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Granite Millstones of Shropshire and Adjoining Counties

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LANGFORD, J.I. (2011). Granite Millstones of Shropshire and Adjoining Counties. *Proceedings of the Shropshire Geological Society*, **16**, 51–59. Granite millstones in Shropshire and adjoining counties occur in a region about 20 miles wide that extends from Clun in the west to Sutton Coldfield in the east. Differences in profile and other features suggest a large spread in age. On the other hand, their composition and texture, at least visually, are remarkably similar, implying a common source for the material from which they were manufactured. So what was their origin, when and why were they produced and where were they used? In this survey of granite millstones in the West Midlands their composition and source are considered in some detail and the other points are discussed briefly.

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INTRODUCTION

An unusual feature of several mills in the West Midlands was the occasional use of granite millstones. So far 22 have been recorded at 17 sites (Table 1 and Figure 1), though not all are complete. 18 of them, mostly in Shropshire, occur in a region about 20 miles wide that extends from Clun in the west to Sutton Coldfield in the east. Of the remainder, one is at Beanhall Mill (2), near Feckenham, one is at Much Cowarne Mill (14), 8 miles northeast of Hereford, and there are a couple at Standon Mill (19 and 20), 10 miles northwest of Stafford. A detailed account of the millstones is given by Langford (2011) and three representative examples are displayed at Daniel's Mill, near Bridgnorth (Plate 1).

Differences in profile and other features suggest a large spread in age. On the other hand, their composition and texture, at least visually, are remarkably similar, implying a common source for the material from which they were manufactured. So what was their origin, when and why were they produced and where were they used? In this survey of granite millstones in the West Midlands their composition and source are considered in some detail and the other points are discussed briefly.

POSSIBLE SOURCES OF GRANITE

The West Midlands is not the only region of the British Isles where granite millstones are to be found. There was a thriving industry based on Dartmoor, notably around Brent Moor and Shaugh, from the late Middle Ages until at least the 16th century (Fox, 1994) and there is a granite millstone in the Creetown Heritage Museum in Dumfries and Galloway. There are vast tracts of granitic rocks in Devon and Cornwall and in southern Scotland, but they do not outcrop anywhere in or near the West Midlands. There are granite quarries around Mount Sorrel in Leicestershire, a main source of setts for street paving in the Midlands and elsewhere during the 19th and early 20th centuries, and the rock is found in Anglesey and neighbouring Caernarfon. The nearest occurrence to the south is Dartmoor and to the north is the Lake District. Granite for the Midland millstones was therefore not quarried locally, but had been transported over a considerable distance.

The Manchester Museum has a large and comprehensive collection of granites and related rocks from localities throughout the British Isles and elsewhere and the first stage in tracking down the origin of the Midland stones was a visual comparison of small samples from the millstones with the museum specimens. Significantly, the only British granites indistinguishable from the Midland material were from a quarry near Creetown and from Princetown Quarry on Dartmoor.

The Dartmoor millstones were produced from 'clitter' or 'moorstone' – loose blocks of granite split by the action of frost and weathering from the tors that dominate the moor. The stones were used in monastic and manorial mills and were transported up to 20 miles from the moor, the cost of shipment sometimes being greater than that of manufacture (Fox, 1994). Dartmoor is thus an unlikely source for the Midland stones, since shipment would have entailed a long and expensive journey by sea via Land's End and the Severn estuary. Aside from that, no granite stones have been reported for the intervening counties.

X-RAY POWDER DIFFRACTION DATA

The principal method for identifying small quantities of crystalline material is by means of X-ray powder diffraction (XRPD), whereby a small powder sample is placed in an X-ray beam. The beam scattered by the sample is unique; no two substances have the same *diffraction pattern* and, by comparison with standard data in the *Powder Diffraction File* (PDF), produced by the International Centre for Diffraction Data, minerals present in a rock sample, for example, can be ascertained.

