Feeling the Peat: An investigation into an alternative metalworking fuel for the Scottish Iron Age

As the title of this research might suggest, my masters dissertation at the University of Sheffield is all about investigating the possible use of peat for metalworking in Iron Age Scotland, primarily iron smelting in the Northern Isles.

My interest in peat as a possible metalworking fuel stems from the short experimental campaign into smelting furnaces and heat resistant tempers funded by the Carnegie Institute during my third year studying archaeology in Orkney with the University of the Highlands and islands. I was repeatedly asked by visitors to the site if, instead of the charcoal I was using, peat could have been used. Considering that the Northern Isles are not famed for dense woodland a characteristic that appears to hold true doing the Iron Age (Farrell 2015:473; Timpany *et al* 2020:10; Edwards *et al* 2005:1745). This is greatly problematic considering that it can take approximately 60kg of wood to produce just 1kg of iron during a bloomery smelt (Pleiner 2000:126; Oaks 2018:48). Within a Scottish context, the only comments that I could find were by Curle (1936:153, 165), who assumed that peat must have been used for smelting in Shetland because of the lack of woodland resources, and Tylecote (1990:140), the doyen of archaeometallurgy, who saw no reason for it not to work. What was missing was proof that it worked and proof that it was done.

Evidence for using peat archaeologically is slim but peat ash is found in metalworking deposits at sites such as Underhoull (Small 1964:230), The Howe (Dickson 1994:131; 134) and Mine Howe (Gibson forthcoming). While charcoal was also recovered from these sites (Small 1964:234; Dickson 1994:133; Gibson forthcoming) peat is likely to be underrepresented as it turns to ash which is difficult to recover via flotation or sieving (Dickson 1994:134). Opening up some early 20th century accounts from the Western and Northern Isles proved fascinating however, with accounts of blacksmiths using a 'smiddy coal' by charcoaling peat (MacLeod and Maclean 1972; MacDonald 1962; Fenton 1997:206-10; 238). These accounts didn't mention smelting, but they contained some great information on how to produce it and the specific kind of peat was used. A deeper and more humified 'Blue Peat', 'Black Peat', or 'mòine dhubh' depending on if you're from Shetland, Orkney, or the Western Isles (Dr Ian Tait pers. comms; MacLeod and Maclean 1972; Fenton 1978:213.) was kindly gifted by PeatHeat and Highland Park. Over two months Charlotte Cooper, a fellow MSc student, and I burned 160kg of the peat to be the, if I'm not mistaken, first people in the UK to produce charcoal peat in 100 years and

Figure 1: The smokey business of charcoaling

attained an average charcoal yield of 6.8:1, the best being 4.7:1. it wasn't going to be the coronavirus that was going to ruin our lungs it would be the smoke that billowed out of these pits (Figure 1)!

After no doubt developing several long extinct lung diseases the peat charcoal (Figure 2) obviously needed to be put into a furnace! I built two furnaces based on the same example from The Howe, a broch settlement outside Stromness. One was for a wood charcoal iron smelt and the other was for the peat charcoal so I could compare the products. Unfortunately, while I was able to determine the diameter simply from this site photograph (Figure 3) there was no depth or height. A quick bit of maths suggested that it was only 6cm deep, quite unusual as furnace depths tend

Figure 2: Some of the first batch of peat charcoal

Figure 3: Furnace base from The Howe (Canmore n.d)

to be 15-20cm, or even more in the case of slag pit furnaces, but it was the only indication for depth I had. As furnace shafts rarely survive, I decided to build them up to a meter because taller shafts aids both the creation of hotter temperatures but also the creation of the all-important reducing atmosphere and so should offer the fuels a best-case scenario.

So how did the peat charcoal fare? Did it work? Yes… no…. well sort of! Compared to the wood charcoal smelt the peat charcoal produced very little iron but by performing a metallographic study of the smelt material (dissecting it, grinding it down to a 1-micron finish, and looking at it under the microscope) I could see that the microstructures (Figure 5) from the two smelts were very similar. Both had wüstite and fayalite microstructures with iron in parts suggesting that the peat charcoal was capable of producing the same reducing atmosphere as the wood charcoal. The only difference was that the fayalite was often more crystalline in the peat charcoal smelt. This suggests that the quartz, fayalite, and magnetite buffer equilibrium was altered at points, or to put that in non-star trek technobabble, that the temperatures or reducing atmosphere within the peat charcoal furnace was interrupted at points. Having placed four thermocouples (fancy thermometers) into the furnaces it was clear that temperature wasn't the issue, in fact, the peat charcoal got hotter and did so quicker than the wood charcoal. This heat struggled to spread vertically possibly because of the peat charcoal often blocked the shaft of the furnace, creating voids and suspending the ore on its way down the furnace (it's added from the top) before dropping it rapidly down the shaft as the blockage finally burnt away. Charcoal is typically cut or crushed to stop this from happening, but it appears that the peat charcoal needed to be cut smaller than the wood charcoal. Since the microstructures suggest the fuel was capable of producing the right conditions at times, I think this is the culprit for the low iron output, that is to say that it was my fault and that the peat charcoal should work when used by someone sufficiently proficient in its use!

