Quartzite Anvils on the Loch Borralie Headland, Durness, NW Scotland

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1. Abstract

Quartzite, a metamorphic rock formed through the recrystallisation of sandstone, was one of several important lithic raw materials exploited by prehistoric communities across Scotland from the Mesolithic period through the Iron Age. It assumed significant importance throughout the Scottish Highlands and Islands where it is readily available, because of the region's complex geological history. Here we report the finding of three quartzite anvils at a metal working site in the Durness area on the NW corner of the Scottish mainland. The anvils show clear evidence of pecking marks, depressions, and iron staining on the surface from repeated use. The anvils have been moved some tens of metres from their original functional site. There, several quartzite cobbles and rocks, exhibit characteristic iron splatter patterns and numerous bloomery iron slags and hammer-scales have been collected in addition to bloomery fragments. A limited number of iron slags have been identified at other archaeological sites in and around Durness, indicating that small-scale metal working was practiced in the area through prehistoric and Medieval times. However, none are as substantial as the one reported here. The site overlaps with a Bronze/Iron Age settlement, and Medieval artifacts have been reported from the immediate area. We have not found any on-site artifacts which would allow rough chronological context. However, it is likely that by the transition to the Early Medieval period (post-AD 400), traditional quartzite stone anvils had been largely replaced by iron versions in northern Scotland, even though their use may have extended into later times in the Durness area reflecting the remoteness of the region.

2. Quartzite as a Raw Material for Prehistoric-Medieval Anvils

It is generally recognized that, in the Stone and Bronze Ages of Scotland, numerous different lithic raw materials were used for the manufacture of tools. While there are considerable local variations, taking Scotland as a whole the most common raw materials exploited were flint, chert and quartz/quartzite. Many prehistoric excavations have revealed a range of undiagnostic stone tools such as hammerstones or whetstones amongst many others. The extent to which struck lithic production and use is commonly little known and often ignored in contrast to the focus on more exotic materials for tools.

Quartzite is one of the hardest common rocks in the British geological record, with a Mohs hardness of approximately 7, which easily scratches glass. Its interlocking granular texture gives it superior toughness compared to fine-grained flint or chert, which tend to fracture conchoidally under heavy impact. For anvil use, these properties are critical as the anvil must be harder than the material being worked. It must resist fracture under repeated heavy blows, and have a sufficiently flat, stable surface to support the workpiece. Quartzite meets all these criteria for metalworking contexts.

A further important property is resistance to thermal shock. When hot iron is placed on a stone anvil for hammering, there is a rapid, localised transfer of heat to the stone surface. Quartzite, being almost entirely composed of quartz (SiO_2) with a melting point of about 1500-1700°C), can withstand repeated short-duration heat exposure without crumbling, whereas limestone or fine-grained metamorphic rocks, common in the Durness area, may easily crack. This thermal resilience is a practical reason why quartzite was preferred over other rock types for iron smithing.

Quartzite occurs throughout Britain as a bedrock and, more importantly for archaeological exploitation, as rounded cobbles and boulders in river gravels, beach deposits, and glacial till, the very environments from which communities drew their everyday raw material resources. Some of the most visually striking quartzite outcrops in Scotland occur in the north-west Highlands, where silvery-white quartzite caps many mountain tops, and intensely reflects the sunlight, making it visually distinctive and potentially symbolically significant to prehistoric people, just as the sparkling mountains in the Scottish Highlands affect many present day travellers.

In the Durness area quartzite, from pebbles to boulders, is very common as glacial erratics and as bedrock, in particular on the west side of Loch Eriboll. It is of Lower Cambrian age, roughly 540 to 520 million years old (e.g. Goodenough and Krabbendam, 2011). There is clear evidence that in the Durness area quartzite was used from Neolithic to modern times for burial cairns, stone tools, habitation, and dry-stone dykes and, as reported here, anvils.

3. Quartzite Anvil Stones from the Mesolithic to the Bronze Age

3.1 The Mesolithic (10,000-4000 BC)

There is relatively little evidence for Mesolithic structures throughout the Scottish Highlands. While some are found along the west coast and on islands like Rùm and Skye, recent discoveries show that Mesolithic hunter-gatherers also utilized inland areas, including the Cairngorms. Key Mesolithic sites in the Highlands include coastal shell middens and lithic scatters, notably at Sand (Wester Ross), Camas Daraich (Skye), and An Corran (Skye).