XRPD data were obtained for samples from three Shropshire millstones, Aston Rogers (1), Cooper's Mill in the Wyre Forest (6), and Ratlinghope (18), and compared with those from the Dartmoor specimen (M1378) and the one from Creetown (M2633) in the Manchester Museum. The specimens were milled at 600 rpm for 15 minutes and back-loaded into aluminium sample holders to obtain flat samples. Diffraction data were obtained with CuKα X-rays (0.15406 nm wavelength) by scanning over the range 5 to 100 º(2θ) in steps of 0.05 º(2θ), with a counting time of 25 sec/step.

The resulting diffraction patterns contained over 100 peaks (reflections) and part of the patterns for the Shropshire and Dartmoor samples are shown in Figure 2. Identification of the minerals present is based on a list of the positions and intensities of reflections by a procedure known as *search/match*; an automatic search is made of entries in the PDF, in this case a subset of several thousand mineral datasets, and a list of matches is produced, ranked according to the quality of fit. By means of this procedure, the main minerals in all samples were confirmed as quartz (Q), alkali feldspar (A), plagioclase feldspar (P) and biotite ('black') mica. These minerals and an indication of the texture can be seen in Plate 2, a fragment of a millstone found in the garden at Newhall Mill, Sutton Coldfield, (16). The other stones are similar, though due to the effects of weathering the minerals are often less obvious.

Diffraction patterns are almost identical for the three Shropshire samples (Figure 2), again inferring that the material could have come from the same source, but there are small differences with the Dartmoor data, e.g. around 12.5 º and 34 º. Mineral identification indicated that in all samples the alkali feldspar is microcline, the plagioclase is an ordered albite, possibly calcian, and the mica is biotite 2M1. This is demonstrated in Figure 3 for the Dartmoor data, where the PDF data are plotted as lines at appropriate angles and of length proportional to the intensity *(a)* and superimposed on the diffraction pattern *(b)*. In addition, there is a small quantity, in the range 0.5% for 18 to 1.7% for 6, of kaolinite, due to the partial breakdown of feldspar into china clay. Kaolination is evident in the Creetown data, but not in those from Dartmoor.

Rocks containing quartz can be characterised by means of the QAP diagram (Figure 4), a simplified version of a classification system for all plutonic rocks. QAP values can be obtained from the relative areas of non-overlapping reflections from quartz, microcline and albite in the diffraction pattern. These are listed in Table 2 for the three Shropshire stones and, from Figure 4, are within the range for true granite. The quartz content is about the same for all three samples and, at about 50%, is relatively high. The difference between the relative feldspar content of 18 and the other samples may be significant. Reliable QAP values from X-ray data depend on the sample being a completely random powder and this can be achieved by careful preparation. However, any tendency for feldspar grains to orient preferentially will introduce an error.

OPTICAL MICROSCOPY

Although the evidence from XRPD data infers that southern Scotland is the source of the granite, Dartmoor cannot be ruled out with absolute certainty. Thin sections for optical microscopy were therefore made for 6 (Cooper's Mill) and 18 (Ratlinghope), for which there was sufficient material, and the two museum specimens. A polarizing microscope revealed the following features for the main minerals:

Quartz

The quartz crystals in 6, 18 and M2633 (Creetown) have high to moderate relief with poorly defined (anhedral) edges (e.g. Plate 3). Some crystals exhibit intergrowth (myrmekite) textures. There are also some granoblastic grain boundaries, indicating low grade metamorphism *[granoblastic: Descriptive of the texture of igneous rocks. Grains are visible to the eye, often have sutured boundaries and are approximately equidimensional. The grain boundaries intersect at 120° triple junctions under ideal conditions]*.

The quartz in M1378 (Dartmoor) is quite different. Here it displays undulose extinction, a feature not observed for the other samples *[undulose extinction: Grains appear black (no light transmitted) with cross-polarised light as the specimen stage is rotated.]*.