Figure 4: Fuelling one of the furnaces and getting it up to temperature

But was the iron that we got any good? Using the departments portable X-Ray Florescence (pXRF) device allowed me to look at the elemental composition of the smelting debris. This showed that the smelting products from the peat charcoal smelt had a much higher

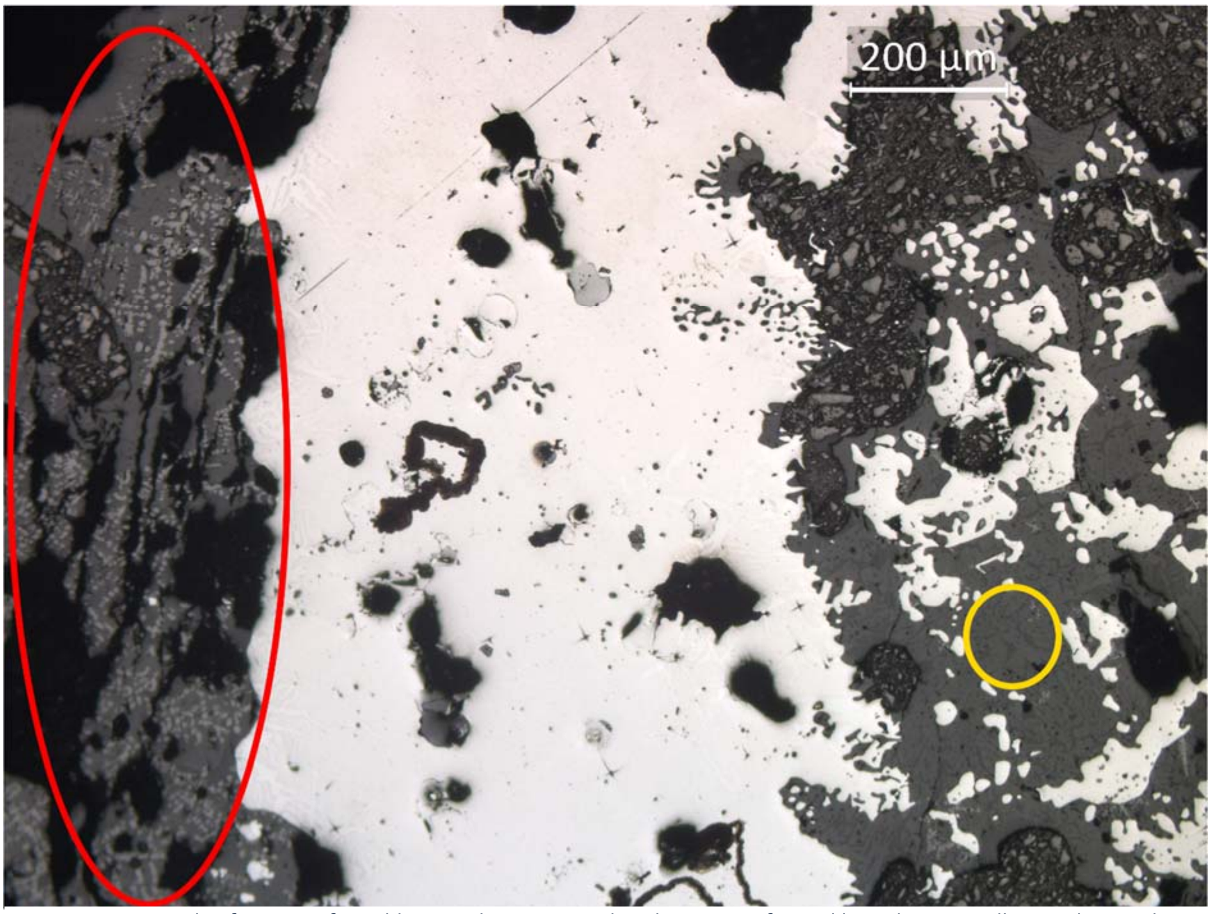

Figure 5: An example of a piece of iron bloom. White=Iron, Red circle=Wüstite formed by reduction, Yellow circle=Fayalite

sulphur content (243-3699% higher!). This was bad news as sulphur produces a brittle steel that's hard, if not impossible, to work. Looking at the temperature data from the charcoaling revealed that this content likely stemmed from being unable to maintain temperatures above the boiling point of sulphur (444.6°C) in parts of the pit. With temperatures typically hovering between 400 and 500°C and fanning easily bringing the charcoaling temperatures up to 600°C, however, I dare say a bit more practice, and perhaps a little bit of help from the Northern Isles wind, and this sulphur content would be reduced by a lot!

