Mylonite in Archaeology
with Special Reference to Scotland and Durness

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1. Introduction

Mylonite is a fine-grained, foliated metamorphic rock produced by intense ductile deformation along shear zones deep within the Earth's crust. Its name derives from the Greek *mylos*, meaning mill, reflecting the grinding and crushing action that reduces mineral grains to a characteristic streaked, ribbon-like texture. Here we report worked high-grade mylonite artifacts, recently discovered at a Bronze Age site in the Durness area on the NW coast of Scotland. The finds consist of arrow heads, scrapers and spearhead. These finds may further enhance our understanding of the preferred material used by people of that time for tool making. The term mylonite was first introduced into the geological literature by Charles Lapworth in his landmark study of the Moine Thrust Zone in north-west Scotland (Lapworth, 1885), the rock type has since been recognised across the globe where major tectonic displacements have occurred. Scotland, with its extraordinarily complex Precambrian and Caledonian geology, contains some of the world's most celebrated exposures of mylonite, and it is in this landscape that the interplay between geological structure and human prehistory is most richly expressed. From an archaeological perspective, mylonite occupies a curious position. It is rarely the primary subject of lithic archaeological studies in the way that, for example, flint, chert, obsidian or quartz are, yet it surfaces repeatedly in petrographic analyses of stone tools, architectural masonry, and landscape features across Scotland and beyond. Its hardness, fine grain, and capacity to be worked with reasonable precision made it a practical material for prehistoric and historic communities who lived close to the great shear belts of the Scottish Highlands and Islands. The Durness area sits on dolomitic limestone which contains significant exposures of chert, which is also ideal for toolmaking. However, the high-grade metamorphic mylonite found on the Faraid Head in Durness, may be easier to shape for certain tools in addition to being visually exquisite. Distinguishing features which are diagnostic of true mylonites can superficially be very similar in other metamorphic rock types and in such context, archaeology can benefit from geological input.

2. Mylonite

Mylonites are formed in shear zones where rocks deform plastically under elevated temperature and confining pressure, typically at depths between 10 and 25 kilometres within the crust (e.g. Davis and Reynolds, 1996; Twiss and Moores, 2007). The deformation is accommodated by crystal-plastic mechanisms. Dislocation creep, grain boundary migration, and dynamic recrystallisation progressively reduce grain size and produce a pronounced planar fabric called foliation, and a linear alignment of minerals called lineation (White, 1977;

Sibson, 1977). The resulting rock is typically very fine-grained, dense, and hard, with a distinctive streaky or banded appearance. Minerals such as quartz and feldspar are practically drawn out into ribbons, while mica aligns parallel to the shear plane, giving the rock its characteristic and exquisite silvery sheen. Ultramylonites, which are found on the Faraid Head near Durness, represent the extreme end of the deformation spectrum where the rock has been so thoroughly recrystallised and reduced in grain size, it approaches an almost homogeneous, glassy appearance, entirely lacking the coarser remnants of the protolith. It is almost impossible to realise the pristine origin of a rock that has experienced such immense forces.

The mechanical properties of mylonite are directly relevant to its archaeological exploitation. Its fine grain and structural homogeneity give it a high tensile strength and an ability to hold a sharp or smooth edge under abrasion, making it well suited for grinding and polishing tools (e.g. Cashman et al., 1992; Mukherjee, 2011). Competent mylonites resist fracture across a wide stress range, though they may have preferred cleavage planes exploitable by a skilled knapper or mason. In contrast to the conchoidal fracture of chert, flint or obsidian, which makes those materials ideal for flaked cutting tools, the toughness and anisotropy of mylonite render it more suitable for ground stone implements, heavy-duty tools, and building materials (e.g. Clough and Cummins, 1979). The unique, flowing, and banded patterns, often with colourful, semi-precious minerals makes mylonite ideal in jewellery making, featuring in handcrafted silver pendants.

3. Mylonite Identification

The reliable identification of mylonite in archaeological assemblages requires a combination of macroscopic observation, thin section petrography, and, increasingly, instrumental geochemical analysis (Fettes and Desmons, 2007; Clough and Cummins, 1988). Because mylonites form in a very specific geological context, namely major fault zones, researchers can often trace archaeological artifacts back to their source. Sourcing analysis can thus reveal prehistoric exchange networks, identifying cases where people acquired mylonite from geological sources well outside their local area.