Microcline

Optical data confirm that microcline is the dominant alkali feldspar in all four samples. In 6 the microcline is highly broken down to clay mineralization and there is distinct cross-hatching under polarized light for 18 (Plate 4).

Albite

Low relief, single cleavage and lamellar twinning in both 6 and 18.

Mica

In all samples the mica is mainly biotite, somewhat altered to chlorite in 6 (Plate 5) and 18. The mica in the Dartmoor sample has small embedded zircon crystals, each surrounded by a pleochroic halo, a spherical region in which there is a change of colour (Plate 6). This is caused by radiation damage from radioactive decay of zircon, a common feature of the granite that outcrops in Devon and Cornwall. The effect is not present in M2633 and it does not occur in the Shropshire samples.

The lack of radiation damage in mica, plus the different nature of quartz grains, rules out Dartmoor as a source of rock for the granite stones. The partial breakdown of microcline to clay mineralisation in 6 is also evident from the larger kaolin content obtained from X-ray data for this specimen and is probably the reason for the Cooper's Mill stone having broken into several pieces. Otherwise, optical data indicate that the mineralogy of 6 and 18 is similar.

TRANSPORTATION

It is clear, therefore, that granite for the West Midland millstones came from southern Scotland, the region now known as Dumfries and Galloway. The rock at Creetown is part of an extensive area of granite centred on Mount Criffel. Glaciers plucked an immeasurable quantity of rock from the mountains in this region and conveyed it southwards. When climatic warming caused the glaciers to melt and retreat, the boulders they carried were deposited as 'glacial erratics' in the Midlands. This was not the only ice to reach the area during the last glacial epoch; glaciers from Wales and the Lake District contributed to the variety of rock types found there, from huge boulders to tiny pebbles, but no granite.

A systematic survey of the glacial material that litters the Midland landscape was carried out by Macintosh (1879). He identified the erratic boulders as Criffel granite and rock from the Lake District, transported by what is termed the Irish Sea ice, since it traversed that sea, and also from the region around Arenig Fawr in mid-Wales. He also noted the approximate southern limit of the boulders. Building on the work of Macintosh, Martin (1888; 1890) recorded several hundreds of glacial erratics from Much Wenlock to Sutton Coldfield and from Stafford to Bromsgrove, grouping them as: *(a)* Mount Criffel and south Scotland, *(b)* the Lake District, *(c)* Mount Arenig and North Wales, and *(d)* local rocks.

Figure 5, part of the record of his remarkable survey, shows how prolific erratics are throughout the region. In addition to the locality of each boulder, Martin gives its dimensions and describes the rock type; he identified about 350 of them as granite, usually grey, of 'Criffel type'. From the work of these early geologists and others, notably Wills (1948), the southern limit of the Scottish and Lake District boulders was shown to be more-or-less scattered along a line from Church Stretton through Wolverhampton to Burton-on-Trent, known as the 'Wolverhampton Line' (Figure 1). It has been demonstrated that the southernmost advance of the Irish Sea Glacier to what is now the Midlands occurred about 25,000 years ago (Shotton, 1967).

The majority of the Midland granite millstones are within a few miles of the Wolverhampton Line and were clearly derived from boulders transported from southern Scotland. Robert Plott (1686) recorded that 'some [millstones] are made out of great loose stones, and others dug out of Quarries. Of the former there have many been made out of great round pebbles found on Braden Heath between Sherriff Hales and Blymhill, and so there has at Seasdon [Seisdon], where on the Heath there lye some pebbles so vastly great, that as I was told, there have 3 Mill-stones been made out of one of them. These Mill-stones out of pebbles they use for grinding wheat and some think them not short of Colen [Cullin or Cologne] stones'. Plott does not specify the nature of the 'loose stones', but they must have been granite boulders; no other Midland erratics were suitable for milling.