The use of caves and rock shelters is well documented in the Highlands on the west coast, and caves hold great potential for preserving Mesolithic activity (ScARF, 2023a). In the Durness area, early finds reported from Smoo Cave indicate Mesolithic activity. No radiocarbon dates, however, are available (Pollard et al., 2005).

Mesolithic people made use of a wide range of locally available lithic raw materials including flint, chert, quartz, quartzite, bloodstone, baked mudstone, and chalcedonic silica (ScARF, 2021a). In the western Highlands and Islands, sources of flint are scarce, and alternatives had to be sought. In the west, quartz, quartzite, and chert were among the materials most used (Wickham-Jones , 1986, 2009). While specific, individually catalogued "quartzite anvils" are less frequently highlighted than the quartz tools themselves, anvil-based bipolar techniques have been reported like at Camas Daraich on Skye (Wickham-Jones and Hardy, 2004).

3.2 The Neolithic (4000–2500 BC)

The Durness area, although located at the very north-western periphery of mainland Scotland, does not stand archaeologically isolated. Its Neolithic remains preserve a varied and significant body of archaeological evidence, reflecting the importance of this coastal dolomitic limestone landscape as a locus of prehistoric human activity. In addition, it is connected firmly to the wider cultural traditions of northern Scotland, particularly the Orkney-Cromarty tradition of chambered cairn construction that dominates Caithness and Sutherland (Lelong and MacGregor, G., 2003; MacGregor, 2004; Pollard et al., 2005; O´Reilly and Crockford, 2006).

In Scotland, Neolithic quartzite hammerstones or anvils typically found in settlement sites, axe-finishing workshops and ritual complexes, are rarely interpreted as single-purpose tools, rather multi-functional objects. While specific quartzite anvils are less common than other stone tools, notable findings and sites where related stone working occurred, are particularly well documented in Orkney. Neolithic settlers in Orkney, such as those at Skara Brae, relied heavily on local beach pebbles and quartzite for various tools, including anvils and hammerstones used in daily craft (see Clarke, 2006, 2009).

3.3 The Bronze Age (2500-800 BC)

The Bronze Age marks the first unambiguous use of stone anvils specifically for metalworking in Britain. The transition from stone to bronze working changed the demands placed on the anvil. Bronze working involved both cold-hammering and hot-hammering of cast objects, as well as the finishing and repair of cast objects. Because bronze is softer than iron, the impacts absorbed by the anvil are less severe than in iron-working, and the anvil does not need to withstand the thermal shock of the contact of a hot iron bloom. Flat, hard cobbles of quartzite, sandstone, or other siliceous rock served adequately for these purposes.

Childe (1948) describes Bronze Age bronze-working anvils, establishing the typological and functional basis for the identification of these objects that several subsequent researchers have built upon. However, the most visually striking and archaeologically significant use of quartzite in Bronze Age Scotland is its deliberate incorporation into burial and ceremonial monuments. This practice is well attested, where recumbent stone circles and burial cairns show an intentional and often repeated use of white quartzite

Anvil stones, along with various other rude stone tools, have been found at Jarlshof in Shetland. These tools, including hammerstones and stone anvils, were part of the large assemblage of artifacts discovered within the multi-period prehistory. These tools were found in contexts associated with the site's rich history, which spans from the Neolithic to the Norse period. Jarlshof is a particularly important site for Bronze Age stone anvil evidence. The assemblage included tools associated with metal-casting and working, and the association of flat stone slabs with bronze-working debris (slag, crucible fragments) at the site provides contextual identification of the working stones as anvils.

4. The Iron Age (800 BC-AD 500)

The adoption of iron in Britain, beginning in the later Bronze Age transition and established by approximately 800–600 BC, fundamentally changed the demands placed on the anvil. Unlike bronze, iron bloom from the bloomery furnace was not liquid but was instead a spongy, slag-saturated mass that required immediate hot-working to consolidate it. The iron bloom was reheated to approximately 900–1100°C and then subjected to repeated heavy hammer blows on an anvil to expel the entrapped slag and weld the iron particles together. This process was executed while the metal was still glowing and would involve placing the blistering bloom directly onto the anvil surface. The forces involved are substantially greater than in bronze-working: iron is harder than bronze and requires heavier blows, and the heat involved is far greater.

