Quartz technology in Scottish prehistory

by Torben Bjarke Ballin

Scottish Archaeological Internet Report 26, 2008
www.sair.org.uk

Published by the Society of Antiquaries of Scotland, www.socantscot.org.uk
with Historic Scotland, www.historic-scotland.gov.uk
and the Council for British Archaeology, www.britarch.ac.uk
Editor Debra Barrie
Produced by Archétype Informatique SARL, www.archetype-it.com

ISBN: 9780903903943
ISSN: 1473-3803

Contents

List of illustrations

List of tables

1 Summary

The project *Quartz Technology in Scottish Prehistory* was initiated in the year 2000, and over the following five years a large number of quartz assemblages were examined from all parts of Scotland, and from all prehistoric periods. The general aim of the project was to shed light on quartz variability, that is, to define how quartz assemblages in different periods and areas of the Scottish quartz province (the north, north-west and Highland regions of Scotland) differ. Subsequently it was attempted to explain the observed variability, focusing on factors such as chronology, territoriality, access to lithic resources, technology and activity patterns. In the larger framework, the present paper forms part of international efforts to increase awareness of archaeological quartz as an important resource. It is hoped that the research put forward in this paper may prove useful to quartz researchers in other parts of the world.

2 Introduction

2.1 Project background, aims and working hypotheses

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 (Saville 1994). While there are considerable variations at local level [eg involving bloodstone (Wickham-Jones 1990) or pitchstone (Haggarty 1991, 91)], taking Scotland as a whole the most common raw materials exploited are flint (the coastal regions and East Scotland), chert (the Southern Uplands) and quartz (the north, north-west and Highland regions of Scotland). The true importance of quartz has, to a degree, been obscured by research bias as, probably owing to difficulties associated with identifying tools in quartz (cf Lindgren 1998), many archaeologists have shunned this raw material.

As a result, many publications of Scottish quartz assemblages, as well as quartz reports world-wide, tend to be characterized by lack of enthusiasm, detail and precision (cf Saville & Ballin 2000, table 1). The sparse literature gives the impression that quartz was a raw material only used in a few remote corners of prehistoric Scotland, whereas in fact it was a major lithic resource, or at least an important supplement, in approximately one-third of the country over several millennia. The broader purpose of the project *Quartz Technology in Scottish Prehistory* (in the following text simply referred to as the Quartz Project) is to increase awareness of the significance of quartz throughout Scottish prehistory.

The main aim of the Quartz Project is to shed light on quartz variability, that is, to define how quartz assemblages in different periods and areas of the Scottish quartz province (the north, north-west and Highland regions of Scotland) differ. With the general variation defined, it will be attempted to explain the observed variation. In advance of the project, it was assumed that most differences between assemblages would be due to differences in:

- chronology
- regionality (territoriality)
- availability (access to resources)
- adaptation to the specific flaking properties of the available raw material, or
- activity patterns (subsistence economy and on-site behaviour).

Due to its general properties, quartz is undoubtedly more demanding to examine and characterize than, say, flint or chert. It is, however, the basic assumption of the present paper that, if quartz assemblages are excavated and examined as meticulously as assemblages in other raw materials, they offer similar potential for information on prehistoric societies and behaviour. If the tools to achieve this are not presently available, it is possible to develop these over time.

In the larger framework, the present paper forms part of international efforts to increase awareness of archaeological quartz as an important resource. It is hoped that the research put forward in the present paper may prove useful to quartz researchers in other parts of the world.

2.2 Methodology

In the course of the project, the following research topics were given special attention:

- raw materials
- typology
- technology
- spatial patterns (intra-site as well as inter-site), and
- assemblage dates.

These topics formed the back-bone of the defined standard research design, or approach, the purpose of which was to ensure comparability between the selected quartz-bearing assemblages (in the present paper, the term 'quartz-bearing assemblage' refers to an assemblage which is either completely dominated by quartz, or which has quartz as an important or a minority component. The selection of quartz assemblages for the Quartz Project is described below, as part of the project history [Section 2.3]).

2.2.1 Raw materials

When dealing with quartz, it is important to realize that this resource encompasses a group of closely related, but more or less distinctive, materials. The pilot project (see below) showed that milky quartz, rock crystal and 'greasy' quartz are three varieties with different appearances and different flaking properties, and they would probably have been perceived by prehistoric people as three different materials with different functional and perhaps symbolic values. The sub-division of quartz is discussed in Section 4.3. Generally, lithics analysts tend to lump all quartz sub-types into one main category. As Abbott states, this is '. . . like a faunal analyst putting all furry animal remains into a "mammal" category without separating them by specific name, genus and/or species' (Abbott 2003, 106). In doing so, a great deal of valuable information is lost.

2.2.2 Typology

The application of a sensible typo-technological framework is of immense importance to the discussion of chronology (diagnostic types), regionality ('style'; Wiessner 1983), as well as economical aspects and intra-site spatial patterns (functional types). It is a truism that it can be difficult to identify retouch, and thereby tools, in quartz. Another problem is that, due to the different flaking properties, many quartz blanks and tools have a different appearance to that of artefacts in flint-like silica. For this reason, some scholars have attempted to develop a typology solely for quartz artefacts (Broadbent 1979; Lehane 1986; Callahan 1987). Unfortunately, the introduction of a separate quartz typology prevents comparison of quartz tools and those in other raw materials, and the author believes this practice should be discouraged (discussed in more detail as part of Section 8.2). As demonstrated in the lithic analyses already undertaken as part of the pilot project (Ballin 2001c), it is quite practicable to apply the same typology to all raw materials.

2.2.3 Technology

The common use of bipolar technique in connection with reduction of quartz material, combined with the fact that the bipolar technique was not generally recognized as such until the mid-1980s (though correctly identified by White in 1968), means that most older presentations of quartz assemblages are heavily flawed (Saville & Ballin 2000, table 1). Bipolar material was classified as, *inter alia*, opposed-platform cores, wedges and scrapers, which firstly creates a bias in inferences about the assemblages and activities associated with them, and secondly makes comparison based on or including older literature highly problematic. With bipolar material classified correctly, it is possible to achieve a detailed picture of prehistoric lithic technologies, in particular combined with the *chaînes opératoire* approach (Leroi-Gourhan 1965; Lemonnier 1976; Eriksen 2000). As a consequence of this state of the art, it was chosen to re-examine a number of significant Scottish quartz assemblages, and update the general typo-technological terminology and nomenclature (eg Kilmelfort Cave, Argyll: Saville & Ballin forthcoming; Lealt Bay and Lussa River, Jura: Ballin 2001b; Ballin 2002b; Shieldaig, Wester Ross: Ballin *et al* forthcoming; and Scord of Brouster, Shetland: Ballin 2007a). The results of these analyses are summarized in Section 2.4.

2.2.4 Distribution analysis

Analysis of quartz assemblages may include distribution analyses to either: (i) shed light on intra-site settlement organization; or (ii) test the chronology of the site and/or the quartz assemblage. The main precondition for carrying out a distribution analysis is the existence of a standard grid system with square grids of maximum 1sq m (preferably 0.25sq m or less), or the recovery of finds must include detailed reference to site contexts (less precise).

In Scottish archaeology, quartz has rarely (if ever) been exposed to distribution analyses. This is not due to quartz being less suited for this kind of investigation; it is more a combination of traditionally low expectancies and recovery/recording policies. Most known quartz assemblages are from excavations, but unfortunately many of these were documented in ways inappropriate for distribution analysis (as, for example, in the case of the three assemblages studied in the pilot project; see Section 2.3).

Today, it is common practice in Scotland to excavate Stone and Bronze Age sites with accurate recording of finds to either standard grids or well-defined contexts, and many assemblages excavated in the last 15–20 years are well-suited for analysis of settlement organization. The assemblages selected for the Quartz Project were subjected to general distribution analysis whenever this was possible (eg Bayanne and Scord of Brouster, Shetland: Ballin 2007a; Ballin forthcoming j; Dalmore and Calanais, Lewis: Ballin forthcoming a; Ballin forthcoming g; and Rosinish, Benbecula: Ballin forthcoming h).

2.2.5 Dating

As demonstrated in the pilot project report (Ballin 2001c), quartz is just as useful for dating purposes as other lithic materials, as long as diagnostic artefacts or attributes are present. At a general level, dating quartz assemblages by the use of diagnostic artefacts or technological attributes is hampered by the lack in Scotland of an adequate typo-chronological framework for the Mesolithic and Neolithic periods. It must be an important aim in Scottish Stone Age research to improve the chronological framework by identifying new diagnostic types or diagnostic technological attributes. In connection with the Quartz Project, one implement type with chronological and regional diagnosticity was identified, namely the curved knife (see presentation of the Scord of Brouster assemblage; Section 2.4.3), which seems to be a form produced in the later part of the Early Neolithic period and, apparently, only in the Scottish quartz province (though not exclusively manufactured in quartz).

2.3 Project history

A draft project proposal was produced by the author and discussed with Alan Saville (National Museums of Scotland) and Patrick Ashmore (Historic Scotland). A two-stage project structure was suggested, with a pilot project to be completed in the financial year

2000/01 and a main project to be carried out over the following years, founded on the results and recommendations of the pilot project. Historic Scotland and the National Museums of Scotland agreed to fund the initial stage jointly, and during the main project funding was received from Historic Scotland, the National Museums of Scotland, the Society of Antiquaries of Scotland, the Russell Trust and the Catherine McKichan Bursary Trust.

2.3.1 Pilot project

After discussion of the selection criteria for the pilot project and following examination of material in the care of the National Museums of Scotland, a number of quartz assemblages were accepted as suitable for further research. As, at that time, most published quartz assemblages were of Bronze Age date, it was decided to focus on Mesolithic assemblages, and Kilmelfort Cave, Argyll (Coles 1983), Lealt Bay, Isle of Jura (Mercer 1968) and Shieldaig, Wester Ross (Walker 1973) were those selected for initial study. A specialist report was produced on each of the three chosen assemblages (for summaries, see Section 2.4), together with a project report (Ballin 2001c), which included recommendations for the proposed main project. In general, it was recommended that 'To satisfy the aims set up by this project, a substantial number of representative quartz assemblages must be examined and compared'. Specific recommendations included the following four points:

- chronology
- territoriality
- resources
- activities.

Chronology

It is most likely that the appearance of quartz artefacts will vary over time. To detect this variation it is necessary to examine assemblages from all quartz-using periods and phases. To test whether the observed variation is in fact chronological (that is, *not* due to differences in territoriality, raw material availability, specific flaking properties, or site economy/activities), it is vital to include in the project as many *different* assemblages as possible from each period and phase.

Territoriality

To test whether territoriality may explain some morphological details of individual quartz types (stylistic variation), as well as the composition of quartz assemblages, it is imperative that all regions of the Scottish quartz province are represented by suitable assemblages. Stylistic variation (Wobst 1977; Wiessner 1983; Gebauer 1988) is usually associated with the distinction of social territories (Clark 1975, 12; Ballin 2007a), and, for example, Scandinavian research (Bruen Olsen & Alsaker 1984; Andersen 1983; Andersen 1995a; Andersen 1995b) suggests social territories to be identical to specific sets of biotopes ('economic zones') delimited by significant topographical features (fjords, rivers, mountain ranges or water divides). For this reason, the Quartz Project should attempt to cover as many economic, as well as topographical, zones as possible.

Resources

The effect of chronology and territoriality on the variation within and between quartz assemblages is as yet unproven, but it is fairly certain that some of the observed variation is due to raw material differences. The following points have been established: (i) throughout the Scottish quartz province different types of quartz were used; (ii) of the main five quartz types (Section 4.3), some varieties are better suited for the manufacture of flaked tools than others; and (iii) in some assemblages, quartz was supplemented by other materials, or it was itself a supplement. In the attempt to analyse the influence of raw material variability (availability) on assemblage variability, quartz assemblages should be selected from all geological zones of the Scottish quartz province.

Activities

As the specific subsistence economy and activities at a particular site may influence the composition of its assemblage, the Quartz Project should include assemblages from different types of site. Relevant site types are: (i) open-air lithic scatters (ie sites not associated with more substantial dwelling structures); (ii) house sites; (iii) ritual sites; and (iv) burial sites. One could, for example, envisage a marked difference between assemblages from sites of Types i/ii and iii/iv. The composition of assemblages from the former group of sites may be dominated by utilitarian choices, and they might include a certain amount of production refuse. The composition of assemblages from the latter group of sites may be dominated by choices involving the symbolic value of artefact raw materials and style, and might contain less refuse, fewer blanks, and more tools.

In summary, it was concluded that the Main Project should attempt to cover:

- assemblages from all Stone and Bronze Age phases, as well as the Early Iron Age
- assemblages from as many biotopes/economic zones as possible
- assemblages in different types and sub-types of quartz, and assemblages in which quartz is supplemented by other raw materials
- assemblages from all main geological zones
- assemblages from different site types.

2.3.2 Main Project

During the Main Project, it was attempted to cover as many of the periods, zones, raw materials/raw material combinations, and site types listed above. The various sub-projects make up four groups, namely:

1. assemblages analysed as part of the author's general contract work as a lithics specialist
2. assemblages analysed in the form of additional research projects (Lussa River and Scord of Brouster)
3. privately funded/grant-funded investigation of the Cnoc Dubh quartz quarry
4. privately funded experimental work examining the effect of fire on quartz.

The Mesolithic quartz assemblage from Lussa River on Jura was examined first (Ballin 2002b) in an attempt to expand the available data on early prehistoric quartz reduction. This work was supported by a grant from the National Museums of Scotland. With the addition of the material from Lussa River, the Mesolithic period was satisfactorily covered (although it had not been possible to find suitable Early Mesolithic quartz assemblages), and as practically all quartz assemblages examined as part of contract work were from the Bronze and Early Iron Age periods, only the Early Neolithic period represented a serious chronological hiatus. Only one sizable Early Neolithic quartz assemblage was available for analysis, namely the finds from Scord of Brouster on Shetland (Ballin 2007a). This assemblage was originally excavated and published (by Whittle 1986), but as Whittle's analysis was carried out before the general recognition of bipolar technology, the collection was in need of re-examination, re-classification and, consequently, re-interpretation. This work was financed by Historic Scotland and the Society of Antiquaries of Scotland, and practical assistance was provided by the Shetland Museum and its staff.

As part of the general analysis of quartz procurement, the worked quartz vein, or quarry, of Cnoc Dubh on Lewis was inspected (2002), and a paper was produced (Ballin 2004e) in which the technical and territorial/social background to quartz procurement was explored. This sub-project was supported financially by the Catherine MacKichan's Bursary Trust, and practical assistance in the field was received from Western Isles Archaeologist Mary MacLeod and local amateur archaeologist James Crawford.

In response to an almost complete absence of reports on burnt quartz from excavated sites, the author decided to look into this question (Section 4.4.3). This work took two forms, namely, (i) experimentation and (ii) focused scrutinizing of quartz from contract and research projects. Quartz was deliberately exposed to fire to gain insight into the appearance of fire-affected quartz, and the experience from the experimentation was then applied as part of the general analysis of quartz assemblages. This work, which was funded privately, took place in 2003, and it is intended to publish the results in full at a future stage (Ballin forthcoming k).

Through the Pilot Project and the Main Project it has been possible to embrace most of the zones, raw materials/raw material combinations and site types listed above, but to a varying degree (illus 1): the Later Mesolithic period and the period from the Late Neolithic to the Early Iron Age are well-covered, but it has only been possible to analyse one Early Neolithic quartz assemblage and no Early Mesolithic assemblages (the material from Kilmelfort Cave is thought to be of a Final Palaeolithic date; Section 2.4.1); practically all assemblages are from coastal sites (defined as sites located directly on the coast, or with a distance to the coast of less than 10km; cf Higgs & Vita-Finzi 1972, 28; Ballin 2007b), with the only exception being the finds recovered along the St Fergus to Aberdeen Natural Gas Pipeline (FERG) in Aberdeenshire (Ballin forthcoming c); the analysed assemblages include all major quartz types (see Section 4), and a variety of geological zones are covered, with the only general exceptions being zones where quartz was rarely used; and a spectrum of site types are embraces, such as settlement sites (eg Dalmore), burial/ritual sites (eg Calanais). Even an assemblage from a cave site is represented (Kilmelfort Cave).

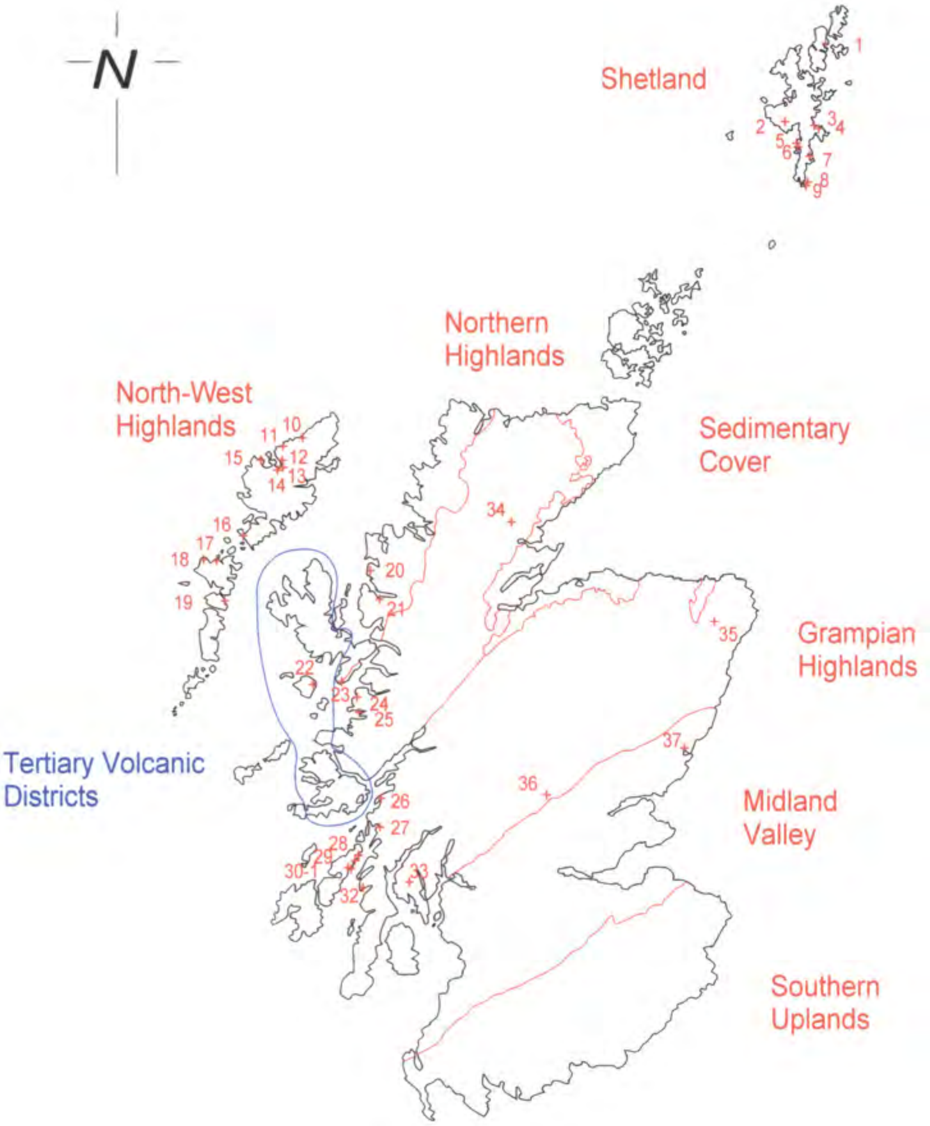
Some of the weaknesses, in terms of coverage, are remedied by assemblages available through the archaeological literature (Section 3), but at present substantial Early Neolithic quartz assemblages are simply not known (apart from the finds from Scord of Brouster). Inland sites with quartz are also rare, but a small number of these sites have been excavated, although they are still in the process of being written-up, or published (eg Ben Lawers; Atkinson *et al* 1998).

2.4 Presentation of sub-projects

In this section, the main results of the Quartz Project's various sub-projects are presented. The individual accounts are based on relevant sections of the original specialist reports and papers. In a number of cases, where assemblages include the exploitation of more than one raw material, the entire assemblage was examined (eg Kilmelfort Cave, Calanais and Dalmore), whereas in other cases only the quartz component of such assemblages was analysed (eg Lealt Bay, Lussa River and Shieldaig).

2.4.1 Palaeolithic material

Kilmelfort Cave, Argyll (original excavation report published in Coles 1983; re-examination to be published as Saville & Ballin forthcoming).



Illus 1 Prehistoric sites with quartz assemblages, or substantial quartz sub-assemblages. Shetland: *1) Bayanne, 2) Scord of Brouster, 3) Kebister, 4) Cruester, 5) Burland, 6) Tougs, 7) Catpund, 8) Sumburgh, 9) Jarlshof.* Western Isles: *10) Barvas, 11) Dalmore, 12) Olcote, 13) Calanais, 14) Cnoc Dubh (quarry), 15) Valtos, 16) Northton, 17) Udal, 18) Eilean Domhnuill, 19) Rosinish.* Southern Hebrides and West Mainland: *20) Redpoint, 21) Shieldaig, 22) Kinloch, 23) Camas Daraich, 24) Rudha'n Achaidh Mhòir (Morar), 25) Risga, 26) Carding Mill Bay, 27) Kilmelfort Cave, 28) North Carn Bay, 29) Lealt Bay, 30) Lussa River, 31) Lussa Wood, 32) Ellary Boulder Cave, 33) Auchategan.* Highlands and East Scotland: *34) Lairg, 35) FERG Sites 4 and 5, 36) Ben Lawers.* Midland Valley: *37) Fordhouse Barrow*

In 1956 the North of Scotland Hydro-Electric Board carried out construction work on the south-east face of An Sithean near Oban. The blasting operations exposed a small cave, and a number of flint and quartz artefacts were recovered (illus 2; illus 3; illus 4). Approximately 6m of the cave entrance were destroyed, and as the original cave depth was estimated to have been 10m, only a small part of the cave was left unaffected. A small number of lithic artefacts were recovered from the surviving parts of the cave, but the major part of the assemblage was recovered from the post-blast deposits in front of the cave (Coles 1983, plate 1). No artefacts were collected with reference to on-site provenance (grid system, context, etc).

Due to the manner in which the lithic finds were recovered, it is uncertain whether the flint and quartz sub-assemblages are contemporary. The two sub-assemblages are of roughly the same size (flint 404 pieces and quartz 336 pieces; Table 1), but the flint artefacts include 103 tools (of which 40 are 'microlithic' backed pieces) and the quartz artefacts only six. This difference may reflect different ages, but it may also simply be a result of different flaking properties, with flint representing the main lithic resource and quartz a local supplement for cruder tool forms.

Illus 2 Kilmelfort Cave. Blades, bladelets and spalls

Illus 4 Kilmelfort Cave. Crested pieces and tools: three crested blades / flakes, one end-scraper, and one bladelet with edge-retouch

Illus 3 Kilmelfort Cave. Cores: one discoidal core, and three bipolar cores

In the author's original report on the assemblage (Ballin 2001a), the many angle-backed pieces were perceived as large variants of Early Mesolithic microliths, and it was suggested that the finds may generally date to this period. Since then, the finds have been re-examined and discussed by the present author and Alan Saville of the National Museums in Edinburgh, who agree that, due to the similarity to

Table 1 The Kilmelfort cave lithic assemblage: general artefact list

Debitage	**Flint**	**Quartz**	**Total**
Chips	117	54	171
Flakes	120	210	330
Indeterminate pieces		40	40
Blades	18	5	23
Microblades	25	9	34
Crested flakes / blades	4	5	9
Total debitage	284	323	607
Cores			
Discoidal cores		1	1
Irregular cores	2		2
Bipolar cores	15	6	21
Total cores	17	7	24
Tools			
Various backed forms	40		40
Scrapers	23	3	26
Piercers	1		1
Burins	4		4
Burin spalls	7		7
Truncations	2		2
Piece w notch(es)	1	1	2
Denticulated piece	1		1
Combined tools	2		2
Pieces w edge-retouch	22	1	23
Hammerstones		1	1
Total tools	103	6	109
TOTAL	**404**	**336**	**740**

Table 2 The Lealt Bay quartz sub-assemblage: general artefact list

Debitage	**Quartz**	**Rock crystal**	**Total**
Chips	745	147	892
Flakes	738	109	847
Indeterminate pieces	656	9	665
Blades	4		4
Microblades	6	1	7
Crested flakes / blades	2		2
Total debitage	2151	266	2417
Cores			
Split pebbles	5		5
Single-platform cores	4		4
Opposed-platform cores		1	1
Irregular cores	1		1
Bipolar cores	13	4	17
Total cores	23	5	28
Tools			
Microliths	1		1
Short end-scrapers	8		8
Side-scrapers	5	1	6
Piercers	5		5
Burins	1		1
Pieces w oblique truncations	1		1
Pieces w notch(es)	3		3
Pieces w edge-retouch	6	1	7
Total tools	30	2	3
TOTAL	**2204**	**273**	**2477**

assemblages from the transitional period between the so-called Shouldered Point Complex (ie the Hamburgian and Creswellian material cultures; Burdukiewicz 1986) and the Federmesser Complex (cf Schwabedissen 1954), the assemblage may actually date to the Final Palaeolithic or, more precisely, *c* 12,000 BP.

A great number of similar assemblages are known from the north European plain, such as, Hoyle's Mouth in Wales (David 1991, fig 14.3) and Weitsche in eastern Germany (Veil & Breest 2002, fig 10; also Schwabedissen 1954). Apart from the actual curved-backed Federmesser points and some scalene, or angle-backed, forms, the Federmesser Culture is also characterized by large so-called 'Dreieckmessern', or triangular (isosceles) knives or points. The assemblage from Kilmelfort Cave includes two pieces resembling 'Dreieckmessern' (see Saville 2003a, fig 46.3.15–16). The flint and quartz artefacts from Kilmelfort Cave are to be presented and discussed in a future paper (Saville & Ballin forthcoming).

2.4.2 Later Mesolithic material

Lealt Bay, Jura (original excavation report published in Mercer 1968; re-examination filed as Ballin 2001b).

Lealt Bay was excavated by John Mercer in the late 1960s as part of his investigation of the Mesolithic chronology of the Isle of Jura (Mercer 1968; Mercer 1970; Mercer 1971; Mercer 1972; Mercer 1974; Mercer 1980; Mercer & Searight 1987). Mercer's main approach was to combine typological evidence with information regarding local shoreline displacement. In his presentation of the finds from Lealt Bay (1968), Mercer did not deal with the flint and the quartz separately, and, consequently, it is not possible to get an overall impression of the typology, technology and date of the quartz. The excavation of Lealt Bay was carried out with reference to site stratigraphy and trenches (Mercer 1968, 8), and the absence of a standard grid system makes it impossible to separate any Mesolithic and Neolithic units horizontally, or to define different activity areas, by distribution analysis.

The Lealt Bay quartz assemblage comprises 2417 pieces of which 89% is milky quartz (quartz) and 11% rock crystal (Table 2). The quartz was collected as pebbles, probably from a nearby shore, whereas rock crystal was quarried as crystals, probably in the local bedrock. Due to consistent sieving during excavation, the assemblage contains a large proportion of very small chips (37% of the debitage). Approximately one-third of the debitage is flakes; the quartz production at the site did not aim at manufacturing blades or microblades. Owing to differences in flaking properties, indeterminate pieces are abundant in milky quartz (31%) and rare in rock crystal (3%).

The core group is characterized by small platform cores (single-platform and opposed-platform cores) and bipolar cores, and the tool group is relatively varied, containing one microlith, scrapers, borers, burins, one truncated piece and a number of notched and retouched pieces. The microlith is a lanceolate microlith of Clark's type C. The scrapers are evenly distributed across short end-scrapers and side-scrapers. The piercers are relatively small, and include one small blade piercer, probably a drill-tip. The burin is a typical angle-burin. Most of the tools display some degree of use-wear.

Technologically, there is evidence of both platform technique and bipolar technique having been applied at Lealt Bay. One cannot exclude the possibility that some exhausted platform cores were reduced further in bipolar technique, but the evidence suggests that, generally, pebbles were dealt with entirely in one technique: larger pebbles were probably reduced in platform technique, as preparation of platform cores requires some surplus material, and smaller pebbles, unsuitable for decortication and preparation, were reduced in bipolar technique. A number of factors indicate a Mesolithic date for the quartz assemblage, corresponding to the date suggested by the flint assemblage from Lealt Bay (Mercer 1968).

Lussa River, Jura (original excavation report published in Mercer 1971; re-examination filed as Ballin 2002b).

Lussa River was excavated by John Mercer in the late 1960s as part of his investigations of the Mesolithic chronology of the Isle of Jura (Mercer 1968; Mercer 1970; Mercer 1971; Mercer 1972; Mercer 1974; Mercer 1980; Mercer & Searight 1987). The assemblage was recovered and recorded very much in the same way as the finds from Lealt Bay (see above). As a consequence, the quartz from Lussa River has been analysed as an unstratified and uncontexted assemblage.

Table 3 The Lussa River quartz sub-assemblage: general artefact list

	Quartz	Rock crystal	Total
Debitage			
Chips	2092	58	2150
Flakes	7215	71	7286
Indeterminate pieces	1104	1	1105
Blades	126		126
Microblades	260	5	265
Crested blades	1		1
Total debitage	10,798	135	10,933
Cores			
Split pebbles	3		3
Single-platform cores	12		12
Handle-cores	1		1
Opposed-platform cores	1		1
Cores with two platforms at an angle	3		3
Irregular cores	10		10
Bipolar cores	155	9	164
Total cores	185	9	194
Tools			
Microliths (needle points)	3		3
Fragments of microliths / backed bladelets	1		1
Blade-scrapers	1		1
Short end-scrapers	37	1	38
Double-scrapers	1		1
Side-scrapers	19		19
Side-/end-scrapers	1	1	2
Scraper-edge fragments	3		3
Piercers	2		2
Burins	1		1
Pieces with oblique truncations	2		2
Pieces with retouched notch(es)	3		3
Denticulated pieces	2		2
Pieces with edge-retouch	23		23
Total tools	99	2	101
TOTAL	**11,082**	**146**	**11,228**

A total of 11,228 pieces of worked quartz were recovered at the Lussa River site, 98.8% of which is milky quartz, with 1.2% being rock crystal (Table 3). The milky quartz was collected in the form of pebbles, either from the nearby river or from the shores of Lussa Bay, whereas the rock crystal was collected as fairly large crystals, probably from local

Illus 5 Shieldaig. Preparation flakes – four crested pieces, and one platform rejuvenation flake

rock outcrops. The rock crystal sub-assemblage includes larger proportions of cores and tools than the milky quartz sub-assemblage; this may be partly due to its better flaking properties, and partly to the possible symbolic value of this raw material.

The debitage is heavily dominated by flakes (67%), with chips amounting to *c* 20% and indeterminate pieces *c* 10%. Blades only make up 4%, and only a small number of these are regular platform blades, with the majority being elongated bipolar spalls. This composition clearly defines the Lussa River quartz assemblage as representing a flake industry. The core group consists mainly of bipolar cores (164 pieces), with bipolar cores outnumbering platform cores at a ratio of 6 to 1. Single-platform cores and irregular cores are present in roughly equal numbers (12 and 10 pieces, respectively), with other core types numbering no more than three pieces each. Three split pebbles most likely represent the first stage of a bipolar reduction sequence.

The tool group includes a large number of different implement types, such as microliths, scrapers, piercers, burins, truncated pieces, notched pieces, denticulates and pieces with edge-retouch. Almost two-thirds of the tool group are scrapers, and approximately one-quarter of the tools are pieces with edge-retouch. At four pieces, microliths are relatively uncommon, and each of the remaining tool types are even fewer in number.

Apart from one unspecified fragment of a microlith or backed bladelet, all microliths are needle points. The scrapers are mainly short end-scrapers and side-scrapers, supplemented by one blade-scraper, a double-scraper and some scraper-edge fragments. The only burin is a typical angle-burin. Two obliquely truncated pieces are interpreted as a flake-knife and an insert for a slotted bone point. The piercers, notched pieces and denticulates are all expediently made, rather informal pieces.

Technologically, the assemblage is characterized by the application of bipolar technique, with platform technique having been applied sporadically: amongst the definable unmodified and modified flakes, bipolar flakes make up *c* 80–90%; *c* 85% of the cores are bipolar specimens; and, with a few exceptions, all blades are elongated bipolar spalls. The evidence suggests that two reduction methods were applied at the Lussa River site, namely (i) a combination of platform technique and bipolar technique, with the latter representing the final stage of the reduction sequence, and (ii) the application of bipolar technique from opening of the nodule to abandonment of the core. The massive dominance of bipolar cores and blanks indicates that the exclusively bipolar approach may have been the preferred option.

