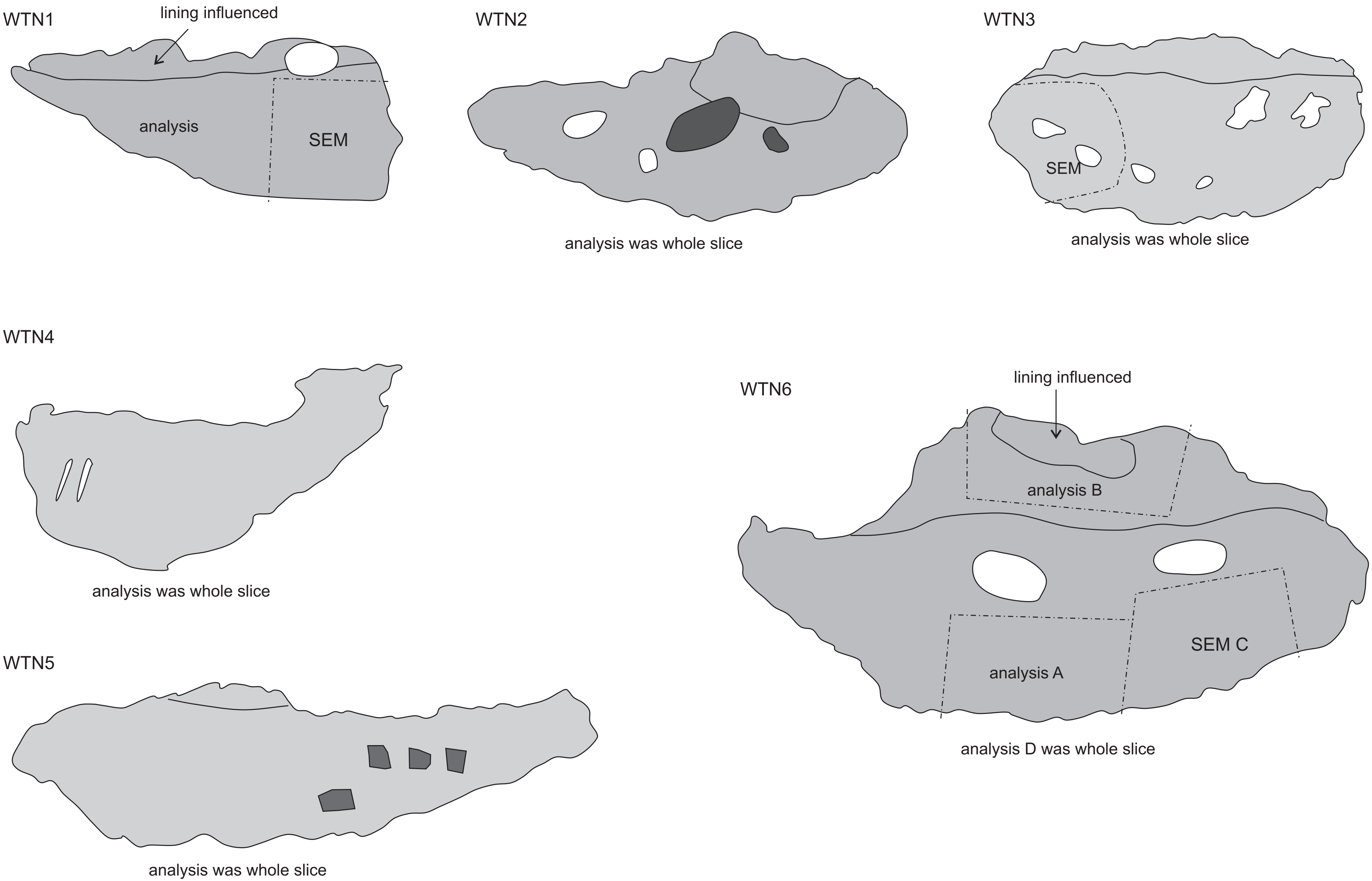
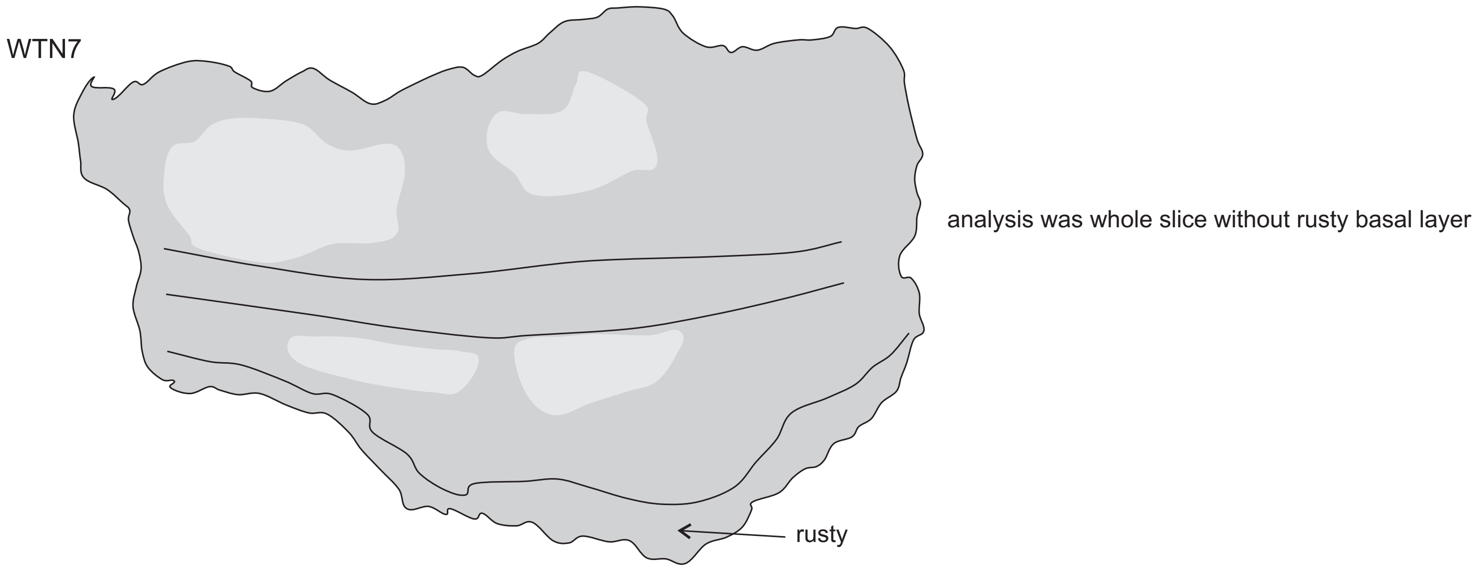
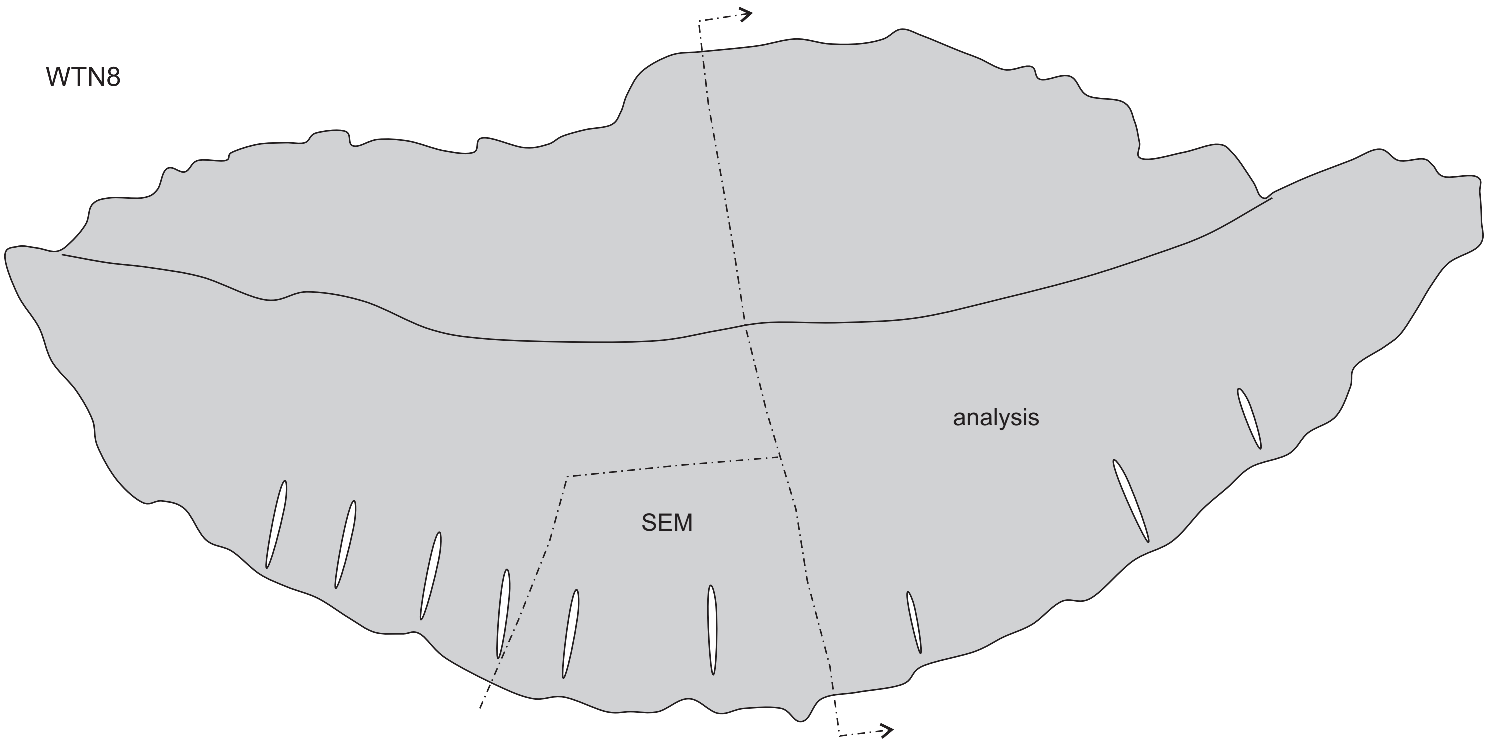

WTN1
lining influenced
analysis
SEM
WTN2
analysis was whole slice
WTN3
SEM
analysis was whole slice
WTN4
analysis was whole slice
WTN5
analysis was whole slice
WTN6
lining influenced
analysis B
analysis A
SEM C
analysis D was whole slice

Figure 2



WTN7
analysis was whole slice without rusty basal layer
rusty



WTN8
analysis
SEM

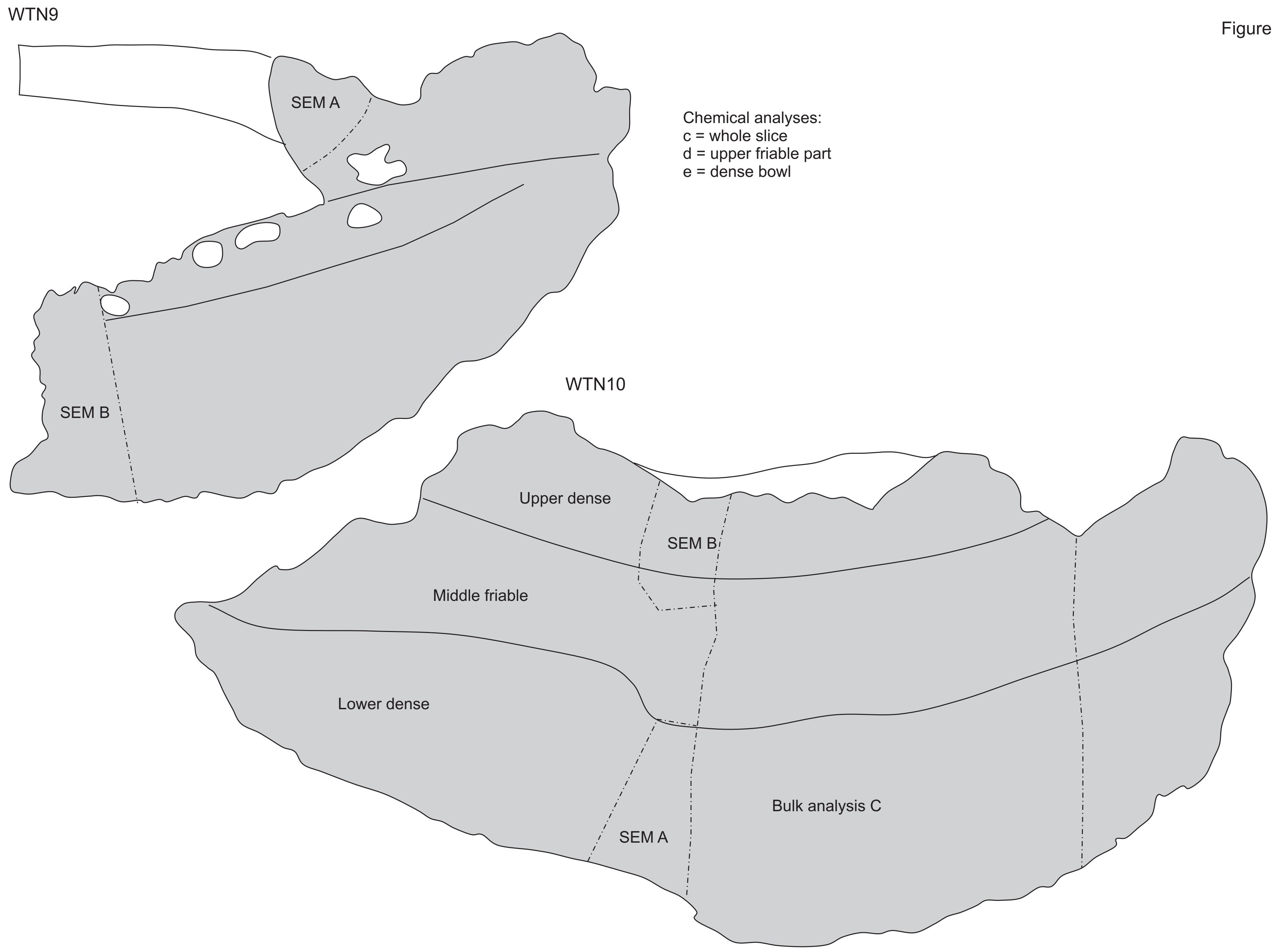

WTN9
SEM A
SEM B
Chemical analyses:
c = whole slice
d = upper friable part
e = dense bowl
WTN10
Upper dense
SEM B
Middle friable
Lower dense
SEM A
Bulk analysis C