Geochemical and isotopic approaches have been applied successfully to metamorphic rock sources for Neolithic polished axes in Ireland and Scandinavia and deserve broader application in the Scottish context (e.g. Clough and Cummins, 1988). Comprehensive analyses of lithic and stone quarries are obviously of importance to the definition and understanding of exchange networks, as the quarries form one end of chains of exchange. At present, practically no Scottish lithic and stone quarries have been analysed in detail. However, the importance of using such analytical techniques for sourcing has recently been highlighted, proving that the Stonehenge Altar Stone originates from the Orcadian Basin in northeast Scotland, not Wales as previously believed (Clarke et al., 2024).

4. The Mylonitic Landscape of Scotland

Scotland's geological history has bequeathed it an extraordinary abundance of mylonitic rock. The country straddles a succession of major crustal sutures generated during the Caledonian Orogeny (roughly 490–390 Ma), the tectonic event that assembled the ancient supercontinents of Laurentia and Baltica, and left an indelible imprint on the physical landscape of northern Britain (Strachan et al., 2002; Trewin, 2002). Three principal shear zones are of special relevance to the archaeologist: the Moine Thrust Zone, the Great Glen Fault, and the Highland Boundary Fault.

4.1 The Moine Thrust Zone

Extending some 190 kilometres from Loch Eriboll in the north to the Sleat peninsula of Skye in the south, the Moine Thrust Zone is arguably the world's most intensively studied example of a thin-skinned thrust belt, consisting of series of thrust faults that branch off the Moine Thrust itself. It was here that Lapworth, working in 1882–1883 around Loch Eriboll and the Stack of Glencoul, first made sense of the chaotic and apparently inverted stratigraphy (The NW Highland Controversy) that had confounded geologists for years (Lapworth, 1885), He recognised that vast sheets of ancient Lewisian gneiss and Moine metasediment had been transported westward over younger Cambrian and Ordovician rocks by a series of gently inclined thrust faults rooted deep in the crust, and that the rocks immediately above and below each thrust surface had been metamorphically transformed into mylonites by the enormous strain energy expended in the process (e.g. Coward and Kim, 1981; Law, 1987).

The classic mylonite localities of the Moine Thrust Zone, Knockan Crag, the Assynt culmination, Kinlochewe, Loch Maree and Faraid Head Durness, expose a range of mylonitic textures derived from Lewisian gneiss, Torridonian sandstone, Cambrian quartzite and Moine schist protoliths (e.g. Strachan et al., 2002; Mendum et al., 2009; Goodenough and Krabbendam, 2011). These rocks have been exploited by human communities for millennia. The rugged territory of Assynt and the adjacent coastal plains contain clusters of Neolithic and Bronze Age monuments, chambered cairns, stone circles, roundhouses, built in part from locally available lithologies that include the highly foliated mylonites of the thrust belt (Ritchie and Ritchie, 1981). Detailed examination of architectural stones from several Caithness and Sutherland chambered cairns has identified mylonite derived from Lewisian Gneiss protoliths, suggesting either quarrying or opportunistic collection from thrust-zone outcrops.

4.2 The Great Glen Fault

The Great Glen Fault is a major strike-slip structure that bisects Scotland from Inverness in the north-east to Fort William in the south-west, its course now occupied by a chain of lochs, including Loch Ness. Total displacement or movement along the fault has been estimated at least 100 kilometres accumulated during several episodes of Caledonian and post-Caledonian activity. Mylonitic rocks outcrop along the valley floors and lower slopes of the Glen, where they would have been readily accessible to prehistoric and historic communities travelling this fundamental routeway through the Highlands (see Ritchie and Ritchie, 1981; Wickham-Jones, 1994).

4.3 The Highland Boundary Fault

The Highland Boundary Fault runs from Stonehaven on the North Sea coast south-westward to Helensburgh on the Firth of Clyde, separating the Dalradian metasediments of the Grampian Highlands from the Old Red Sandstone of the Midland Valley (e.g. Trewin, 2002; Harte and Hudson, 1979). Associated shear zones contain mylonites, particularly notable around Aberfoyle, Loch Lomond, and the Trossachs.

5. Mylonite as Archaeological Material

5.1 Ground Stone Tools

The most archaeologically significant use of mylonite is in the production of ground stone tools. The category encompasses a broad range of implements, saddle querns, rotary querns, rubbing stones, polishers, scrapers, arrowheads, axes, whetstones, and pounders, whose manufacture depends not necessarily on knapping but on abrasion, grinding, and shaping by friction (e.g. Clough and Cummins, 1979). For these purposes, a hard, fine-grained, structurally tough rock with natural surface roughness is ideal. Mylonite meets these criteria well: its recrystallised grain structure resists wear, its foliation provides a textured working surface, and its density ensures that the tool retains its mass during prolonged use (Cashman et al., 1992; Mukherjee, 2011).