Stone anvils were a widely recognised Iron Age smithing technology, before wrought iron anvils became available. The evidence for anvil location does not always require finding the anvil itself: the spatial patterning of hammer-scale and iron splatter deposit around where an anvil once stood is a primary means of identifying anvil position in excavations.

5. Medieval-Norse Times (AD 500-1500s)

Norse evidence at Loch Borralie fits within a well-documented pattern of Norse settlement and activity along the north Sutherland coast in the 9th–12th centuries AD (Beatey, 1993). At Smoo Cave, radiocarbon dates spanning the 8th–12th centuries AD from stratified midden deposits (rubbish heap), document Norse maritime activity including fishing, boat-building or repair (Pollard et al., 2005). At Sangobeg (approximately 10 km east of Loch Borralie), a Norse-period settlement with stone walling, a hearth, and occupation deposits was excavated in 2000, overlying a late Iron Age child burial dated 170 BC-AD 30 (Brady et al., 2008). A Viking burial at Balnakeil Bay was radiocarbon dated to cal AD 680–860, with artefact typology suggesting a late 9th-century date (Batey and Paterson, 2013).

Together, these sites create a coherent picture of intensive Norse coastal settlement in the Durness area during the 9th–13th centuries, exploiting the fertile limestone grasslands, coastal fishing resources, and sheltered anchorages of the Kyle of Durness and Balnakeil Bay. Medieval metalwork, along with later, post-Medieval pottery and metalwork is found at several locations on the Loch Borralie Headland. The timespan represented by the artefacts suggests a long and continuous period of occupation of this discrete area. The nature of the artefacts also hints at a relatively wealthy settlement, able to afford pins, brooches and other well-crafted pieces for personal adornment. There is evidence of a settlement from the late Norse period and continued to exist in the same place over perhaps the following 500 years. As such, it potentially represents an extremely important contribution to Medieval settlement studies in northern Scotland (Gazin-Schwartz and Lelong, 2004).

A striking quantity of Medieval to late Medieval metalwork of some status, have been found on the Borralie headland. A few copper-alloy frustrum-headed pins have been discovered, dating from the thirteenth century. The presence of industrial waste, including metalworking slags, from several different locations on the headland suggests that small scale metalworking was taking place (Lelong and MacGregor., 2003). Other pieces of metalwork, associated with Iron Age burials (MacGregor 2004) may also have been made locally.

6. Characteristics Surrounding Quartzite Anvil Stones Used in Metalworking

The identification of a quartzite cobble or boulder as a prehistoric metalworking anvil rest on the recognition of a suite of surface characteristics produced by use. These characteristics differ substantially depending on whether the anvil was used for lithic knapping, for non-ferrous (Bronze Age) metalworking, or for iron (Iron Age) metalworking.

The most archaeologically recognisable surface characteristics of a quartzite anvil used for Iron Age iron smithing are those produced by the contact of hot iron and iron oxide particles with the stone surface. These include iron splatter (solidified iron oxide droplets), hammer-scale deposits, thermal discolouration, and slag adherences. Together, these traces form a distinctive "signature" of iron-working that is largely absent from anvils used only for stone-knapping or non-ferrous metalworking.

In a typical early smithing setup, the hearth and the anvil were positioned close together so that the smith could move the heated iron rapidly from the fire to the anvil without losing too much heat. The combined distribution of heat-affected floor surfaces (from the hearth), hammer-scale (tiny, magnetic, and flaky or spherical byproduct created during the hot-forging of iron and its alloys), iron splatter (concentrated around the anvil), and smithing slag thus creates a characteristic spatial assemblage that defines the Iron Age smithing "footprint."

During excavations, identifying this “footprint”, hearth evidence, nearby quartzite anvil stone with surface characteristics as described above, and surrounding floor matrix rich in hammer-scale, iron splatter and iron slag, provides the most robust identification of an iron-working area.