Figure 4

WTN11

analysis was material from whole slice

Figure 5

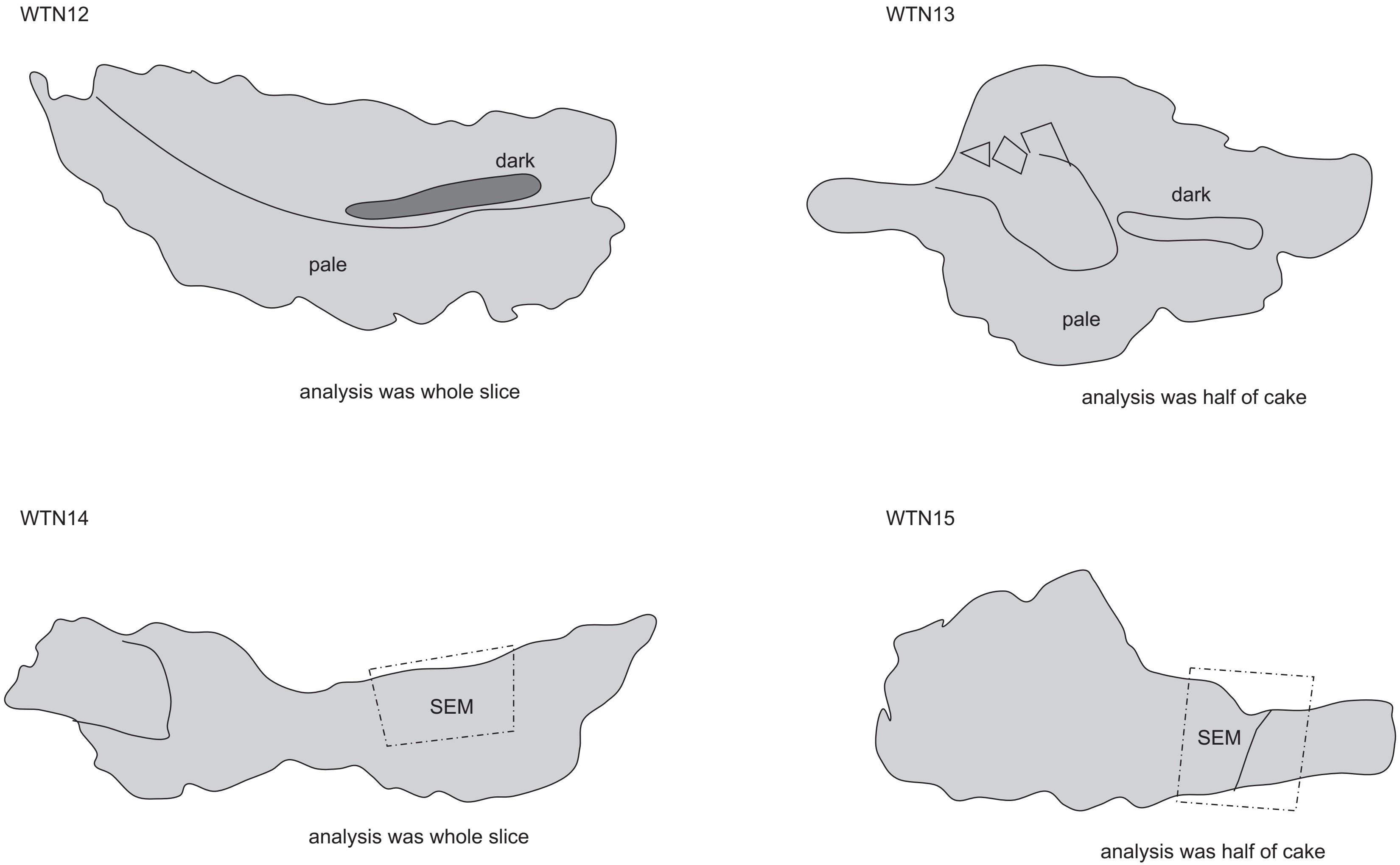

WTN12
dark
pale
analysis was whole slice
WTN13
dark
pale
analysis was half of cake
WTN14
SEM
analysis was whole slice
WTN15
SEM
analysis was half of cake

Figure 6

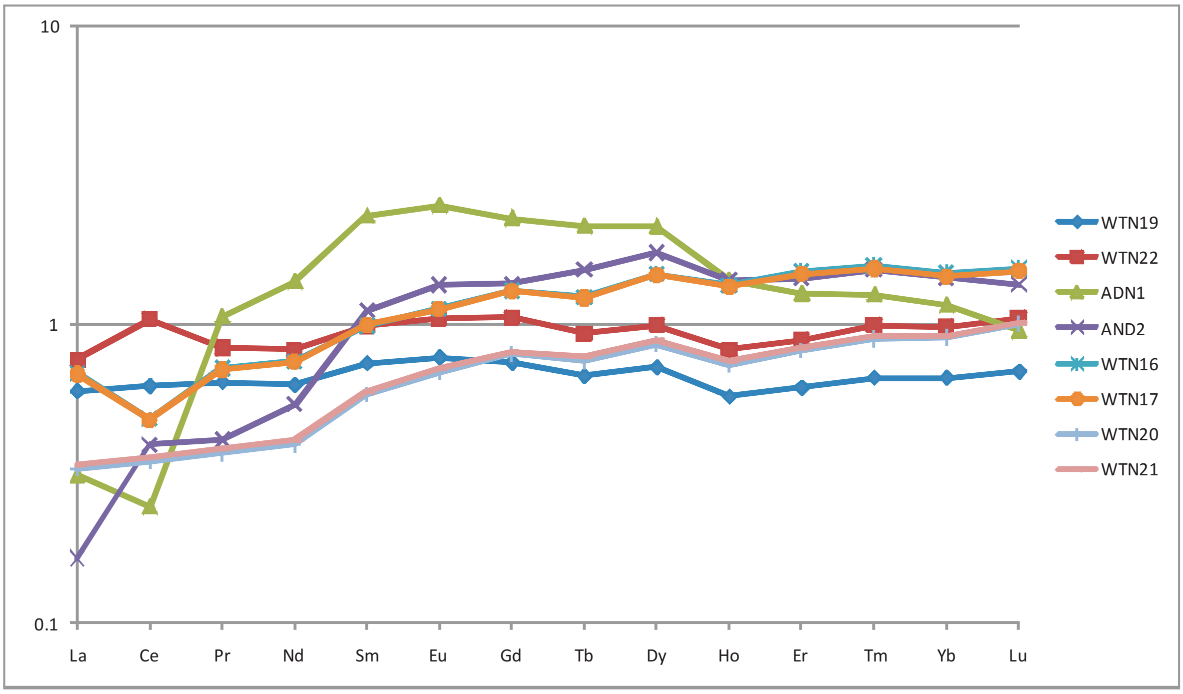
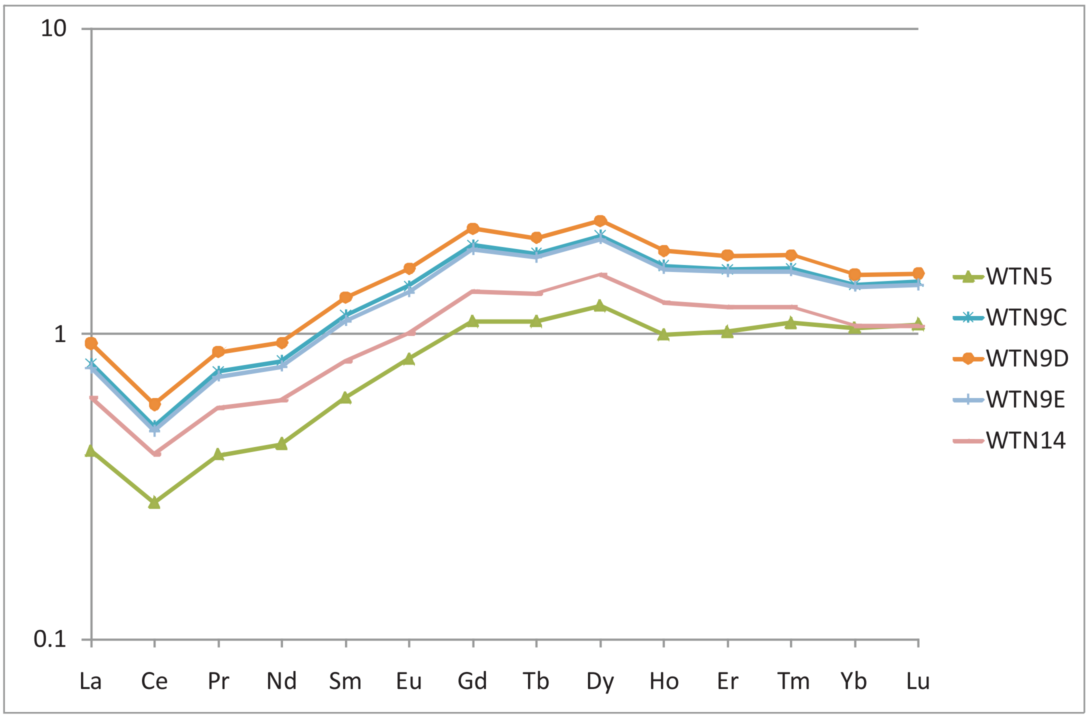
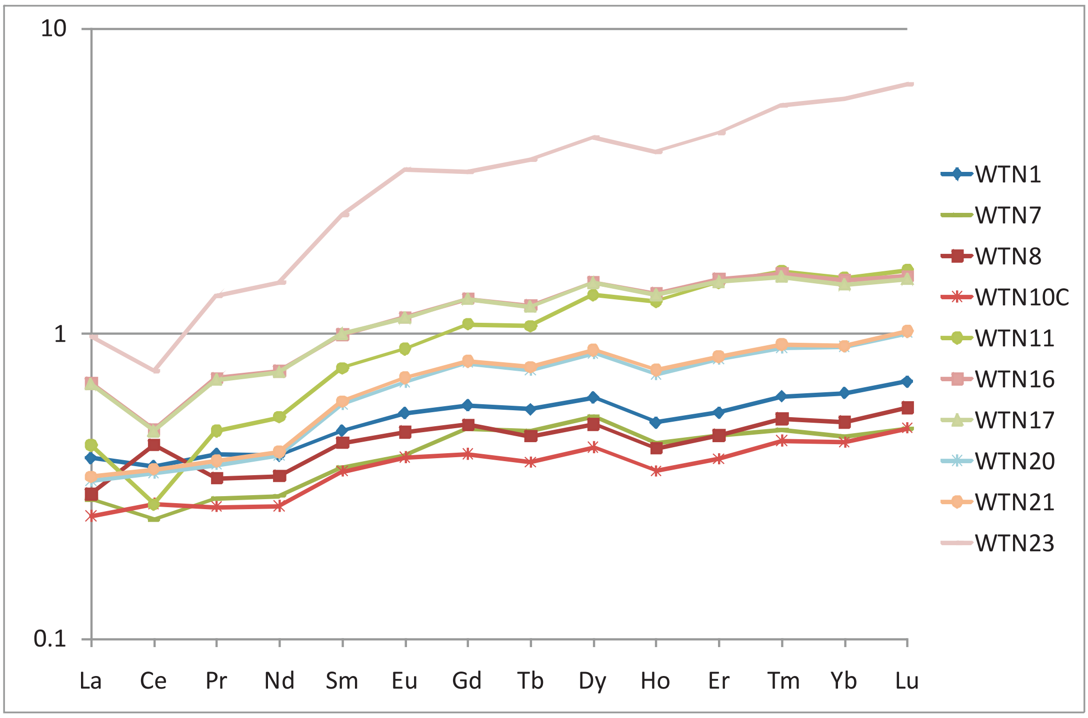

10
1
0.1
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
WTN19
WTN22
ADN1
AND2
WTN16
WTN17
WTN20
WTN21

Figure 7


10
1
0.1
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
WTN5
WTN9C
WTN9D
WTN9E
WTN14


10
1
0.1
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
WTN1
WTN7
WTN8
WTN10C
WTN11
WTN16
WTN17
WTN20
WTN21
WTN23