The quartz assemblage itself gives few clues as to the date of the Lussa River settlement. The clear separation of the bipolar cores into smaller and larger specimens suggests that the quartz assemblage represents at least two different occupations at the site. The presence of small needle point microliths dates one of these as probably Late Mesolithic, and two radiocarbon dates (3450 and 2940 cal BC, respectively) indicate a Neolithic presence at the Lussa River site. The Neolithic date is supported by flints with invasive retouch and artefacts in pitchstone.

Shieldaig, Wester Ross (to be published as Ballin et al forthcoming; original archive report by Walker 1973).

The Shieldaig site was situated by the Shieldaig–Kenmore road at Loch Torridon in Wester Ross. As nearby gravel extraction and road construction

Illus 6 Shieldaig. Platform cores: one discoidal core, and one irregular (multi-directional) core

Illus 7 Shieldaig. Platform cores: three conical / sub-conical cores, and two opposed platform cores. No 5 was worked from one direction on one face, and from the opposite direction on the other face

threatened to undermine the site, a small excavation was carried out in 1973 by Dr Michael Walker, then at the Department of Anatomy, University of Edinburgh. The settlement had already been affected by the activities in the area, and there was little hope of recovering an intact assemblage. The aim of the excavation was therefore limited to retrieving the remaining *in situ* material before total destruction of the site.

The excavation of Shieldaig was carried out with reference to site stratigraphy and trenches (Walker 1973, 2), but the absence of a standard grid system makes it impossible to separate the Palaeolithic, Mesolithic and Neolithic units (for discussion of

Table 4 The Shieldaig quartz sub-assemblage: general artefact list

	'Ordinary' quartz	'Greasy' quartz	Quartzite	Other silica	Total
Debitage					
Chips	918	513			1431
Flakes	1273	1784	22	4	3083
Indeterminate pieces	81	164	1	2	248
Blades	9	36	2		47
Microblades	13	18			31
Core preparation flakes	1	8			9
Total debitage	2295	2523	25	6	4849
Cores					
Single-platform cores (incl. conical)	4	6	1		11
Opposed-platform cores	1	2			3
Discoidal cores		2			2
Irregular cores		13			13
Bipolar cores	14	17			31
Core rough-outs	1	1			2
Collected crystals	2				2
Total cores	22	41	1		64
Tools					
Microliths	5	12	2		19
Fragm. of microliths or backed bladelets	1	3			4
Microburins		1			1
Scrapers	4	14			18
Piercers	1	3			4
Pieces w truncations		3			3
Tanged implements		1			1
Pieces w notch(es)		1	1		2
Pieces w invasive retouch		1			1
Pieces w edge-retouch	4	5			9
Hammerstones	1				1
Total tools	16	44	3		63
TOTAL	**2333**	**2608**	**29**	**6**	**4976**

dating, see below) horizontally, or to define different activity areas, by distribution analysis.

A total of 4976 artefacts in quartz were recovered during the excavation of the site (illus 5; illus 6; illus 7; illus 8; illus 9; illus 10). Most of these pieces are in 'ordinary' quartz or 'greasy' quartz (in roughly equal proportions), with less than one per cent being in quartzite or other raw materials (Table 4); a large (unquantified) part of the material defined as 'ordinary' quartz is rock crystal, albeit not in crystal form. The recovered quartzite is probably from local bedrock, whereas almost all the quartz was quarried at (probably local) vein sources.

Approximately one-third of the debitage is chips, and two-thirds are flakes. There are considerable differences between the composition of the debitage in 'ordinary' quartz and 'greasy' quartz, which can be explained by different flaking properties and focused selection processes. There are several core preparation-flakes in the assemblage, mainly in 'greasy' quartz. The core group is dominated by bipolar cores (approximately half of all cores), irregular cores and single-platform cores; other core types present are opposed-platform cores and discoidal cores. Two core rough-outs (one in 'ordinary' quartz and one in 'greasy' quartz) are excellent examples of how cores were prepared at Shieldaig. The tool group is relatively varied and dominated by microliths and scrapers (*c* one-third of all tools each). The two dominant tool types

Illus 8 Shieldaig. Bipolar cores

Illus 9 Shieldaig. Microliths: ten geometric microliths, and one microburin

Illus 10 Shieldaig. Tools: one tanged implement, three end-scrapers, one side-scraper, two piercers, and one piece with an oblique concave truncation (?knife)

were supplemented by one microburin, and a few piercers, truncated pieces, pieces with various retouch and a hammerstone. A tanged implement is most probably a small knife, and a piece with invasive retouch may be a rough-out for a leaf-shaped arrowhead. The microlith assemblage includes lanceolates, small isosceles and scalene triangles, crescents and needle points.

In general, the quartz technology at Shieldaig does not differ from the technology at some later sites, such as Bayanne, Shetland (Ballin forthcoming j). The main bulk of the raw material was obtained from local veins; the technology is a flake technology based on platform technique supplemented by bipolar technique to exhaust cores completely; and cores were carefully prepared before (cresting) and during (trimming) production. The main visible difference is the fact that the production at Shieldaig aimed at the manufacture of relatively small flakes in comparison with the more 'chunky' blanks of later sites.

The Shieldaig quartz assemblage contains some diagnostic material, primarily microliths, suggesting that most of the finds belong to the Mesolithic period. The microlith sub-types allow this date to be narrowed down to the later Mesolithic, and comparison with the microliths from Gleann Mor, Islay (Mithen & Finlayson 2000), suggests a date in the region of 7000 BP. A flake with invasive retouch is possibly evidence of the intrusion of Neolithic material. This corresponds well with the flint assemblage from Shieldaig, as this material includes the same types of microliths and two Neolithic leaf-shaped points. In addition, the flint assemblage contains a typical Ahrensburgian point (Ballin & Saville 2003), testifying to the site having been visited before the Mesolithic occupation.

2.4.3 *Early Neolithic material*

Scord of Brouster, Shetland (original excavation report published in Whittle 1986; re-examination published as Ballin 2007a).

The Scord of Brouster settlement and field system is situated in the west mainland, or Walls peninsula, of the Shetland Islands, at the northern shores of Gruting Voe. At the time of the Scord of Brouster excavation, the area of the Gruting Voe inlet had already been extensively investigated, and the site formed part of a group of mainly Neolithic and Bronze Age house sites and settlements (Calder 1956; Calder 1964). Scord of Brouster was excavated by Alasdair Whittle in the late 1970s, and the main purpose of the investigation was to shed light on early agricultural settlement in Britain by examining a settlement site in a remote part of the country, unspoilt by modern development. The fieldwork produced sizeable assemblages of pottery, stone tools and lithic artefacts (almost exclusively quartz), with struck, and probably struck, quartz numbering nearly 10,000 pieces. Unfortunately, the

Illus 11 Scord of Brouster. Single-platform core

Illus 12 Scord of Brouster. Bipolar cores. Nos 1 and 3 have been burnt

Illus 13 Scord of Brouster. Leaf-shaped points

Illus 14 Scord of Brouster. Curved knives. Note the scorched surface of No. 2 (upper right corner)

Illus 15 Scord of Brouster. End-scrapers. No. 8 has been burnt

worked quartz was characterized at a time when quartz technology and, in particular, the associated bipolar technique was poorly understood, and, as the excavator puts it, ' . . . further advance in our understanding of this important raw material must be wished for as soon as possible' (Whittle 1986, 64).

From Scord of Brouster, a total of 9687 lithic artefacts were recovered. Almost all finds are in quartz (illus 11; illus 12; illus 13; illus 14; illus 15; illus 16; illus 17), supplemented by eight pieces in flint, one piece of felsite, one piece of metamorphic rock, and eight pieces of 'other' raw materials (Table 5). The struck quartz is a combination of white milky quartz and fine-grained quartz, some of which

Table 5 The Scord of Brouster lithic assemblage: general artefact list (if the raw material of a type is not specified, all pieces are in quartz). * Two short end-scrapers in sandstone are described as part of the Scord of Brouster monograph's chapter on stone tools (Rees 1986, 64–5).

	Numbers				Percentages			
	House 1	**House 2**	**House 3**	**Total**	**House 1**	**House 2**	**House 3**	**Total**
Debitage and natural pieces								
Chips, quartz	854	755	8	1617	15.5	20.8	3.5	17.2
Flakes & indet. pieces, quartz	4306	2748	170	7224	78.1	75.4	75.6	77.0
Flakes & indet. pieces, other	8	8	1	17	0.2	0.2	0.4	0.2
Flakes & indet. pieces, flint		4		4		0.1		0.1
Flake with dorsal polish, metamorphic rock	1			1	<0.1			<0.1
Natural pieces, quartz	308	120	44	472	5.6	3.3	19.6	5.0
Natural pieces, steatite or chlorite	34	8	2	44	0.6	0.2	0.9	0.5
Total debitage	5511	3643	225	9378	100.0	100.0	100.0	100.0
Cores								
Single-platform cores	13	6	1	20	23.2	15.4	100.0	20.8
Cores w two platforms at an angle	6	1		7	10.7	2.5		7.3
Discoidal core	1			1	1.8			1.0
Irregular cores	5	6		11	8.9	15.4		11.5
Bipolar cores (incl. 1 flint)	28	23		51	50.0	59.0		53.1
Core fragments	3	3		6	5.4	7.7		6.3
Total cores	56	39	1	96	100.0	100.0	100.0	100.0
Tools								
Leaf-shaped arrowheads	2			2	1.7			0.9
Knife (scale-flaked)	1			1	0.8			0.5
Curved (bifacial) knives	5	7		12	4.1	7.8		5.7
Short end-scrapers* (incl. 1 felsite)	62	54		116	51.2	60.0		54.7
Double-scrapers	4	4		8	3.3	4.4		3.8
Side-scrapers (incl. 2 flint)	10	6		16	8.3	6.8		7.6
Side-/end-scrapers	5	1		6	4.1	1.1		2.8
Other scrapers	4			4	3.3			1.9
Scraper-edge fragments	6	4		10	5.0	4.4		4.7
Piercers	4	2		6	3.3	2.2		2.8
Piece with oblique truncation	1			1	0.8			0.5
Pieces with retouched notch(es)	2			2	1.7			0.9
Denticulated pieces		2		2		2.2		0.9
Pieces with invasive retouch	3	4		7	2.5	4.4		3.3
Pieces with edge-retouch (incl. 1 flint)	9	5	1	15	7.4	5.6	100.0	7.1
Fabricator	1			1	0.8			0.5
Hammerstones	2	1		3	1.7	1.1		1.4
Total tools	121	90	1	212	100.0	100.0	100.0	100.0
TOTAL	**5688**	**3772**	**227**	**9687**				

derives from pebble sources and some from vein sources. It is thought that several vein sources were exploited, probably all within a 10km radius.

As much of the quartz had been burnt to a degree preventing precise characterization, it was decided to combine the categories of flakes and indeterminate pieces. A total of 8863 pieces of debitage were recovered, with 1617 being chips and 7246 flakes and indeterminate pieces; true blades are practically absent. Approximately half of the cores are bipolar,

Illus 16 Scord of Brouster. Side- and side-/end-scrapers

Illus 17 Scord of Brouster. Piercers. No. 1 has been burnt

supplemented by single-platform and irregular cores, as well as a small number of cores with two platforms at an angle. The assemblage includes a large number of tools, most of which are scrapers. Two leaf-shaped points, three basal fragments of such points, six piercers and 12 curved knives were also found, as well as several expedient implement forms. The curved knives may be a regionally and chronologically diagnostic tool type, characteristic of Late Neolithic northern Scotland, as it has only been recovered from two other sites in this area (Camster Long, Caithness, and Druim Arstail, Oronsay; Wickham-Jones 1997, fig 22.28; Wickham-Jones *et al* 1982, plate 3.197).

Due to the severely burnt state of a large proportion of the assemblage it was decided not to undertake an attribute analysis of the sizeable collection of debitage. However, the initial detailed classification of cores and tools did give the author an impression of the applied percussion techniques (platform core: bipolar core ratio 47:53), and the debitage is undoubtedly dominated by bipolar material, though flakes detached by the application of hard percussion are also common. A significant proportion of the platform flakes have trimmed platform-edges. The technological attributes of the various core types suggest the sequential transformation of one core type into another, with single-platform cores representing the first stage of the reduction sequence and bipolar cores the last. The first step of core preparation at Scord of Brouster was the removal of adhering rock, or cortex, and poor-grade outer quartz. Core rough-outs were produced, characterized by the existence of a mainly plain platform and, usually, two bilateral crests or guide ridges.

The distribution of artefacts within the individual houses, and across the three houses, was discussed. The distribution analysis proved that some spatial organization took place at both levels. Within the houses, it was possible to show how work was organized around the hearths, as well as within the individual cells. House 3 appears to have had a workshop-like function, focusing on the decortication of raw quartz and possibly production of rough-outs, whereas Houses 1 and 2 may have been actual dwellings.

The presence of one kite-shaped point suggests a date of the assemblage in the later part of the Early Neolithic period (eg Green 1980, 85). This estimate is supported by a series of radiocarbon dates, dating Houses 1 and 2 to this point in time (possibly with one dwelling replacing the other), but with House 3 probably dating to the Early Bronze Age. Dates from Camster Long are contemporary with the earliest settlement at Scord of Brouster, and this assemblage also combines kite-shaped points and curved knives.

By comparing this Neolithic Shetland collection with contemporary material from other regions of Scotland, it was possible to define two distinctly different raw material provinces, as well as a third, hybrid form. The quartz province, to the north and west, and the flint/chert province, covering the eastern, central, and southern parts of the country, were characterized as techno-complexes, whereas the author was uncertain which status to attach to the mixed quartz/flint province of the west mainland and the Southern Hebrides. This topic is discussed in more detail in the present paper.

2.4.4 Late Neolithic/Early Bronze Age material

Calanais, Lewis (to be published as part of Ashmore forthcoming).

In order to allow necessary repairs of the central cairn, Historic Scotland undertook excavations of the Calanais ritual complex. These excavations were carried out by Patrick Ashmore (1980/81) and the results subsequently published in popular form

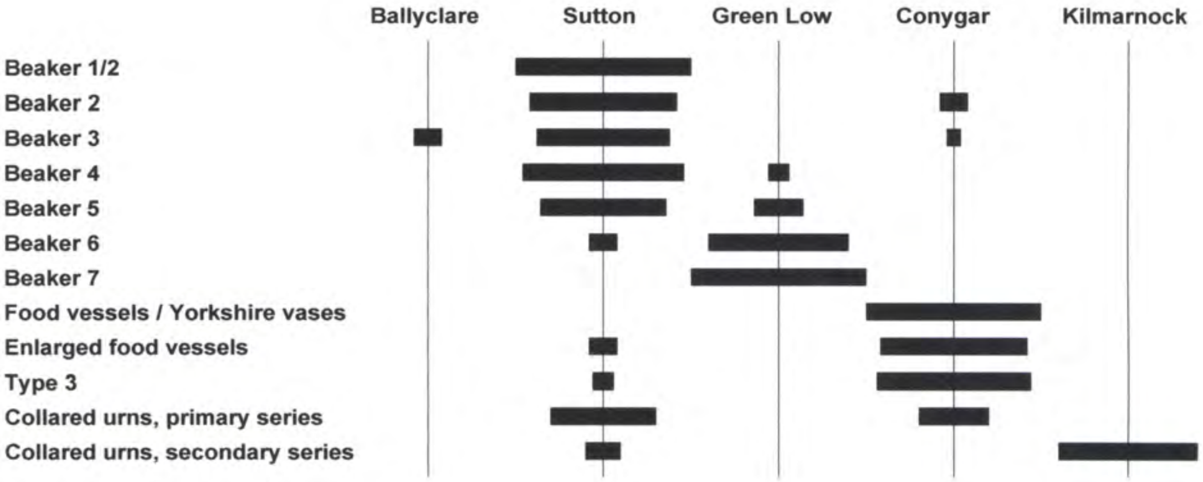
Illus 18 Calanais. Cores: one single-platform core, and one bipolar core

Illus 19 Calanais. Barbed-and-tanged arrowheads. No. 5 is probably a damaged rough-out

Illus 20 Calanais. Tools: three end-scrapers, one side-scraper, and one flake with edge-retouch (?knife). No 4 may have been burnt

Table 6 The Calanais lithic assemblage: general artefact list

	Quartz	Flint	Mylonite	Others	Total
Debitage					
Chips	9	6	2		17
Flakes	83	26	13	1	123
Indeterminate fragments/chunks	118	3	10		131
Blades	1		1		2
Microblades		1			1
Total debitage	211	36	26	1	274
Cores					
Single-platform cores	4				4
Bipolar cores	4				4
Core-fragments	1	1			2
Total cores	9	1			10
Tools					
Barbed-and-tanged arrowheads	5		1		6
Short end-scrapers	3	3	6		12
Double-scrapers		1			1
Side-scrapers	1	1	1		3
Pieces w bifacial retouch		1	1		2
Pieces w edge-retouch	3	3			6
Total tools	12	9	9		30
TOTAL	**232**	**46**	**35**	**1**	**314**



Illus 21 Seriation of British barbed-and-tanged arrowhead sub-types in relation to pottery styles (produced for Ashmore forthcoming)

(Ashmore 1995). This publication dealt mainly with the monuments (stone circle, cairn, avenue and half-oval structure), and the sequence of construction and abandonment of the structures at Callanais. The small finds were only mentioned briefly.

The lithic assemblage from Calanais is relatively small. It contains 314 pieces, most of which is quartz (74%) (illus 18; illus 19; illus 20), supplemented by some flint (14%) and mylonite (11%) (Table 6). The quartz and flint is probably local, with the quartz being quarried vein quartz, and the flint having been collected as small pebbles on a nearby beach. The mylonite is probably from local sources on Lewis (Smith & Fettes 1979, fig 3).

The assemblage comprises 274 pieces of debitage, nine cores and 30 tools. The cores are single-platform cores (quartz) and bipolar cores (quartz and flint), and the tool group is dominated by barbed-and-tanged arrowheads (Sutton) and thumbnail scrapers. All arrowheads are in quartz, with several being in 'greasy' quartz, whereas the scrapers were manufactured in all three raw materials. The quartz and mylonite sub-assemblages were produced by the application of platform technique, with the flint material manufactured mainly in bipolar technique.

Almost all the lithic artefacts were recovered from within an area of up to 2m from the cairn. Approximately half of the quartz came from trench D, with the remaining quartz material being evenly distributed across trenches B and H. The flint artefacts were evenly distributed across trenches B and D, and the mylonite came almost exclusively from trench B. For details on the excavation's trench structure, as well as the site's general layout (see Ashmore forthcoming). Quartz, flint and mylonite were found at all stratigraphical levels, but with a major part of the quartz being early, and most of the flint and mylonite being late. Cores and tools, as well as burnt lithics, appeared at all levels, that is, contexts from before the construction of the stone circle till after the central cairn's construction.

The only truly diagnostic lithic artefacts in the assemblage are the six barbed-and-tanged arrowheads. Barbed-and-tanged arrowheads are datable to the Early Bronze Age, and the fact that all arrowheads in the Callanais assemblage are of Green's Sutton type suggests that they are from the Beaker period (illus 21). One arrowhead was found in the chamber of the cairn and three east of the cairn, assumed to be cleared-out material. One arrowhead was recovered in a context associated with a half-oval structure and one from a palisade slot, suggesting a Bronze Age date for both features (Ashmore forthcoming).

Callanais is a highly complicated site with structures and finds representing activities in the Early Neolithic (pre-stone circle cultivation), the Late Neolithic (stone circle and cairn), and the Early Bronze Age/Beaker period (secondary burials, clearing-out of the cairn chamber, and cultivation). Due to the complicated stratigraphy of the site, it is not possible to prove absolute contemporaneity of any two artefacts, although some are so stylistically similar that contemporaneity is likely (for example, the quartz arrowheads from the area east of the cairn). It is thought that most of the quartz artefacts represent settlement material (earlier, contemporary with, and later than the structures), whereas a proportion of the tools (quartz, flint, and mylonite arrowheads and scrapers) may represent activities associated with the structures (probably mainly the cairn).

2.4.5 *Early Bronze Age (Beaker) material*

Rosinish, Benbecula (to be published as part of Shepherd & Shepherd forthcoming; preliminary report published in Shepherd 1976)

Illus 22 Rosinish. Platform cores: one single-platform core, two irregular (multi-directional) cores, and one crested flake. No. 1 is distinctly burnt

Illus 23 Rosinish. Bipolar cores: Nos 1 and 6 are distinctly burnt

In 1964, Iain Crawford excavated a circular, corbelled structure at Rosinish on Benbecula, Outer Hebrides (Crawford 1977). It was discovered that wind-induced erosion was taking place, affecting the main east-facing dune slope at Rosinish, thus revealing old land surfaces and occupation traces from the Beaker Period. In 1974, a survey and a trial excavation were carried out at Rosinish,

Illus 24 Rosinish. Scrapers: three end-scrapers, and two side-scrapers. No. 3 has split along the long-axis. No 4 (which is distinctly burnt) has a slightly concave working-edge along the left lateral side. No 5 (which was made on an abandoned bipolar core) has a simple working-edge along its right lateral side

followed in 1975, 1976 and 1977 by full scale rescue excavations (Shepherd & Tuckwell 1974; Shepherd & Tuckwell 1975; Shepherd & Tuckwell 1976; Shepherd & Tuckwell 1977). This resulted, *inter alia*, in the lithic assemblage presented below. The excavation results in general have been briefly discussed previously (Shepherd 1976; Shepherd & Tuckwell 1977b).

Due to a stylistic analysis of the pottery from Rosinish, it is assumed that the lithic assemblage from the site is Early Bronze Age (Beaker period) with a possible admixture of some material from the Late Neolithic. The assemblage is mainly in milky quartz (illus 22; illus 23; illus 24) and flint, supplemented by a small number of unworked flakes in quartzite. There are only 27 artefacts in flint to 3532 artefacts in quartz, but almost half of the tools are in flint (17 of 37). As is commonly seen in the case of Bronze Age quartz assemblages (eg Calder 1956; Hamilton 1956), the majority of the tools are scrapers (Table 7); in this particular case, half of the scrapers are small regular thumbnail scrapers, whereas the quartz scrapers are larger and much more irregular. Other tools, mainly in quartz, include three piercers, a burin, a truncated piece (a knife), two pieces with edge-retouch, and two hammerstones. Approximately one-third of the quartz is heavily burnt.

Technologically, the Rosinish assemblage is characterized by a combination of platform and bipolar techniques, with the latter dominating heavily. In Binford's terminology (Binford 1976), the quartz assemblage represents expedient technology, whereas the flint assemblage represents curated technology. This is probably mainly due to the fact that flint has better flaking abilities than quartz, and at Rosinish it is much rarer, possibly exotic.

A basic distribution analysis showed that most of the artefacts are concentrated in three south-west/north-east orientated bands ('ridges') with find-poor bands ('valleys') separating them. At present, it is not known whether this distribution pattern is due

Table 7 The Rosinish lithic assemblage: general artefact list

	Quartz	Quartzite	Flint	Total
Debitage and blanks				
Chips	992			992
Flakes	1767	7	6	1780
Indeterminate pieces/chunks	678	2		680
Crested flakes	1			1
Total debitage	3438	9	6	3453
Cores				
Single-platform cores	3			3
Opposed-platform cores	1			1
Irregular cores	12			12
Bipolar cores	57		4	61
Total cores	73		4	77
Scrapers				
Circular scrapers			1	1
Short end-scrapers	7		11	18
Side-scrapers	7			7
Other scrapers	1			1
Scraper-edge fragments			1	1
Piercers	1		2	3
Burins	1			1
Pieces with a straight truncation	1			1
Pieces with edge-retouch	1		1	2
Pieces with invasive retouch			1	1
Hammerstones	2			2
Total tools	21		17	38
TOTAL	**3532**	**9**	**27**	**3568**

to human activities or natural causes (wind activity and dune building). The most important distributional phenomenon is the fact that most of the burnt quartz was recovered immediately to the north, north-west, west, and south-west of the site's U-shaped structure. The burnt quartz must therefore be associated with this structure and activities in it. A weaker tendency in the distribution of flint artefacts suggests that the flint tools were not produced and used in the same areas, with the unworked flakes mainly deriving from the southern part of the main trench (Area I), and the flint scrapers from areas outside this zone. Generally there is very little flint debitage, and most likely the majority of the flint tools were manufactured outside the site.

2.4.6 Early Bronze Age (non-Beaker) material

Dalmore, Lewis (to be published as part of Sharples forthcoming; original archive reports by Sharples 1983a; Sharples 1983b).

In 1978 Trevor Cowie of the National Museums of Scotland carried out a coastal erosion survey of Lewis and Harris. As part of this survey, the beach at Dalmore was explored. A small surface collection of finds was examined, suggesting the presence of a prehistoric settlement. As there was little sign of *in situ* archaeological deposits, the site was not excavated. In 1979 a breakwater was constructed to protect the western part of the Dalmore beach from erosion. It was noticed that the construction trench cut through a layer rich in archaeological finds, and this layer appeared to extend in front of the breakwater where it was exposed to erosion. Over the following four years, this area was closely monitored by local amateur archaeologist Mrs Margaret Curtis (then Ponting), who managed to excavate a large area, and a significant number of archaeological artefacts were recovered.

At the end of 1982, severe gales and rainstorms altered the beach configuration dramatically, and the sea wall collapsed. Following this event, a modified sea wall was erected, which involved horizontal ties running into the dune, anchored by large cast iron piles. As part of the construction work, a large area

Illus 25 Dalmore. Platform cores: core rough-out (with two crude opposed crest along the lateral sides), single-platform core (with its flaking-front to the left), and an irregular (multi-directional) core

Illus 26 Dalmore. Bipolar cores. No 2 has been burnt

Illus 27 Dalmore. Barbed-and-tanged arrowheads: rough-outs, rejects, and almost complete specimens. No. 2 has been burnt. Nos 5 and 7 have characteristic Kilmarnock Type tangs (Green 1980, 123)

of the machair was removed behind the breakwater, and further archaeological deposits were exposed. Mrs Curtis was encouraged to examine the deposits, which turned out to be deep and complex and associated with structures.

At this stage, Niall Sharples from Cardiff University was asked by Historic Scotland (then the Scottish Development Department) to undertake excavations in order to gauge the extent and significance of the preserved deposits, and to provide a context for the now large collection of artefacts obtained from the site. The excavation was carried out in 1983, covering an area originally exposed and examined by Mrs Curtis, as well as a 2m wide untouched strip.

Illus 28 Dalmore. Tools: three end-scrapers, and one burnt piercer

The trench measured approximately 10 x 9m, at its widest (Sharples 1983a; Sharples 1983b).

During Sharples' excavation a number of superimposed structures were investigated. These structures were separated stratigraphically into five main phases, as well as a number of sub-phases: Phase I (the earliest occupation), Phase II (House 077), Phase III (House 078), Phase IV (House 091, including recess 033), and Phase V (the final stage of destruction). In association with these structures, a large number of prehistoric artefacts were discovered, such as pottery and worked lithics.

The large lithic assemblage from Dalmore (2665 pieces; illus 25; illus 26; illus 27; illus 28; Table 8) consists of two parts, namely finds from Sharples' 1983 excavation, and material collected and excavated by Mrs Curtis before and after this excavation. The Dalmore lithics report (Ballin forthcoming g) is based on the detailed analysis of the entire assemblage from Sharples' investigation of the site (2564 pieces), as well as the cores and tools from the Curtis collection (101 pieces). In total, Sharples' excavation resulted in the recovery of 2503 pieces of debitage, with a somewhat smaller number having been found by Mrs Curtis (due to constraints on time, the debitage from Mrs Curtis' collection was not included in the initial analysis). The combined Dalmore collection includes 72 cores and 90 tools, and 92% of this assemblage is in quartz, with 4% being flint, 3% mylonite and less than 1% 'other' raw materials (mainly gneiss and basalt).

The dominant core types are irregular and bipolar cores with 16 and 35 pieces, respectively, but, summed up, the various forms of platform cores (including irregular specimens) number 33 specimens, thus making them as numerous as the bipolar cores. Disregarding 'pieces with edge-retouch', which is not a *proper* tool type but a category of indeterminate tools and tool fragments, the combined tools are dominated by arrowheads and scrapers. Barbed-and-tanged arrowheads and rough-outs for arrowheads make up 19 pieces, whereas scrapers amount to 38 pieces. These tools are supplemented by a small number of piercers, hammerstones, and notched, denticulated, truncated and retouched pieces.

The lithic technology is a combination of platform and bipolar techniques, including a hybrid approach. Most probably, blank production was initiated on single-platform cores which, as the reduction process progressed, acquired more and more platforms. When a platform core had become too small to work in free-hand style, it was supported on an anvil and, finally, the resultant very small cores would be reduced in bipolar technique (cf Callahan 1987).

The vertical and horizontal distribution of the lithic artefacts support the phasing suggested previously (Sharples 1983a; Sharples 1983b). Most of the lithics were found inside the site's small building, and primarily in association with its hearths. The lithic distribution suggests that, in each phase, the house had one hearth, which was relocated between phases. Probably most activities, such as primary and secondary production, as well as tool use, was carried out by the dwelling's fireplace. When debitage, cores or tools were abandoned, they were either tossed to the periphery of the house or

Table 8 The combined Dalmore lithic assemblage: general artefact list

Debitage		**Quartz**	**Flint**	**Mylonite**	**Others**	**Total**
Chips		1460	64	53	5	1582
Flakes		432	20	5	5	462
Indeterminate pieces		256		1	4	261
Wet-sieved quartz flakes/indet.		196				196
Microblades			2			2
Total debitage		2344	86	59	14	2503
Cores						
Split pebbles		1				1
Core rough-outs		5				5
Single-platform cores		7				7
Opposed-platform cores		1				1
Cores w two platforms at an angle		2				2
Discoidal cores		2			1	3
Irregular cores		16				16
Bipolar cores		24	7	3	1	35
Core fragments		2				2
Total cores		60	7	3	2	72
Tools						
Barbed-and-tanged arrowheads		6		2		8
Arrowhead rough-outs		9		2		11
Backed blades/bladelets			1			1
Scrapers:	Discoidal scrapers		2	1		3
	Short end-scrapers	11	13	2		26
	Double-scrapers		1			1
	Side-scrapers		4	2		6
	Other scrapers	1				1
	Scraper-edge frags	1				1
Piercers		4				4
Pieces w straight truncations			1			1
Pieces w notch(es)		1				1
Denticulated pieces		2				2
Pieces w invasive retouch		3				3
Pieces w edge-retouch		14	1	4		19
Hammerstones		2				2
Total tools		54	23	13		90
TOTAL		**2458**	**116**	**75**	**16**	**2665**

deposited in one of the door dumps. The main activities at Dalmore, as suggested by the composition of the lithic collection, include production of arrowheads and the production and use of scrapers. The relatively acute scraper-edge angles of the latter indicate the processing of hides or skin.

It is not possible to recognize any typo-technological differences between the lithic sub-assemblages from the various phases, and the collection's only strictly diagnostic tool type is the barbed-and-tanged arrowhead. This type suggests a date in the Early Bronze Age in general, and the presence of a small number of Kilmarnock points (Green 1980, 123) demonstrates that at least part of the occupation at the Dalmore site took place in the later part of this period (the Urn Period; see illus 21). Analysis of the Dalmore pottery supports the general date of Early Bronze Age, with the recovery of Beaker and Food Vessel influenced ceramics, as well as sherds from at least one very large carinated urn.

Table 9 The combined lithic assemblage from FERG Sites 4 and 5: general artefact list

	Flint	**Quartz**	**Others**	**Total**
Debitage				
Chips		1		1
Flakes	8	45	1	54
Indeterminate pieces	2	10		12
Total debitage	10	56	1	67
Cores				
Split pebbles		2		2
Single-platform cores	3			3
Irregular cores	2	4		6
Bipolar cores	4			4
Core fragments		2		2
Total cores	9	8		17
Tools				
Discoidal scrapers	1			1
Short end-scrapers	2	1		3
Double-scrapers		1		1
Side-/end-scrapers	1			1
Other scrapers	1			1
Scraper-edge fragments		1		1
Pieces w convex truncations	1			1
Pieces w retouched notch(es)	2	1		3
Pieces w edge-retouch	4			4
Total tools	12	4		12
TOTAL	**31**	**68**	**1**	**100**

With its combination of mainly Early Bronze Age artefacts in quartz, flint and mylonite, the Dalmore collection compares well with a number of contemporary assemblages excavated or collected along the west coast of Lewis and Harris, such as, Barvas 2 (Ballin 2003a), Olcote (Neighbour 2005), Calanais (Ballin forthcoming a), Berie Sands (Lacaille 1937) and parts of the Northton assemblage (Simpson 1976; Murphy & Simpson 2003). Together, these Early Bronze Age assemblages present a detailed picture of lithic variation within a limited geographical area.