6.1 Impact Pitting and Pecking

The most universal feature of any anvil stone is impact pitting, small, sub-circular to irregular depressions produced on the working face by the repeated contact of hard material (stone hammerstone, metal hammer, or the workpiece itself). On quartzite, impact pitting appears as a zone of crushed, whitened, granular surface texture, with the individual pits typically 1–5 mm across and 0.5–2 mm deep. The overall pattern of impact pitting is distributed across the working face but may be concentrated in a central zone where the workpiece was habitually placed.

6.2 Flat-Worn Facets

Extended use as a metalworking anvil gradually polishes and flattens the working surface through a combination of impact and abrasion. On quartzite, this appears as one or more flat, smooth, or mildly worn facets on the upper face of the cobble, which may contrast with the rougher natural texture of the surrounding unworked surface. A worn flat facet on a naturally rounded quartzite cobble is one of the most diagnostic features of anvil use in a metalworking context.

6.3 Deliberate Shaping

In some Bronze Age and Iron Age contexts, quartzite anvil stones show evidence of deliberate shaping, the pecking or grinding of the working surface to produce a flatter, more regular face than the natural cobble provided. This shaping is visible as a zone of evenly distributed small peck marks across the intended working face, distinct from the more concentrated impact pitting of use in service. In extreme cases, the stone may be ground to a near-flat surface. Such deliberate preparation indicates that the craftsperson invested effort in optimising the anvil, a behavioural indicator of regular, skilled metalworking.

6.4 Iron Splatter — Formation and Appearance

When a hot iron bloom or billet is hammered on an anvil at temperatures around 900–1100°C, two things happen simultaneously. First, the rapid oxidation of the hot iron surface produces a thin, brittle oxide scale layer (FeO/Fe_3O_4). This scale is constantly being broken off the iron surface by the hammer blows and spalls outward in all directions. Second, during forge-welding operations (joining pieces of iron), the smith heats the iron to near-welding temperature (c. 1300°C) and strikes it sharply. At this point, the molten oxide is violently expelled when the weld is hammered and forms droplets (usually less than 2mm diameter) which chill to give the micro-residues known as spheroidal hammer-scale.

The larger droplets of this expelled molten iron oxide travel outward from the weld point at high velocity, cool rapidly in the air, and land on surrounding surfaces including the anvil face, the surrounding floor, and nearby walls or structural features. On the quartzite anvil surface, these droplets solidify almost instantaneously on contact with the cooler stone. They adhere to the quartzite surface as small (typically 0.5–3 mm), dark, sub-spherical to flattened droplets. They are strongly magnetic and a magnetic test is one of the simplest and most reliable field tests for iron splatter on a suspected smithing anvil.

6.5 Iron Oxide Staining of the Quartzite Surface

The prolonged hammering of hot iron on a quartzite anvil produces diffuse iron oxide staining of the working face. Iron oxide particles penetrate the grain boundaries of the quartzite surface, producing a reddish-brown to orange-brown discolouration that can extend several millimetres below the surface in porous or fractured zones. This iron staining is distinct from normal weathering of the stone as it is confined to the working face and does not occur on unworked surfaces of the same cobble and it becomes a permanent feature of the stone.

7. Quartzite Anvils on the Loch Borralie Headland

7.1 Site Location

The anvils are located on the east side of the Kyle of Durness (Figure 1) on the Borralie Headland (NC 3761 6670 centred).

Figure 1. Location of anvil site east of the Kyle of Durness (red square).

The calcareous and freely draining nature of the local soils has produced a green and fertile pocket of the land, which includes the survey area. It is characterised by sandy grassland, eroded by the wind in places, forming blow-throughs, exposing sandy faces where the thin turf has been scoured off (Figure 2). In some places the soil has been eroded down to the dolomitic limestone bedrock.

Figure 2. Location of anvils (red arrows) and slags and hammer-scales (black arrow).

It is intriguing that the ground surrounding the anvils does not show the typical “footprints” of an iron-working floor. However, 25-50 m to the northeast (black arrow on Figure 2), the site is littered with iron slag and hammer-scales and the soil is, in places, intensely charcoal-contaminated (Figure 3).

Figure 3. Charcoal-contaminated soil on location.