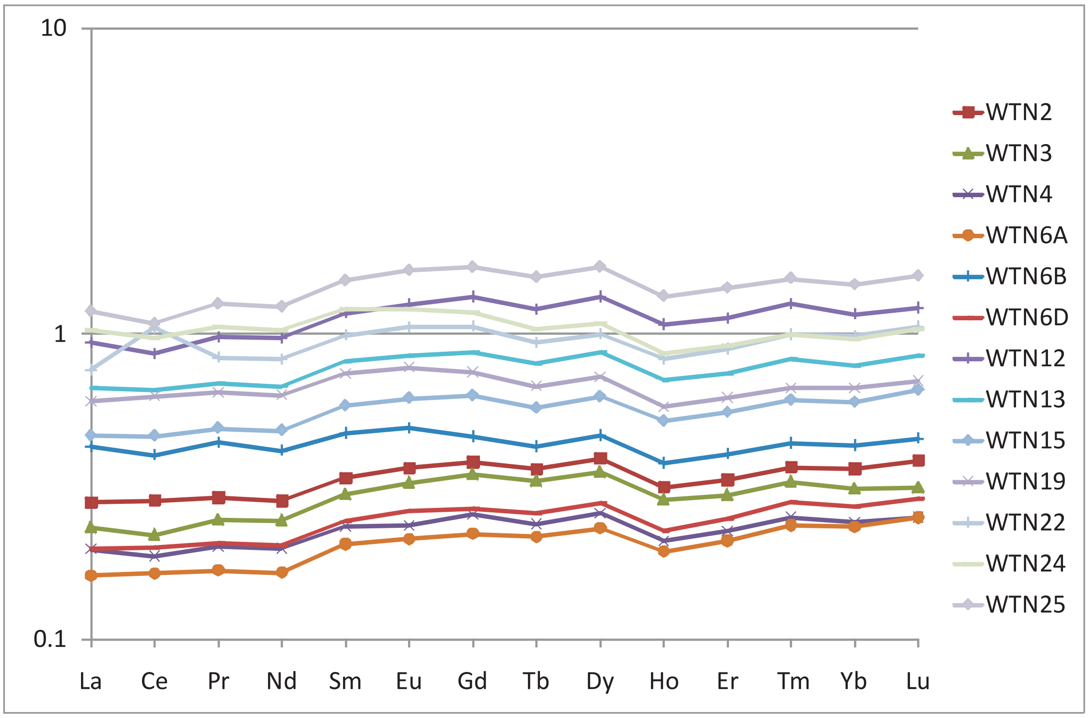
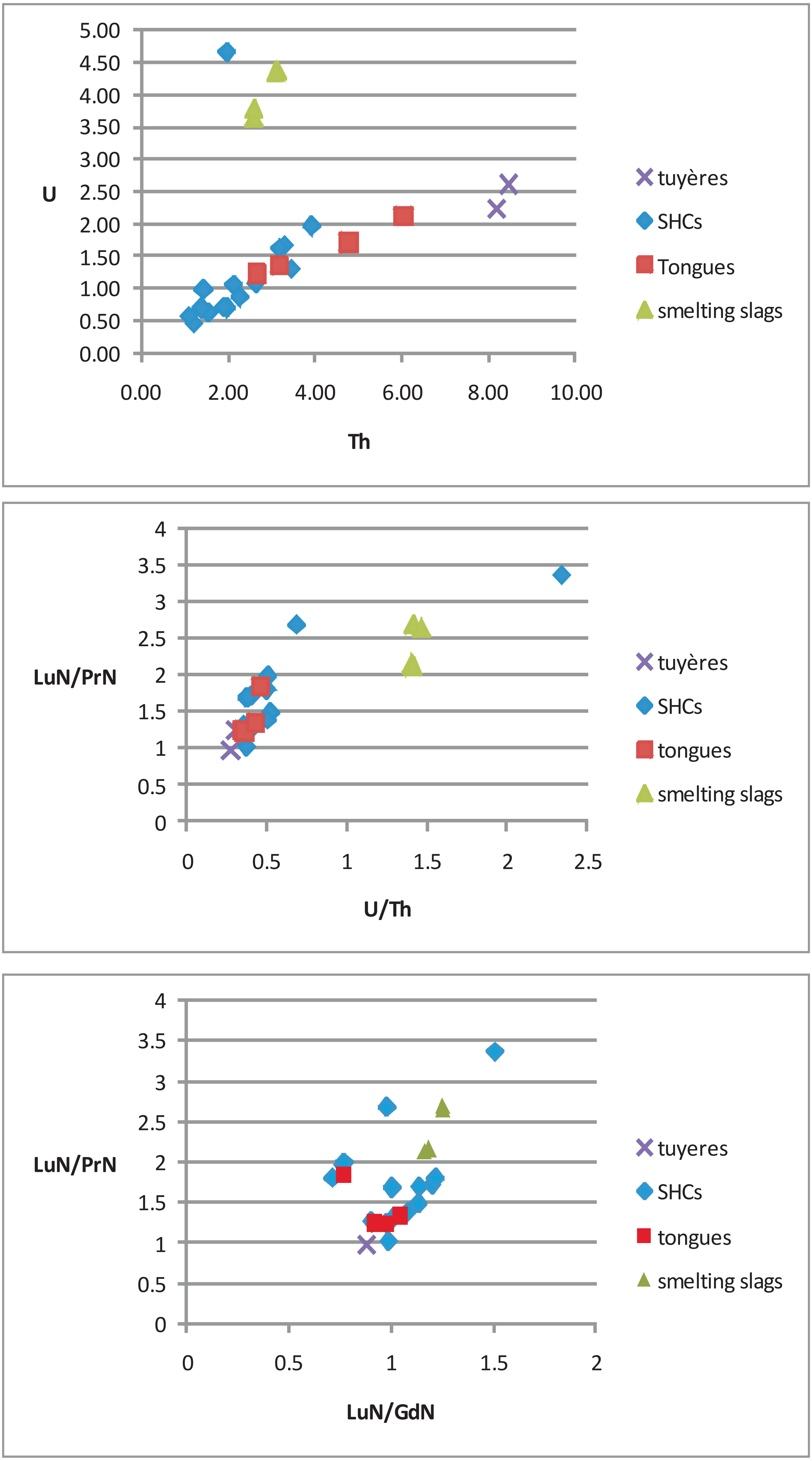

10
1
0.1
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
WTN2
WTN3
WTN4
WTN6A
WTN6B
WTN6D
WTN12
WTN13
WTN15
WTN19
WTN22
WTN24
WTN25

Figure 8



5.00
4.50
4.00
3.50
3.00
U
2.50
2.00
1.50
1.00
0.50
0.00
0.00
2.00
4.00
6.00
8.00
10.00
Th
tuyères
SHCs
Tongues
smelting slags
4
3.5
3
2.5
LuN/PrN
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
U/Th
tuyères
SHCs
tongues
smelting slags
4
3.5
3
2.5
LuN/PrN
2
1.5
1
0.5
0
0
0.5
1
1.5
2
LuN/GdN
tuyeres
SHCs
tongues
smelting slags

Plate 1

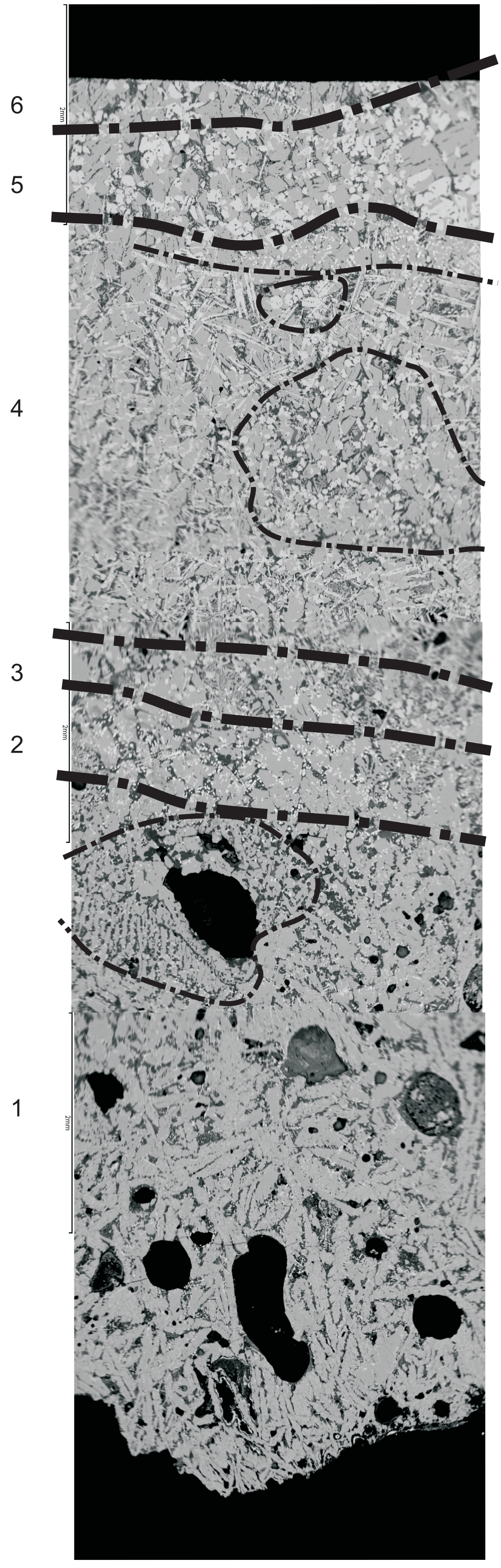
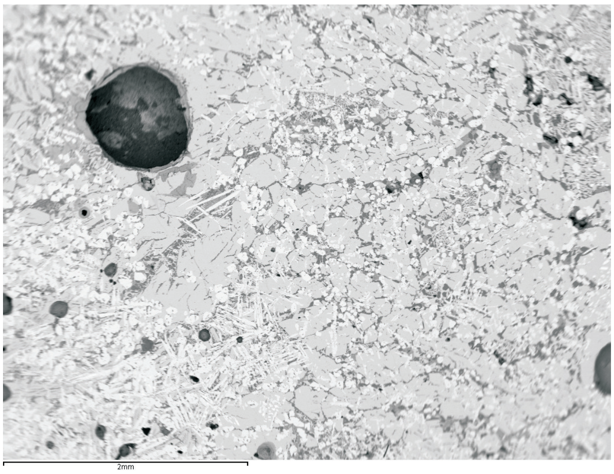
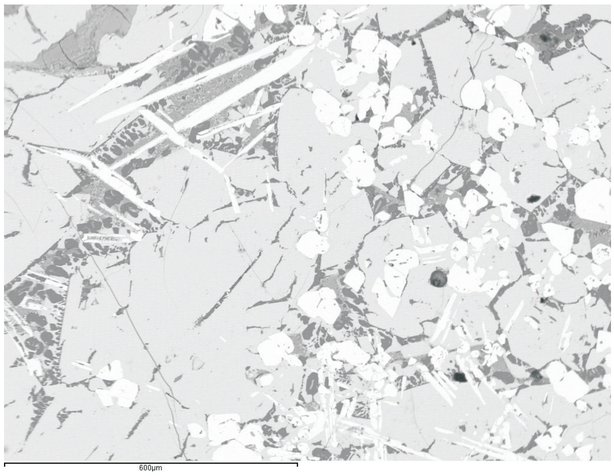


Plate 2

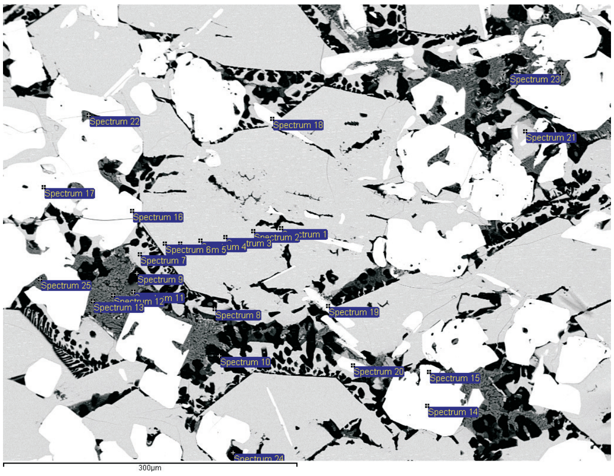
a



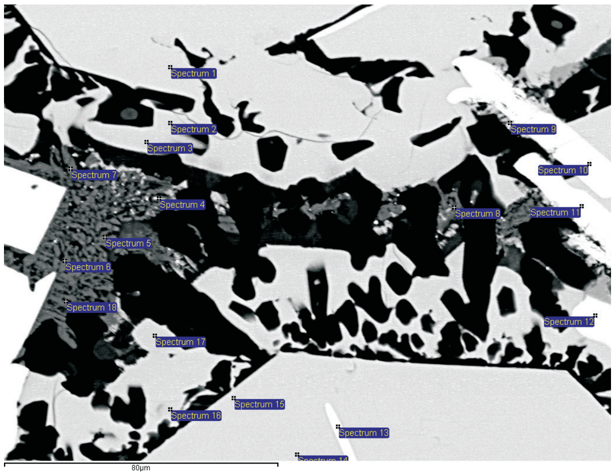
b



c



d



e

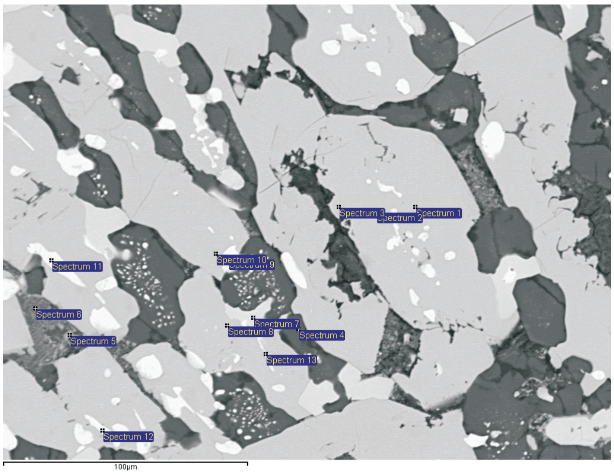
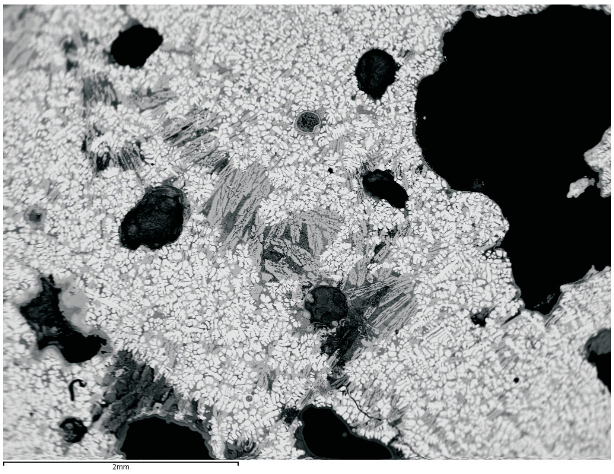
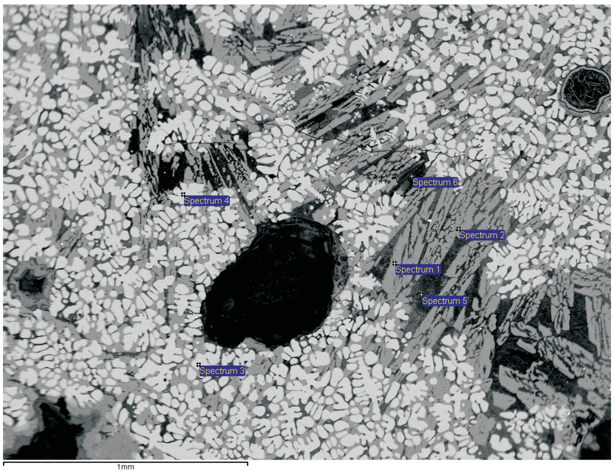