FERG Site 4, Aberdeenshire (to be published as part of Johnson forthcoming).

In 2001 CFA Archaeology Ltd carried out excavations along the route of the St Fergus to Aberdeen Natural Gas Pipeline (FERG) in eastern Aberdeenshire (Cameron 2002). The investigation dealt with a number of sites, but only from Sites 1, 4, 5 and 6 were lithic artefacts recovered. The first lithic finds from these sites were discussed in Ballin (Ballin 2003b). Additional lithic artefacts from FERG Site 4 were described in a later report (Ballin 2004c), and the main characteristics of this more substantial collection are summarized below. This site is located roughly 400m south-east of Auchmachar Farm and included two truncated ditches (contexts 005 and 006), a shallow pit (context 001) and two rock outcrops (contexts 004 and 008).

The assemblage from Site 4 includes 66 lithic artefacts (Table 9). Twenty-two of these are flint, 43 are quartz and one small flake is in dolerite. Most of the flint and quartz is assumed to have been collected locally, the flint possibly from the Buchan Ridge Gravel deposits. The quartz was most likely procured in the form of erratics, though individual pieces may be from river or beach sources. Three large objects in fine, grey flint may represent imported raw material (cf Saville 2003b, 407). The dolerite flake may have been based on an erratic nodule.

Thirty-nine pieces are unmodified debitage, supplemented by 15 cores and 12 tools. The debitage is mainly milky quartz, whereas the cores and tools are dominated by flint. The debitage consists of 32 flakes and seven indeterminate pieces, and no chips or blades were recovered. The cores include three regular single-platform cores, six irregular cores and four bipolar cores; two split pebbles had been worked in bipolar technique. The tool category is dominated by seven scrapers, supplemented by two notched pieces and three pieces with edge-retouch. An end-scraper and a retouched piece, both with coarse inverse retouch, may be early-stage 'flaked flakes' (Ashton *et al* 1991).

The assemblage is dominated by a simplistic hard-percussion/bipolar technique (Industry 1), but three single-platform cores represent a microblade industry (Industry 2), characterized by soft percussion and sophisticated core preparation. However, no blades or microblades were found at Site 4. The distribution patterns of the assemblage suggest that flake production, by the application of hard and bipolar percussion, was centred on rock outcrop context 008 (for site details, see Johnson forthcoming), whereas the single-platform cores may have been scattered across the site in connection with relatively recent dumping of soil.

The dates of the two industries are indicated by a combination of typology, technological attributes and raw material preference. It is suggested that Industry 1 is most likely to be post Early Bronze Age, due to its simple core forms, the presence of possible early-stage 'flaked flakes' (cf Ballin 2002a), and the use of possibly imported grey flint (Saville 2003b, 407), whereas Industry 2, with its single-platform microblade cores, must be early prehistoric (either Late Mesolithic or Early Neolithic).

One quartz chip and one indeterminate piece in quartz, both from Pit 001, were discussed previously (Ballin 2003b). They were not included in the present analysis.

FERG Site 5, Aberdeenshire (to be published as part of Johnson forthcoming).

This site was excavated as part of the same general project as FERG Site 4 (above). The main lithic assemblage from FERG Site 5 were characterized (in Ballin 2004d), and the main characteristics of this collection are summarized below. This site is located towards a low ridge, *c* 200m from Mains of Bruxie Farm, and it included the truncated remains of a ring-ditch and a number of internal pits.

The assemblage from Site 5 includes 34 lithic artefacts, nine of which are flint, with the remainder being quartz (Table 9). Both raw materials are assumed to have been collected locally, the flint probably from the Buchan Ridge Gravels, and the quartz most likely in the form of erratics, though some may be from river or beach sources. Twenty-eight pieces are unmodified debitage, supplemented by two core-fragments and four tools. The debitage is mainly quartz, the core-fragments are in quartz, and all tools are in flint. Only one chip was found, as well as 22 flakes and five indeterminate pieces. The two core-fragments are detached core-sides. The tools include one discoidal scraper, one truncated piece, one notched piece and one retouched piece.

None of the flakes are soft-percussion blanks, with hard percussion and bipolar technique having been applied in equal measure. Core preparation appears to have been kept to a minimum, and only the truncated blade (CAT 29) has had its platform edge trimmed. Though it is not absolutely certain that CAT 29 is contemporary with the rest of the assemblage, the entire assemblage is probably the product of one or more expedient flake industries, and a general date of the later prehistoric period seems likely. No diagnostic artefact types were found. The excavators (Cameron 2002) suggest an Iron Age date for the site's ring ditch, and the lithic assemblage may be residual to this structure. This option is not contradicted by the stratigraphical position of the finds.

Eleven lithic artefacts from the same site were discussed in Ballin (Ballin 2003b), and this small assemblage has a typological, technological and raw material composition similar to the material described above. The 2003 assemblage, which was not included in the present analysis, generally supports the above conclusions.

2.4.7 Later Bronze Age material

Bayanne, Shetland (to be published as part of Moore & Wilson forthcoming a).

During the excavations at Bayanne on Yell, Shetland, EASE Archaeological Consultants recovered a large lithic assemblage which consists almost entirely of quartz. The work was carried out in response to the threat from continued coastal erosion of the site and, though parts of the deposits were lost to the sea, several structures were still intact, or partly intact, as were their contents of, *inter alia*, pottery and lithic artefacts. The internal site chronology includes six phases, covering early cultivation and a post-built structure, a number of Later Bronze Age dwellings, workshops and middens, two Pictish figure-of-eight houses, as well as layers relating to site abandonment and later cultivation.

The large lithic assemblage from Bayanne includes 2955 pieces (illus 29; illus 30; illus 31; Table 10), or approximately 40 kg, of which 99.4% is in quartz and the remainder in quartzite. Contrary to most other quartz assemblages, the Bayanne material contains a large number of classifiable cores and tools, with a tool ratio of 7%. Cores amount to 53 pieces, whereas tools constitute 205 pieces, of which 153 (75%) are scrapers, 11 are piercers, 23 are retouched pieces and 16 are hammerstones; one piece was classified as a small knife, and one piece is a fragmented barbed-and-tanged arrowhead. Most of the scrapers are plain short end-scrapers (111 pieces, or 73% of the scraper group), supplemented by some double-scrapers and side-scrapers.

The primary reduction technique at Bayanne is a combined approach applying hard-hammer as well as bipolar technique. This is indicated by the cores, the core preparation/rejuvenation flakes, and the debitage: most cores are hard-hammer cores

Illus 29 Bayanne. Cores: three single-platform cores, one opposed-platform core, one irregular (multi-directional) core, and one bipolar core

Table 10 The Bayanne lithic assemblage: general artefact list

Debitage	
Chips	281
Flakes	1416
Chunks	972
Blades	14
Microblades	8
Crested blades and flakes	4
Platform flakes	2
Total debitage	2697
Cores	
Single-platform cores	13
Opposed-platform cores	2
Irregular cores	19
Bipolar cores	18
Core rough-outs	1
Total cores	53
Tools	
Circular scrapers	2
Short end-scrapers	111
Double-scrapers	18
Side-scrapers	16
Scraper-edge fragments	6
Piercers	11
Pieces with a curved truncation	1
Pieces with edge-retouch	23
Combined tools (scraper-piercers)	1
Hammerstones	16
Total tools	205
TOTAL	**2955**

Illus 30 Bayanne. Preparation flakes and tools: one crested flake, one core rejuvenation flake, one base of a barbed-and-tanged arrowhead (with residual barbs), two piercers, and one backed knife

(platform and irregular cores) with approximately one-third of the cores being bipolar; bulbar and bipolar flakes are present in roughly equal numbers. A detailed inspection of the cores and the debitage suggests that hard-hammer technique was the main percussion technique, with bipolar technique mainly being applied in the initial and final stages of production, that is, in connection with the 'quartering' of raw nodules and with the reduction of exhausted platform cores.

The quartz artefacts were distributed across 14 events (six phases), with quartz deriving from wall cores, occupation layers in houses, as well as middens. Most pieces of quartz were found outside the houses, suggesting that either the main part of the primary production took place in the open air, or the houses were cleaned regularly and rigorously. It is at present unknown which activities required the large quantities of scrapers, but use-wear analyses suggest that steep edge-angles, as seen in connection with the scrapers from Bayanne, were not intended for hide-working but for the processing of harder materials, such as wood, bone and antler (Broadbent & Knutsson 1975; Knutsson 1978; Knutsson 1988, 133; Broadbent 1979, 89; Jeppesen 1984; Thorsberg 1986; Juel Jensen 1988, 70f). The fact that the Bayanne scrapers are generally heavily worn and damaged support this.

In the report (Ballin forthcoming j), the Bayanne assemblage is compared to other quartz assemblages from Shetland, and a basic (and preliminary) techno-chronological schema is presented. In this schema, the material from Bayanne is suggested to typify an Early to Late Bronze Age stage, differing technologically from earlier and later stages. The presence of a barbed-and-tanged arrowhead indicates an Early Bronze Age date for the quartz of Phase 1, whereas the complete absence of invasive retouch in the later phases indicates a Later Bronze Age date for the remaining quartz assemblage. The relatively sophisticated operational schema of the Bayanne industry rules out an Iron Age date, as Shetland assemblages with Iron Age components appear to have been produced in a more expedient manner (Section 2.4.8). The dating proposed by the typological and technological attributes of the collection is

Illus 31 Bayanne. Scrapers: four end-scrapers, one double-scraper, one side-scraper (working-edge along the left lateral side), and one side-/end-scraper (the lateral working-edge is to the right side)

supported by radiocarbon evidence, suggesting a date for the Phase 1 finds of approximately 3400 BP, and a date of *c* 3200–2700 BP is suggested for the main bulk of the assemblage.

Cruester, Shetland (to be published as part of Moore & Wilson forthcoming c).

In October–November 2002 EASE Archaeological Consultants carried out excavations at the Cruester burnt mound on Bressay, Shetland. The work was undertaken in response to the threat from continued coastal erosion of the site. Prior to excavation the site was visible as a large mound measuring some 20m in diameter, and it was about 2m high (Moore & Wilson 2003a).

The burnt mound at Cruester was initially described by surveyors of the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS 1946, no 1092), and resurveyed by the Ordnance Survey during 1964. In 1996, the site was examined as part of the Shetland Burnt Mounds Project (Moore & Wilson 1999), funded by Historic Scotland and Shetland Amenity Trust. At this point of time, the entire erosion face was transformed into a 17m long section, and the overall site area and the section face were recorded in detail. The excavation of 2000 revealed a complex cellular stone structure at the centre of the mound, almost identical in plan to the structure associated with the burnt mound at Tangness, Eshaness, Shetland (Moore & Wilson 1999). This structure was incorporated into the burnt mound, demonstrating some degree of contemporaneity between the activities associated with the burnt mound and the cellular structure.

With its 173 lithic artefacts (Table 11), the Cruester assemblage is relatively small. It includes 160 pieces of debitage, nine cores and four tools. Apart from a single flint artefact, all finds are in quartz. Some quartz is homogeneous milky quartz of uncertain provenance, but the larger part of the assemblage is dense saccharoidal quartz from the local shores. The debitage is heavily dominated

Table 11 The Cruester lithic assemblage: general artefact list

Debitage	
Chips	1
Flakes	42
Blades	4
Indeterminate pieces	111
Crested flakes	2
Total debitage	160
Cores	
Single-platform cores	3
Opposed-platform cores	1
Irregular cores	1
Bipolar cores	3
Core fragments	1
Total cores	9
Tools	
Short end-scrapers	1
Pieces with retouched notch(es)	1
Pieces with edge-retouch	1
Hammerstone	1
Total tools	4
TOTAL	**173**

by indeterminate pieces (*c* 70%), supplemented by some flakes (*c* 25%), and small numbers of chips, blades and crested pieces. The flakes were mainly detached by the application of hard percussion, but bipolar flakes are also present. Most of the cores are platform cores, with three single-platform cores dominating the category. Three bipolar cores were also recovered. The tools are plain and include an end-scraper, a notched piece, a piece with edge-retouch and a hammerstone.

The industry represents a flake technology, with blanks having been produced mainly on simple single-platform cores. The operational schema did not include systematic decortication, cresting or platform preparation, but some trimming of platform-edges did occur. Rejuvenation of platforms by the detachment of core tablets did not take place either. When platform cores were abandoned, they were frequently reduced further by the application of bipolar technique. A proportion of the many indeterminate pieces may reflect the activities associated with the covering burnt mound (splitting due to the exposure to heat), rather than the lithic technology.

The assemblage is probably mainly a product of activities associated with the construction and use of the central structure (Phase 3), and activities post-dating the abandonment of this structure (Phase 4). These activities are likely to include primary and secondary production, as well as the use of unmodified and modified tools. During Phase 3, quartz blanks and tools were produced, used or stored throughout the structure. The horizontal distribution of quartz may suggest some specialization between the various cells. The lithic assemblage does not include diagnostic elements, but, combined, the structural details of the building, burnt mounds in general, radiocarbon and thermoluminescense dates, and diagnostic pottery suggest a Later Bronze Age date.

2.4.8 ?Iron Age material

Burland, Shetland (to be published as part of Moore & Wilson forthcoming b).

In 2000 and 2002, EASE Archaeological Consultants carried out excavations at Burland Farm on the isle of Trondra, Shetland. The work was undertaken in response to the threat from continued coastal erosion of the site. The project was commissioned and funded by Shetland Amenity Trust and Historic Scotland. The presumed settlement site was visible as a low mound near the coastal edge at *c* 5m OD, with the hinterland to the east rising to approximately 50m OD.

The excavations uncovered the remains of at least three separate structures, and the deposits were divided into the following seven phases of activity (Moore & Wilson 2003b):

- Phase I: Early cultivation remains
- Phase II: Early activity (anthropogenic soils and cut features) – associated with metalworking
- Phase III: Structure 2 – associated with metalworking
- Phase IV: Structure 3
- Phase V: Structure 1
- Phase VI: Abandonment (hill wash)
- Phase VII: Peat stack.

The 515 lithic artefacts (illus 32; illus 33; illus 34; illus 35; illus 36) were mainly recovered from Phases II–III (22%) and VI–VII (76%), with Phase IV–V contexts constituting an almost sterile separation of the two groups of finds (<2%). No worked quartz was found in Phase 1 deposits. The following summary focuses on the finds from Phases II–III and VI–VII, and the similarities and differences between the two sub-assemblages.

The assemblage from Burland Farm includes 515 lithic artefacts (Table 12), 514 of which are in quartz with one piece being in jasper. The quartz was procured from a number of vein and pebble sources; the vein quartz probably from east or south Trondra, whereas the pebble quartz may be from the local beach. The jasper may have been collected or quarried on the island (forming part of the metamorphic Whiteness Division), though jasper is more frequently encountered in igneous environments (eg Papa Stour).

The 437 pieces of debitage are heavily dominated by indeterminate pieces (68%), supplemented by

Illus 32 Burland. Platform cores: one large and one small irregular (multi-directional) core, and one small single-platform core (lower right corner)

Table 12 The Burland lithic assemblage: general artefact list

	Total
Debitage	
Chips	3
Flakes	126
Blades	12
Indeterminate pieces	295
Crested pieces	1
Total debitage	437
Cores	
Single-platform cores	3
Irregular cores	13
Bipolar cores	21
Core fragments	1
Total cores	38
Tools	
Leaf-shaped arrowheads	1
Short end-scrapers	12
Side-scrapers	5
Hollow scrapers	1
Scraper-edge fragments	1
Piercers	3
Backed knives	1
Notched pieces	2
Pieces with edge-retouch	7
Fabricators	6
Other tools	1
Total tools	40
TOTAL	515

Illus 33 Burland. Bipolar cores: two large specimens, and three smaller specimens

some flakes (29%), and small numbers of chips, blades and a crested piece. More than nine-tenths of the flakes and blades were detached by the application of bipolar technique, with the remainder having been manufactured mainly by hard percussion. Approximately 55% of the 38 cores are bipolar cores, supplemented by 34% irregular cores and a small number of single-platform cores. However, all irregular and single-platform cores were reduced by the use of an anvil, and, though both core types are technically platform cores, some bipolar flakes may have been produced on these cores (due to the application of anvils), explaining the discrepancy between the technological composition of the debitage and core categories.

The 40 tools are mostly expedient forms of scrapers, piercers, fabricators, notched pieces and edge-retouched pieces, but a fragment of a leaf-shaped point in jasper, and a backed knife were also found. The scrapers dominate the tool category (48%), with edge-retouched pieces and fabricators representing *c* 16% each. The fragment of a leaf-shaped point represents a fairly well-executed bifacial piece, which probably broke during manufacture. It stands out as an implement of much higher quality than the main bulk of the assemblage, and it probably predates it.

Though distributed across two stratigraphical levels (Iron Age Phases II–III, and later hillwash layers), separated by almost sterile Norse layers, the assemblage appears to represent a single, very simplistic industry. Both sub-assemblages are based on the same mixture of vein and pebble quartz, and they follow the same typological and technological schemas. Typologically, the two sub-assemblages include almost the same, mostly plain and informal, tool types, with large fabricators being an important common denominator; three piercers and a knife are exclusive to the Iron Age level. Technologically, the two sub-assemblages are based on the same combination of bipolar and platform-core-on-anvil approaches, and the individual debitage and core types of both finds groups cluster metrically to form separate size categories. Most likely, this is an expression of a phased operational schema, with large flakes and cores representing the first

Illus 34 Burland. Scrapers: three end-scrapers, two side-scrapers (with a left and right lateral working-edge, respectively), and one concave scraper (furthest to the right)

Illus 35 Burland. Tools: one knife (backing along the right lateral side), two piercers, and one notched piece

Illus 36 Burland. Fabricators

step of the reduction process ('quartering'), while the smaller pieces represent the second and last step (discarded blanks and totally exhausted cores). Though the Burland industry is based on few and very simple technological choices, it clearly represents a planned process or operational *schema*.

Apart from the fragment of a residual Early Neolithic leaf-shaped point, the assemblage does not include any diagnostic types. The basic lithic technology, however, suggests a date of the main bulk of artefacts in the later part of Scottish prehistory. The distribution of finds across the Phase II and III Iron Age features and structures indicates that, at Burland, quartz knapping may have occurred later than usually expected. Similar Iron Age dates have been obtained from the quartz-bearing layers at Kebister, Shetland (Clarke 1999, 164; Owen & Lowe 1999, 148), and the presentation of the finds from Jarlshof (Hamilton 1956, 15, 26) suggests production of simple quartz blanks and tools around the transition of the Bronze Age and Iron Age periods, and possibly into the Iron Age proper.

The majority of the finds were recovered from the upper hillwash layers, and, due to the similarity between these finds and finds from the Iron Age layers, it is thought that they originally formed part of a peripheral section of the Iron Age settlement located east of the structures at a higher topographical level. From this position, they slid down

Table 13 The Barvas 2 lithic assemblage: general artefact list

Debitage	**Quartz**	**Flint**	**Total**
Chips	1		1
Flakes	18	6	24
Indeterminate pieces	7	1	8
Total debitage	26	7	33
Cores			
Split pebbles	3		3
Irregular core	1		1
Bipolar cores		1	1
Total cores	4	1	5
Tools			
Short end-scrapers	1		1
Pieces w notch(es)		1	1
Pieces w edge-retouch		5	5
Combined tools		1	1
Total tools	1	7	8
TOTAL	**31**	**15**	**46**

the hillside, encouraged by the combined forces of gravity and modern ploughing. Even if the lithic material from the site's Iron Age level should prove to represent hillwash, and therefore pre-date the Iron Age settlement, a date earlier than the Bronze Age–Iron Age transition is unlikely.

2.4.9 *Minor assemblages*

Barvas 2, Lewis (Ballin 2003a).

During archaeological investigation of the dune area near Barvas on the Isle of Lewis, Western Isles, 46 lithic artefacts were recovered. The assemblage includes 31 pieces of quartz and 15 pieces of flint (Table 13). The quartz is partly milky quartz and partly saccharoidal quartz. Flint as well as quartz were procured from the local beaches. Most of the lithic finds constitute debitage, supplemented by five cores and eight tools. Flakes make up three-quarters of the debitage, with the remainder being indeterminate pieces; the cores include three split pebbles (early-stage bipolar cores), one bipolar core and one irregular core; and the tools are mainly edge-retouched pieces, supplemented by one end-scraper, one notched piece and a combined tool (scraper-piercer).

Approximately 80% of the flakes were manufactured by the application of bipolar technique, with 4% having been produced in hard-hammer technique and the remainder in indeterminate platform technique. Most likely, some flakes were produced on irregular cores and then, when these cores became too small for further free-hand reduction, flake production continued by the application of bipolar technique. However, the presence of split pebbles, worked in bipolar technique, shows that some nodules were reduced entirely by the use of anvils. The total absence of true blades, combined with a largely unschematic operational schema, favour a date in the later part of prehistory.

Catpund, Shetland (Ballin 2005).

In connection with the excavation of the Late Neolithic/Early Bronze Age house at Catpund, a number of quartz artefacts were recovered, in total 31 bags of quartz. Unfortunately, it has only been possible to locate one of these bags (SF 513), and the following summary of the quartz assemblage is based on this sample (31 pieces). If SF 513 represents an average bag, the assemblage will have contained approximately 900 pieces of quartz. However, this bag is from a small dense concentration of samples from the north-west corner of the house, and it is likely that these bags contained a higher than average number of quartz, with the bags collected from scatters in the rest of the house being slightly less full. Assuming that the quartz assemblage constituted 450–900 pieces, the sample SF 513 could account for 3.3–6.7%. As the contents of this bag corresponds well to quartz assemblages from other Late Neolithic and Bronze Age sites in the west and north of Scotland (compare with other accounts in this section), it is quite possible that bag SF 513 is representative of the entire Catpund assemblage.

Table 14 The Catpund lithic assemblage: general artefact list

Debitage	**Total**
Bipolar flakes	17
Platform flakes (?)	1
Total debitage	18
Bipolar cores	5
Tools	
Piercers	1
Short end-scrapers	6
Double scrapers	1
Total tools	8
TOTAL	**31**

SF 513, the only quartz bag it was possible to locate, contained 31 artefacts of white pebble quartz (milky quartz). The assemblage comprises 18 flakes, five cores and eight tools (Table 14). Apart from one possible platform flake, all flakes and cores are bipolar, and all tools are on bipolar flakes. The tool group consists of one piercer, six short end-scrapers and one double-scraper. On the basis of the available quartz it could be concluded that the assemblage from Catpund represents an almost exclusively bipolar technology. This corresponds well with other Scottish quartz assemblages based mainly on pebble quartz (eg Rosinish, Benbecula: Ballin forthcoming h, and Sumburgh, Shetland: Finlayson 2000). No attempt had been made at producing blanks of certain fixed dimensions (eg blades or elongated flakes).

A distribution analysis based on information from the initial artefact and site reports of 1988 and 1990 demonstrated that the quartz had mainly (71%) been recovered from the later post-occupation phases (Phases VI and VII) and none from the main occupation phase (Phase III). Most of the late quartz came from two clusters in the central and eastern parts of the house, possibly activity areas. The densest cluster of nine bags was situated between the wall and the north-west orthostat and may be a cache. The quartz, as a whole, is completely non-diagnostic and the assemblage cannot be dated more accurately than to the interval Neolithic–Early Iron Age.

2.4.10 *The Cnoc Dubh quartz quarry project (Ballin 2004e)*

In 2002, an examination was carried out of a small quartz vein at the knoll of Cnoc Dubh, a few hundred metres from the bottom of Loch Ceann Hulabhig on the Isle of Lewis. The vein (illus 37) proved to have been worked in prehistoric time, defining it as a quarry, and it was measured, photographed and characterized. The Cnoc Dubh quartz quarry is presented in detail in Ballin (Ballin 2004e), to allow comparison with other lithic quarries, and it is attempted to define attributes diagnostic of prehistoric exploitation, and to schematically describe the 'mining operations' by which the quartz was procured. As part of this process, quartz quarrying is compared to the procurement of other lithic and stone raw materials, mainly drawing on research from Scandinavia, Australia and the USA, and the location of quartz quarries in relation to prehistoric settlements is discussed. The average distance between quartz sources and Neolithic–Bronze Age sites on Lewis is then used to discuss ownership of, and access to, prehistoric quartz sources, as well as the possible exchange of quartz.

Results of this research form part of the discussions in Sections 5–8.

2.4.11 The burnt quartz project ('The recognition of burnt quartz and its relevance to the interpretation of prehistoric sites'; Ballin forthcoming k)

It is a well-known fact that flint, when exposed to fire, undergoes a number of distinct changes. Depending mainly on distance to the heat source and duration of the exposure, flint artefacts may change colour, lustre, and weight, and they will, ultimately, crackle and disintegrate (eg Fischer *et al* 1979, 23). These alterations are used by lithics analysts to interpret assemblages and sites, and burnt flint has, *inter alia*, been used to suggest the presence of otherwise invisible hearths (eg Ballin forthcoming j), site maintenance (dumping of hearth material; eg Binford 1983), the destruction of prehistoric dwellings by fire (eg Fischer *et al* 1979, 22–7), and heat-treatment of lithic raw material (Price *et al* 1982). As a consequence, the recording of burnt flint has become a standard part of post-excavation processing of flint assemblages.

In contrast, burnt quartz is rarely recognized, reported, described or discussed, and, as a result, analyses of quartz assemblages appear less fruitful. This state of affairs has added to the general perception in the archaeological world, that investing in the analysis of quartz assemblages is 'a waste of time and money'. However, a combination of experimentation and analysis of prehistoric assemblages suggests that burnt quartz *is* recognisable, although it may be more difficult to identify than burnt flint. Inspired by observations, first of all the non-random distribution of potentially burnt quartz on Neolithic and Bronze Age sites in north-west Scotland (eg Rosinish: Ballin forthcoming h; Calanais: Ballin forthcoming a; Dalmore: Ballin forthcoming g), the author undertook a series of trials. The experimental burning of quartz showed that quartz, when exposed to fire, undergoes the same basic alterations as flint (change of colour, lustre, weight and general cohesion), and the tests managed to elucidate some of the observations, whereas other observations remain unexplained.

Preliminary results of this research are discussed in Section 4.4.

Illus 37 The Cnoc Dubh quartz quarry, Lewis

3 The Investigation of Quartz Technology – A Brief Research History

3.1 The international scene

Until approximately two decades ago, quartz studies were characterized by relatively unfocused attention. Only in the late 1970s and 1980s (eg Siiriäinen 1974; Broadbent 1979; Baker 1983; Callahan 1987; Knutsson 1988) did quartz begin to receive special consideration, and to develop into a specialized research field. Before that moment, quartz was essentially dealt with as an archaeological oddity and it was either ignored or the 'nicer' cores and tools (or pieces erroneously interpreted as such) were recovered selectively. Research designs were not tailored to fit this particular material, its specific availability, flaking properties, reduction techniques, or research potential. In general, quartz research has been characterized by contributions from a small number of countries where quartz either dominates assemblages, or where it may be an important minority resource; these are Sweden, Finland, USA, Canada, Australia and Scotland.

The period after the Second World War saw the interest in quartz artefacts and assemblages rising (eg Caldwell 1954; Luho 1956), but due to the difficulties in recognizing tools in quartz, there was a general tendency to define quartz fragments and flakes as tools, if they had any superficial resemblance to well-known tool types in flint or flint-like silica. This tendency characterized, for example, Luho's (1956) work and his definition and dating of the Finnish Askola Culture (see comments by Kinnunen 1993, 9).

In the late 1970s and the 1980s, the archaeological interest in quartz 'mushroomed', possibly as a consequence of New Archaeology's preoccupation with 'scientific' approaches and precise characterization and quantification (Renfrew & Bahn 1996, 36–7). The attention included:

- quartz as a mineral, its physical properties, and fracture patterns (eg Siiriäinen 1974)
- quartz technology and its operational schema(s) (eg Baker 1983; Callahan 1987; Knutsson 1988)
- the definition and dating of specific quartz industries, or 'cultures' (eg Siiriäinen 1977)
- quartz procurement and quarrying (eg Broadbent 1973; Broadbent 1979)
- regional aspects of quartz production (eg Sassaman *et al* 1988)
- experimental and use-wear analysis of quartz tools (Broadbent & Knutsson 1975; Sussman 1988).

The classification and interpretation of quartz assemblages were markedly transformed by the general acceptance of White's conclusion that the so-called '*outils éscaillèes*' (ie scaled tools) are in fact bipolar cores, produced on anvils (White 1968). Prior to this realization, bipolar cores had been classified as implements (eg Whittle 1986) such as wedges and scrapers (for a general discussion of bipolar cores, see Ballin 1999a).

One of the main questions discussed by the 1980s Scandinavian analysts was whether quartz artefacts should be classified according to the same type schema as, for example, worked flint. As a response to the difficulties experienced in the classification of quartz assemblages, lithics specialist working in Scandinavia favoured a separate quartz typology (Broadbent 1979, 48; Callahan 1987, 65). The present author disagrees strongly with this approach, as its logical consequence is that assemblages in flint/flint-like silica and quartz cannot be compared directly (in Scotland, this would make the interpretation of mixed flint/quartz assemblages, such as the well-known Mesolithic assemblages from Jura, particularly problematic). A separate quartz typology is still very much favoured in parts of Scandinavia, where Knutsson argues that the difficulties of quartz analysis is largely a product of the automatic use of an ill-fitting flint artefact typology (Knutsson 1998, 79).

However, his examples (Knutsson 1998, figs 2 and 3) clearly demonstrate that the main problem is a prevailing tendency amongst Scandinavian analysts to classify quartz chunks and fragments as tools if they have the slightest formal likeness to traditional lithic tool types (eg Halén 1994; Knutsson 1998, 76, fig 2). This problem could be dealt with simply by adhering to a simple rule: that a quartz artefact is not a tool unless it has the distinctive retouch generally associated with a particular tool type (eg Ballin 1996). Lindgren demonstrates experimentally, and by blind-tests, how difficult it can be to recognize modification on quartz artefacts (Lindgren 1998), and it is a fact that many quartz assemblages seem to either lack quartz tools or have very low tool ratios. However, it is, in the author's view, an illusion that classification of quartz tools (ie the recognition of retouch) would become any easier with a different typology.

Since the 1980s, quartz research continued within each of the above main study areas, producing increasingly detailed results. They include: sustained discussion of bipolar debitage and cores, mainly in quartz (eg Knight 1991); experimental analysis of quartz fracturing (eg Callahan *et al* 1992); procurement, not least quarrying, of quartz (eg Abbott *et al* forthcoming); the organization of quartz artefact manufacture, and the transport and exchange of quartz implements (McNiven 1994); and exposure to fire and possible heat-treatment of quartz (Gonick 2003). In recent years, social aspects of quartz use have been added to the list of themes, focusing on the raw material's use in the ritual sphere (eg Taçon 1991), as well as its presence on, and distribution across, settlement sites (eg Bang-Andersen 1998; Rankama 2002).

Though the low number of quartz analysts worldwide forced researchers to seek inspiration outside the borders of their own country ('go international'), communication between quartz specialists has generally been hampered by the vast distances separating people, as well as the publication of quartz literature in a multitude of national and local periodicals. With the continued development of the Internet, in conjunction with increasingly fast computers and connecting networks (eg the Broadband), this problem is in the process of evaporating. More and more quartz papers are now being published directly on 'the Net' (eg McNiven 1994), and it is today very easy to get in touch with colleagues and fellow specialists throughout the world, for instance in the form of email.

By this means, the author managed to establish contact with quartz analysts in, among other countries, USA, Canada and Finland, and it was possible to substantially increase the sum of available quartz reference material for the present paper. In the wider picture, it allowed the author to communicate with relevant individuals in the USA, who are now planning and organizing a future international quartz conference.

3.2 Scottish quartz research

With a few exceptions, Scottish quartz research developed along the lines summarized above, and, in the first half of the 20th century, quartz was mostly recovered on a selective basis (eg Calder 1956; Hamilton 1956). However, a small number of Scottish analysts were ahead of their time, and Lebour, for instance, discussed social aspects of quartz use as early as 1914 (quartz pebbles recovered from burial and ritual sites), whereas Lacaille dealt with the fracture patterns of quartz (Lacaille 1938) long before the Scandinavian experimental initiatives in this area (Knutsson 1988; Callahan *et al* 1992).