7.2 Sample Collection

We have sampled a representative collection of slag (2,5 kg), hammer-scales (30 g) and bloomer fragments (6), which were logged in the field, archived and stored. The area is very dynamic, being continuously covered and uncovered by sand and soil resulting in intermittent artifact exposures and relics may also be accidentally removed by passers-by and grazing animals. Conserving a representative collection in a safe place is therefore crucial.

The three anvils were examined and described in the field. Samples of Iron slag, splatter and staining were scrutinised using a stereoscope but no geochemical analysis or geophysical surveys are available. No excavation or test units/trenching was executed.

7.3 Quartzite Anvils

Three potential quartzite anvils were identified in the field (Figure 4). They are composed of the local Cambrian quartzite succession, deposited as glacial erratics, which are very common in the Durness area.

Figure 4. Quartzite anvil stones on the Loch Borralie Headland.

The size of the anvils is in the order of 55 X 35 X 30 cm, with some corners broken off, probably because of prolonged use. The surface shows clear iron oxide staining of the working face which varies in smoothness due to impact pitting. There is significant iron splatter (solidified iron oxide droplets) adhering to the quartzite surface as small, dark, sub-spherical to flattened droplets. The Iron oxide particles have penetrated the grain boundaries of the quartzite surface, producing a reddish-brown to orange-brown discolouration.

7.4 Iron splatter and staining

Pebbles and cobbles in the smithy area show intense iron staining and splatter, often leaving “pencil-like” marks and the formation of rust stains and evidence of the iron having reacted with the quartz minerals (Figure 5).