Plate 3

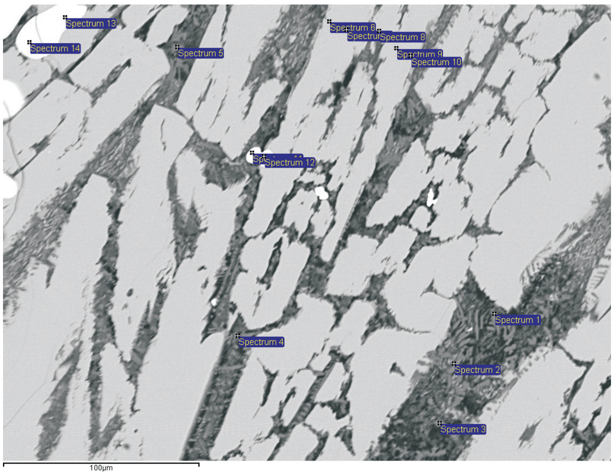
a



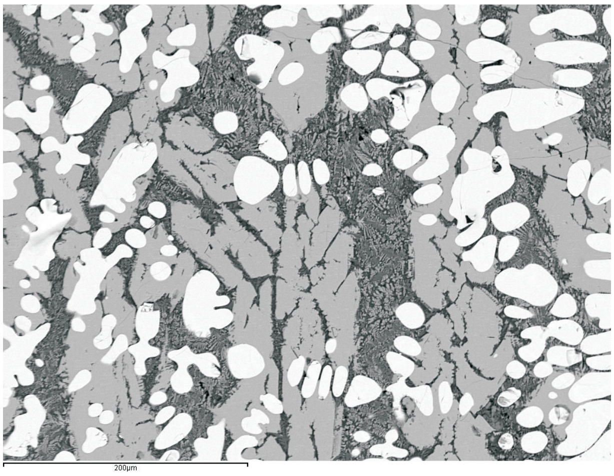
b



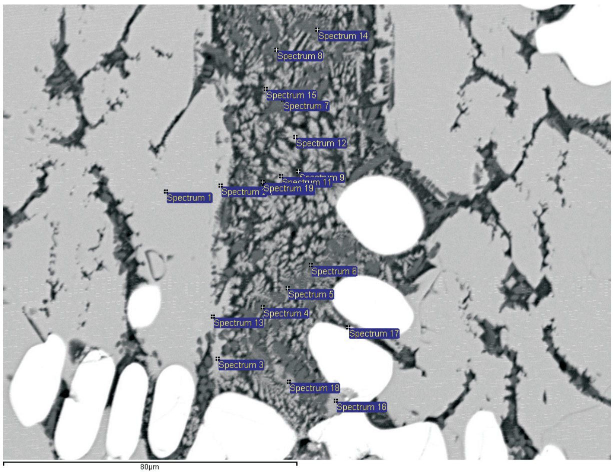
c



d



e



a b Plate 4

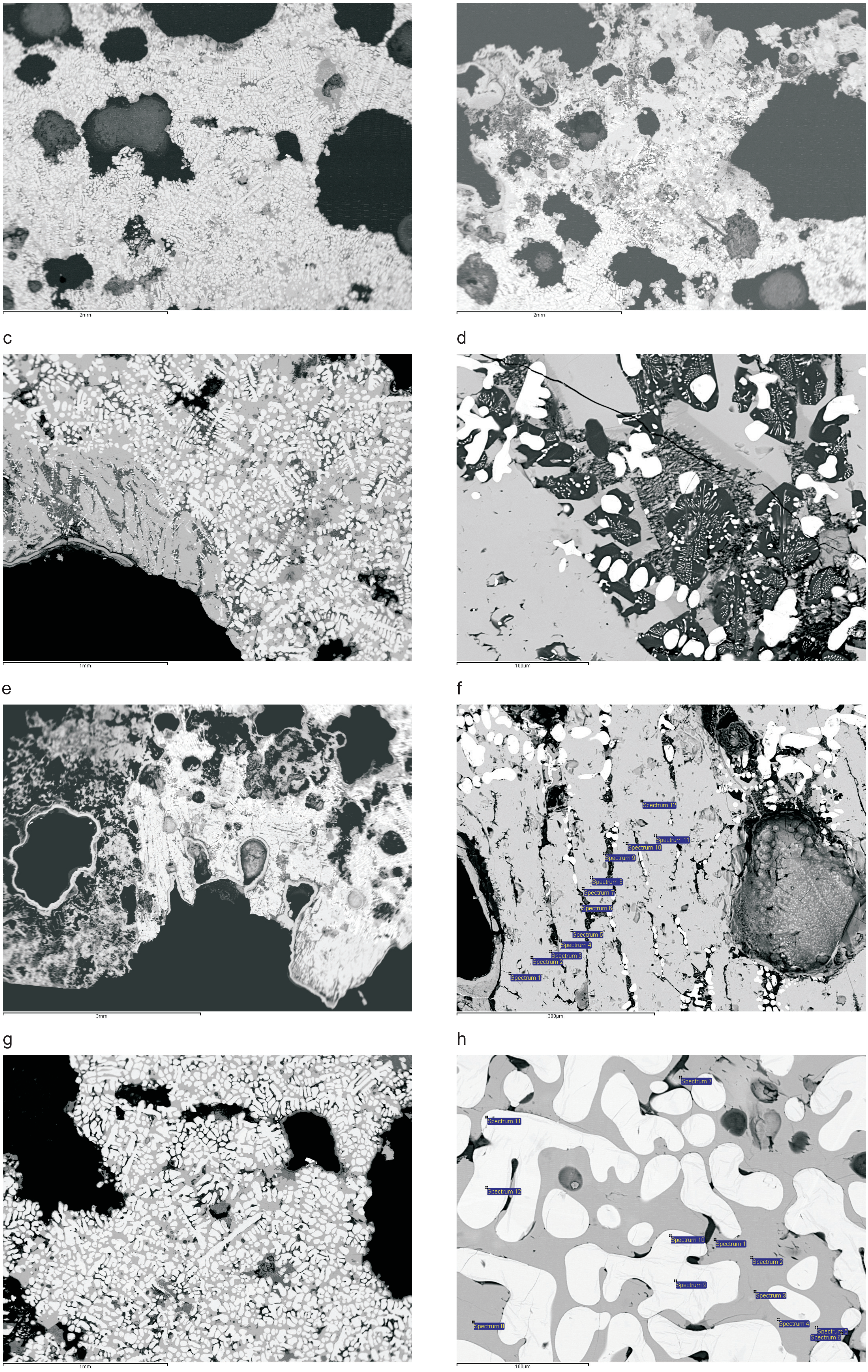
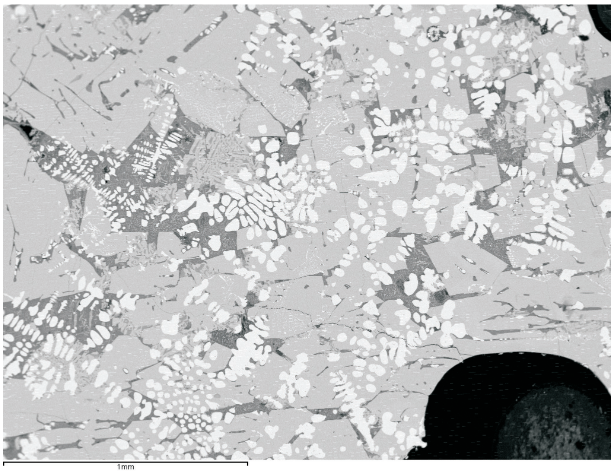
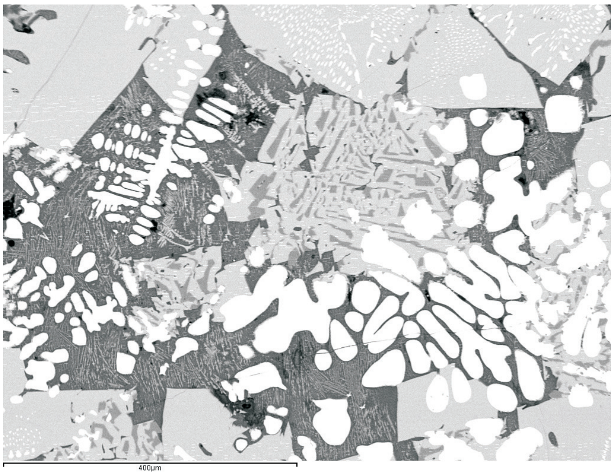

2mm
2mm
c
d
1mm
100µm
e
f
Spectrum 12
Spectrum 11
Spectrum 10
Spectrum 9
Spectrum 8
Spectrum 7
Spectrum 6
Spectrum 5
Spectrum 4
Spectrum 3
Spectrum 2
Spectrum 1
3mm
300µm
g
h
Spectrum 7
Spectrum 11
Spectrum 12
Spectrum 10
Spectrum 1
Spectrum 2
Spectrum 9
Spectrum 3
Spectrum 4
Spectrum 8
Spectrum 5
Spectrum 6
1mm
100µm

Plate 5

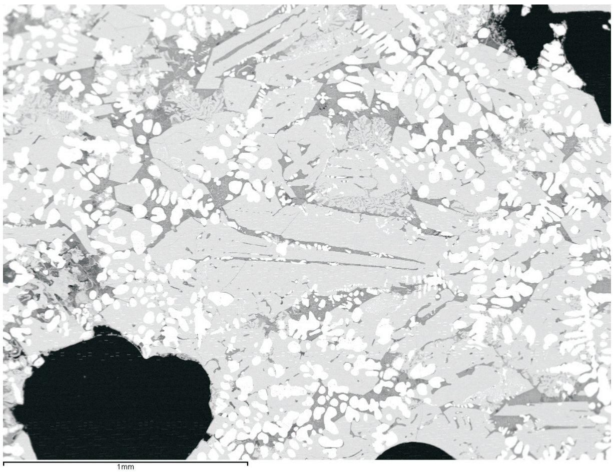
a



b



c



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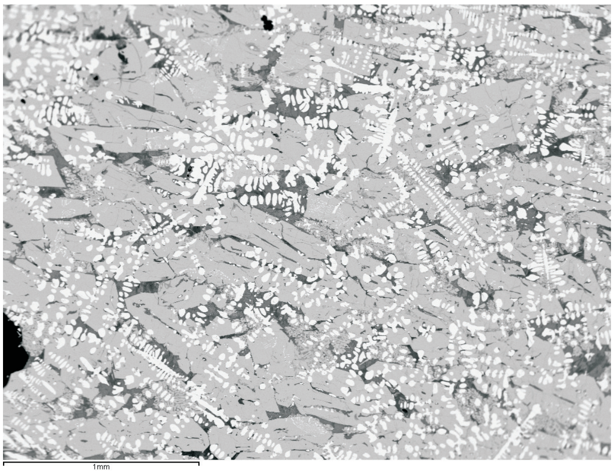

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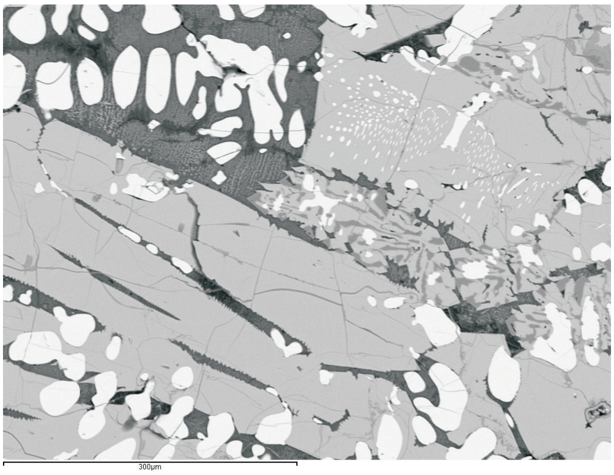