As a consequence of the distinctive quartz dominance in parts of the country, such as the Western Isles, this raw material saw a steady interest from the archaeological community, not least from AD Lacaille (Morrison 1986). Raised in Glasgow, Lacaille had a natural interest in the west of Scotland, and, during his years in Scottish archaeology, several quartz assemblages were presented and discussed (see bibliography in Morrison 1986), although in the 'broad-brush style' of the period. One of his first academic papers dealt with a small quartz surface collection from Ward Hill on Shetland (Lacaille 1933), and over the next two decades he discussed, *inter alia*, important quartz assemblages from Berie Sands on Lewis (Lacaille 1937), and Morar in Inverness-shire (Lacaille 1951).

Though Lacaille did not die until 1971, his Scottish production more or less seized in the mid 1950s, after the publication of his greatest work, *The Stone Age in Scotland* (Lacaille 1954). In terms of quartz research, the 1950s was characterized by extensive surveys and excavation activity on Shetland, where the investigation of prehistoric stone structures, such as Neolithic and Bronze Age houses and burial monuments, as well as Iron Age brochs, led to the presentation of new quartz assemblages. Calder carried out surveys for the Royal Commission's *Inventory for the County of Shetland*, and in his papers in the *Proceedings of the Society of Antiquaries of Scotland* (Calder 1956; Calder 1964) he presented many finds in quartz. His more substantial assemblages were characterized and discussed (by Henshall 1956). Hamilton published quartz sub-assemblages from the Bronze Age and Early Iron Age layers of the Jarlshof broch in southern mainland Shetland (Hamilton 1956).

Quartz reports from the inter-war period and the early post-war years are generally characterized by 'broad strokes of the brush'. In most cases, the authors presented the assemblages in terms of their general characteristics, rather than by precisely quantifying whole assemblages, and complete finds lists basically do not exist. This trend changed with the onset of the 1970s (the introduction of New Archaeology), and the commencement of Mercer's 'Jura Project', during which the Mesolithic chronology of the Isle of Jura was investigated and discussed (Mercer 1968; Mercer 1970; Mercer 1971; Mercer 1972; Mercer 1974; Mercer 1980; Mercer & Searight 1986). Mercer's main approach was to combine typological evidence with information regarding local shoreline displacement. His methodology represents a step forward, compared to the work of the archaeologists of the thirties, forties and fifties, as assemblages are now recovered in total, and the finds are characterized precisely, type by type, and with the inclusion of complete finds lists.

Unfortunately, Mercer chose to present the finds in various raw materials (flint, quartz, pitchstone and bloodstone) *en masse*, and, though he details the amounts of flint and quartz recovered from the individual sites (in pounds and ounces), it is not possible to assess whether the various raw materials are contemporary, and whether they may have been reduced by the application of one or the other percussion technique. Another major problem to the interpretation of quartz assemblages recovered during the seventies and early eighties is the lack of precise recording of finds, making it impossible to carry out chronological controls as well as distribution analysis of the retrieved material.

In the 1980s and the 1990s, Scottish quartz research developed much along the same lines as Scandinavian and American quartz studies (see above). The physical properties of quartz, and its distribution throughout Scotland, was dealt with in papers on lithic raw materials in general (Wickham-Jones 1986; Saville 1994); quartz technology was discussed as part of Finlayson's production (eg Finlayson 1992; Finlayson 1996); and Bradley attempted use-wear analysis on quartz artefacts (Bradley 1986). The introduction of bipolar material into the general lithic type schema was carried out as a gradual process through the 1980s. This decade saw the simultaneous production of lithic reports in which '*outils éscaillèes*' were characterized as, for example, scrapers (eg Whittle 1986), and, correctly, bipolar cores (eg Hedges 1986; Finlayson 1992). After the end of the 1980s, these pieces were consistently classified as products of the hammer-and-anvil technique.

A general discussion of quartz typology has never been undertaken in Scotland, as it was in Scandinavia. It was, however, attempted to apply a separate quartz typology on one occasion, namely in connection with the presentation of the lithic finds from Tougs on Shetland:

> The physical properties of quartz play such a large part in determining the nature of the flakes produced, that implements cannot be classified along the lines used with flint assemblages (Lehane 1986, M6).

Consequently, all tools from Tougs were defined as various forms of edge-modified pieces, avoiding the use of traditional tool types (such as scrapers) and, consequently, it is not possible to compare this quartz assemblage with any other Scottish quartz assemblages or assemblages in flint. Despite the lack of a general discussion of the issue, it is thought that fellow specialists must have experienced problems when attempting to use this experimentally characterized material for comparison (as the author did), and the traditional lithic typology was simply retained without further debate.

Though the possible sources of quartz were occasionally discussed in general terms, that is, assemblages with abraded cortex are from pebble sources and assemblages without probably from vein sources, quartz procurement was not discussed in detail until recently (Ballin 2004e). Apart from Lebour's interesting and innovative paper of 1914, social aspects of quartz use have only begun to be discussed in the beginning of the 21st century (eg Darvill 2002; Warren & Neighbour 2004), as a response to the general criticism of traditional (processual) archaeology and its lack of interpretation of the meticulously characterized finds (Renfrew & Bahn 1996, 43).

The present Quartz Project has been carried out in stages over the period 2000–2005, and it deals with a number of the above issues, attempting to cover obvious lacunae in our knowledge on quartz technology in Scottish prehistory, as well as responding to specific methodological or interpretational problems (Section 2). As part of this task, a number of important 'old' assemblages were re-examined, re-classified and re-interpreted, such as two mainly Mesolithic assemblages from Mercer's Jura Project (eg Lealt Bay: Mercer 1968; Ballin 2001b), and Lussa River: Mercer 1971; Ballin 2002b); the Early Neolithic finds from Scord of Brouster (Whittle 1986; Ballin 2007a); and the potentially Final Palaeolithic finds from Kilmelfort Cave (Coles 1983; Saville & Ballin forthcoming). In this paper, quartz typology, technology and chronology is discussed, as is quartz procurement, quartz intra-site distribution and site behaviour, as well as quartz as a factor in the definition of Scottish prehistoric techno-complexes and social territories.

4 Quartz as a Mineral – Its Properties, Formation and Provenance

4.1 General properties

To fully understand quartz, its properties, formation and provenance, it is necessary to make a distinction between minerals and rocks, and to clearly define the two. This distinction is particularly important in connection with the subdivision of quartz into sub-types, such as, macro-crystalline and crypto-crystalline varieties, as well as quartz-dominated rock forms (see below).

A *mineral* is composed of an orderly arrangement of certain elements which makes it possible to present it in the form of a representative chemical formula, and a specific internal (crystal) structure. A *rock*, on the other hand, is a mountain-building aggregate of minerals (Pellant 1992, 16). Chemically, the mineral quartz is a silicon dioxide, and its formula is SiO^2. It is grouped within a general class of minerals known as *silicates* (Luedtke 1992, 7), including feldspars, pyroxenes and amphiboles, but quartz is without doubt the most diverse silicate in terms of varieties, shapes and forms, and, due to its mineralogical properties, it definitely represents the most knappable silicate. To confuse matters slightly, lithics analysts tend to refer to silicon-dominated raw materials as *silica* (eg Brown 1992), irrespective of whether they are silicate minerals or rock types (eg quartz, jasper, flint, chert, obsidian and quartzite). Silicates are estimated to make up approximately 59% of the Earth's crust, and quartz *c* 12% (Jensen 1973, 68).

The *crystal structure* of quartz (illus 38) is important to the way mineral forms of this material flakes and fractures:

> Structurally, quartz is a tectosilicate, and it contains corkscrewing helical chains of silicon tetrahedrons. The 'corkscrew' consists of four

Illus 38 Quartz crystals (Kongsberg, Norway)

> tetrahedrons, making three turns or twists (trigonal structure) in order to repeat the structural sequence. Each tetrahedron is rotated 120 degrees relative to one another and is aligned along the c-axis of the crystal. Each chain is connected to two other chains at each tetrahedron. This crystalline structure gives quartz many of its unique physical attributes. The tectosilicate structure of quartz and other silicates, with its trigonal symmetry, disrupts cleavage planes and allows a curved fracture quality (conchoidal fracture). This fracture quality is what essentially makes many of these [mineral forms] highly suitable as raw materials for the construction of stone tools (Abbott *et al* forthcoming).

Quartz may be divided into two general types, macrocrystalline and cryptocrystalline (or microcrystalline) varieties, based on the size of the individual crystals within a given quartz form. The crystals of the former variety are large and can be distinguished with the naked eye, whereas those of the latter are too small to see even by microscope (Luedtke 1992; Abbott *et al* forthcoming). Macrocrystalline quartz includes, *inter alia*, milky quartz, rock crystal, smoky quartz and rose quartz, and cryptocrystalline quartz includes flint, chert and chalcedony. As explained in the introduction, only macrocrystalline quartz is discussed in the present paper, and in the following text the term 'quartz' refers to this variety.

A *cleavage* plane is a specific attribute associated with the crystal and atomic structures of a mineral and, in general, quartz is said to have none. This is not entirely true, as quartz cleavage can be induced by either electrical or thermal shock (Howard & Howard 2000; also Siiriäinen 1974), but this fact is, obviously, irrelevant to a knapper. *Fracture* has been defined as the manner in which a mineral breaks when cleavage is not well-developed (Howard & Howard 2000), and the principle fracture manifestations of quartz are intricate cracking and conchoidal, or sub-conchoidal, flaking (Lacaille 1938; Broadbent 1979, 50; Callahan *et al* 1992). The former, which is a genuine problem to quartz knapping, tends to produce cubic fragments in an uncontrollable fashion, whereas the latter allows the production of usually irregular, thick quartz flakes.

However, the quality of quartz fracturing, or flaking, differs from variety to variety, and it is possible that a prehistoric knapper therefore perceived the various quartz-types as different raw materials. Milky quartz, for example, mainly fractures in the intricate manner described above, but rock crystal (and the related smoky quartz) has excellent flaking properties, allowing the manufacture of exceedingly small regular microblades (eg Ballin 1998a), and quartz with a 'greasy' lustre (presented below) probably flakes as well as some coarser flint varieties (Ballin *et al* forthcoming).

Quartz veins tend to crack along three axes (for example, the vein at Cnoc Dubh, Lewis; Ballin 2004e), with one well-developed plane being parallel to the exposed surface, frequently forming actual layers, and two secondary planes running into the vein mass from the surface. This pattern does not represent cleavage planes, as quartz displays very weak (see above) cleavage (Howard & Howard 2000), and at present this habit is not well understood. In his discussion of quartz quarrying (Ballin 2004e), the author suggests that the three-dimensional cracking of quartz veins may be associated with the way hydrothermal fluids solidify. It has been suggested by several researchers (Powell 1965; Ballin 2004e) that this tendency to form secondary layers was a quality in quartz exploited by prehistoric quarriers and knappers in, first, mining the resource and, later, transforming it into blanks and tools.

Quartz is one of the hardest common minerals, and on Moh's *hardness scale* (Table 15) it has been given the number seven of 10 possible (Pellant 1992, 25). As a general rule, minerals with higher Moh's numbers will scratch those lower in the scale. The hardness of quartz is important to the flaking properties of the mineral, but it is also one of the factors defining quartz as a high-quality 'tool-stone', usable for most imaginable functions (scraping, shaving, chopping, drilling, cutting, graving, etc.).

Table 15 Moh's hardness scale

Talc	1	Feldspar	6
Gypsum	2	Quartz	7
Calcite	3	Topaz	8
Fluorite	4	Corundum	9
Apatite	5	Diamond	10

The mineral quartz is also characterized by several other attributes, such as *colour*, *transparency / translucency* and *lustre*. These characteristics are of no importance to the practical application of quartz, but define a number of semi-precious sub-varieties. The most common natural variety of quartz, milky quartz, is white and translucent, and it has a vitreous lustre. It is quite possible that some of the quartz sub-varieties were appreciated by prehistoric people for their beauty or for symbolic, for example, totemic values (eg rock crystal and quartz with a 'greasy' lustre; see Section 8).

4.2 Formation of quartz sources, and general geological provenance

Quartz is a common, if not abundant, component of many igneous, metamorphic and sedimentary rocks, and, due to its resistance to weathering, it may form single-mineral sedimentary and metamorphic rock types (eg sandstone and quartzite). It is frequently found as large grains, crystals or veins in igneous rocks, like granite and granite pegmatites, and metamorphic rocks, like gneisses, but it also occurs as veins in sedimentary rocks, such as shale and sandstone (Neumann 1985; Howard & Howard 2000).

In addition to these primary geological sources, quartz may also be acquired from secondary (pebble) sources. In a previous paper (Ballin 2004e), the author discussed prehistoric quarrying in general, and sub-divided lithic raw material sources into the following groups:

- open pebble sources (river banks/beaches/erratics)
- covered pebble sources (glacial till, fossil riverbeds and fossil sea-shores)
- intermediary sources (mainly chalk sources)
- bedrock outcrops (veins, dykes and sills).

In prehistory, quartz was procured from all but intermediary sources, though quartz may occasionally be found in dolomites and limestones (sedimentary carbonate rocks; Howard & Howard 2000).

The mineral quartz may form in a number of ways, but most commonly it forms as crystallization in magmatic rocks, or as the solidification of hydrothermal fluids in various host-rock types. It is found in two forms, alpha-quartz and beta-quartz (for distinction, see Howard & Howard 2000), but as only alpha-quartz is staple at normal temperatures and pressure (all archaeological quartz is alpha-quartz), the following text applies the term ‘quartz’ as a synonym for this type of the mineral. Alpha-quartz (or low quartz) forms at temperatures lower than 573°, whereas beta-quartz (or high quartz) forms at temperatures between 573° and 867°. Given time, beta-quartz will invert or change its internal structure to that of alpha-quartz (Luedtke 1992, 7; Howard & Howard 2000).

In granite, quartz crystals formed at considerable depth in the Earth’s crust. Its crystals are usually in the order of 5mm in diameter, but crystals several centimetres long are not uncommon (Pellant 1992). However, due to the relatively small size of the individual pieces of quartz, this form was of little relevance to prehistoric knappers. Pegmatite, on the other hand, has the same mineral composition as granite, but its crystals are larger than those of granite and therefore attracted some attention in early prehistory. In pegmatites, quartz crystals may be many metres long (Pellant 1992), and many of the well-known Scandinavian quartz extraction sites are pegmatite sources (eg the Gummark quarries: Broadbent 1973; Broadbent 1979; the Koppinkallio quarry: Kinnunen 1993).

However, most quarried quartz sources are veins. Veins are sheet-like areas of minerals which cut through existing rock structures (Pellant 1992, 18), and most of these formed from hydrothermal fluids (eg Jensen 1973, 159–60; Kourimsky 1995, 26). These hot fluids, containing concentrated volatile elements from the magma chamber, solidified in cracks and fissures of various host rock types. As the formation of prominent fissures generally coincides with active geological environments, large veins are frequently associated with specific geological features. Two forthcoming papers (Abbott *et al* forthcoming; Jones forthcoming) recognize three dynamic geological processes which, in their reaction with other local rocks, are responsible for a variety of culturally important silicates, such as quartz. These are the formation of:

1. diabase (in British English terminology: dolerite) dykes
2. granite plutons
3. fault zones.

Usually veins occur as complex series of seams that follow the fracture patterns of the rocks that were broken and shattered by the mountain-building processes (Howard & Howard 2000). Typically, deposition of quartz took place several times, interrupted by breakage and refracturing of the host rock.

Most quartz veins are limited, centimetre thick seams, but in the Ouachita Mountains (Howard & Howard 2000) veins in shale have been reported that measure ‘... several hundred feet in outcrop length and 60 to 100 feet in thickness’, whereas an occurrence in the pegmatites of the Norwegian Froland/Risør area (Neumann 1985, 221) was reported as being ‘... close to 1km in length and several hundred metres in width’ [translated by the author].

At higher metamorphic grades, quartz not orientated properly to the pressure is dissolved and those grains with the right orientation grows (Howard & Howard 2000). The quartz ‘augen’, or eyes, of some gneisses form in this manner (eg Pellant 1992, 214). In gneiss, quartz actually separates into bands, which are seen as light-coloured bands alternating with darker bands of mafic minerals (Fichter 2000). Though some of these bands may occasionally develop into substantial veins, most veins in gneiss were probably formed by the solidification of hydrothermal fluids.

Sandstone was formed when sand, deposited by wind, water or ice, was compressed into rock. Quartz is generally the main component, but sandstone usually also contains small amounts of feldspar, mica or other minerals. Some sandstones may contain a silica cement, binding the grains firmly. This type of rock has poor flaking properties and is of little relevance to the present discussion. Quartzite, on the other hand, forms by the metamorphosis of sandstone, and some quartzites are dense and knappable. The processes involved are either contact metamorphism of sandstone near a large igneous intrusion, or regional metamorphism in mountain-building zones.

It may be difficult, in some cases impossible, to distinguish hand-samples of saccharoidal (‘sugary’) quartz from samples of lightly altered quartzite. Saccharoidal quartz and quartzite both appear in fine-, medium- and coarse-grained forms, and the two forms of raw material may have the same texture. The main difference in these cases is the origin of the two types of material, where saccharoidal quartz derives from hydrothermal veins, whereas quartzite was formed by the alteration of sandstone. In contrast to saccharoidal quartz and quartzite, milky quartz is not grainy, but massive.

The pebble quartz exploited by Scottish prehistoric people was procured from two main sources, namely i) beach deposits (mainly coastal sites, such as Dalmore; Ballin forthcoming g), and ii) river gravels (mainly non-coastal sites, such as inland sites in Aberdeenshire, in combination with erratics; Ballin forthcoming c). Pebble quartz and vein quartz do not represent two inherently different quartz types, as pebble quartz is only vein quartz which has been detached from its original matrix and subsequently abraded and rounded by one of a variety of water media.

4.3 Quartz varieties encountered in Scottish lithic assemblages (geological classification of quartz)

As indicated above, quartz is found in a number of forms, most of which only differ by their varying colours or grain sizes. Smoky quartz, for example, is a dark variety of rock crystal, but it occurs rarely in Scottish archaeological assemblages, and only in small numbers (eg eight pieces out of a total of 315 lithic artefacts at Fordhouse Barrow in Angus; Ballin forthcoming f). In 2002, amateur archaeologist Jim Crawford showed the author a substantial vein of rose quartz on one of the small islands west of Lewis, but it was unworked and unassociated by lithic artefacts or waste. In the following presentation, only Scottish quartz types commonly recovered as parts of archaeological assemblages are dealt with.

Few people have attempted to construct an archaeologically relevant classification system, covering the different variants of macrocrystalline quartz. Apart from the quartz classification presented and followed in this volume, the author is only familiar with one other system (namely that of Jones forthcoming). The two systems differ in their premises, as the system favoured by the author is based entirely on colour and grain size (geological attributes), whereas the system presented by Jones is based on opacity and fracture surface texture (geological and technological attributes). The definition of a sample's fracture surface texture is based on the quality and character of its flake scars.

The two systems are both logical in their structure, but they emphasize, and sub-divide, different quartz types. Jones sub-divides the broad group of milky quartz into three sub-types, whereas the system promoted by the author sub-divides Jones' 'sugar-quartz' into two sub-types with different grain sizes. The two typologies probably emerged as the products of different geological environments (Scotland, and The South Atlantic Slope, running from southern Virginia to Georgia, USA) and they attempt to answer different geological and archaeological questions. This makes it difficult to favour one system over the other in general terms.

However, in the Scottish archaeological reality, with many assemblages being characterized by variations in the broad category of grainy quartz, the classification sytem presented in Table 16's left column is thought to be the most useful quartz classification. In general terms, this classification may be the most convenient system, as it is based on simple visual attributes, and it is applicable in the majority of geological as well as archaeological contexts, whereas that of Jones requires the presence of manufactured flakes with fresh dorsal and ventral faces. Yet, in the future, it probably should be considered to sub-divide the broad category of Scottish milky quartz.

Table 16 The quartz types applied in the present volume compared with the ones suggested by Jones (forthcoming)

	Present volume	Jones forthcoming
Increasing grain size ⇓	Rock crystal	1. Crystal
	Milky quartz	2. Ice
		3. Milk glass
		4. Irregular
	Very fine-grained ('greasy')	5. Frosty
	Fine-grained	6. Grainy/sugary
	Coarse-grained	
	Quartzite	(7.) Quartzite

In the presentation of his quartz classification, Jones states:

> Inevitably, when a well-intended system is devised to pigeon-hole objects or artefacts that are part of a continuum, a multitude of miscreants arise that defy all attempts to be classified. Try to envision each of the [...] six groups [in Table 16, right column] as a continuum within itself, with one grading into one or more of another. This system is not linear; that is, the first category doesn't grade neatly into the second, the second into the third, etc. Realize, too, that a single outcrop of quartz will often contain several types; a hand-sample or artefact may even contain two distinct types (Jones forthcoming).

This statement also applies to the classification put forward by the author (Table 16, left column).

4.3.1 Rock crystal

Rock crystal is defined as '... colourless and transparent crystals of quartz' (in Jensen 1973, 24, translated by the author), but in the present

Illus 39 Rock crystal. Microblade from southern Norway

context it is suggested to simply define rock crystal as colourless and transparent quartz (illus 39). Actual crystals are not unique to this quartz variety and commonly occur in, for example, milky quartz environments. Though occasionally found as crystals, most rock crystal is recovered from veins dominated by milky quartz (Howard & Howard 2000).

Many massive (ie not grainy) forms of quartz are mixtures of rock crystal and milky quartz, but rock crystal is also found as lenses in very fine-grained ('greasy') quartz (eg at Shieldaig, Wester Ross; Ballin *et al* forthcoming). Eleven per cent of the quartz sub-assemblage from Lealt Bay, Jura (Ballin 2001b), is transparent quartz (273 pieces of 2477), but the composition of this collection varies from artefact category to artefact category. Eleven per cent of the debitage, and 22% of the cores, are rock crystal, but only 6% of the tools are in this material. At Lussa River (Ballin 2002b), also on Jura, 146 artefacts in rock crystal were recovered, but as this quartz sub-assemblage is huge (11,228 pieces), transparent quartz only makes up 1.3%. At both sites, crystals of transparent quartz appears to have been collected, as evidenced by flakes and cores with remaining dorsal crystal facets. These crystals appear to have had lengths of approximately 2.5–4.5cm.

In general, the way this material was used in Scottish prehistory is somewhat puzzling. Rock crystal is a very homogeneous material with fine flaking properties, and the arrises between the crystal facets of the actual crystal prism (rather than those of the terminal pyramids) would have functioned well as six 'pre-fabricated' guide ridges. However, the main approach to rock crystal in Scottish prehistory is to reduce it by the application of bipolar technique, practically shattering the crystals and nodules. In the Mesolithic of southern Norway (eg Ballin 1998a, 40), crystals of transparent quartz was collected (along with the related smoky quartz; Ballin 1998a, 85) for the manufacture of exceedingly narrow regular microblades for insertion into slotted bone points (illus 39). At Lealt Bay (Ballin 2001b), and at neighbouring Lussa River (Ballin 2002b), only two rock crystal tools were made per site, and three of those are scrapers.

4.3.2 Milky quartz

Milky quartz is defined as massive translucent (not transparent) quartz (illus 40). It is the main component of most quartz-bearing rock types, and, like rock crystal, it is occasionally found in crystal form. In prehistory, however, most milky quartz was acquired from veins or pebble sources.

The flaking properties of this quartz variety varies considerably, which is the background to Jones' sub-division of the resource into three sub-categories (ice, milk glass, and irregular; see above). This variation is partly due to the fluctuating qualities of the quartz itself (such as, more or fewer inherent planes of weakness), but many quartzes are also marred by impurities, such as intersecting planes of mica, chlorite or micro-crystals. The colour varies, with milky white varieties dominating, but, as indicated by Jones' terminology, some quartzes have colours and lustres more like ice, and quartz with a blue hue is not uncommon. In some Norwegian granites, blue quartz is found as a rock-forming mineral (Neumann 1985, 221), and at Bayanne on Yell, Shetland (Ballin forthcoming j), the exploited vein material appears to have been white with a relatively dull lustre near the surfaces, whereas the inner (less oxidized?) parts of the quarried material consisted of bluish-white quartz with a more 'waxy' lustre.

Milky quartz is the most widespread quartz form exploited in Scottish prehistory, and it is found on archaeological sites throughout the country. In the two main quartz-using geological areas, Shetland and the Lewisian of the Scottish Mainland/the Western Isles, milky quartz may be the dominant variety, but many assemblages are based on the combined use of massive and saccharoidal quartzes, and assemblages without milky quartz also occur. Most of the erratic quartz nodules collected by prehistoric people in

Illus 40 Milky quartz. Scraper from Kilmelfort Cave, Argyll

Illus 41 'Greasy' quartz. Flakes and blades from Shieldaig, Wester Ross

inland Aberdeenshire (Ballin forthcoming c) appear to be in milky quartz, which may be a fact based on this massive quartz form being more weather and erosion resistant than saccharoidal quartzes.

4.3.3 *Very fine-grained quartz or 'greasy' quartz*

This type of quartz is so fine-grained that it is impossible to see the individual grains without the use of a microscope. The grainy character of this resource is primarily experienced as a slightly rough surface texture, and it is most likely the presence of almost microscopic grains which creates the 'greasy' lustre of the raw material by altering the way light is reflected from it (illus 41). This form of quartz is thought to correspond to Jones' 'frosty quartz', which he describes in the following fashion:

> Increasing graininess of Types 1 and 3 (this paper, Table 16, right column) may result in this type. Very homogeneous with relatively obvious flake scars and correspondingly even edge, this quartz has the appearance of frosted or sandblasted glass. Grades into Type 4 and 6. Usually clear, white buff, pale green, or pink (heat-altered), and almost always translucent (Jones forthcoming).

The author chose not to refer to this quartz variety as 'frosty quartz' as this may allow the raw material to be confused with naturally wind-blown quartz (below), which is best described as having a frosted appearance (eg Ballin forthcoming h).

On Lewis, so-called 'greasy' quartz was preferred for better pieces, such as, arrowheads. As demonstrated (in Ballin forthcoming a), the Calanais ritual complex, and its central megalithic tomb, is dominated by homogeneous milky quartz, but the site's barbed-and-tanged arrowheads are mainly in quartz with a 'greasy' lustre. At Dalmore (Ballin forthcoming g), further to the north, seven out of 15 quartz arrowheads are in 'greasy' quartz, though the dominating variety of that site is coarse-grained quartz. It is quite possible that this preferred arrowhead material was imported into Lewis, but presently it is not possible to say from where. No Lewisian sites are dominated by 'greasy' quartz, and only one site on mainland Scotland is known for the presence of greater quantities of this material – Shieldaig in Wester Ross (Ballin *et al* forthcoming). Given the distances across which, for example, pitchstone was traded (Williams Thorpe & Thorpe 1984; Ness & Ward 2001), it is not impossible that Shieldaig, or other sites or quarries in that general area, is the main source of 'greasy' quartz, particularly if it had some symbolic, for example totemic, connotation. As the crow flies, the distance from Shieldaig to the Lewisian west coast sites is approximately 100km.

At the present time, Shieldaig is the only known assemblage where 'greasy' quartz has been employed in the production of the full range of lithic tools whereas, in assemblages dominated by other quartz varieties, this quartz form was mainly used to manufacture arrowheads and, in some cases, more sophisticated knives. It is quite possible that this

Illus 42 Fine-grained quartz. Core from Scord of Brouster, Shetland

state of affairs purely reflects the fact that 'greasy' quartz has better flaking properties and, as a consequence, was saved for the production of more complex, invasively retouched lithic tools (a mainly functional view is favoured by McNiven in his analysis of the technological organization and settlement pattern of prehistoric Tasmania; McNiven 1994), but it is just as likely that this quartz type had some inherent symbolic meaning to prehistoric people in Scotland (totemic association between people and raw materials has been demonstrated in anthropological research by, *inter alia*, Gould 1980, 141–59; Clemmer 1990). This distribution and use pattern corresponds well with that of pitchstone, where pitchstone found general use on the source island of Arran, whereas it was used sparingly, and in a selective, probably symbolically laden manner, further afield.

4.3.4 Fine-grained quartz

Most saccharoidal quartzes belong to this category of visibly grainy material (illus 42). It is generally white, and, at present, the distinction between this form of quartz and the following coarser variety is subjective, in the sense that the defining grain-sizes have not been quantified *precisely*. However, fine-grained quartz usually have visible grains in the size order of fractions of a millimetre, and it is relatively compact, whereas coarse-grained quartz occasionally reaches grain-sizes of more than a millimetre, and it is comparatively loose-textured. Consequently, the two resources have considerably different flaking properties, with fine-grained quartz usually flaking well and coarse-grained quartz less well.

Some collections are entirely in this material (such as Barvas 2, Lewis: Ballin 2003a), but mostly fine-grained quartz is found as a component of assemblages dominated by either milky quartz (eg Scord of Brouster, Shetland: Ballin 2007a), very fine-grained quartz (eg Shieldaig, Wester Ross: Ballin *et al* forthcoming), or coarse-grained quartz (eg Dalmore, Lewis: Ballin forthcoming g).

Illus 43 Coarse-grained quartz. Flake from Dalmore, Lewis

4.3.5 Coarse-grained quartz

At present, only one Scottish assemblage is known to be dominated by coarse-grained quartz (illus 43), namely Dalmore on Lewis (Ballin forthcoming g). Due to the poorer flaking-properties, and the fact that the large grain-sizes would not allow the production of 'proper' cutting implements (at Dalmore, a tool, which would have been a knife if manufactured in, for example, the fine-grained material of other quartz-bearing sites, would automatically become a saw), supplementary quartz forms (such as 'greasy' quartz) had to be imported into the site for the manufacture of finer tools.

The assemblage from Cruester on Bressay, Shetland (Ballin forthcoming e) included some coarse-grained quartz, in conjunction with the more numerous variants, milky quartz and fine-grained quartz. However, this type of quartz is exceedingly dense, unlike the Dalmore variant. With its steel-grey to purple colours, it is quite likely that the coarse-grained Cruester variant is actually a form of quartzite, not dissimilar to the material capping the Fordhouse Barrow in Angus (Ballin forthcoming f). As stated above, the main difference between the grainy forms of the mineral quartz and the metamorphic rock type quartzite is not so much appearance as geological formation.

4.3.6 Quartzite

No known Scottish assemblages are dominated by this resource (illus 44), and quartzite is mainly

Illus 44 Quartzite. Part of a raw nodule from Glentaggart, South Lanarkshire

recovered as individual flakes, hammerstones and anvils (cf the various Jura sites, eg Mercer 1980; also Claish by Stirling, Barclay *et al* 2002, 88). Only one assemblage includes substantial numbers of flaked quartzite, namely that of Fordhouse Barrow in Angus (Ballin forthcoming f), where it dominates the finds from the upper layers (49% quartzite, 43% flint and 8% other raw materials). In this case, the quartzite seems to have been scavenged by Later Bronze Age people from the Early Bronze Age capping of the Neolithic barrow, and in terms of formation the sub-assemblage may be compared to other post-mound assemblages from the later part of the Bronze Age (cf Ballin 2002a).

Most likely, this metamorphic raw material was acquired in the vicinity of the site, deposited in the mainly sedimentary Montrose area by either Lower Devonian streams (Cameron & Stephenson 1985, 18–21) or more recent glacial activity. The quartzite is relatively homogenous and dense, with few impurities, and it flakes relatively well, its considerable grain-size taken into consideration. Some pieces are grey, but many are in nuances of red, brown or purple.

4.4 Forms of 'altered' quartz

As a complement to the above geological quartz varieties, many Scottish assemblages include less easily identified quartz forms. These are frequently 'altered' types of the raw material, and they may have been altered either by natural agents (eg water or wind) or anthropogenically (eg exposure to fire).

4.4.1 Water-rolled quartz

Few water-rolled quartz objects have been encountered on Scottish sites, but this is probably more a case of such pieces being more difficult to identify than, for example, rolled flint objects. It is a well-known fact that fresh quartz artefacts are more difficult to recognize than fresh flint artefacts, and when worked quartz is abraded, for example after years in an active tidal zone, they rapidly acquire seemingly natural shapes.