Millstones were not the only commodity manufactured from granite erratics; a fairly plentiful source of such a hard rock would have been used for other purposes. For example, two granite grindstones are set into the wall at the entrance to Seisdon mill (19). It is therefore not surprising that large granite boulders have not survived. There are, however, examples of other immense glacial erratics in the Midlands; for example, there is an Arenig boulder weighing several tons outside the East Building of the School of Physics at the University of Birmingham. Smaller granite boulders are abundant throughout the region, though they have often been moved to the edges of fields or the sides of roads. There is a good example of one *in situ* in the grounds of the National Trust's Dudmaston Hall, to the left of the path through a wood towards the Severn [GRID SO 747 885]. One of the more westerly granite erratics is by the side of the road at Plush Hill, on the eastern slopes of the Long Mynd [SO 451 964].

Although granite millstones were derived from glacial boulders, it should be borne in mind that more recent stones could have been purchased from mill furnishers, since they were available commercially in the latter part of the 19th century. For example, J. Hughes & Sons of London advertised granite, peak and Cologne stones in *The Miller* (1880) and Peter Reid of Glasgow offered French burr, Kaimhill, Derby Peak, granite and Whin millstones (*The Miller*, 1881). The latter almost certainly sourced his granite from the Creetown/Criffel area and Hughes may have done so. From the 1700s onwards considerable quantities of granite were shipped from quarries around Creetown. Many of the country's major docks were constructed from it, as was the Thames Embankment in London.

AGE OF GRANITE MILLSTONES

Earlier millstones tended to have a smaller diameter (4 feet or less) than later ones. To give added weight, the back surface of runner stones was therefore significantly rounded, whereas later stones usually had parallel surfaces. The arrangement of ridges and furrows (the dressing) evolved over the years. For mediaeval stones it was somewhat crude and had no particular pattern (Plate 7), though the direction of the leading (master) furrows was usually more-or-less contained within the central hole (the eye). Then around the middle of the 18th century it was realised that a systematic approach to dressing greatly increased the efficiency of milling. This was achieved by advancing the furrows in the direction of rotation.

Another development was type of support for the runner stone (the rynd). Curved rynds were favoured in the 17th century, whereas straight rynds are likely to date from the 18th century. Mortises for both types can be seen Plate 1. Another diagnostic is the furrow profile; this was a simple 'U' or 'V' section for earlier stones, but an asymmetric 'V' later became standard (Plate 2), and the quality of dressing improved (*cf.* Plates 1 and 7). Aside from the early Ratlinghope stone, the granite millstones mostly appear to date from the 17th century, as noted by Plott (1686), and the 18th century. Further information on the approximate dating of the millstones, or at least their final dressing, is given by Langford (2011).

WHY USE GRANITE?

Before Peak (Derbyshire) stones became widely available with the growth of the railway network, the preferred monolithic millstones in the area, at least within reach of the Severn, were often from quarries at Penallt, about 2 miles south of Monmouth. These 'Welsh stones' are a coarse quartz conglomerate or 'pudding stone' from Old

Red Sandstone strata that was quarried extensively high above the river Wye from the 14th to the 19th centuries (Tucker, 1971; Ward, 1990). In order to reach the West Midlands, they were conveyed down the Wye and then up the Severn in shallow-draught sailing barges called 'trows'. It is therefore not surprising that locally available granite boulders were used where practicable, though Penallt stones may have been somewhat superior; granite stones would tend to become highly polished, needing to be re-dressed more frequently, but they had the advantage of minimal transport costs. In view of the evident spread in age of granite stones and the small number that have survived, compared with other millstones, it is unlikely that their manufacture was ever a major industry.