Saddle querns and rubbing stones of Neolithic and Bronze Age date from the Northern Isles, Orkney and Shetland in particular, have been the subject of systematic petrographic study, and mylonitic lithologies appear with some frequency in assemblages from Neolithic settlements such as Skara Brae and the Ness of Brodgar, as well as from Bronze Age sites in Shetland (Ritchie and Ritchie, 1981; Mercer and Midgley, 1997). The fine-grained mylonitic schists derived from Lewisian gneiss protoliths appear to have been specifically selected over coarser-grained alternatives, suggesting that prehistoric communities possessed a practical knowledge of local rock properties that informed their raw material choices. In Shetland, where the geology includes significant exposures of ductile shear zones within the Dalradian and Lewisian basement, mylonite and related mylonitic gneiss were among the materials available for quern production alongside the sandstones, phyllites, and serpentinites of the archipelago (Mendum et al., 2009; Strachan et al., 2002).

Rotary quern production in Iron Age and Roman-period Scotland was a specialised craft with identifiable production sites and regional distribution networks (e.g. Sherratt, 1997). The Clatchard Craig quern quarry in Fife and several Highland quarries exploited schists and micaceous rocks including mylonitic varieties. Analysis of quern fragments from Iron Age settlements in Perthshire, Angus, and the Moray Firth region has revealed the circulation of mylonitic lithologies over distances of 30–80 kilometres, implying organised exchange or specialised production and distribution rather than entirely local procurement. The characteristic physical appearance of well-foliated mylonite, its laminated, slightly lustrous surface, may have been aesthetically valued as well as functionally appreciated (e.g. Clough and Cummins, 1988).

5.2 Architectural Uses of Mylonite

In addition to its use as a worked material for tools and implements, mylonite features in prehistoric and historic architecture across Highland Scotland, the Western Isles, and the Northern Isles (Glendinning and MacKechnie, 2004; Ritchie and Ritchie, 1981). Its use as a building stone is largely pragmatic: in a treeless or near-treeless landscape where timber is scarce and local stone the primary construction material, communities would select whatever lithology is most abundant and most easily shaped within their immediate territory. Where shear zones run close to settlement sites, mylonitic rocks were inevitably incorporated into drystone walling, chambered cairns, and souterrains (e.g. Mendum et al., 2009).

The Neolithic chambered cairns of Caithness and Sutherland like the Grey Cairns of Camster and South Yarrows, are constructed primarily of Caithness flagstone, a Devonian lacustrine siltstone that splits readily along bedding planes into slabs suitable for corbelling and walling (Ritchie and Ritchie, 1981; Mercer and Midgley, 1997). However, petrographic surveys of the less well-known cairns in the western and central Sutherland uplands, where Caithness flagstone is unavailable, reveals a higher proportion of metamorphic rock including mylonitic Lewisian gneiss and Moine schist. The structural properties of mylonite, its tendency to split along foliation planes, may have been exploited to produce flat-faced stones for corbelling, in a functional analogue of the use of flagstone elsewhere (Mendum et al., 2009; Strachan et al., 2002).

5.3 The Sutherland Broch Landscape

The Iron Age broch towers of Sutherland represent one of the most remarkable architectural traditions in prehistoric Europe: drystone towers, sometimes exceeding 10 metres in height, with walls of extraordinary precision and complexity (e.g. Ritchie and Ritchie, 1981; Glendinning and MacKechnie, 2004).

Broch architecture of the Iron Age, which demands large quantities of carefully selected stone for its double-walled, hollow-core construction, has also been examined for lithological diversity (Ritchie and Ritchie, 1981; Glendinning and MacKechnie, 2004). Several brochs in the western Highlands and Islands, including Carn Liath near Golspie, Dun Creigh near Loch Broom, Clachtoll in Assynt, and the partially excavated sites of the Applecross peninsula, are situated by or close to the Moine Thrust Zone and incorporate thrust-zone mylonites alongside undeformed Torridonian sandstone and Moine schist (Mendum et al., 2009). The preference for foliated mylonitic material for the inner wall faces at some sites, where its laminar character would produce a relatively smooth surface, may reflect both the local availability of the rock and an aesthetic and decorative preference for regularity in finished masonry.