This is probably the reason why the Mesolithic assemblages from Lussa River (which was transgressed in prehistoric times) and Lussa Bay (which represents a find location in an active tidal zone), both from Jura, differ in terms of quartz content. Where the lithic finds from Lussa River (Mercer 1971; Ballin 2002b) included *c* 33.7kg of quartz (an approximate quartz:flint ratio of 8:1), Lussa Bay did not include any quartz (Mercer 1970), though more than 4000 pieces of flint were found. All Mercer's other prehistoric assemblages from Jura contain some quartz (Mercer 1968; Mercer 1972; Mercer 1974; Mercer 1980). Another important detail is the fact that, though Mercer reports the recovery of many rolled flint objects from the quartz-bearing Lussa River settlement, he does not mention the recovery of any rolled quartz objects with a word. The different raw material composition of the two sites may simply be based on varying degrees of natural rolling of the artefacts, with the finds from Lussa Bay in the present tidal zone of Jura being more severely rolled than the finds from Lussa River, thus masking the worked character of these pieces.

4.4.2 Wind-blown quartz

Wind-blown ('sand-blasted') quartz occurs in two forms, namely (i) quartz nodules shaped by wind prior to collection by people, and (ii) quartz artefacts affected by wind after deposition. These two forms of altered quartz are represented by the finds from the St Fergus to Aberdeen Natural Gas Pipeline, Aberdeenshire (Ballin forthcoming c), and Rosinish on Benbecula (Ballin forthcoming h). Both types are characterized by a slightly frosted appearance and, though abraded, wind-blown pieces tend to be slightly more angular than pieces abraded by water action (illus 45).

The wind-blown artefacts from the inland sites along the Aberdeenshire pipeline probably represent reduced and modified erratic blocks, collected by later prehistoric people. The wind-blown pieces from Rosinish, on the other hand, were clearly 'sand-blasted' after their having been transformed into artefacts. They were recovered from a Beaker site in the Benbecula machair, and the site's general distribution pattern suggests some influence from natural forces. A basic distribution analysis showed that most of the artefacts are concentrated in three south-west/north-east orientated bands ('ridges') with find-poor bands ('valleys') separating them. The 'valleys' and 'ridges' run perpendicular to the main blow-out (Shepherd & Tuckwell 1977b, fig 1), and it is possible that these distributional features

Illus 45 Wind-blown erratic quartz from various sites in Aberdeenshire

owe their existence mainly to wind-erosion/dune-building, which may also have altered the surfaces of the worked quartz.

4.4.3 Burnt and heat-treated quartz

It is a well-known fact that flint, when exposed to fire, undergoes a number of distinct changes. Depending mainly on distance to the heat source and duration of the exposure, flint artefacts may change colour, lustre and weight, and they will, ultimately, crackle and disintegrate (Fischer *et al* 1979, 23). These alterations are used by lithics analysts to interpret assemblages and sites, and burnt flint has, *inter alia*, been used to suggest the presence of otherwise invisible hearths (Ballin forthcoming j), site maintenance (dumping of hearth material; Ballin & Lass Jensen 1995, 55), the destruction of prehistoric dwellings by fire (Fischer *et al* 1979, 22) and heat-treatment of flint nodules and blanks (Price *et al* 1982). As a consequence, the recording of burnt flint has become a standard part of post-excavation processing of flint assemblages. In contrast, burnt quartz (illus 46) is rarely recognized, reported, described or discussed and, as a result, analyses of quartz assemblages appear less fruitful.

However, a combination of experimentation and analysis of prehistoric assemblages suggests that burnt quartz *is* recognisable, although it may be more difficult to identify than burnt flint (Ballin forthcoming k). Two forms of burnt quartz were identified:

Illus 46 Burnt and unburnt bipolar cores from Rosinish, Benbecula

- The inspection of prehistoric quartz assemblages revealed that a large proportion of the quartz from post-Mesolithic sites has a yellow-brown colour. This material is generally characterized by pitted or 'peeled-off' surfaces (although not generally in a state of disintegration), and it has a sheen usually associated with heat-treated silica. In most cases, the on-site distribution of the yellow-brown objects was non-random (eg at Calanais, Dalmore and Rosinish) supporting the interpretation of this quartz form having been 'altered' in some way, probably burnt.
- Inspired by these observations, the author undertook a series of trials. The experimental burning of quartz showed that most quartz, when exposed to fire, undergoes the same basic alterations as flint, and the experimentally burnt quartz was generally characterized by (i) pitting and 'peeled-off' surfaces, (ii) a dull and opaque appearance (where fresh quartz tends to be clear and vitreous), (iii) various degrees of 'granulation' and disintegration, and (iv) occasional areas with either a reddish or a pink hue. This form has been identified in most quartz assemblages.

The tests managed to elucidate some of the distribution patterns (for details, see the individual archive reports or publications), whereas other observations remain unexplained, such as the extremely high burnt quartz ratios of some assemblages (Table 17).

Table 17 The burnt quartz ratio of a number of assemblages from the northern and western parts of Scotland

Assemblage	Period	%
Cruester, Shetland	LBA	65
Dalmore (Sharples), Lewis	EBA	53
Scord of Brouster, Shetland	EN/LN	41
Rosinish, Benbecula	EBA	38
Calanais, Lewis	LN/EBA	34
Burland, Shetland	EIA	22

As the yellow-brown pieces of quartz seems to be mainly associated with later prehistoric sites from the Northern and Western Isles, and not the Mesolithic sites of the western mainland and the Southern Hebrides, the author assumed that the burning of peat, particularly characteristic in Scottish later prehistory, might have caused the differences in appearance. It has not been possible to reproduce experimentally the yellow-brown colour of burnt quartz from the Northern or Western Isles, but the author believes this discolouration to be the result of either the accidental burning of quartz in peat fires, or the deposition of the burnt pieces in a peaty environment (eg in peat ash deposited in domestic middens). As the experimental burning of quartz in a peat fire did not produce the anticipated colours, the author expects the discolouration to probably be the combined result of (1) weakly developed 'granulation' due to the exposure of heat/fire, making the quartz slightly more porous, (2) deposition in iron-rich peat or peat ash and (3) time.

Heat-treatment of quartz is a hotly disputed subject (Flennikin 1981, 27, disputes the usefulness of heat-treating quartz, whereas Knight 1991, 44, suggests that, although heat treatment may not alter the quartz itself, the heat possibly alters minerals within it, thereby improving the working characteristics of the quartz), and at present the author is not aware of any Scottish or non-Scottish assemblages where this form of reduction was generally used. However, at Scord of Brouster (Ballin 2007a), one potentially heat-treated bifacial implement was identified. Curved knife CAT 2299 retains an unmodified, superficially burnt area in the central part of either face, whereas the peripheral zone of the piece – which appears unburnt – has been modified by the bifacial detachment of thin flakes. This suggests that some quartz blanks may have been subjected to heat-treatment. Experiments (Crabtree & Gould 1970, 194; Eriksen 1999) have shown that flakes from heat-treated silica nodules tend to become thinner than flakes from raw nodules, and it is possible that, at Scord of Brouster, blanks were heat-treated mainly as part of the production of bifacial implements (thinning). The fact that, at this location, many implements (eg many scrapers) had been burnt after their modification into tools indicates that heat treatment is not the main cause of the high burnt-quartz ratio of this assemblage (Table 17).

5 The Archaeological Distribution

5.1 Geographical distribution

Throughout Scotland, quartz assemblages are mainly recovered from prehistoric sites in the north and west of the country. This is shown in the distribution map (illus 1), in which substantial quartz-bearing sites are displayed in relation to the major geological regions. Apart from one area, the selected regions correspond to the geological divisions used by the British Geological Survey in their series British Regional Geology (eg Johnstone & Mykura 1989). The region referred to in illus 1 as 'Sedimentary Cover' has been added, as the geological realities of this area is thought to have some importance to the use of quartz (or not, as it is) in north-east mainland Scotland.

At the present stage of Scottish quartz research, the general distribution pattern is as follows (illus 1 and Table 18): Shetland, the Western Isles and some sites in western mainland Scotland are heavily dominated by quartz; the Southern Hebrides, in and south of the Tertiary Volcanic Districts, as well as some sites in western mainland Scotland, are characterized by mixed exploitation of quartz sources and sources of flint and flint-like silica (parts of this area are heavily dominated by flint-use, for example, Islay: McCullagh 1989); some quartz-bearing sites have been investigated in the various Highland regions; and the north-east and south of Scotland (the Sedimentary Cover, the Midland Valley and the Southern Uplands) are practically devoid of archaeological quartz. A number of relatively small areas are characterized by the preference for locally available silica, such as, Rhum (bloodstone; Wickham-Jones 1990), Arran (pitchstone; Ness & Ward 2001), Skye (baked mudstone; Saville & Miket 1994) and Angus (chalcedony/agate; Warren no date). In general, sites in the coastal zone of mainland Scotland are dominated by flint.

5.1.1 Shetland

The northernmost geological region of Scotland, the Shetland Isles, is heavily dominated by quartz-use, with flint either being absent or making up at most 1% (eg Sumburgh; Finlayson 2000). The large assemblage from Scord of Brouster included only one per thousand flint, and the Kebister assemblage included two per thousand flint. In general, other lithic raw materials are extremely rare. The Burland assemblage, for example, includes the fragment of a leaf-shaped arrowhead in jasper; the collection of Catpund, a felsite knife; and at Scord of Brouster a small expedient scraper was based on the fragment of an abandoned felsite axe.

Felsite is not a general substitute for the main silica varieties, as it was almost exclusively used in the production of a particular type of polished knife, as well as for polished axes, but occasionally it was used for arrowheads and scrapers. However, in connection with the examination of felsite objects in the Shetland Museum, the author found that most felsite scrapers had polished 'ventral' faces, suggesting that this raw material was only used for more mundane tool types when a damaged knife or axe was recycled.

Most of the quartz from Shetland is milky quartz, but some assemblages also contain saccharoidal quartz (eg Scord of Brouster and Cruester). The very dense, steel-grey to purple quartz variety from Cruester is probably a quartzite. In general, the prehistoric people of Shetland procured quartz from several sources, and many assemblages contain vein quartz as well as pebble quartz. The material from Bayanne, however, appears to be mainly vein quartz, and several conjoining parts of quarried quartz 'plates' were found. The assemblage from Cruester is primarily based on rolled beach pebbles, with approximately two-thirds of all pieces having smooth, abraded cortication.

Apart from the finds from Neolithic Scord of Brouster, and possibly a proportion of Calder's finds (Calder 1956), Shetland quartz assemblages apparently mainly date to the Bronze Age or the Early Iron Age. A minority of the involved sites were dated to the Early Bronze Age, such as Tougs Phase 1 (Hedges 1986, 12), but the vast majority of quartz-bearing sites are of Later Bronze Age dates (eg Bayanne, Cruester, Sumburgh). Stratigraphical evidence, in conjunction with technological comparison, suggest that the quartz finds from Kebister and Burland may largely be from the Iron Age.

5.1.2 The Western Isles

The Western Isles region is also dominated by quartz use, though not as exclusively as Shetland. As indicated in Table 18, the proportion of quartz usually varies between 75% and 100%, with flint varying between 0% and 14%, and mylonite between 0% and 11%. Barvas 2 represents the only analysed assemblage of a number of excavated lithic assemblages from the Barvas area, and, with only 46 lithic finds, the raw material information presented in Table 18 should be used with caution (67% quartz; 33% flint; no other silica). The collection from Berie Sands was published (Lacaille 1937), though not in

Table 18 Quartz and other raw material frequencies in the various Scottish regions

	Assemblages	Quartz/flint/other silica	Other silica
1	Bayanne	100:00:00	
2	Scord of Brouster	999:001:000	
3	Kebister	998:002:000	
4	Cruester	99:01:00	
5	Burland	100:00:00	1 piece of jasper of 515 pieces
6	Tougs	100:00:00	
7	Catpund	100:00:00	
8	Sumburgh	99:01:00	
9	Jarlshof	Not quantified in publ.	
10	Barvas 2 (i)	67:33:00	
11	Dalmore	93:4:3	Mylonite, dolerite/basalt
12	Olcote	98:01:01	Mylonite
13	Calanais	74:14:11	Mylonite
14	Cnoc Dubh (quarry)	N.A.	N.A.
15	Berie Sands	Not quantified in publ.	Mylonite, other igneous rock types
16	Northton	Not quantified in publ.	Few lithics: quartz, flint, mylonite, basalt
17	Udal	100:00:00	
18	Eilean Domhnuill	???	Awaiting publication
19	Rosinish	99:01:00	
20	Redpoint	80:03:17	Bloodstone, mudstone
21	Shieldaig	87:12:1	Bloodstone
22	Kinloch (ii)	Approx. 0.5% quartz	Mostly bloodstone, some flint, and other silica
23	Camas Daraich (ii)	19:c.46:c.35	Other silica is mainly bloodstone, some mudstone
24	Rudha'n Achaidh Mhòir	Not quantified in publ.	Some flint
25	Risga	Not quantified in publ.	Some flint
26	Carding Mill Bay	99:01:00	
27	Kilmelfort Cave	45:55:00	
28	North Carn Bay	28:72:00	1 piece of pitchstone
29	Lealt Bay	24:76:??	43 pieces of pitchstone
30	Lussa River	89:11:00	
31	Lussa Wood	20:80:??	28 ?silicified siltstone, 71 pitchstone
32	Ellary Boulder Cave	86:13:01	75 pieces of pitchstone
33	Auchategan	33:20:47	92 pieces of pitchstone, two flakes in agate and sandstone
34	Lairg	99:01:00	
35	FERG Sites 4-5	68:31:01	Dolerite
36	Ben Lawers	Mostly quartz:some flint	Awaiting publication

(i) At Barvas, only the numerically less important Barvas 2 assemblage has been analysed and quantified;
(ii) in the published reports, flint was counted as part of a more general raw material group, 'chalcedonic silica', which includes, inter alia, flint, chert and chalcedony

quantified form, and the composition of this material is only known in general terms: the finds from Berie Sands are dominated by quartz, with mylonite and various igneous raw materials being present.

The composition of the Northton settlement site is not entirely clear (Simpson 1976; Murphy & Simpson 2003). Apparently, only small amounts of lithic material was reduced at this site, including quartz, flint, shale and basalt. A resource referred to in the 1976 preliminary report as mylonite, with a reference to the existence of a mylonite source in the site's vicinity, is not mentioned in the 2003 paper and may have been re-interpreted as shale – but what happened to the local mylonite source?

Table 19 A number of Neolithic and Bronze Age settlement and ritual sites along the Lewisian west coast, their individual distances, and dominating quartz types

Assemblage	Reference	Approximate distance	Dominating quartz variety
Barvas 2	Ballin 2003a		Fine-grained and milky quartz, pebble source
		14.5 km	
Dalmore	Ballin forthcoming g		Coarse-grained quartz, pebble source
		10.0 km	
Olcote	Neighbour 2005		Fine-grained and milky quartz, vein and pebble sources
		2.0 km	
Calanais	Ballin forthcoming a		Milky quartz, vein source
		3.5 km	
Cnoc Dubh	Ballin 2004e		Milky quartz, vein (quarry)
		16.0 km	
Berie Sands	Lacaille 1937		Fine-grained quartz, vein source

Mylonite is distinctly layered, with some layers being brownish grey and some bluish grey or white/grey. It is very fine-grained and most pieces from sites on the Western Isles are slightly or severely weathered. In the archaeological literature, this raw material has been defined as either mylonite (Lacaille 1937; Ballin forthcoming a), baked mudstone (Wickham-Jones 1986), or baked shale (Neighbour 2005), but in connection with the examination of similar pieces from the Calanais ritual complex (Ballin forthcoming a) one sample was classified as a typical mylonite, possibly a 'tectonised amphibole', whereas others could only be defined as 'either fine-grained sedimentary rock, hornfels or mylonite' (report by Geologist Dr Allan Hall, Department of Archaeology, University of Glasgow). For this reason the author has chosen to classify these pieces as mylonite, until a more detailed geological study of this raw material can be carried out. At present, the provenance of the mylonite is uncertain: if it is, in fact, mylonite, it may be local and derive from eastern Lewis (see geological map of Western Isles in Smith & Fettes 1979, illus 3).

The quartzes exploited in the Western Isles form a wide spectrum, including milky quartz, fine-grained quartz and coarse-grained quartz. Rock crystal is practically absent. Milky quartz and fine-grained quartz are equally common, whereas coarse-grained quartz has only been exploited regularly at the Dalmore site. As shown in Table 19, most assemblages appear to be clearly dominated by either pebble quartz or vein quartz, rather than including an even mixture of the two. The fact that the assemblages from these closely situated sites differ, in terms of quartz type, indicates that the quartz sources may have been extremely local and probably only supplied individual sites and families. All the sites in Table 19 are situated close to the coast, and the pebble sources of Barvas 2, Dalmore and Breasclete are most likely the beaches immediately next to these sites. The exact distance between settlement and quarry, in the cases of the vein quartz dominated sites of Calanais, Cnoc Dubh (quarry) and Berie Sands, is unknown, but the distances between the individual locations suggests that it may be as much as 10km (though the author expects it to be much less).

On Lewis, one form of quartz appears to have been preferred for, for example, arrowheads, namely the so-called 'greasy' quartz. As shown in Table 19, the Calanais ritual complex is dominated by homogeneous milky quartz (also Ballin forthcoming a), and the Dalmore site by coarse-grained material (Ballin forthcoming g), but the sites' barbed-and-tanged arrowheads are mainly in quartz with a 'greasy' lustre. No Lewisian sites are dominated by 'greasy' quartz, and only one site on mainland Scotland is known for the presence of greater quantities of this material – Shieldaig in Wester Ross (Ballin *et al* forthcoming). Given the distances across which pitchstone, for example, was traded (Williams Thorpe & Thorpe 1984; Ness & Ward 2001), it is quite possible that Shieldaig is the main source of 'greasy' quartz. As the crow flies, the distance from Shieldaig to the Lewisian west coast sites is approximately 100km.

Most of the quartz assemblages from the Western Isles date to the period Late Neolithic/Early Bronze Age. Association with pottery suggests that Rosinish may be a Beaker period settlement, and the Kilmarnock points of the Dalmore site indicate a date in the later part of the Early Bronze Age (Kilmarnock points are generally associated with Collared Urns, Secondary Series; Green 1980, various tables; also discussed in Ballin forthcoming a). The quartz from Calanais can only be dated approximately to the Late Neolithic/Early Bronze Age, and the quartz assemblage from Barvas 2, devoid of any diagnostic lithic elements, may date to this same general period. The stratigraphy of the Northton site included Neolithic and Beaker levels, and associated diagnostic pottery. In the latest report on the finds (Murphy & Simpson 2003), the sparse lithic material is compared to the assemblages from Eilean Domhnuill (Finlayson forthcoming) and Alt Chrysal (Foster 1993, 5), which are equally small and associated with substantial collections of pottery. It appears that, on the Western Isles, much pottery/few lithics is a distinct Neolithic feature.

5.1.3 The Southern Hebrides and the western part of mainland Scotland

This region embraces the Tertiary Volcanic Districts, the islands immediately south of this area (including Arran), as well as the immediately adjacent parts of western mainland Scotland. In the Southern Hebrides/western mainland Scotland raw material preferences were extremely varied. Some assemblages only contain a variety of quartzes (eg Carding Mill Bay: Finlayson 1993) or flint (eg Newton, Islay: McCullagh 1989), most are mixed collections of quartz, flint and other silica (eg Camas Daraich: Wickham-Jones & Hardy 2004; Shieldaig: Ballin *et al* forthcoming), whereas a third group of assemblages are heavily dominated by locally abundant resources, such as bloodstone (Kinloch, Rhum: Wickham-Jones 1990), baked mudstone (An Corran, Skye: Saville & Miket 1994) and pitchstone (Arran: Ness & Ward 2001).

The most wide-spread use of quartz is encountered on the coastal strip of western mainland Scotland, from Auchategan in Bute (Marshall 1978) to Redpoint in Wester Ross (Gray 1960), as well as in connection with individual sites on the east-coast of Jura (eg Lussa River: Mercer 1971; Ballin 2002b); the use of quartz as an important minority resource characterizes sites throughout the region, on the mainland as well as on many individual islands; and the preference for non-quartz raw materials is usually associated with more discrete zones, possibly defining prehistoric territories. Bloodstone only dominates the source island itself, Rhum, but is found as important sub-assemblages or individual pieces on sites within a 70km radius from the bloodstone quarries and beaches (Clarke & Griffiths 1990, 154). The main outcrop of (Staffin) baked mudstone may be a seam near the An Corran rock shelter, on the north-eastern coast of Skye; the distribution pattern of this material corresponds well with, and overlaps, that of bloodstone, and covers an approximately equal area (from Redpoint, Wester Ross, in the north, to Acharn, Morvern, in the south; Clarke & Griffiths 1990, 155). The distribution of pitchstone is unique, with dominant pitchstone use characterizing Arran itself throughout prehistory, in conjunction with restricted use of flint and quartz, whereas limited exploitation of this resource is seen on the Scottish mainland through the Early Neolithic period, and possibly into the later prehistoric periods (cf Ness & Ward 2001).

Most of the quartz procured within this region is milky quartz. In connection with the author's characterization of assemblages from the Southern Hebrides and western mainland Scotland, many pieces were described as grainy or saccharoidal. Most of these samples had a dull lustre and loose texture, and after experimentation with the exposure of quartz to fire, the author now assumes that most of the dull, loose-textured, grainy quartz is burnt quartz at various stages of disintegration. The burnt quartz from this region is rarely yellow-brown as the burnt quartz from the Western Isles and Shetland (Ballin forthcoming k).

The archaeologically relevant quartzes of this region includes varieties which are relatively rare in, for example, Shetland and the Western Isles, such as rock crystal and 'greasy' quartz. Though rock crystal may be encountered as individual pieces on most prehistoric quartz sites, only on Jura is it a significant resource: the collection from Lussa River includes *c* 1.5% of the quartz sub-assemblage (Ballin 2002b), and the collection from Lealt Bay *c* 11% (Ballin 2001b). Remaining dorsal crystal facets on flakes and cores suggest procurement of this raw material in the form of large crystals. A small number of flakes and bipolar cores have series of dorsal crystal facets, allowing estimation of the original size of the crystals; most probably, the majority of collected crystals had diameters of approximately 2.5–4.5cm. Rock crystal has excellent flaking properties, and it is suitable for production of microblades (cf Ballin 1998a). This, however, was not attempted at the Jura sites. The general approach in Scottish rock crystal reduction was by the application of bipolar technique, disregarding the possibilities of the raw material. It may have been collected for its appearance (symbolic value) more than for its utilitarian value. Mercer located a source of 1-inch crystals half a mile south of the Lealt Bay site (Mercer 1968, 20), whilst the local people's 'Glittering Rock' at Carn, further to the north, owes its name to a covering of variously sized pink or white specimens.

The so-called 'greasy' quartz is mostly grey, but it is also found in white, light brown, red or green colours. As mentioned above, it was used throughout the Western Isles, the Southern Hebrides and western mainland Scotland for the production of arrowheads and other 'finer' pieces, but it only makes up a significant proportion of one assemblage – that of Shieldaig in Wester Ross (52%; Ballin *et al* forthcoming). This resource has markedly better flaking properties than most other quartzes. If 'greasy' quartz was mainly procured from sources in the vicinity of Shieldaig, the recovery on Lewis of tools in this material indicates the presence of an exchange network somewhat more extensive than those of Rhum bloodstone and Staffin baked mudstone. Throughout the region, other silica found limited use, but particularly small sub-assemblages of grey chalcedony are common (particularly in Ardnamurchan and its immediate hinterland; Clarke & Griffiths 1990, 155).

Analysis of the surfaces of the quartz forms demonstrates how some assemblages are dominated by vein quartz (characterized by the presence of red, brown and yellow coated surfaces; cf Ballin 2004e), and some by pebble quartz (abraded surfaces). Mainland sites seem to have favoured vein quartz, and the milky quartz and 'greasy' quartz recovered from, for example, Shieldaig (Ballin *et al* forthcoming) and Kilmelfort Cave (Saville & Ballin forthcoming) were quarried from bedrock sources. The various quartzes from sites on Jura, on the other hand, appear to be largely pebble quartz (Ballin 2001b; Ballin 2002b), as are assemblages from other Southern Hebrides islands (eg Camas Daraich on Skye: Wickham-Jones & Hardy 2004, 21).

Contrary to the mainly later prehistoric material from sites in Shetland and the Western Isles, the quartz assemblages from the present region are heavily dominated by early prehistoric activity. Though most sites include the occasional Neolithic and/or Bronze Age element, the majority of sites are Mesolithic, with one possibly dating to the Final Palaeolithic (Kilmelfort Cave; see discussion in Saville 2003a), one to the Mesolithic–Neolithic transition (Carding Mill Bay: Finlayson 1993), and two may mainly be Early Neolithic (Ellary Bould Cave: Tolan-Smith 2001; Auchategan: Marshall 1978). Collections dominated by finds from the Late Neolithic or Bronze Age are absent.

5.1.4 The Highlands

The Northern Highlands and the Grampian Highlands are characterized by the discovery of a limited number of quartz assemblages. At present, only three quartz assemblages of some quantity or importance are known from the two main Highland regions, namely Lairg, Highland (Finlayson 1996), FERG Sites 4–5, Aberdeenshire (Ballin forthcoming c), and Ben Lawers, Perth & Kinross (Atkinson *et al* 1998). They differ on several accounts.

With approximately 10,000 pieces, the assemblage from the settlement site of Lairg is the larger of the three (Finlayson 1996). It is heavily dominated by quartz (99%), with flint also being present (1%). The assemblage appears to include milky quartz as well as saccharoidal quartz, and the vast majority of the resource was procured in the form of pebbles. The lithic artefacts were deposited during the Late Neolithic, Early Bronze Age and Late Bronze Age periods.

Mixed quartz–flint collections were recovered in connection with excavations along the St Fergus to Aberdeen Natural Gas Pipeline (FERG) in Aberdeenshire. Two sites, FERG Sites 4 and 5 (Ballin forthcoming c), yielded assemblages composed of approximately two-thirds quartz and one-third flint, supplemented by a single artefact in dolerite. Almost all of the quartz is milky quartz, and, as roughly two-thirds of the pieces have abraded cortex, it is most likely that this resource was procured from one or more pebble sources. Some of these artefacts may be from river or beach gravels, but the slightly frosted appearance of the cortication, combined with the frequently angular shape of the parent pieces, suggests that the quartz may have been collected mainly in the form of erratic blocks or nodules (cf the description of quartz from the deflation zones of the Western Isles machair; Ballin 2003a; Ballin forthcoming h). Both assemblages include pieces struck off large crystals. FERG Sites 4 and 5 are both multi-occupation sites, including material from various parts of the Neolithic, Bronze Age and possibly Early Iron Age periods.

During excavations carried out as part of the Ben Lawers Historic Landscape Project, Perth and Kinross (Atkinson *et al* 1997), a Mesolithic hunting camp was investigated. From this site an assemblage of predominantly quartz was recovered, but a small number of flint artefacts were also found. The preliminary notes on the assemblage (Atkinson *et al* 1997, 63; Anonymous 2001; Donnelly 2003) do not define the quartz in any detail, but Donnelly does reveal that different types of quartz were retrieved, some 'low-quality' and some better varieties which '… split with a conchoidal fracture, as opposed to tabular' (Donnelly 2003). It is thought that the quartz is local, whereas the flint may have been brought to the site.

5.1.5 The various sedimentary regions

Three of the eight geological regions in illus 1 are characterized by sedimentary rocks. In the north-east of mainland Scotland, and on Orkney, the bedrock is dominated by Middle and Upper Old Red sandstone formations (Johnstone & Mykura 1989, 118), whereas the Midland Valley (Cameron & Stephenson 1985) and the Southern Uplands (Greig 1971) are dominated by sandstone of Devonian age (north), Carboniferous limestone (the Central Belt) and Ordovician and Silurian sediments (south).

Though quartz in some parts of the world is common in a number of sandstones and shales (Neumann 1985; Howard & Howard 2000), it is relatively scarce in Scottish sedimentary rock formations, and no major quartz assemblages have been recovered from the sedimentary rocks of the north-east and south. From the Mesolithic site of Oliclett in Caithness (Pannett 2002) more than 1100 lithic artefacts were recovered, but only 50 pieces of worked quartzite. The excavator assumes that quartzite pebbles formed part of the glacial till (Pannett 2002, 16).

Some milky quartz (*c* 8%) was found in connection with the excavation of Fordhouse Barrow in Angus (Ballin forthcoming f), and it was encountered in roughly equal proportions through the barrow's various layers. It was collected in the form of relatively small pebbles, probably deriving mainly from river or beach gravels. In addition, the assemblage includes eight pieces of rock crystal/smoky quartz, also collected from pebble sources, as well as *c* 16% of quartzite. The quartzite is similar to the dense saccharoidal quartz variety from Cruester in

Shetland (Ballin forthcoming e), and it may have been collected as large cobbles in the vicinity of the site, deposited in the mainly sedimentary Montrose area by either Lower Devonian streams (Cameron & Stephenson 1985, 18–21) or more recent glacial activity. Sources of milky quartz were probably exploited in the various Neolithic and Bronze Age periods represented at Fordhouse Barrow, whereas the quartzite is thought to represent mainly Later Bronze Age post-barrow activity.

In general, the three sedimentary regions are characterized by the use of flint (the north-east and the coastal zone of the south), and chert (the central parts of the Midland Valley and the Southern Uplands; cf Saville 1994).

5.2 Explaining the observed distribution patterns

As demonstrated by illus 1, the distribution of quartz-bearing sites throughout prehistoric Scotland is fairly uneven: two geological regions are characterized by a marked preference for quartz (Shetland and the Western Isles); one area is characterized by frequent use of quartz, but with assemblages occasionally being supplemented, or even dominated, by other silica (Southern Hebrides and west mainland Scotland); from the two larger Highland regions (the Northern Highlands and the Grampian Highlands) only a small number of quartz assemblages are presently known; and from the various sedimentary regions (Sedimentary Cover, Midland Valley and Southern Uplands) no substantial quartz assemblages, or quartz sub-assemblages, have been recovered.

This distribution pattern is only partly accurate, as it has been affected by various forms of research bias. First of all, there are areas with no or little human settlement, such as the Highlands (not least the inner parts of this area), and the north-west corner of the Scottish mainland. Secondly, some areas are characterized by development of society's infrastructure, even though few people may live there, such as the construction of roads, railways, hydroelectric development and pipelines. And thirdly, there are areas which enjoy preferential status in the archaeological community, either because the actual archaeology is more relevant or better preserved (eg the Western Isles and the Scottish west coast), or because some locations are socially more attractive ('cosier' – this may explain why Orkney is well-surveyed and well-excavated, whereas Caithness, which has just as much to offer in terms of relevant and well-preserved archaeology, has, until recently, been shown little interest).

Two questions need to be addressed in this section, namely: (i) why are quartz-bearing sites located where they are (including: why are quartz-bearing sites absent in some regions) (illus 1), and (ii) why are quartz-assemblages from different regions composed differently (Table 18)? Possible answers include:

(a) geological availability, that is, the presence or absence of quartz (different quartz types) and alternative lithic raw materials
(b) quality of flaking properties of the available lithic resources ('knappability')
(c) higher or lower use value of the available lithic resources (how do they perform in relation to specific tasks, or in specific contexts?)
(d) the attachment of ideological ('symbolic') values to different types of stone.

In general terms, the use of specific raw materials reflects either function (a–c), or style (d). In the present paper style is defined as '…formal variation in material culture that transmits information about personal and social identity' (Wiessner 1983, 256; for a general discussion of the concept of style, see Ballin 2007b).

Raw-material preference as an expression of function usually results in a gradually declining *fall-off curve* (Renfrew 1977, 73) with growing distance to the outcrop, whereas raw-material preference as an expression of style is characterized by a marked drop in frequency at the borders of the social territory in question (Hodder 1979, 447). Stylistic use of a raw material is demonstrated by the almost exclusive use of rhyolite in Early Neolithic south-west Norway, with the raw material deriving from one central locality (the Bømlo Quarry: Alsaker 1987), and with a marked drop in the rhyolite frequency at the borders of that territory (Ballin 2007b).

5.2.1 Shetland

There is no doubt that the geological realities, that is, availability, plays a major part in the formation of the observed distribution patterns (illus 1). The total dominance of quartz on Shetland sites, and the lack of flint, probably relates to the fact that, on these islands, quartz sources are abundant, and flint sources almost completely absent. Only one source of pebble flint is presently known, namely beach deposits on the island of Yell (Whittle 1986, 72). Few alternative lithic raw materials are known on Shetland, such as jasper and felsite, with the former being a relatively poor substitute, usually flawed by impurities, and the latter obviously associated with some ideologically based regulation.