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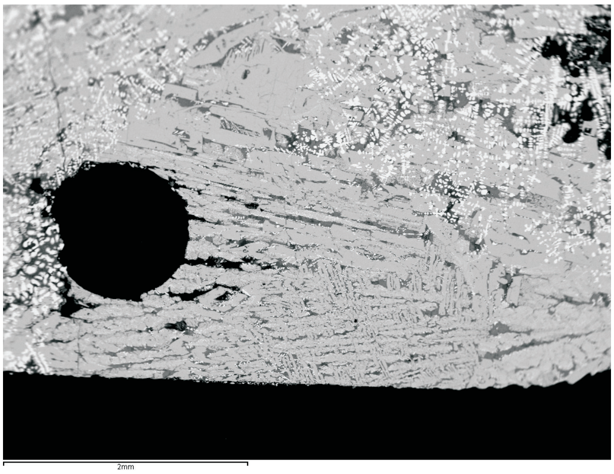
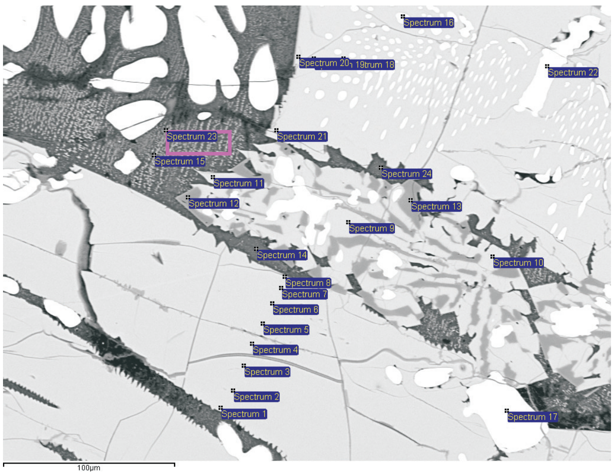


g



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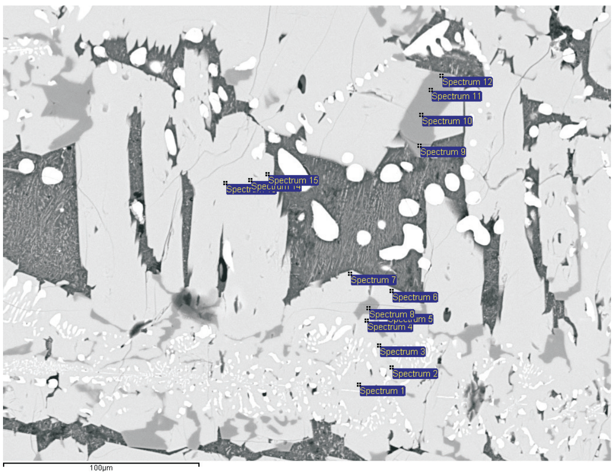


Plate 6

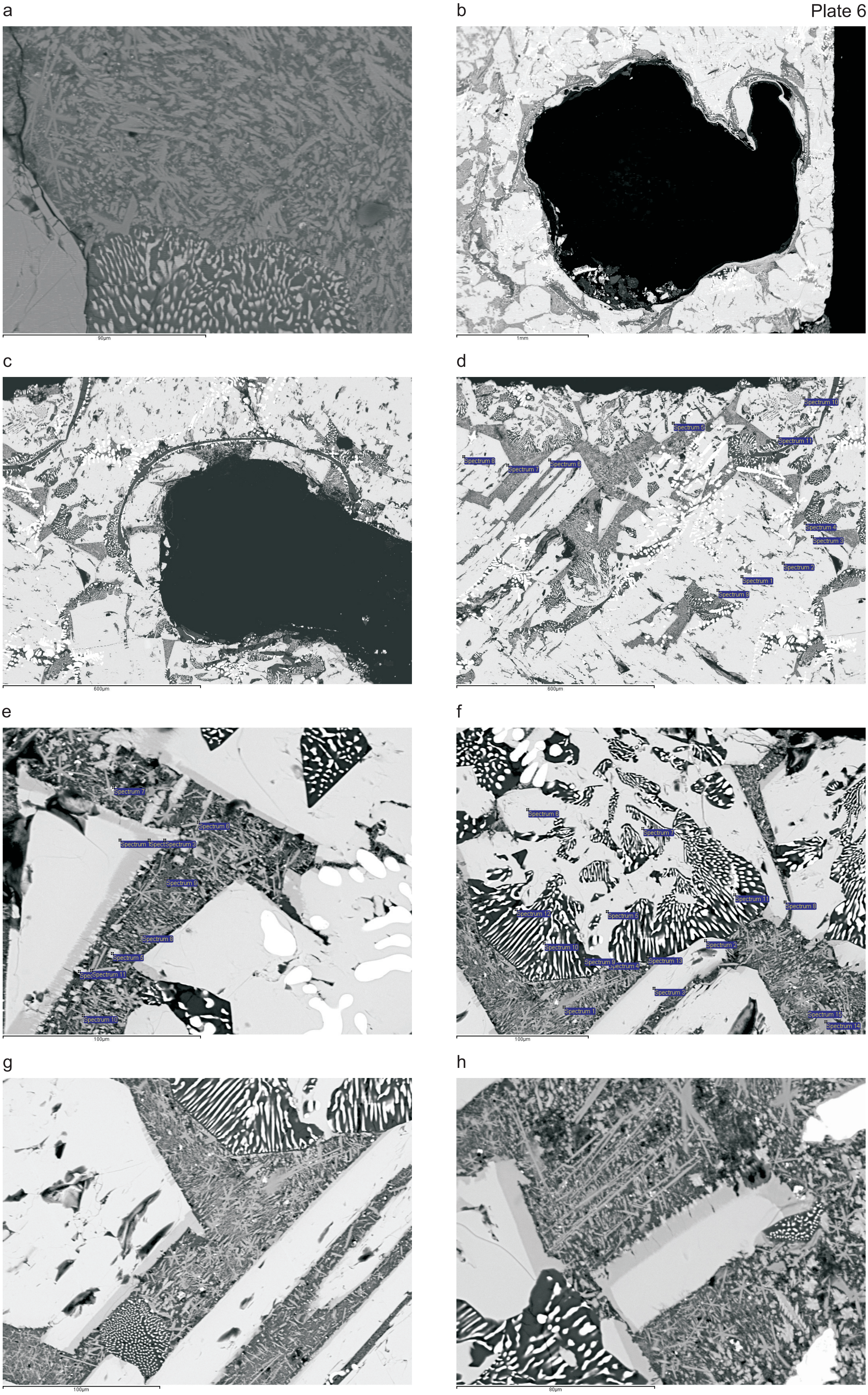
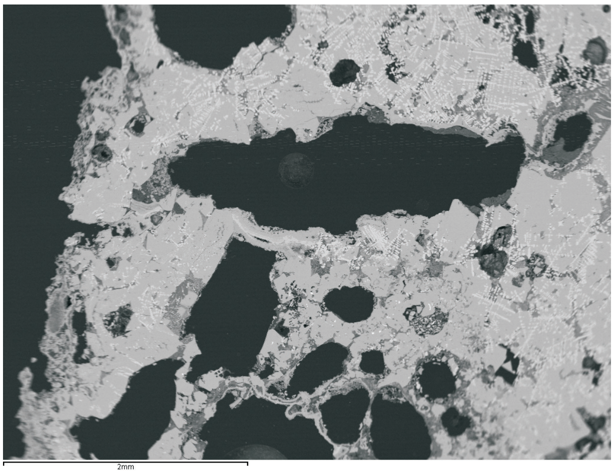
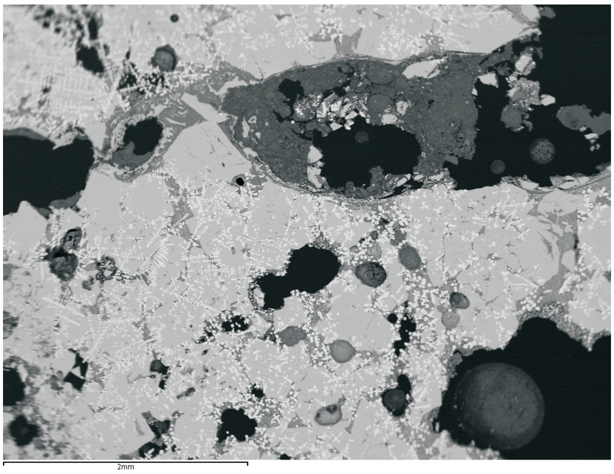


Plate 7

a



b



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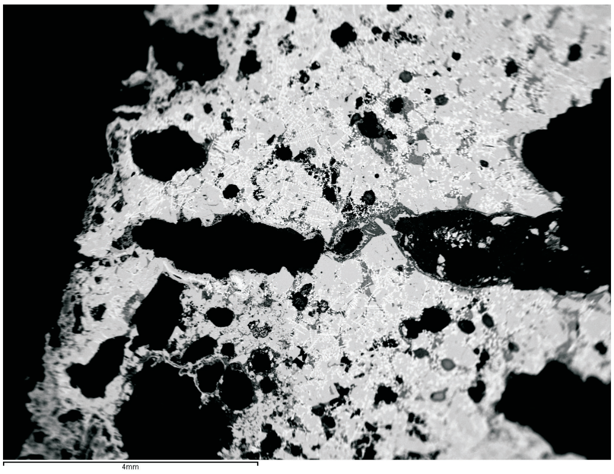

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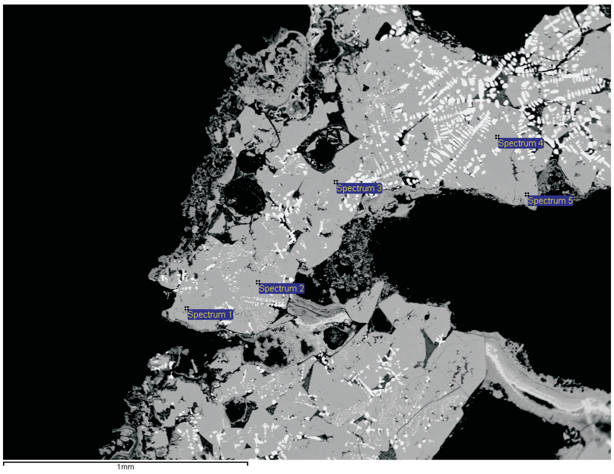

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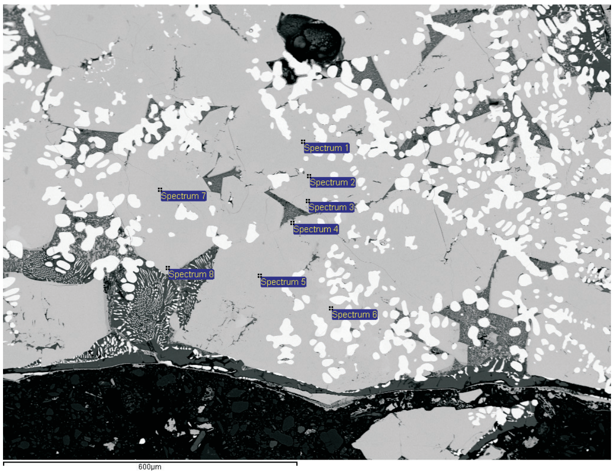

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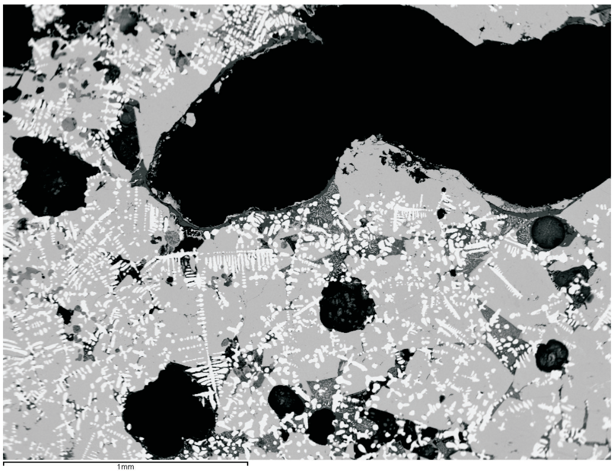