6. Mylonite at a prehistoric site in Durness

The Faraid Head (Scottish Gaelic: *An Fharaird*, 'the projecting cape') is a small but geologically and archaeologically remarkable peninsula on the northwest coast of Sutherland, extending approximately 3.6 km NNW into the North Atlantic between Balnakeil Bay in the west and the entrance to Loch Eriboll to the east, terminating in cliffs that rise nearly 100 metres above the sea (Figure 1). Despite its remoteness, the peninsula, and its immediate hinterland at Balnakeil and Durness, constitute one of the archaeologically richest landscapes on the north coast of Scotland.

The geology on the Faraid Head, represents an offlaying segment of the Moine Thrust Sheet. The outcrops here are of great historical importance as Peach and Horne (Peach et al., 1907) were able to deduce from them a minimum westerly crustal displacement of about 15 km from the focus of the Moine Thrust at Loch Eriboll in the east. At the Faraid Head metasediments of the Moine Supergroup (about 1000 million years old) have been pushed and thrust over the much younger Durness Limestone (*c.* 500 million years old), forming ultramylonite at the boundary between the two.

Beach outcrops on the west side of Faraid Head reveal spectacular exposures of mylonites (Site A on Figure 1) which exhibit a wide variety of features typical of mid-crustal shear zones. The mylonites vary from creamy-pink types derived from acid gneiss to strips and pods of faint, greenish lustre of chlorite-actinolite schist that represent highly retrogressed amphibolites (e.g. Goodenough and Krabbendam, 2011).

The landscape in and surrounding Loch Borralie Headland (Figure 1) constitutes one of the most archaeologically significant multi-period landscapes on the north coast of mainland Scotland, yet still being poorly explored. Situated between the Kyle of Durness to the west and Balnakeil Bay to the east, this area of undulating, fertile dolomitic limestone, loch-margin grassland, machair and deflating sand dunes has attracted and preserved proof of human occupation spanning at least from the Neolithic to early Bronze Age, through to Iron Age settlements, the Norse-period, and post-medieval township to the pre-Clearances (e.g. Reid et al., 1968; Lelong and MacGregor, 2003; MacGregor et al., 2003; Gazin-S and Lelong, 2004). The abundance of prehistoric evidence, clearly indicates a densely populated area since Neolithic times (Lelong and MacGregor, 2003).

***Figure 1.** Location of the mylonite outcrop on the Faraid Head (A) and Bronze Age site (B).*

A cluster of hut circles, constructed principally of quartzite, is found west of Loch Borralie, near the east coast of the Kyle of Durness (Site B on Figure 1), one of which is shown in Figure

2. It is noteworthy that the building material of hut circles on the Borralie Headland was overwhelmingly quartzite.

Numerous artifacts have been found at the site dating from the early Bronze Age to present times. There is clear evidence of metal working and iron smelting at the location and several kg of iron slag has been sampled, as well as some bloomer furnace linings (Hardarson and Macdonald, 2025). A quartzite anvil is located onsite with associated iron splatter on the anvil and the adjacent surroundings (Figure 3). Extended use as a metalworking anvil gradually polishes and flattens the working surface which contrasts with the rougher natural texture of the surrounding less worked surface, as clearly indicated in Figure 3 (Hardarson and Macdonald, 2025)

Figure 2. *Hut circle east of the Kyle of Durness.*

Figure 3. *Quartzite anvil (55 X 35 X 40 cm). The left upper corner of the anvil has broken off. The surface shows impact pits caused by bipolar knapping and associated iron splatter.*

However, one of the most intriguing finds at the site are samples of worked mylonite which has only been found at this location on the Headland so far. The source of the mylonite is at the Faraid Head, some 5 km away to the north east (Figure 1). The artifacts consist of arrow heads (2), scrapers (3), and a spear head (1). Samples of unworked mylonite (7) are also present, less than 15 cm in diameter and thin (3-5 cm).