Jasper is not common in Shetland, but it is available in a number of locations, such as Papa Stour, and the fragment of a leaf-shaped arrowhead in jasper was recovered from the Burland site (Ballin forthcoming d). This fragment demonstrates the problems relating to the reduction and use of Shetland jasper, as the presence of specks of quartz and chalcedony makes it brittle, and it breaks easily. Felsite was quarried and worked in the northern parts of mainland Shetland, and examination of felsite artefacts in the Shetland Museum shows how this material was reserved for the production of polished knives and axes. A number of kite-shaped arrowheads in felsite suggests that

**Table 20 The assemblage from Sharples' excavation.
The distribution of the main raw materials by artefact categories**

	Numbers				%			
	Quartz	Flint	Mylonite	Total	Quartz	Flint	Mylonite	Total
Debitage	2344	86	59	2489	98	87	93	98
Cores	24	5	1	30	1	5	2	1
Tools	20	8	3	31	1	8	5	1
Total	2388	99	63	2550	100	100	100	100

**Table 21 The assemblage from Rosinish.
The distribution of the main raw materials by artefact categories**

	Numbers			%		
	Quartz	Flint	Total	Quartz	Flint	Total
Debitage	3447	6	3453	97.3	22.2	96.8
Cores	73	4	77	2.1	14.8	2.2
Tools	21	17	38	0.6	63.0	1.0
Total	3541	27	3568	100.0	100.0	100.0

points were occasionally manufactured in this material. The museum's felsite scrapers generally have polished 'ventral' faces, indicating that mundane tool forms were only produced in this resource when the more prestigious objects broke. The kite-shape of the points implies that the use of felsite may have started earlier than previously thought (Fojut 1986, 17–18). These points are usually associated with the later part of the Early Neolithic (in northern England, the Towthorpe Burial Tradition, Green 1980, 85; or Early Individual Burials, Clarke *et al* 1985, 63–7), and with artefacts, such as Seamer/Duggleby axes and polished flint knives. The Scord of Brouster assemblage (Ballin 2007a) combines an expedient felsite scraper with kite-shaped quartz arrowheads.

5.2.2 The Western Isles

The Western Isles are characterized by approximately the same lithic raw material availability as Shetland. Quartz is abundant throughout the island group, whereas suitable lithic alternatives are scarce. Flint occurs on some Western Isles beaches (James Crawford, pers comm), and it is present in most assemblages from the region. Mylonite may have been quarried in the eastern parts of Lewis and South Uist, where it is associated with the Outer Hebrides Thrust Zone (Smith & Fettes 1979, fig 3); mylonite artefacts have been found on most of the main quartz-bearing sites on Lewis (eg Dalmore, Olcote, Calanais and Berie Sands). In addition, most of the discussed assemblages include individual specimens, or handfuls of pieces, of various igneous rock types, mainly locally available dolerite (see distribution of dykes in Woodland 1979).

None of the available lithic alternatives is characterized by the same exclusive uses as Shetland felsite. Though mylonite had to be quarried and traded from outcrops in the eastern parts of the island group to sites on the west coast, there is no evidence that this resource was applied differently to quartz: the same forms of tools were manufactured (arrowheads, scrapers, knives and edge-retouched pieces; eg Ballin forthcoming a; Ballin forthcoming g), and mylonite artefacts are found in the same parts of the sites as quartz artefacts. However, the distinct appearance of this raw material (colour and patterning), in conjunction with the fact that it had to be procured from distant parts of the island group, suggest that other than functional values may have been behind the wish to exploit this resource – even if it is not presently possible to prove this hypothesis.

Though some of the flint from the Western Isles is relatively poor, in the sense that it may be coarse-grained and impure, it was possible to flake it in a controlled manner. Due to the small sizes of the collected flint pebbles (probably between 4cm and 6cm), tools in this material tend to be small, but well-executed pieces. Apparently, flint tools were easier to produce, due to the homogeneous nature of the raw material, and their edges were more regular than edges in quartz, and definitely more durable than edges in mylonite. The preference for this good, but scarce, resource is demonstrated by the professionally excavated sub-assemblage from Dalmore (Ballin forthcoming g) and the raw material composition within the categories debitage, cores and tools (Table 20): where only 1% of the quartz artefacts are tools, 8% of the flint artefacts are tools and 5% of the mylonite pieces. At Rosinish (Ballin forthcoming h), this trend is even more distinct (Table 21).

The various igneous raw materials appear sporadically, such as, dolerite (eg Dalmore; Johnstone & Mykura 1989, 140–3) and biotite-granite (eg Berie

**Table 22 The assemblage from Shieldaig.
The distribution of the main raw materials by artefact categories**

	Numbers					%				
	Quartz	'Greasy' quartz	Blood-stone	Flint	Total	Quartz	'Greasy' quartz	Blood-stone	Flint	Total
Debitage	2295	2523	55	565	4873	98.4	96.7	87.3	82.6	97.4
Cores	22	41	6	27	69	0.9	1.6	9.5	3.9	1.4
Tools	16	44	2	92	62	0.7	1.7	3.2	13.5	1.2
Total	2333	2608	63	684	5004	100.0	100.0	100.0	100.0	100.0

Sands: Lacaille 1937). Being much more coarse-grained than any of the above raw materials, it was not possible to control the reduction process as well, and most of the tools manufactured in igneous rock types are relatively large and crude. Most probably, these raw materials represent expedient local resources.

5.2.3 The Southern Hebrides and the western part of mainland Scotland

The raw material distribution of this region differs considerably from that of Shetland and the Western Isles. Though some assemblages are almost exclusively in quartz (eg Carding Mill Bay: Finlayson 1993), most include substantial proportions of flint, in conjunction with other important silica. 'Ordinary' quartz was apparently used in the same manner as in the most northerly and westerly regions, but exchange in alternative silica was widespread. The majority of the alternative resources were procured from restricted sources, with bloodstone being quarried or collected on Rhum (Clarke & Griffiths 1990), baked mudstone on Skye (Wickham-Jones 1986, 7), 'greasy' quartz possibly from the Shieldaig area (though this outcrop has not yet been located), and pitchstone from Arran (Williams Thorpe & Thorpe 1984).

All of the above have first-class flaking properties and they are all distinctly coloured an/or patterned. Most likely, each resource was associated with some symbolic value, but the different distribution patterns, and thereby exchange mechanisms, indicate that these values may have differed considerably. The distribution of Rhum bloodstone and Staffin baked mudstone appears to be approximately the same, in the sense that the area in the immediate vicinity of the main source is dominated by the raw material, with small sub-assemblages occurring up to *c* 70km from the location of procurement. It is by no means certain that all 'greasy' quartz was acquired from Shieldaig, but if this was the case, the exchange network of this resource would have been somewhat larger, with a distance from Shieldaig to the find-spots on the west coast of Lewis of *c* 100km.

The largest, and seemingly most complex, of the prehistoric exchange networks is that of Arran pitchstone: Arran itself was dominated by the use of pitchstone throughout prehistory, but the remainder of Scotland is characterized by two different distribution patterns. Pitchstone knapping debris has been recovered from mainly Early Neolithic sites in southern Scotland and southern Argyll (Ness & Ward 2001; Tolan-Smith 2001), but on most contemporary sites outside this area pitchstone appears as individual, or at most a handful, of pieces. Warren points out that these specimens are usually high quality pieces of unmodified debitage (Warren forthcoming), and they were probably not intended for practical use [a small pitchstone nodule from the site of Achnahaird Sands in north-west Sutherland (Ballin forthcoming b), does not fit this picture]. The fact that these four raw material zones overlap means that they do not precisely define the specific outlines of four separate social territories. It is, however, possible that these raw materials were used in prehistory to maintain, or identify, tribal alliances (cf Clemmer 1990) involving four social groups in the Southern Hebrides/western mainland Scotland, with Lewisian mylonite functioning in very much the same way in the Western Isles.

It is possible that, within this region, flint may have been a mainly functional resource, as it may have been on the Western Isles. This is demonstrated in Table 22, where flint has a much higher tool ratio than any of the other raw materials used on that site. On some islands, such as Mull and Islay, flint beach pebbles remain common (Wickham-Jones & Collins 1978; Marshall 2000a; Marshall 2000b).

The use of rock crystal on Jura is somewhat puzzling. Though this form of quartz flakes well (cf Ballin 1998a), it was reduced ('smashed') entirely by the application of bipolar technique. This may be an indication that the raw material was valued more for its light-reflecting appearance than for its practical use-value.

5.2.4 The Highlands

Only three substantial quartz assemblages are known from the two main Highland regions – at the time of writing, only Lairg (Highland) has been published (Finlayson 1996), with the other two being in the process of publication (FERG Sites 4–5: Ballin forthcoming c; Ben Lawers: Atkinson *et al* forthcoming). Due to the low number of available assemblages, and their recovery from vastly different local environments, few general conclusions can be reached on the distribution of quartz-bearing sites in these regions, and the assemblages are most appropriately discussed on an individual basis.

As indicated by Table 18, the composition of the Lairg assemblage mirrors that of Shetland assemblages. It consists almost entirely of quartz with a minor proportion of flint. The background to this composition is most likely raw material availability, with quartz being locally abundant, whereas flint had to be imported from the nearby North Sea beaches (Saville 1994, fig 1). No other raw materials seem to have been exploited at Lairg.

Although located at approximately the same distance to the coastal flint resources as the Lairg site, the two quartz-bearing settlements from Aberdeenshire, FERG Sites 4 and 5 (Ballin forthcoming c), yielded much higher proportions of flint. This may be due to a number of factors, such as: (i) proximity to the inland flint mines of the Buchan Ridge Gravels (Saville 1995; Saville 2005); and (ii) differences in the perception of the various raw materials and their non-utilitarian values.

The presently available evidence suggests that intensive exploitation of the Aberdeenshire gravel-flint deposits commenced in Late Neolithic times and continued through the Bronze Age periods. In the immediate vicinity of the deposits (eg at Stoneyhill Farm: Ballin forthcoming i), Neolithic and Bronze Age assemblages are almost exclusively in flint, and it is quite likely that the lower (though still relatively high) flint ratios of the FERG sites represent a rapidly declining fall-off curve. This would imply that flint was perceived as a largely utilitarian resource.

However, the composition of most known lithic assemblages from East Scotland (cf Ballin 2004a) indicates that, in this region, flint was perceived as more than a purely utilitarian raw material. Where, on the inland site of Ben Lawers on Loch Tay, flint had been more or less completely substituted by local quartz, an almost exclusive use of North Sea flint characterizes sites along the Aberdeenshire rivers, and well into the mountainous areas of the Aberdeenshire hinterland. The explanation may be a combination of the two, with flint possibly possessing some symbolic value in Aberdeenshire – and thereby rarely dropping to the low proportions experienced in other regions, but, nevertheless, with falling ratios at growing distances to the flint sources, when sites were not situated immediately on the main watercourses. The FERG sites are not riverine settlements, and transportation of flint would have posed a logistical problem, favouring at least partial substitution of flint by locally available resources, such as erratic quartz. An additional factor is probably the generally low quality of the Buchan Ridge flint, which made it even less attractive to invest resources in the transportation of this resource.

As mentioned above, the Ben Lawers assemblage is heavily dominated by quartz, with some use of flint. The available information (eg Atkinson 1997; Anonymous 2001; Donnelly 2003) suggests that it may be composed approximately like the collection from Lairg. Both raw materials appear to have been perceived as utilitarian resources, with local quartz substituting flint, as the distance to the coastal flint sources grow, but with small amounts of flint being transported inland for the production of tools which require regular sharp edges (the typological composition of the geologically mixed west coast sites indicates that, in the Mesolithic period, flint was preferred for the production of acutely pointed, sharp-edged microliths – at Shieldaig, microliths make up 4% of the total flint sub-assemblage, but only 0.5% of the quartz sub-assemblage).

5.2.5 The various sedimentary regions

As mentioned above, no substantial quartz assemblages are known from the various sedimentary regions, and whenever quartz is encountered, it forms very small sub-assemblages, such as at Fordhouse Barrow in Angus (*c* 8%; Ballin forthcoming f). This probably reflects the geological realities of these regions, with Scotland's Old Red Sandstone formations, as well as its formations of limestone and shale, containing little quartz.

5.2.6 Summary

Though 'symbolic values' can be difficult to detect, it appears that, in Scottish prehistory in general, quartz was mainly perceived as a utilitarian resource. The main trend in Scotland is that quartz dominates assemblages where other 'better' (more flakable) raw materials are absent or scarce, and the more abundant these other resources are, the more quartz is substituted by them, or even fully replaced (like on Islay, where flint dominates completely; McCullagh 1989).

Only one form of quartz, the so-called 'greasy' quartz, may have been perceived differently. If Lewisian artefacts in this material are in fact based on material quarried in the Shieldaig area, the only site where 'greasy' quartz is an abundant resource, this implies the existence of a relatively extensive exchange network. The distribution of other quartz varieties on Lewis indicates that ordinary quartz forms may have been procured exceedingly locally, with beach deposits and veins representing a form of 'back-yard supplies' for individual families. Rock crystal was procured in the same ultra-local fashion, and only the assemblage from Lealt Bay (Ballin 2001b) included noticeable amounts of this material. This material, however, may have been associated with some symbolic value, based on its tendency to 'glitter'.

Several of the alternatives to quartz found wide-spread use, and Lewisian mylonite, Rhum bloodstone, Staffin baked mudstone and Arran pitchstone were exchanged across relatively large distances. Mylonite was only exchanged within the Western Isles; bloodstone and baked mudstone supplied overlapping parts of the Southern Hebrides; and Arran pitchstone was traded throughout Scotland (though presently not encountered on Shetland). It is thought that these overlapping exchange networks may indicate a web of criss-crossing tribal alliances in prehistoric western Scotland. All these materials are distinct, in terms of colour and patterning, which may explain the possible symbolic values attached to them. It may be that the equally distinctive 'greasy' quartz, which also seems to have been attributed with symbolic values, was experienced as a separate resource and not as a variant of the more dull-looking milky quartz and saccharoidal quartzes (cf the discussion of 'emic' and 'etic' classification; Hayden 1984).

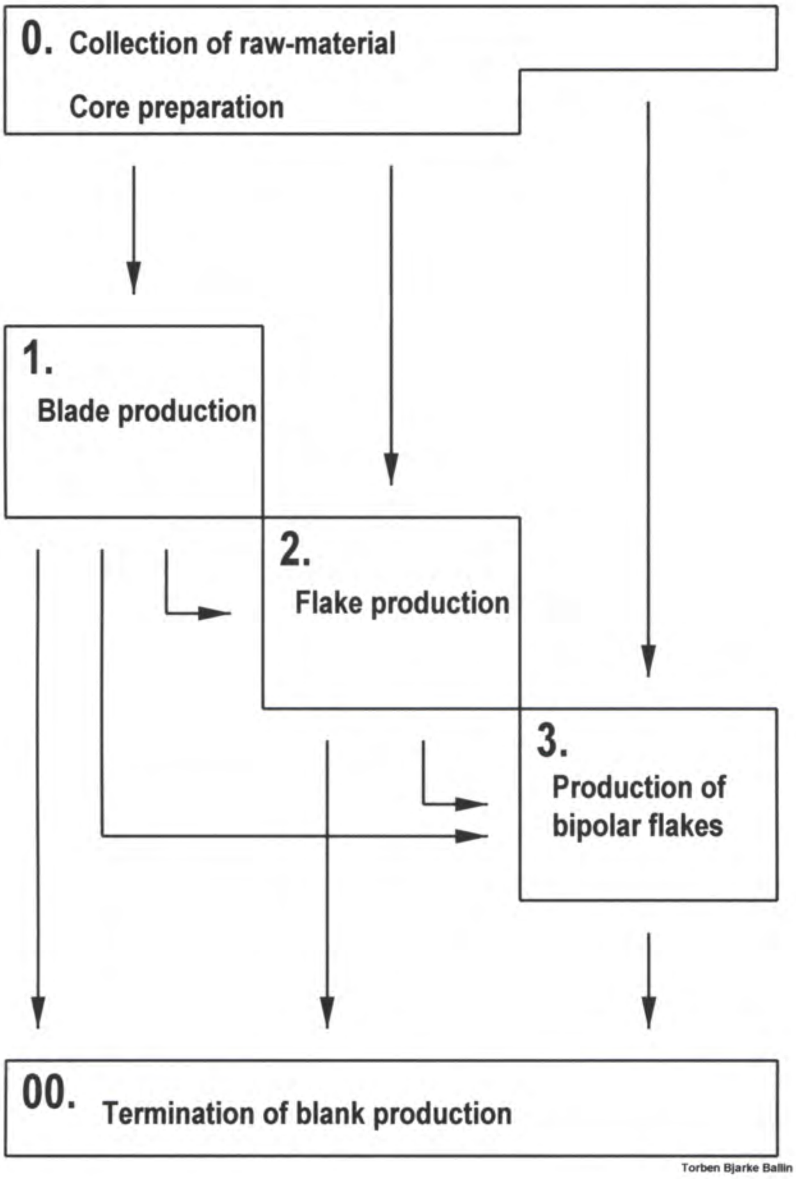
6 Technological Approaches (Operational Schemas)

6.1 Introduction

The following discussion of the technological aspects of quartz production presents Scottish quartz technology in terms of its various operational schemas (*'chaîne opératoire'*; Leroi-Gourhan 1965; Lemonnier 1976; Eriksen 2000, fig 1), as experienced through the available assemblages (Section 2.4 and Section 3). The discussion is based, mainly, on the approach outlined in the presentation of the Later Bronze Age quartz assemblage from Bayanne on Yell, Shetland (Ballin forthcoming j). The basic elements, or stages, of a complete operational schema (a 'master' schema) are shown in illus 47 and illus 48.

6.2 Procurement of quartz

As demonstrated in Section 4, quartz occurs in a number of forms, such as, rock crystal (or one of its coloured variants), milky quartz, various types of saccharoidal quartz and the meta-sedimentary rock



Illus 47 The modules and sequences of most operational schemas. For detailed explanation and discussion (see Ballin forthcoming m)

		REDUCTION STAGES (processual elements A-E)	CORE TYPES	BLANK TYPES	REFUSE TYPES
0.	A. B.	Procurement of raw-material Nodule testing Core preparation	Nodule Split pebble Core rough-out		Unsatisfactory nodules Unsatisfactory split pebbles Unsatisfactory core rough-outs Decortication flakes Chips, flakes, chunks
1.	C.	1. blade series	Blade core (e.g. conical core, handle-core or opposed-platform core)	One primary crested blade Several secondary crested blades Blades and/or microblades	Unsatisfactory blades Blade fragments Chips
	D.	1. core rejuvenation			Platform rejuvenation flakes Core-edge and core-side flakes Chunks and chips
	C.	2., 3., etc. blade series	Blade core	Blades and/or microblades	Unsatisfactory blades Blade fragments Chips
	E.	Termination of blade production			Exhausted blade core
2.	C.	1. flake series	Flake core (e.g. platform core, irregular core, or discoidal core)	Flakes	Unsatisfactory flakes Flake fragments Chips
	D.	1. core rejuvenation			Platform rejuvenation flakes Core-edge and core-side flakes Chunks and chips
	C.	2., 3., etc. flake series	Flake core	Flakes	Unsatisfactory flakes Flake fragments Chips
	E.	Termination of flake production			Exhausted flake core
3.	C.	Production of bipolar flakes	Bipolar core	Bipolar flakes	Unsatisfactory bipolar flakes Fragments of bipolar flakes Chips
	E.	Termination of bipolar production			Exhausted bipolar core

Illus 48 Complete operational schema ('master schema'), including all modules of illus 5A (the numbers in the left column refer to this figure). For detailed explanation and discussion (see Ballin forthcoming m)

form quartzite, which is pure silica (compressed quartz grains). These varieties of raw material are found in a wide range of geological contexts, but in terms of procurement, the most important distinction is that of vein and pebble sources (Ballin 2004e). The specific type of source defines whether quartz was collected, quarried, or acquired in the form of exchange. Based on Binford's work (Binford 1976; Bindford 1979), Morrow & Jeffries suggested three classes of procurement (Morrow & Jeffries 1989; also see Eriksen 2002, 45), namely (i) embedded procurement, where raw material is simply collected along the way as the group moves through the landscape, with other tasks defining the group's movements; (ii) direct procurement, where raw materials are acquired in connection with organized visits to the sources (this would usually take the form of quarrying, but could include visits to particularly rich quartz gravels, or fields of erratics; eg Ballin 2004c; Ballin d); and (iii) indirect procurement through exchange networks within and outwith the social territory (for discussion of prehistoric territorial structures, see Ballin 2007b). A fourth variety may be seen as a post-Mesolithic sub-form of direct procurement, where the group, or family, chose to settle immediately adjacent to a major source, instead of constantly having to organize procurement trips to it.

6.2.1 Embedded procurement

There is little evidence of Scottish quartz having been acquired as embedded procurement, although it is quite possible that the individual pieces of worked quartz found on sites outwith the quartz province (that is, in north-east, south and central Scotland) were collected in an unstructured manner. Many of these nodules may have been collected at gravel sources (eg river banks), as the group passed these during its daily movements, but erratics may also have been exploited (eg FERG Sites 4–5: Ballin forthcoming c). Due to the amounts of quartz needed by prehistoric man to cover the daily replenishment of lithic tools (partly as a result of this resource flaking in a more irregular fashion, subsequently having a lower than average tools-per-nodule ratio), in conjunction with the considerable weight of the required raw material (Broadbent 1979, 190), it is most likely that quartz procurement was a more focused activity.

6.2.2 Direct procurement

Owing to the amounts of quartz needed, as well as its weight, it is thought that most quartz-bearing Scottish sites were located immediately adjacent to their main sources, or these sources are situated within a traditional catchment area (as defined by Vita-Finzi & Higgs 1970), that is, an area with a radius of no more than 10km. This hypothesis definitely holds true on the island of Lewis in the Western Isles (Table 19), where the main quartz source of the individual coastal settlement is either a shingle beach in front of the site, or a vein quartz quarry in the immediate hinterland (such as Cnoc Dubh: Ballin 2004e).

The same holds true at Scord of Brouster on Shetland (Ballin 2007a), where it was argued that the recovered quartz was procured from a number of sources. The material adhering to the artefacts (sandstone, feldspar and steatite/chlorite) defines the exploited raw material forms as mainly vein quartz. The sandstone indicates the use of local veins, as the area around Gruting Voe is completely dominated by Old Red Sandstone (Mykura 1976, 52). The large feldspar crystals points to the use of veins from areas of igneous (granite) or metamorphic rock (gneiss), whereas steatite and chlorite indicate the exploitation of veins from areas of metamorphic rock. The nearest known outcrops of granite or gneiss are at 6–10km distance towards the south (the Sandsting Complex) and east (east of the Walls Boundary Fault: Mykura 1976, figs 9–10), whereas the steatite/chlorite may derive from the metamorphic zone east of the Walls Boundary Fault (Mykura 1976, plate IV). Most probably, all quartz was procured within the site catchment area of the Scord of Brouster site. In northern Sweden, Broadbent examined a complex of settlement sites (Lundfors) and quartz quarries (Gummark), where the settlements were separated from a cluster of quarries by approximately 7km (Broadbent 1979, 190).

However, the Shetland and Western Isles assemblages mainly date to the post-Mesolithic period. Most Mesolithic quartz assemblages have been discovered in the region of the Southern Hebrides/west mainland Scotland, where later prehistoric assemblages are scarce. Most of these assemblages are chronologically mixed, and many were recovered decades ago, in ways we today would characterize as unsatisfactory (Section 3). There are, nevertheless, some indications as to where the quartz was acquired. It seems that, on the mainland, most resources were quarried at veins, though supplemented by some pebble quartz (eg Kilmelfort Cave: Saville & Ballin forthcoming; Shieldaig: Ballin *et al* forthcoming), whereas the island assemblages are largely based on pebble quartz (eg Lealt Bay: Ballin 2001b; Lussa River: Ballin 2002b). The mainland veins have not yet been located, but the pebble sources are without doubt the local gravel deposits in the tidal zone, or on the raised beaches (see for example Mercer 1971, fig 4).

The specific quarrying techniques have been discussed previously (Ballin 2004e). In this paper, it is suggested that the choice of approach was generally determined by the combination of the factors:

(i) source type (hardness of matrix and source location in relation to the ground surface)
(ii) type of material (mineral or rock)
(iii) the presence or absence of inherent layers parallel to the exposed surface.

It appears that quartz extraction from vein sources is carried out in more or less the same fashion as the extraction of related silica, such as jasper and novaculite (a form of chert; Luedtke 1992, 125), that is, by the use of hammerstones and the successive detachment of raw material layers (resulting in the stepped appearance demonstrated by Ballin 2004e, illus 6–7). The matrix is too hard to allow the use of antler picks (as in the procurement of flint from Cretaceous chalk; Barber *et al* 1999; Russell 2000), and the raw material is too solid to allow the use of fire (as in the procurement of greenstone and rhyolite; Alsaker 1987, 76–7), or the raw material would be damaged by the use of fire (quartz would disintegrate).

As mentioned above, no Scottish procurement sites based on the extraction of pebble quartz are known. A paper on a number of locations in the vicinity of the John H Kerr Dam in the Piedmont Province, Virginia (Brockington 1992) discusses the finds from several pebble extraction sites, as well as the organization and character of these sites. Brockington mainly focuses on the identification of the four main locations as representing a foraging or logistical form of economic organization (corresponding to Binford's 1980 residential and logistical mobility). The following conditions should be met (modified after Espenshade 1986):

Foraging assemblages (residential mobility)

1. Tool diversity should be high, including tools unrelated to lithic reduction.
2. Caching of site furniture should be present.
3. Exhausted tools should be present, as 'gearing up' occurs at these base camps.
4. Storage vessels (in later assemblages) should be found (high pottery counts).
5. Non-quartz lithic artefacts should be a strong minority.

Logistical assemblages (logistical mobility)

6. Tool diversity should be low especially in non-lithic manufacturing categories.
7. Low site furniture counts.

Table 23 Foraging or logistical conditions by site (Brockinton 1992, 96). * = inconclusive

Site	Conditions									
	1	2	3	4	5	6	7	8	9	10
44MC176						x	x	x	x	x
44MC175						x	x	x	x	x
44MC174	x		x	*	x		x		*	
44MC173						x	x	x	x	x

8. Few exhausted tools should be present.
9. Storage vessels should be absent (low pottery counts).
10. Lithic assemblage should be almost pure quartz.

In Table 23, Brockington shows how most of his sites clearly fall into the logistical category, and, most likely, the pebble extraction sites were visited on an occasional basis. It is not, however, possible to say whether they were exploited in the form of embedded (unfocused) or direct (focused) procurement.

Though some crystals may have been acquired in the form of embedded procurement, it is most likely that crystals of milky quartz and rock crystal were acquired in connection with visits to known veins, where knappable crystals formed in cracks between quartz layers. If rock crystal did have symbolic connotations in parts of prehistoric Scotland (eg Lealt Bay; Section 2.4.2, Section 4.3 and Section 7), it is possible that they were procured in connection with targeted visits to veins specifically aimed at providing this visually impressive material.

6.2.3 Indirect procurement

On Lewis, one form of quartz appears to have been preferred for, for example, arrowheads, namely the so-called 'greasy' quartz. As shown in Table 19, the Calanais ritual complex (Ballin forthcoming a), and its central megalithic tomb, is dominated by homogeneous milky quartz, but the site's barbed-and-tanged arrowheads are mainly in quartz with a greasy lustre. At Dalmore (Ballin forthcoming g), further to the north, seven out of 15 quartz arrowheads are in 'greasy' quartz, though the dominating variety of that site is coarse-grained quartz. It is quite possible that this preferred arrowhead material was imported, but presently it is not possible to say from where. No Lewisian sites are dominated by 'greasy' quartz, and only one site on mainland Scotland is known for the presence of greater quantities of this material – Shieldaig in Wester Ross (Ballin *et al* forthcoming). Given the distances across which pitchstone, for example, was traded (Williams Thorpe & Thorpe 1984; Ness & Ward 2001), it is not impossible that Shieldaig, or other sites or quarries in that general area, is the main source of 'greasy' quartz, particularly if it had some symbolic, for example totemic, connotation. As the crow flies, the distance from Shieldaig to the Lewisian west coast sites is approximately 100km.

At the present time, Shieldaig is the only known assemblage where 'greasy' quartz has been employed in the production of the full range of lithic tools whereas, in assemblages dominated by other quartz varieties, this quartz form was mainly used to manufacture arrowheads and, in some cases, more sophisticated knives. It is quite possible that this state of affairs purely reflects the fact that 'greasy' quartz has better flaking properties and, as a consequence, was saved for the production of more complex, invasively retouched lithic tools (a mainly functional view is favoured by McNiven in his analysis of the technological organization and settlement pattern of prehistoric Tasmania; McNiven 1994), but it is just as likely that this quartz type had some inherent symbolic meaning to prehistoric people in Scotland (totemic association between people and raw materials has been demonstrated in anthropological research by, *inter alia*, Gould 1980, 141–59, and Clemmer 1990).

When a lithic raw material is accessed or exchanged in primitive societies, whether this resource has mainly functional (eg White & Modjeska 1978) or symbolic (eg Gould 1980) connotations, access/exchange is mostly restricted to kinship-related individuals (Sassaman *et al* 1988, 80), but non-kinship-based access/exchange does also take place, creating, or reinforcing, alliances (Gould 1980, 155). In cases, where the use of a lithic resource is associated with symbolic values or style (Ballin 2007b), the frequency of that raw material usually drops abruptly at the borders of that specific social territory, but quantification of the lithic raw material distribution across Scotland (raw material composition of the various assemblages, region by region) is still to be carried out (According to Polly Wiessner, style is '...formal variation in material culture that transmits information about personal and social identity'; Wiessner 1983, 256). The analysis of raw-material fall-off curves throughout northern Britain may allow the construction of an, at least rudimentary, territorial structure of early prehistoric Scotland.

However, in the investigation of the use and exchange of quartz and lithic materials throughout Scotland, it is probably necessary to distinguish between sites and assemblages from different periods, as symbolic values and access/exchange patterns are likely to have varied over time. The rules of access and exchange ought to vary between, for example, highly mobile hunter–gatherer communities with relatively loosely defined and, occasionally, overlapping territories, and sedentary farming communities with more precisely defined territories and stricter perceptions of land-rights and ownership of quarries and other resources. Exceptions are, nevertheless, known, and in 19th-century Australia the Kalkadoons, a hunter–gatherer tribe, were fiercely territorial about their homeland and its quarries (Hiscock 2001). However, it is uncertain whether the well-organized and militaristic Kalkadoon society arose as a result of their prehistoric mining activities, and the associated complex trading patterns, or whether the socio-economic structure of this Australian tribe was a response to European expansion.

In this light, one probably ought to distinguish between the Mesolithic sites and assemblages of Scotland on one hand, and Neolithic/Bronze Age sites and assemblages on the other. The distribution patterns witnessed in connection with the post-Mesolithic lithic material from the Western Isles are most likely an expression of ideas about landrights typical of farming communities, such as the tendencies of quartz sources to almost exclusively supply individual families or farms. In the Neolithic/Bronze Age period, the exchange of the better quartz variety with a 'greasy' lustre may mainly have been linked to clans, or the tribe (in geographical terms: the social territory), though some inter-lineage or inter-tribal trade may have occurred (as possibly in the case of Scottish pitchstone exchange). The Scottish pitchstone distribution, in particular, paints a picture of generally more complex, regulated exchange, possibly even in the form of 'proper' trade.

In the more egalitarian hunter–gatherer societies, ownership to lithic resources was probably less formalized and quarry access more open, as suggested in Bruen Olsen & Alsaker's analysis of West Norwegian rhyolite, greenstone and diabase sources (Bruen Olsen & Alsaker 1984; Alsaker 1987). They suggest that, in the Norwegian hunter–gatherer period (*c* 10,000–3800 14C years uncal BP), lithic resources may have been '...exploited directly, and on open terms...' by the people populating a social territory (Bruen Olsen & Alsaker 1984, 96). This assumed difference between Mesolithic and post-Mesolithic access/exchange signals a change in emphasis, from generalized reciprocity to balanced reciprocity (Sahlins 1972, 199).

6.3 Core preparation and rejuvenation

As illustrated by Table 25 and illus 49, most assemblages pre-dating the Bronze Age are dominated by bipolar cores, whereas most assemblages post-dating this watershed are dominated by platform cores. This does not necessarily mean that assemblages dominated by a specific core type are also dominated by the technique associated with that core form (eg bipolar cores/bipolar technique) – many bipolar cores frequently represent the last stages of exhausted platform cores, and assemblages dominated by bipolar cores may largely have been manufactured in platform technique.