Plate 8

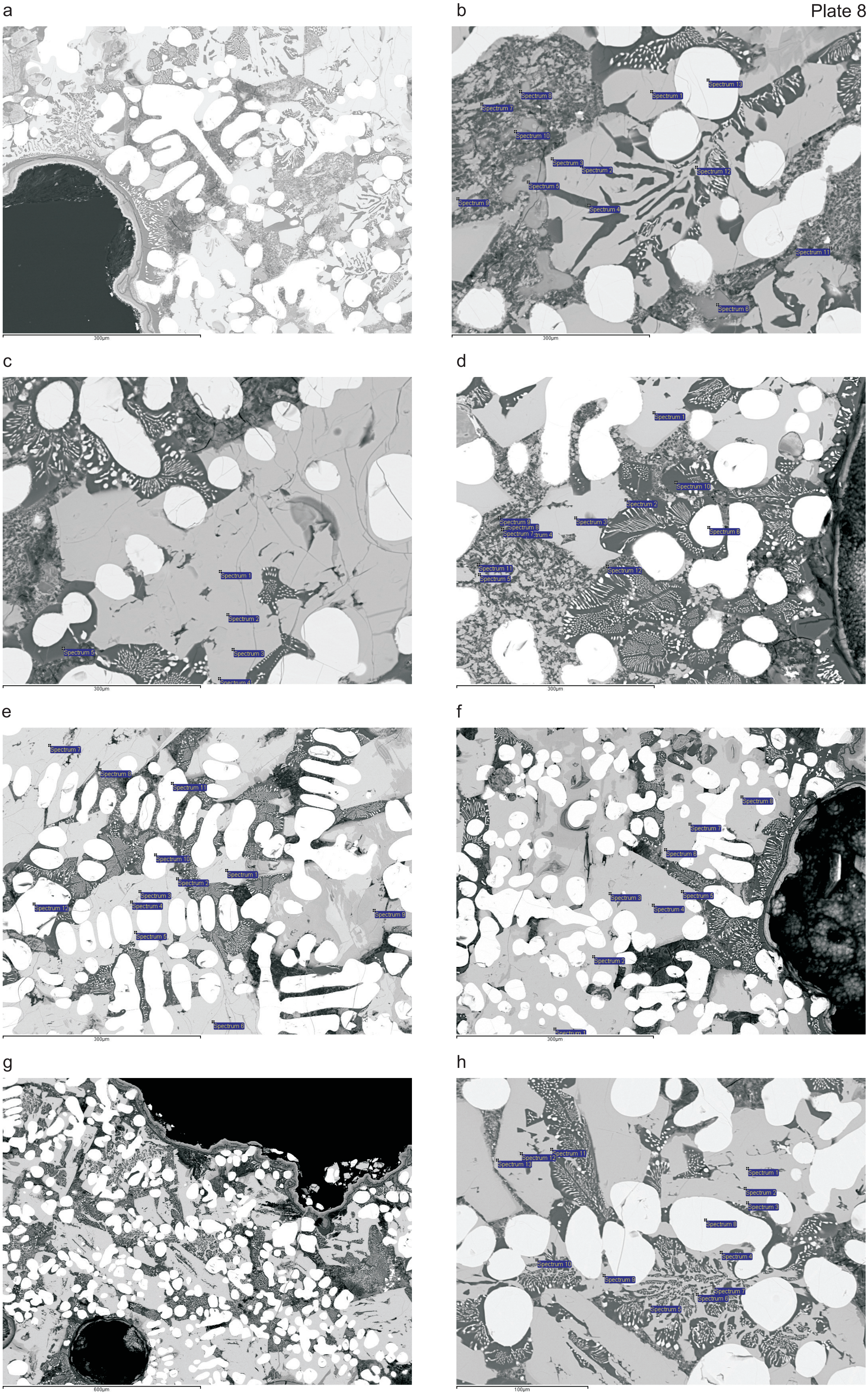
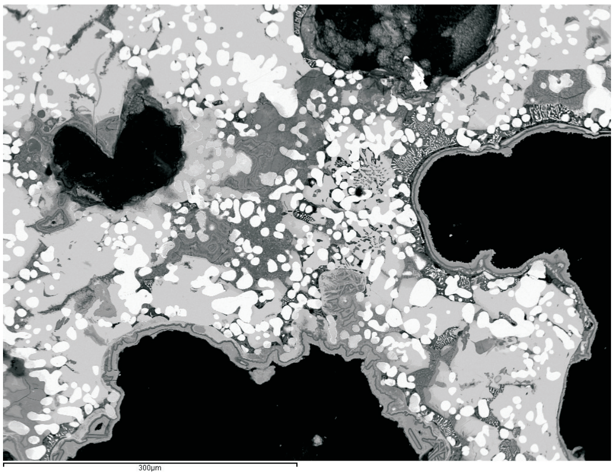
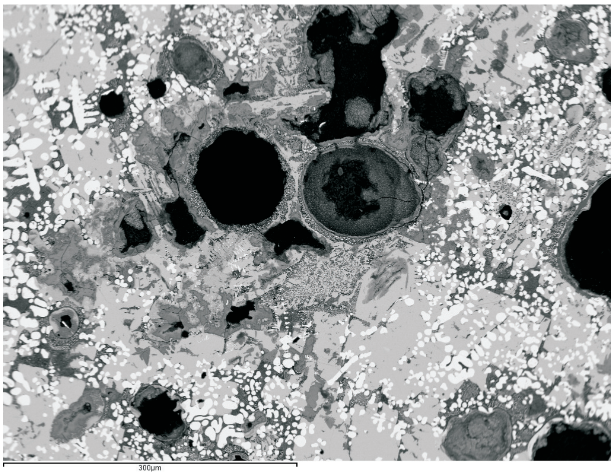


Plate 9

a



b



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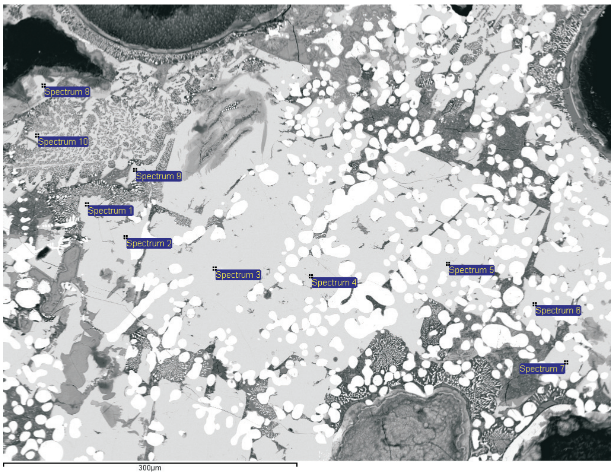

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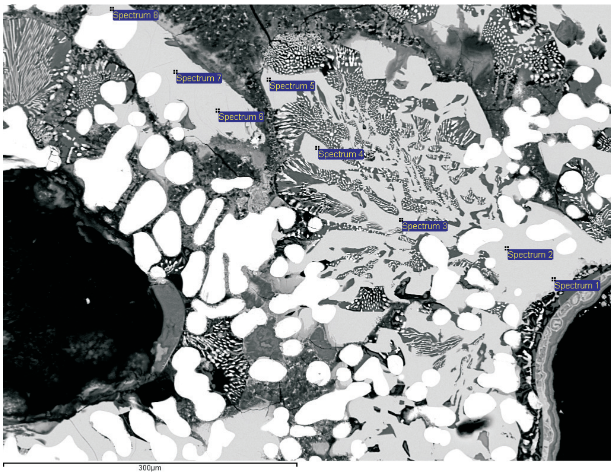

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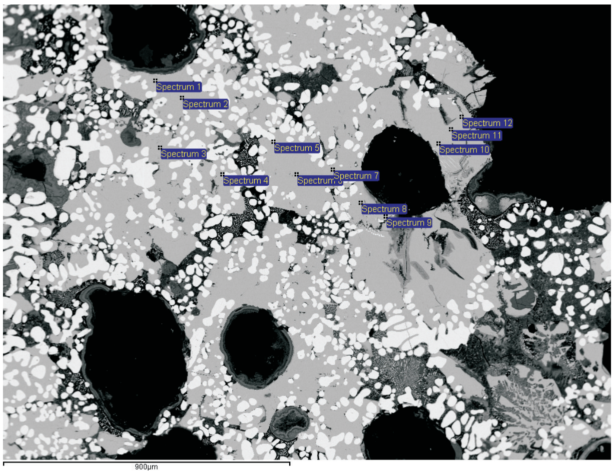

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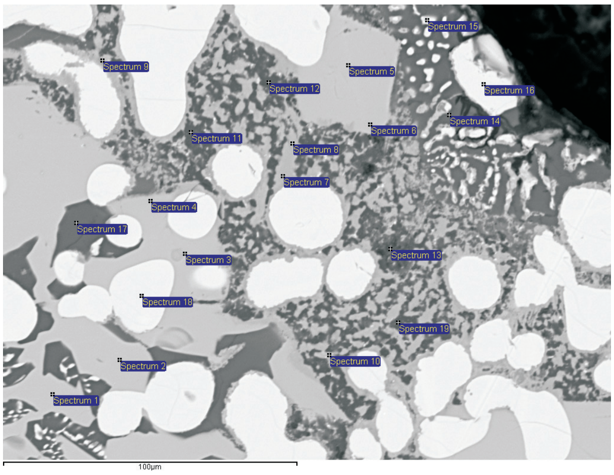
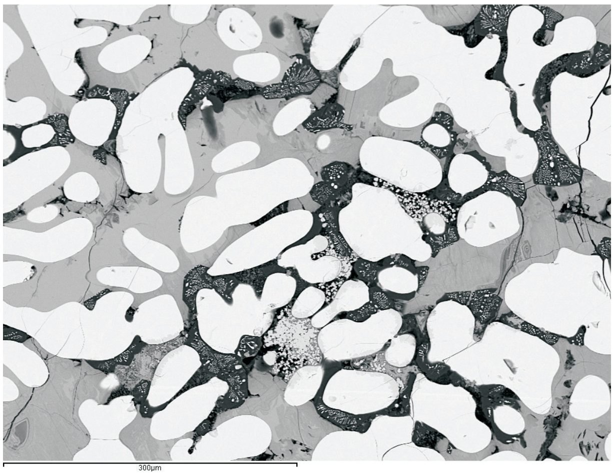


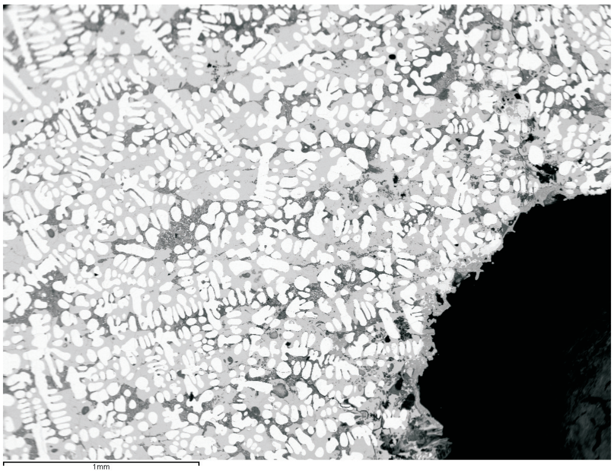
Plate 10

a

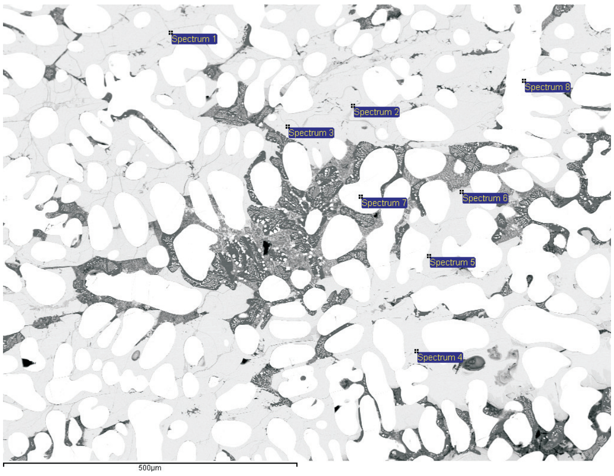
b



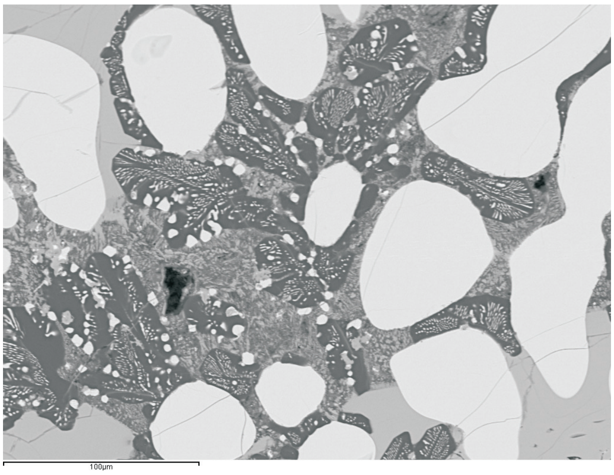
c



d



e



f

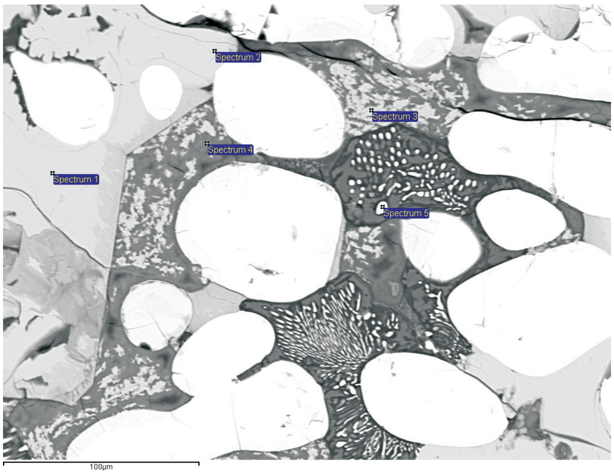
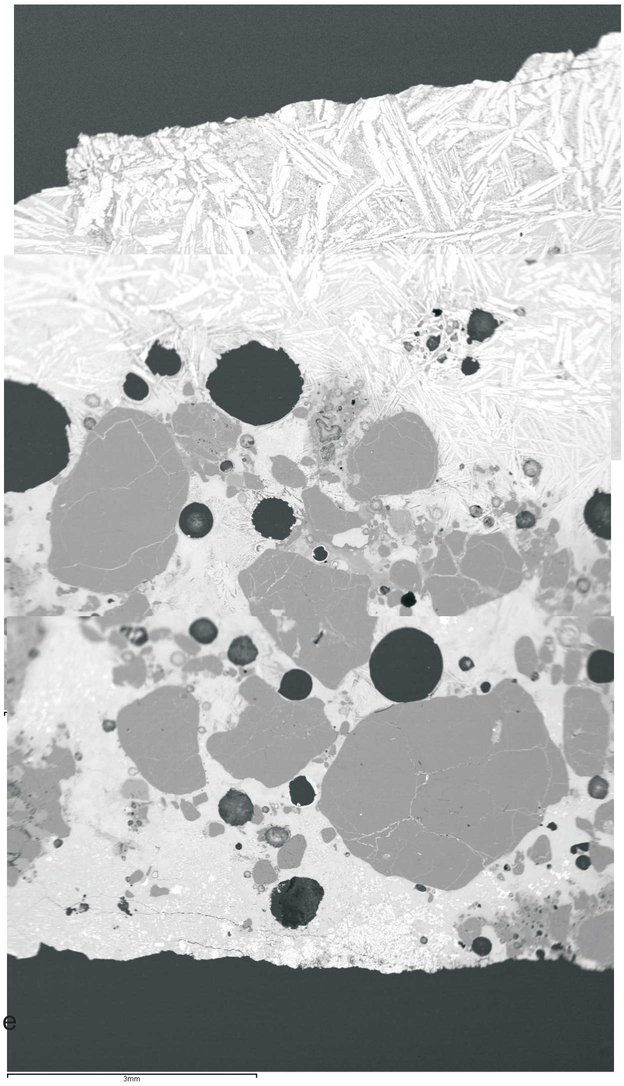