Considering the similarity of the peat charcoaling method with charcoaling wood in pits I see no reason why our prehistoric metalworker couldn't figure it out and relieve woodland resources of a considerable strain. The already established link between metalworking with bogs, either through the use of bog ore or the deposition of iron metalwork in watery places, may have inspired metalworkers to use peat as a fuel to involve the deeply meaningful bogs in every aspect of the production of iron. If metalworkers desired social distinction, however, peat charcoal might have been avoided as it doesn't leave the strong scent that wood charcoal does on those around the furnace. The use of wood charcoal might also have been an important as an act of conspicuous consumption for the metalworker and/or the groups they worked for. Even in these scenarios where wood charcoal might be preferable peat charcoal may still have been used, mixed with wood charcoal, or simply to preheat the furnace out of an appreciation for the economic realities of marginal woodland resources.

Detecting, or not detecting its presence archaeologically is clearly very important but how can we do this? Certainly, charcoaling in pits is unlikely to produce much of an archaeological signature. Well to was also possible, with a bit of statistical wizardry, to produce what is called a 'discriminant model' which can discriminate the peat charcoal furnace lining from the wood charcoal furnace lining with

100% accuracy (or a still mightily commendable 97.6% accuracy if I remove the sulphur content). No doubt modern pollution trapped in bogs will hinder the application of this model directly to archaeological material but it's an exciting start!

p-jack@outlook.com

Twitter: @Righ_Gobha

References

Curle, A. O. (1936) 'Account of the excavation of an iron smeltery, and of an associated dwelling and tumuli at wiltrow in the parish of Dunrossness, Shetland.' *The Society of the Antiquaries of* Scotland, 70, 153-69.

Dickson, C. (1994) 'Plant remains'. In *Howe: four millennia of Orkney prehistory: 1978-82*. ed. by. Smith, B. B. Edinburgh: Society of Antiquaries of Scotland, 125-39.

Edwards, K, J., Whittington, G., Robinson, M. and Richter, D. (2005). 'Palaeoenvironments, the archaeological record and cereal pollen detection at Clickimin, Shetland, Scotland'. *Journal of Archaeological Science* 32, 1741-56

Farrell, M. (2015) 'Later prehistoric vegetation dynamics and Bronze Age agriculture at Hobbister, Orkney, Scotland'. *Vegetation History and Archaeobotany*, 24(4), 467-86.

Fenton, A. (1978) *The Northern Isles: Orkney and Shetland.* 1st edn. Edinburgh: John Donald Publishers.

Fenton, A. (1997) *The Northern Isles: Orkney and Shetland.* 2nd edn. East Linton: Tuckwell Press

Gibson, C. (forthcoming) 'Mine Howe - the Workshop Area: Stratigraphic Narrative'. In *Excavations at Mine Howe.* ed. by. Card, N. and Downes, J.

MacDonald, D, A. (1962) A' dèanamh gual Gàidhealach nuair a bha gual gann. 37403. MacLean, D., Blacksmith and crofter in North Uist. Tobar an Dualchais, accessed from <http://tobarandualchais.co.uk/en/fullrecord/37403> [19/11/2020].

MacLeod, M. and Maclean, J. (1971) Smithy and hen-farm in Jura. 101105. MacDougall, C. Unknown (female), Blacksmith, farrier and hen-farmer in Jura. Tobar an Dualchais, accessed from <http://tobarandualchais.co.uk/en/fullrecord/101105> [19/11/2020].

Oaks, R. (2018) *Making Charcoal and Biochar: A Comprehensive Guide*. Wiltshire: The Crowdwood Press

Pleiner, R. (2000) *Iron in Archaeology: The European Bloomery Smelters*. Praha: Archeologický ústav AVČR.

Timpany, S., Mighall, T., Foster, I., Martinez Cortizas, A., Owen, O., Krus, A. and Kamerling, I. (2020). 'Later Prehistoric and Norse Communities in the Northern Isles: multi-proxy environmental investigations on Orkney'. Environmental Archaeology, 1-22.

Tylecote, R. F. (1990) *The Prehistory of Metallurgy in the British Isles*. London: The Institute of Metals.