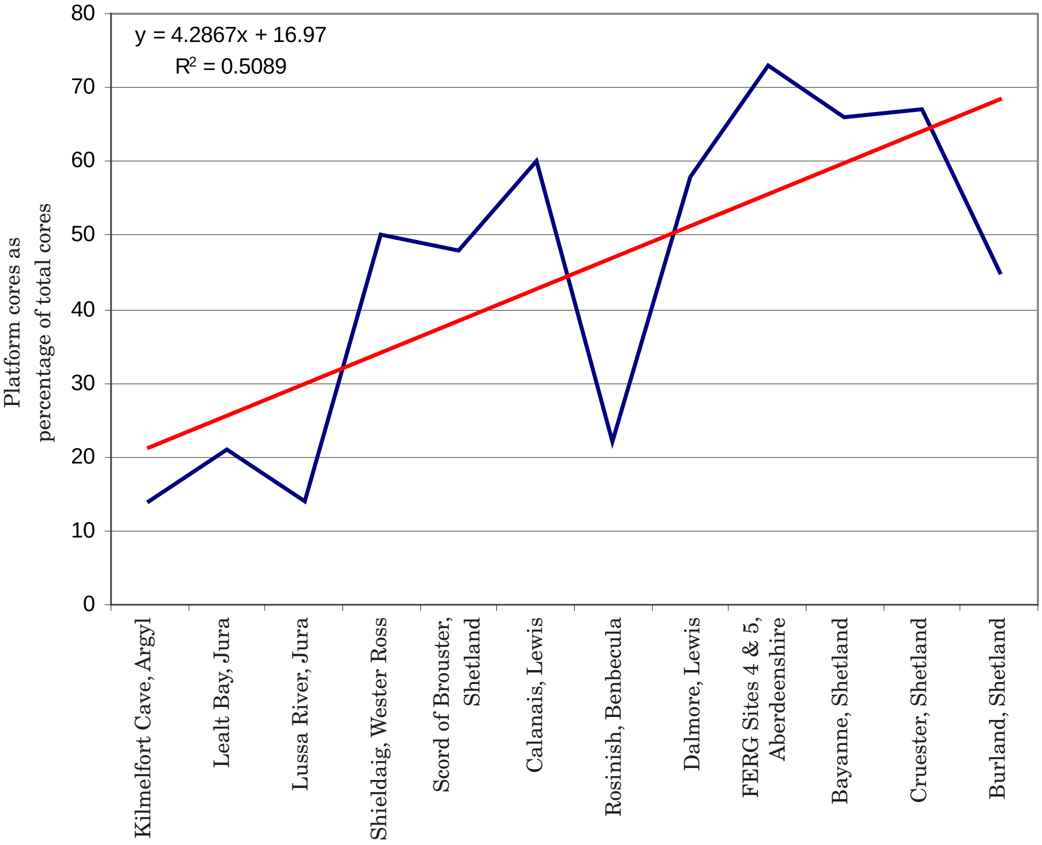
Table 24 Core preparation and rejuvenation flakes in the analyzed quartz assemblages

	Crested pieces	Platf. rejuv. flakes
Kilmelfort Cave, Argyll	5	0
Lealt Bay, Jura	2	0
Lussa River, Jura	1	0
Shieldaig, Wester Ross	8	1
Scord of Brouster, Shetland	0	0
Calanais, Lewis	0	0
Rosinish, Benbecula	1	0
Dalmore, Lewis	0	0
FERG Sites 4 & 5, Abd.shire	0	0
Bayanne, Shetland	4	2
Cruester, Shetland	2	0
Burland, Shetland	1	0

However, as not all assemblages analysed in connection with the present project were subjected to detailed attribute analysis of their blanks, the cores represent the best consistent indicator of the applied percussion techniques, and it must be assumed that the lower the proportion of platform cores, the lower the likelihood of encountering core preparation flakes or core rejuvenation flakes. As shown in illus 47, nodules were not prepared before commencement of bipolar production, and core rejuvenation was not carried out during bipolar production (illus 48), apart from the occasional re-orientation of the cores.

Table 24 lists the number of crested pieces and platform rejuvenation flakes discovered in connection with the examination of the project's selected assemblages. It is obvious that crested pieces are few, and platform rejuvenation flakes are almost entirely absent. In comparison, the Mesolithic chert assemblage from Glentaggart in South Lanarkshire (Ballin & Johnson 2005) includes 15 crested pieces and five platform rejuvenation flakes (of 384 flakes and blades), and the Late Neolithic flint assemblage from Area 1/Grid J at Stoneyhill in Aberdeenshire (Ballin forthcoming i) includes 11 crested pieces and four platform rejuvenation flakes (of 577 flakes and blades).

The only quartz assemblage with substantial numbers of preparation flakes is Shieldaig with



Illus 49 Platform cores as a percentage of the total number of cores, by assemblage. The assemblages are listed in chronological order, starting with the oldest (Kilmelfort Cave)

eight crested pieces and one core tablet. This assemblage consists of almost equal amounts of milky quartz and 'greasy' quartz (*c* 1300 and 1800 flakes and blades), but only one crested piece is in milky quartz, with all other preparation flakes being in 'greasy' quartz. It is apparent that the common quartz forms are not well-suited for 'sophisticated' details, such as core preparation, and the use of cresting and platform rejuvenation in connection with the reduction of 'greasy' quartz is clearly a consequence of this raw materials superior (compared to other quartz forms) flaking properties. As mentioned above, it is quite likely that prehistoric people would have perceived 'greasy' quartz as an independent raw material, unrelated to quartz in general.

The use of limited cresting on some sites in northern and western Scotland may largely be the product of three conditions:

1. extensive use of platform technique
2. the access to quartz in the form of large 'plates'/blocks (from veins) or large pebbles
3. widespread use of flint or flint-like raw materials, allowing technical elements from one operational schema (one raw material) to be transferred to another operational schema (another raw material) simply as a matter of technological tradition.

Bayanne and Cruester, both later prehistoric assemblages from Shetland, are examples of Points 1–2, whereas Kilmelfort Cave, Lealt Bay, Lussa River and Shieldaig, all Mesolithic assemblages from the Scottish west coasts, and characterized by widespread use of flint, may be examples of Point 3 (however, see discussion below, in Section 6.4). The detachment of core tablets requires either large cores which will allow the detachment of more than one flake or blade series, thereby making core rejuvenation relevant (Bayanne and Cruester), or access to quartz with exceptionally good flaking properties, like 'greasy quartz' (Shieldaig), allowing well-controlled detachment of relatively thin core tablets from small cores.

Though crested pieces *proper* are rare in quartz assemblages (with cresting being defined as dorsal ridges formed by the detachment of small flakes perpendicular to the main flaking direction), some degree of alternative ridge formation occasionally took place. At Bayanne (Ballin forthcoming j), crude crests were made by simple crushing, leaving characteristic battered arrises. These plainer crests functioned in the same way as the

Table 25 The selected assemblages, their ratios of platform and bipolar cores, quartz ratios, and dominant quartz forms. The assemblages are listed in chronological order, starting with the oldest (Kilmelfort Cave)

Assemblages	Number		%				
	Platform cores	**Bipolar cores**	**Platform cores**	**Bipolar cores**	**Quartz ratio**	**Quartz ratio**	**Dominant quartz form**
Kilmelfort Cave, Argyll	1	6	14	86	45	Below 50%	Vein
Lealt Bay, Jura	6	22	21	79	24		Pebble
Lussa River, Jura	27	167	14	86	89	Between *c* 70% and 100%	Pebble
Shieldaig, Wester Ross	31	31	50	50	87		Vein
Scord of Brouster, Shetland	46	50	48	52	100		Vein
Calanais, Lewis	6	4	60	40	74		Vein
Rosinish, Benbecula	16	57	22	78	99		Pebble
Dalmore, Lewis	35	25	58	42	93		Pebble
FERG Sites 4 & 5	11	4	73	27	68		Erratics
Bayanne, Shetland	35	18	66	34	100		Vein
Cruester, Shetland	6	3	67	33	99		Pebble
Burland, Shetland	17	21	45	55	100		Vein/pebble

more sophisticated traditional crests, that is, as a directional guide for the force detaching the first blank of a blank series.

6.4 Blank (primary) production

6.4.1 Platform or bipolar technique?

Quartz blank production (Modules 1–3 in illus 47 and illus 48) may take many forms, but the most significant technological choice made by the prehistoric knapper was whether to rely mainly on platform (free-hand) technique or bipolar (hammer-and-anvil) technique. Table 25 presents a crude overview of these basic technological choices made in Scottish quartz knapping. As shown in illus 49, bipolar technique apparently dominates the earlier industries, and platform technique the later industries, and some assemblages of intermediate age are characterized by approximately equal proportions of platform and bipolar cores.

As the earliest collections consist exclusively of material retrieved from sites in the Southern Hebrides and west mainland Scotland, the later collections of material mainly from the Western Isles, and the latest collections entirely of material from Shetland, it is possible that this trend is not a wholly accurate reflection of technological change through Scottish prehistory, from predominantly bipolar to predominantly platform technique. With reference to the uneven chrono-geographical distribution, it is possible that this trend instead reflects local raw material availability, with some assemblages being based on vein quartz and some on pebble quartz, the local pebbles may be available in different sizes, and the quartz may have been supplemented by other silica introducing different approaches to lithic reduction (cf Thorsberg 1986, 10; Ballin 1999a, 20).

It is highly likely that the size and shape of the available nodules or blocks/plates influenced preferences. It is generally accepted, that small pebbles are ill-suited for platform technique (eg Callahan 1987, 63; Finlayson 2000, 105), as:

- they do not contain sufficient mass to allow the necessary decortication and preparation of platforms, flaking-fronts and platform-edges
- due to their small size and curved exterior, primary blows tend to glance off these pebbles
- small pebbles have so little mass that a blow tends to move the hand and pebble, rather than detach a flake.

The reason why, for example, the Lussa River assemblage is dominated heavily by bipolar technique and the Cruester assemblage by platform technique may largely be the fact that the available pebbles are relatively small along the eastern shores of Jura and larger along the shores of Bressay, in Shetland.

Apart from the worked quartz from Kilmelfort Cave, which is dominated by bipolar technique, assemblages based on vein quartz are mainly dominated by platform technique. This is probably a result of vein quartz mostly being procured in the form of relatively large blocks or plates (Ballin 2004e), allowing the core preparation required by this approach. Powell suggests that, to prehistoric knappers, the tendency of vein quartz to form natural layers (cf Ballin 2004e) was a desired attribute in this material: ‘Because of the flat-sided nature of quartz […], the quarriers were able

Table 26 Flatøy XI. Attributes for blades in flint and quartzite

Attributes	Flint	Quartzite
Width (mm)	7.0	6.3
Thickness (mm)	1.7	1.9
Platform width (mm)	3.6	3.6
Platform depth (mm)	1.2	1.4
W:Th ratio	4.1	3.3
Platform W:D ratio	3.0	2.6
Striking-angle (degrees)	83.5	76.7
Dorsal arriss index	1.68	1.48

to secure a wide range of pieces having roughly parallel sides. These constituted natural cores, with ready-made striking and anvil platforms (Powell 1965). In this respect, Scottish rock crystal (clear quartz, mostly acquired in crystal form) constitutes an exceptional case, as this material is particularly well-suited for platform technique, having six ready-made crests, but Scottish knappers chose only to reduce this resource by the application of bipolar technique. One may suspect that the purpose of this enterprise was to, mainly, produce shiny, iridescent shatter rather than functional implements and that, in Scotland, this end-product had symbolic meaning.

It is possible, in the cases of mixed flint-quartz assemblages, that operational elements could be transferred from the reduction of one raw material to the reduction of another. This, however, requires ideological, or non-functional, considerations to be the knapper's main concern, and in most technological matters this obviously was not the case. Most raw materials have distinctly different flaking properties, requiring different reduction methods. The synchronous exploitation, in the Late Mesolithic of west Norway, of flint and quartzite followed different operational schemas, even within the same assemblages (manufactured by the same craftsmen?), and the author assumes that the individual knappers adapted their approaches to the raw material at hand. Table 26 presents key attributes for flint and quartzite microblades from the single-occupation site of Flatøy XI (Ballin 1999b).

The three main values in Table 26 are the W:Th ratio, the W:D ratio, and the striking-angle. These values indicate that, in the Flatøy assemblage, quartzite bladelets are generally thicker than the contemporary flint bladelets, they have deeper platform remnants, and their average striking-angle is more acute. In all likelihood, this reflects adaptation to the fact that the fine-grained Norwegian quartzite is more brittle than flint. As a result, quartzite bladelets are more prone to experience platform collapse, and in an attempt to counteract this weakness, the prehistoric knapper positioned the punch further from the platform-edge of the quartzite cores, giving the bladelets greater thickness and a higher W:D ratio. Due to the tendency of blades to curve along their long axes, positioning the punch further from the platform-edge would usually cause the quartzite cores to be used up earlier, and, to avoid premature abandonment of the core, this seemingly small change of the operational schema had to be combined with a change in general core shape. Consequently, the quartzite cores were given a more pyramidal shape with more acute edge-angles, whereas the flint cores of Flatøy XI tend to be bullet (conical) shaped. The difference in the average number of dorsal arrises mainly signify that, on Flatøy XI, quartzite bladelets are slightly less elegant than their flint counterparts, with fewer parallel dorsal ridges (for discussion of this attribute, see Ballin 2004b).

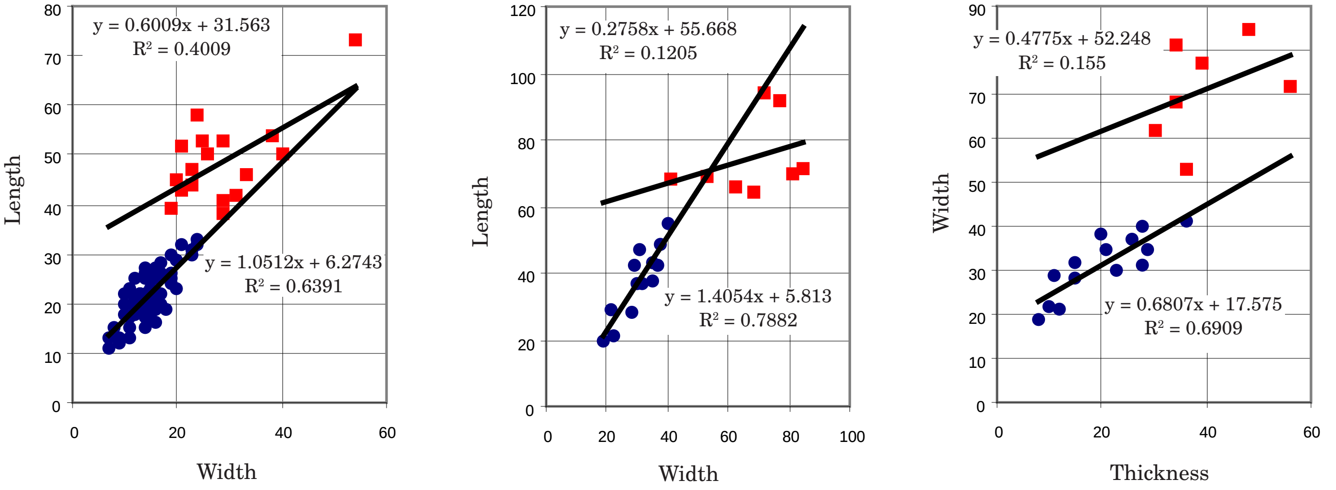
Or to sum up: in all probability, most raw materials, including the various quartz forms, were probably reduced in ways tailored to the specific flaking properties of those resources. This is not to say that ideological or non-functional considerations never entered the technological realm of prehistoric people. In the Late Mesolithic of southern Norway, groups in the east chose to produce microblades from handle-cores, whereas groups in the west preferred to give microblade cores conical shape (Ballin 2004b). Both regions are dominated by flint use (with increasing use of quartzite through the Late Mesolithic of west Norway); in both cases flint was procured in the form of small beach pebbles; and the two methods appear to be equally effective. In the west-Norwegian example, the author suggested (Ballin 2004b) that the two core types functioned as stylistic elements, and identified people as belonging to one of two ?ethnic groups.

6.4.2 The role of bipolar technique in the operational schema

However, quartz knapping was more than simply a question of choosing between platform and bipolar technique. Analysis of the operational schemas of the selected assemblages have shown a variety of technological combinations, with bipolar technique being applied at different stages and for different purposes. Generally, the bipolar approach was used for:

- initial quartering
- general reduction
- final reduction of small platform cores which, due to their low mass, could not be reduced any further by the application of free-hand percussion.

As shown in illus 49, all selected quartz assemblages have a platform and a bipolar component, that is, none was produced by the application of one technique only. The degree to which bipolar technique was used for quartering, general reduction, or final exhaustion may mainly have been a question of nodule or



Illus 50 The length:width of the flakes, and the length:width and width:thickness of the bipolar cores from Burland. The flakes and bipolar cores obviously represent two different populations; in each diagram a trendline has been inserted, and a correlation coefficient (R2) calculated, for each population

block size, with large pieces requiring quartering, medium-sized nodules might allow some platform reduction without quartering but with final small platform cores requiring exhaustion by the application of bipolar technique, whereas small pebbles can only be reduced by bipolar technique, making this approach the main form of reduction.

Quartering by bipolar technique was definitely an element of the operational schema at Burland on Trondra, Shetland (Ballin forthcoming d), where it has been possible to characterize the schema in some detail. The assemblage is based on combined vein and pebble quartz, which was collected or quarried in nodules or blocks of up to 150mm, but probably with average sizes of approximately 100mm. The individual debitage and core types cluster metrically to form separate size categories (illus 50). Most likely, this is an expression of a phased operational schema, with large flakes and cores representing waste from the first stage of the reduction process ('quartering'), whereas the smaller pieces represent the last step (discarded blanks and totally exhausted cores). Between the initial and final stages of this operational schema, quartz flakes were probably manufactured in platform-on-anvil technique (resulting in bruised apexes). Though the Burland industry is based on few and very simple technological choices, it clearly represents a planned process or operational *schema*.

A number of assemblages, such as those from Dalmore, Lewis (Ballin forthcoming g) and Bayanne, Shetland (Ballin forthcoming j), were largely produced by the application of platform technique. Quartering does not seem to have been an integral part of the operational schema, although it may occasionally have taken place, and bipolar technique was mainly used in connection with the final exhaustion of spent platform cores. In connection with the analysis of the Dalmore lithics, the presence of severely battered apexes led the author to suggest the presence of a three-phased operational schema, with one technique replacing another: free-hand platform technique → platform-on-anvil technique → bipolar technique proper. This approach (illus 51) has been described in detail (Callahan 1987, 60, fig 97), and tested by comparison of quartz debitage from Middle Swedish Stone Age sites with debitage from experimental assemblages.

At Bayanne, vein quartz was quarried in the form of large plates which, judging from the refitting of incomplete sequences of plate fragments may have been in the size order of up to 200–300mm. At Dalmore, pebbles were collected in sizes of up to 150–200mm, with one core rough-out having a greatest dimension of 146mm. But instead of quartering the raw nodules, these were carefully prepared and transformed into large single-platform cores.

In illus 49, the assemblage from the Beaker site of Rosinish (Ballin forthcoming h) constitutes an exception from the general trend. Assemblages of similar age (for example, Bayanne and Dalmore) are all dominated by platform technique, or they have roughly equal proportions of platform and bipolar cores, whereas the finds from Rosinish are noticeably dominated by bipolar pieces. Most likely, this is a consequence of the available quartz pebbles generally being in the size order of approximately 80–120mm, or somewhat smaller than the raw nodules or blocks from Bayanne and Dalmore. In this case, bipolar technique represents the main reduction approach (from splitting the pebbles to their final abandonment), with little quartering having taken place.

The general operational schema of the Mesolithic assemblages does not differ noticeably from that of Rosinish: bipolar technique appears to have been the dominant approach, from start to finish, with no

Table 27 The tool ratios of a number of quartz-bearing 'multi-material' assemblages

Site	Quartz (%)	Flint (%)	Mylonite (%)	'Greasy' quartz (%)
Calanais, Lewis	5	20	27	
Dalmore, Lewis	1	8	5	
Rosinish, Benbecula	1	62		
Kilmelfort Cave, Argyll	2	26		
Shieldaig, Wester Ross	1	13		2
FERG, Aberdeenshire	4	12		

quartering having been necessary. The pebble size was not estimated in the reports, but as the average length of the two pebble-based assemblages' bipolar cores (Lealt Bay and Lussa River) is approximately 28mm, against an average length at Rosinish of 36mm, it must be assumed that the beach pebbles on the east coast of Jura are even smaller than on Benbecula. However, the bipolar cores from the two vein-based assemblages (Kilmelfort Cave and Shieldaig) are even smaller, with an average length of *c* 26mm and, though there is no evidence of quartering in the form of broken-up and discarded blocks or plates, raw quartz must have been quartered before the production of miniscule microblades and microliths commenced. The reason for the small artefact sizes at Kilmelfort Cave and Shieldaig is not the size of the raw material blocks, which could probably be delivered from the quarry in whatever size was necessary, but the wish to produce very small implements, that is, a microlithic tradition.

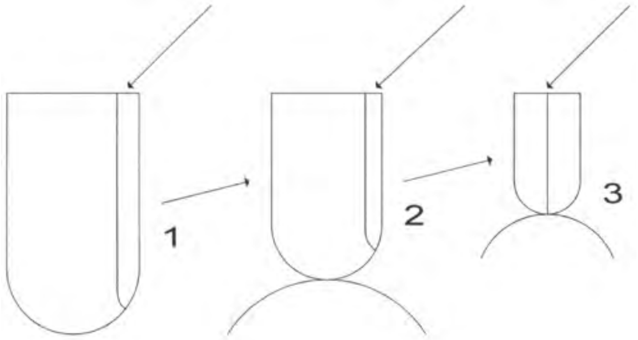
In general, the understanding of prehistoric operational schemas would increase noticeably if attribute analysis of blanks was carried out as part of a methodological 'standard package', aiming at analysis of complete smaller assemblages and, in the case of larger assemblages, analysis of samples (*c* 100 pieces; cf Ballin 2004b). However, attribute analysis is relatively time-consuming and this may not always be possible.

6.5 Tool (secondary) production

When comparing quartz assemblages with assemblages produced in flint or flint-like raw materials, the quartz assemblages are usually found to be characterized by (i) relatively low tool ratios and (ii) little diversity. Below, these two points are discussed in detail, and attempts are made to explain the observed differences.

6.5.1 Tool ratios

As, in Scotland, many older quartz and flint collections were recovered, or published, in less standardized ways than one would expect today (see table 1, in Saville & Ballin 2000), it is almost impossible to compare like with like. The most sensible way to explore the tool ratios of different raw materials is therefore by comparison of sub-assemblages within quartz-bearing 'multi-material' assemblages, such as the finds recovered from sites in the Western Isles and the Southern Hebrides/west mainland Scotland. The ratios of the individual site assemblages (Table 27) are not directly comparable, as excavation procedures differed; the finds represent different prehistoric periods, as well as different local (ie geological) settings; and where most assemblages in Table 27 are from settlement sites, one is from a ritual complex (Calanais; Ballin forthcoming a).



Illus 51 The main stages in the Dalmore operational schema (a simplified version of Callahan 1987, illus 97)

It is, however, quite clear that the quartz component of these geologically mixed assemblages always has the lowest tool ratio, with this ratio occasionally being dramatically lower (eg Rosinish: quartz 1%, flint 62%). Within Lewis, the relative ratios of the quartz, flint and mylonite sub-assemblages appear to be more or less fixed, with the quartz tool ratio being in the size order of approximately one-fifth or one-quarter of the flint tool ratio, or the mylonite tool ratio. At Shieldaig, the tool ratio of 'greasy' quartz is roughly twice that of ordinary quartz.

6.5.2 Assemblage composition

In general, Scottish quartz assemblages display a limited selection of formal types, whereas assemblages, or sub-assemblages, in flint and flint-like materials frequently display a fuller range of tool types. In most cases, quartz assemblages are characterized by a marked dominance of scrapers (Scord of Brouster: 75% of the tools), supplemented by a small number of arrowheads or microliths (if any), some retouched pieces, and individual specimens of other tool types. Uniquely, the quartz assemblage from Scord of Brouster also includes 12 curved knives – a formal type only known from two other Scottish sites (Camster Long, Caithness: Wickham-Jones 1997; Druim Arstail, Oronsay: Wickham-Jones *et al* 1982). Assemblages in flint and flint-like raw materials, for example in east, central and south Scotland, mostly include a slightly smaller proportion of scrapers, though scrapers usually dominate the tools, supplemented by relatively high numbers of arrowheads/microliths, as well as several serrated pieces, burins, piercers, truncated pieces, and – occasionally – larger bifacial pieces, like plano-convex or foliate knives.

6.5.3 Possible explanations

The marked differences in tool ratio and tool group diversity may be due to a combination of factors, with the following probably being the most important:

- Quartz tools are more difficult to recognize than tools in most other lithic raw materials.
- Quartz blanks were frequently usable as tools, without further modification.
- Most quartzes tend to flake in more irregular ways than other silica.
- Economical differences between some quartz-dominated and some flint-dominated assemblages.
- Visually distinctive raw materials were frequently associated with non-functional, or symbolic, values (Gould 1980; Clemmer 1990).

Recognition

The claim that quartz tools are more difficult to recognize than tools in other silica is almost considered a truism by lithics specialists. In connection with a blindtest, in which archaeologists were asked to identify experimentally produced quartz tools, it has been demonstrated (Lindgren 1998, 99) that, frequently, quartz tools were not recognized, or, occasionally, a familiar shape led people to identify unretouched pieces as tools (see discussion of quartz artefact typology, above).

The need for modification

The generally low number of, for example, piercers and burins in quartz may relate to the fact that many quartz blanks are in the form of cubic shatter ('chunks'), with strong corners, points, and edges. These parts of the blanks were immediately usable as piercer-tips, burin-edges, and edges of planes and scrapers, whereas the working-parts of the thinner and more delicate flint tools needed strengthening by modification to prevent immediate damage to the implement.

This view is partly supported by Bradley's examination of quartz artefacts from Tougs, Shetland, revealing that most unmodified utilized pieces had been used for scraping, and one for piercing (Bradley 1986). Knutsson's use-wear analysis of quartz flakes from the Bjurselet site in Sweden (Knutsson 1988, 124–8), showed that 26 pieces had clear wear marks, with 11 thin flakes having been used for cutting, whereas three sturdier pieces were used for grooving, four thick flakes were informal planes, two had been used as piercers, two as 'whittling knives' (a sub-form of planes?), three as scrapers, and one was an informal saw.

Flaking properties

Due to the generally poorer flaking properties of quartz (Callahan *et al* 1992; Knuttson 1998, 75), most quartz reduction is characterized by a lower degree of control and a tendency to produce chunks or irregular, thick flakes. This predisposition poses a problem to the production of finer tools, which may usually be produced by the application of invasive retouch, that is, the detachment of very small, narrow thinning-flakes. Bifacial arrowheads *are* known in ordinary quartz forms [eg the barbed-and-tanged arrowhead from Biggings on Papa Stour, Shetland (Ballin 1999c)] but, on the Western Isles, a high proportion of quartz arrowheads are in the more versatile 'greasy' quartz, or they were manufactured in flint or mylonite.

It is possible that, on Shetland, where quartz alternatives are scarce, it was attempted to improve the flaking properties of quartz by heat-treatment (cf Section 4.4.3; Gonick 2003). At Scord of Brouster (Ballin 2007a), this is suggested by one curved knife, which retains an unmodified, superficially burnt area in the central part of either face, whereas the peripheral zone of the piece – which appears unburnt – has been modified by the bifacial detachment of thin flakes. Experiments (Crabtree & Gould 1970, 194; Eriksen 1999) have shown that flakes from heat-treated silica nodules or flakes tend to become thinner than flakes from raw nodules. It is possible that the tell-tale signs of this approach, such as a particular type of sheen acquired during the treatment (Eriksen 1999, 189), is obscured by the naturally reflective surfaces of most quartz forms.

Economical differences

It is obvious that the available quartz assemblages do not represent an even distribution of sites throughout Scotland, or throughout Scottish prehistory, as the various Scottish regions are either dominated by early, intermediate, or late material. In his comparison of the Scord of Brouster quartz assemblage with Neolithic lithic assemblages throughout the country, the author suggested that some of the compositional differences between Scotland's Neolithic flint and quartz assemblages may be products of the fact that many flint assemblages from the eastern, central and southern parts of the country are from inland sites, whereas most of the quartz assemblages from the north and west are from coastal sites.

As little, or no, organic material has been preserved from most Neolithic sites of Scotland it is difficult positively to demonstrate differences between the economies of the various sites, but it is evident that economical differences must have existed between these two groups of sites. It is logical to associate a 'semi-diagnostic' type such as the serrated piece (which is generally rare in quartz assemblages) with inland sites, as detailed use-wear analysis has demonstrated that this type may mainly have been used for the processing of plant material (Juel Jensen 1988; Juel Jensen 1994).

Symbolic values

The high tool ratio of north and west Scotland's alternative silica, as well as the more diverse assemblage composition of these resources, may be explained by one of two possible scenarios, or a combination of the two:

- In comparison to common quartz forms, alternative silica, such as flint, mylonite and 'greasy' quartz, generally have superior flaking properties.
- These alternative, frequently visually distinctive, silica may have been associated with other than functional values.

It is not possible to decide which of the two scenarios is the dominant one without carrying out a detailed analysis of these matters. It is, however, most likely that an explanation of the observations would include a combination of the two. Most ethnographic analyses of raw material procurement and use indicate that many, or even most, raw materials were associated with some symbolic, or non-functional, values (eg Gould 1980). Congdon writes about the role of white chert in Tosawihi Shoshone beliefs:

> The white chert has a symbolic value as a material and is a physical expression of their identity. Chert from the quarry has religious value as a source of spiritual power and forms an integral part of Western Shoshone religious practice and expression (Congdon 2000, 10–17).

The distribution of 'greasy' quartz, in conjunction with the composition of assemblages in this raw material, clearly define 'greasy' quartz as a material with symbolic connotations. In the area immediately adjacent to the likely source(s) (eg Shieldaig; see Section 2.4.2) assemblages include all tool types, but further from the source(s) the material in question only includes a very select set of artefact types. In the case of, for example, Lewisian assemblages with imported 'greasy' quartz, the 'greasy' quartz sub-assemblages only include more elaborate prestige implements, in most cases exclusively arrowheads. The preference on Lewis for 'greasy' quartz as a material for arrowhead production, and the acceptance at Shieldaig of this quartz form in general tool production, must reflect the existence of different prehistoric belief systems in the 'donor' and 'recipient' areas.

Even though the exact sources of the Lewisian mylonite are not yet known, the geological realities of that island (Smith & Fettes 1979, fig 3) suggest that this raw material was quarried in eastern Lewis partly for use on sites in western Lewis. At some distance from the quarries, this resource seems to have been used in very much the same way as 'greasy quartz', that is, for the production of a selected number of tool types. Flint and bloodstone appear to have been used in a slightly less restrictive manner than pitchstone, 'greasy' quartz and mylonite, and, in these cases, the functional aspect of the lithic selection process may have been dominant.

Overall, the different applications of the quartz alternatives (due to its deviating appearance and qualities it has been chosen to include 'greasy' quartz in this group) suggest that probably all lithic raw materials were associated with symbolic values, with these values differing from raw material to raw material, and with the balance of perception shifting from mainly functional to mainly symbolic. The use of ordinary quartz forms may largely have been based on functional considerations, and pitchstone, mylonite and 'greasy' quartz (away from the main source) largely on ideological considerations, with flint and bloodstone representing more equal mixtures of functional and ideological considerations. Generally, preferred raw materials reflect the identity of the user ('style', see above; also Wiessner 1983; Gebauer 1988), either by identifying him as belonging to a particular social group (band/extended family, lineage, clan or tribe), or by identifying alliances between groups (White & Modjeska 1978; Bruen Olsen & Alsaker 1984, 96; Sassaman *et al* 1988, 80).

7 The Social Context of Quartz Use – Territories and On-Site Behaviour

7.1 Introduction

Where the previous sections discussed mainly geological (eg availability and physical properties) and technological matters (eg the schematic organization of quartz production), the present section deals with the social context of quartz use in Scotland. In prehistory, quartz production was an element of active societies, and below it is attempted to use the available Scottish quartz assemblages to provide information on aspects of these societies.