CONCLUSIONS

From a visual examination, granite millstones in the West Midlands have a similar composition and texture and the rock from which they were manufactured evidently came from the same region. A comparison with granites from known localities in the British Isles showed that this source was either Dartmoor or the area around Creetown and Mount Criffel in Dumfries and Galloway. X-ray powder diffraction data and optical microscopy for samples from 1, 6 and 18 confirmed that the latter was origin of the granite. These data also demonstrated that the stones are true granite, according to the standard definition of this rock type. Most, if not all, the stones were manufactured from glacial boulders (erratics) transported by ice from south Scotland and deposited in the Midlands when the Irish Sea Glacier retreated. Nevertheless, the relative uniformity of composition and texture of the millstones is somewhat surprising, in view of the variety of granitic rocks that occur in Dumfries and Galloway.

So far 22 granite millstones have been found in the West Midlands and there may well be others, but they could hardly have been manufactured on an industrial scale. It seems likely that they were made by opportunist stonemasons, along with other items, such as grindstones, the quantity being dictated by the availability of suitable boulders.

Acknowledgements

The inspiration for this survey of granite millstones in the West Midlands came from Tim Booth of The Midland Wind and Water Mills Group, who located most of the stones studied and provided a wealth of background information. I am also indebted to Alan Stoyel and Martin Watts for their interest and assistance in the project. Access to the Manchester Museum collection was arranged through the late Tony Browne and thin sections for optical studies were prepared by David Green of the museum. X-ray diffraction data were provided by Professor Paolo Scardi, School of Materials Science and Engineering, University of Trento, Italy, and optical data were obtained through Jon Clatworthy, Curator of the Lapworth Museum of Geology, University of Birmingham. Finally, my thanks are due to the many mill owners for granting access to the granite stones and allowing me to take samples.

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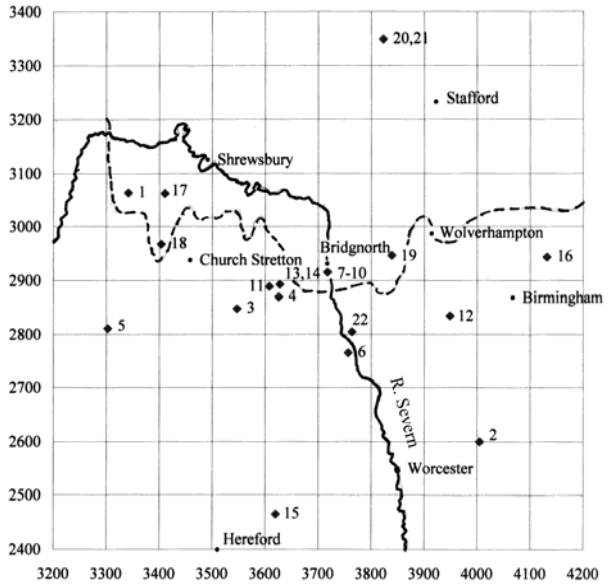

Figure 1. Granite millstones in the West Midlands (Table 1). '- - - -' indicates approximate maximum extent of Irish Sea ice (after Wills, 1948).

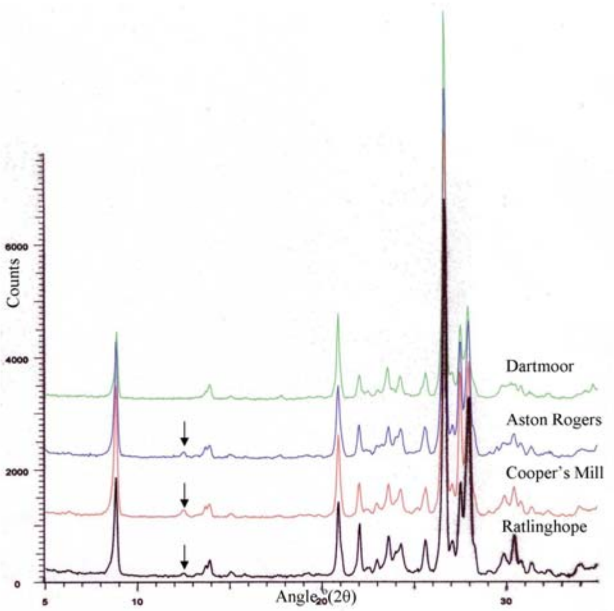

Figure 2. Part of X-ray powder diffraction patterns for Aston Rogers (1), Cooper's Mill (6) and Ratlinghope (18) samples and Dartmoor specimen, CuKα X-rays (0.15406 nm wavelength). Arrows indicate the strongest reflection from kaolinite for the Shropshire samples.