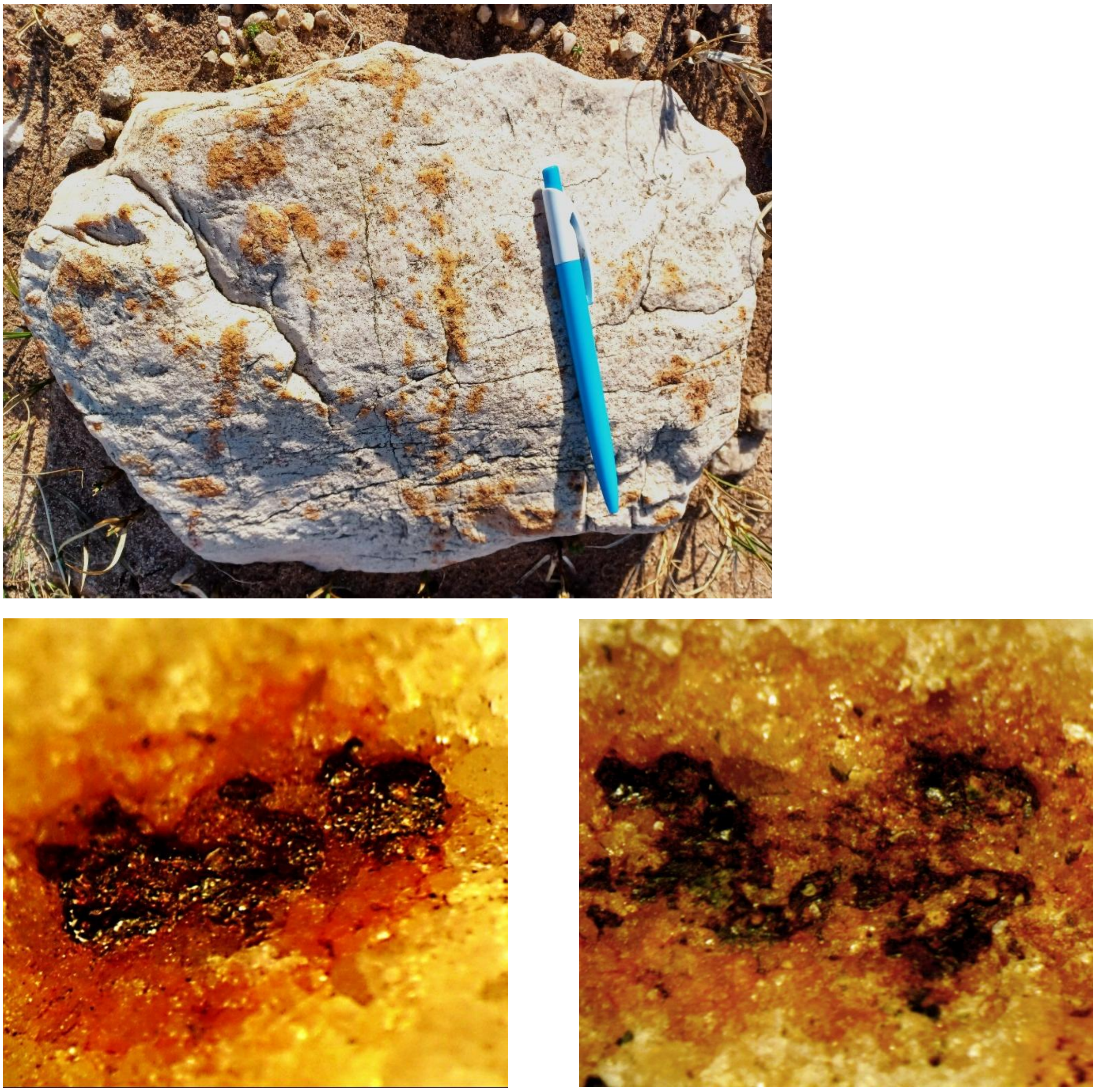

Figure 5. Iron splatter on a quartzite cobble (upper). Closer view (lower, 5 mm across).

7.5 Iron slag and hammer-scales

Archaeometallurgical slag is the stony, vitrified waste generated during ancient metal smelting and smithing. The identification of slag type is a fundamental step in understanding which metal was produced at an archaeological site, what technology was employed, and in some cases when the metalworking took place.

The transition from bronze (Bronze Age) to iron (Iron Age) is partly defined by the adoption of bloomery iron smelting. In the bloomery process, iron ore (haematite, magnetite, limonite, siderite, or bog iron) was reduced in a shaft furnace at temperatures of approximately 1100–1300°C using charcoal as fuel. Iron oxide was converted to spongy metallic iron (the bloom) while the excess minerals combined with silica and charcoal ash form a fluid fayalitic slag (Paynter 2006; Crew 2013). Unlike copper smelting, the iron bloom was never fully molten under bloomery conditions. The slag, however, was liquid and could be allowed to accumulate at the furnace bottom or tapped out through a hole in the furnace wall.

Secondary iron-working (smithing) generated its own distinctive slag type, the smithing hearth bottom or smithing hearth cake, as well as hammer-scale (flakes of iron oxide flung from the hot metal surface during hammering). Both primary smelting slag and smithing slag are commonly encountered at Iron Age and Medieval/Norse sites.

Iron-smelting slag from the bloomery process occurs in the following main morphological types (Bayley et al., 2015; Paynter 2006):

Tap slag is the most characteristic smelting slag. Tap slags are compact, dense, heavy pieces that flowed out of the furnace through a tapping hole and solidified outside. They have a shiny black upper surface with characteristic cord-like or ropy flow structures, and a flat, smooth, or slightly irregular base. They are without blowholes but minor gas bubbles can be observed.

Furnace bottom slag accumulated and built up at the base of the bloomery furnace during smelting. These are irregular, often large and heavy masses, more porous and heterogeneous than the tap slag, with charcoal impressions on the lower surface.

Hammer-scales are small, thin, flaky, or spherical particles of iron oxide spalled from the surface of hot iron during hammering. These are typically only a few millimetres across, dark grey to black, with a characteristic disc or spheroid shape. They are strongly magnetic.

Figure 6. Representative iron-slag samples. Bloomer fragments (2) bottom right.

All the different types of slag are found in the research area and we sampled 2,5 kg of slag on site (Figure 6). The samples vary from being compact, homogenous, and dense with very low porosity (tap slag), to highly heterogenous, porous samples with charcoal impressions (bottom slag). We also sampled hammer-scales (Figure 7) and some bloomer fragments (Figure 6), all consistent with a metalworking smithy.

Figure 7. Hammer-scales, flaky (middle, 5 mm across) and spherical (right, 5 mm across).

The location of the anvils does not overlap with that of the slag, hammer-scales or charcoal concentration, the “footprints” of a metalworking smithy. Instead, the anvils are scattered about 25-50 m away (Figures 2 and 3), as if they had been moved or disposed of at some point after the smithy was no longer in use or after new up-to-date anvils had been acquired. It is not known when metal anvils appeared in the Durness area. However, small, portable iron anvils were a staple in Medieval/Norse smithing.