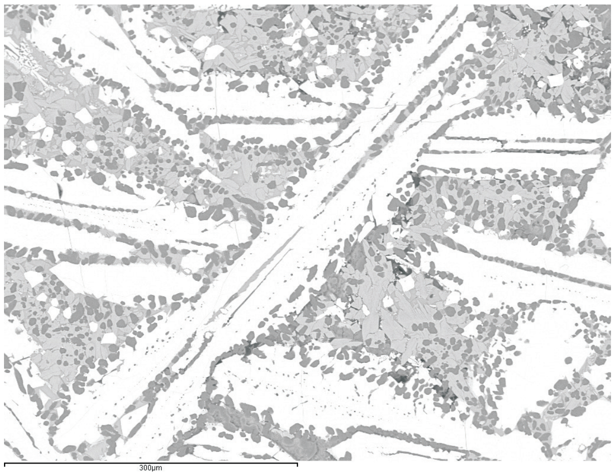
Plate 11

a

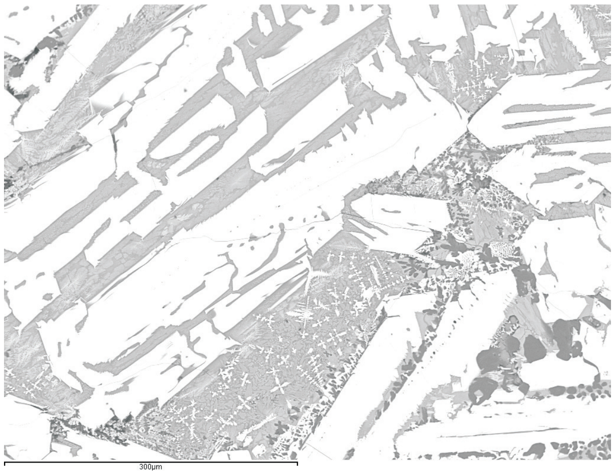


b

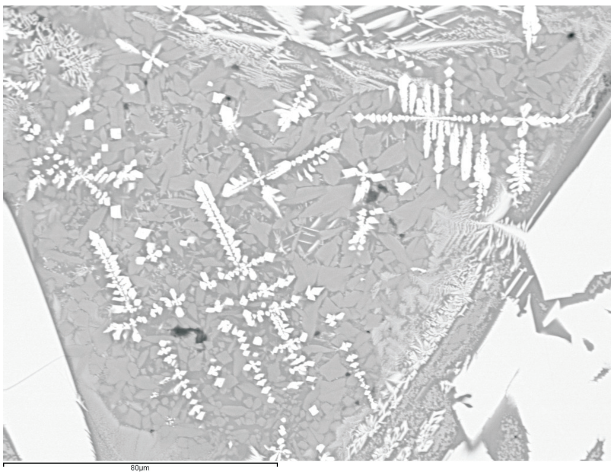
c



d



e



f

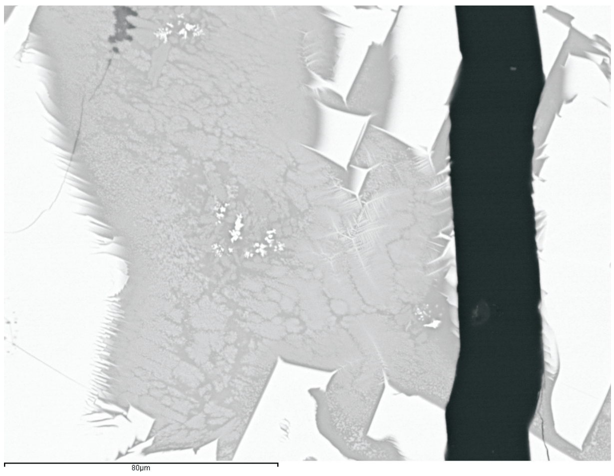
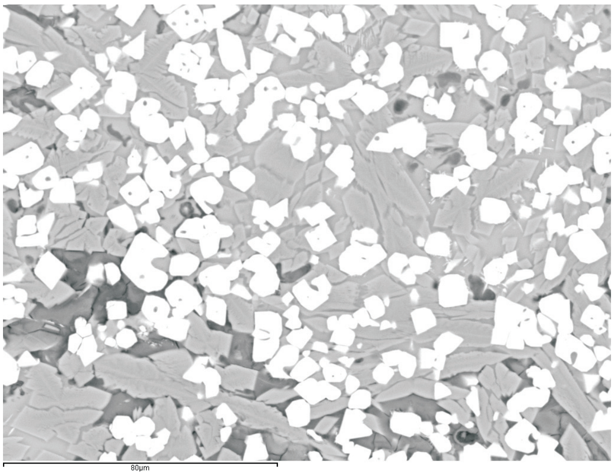
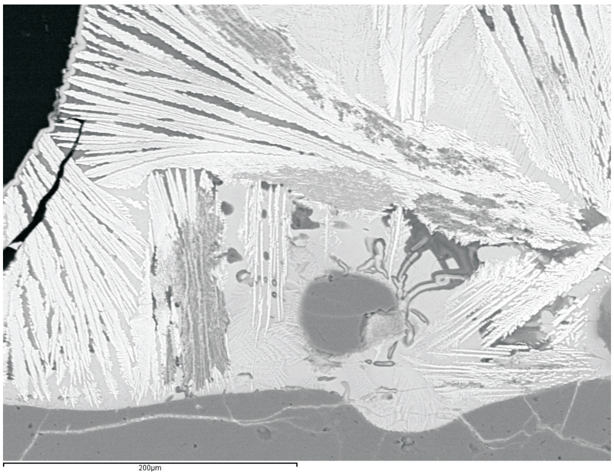


Plate 12

a



b



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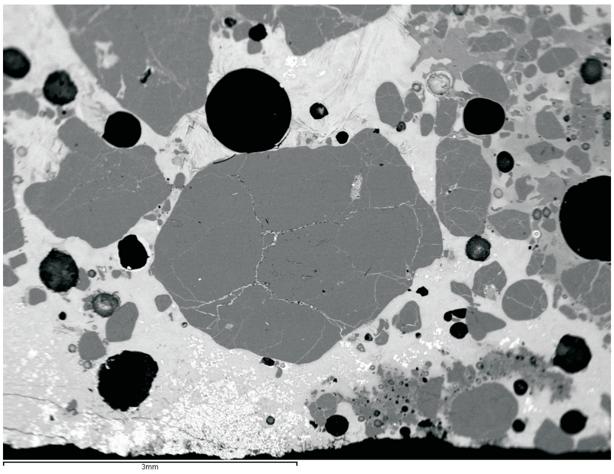

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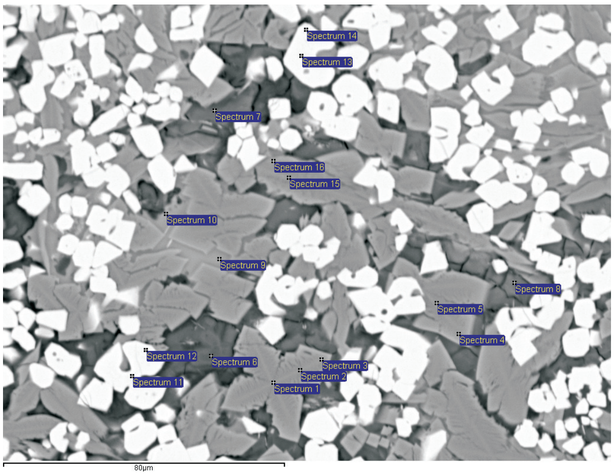

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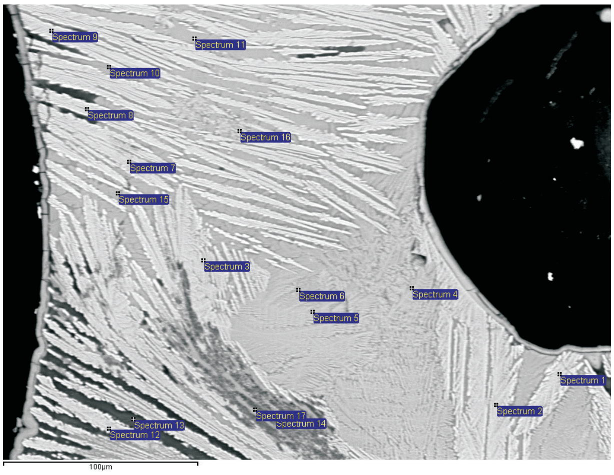
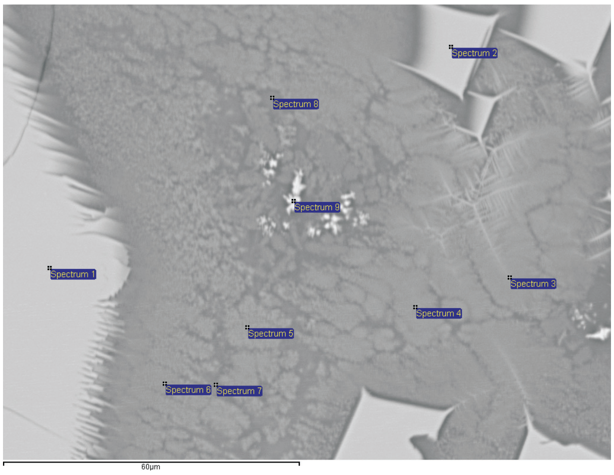


f



g

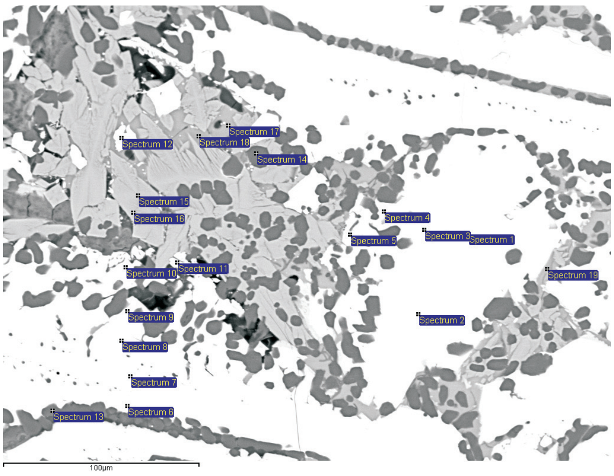


Plate 13

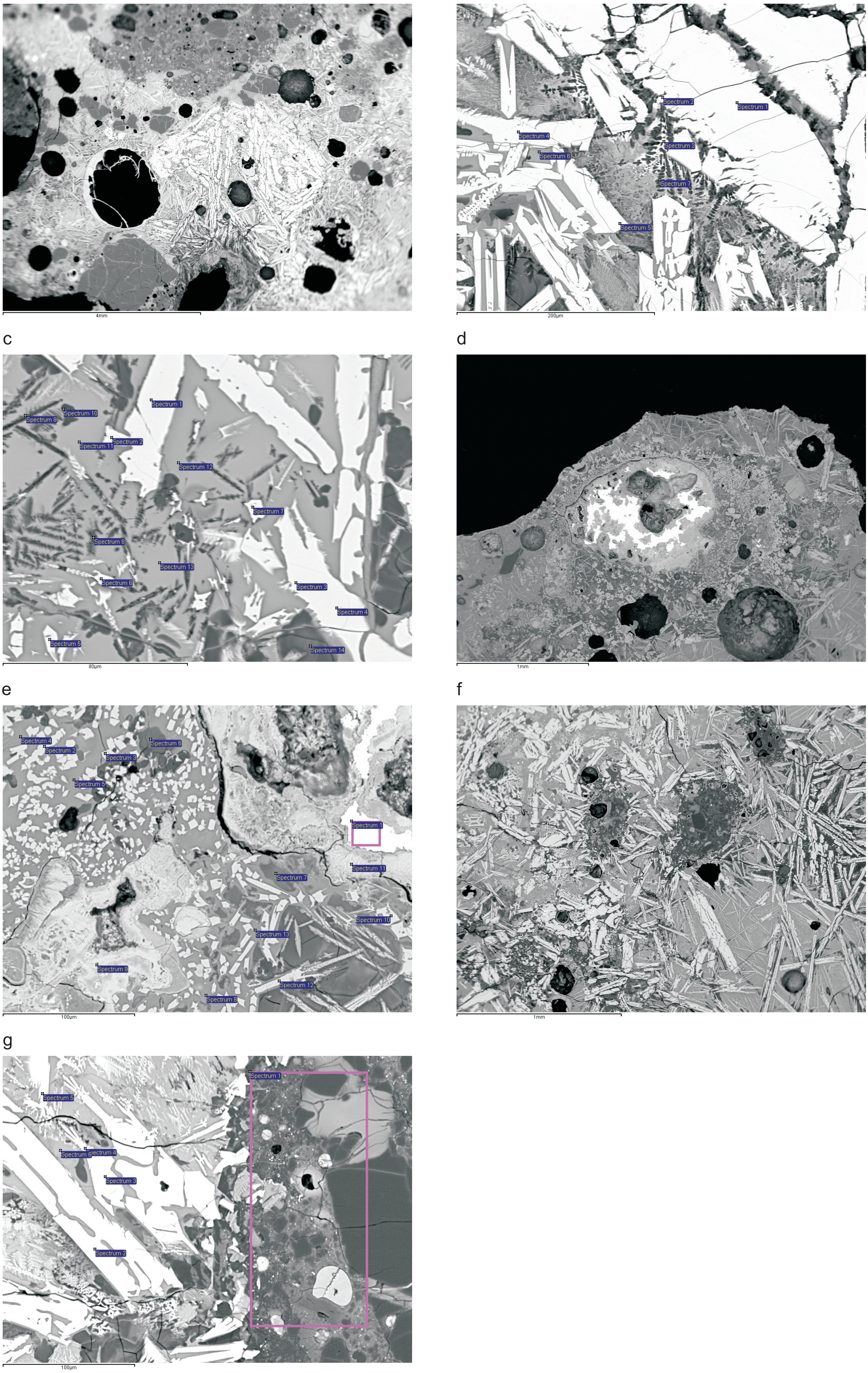
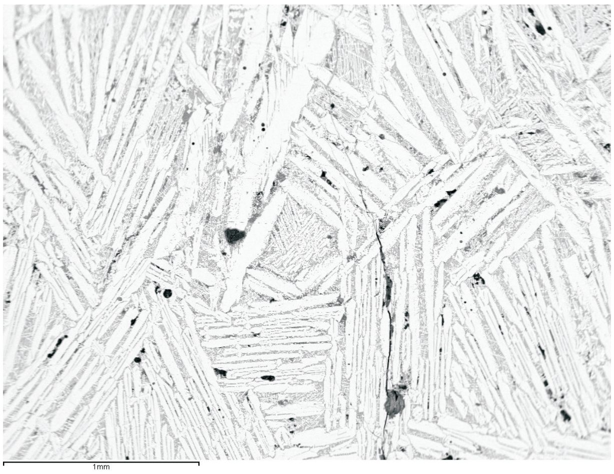
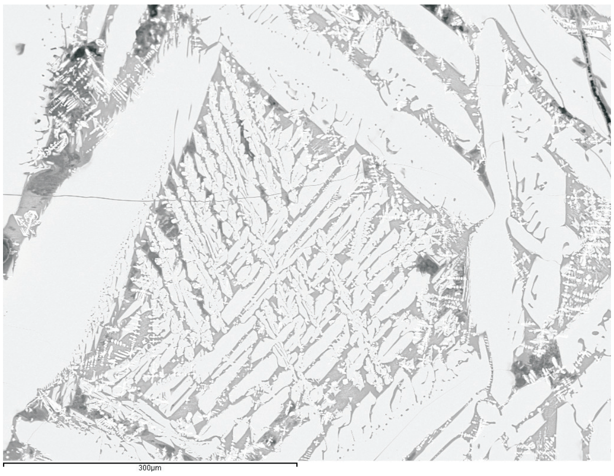