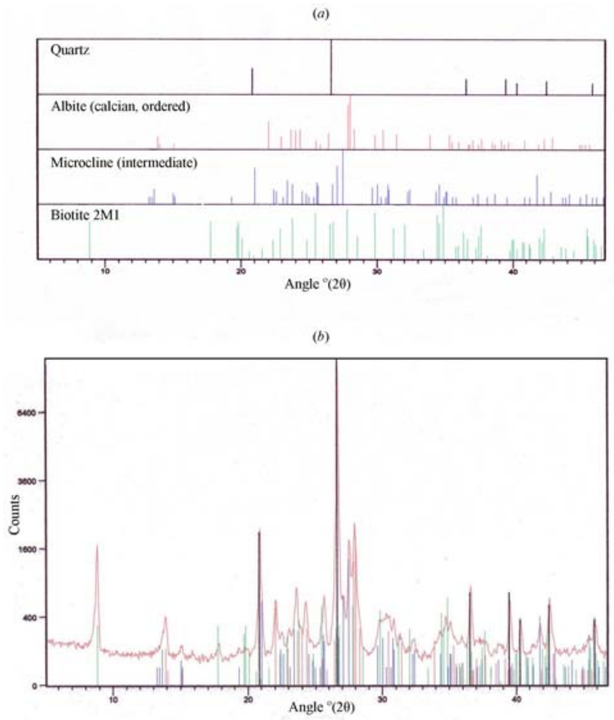

Figure 3. Mineral identification for Dartmoor specimen (M1378). (a) Plot of standard data from Powder Diffraction File for main minerals. (b) Match between experimental and standard data.

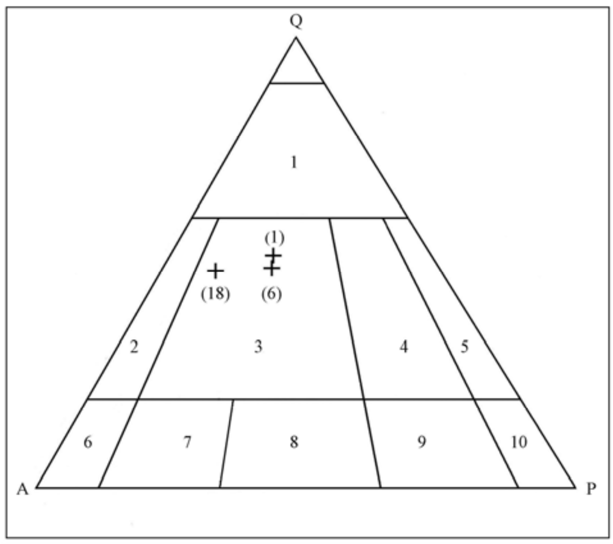

Figure 4. Quartz/Alkali feldspar/Plagioclase feldspar (QAP) diagram for rocks containing free quartz, showing position of Shropshire samples 1, 6 and 18 (Table 2). 1 quartz-rich granitoid, 2 alkali-feldspar granite, 3 granite, 4 granodiorite, 5 tonalite, 6 alkali-feldspar syenite, 7 syenite, 8 monzonite, 9 monzodiorite, 10 diorite/gabbro/anorthosite.