8. Discussion and Conclusion

The Durness area occupies a remote and exposed position at the northwest corner of the British mainland. Despite its geographic isolation, archaeological investigations have revealed evidence for sustained human occupation spanning many thousands of years, from the Mesolithic period through to the Medieval era and beyond. Archaeological survey of the headland centred on Loch Borralie, on the eastern side of the Kyle of Durness (Figure 1), recorded nearly 200 archaeological sites (Lelong and MacGregor, 2003). These vary from isolated, fragmentary structures or walls to extensive settlements and field systems, ranging in date from later prehistory to the Medieval period and to the nineteenth century (Lelong and MacGregor, 2003; Gazin-Schwartz and LeLong, 2004).

Bronze Age activity in the Durness area is evidenced by roundhouse sites and burial traditions across the region. In addition, we have retrieved fragments of a Bronze Age crucible, a barbed-spear mould and bronze slag or prills at the Faraid Head (Figure 1) and some stray-finds on the Borralie Headland may be assigned to the same era.

Iron Age human activity in the Durness area is confirmed by the burial assemblage at Sangobeg (Brady et al., 2007) and the multi-phase burial cairn at Loch Borralie (MacGregor, 2004), both of which provide an important social context for understanding Iron Age occupation in the area. Further social context is provided by broch sites in the region. Some stray-finds along with Iron Age potsherds have been found in the Durness area (Lelong and MacGregor, 2003).

The principal documented iron slag assemblage from the Durness area comes from the Geodha Smoo cave complex, where slag was recovered alongside Viking-type clench nails, placing this smithy activity in the Viking/Norse or early medieval period (8th–11th centuries AD; Pollard et al., 2005). However, the multi-period nature of midden deposits in the cave and the limited number of radiocarbon dates means that some uncertainty persists regarding the full chronological range of metalworking activity at the site.

However, it is evident that the scarcity of well documented Bronze Age and Iron Age metalworking evidence in Durness reflects the limited scale of archaeological investigation, rather than necessarily indicating a genuine absence of metalworking activity. Available archaeological data strongly suggests that within a relatively small area of Durness the land was occupied and cultivated over several millennia. The numerous remains of hut circles, field banks, clearance cairns and burials must therefore represent a longstanding farming the land where generations of families lived, building houses on or near the remains of their ancestors.

The presence of metalworking slags, from several different locations on the Borralie Headland suggests that some metalworking was taking place here, at least since the Iron Age and probably for longer (Lelong and MacGregor, 2003). However, evidence of large scale, almost industrial, metal working has not been discovered until now.

The identification of three quartzite anvil stones with iron-working surface traces has a range of important interpretive implications. First, it confirms the presence of iron smithing activity at or near the find location, activity that may not be detectable from slag or structural evidence alone in heavily disturbed contexts. Second, the surface traces on the anvils can help distinguish primary smithing (bloom refining, which produces the heaviest iron splatter and the most intense thermal effects) from secondary smithing (shaping of finished objects, which produces lighter hammer impact marks and less intense thermal discolouration). Third, the spatial association of the anvil stones with other metalworking evidence (bloomer, slag, hammer-scale and charcoal concentration in the surrounding matrix) builds a coherent picture of the smithing workspace.

The quartzite anvil stone is also, in most cases, the most physically robust component of the metal smithing toolkit. An iron bloom, slag or hammer-scales may be recycled, lost to erosion, or deliberately removed from a site. But a heavy quartzite boulder used as an anvil is rarely moved far from its place of use. Its presence in the archaeological record is therefore a more persistent indicator of smithing location than many other residues, and its surface traces are preserved for millennia.

Hut circles and burial cairns, probably dating to the Bronze Age are found about a 100 m from the quartzite anvils. The location of a possible Iron Age working site with identifiable potsherds, were recovered about a 150 m away from the anvils (Site 20 in Lelong and McGregor 2003). Norse/Medieval structures, including a horizontal mill and some scattered metal slag, have also been reported close to the vicinity of the quartzite anvils. The proximity of these chronologically different sites would probably place some age constraints on the research site. However, a thorough archaeological investigation and targeted excavation would be needed before any such conclusions could be reached.

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