a
4mm
b
Spectrum 1
Spectrum 2
Spectrum 3
Spectrum 4
Spectrum 5
Spectrum 6
Spectrum 7
200µm
c
Spectrum 1
Spectrum 2
Spectrum 3
Spectrum 4
Spectrum 5
Spectrum 6
Spectrum 7
Spectrum 8
Spectrum 9
Spectrum 10
Spectrum 11
Spectrum 12
Spectrum 13
Spectrum 14
80µm
d
1mm
e
Spectrum 1
Spectrum 2
Spectrum 3
Spectrum 4
Spectrum 5
Spectrum 6
Spectrum 7
Spectrum 8
Spectrum 9
Spectrum 10
Spectrum 11
Spectrum 12
Spectrum 13
100µm
f
1mm
g
Spectrum 1
Spectrum 2
Spectrum 3
Spectrum 4
Spectrum 5
Spectrum 6
100µm

Plate 14

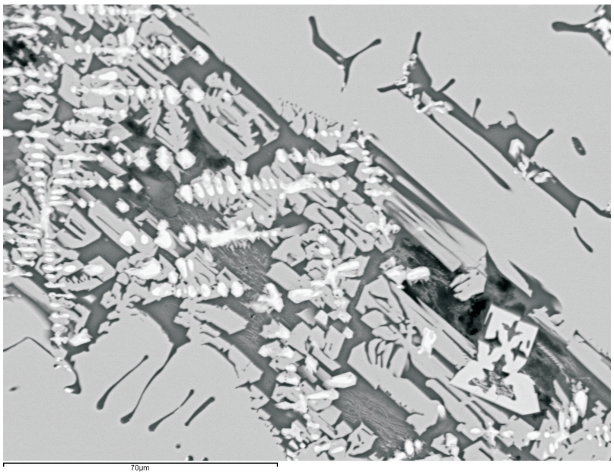
a



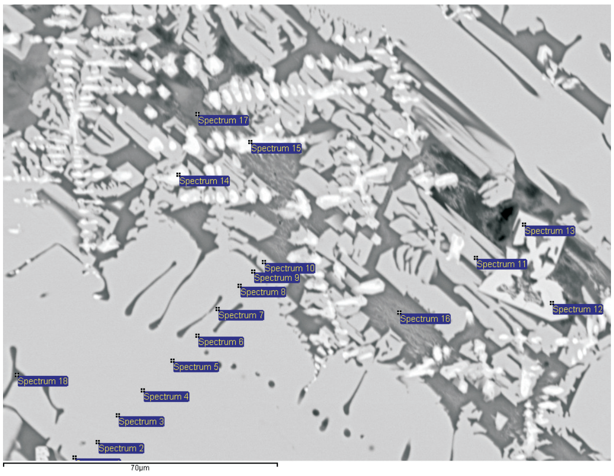
b



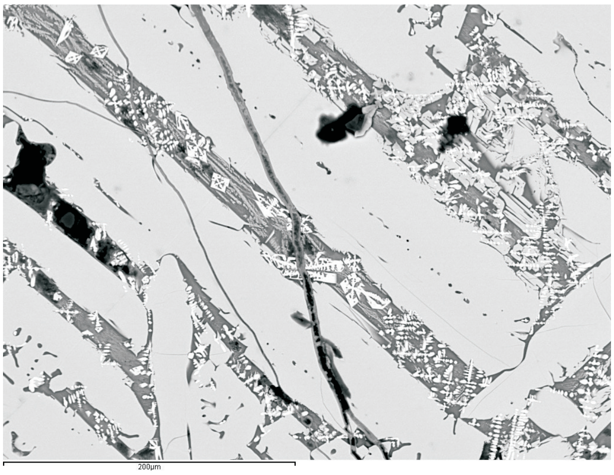
c



d



e



f

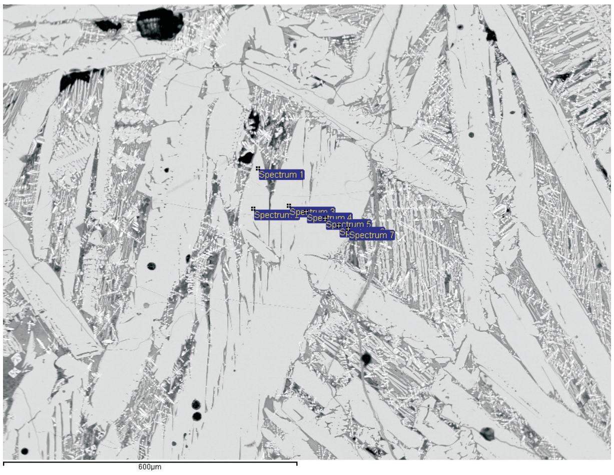
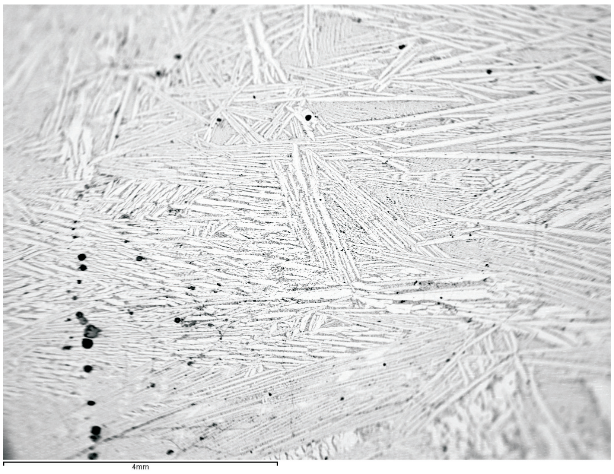
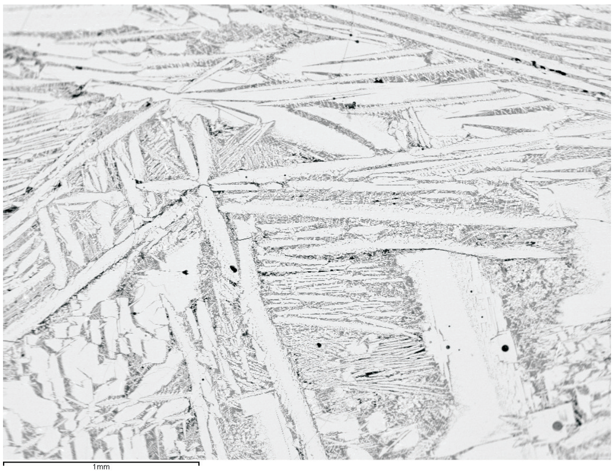


Plate 15

a



b



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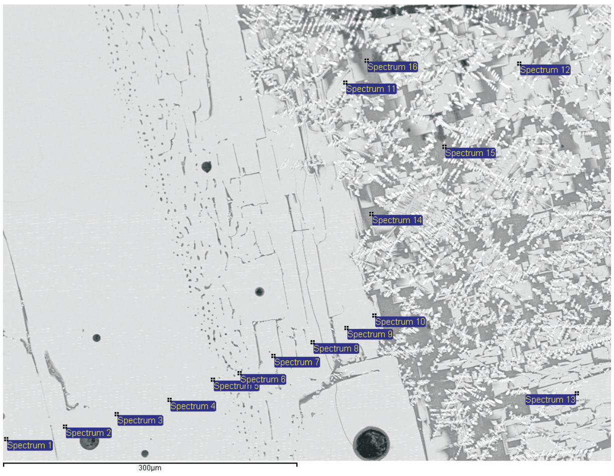

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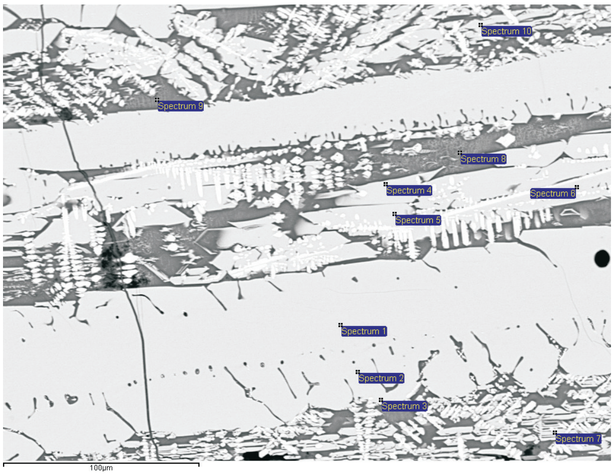
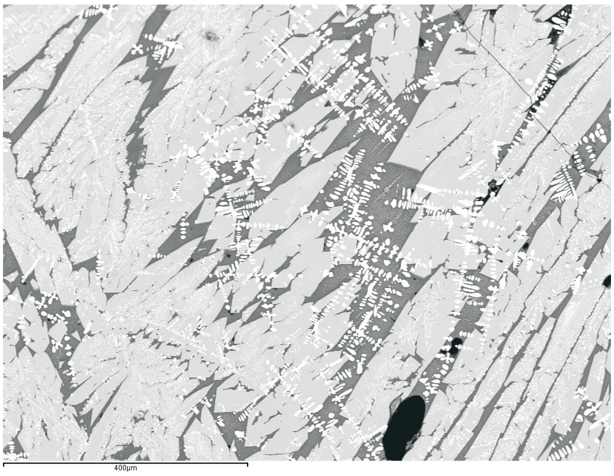


Plate 16

a



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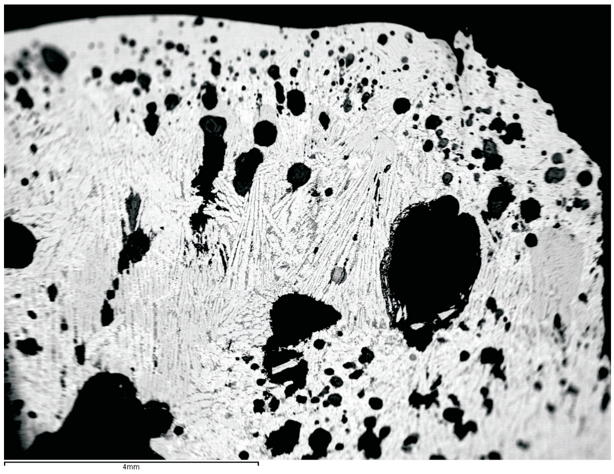

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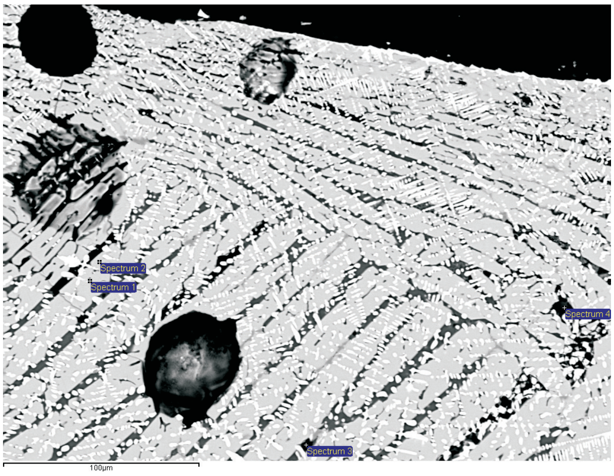

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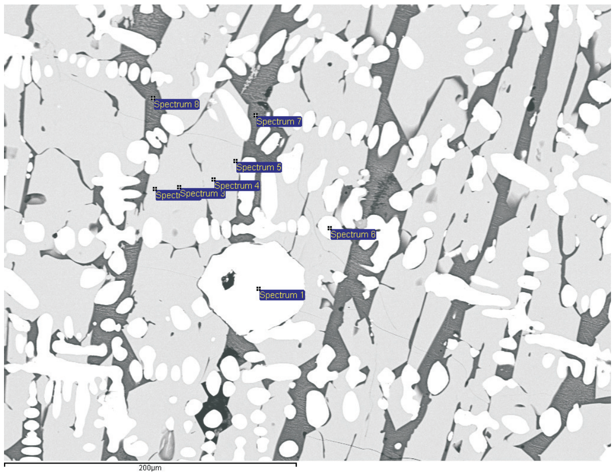

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