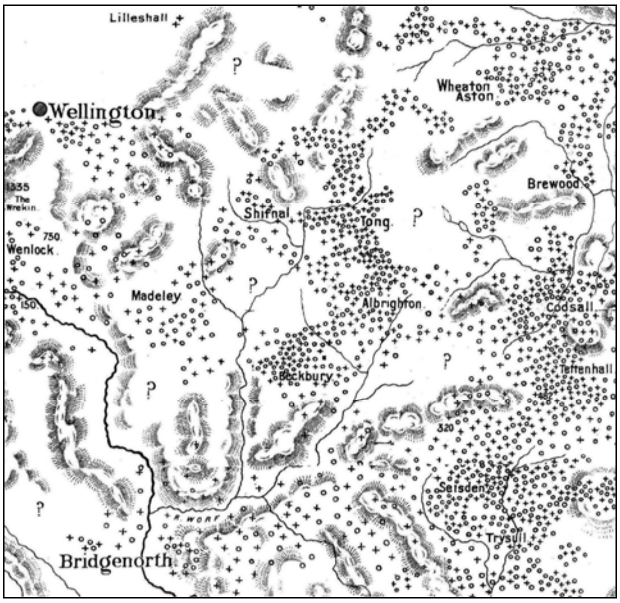

Figure 5. Part of Martin's survey of glacial boulders in the Midlands (Martin, 1890). + Boulders from Mount Criffel and south Scotland. o Boulders from the English Lake District.

Plate 1. Old millstones at Daniel's Mill, Bridgnorth. From the left: *(a)* 25 in. (0.64 m) granite runner stone with straight (cruciform) rynd mortise (7); *(b)* 41 in. (1.04 m) dia. granite runner with curved rynd mortise (8); *(c)* local sandstone with mortises for wooden and iron rynds, possibly from Hexton's Quarry, near Upper Arley; *(d)* 42 in. (1.07 m) granite bedstone (9) for use with (8).

Plate 2. Fragment of granite millstone (16) found at New Hall Mill, Sutton Coldfield, showing minerals and texture. White regions are feldspars, whereas quartz is colourless, and the black areas are mica. Note asymmetric furrow cross-section.

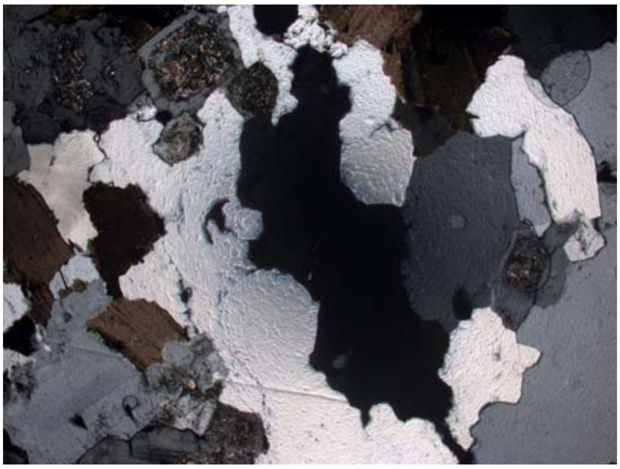

Plate 3. Thin section from Ratlinghope millstone (18) showing anhedral quartz grains similar to 6 (Cooper's Mill) and M2633 (Creetown).

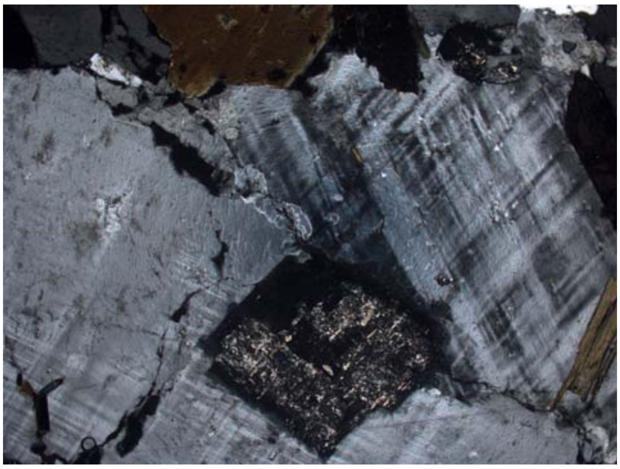

Plate 4. Microcline in 18, showing cross-hatching.