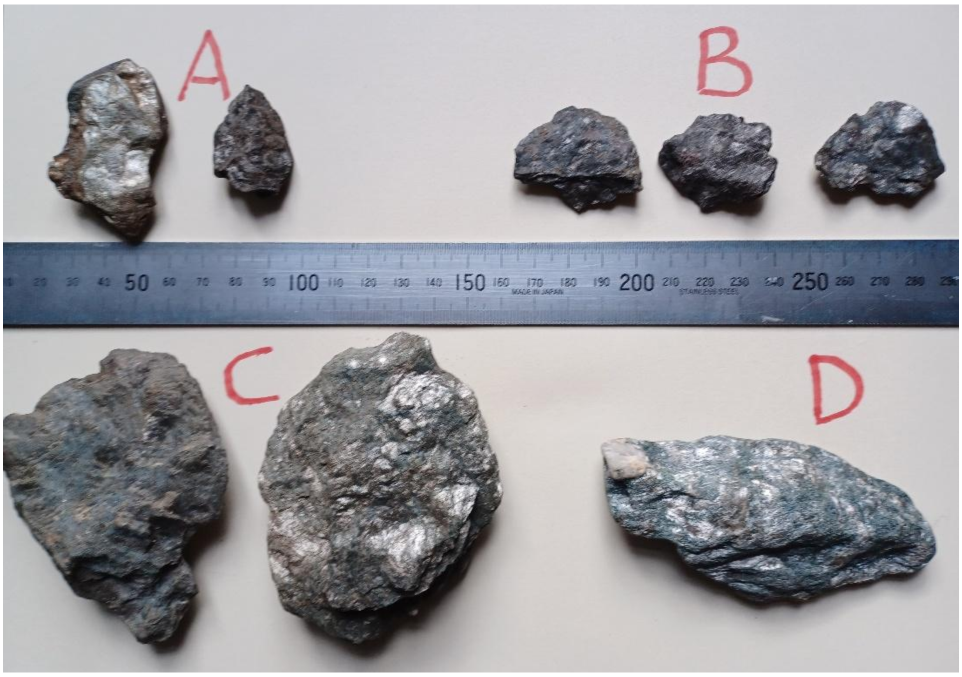

Figure 4. *Mylonite artifacts. Arrow heads (A), Small scrapers (B) Large scrapers (C), Spearhead (D).*

The mylonites we have assembled from this archaeological location, are not stray finds. They are concentrated within a relatively small area of a Bronza Age site. Several artifacts are worked and unworked fragments are small and thin, not resembling unsorted erratic glacial deposits of conglomerate moraine. They are also focussed SW of the source region on the Faraid Head, whilst glacial dynamics would have carried debris to the NE not to the SW.

The worked mylonite clearly shows that people used these rocks for tool making and the mylonite would have been a great addition to chert, which is found in abundance at several locations on the Borralie Headland. While chert was generally preferred for producing razor-sharp edges through flaking, the toughness, foliated nature, and exquisite appearance of the mylonite may have worked in its favour.

It is striking that Durness is about 100 km from Orkney and roughly the same distance away from the Western Isles. It is well documented that people moored in the area during their travels back and forth across Cape Wrath (Hvarf), for example, described in the Saga of King Hákon lV Hákonarson of Norway written by Sturla Þórðarson in 1264. Travellers would have known about the mylonite at the Faraid Head which may have had implications for trade.

Why mylonite has not been, to date, discovered at other Bronza Age or more recent sites in and around Durness remains ambiguous. However, the most obvious explanation is simply that it has not been uncovered, being hidden by sand as the characteristic sand dune system in the area is very dynamic.

7. Conclusions

Mylonite, a rock type born in the deepest and most energetic zones of Earth's crust, has exerted a quiet but persistent influence on human material culture in Scotland and beyond. Its formation along the great shear zones of the country not only shaped the topography of the Scottish landscape but placed outcrops of hard, dense, fine-grained rock, with its characteristic and exquisite silvery sheen, at the disposal of communities from Mesolithic to historic times. The archaeological evidence for its use spans various categories of tool production and even architectural masonry. In each case, the mechanical and aesthetic properties of the material appear to have been understood and deliberately exploited.

Here we report recent intriguing artifact finds of worked mylonite consisting of arrow heads, a spear head, and scrapers. The source of the mylonite is at the Faraid Head, where excellent outcrops of ultra mylonite are found. The worked mylonite clearly shows that people used these rocks for tool making and the mylonite would have been a great addition to chert, which is found in abundance at several locations on the Borralie Headland. Due to the location of Durness, midway between Orkney, the Western Isles and Ireland, it may have formed part of an exchange, or trading network, of mylonite. This question, however, remains unclear.

The study of mylonite in an archaeological context is still at an early stage. Mylonite is not something that people are in general familiar with. However, once again we are reminded of the deep-rooted connection we have with nature, in this case geology, where we learn how to make the most of specific resources surrounding us at different locations and at different times in history. We are not merely observers of the natural world; we are deeply intertwined with it. Distinguishing features which are diagnostic of true mylonites can superficially be similar in other metamorphic rock types and in such context, archaeology can benefit from geological input.

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