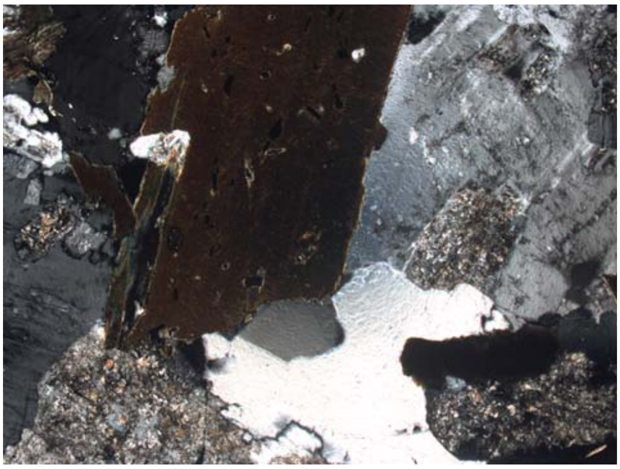

Plate 5. Cooper's Mill (6), showing partial breakdown of biotite (brown) to chlorite.

Plate 6. Dartmoor sample (M1378), with circular pleochroic halos in biotite (brown) from the radioactive decay of small zircon crystals.

Plate 7. Dressed surface of Ratlinghope stone (18). Note widely-spaced symmetrical-section furrows with ill-defined pattern, indicative of an early age for this millstone. Probably from the late mediaeval period.

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Table 1. Granite millstones in the West Midlands.

No.	Location	County	Grid Ref.	Notes
1	Aston Rogers Mill	Shropshire	SJ342066	In house to support stove
2	Beanhall Mill, Feckenham	Worcestershire	SP005602	At Beanhall Farm
3	Bouldon Corn Mill	Shropshire	SO547850	Upright against garden wall
4	Cleobury North Mill	″	SO626872	Embedded in mill floor
5	Clun	″	SO304814	Table top in garden of Lake House, near Clun Mill
6	Cooper's Mill, Wyre Forest	″	SO757767	Broken into several fragments
7	Daniel's Mill, Bridgnorth	″	SO718917	'Clover stone', upright against viaduct wall
8	″	″	″	'Flour stone', upright against viaduct wall
9	″	″	″	Bedstone for 8, upright against viaduct wall
10	″	″	″	Fragment across wheel pit of Clover Mill
11	Ditton Priors (Hillside) Windmill	″	SO608891	Embedded upright against mill wall
12	Lutley Mill, Halesowen	(ex-Worcestershire)	SO949837	Embedded in cobbled yard at front of mill
13	Middleton Priors Mill	Shropshire	SO628895	Upright against wall at converted mill
14	″	″	″	In mill garden
15	Much Cowarne Mill	Herefordshire	SO621468	Lying on dressed surface; unusual profile
16	New Hall Mill, Sutton Coldfield	(ex-Warwickshire)	SP133945	Small fragment of dressed surface found in garden
17	Pontesford Upper Mill	Shropshire	SJ411065	Upright against mill house
18	Ratlinghope Mill	″	SO404969	Two halves, formerly used as steps curb
19	Seisdon Mill	Staffordshire	SO839948	Large fragment in mill garden
20	Standon Mill	″	SJ823351	Embedded upright, displayed at entrance to mill yard
21	″	″	″	″
22	Upper Arley	Worcestershire	SO764807	Embedded upright, adjoining car park of arboretum

Table 2. Quartz (Q), alkali feldspar (A) and plagioclase (P) content (percentage).

Millstone No.	Locality	Q	A	P
1	Aston Rogers Mill	53	13	34
6	Cooper's Mill (Wyre Forest)	49	14	37
18	Ratlinghope Mill	50	9	41

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