Investigation of the social background to quartz production is very much a matter of intra- and inter-site spatial analysis – that is, where was worked quartz found, in combination with which other finds, and where was it absent – and a meticulous recovery policy is essential to the successful outcome of these analyses. For this reason, many 'old' assemblages are not suitable research objects, as they were frequently excavated without the use of proper grid systems, or with too large or irregular grid units, disallowing the production of detailed distribution maps. An insufficient level of stratigraphical observation, or the lack of sieving, may also hamper attempts at using 'old' assemblages for the analysis of social context.

The main questions in relation to the investigation of quartz and social context are: (i) where were different types of quartz artefacts produced, used, and discarded (which sites, and which parts of individual sites), and (ii) who was involved in these various processes (age, gender, rank, etc.)? Detailed analysis of the applied operational schema, and its level of complexity, may shed light on the second question (eg 'the best technicians', 'the less talented technicians', and 'the apprentice-debutants'; Bodu *et al* 1990, 248; Pigeot 1990).

7.2 Inter-site (regional) distribution

The distribution of archaeological quartz throughout Scotland was discussed in Section 5, region by region, and it was concluded (Section 5.2.6) that, probably, the 'ordinary' quartz forms (milky quartz and the various types of saccharoidal quartz) were perceived largely in functional terms, whereas 'greasy' quartz and rock crystal may have been associated with different symbolic values.

The overall distribution of archaeological quartz corresponds well with the relative geological distribution of quartz and quartz alternatives, with quartz use dominating the north and west, as well as the Highland zone, but with quartz being almost absent in the three regions characterized by quartz-poor sedimentary rock forms (the north-eastern, central and southern parts of Scotland). In the entire coastal zone of the mainland, as well as on several of the islands in the Southern Hebrides, flint either dominates, or it is more frequent than in the immediately adjacent parts of the Scottish mainland. This is obviously a consequence of the mainly coastal distribution of Scottish flint, with flint being washed onto the beaches from submarine deposits in the Atlantic and in the North Sea (Wickham-Jones & Collins 1978; Saville 1995, fig 1; Marshall 2000a; Marshall 2000b).

The area surrounding Scotland's only inland flint source, the Buchan Ridge Gravels (Saville 1994; Bridgeland *et al* 1997), is also heavily dominated by flint, but with quartz gaining in importance at short distances to this secondary pebble source. Sites along the St Fergus to Aberdeen Gas Pipeline (FERG; Ballin forthcoming c) are mostly characterized by approximately two-thirds quartz and one-third flint, though the distance to the Buchan Ridge Gravels is negligible (located a few km outside the flint-bearing area, and no more than 5km north-east of the flint mines on Skelmuir Hill). The FERG sites are generally late prehistoric, and as mining of the Aberdeenshire inland pebble sources is assumed to be a mainly Late Neolithic/Bronze Age activity (Saville 1994, 61; Saville 1995, 366), pebble flint should have been readily available to the settlers along the pipeline. The reason not to base the lithic production predominantly on flint from the Buchan Ridge Gravels must have been either that this resource was perceived an unacceptably poor alternative (and it is generally accepted that this flint is of lower quality than most Scottish beach pebbles; Saville 1995; Bridgeland *et al* 1997), or access to the quarried flint was in some way restricted.

An analysis of the use of quartz alternatives show that, wherever acceptable alternatives were available, the proportion of quartz decreased immediately. On Shetland, where few quartz alternatives are known, quartz usually dominates the lithic assemblages completely (99–100%). Northmaven felsite could, in functional terms, have replaced quartz as a raw material for many tool forms, but apparently this resource was quarried exclusively for axes and Shetland knives, and to a lesser extent arrowheads. Practically all scrapers in this material have polished 'under-sides' revealing that they are based on axe-fragments.

On the Western Isles, plainer quartz forms were supplemented by mylonite, flint and 'greasy' quartz, which are all assumed to have been associated – possibly to varying extent – with symbolic values (Section 6.5.3). Mylonite and 'greasy' quartz seems to have been mainly employed in the production of arrowheads (though mylonite seems to have had a slightly broader use-range), possibly as a means of group identification (cf Wiessner 1983), whereas flint may have been highly appreciated as a relatively rare resource, but probably used more widely as a raw material providing regular durable tool edges.

In the Southern Hebrides and western mainland Scotland, the situation was roughly the same as in the Western Isles, but different quartz alternatives were available. Where flint was present, it replaced quartz, and if the resources of flint were rich enough, as on Islay (McCullagh 1989; Marshall 2000a; Marshall 2000b), they replaced quartz completely. Other local quartz alternatives were Rhum bloodstone, Staffin baked mudstone and Arran pitchstone. Apart from Arran pitchstone, which appears to have been particularly valued by prehistoric people in Scotland, and which is characterized by a complex distribution pattern [Zone I: Arran (local: general use of pitchstone through all periods); Zone II: the adjacent parts of the Scottish mainland (regional: pitchstone is occasionally a dominating raw material, but mostly it is a minority resource/mainly Early Neolithic); and Zone III: the remaining parts of Scotland (exotic: individual pieces/mainly Early Neolithic], most quartz alternatives seem to have roughly equal distribution patterns, with exchange networks spanning *c* 70–100km from centre to periphery.

The author believes that the use of these materials was driven partly by functional considerations, but also to an extent by stylistic considerations, in the sense that ownership of objects in these materials identified the bearer as belonging to a particular social group, or a larger alliance of groups (Gould 1980; Clemmer 1990). As touched upon in Section 6, the distribution of 'greasy' quartz bears some resemblance to the distribution of pitchstone, in the sense that the area immediately around the likely sources is characterized by general use of the resource, whereas the use of it becomes increasingly exclusive, in typological terms, with growing distance to the sources.

Only three quartz-bearing sites are known from the various parts of the Highlands, making it almost impossible to draw general conclusions on quartz use in these areas. However, assemblages from the Cairngorms mountain ranges and the surroundings of Ben Lawers differ so distinctly, in terms of raw material composition, that one may assume that quartz and flint were valued differently in those areas. In Aberdeenshire, sites along the River Dee, leading into the Cairngorms, are dominated completely by flint use (eg Paterson & Lacaille 1936; Lacaille 1944; Kenworthy 1981), and even in the foothills of the Cairngorms did flint represent the main lithic resource (Ballin 2004a), even though it had to be transported nearly 100km from the pebble deposits by the North Sea. In contrast, the Ben Lawers Mesolithic site (Atkinson *et al* 1997) is dominated by quartz, with flint representing a minority resource. It seems clear that, along the River Dee, flint was associated with more than functional values, giving sense to long-distance transport of this material, whereas, along the River Tay, flint was 'only' a functional resource, which was replaced, probably gradually, by quartz with growing distance to the North Sea pebble deposits.

The impression of quartz being perceived in prehistory as a largely functional material with few symbolic connotations (albeit used in raw or crushed form as a structural element of burial and ritual monuments; Section 7.3) is supported by the use of quartz in the three sedimentary regions in the north-eastern, central and southern parts of Scotland. As demonstrated by quartz alternatives throughout Scotland, quartz alternatives were frequently exchanged across distances of up to 100km, and in the case of pitchstone much more. However, as shown in Table 18, 'ordinary' quartz does not seem to have been acquired from sources outwith the general site catchment area. At Fordhouse Barrow in Angus, quartz is present through the many layers of the barrow, but it does only make up approximately 8% of the assemblage total. It is thought that this quartz was collected as erratics or river pebbles, originating from primary sources in the Grampian Highlands (Cameron & Stephenson 1985, 21; Ballin forthcoming f), rather than exchanged.

As suggested above, the three quartz forms 'ordinary' quartz (including milky quartz and most saccharoidal quartzes), 'greasy' quartz and rock crystal may have been perceived by prehistoric people as three (or more) different raw materials, with different visual qualities and flaking properties. This proposition is supported by the fact that the three resources are characterized by different distribution patterns, and different patterns of usage. The analysis of the Lewisian quartz forms (Ballin 2004e) and their distribution in relation to prehistoric settlements indicate that 'ordinary' quartz was procured within the limits of traditional catchment areas (radius *c* 10km), and they were used for the production of all tool types; 'ordinary' quartz was not exchanged, and access to the sources was probably in the control of individual families. 'Greasy' quartz may have been procured mainly in the Shieldaig area of Argyll, and if this assumption is correct, it was exchanged across up to 100km; a dual use pattern, with all-purpose use near the source and more selective use away from the source (mainly arrowheads), indicate the existence of two parties – the controlling group at Shieldaig (all-purpose use) and the receiving groups further afield, to whom ownership of artefacts in 'greasy' quartz was mainly emblematic (Wiessner 1983) and indicated their inclusion in a regional alliance. Rock crystal may have found sporadic use throughout Scotland, but the fact that, on Jura, where larger crystals are widely available (Mercer 1968, 20; Ballin 2001b), this highly flakable material was mostly crushed between an anvil and a hammerstone, where it could have been used to produce regular, and very impressive, microblades (cf Ballin 1998a, 40); it is possible that the Jura rock crystal was mainly valued for the iridescent (aesthetic?) quality of rock crystal shatter?

7.3 Intra-site distribution

In the present paper approximately a dozen Scottish quartz assemblages are presented and discussed, but only five of these (Bayanne, Dalmore, Scord of Brouster, Cruester and Rosinish) are suitable objects for one or the other form of intra-site distribution analysis. The main background to this unfortunate situation is the fact that most 'old' assemblages were excavated, recorded and/or published in ways not permitting detailed analysis of on-site artefact distribution, mostly due to insufficient or inconsistent gridding (Saville & Ballin 2000, table 1). Amongst the above five assemblages only three were recovered in ways permitting more detailed analysis (Bayanne, Dalmore and Cruester), but as Dalmore was excavated in a stringent traditional grid system, and Bayanne and Cruester with reference to site contexts, the analytical approaches had to be adapted to the individual cases. Below, the main results of the distribution analyses are put forward.

7.3.1 Bayanne (Ballin forthcoming j)

The quartz assemblage from Bayanne on Yell, Shetland, was recovered from a number of cellular structures or houses, sheds, and areas between the houses and sheds. The finds are thought to date mainly to the Later Bronze Age.

Premises and data

The following analysis of site activities and site organization is based on a set of basic principles, inspired by Binford's discussion of settlement organization and site maintenance (ie clearing) strategies (Binford 1976; Binford 1978; Binford 1980; Binford 1983; also Ballin forthcoming j). The main elements of the analysis are:

- The *chip ratio* (chips as a percentage of the debitage total). Because of their small sizes (< 10mm), chips were rarely exposed to maintenance (preventive or *post hoc*), and a high chip ratio is therefore a localizing factor for primary production (knapping floors).
- The *average weight of the debitage*. The average weight of an assemblage is often a direct result of the chip ratio, that is, the higher chip ratio, the lower average weight; high average weight is, to some extent, a localizing factor for activity areas (ie areas where tools were used but not produced), or middens.
- The *flake ratio* (flakes as a percentage of flakes + chunks). The proportion flakes:chunks is interesting, as a preponderance of flakes indicates an activity area where flakes were used without secondary modification, or a cache. A preponderance of chunks may indicate either an area of primary production (ie where the exterior loose quartz was removed ('decortication'), or a midden.
- The *tool ratio* (tools as a percentage of the assemblage total). A high tool ratio indicates either an area for tool production, an activity area, or a midden.
- The *core ratio* (cores as a percentage of the assemblage total). A high core ratio indicates either an open-air knapping area, with the cores usually having a peripheral distribution, or a midden.
- The *presence/absence of preparation flakes*. The presence of preparation flakes usually indicates a knapping area, but if those flakes are relatively large they may have been cleared out in connection with site maintenance, in which case their location may indicate a midden.
- *Composition of the tool group*. If an event or structure is characterized by a high tool ratio, the composition of the tool group may indicate the actual activities.

The interpretation of a specific event or structure depends on the combination of the above elements, as well as the contexts in which they appear (for example, inside/outside house, house type, associations with non-lithic artefact categories, etc).

Event 1 (ard marks)

This event has the most versatile composition of non-debitage; it contains two cores, one arrowhead, eight scrapers, two piercers, two pieces with retouch, and two hammerstones, which were all found in the sondage in the north-east corner of the site. The high average weight of this sub-assemblage and its high tool ratio suggest that this event represents either a multi-purpose activity area or a dump.

Event 2 (Structure 4)

The debitage from this event is mainly refuse from primary production characterized by a high chip ratio and low average weight. The low core ratio suggests that the area constitutes either living quarters or a central, frequently used area of the settlement, from which cores have been cleared out in connection with site maintenance. However, only approximately 50 of 298 pieces are from actual culture layers, the rest are from pits, cuts and drains and may therefore pre-date Structure 4. The majority of those (114 pieces) are from one pit (context 672/673), and it is possible that this is not a post-hole but, for example, a small refuse pit (the debitage from this context may represent a single knapping-event. This could be tested via refitting, although quartz is a complicated raw-material to conjoin). Only three of the seven scrapers from this event are from occupation layers, the remaining four were distributed in pits and cuts.

Event 3/4 (habitation of Structure 3)

The debitage of these events resembles that of Event 2 with high chip ratios and low average weights thus indicating primary production, but again the main bulk of the finds are from pits, drains and wall cores/piers, or from an area south-east of Structure 3. In the case of Event 3, lithic material from culture layers indicate activities in the norh-east corner of the interior, and in the case of Event 4, approximately 100 pieces are associated with occupation layers and indicate activities in the north-west cell and, primarily, the norh-east cell (debitage, scrapers and a hammerstone). A number of large plates of vein quartz probably represent stored raw material.

Event 5 (midden)

Very little material was retrieved from this event (75 pieces), but the composition of the finds supports the interpretation of Event 5 as a midden: few chips, high average weight, more chunks than flakes, and discarded tools.

Event 6 (Structure 5)

The high chip ratio, relatively low average weight (medium) and low tool ratio suggests that the activities of Event 6 were limited to primary production. The high flake ratio indicates that some sorting of the debitage took place separating out suitable blanks. The activities associated with this event did not take place within Structure 5 but in the area between Structures 3 and 5. Most probably this is an outdoor knapping floor.

Event 7 (Structure 1)

High average weight, low flake ratio, high core ratio with medium chip and tool ratios suggest that Event 7 is either an activity area or, more probably, a midden area: all cores and scrapers as well as a hammerstone were found right outside the entrance to Structure 1 indicating the presence of a 'door dump' (Binford 1983, 151). One scraper was retrieved from Bay 2, but the main bulk of the material from within Structure 1 was from beneath or inside walls and piers and probably pre-dates the event. The actual floor of Structure 1 was almost devoid of quartz debris suggesting that either site maintenance was undertaken regularly or quartz production did not take place inside Structure 1.

Event 8 (Structure 3 and 5 infill – midden)

This sub-assemblage has a low chip ratio, high average weight, and high tool and core ratios (44 scrapers, three piercers, three retouched pieces, three hammerstones and 18 cores) confirming the impression of this event being a midden. Event 8 seems to be a spatial continuation of the 'door dump' outside Structure 1. The composition of the sub-assemblage (Table 28) corresponds closely to that of Event 11 and, to some degree, Event 5 – two other assumed dumps or middens.

Event 9 (Structure 6)

Event 9 can be divided into two areas: outside and inside Structure 6. A low chip ratio indicates very limited primary production, and medium average weight combined with medium tool and core ratios indicate activity areas. A high flake ratio suggests sorting and possibly caching of suitable blanks, or activities in which flakes were used in an unmodified state, for example as knives.

However, the fact that this event is located on top of the outdoor knapping floor of Event 6, which was also characterized by a high flake ratio and sorting/caching, calls for caution in the interpretation of Event 9. We are either dealing with some degree of spatial continuity of activities from Event 6 to Event 9 or material from Event 6 may have been mixed into the Event 9 sub-assemblage.

Event 10 – insufficient material

Event 11 (abandonment of Structure 1)

The composition of this event corresponds to that of Event 8 and suggests that Event 11 is a midden: low chip ratio, high average weight, and high tool and core ratios.

Event 12 (Structure 2)/Event 13 (Structure 7)

The structures in these events are believed to be Pictish, and the worked quartz may be intrusive. For this reason, the two sub-assemblages are not included in this quartz-based activity analysis.

Event 14 (cultivation layer)

Most finds are from topsoil or cultivation soil.

Table 28 Bayanne. The events and their relative ratios

Event	Chip ratio	Av. weight (deb.)	Flake ratio	Tool ratio	Core ratio	Prep. flakes
1	Medium	High	Medium	High	Medium	
2	High	Low	Medium	Low	Low	
3	High	Low	Medium	Medium	Low	
4	Medium	High	Medium	Medium	Low	x
5						
6	High	Medium	High	Low	Medium	x
7	Medium	High	Low	Medium	High	x
8	Low	High	Medium	High	High	x
9	Low	Medium	High	Medium	Medium	
10						
11						
12	High	High	Low	Low	Low	
13	Low	Medium	High	Medium	Low	x
14	Low	High	Medium	Medium	Medium	
	High: 15.0–	High: 10.0–	High: 60.0–	High: 8.0–	High: 2.0–	Present
	Medium: 7.5–14.9	Medium: 5.0–9.9	Medium: 50.0–59.9	Medium: 4.0–7.9	Medium: 1.0–1.9	
	Low: 0–7.4	Low: 0–4.9	Low: –49.9	Low: 0–3.9	Low: 0–0.9	

Events and contexts: summary

The composition of Bayanne's lithic sub-assemblages makes it possible to refer the individual events to a number of spatial/behavioural categories:

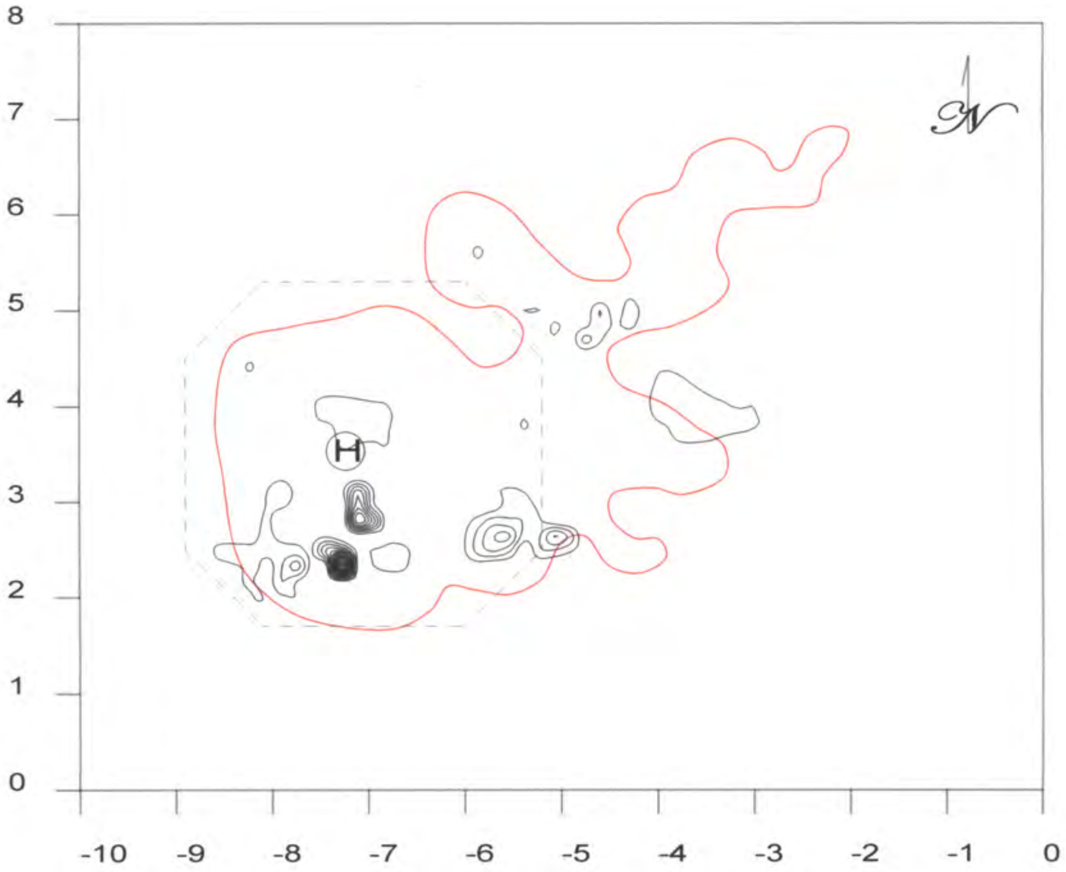
- Event 1: multi-purpose activity area.
- Events 2, 3 and 4: living quarters characterized by primary production and clearing-out of large-size refuse (chunks and cores), or, in case the refuse from primary production pre-dates the events, living quarters with no quartz production.
- Event 7: living quarters with no quartz production + 'door dump'.
- Event 6: outdoor knapping-area, sorting of blanks.
- Events 5, 8 and 11: middens.
- Event 9: some knapping, activity area, ?cache; some secondary material from Event 6?
- Events 12, 13 and 14: probably most of, or all, quartz in these layers originates from earlier deposits.

It is fairly obvious that material from, for example, wall cores pre-dates the structure those walls form part of, but the question is, to what degree this assumption covers material from drains and pits. However, the general impression of the spatial organization of activities on Bayanne is:

- Probably no primary quartz production took place inside the dwellings proper (Structures 1 and 3).
- Most knapping was probably undertaken outside the dwellings, including immediate sorting of suitable blanks (Event 6, between Structures 3 and 5; the quartz material gives no clues as to the function of the smaller Structures 5 and 6).
- The dwellings probably had a 'door dump' immediately outside the main entrance (Structure 1), with proper middens in older abandoned structures.
- No activity areas have been located with certainty, but it must be assumed that most of the numerous scrapers were used in the houses or sheds and dumped on the middens when they were exhausted – or the middens are activity areas as well as dumps.
- A few cores and tools have been found in individual cells or bays in the houses, and it must be assumed that they represent raw material and still usable tools.

7.3.2 Dalmore (Ballin forthcoming g)

During the excavations at Dalmore on Lewis, carried out partly by Sharples and partly by Ponting & Ponting, a number of superimposed house structures were investigated. These structures were separated stratigraphically into five main phases, as well as a number of sub-phases. The recovered pottery suggests some activity on the site during the Neolithic period, but most diagnostic pottery sherds, as well as diagnostic lithic artefacts, indicate a date of the main settlement in the Early Bronze Age.

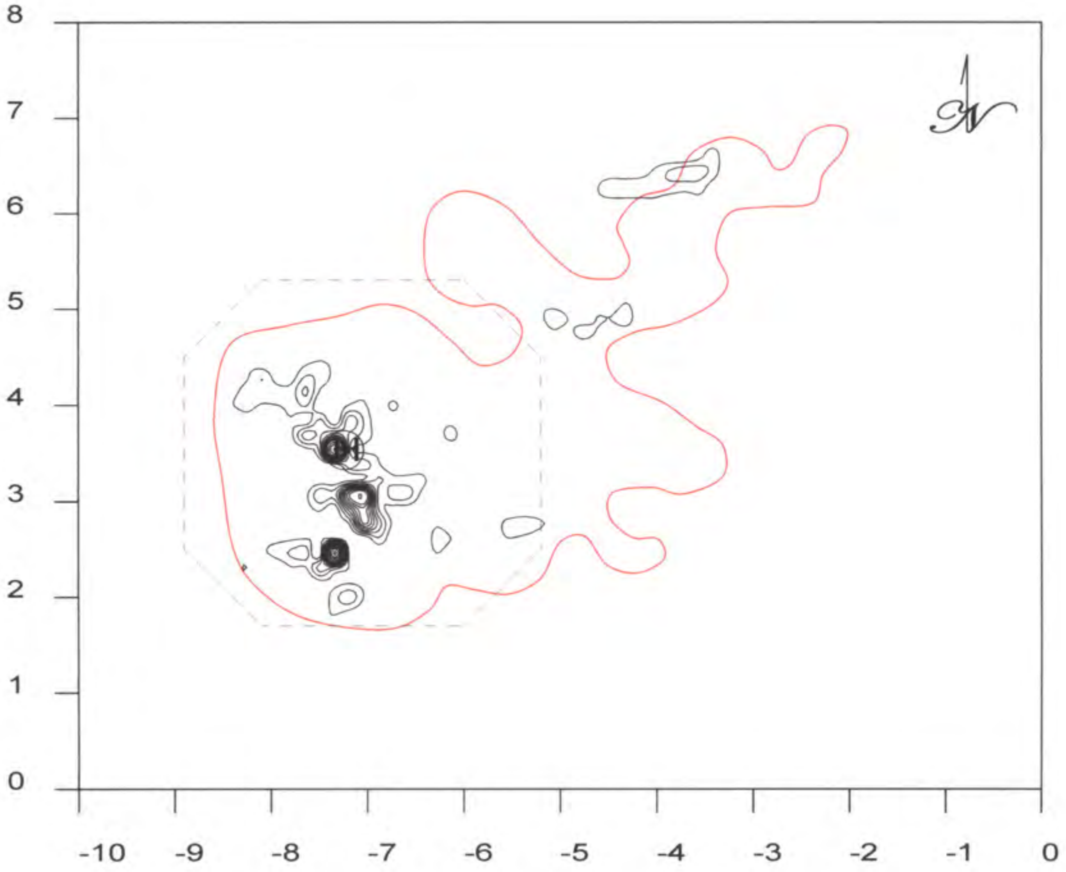


Illus 52 Dalmore. The distribution of all lithic finds from Sharples' excavation. The red wavy line marks the outer limits of the horizontal distribution of lithic artefacts, whereas the finer black contours demonstrate the concentration of these finds. The stippled 'polygon box' indicates the approximate location of the main, undivided oval building (which was re-arranged and divided in the later phases; Sharples 1983a; Sharples 1983b), and the circle (marked H) represents the central slab-built hearth of Phase II (Context 082). Contours at 1 piece intervals (lowest contour = 3 pieces)

The diminutive size (illus 52) of the main building at Dalmore implies that this was the habitation of a small group of people, possibly a family unit. Stratigraphical information (Sharples 1983a; Sharples 1983b) suggests that, at any one time, there was only one hearth in operation and, as a consequence of consecutive re-arrangements of the living-space, this hearth was replaced several times in a south-westerly direction, with the exception of the latest hearth (Phase V) being by the east wall of the building (illus 53). The entrance and passageway is clearly indicated by a north-easterly tongue of lithic debris. Immediately outside the entrance, quartz debris is found on either side of the doorway, indicating the presence of two so-called 'door dumps'.

With few exceptions, the distribution of lithic rubbish, including abandoned cores and tools, is restricted to the area within the oval walls of the Dalmore building. This indicates that most activities involving lithic materials (primary and secondary production, as well as use of tools and unmodified blanks) took place in the house, with limited activities taking place immediately outside the north-easterly passageway. This differentiates the Dalmore site from, for example, the Bayanne site in the Shetland Islands (Ballin forthcoming j). Bayanne is a phased Later Bronze Age site with houses and workshops, and the activity analysis suggests that no primary or secondary lithic work was undertaken inside the dwellings, and only to a minor degree within the workshops; the majority of the *c* 3000 pieces of worked quartz are associated with outdoor middens, knapping floors and activity areas. Evidence from other quartz-rich house sites in northern and western Scotland, suggests that, in most cases, the production and use of lithic blanks and tools took place within buildings rather than outside (eg Scord of Brouster: Whittle 1986, 87; Catpund: Ballin-Smith 2005; Tougs: Hedges 1986, 14–17; Sumburgh: Downes & Lamb 2000, 112–16).

As a general rule, primary production took place by the various hearths of the Dalmore building, possibly secondary production and tool use as well. This association of activities involving lithics with fireplaces is well known throughout prehistory, and it is supported by evidence from other northern and western Scottish house sites, for



Illus 53 Dalmore. The distribution of burnt lithics from Sharples' excavation. Contours at 1 piece intervals (lowest contour = 1 piece)

example Sumburgh (Downes & Lamb 2000, 115). In Dalmore's Phase II, only approximately one-sixth of the quartz was affected by fire, compared to approximately one-half of the site's entire quartz assemblage; this is probably a result of the Phase II knapper sitting slightly further away from the hearth than the later knappers of the building, possibly to the north-east of the central hearth.

A loose concentration of cores suggest a possible internal door dump to the north-east, and tools deposited during Phases II/III in the debris-free areas to the north and east may either represent abandoned material tossed out of the main activity zone to avoid future problems to in-house traffic, or small caches. The notion of caches is supported by a cobbled area to the north which may be the base of a wall, or a paved area: if this is, in fact, a paved area, this may be the sleeping area, which explains why this part of the building is virtually free of knapping debris.

The composition of the tool group suggests that, at Dalmore, an important activity was the production of barbed-and-tanged arrowheads. This suggestion is substantiated by several complete arrowheads (8), as well as a number of early- and late-stage arrowhead rough-outs (11). The many scrapers (38), obviously, indicate 'scraping' activities, and the tendency of some Early Bronze Age scrapers to have acute, or relatively acute, scraper-edge angles (55–65°) may suggest the processing of hides or skin, as opposed to the harder materials wood, bone and antler (Broadbent & Knuttson 1975; Jeppesen 1984; Thorsberg 1986; Juel Jensen 1988). The association of scraper-edge angles with function is discussed in more detail in the report on the quartz assemblage from Bayanne (Ballin forthcoming j). Other tool types than arrowheads and scrapers are present in single-digit numbers (piercers, notches, denticulates and truncations).

7.3.3 *Cruester (Ballin forthcoming e)*

This assemblage was recovered from a complex cellular stone structure at the centre of the Cruester Burnt Mound on Bressay, Shetland (Moore & Wilson 2003a), almost identical in plan to the structure associated with the burnt mound at Tangness, Eshaness, Shetland (Moore & Wilson 1999). The finds are thought to date mainly to the Later Bronze Age. As shown in Table 29, quartz artefacts were distributed across most of the building: the Passage 12 pieces; Cell A 13 pieces; Cell C six pieces; Cell D nine pieces; Cell H (cistern) two pieces; and the Tank Area one piece.

Obviously, the spatially restricted passage would not have been the focus of activities involving the

Table 29 Horizontal distribution of artefacts – Phase 3

Context no.	Context description	Total quartz	Flakes*	Chunks	Core prep.	Cores	Tools
8	Cell A – mottled ashy deposit	5		5			
13	Floor of passage – sandy loam	5	1	3			Scraper
23	Cell A – red-brown soil	6		5		Single-platf.	
24	Cell A – black soil	2		2			
32	Floor of passage – sandy loam	7	4	3			
39	Cell D – grey-brown clay	9	5	4			
40	Cell C – dark brown clay	1		1			
41	Tank Area	1		1			
46	Cell C – dark brown clay	5	1	3		Opp. platf.	
51	Cell H - cistern	2		2			
8/23	See above	5	1	4			

use of quartz tools (modified or unmodified), or for the storage of quartz tools, and it is most likely that the implements recovered in that area were dropped during movements between the exterior and interior of the building. Though it is almost impossible, in the present numerically limited case, to determine with certainty whether the individual tools, blanks and cores were produced, used or stored in the various rooms, the composition of the small sub-assemblages does suggest some specialization between rooms. The fact, for example, that all quartz artefacts in Cell A are either chunks or cores may mean that this room was a focal point for primary production, and the fact that the majority of the pieces from Cell D are either flakes or relatively thin chunks may indicate that in this room unmodified quartz tools were being used (cutting activities)? However, due to the small sizes of the sub-assemblages, these suggestions remain somewhat speculative.

The evidence from various quartz-bearing locations suggests that, in prehistory, different practices were followed regarding structures and quartz use. At the Middle Bronze Age site Bayanne (Yell, Shetland), for example, all primary and secondary production was carried out either outside the dwellings, or in specialized workshops, and the quartz artefacts recovered from the houses are thought to be stored tools, blanks or raw material (Ballin forthcoming j). At the Lewisian Beaker site Dalmore, on the other hand, primary and secondary production was carried out within the building, and quartz artefacts found outside the structure probably mainly relate to dumped material (Ballin forthcoming g). Evidence from other quartz-rich house sites in northern Scotland, suggests that, in most cases, the production and use of lithic blanks and tools took place within buildings rather than outside (eg Scord of Brouster: Whittle 1986, 87; Ballin 2007a; Catpund: Ballin 2005; Tougs: Hedges 1986, 14–17; Sumburgh: Downes & Lamb 2000, 112–16).

7.3.4 Scord of Brouster (Ballin 2007a)

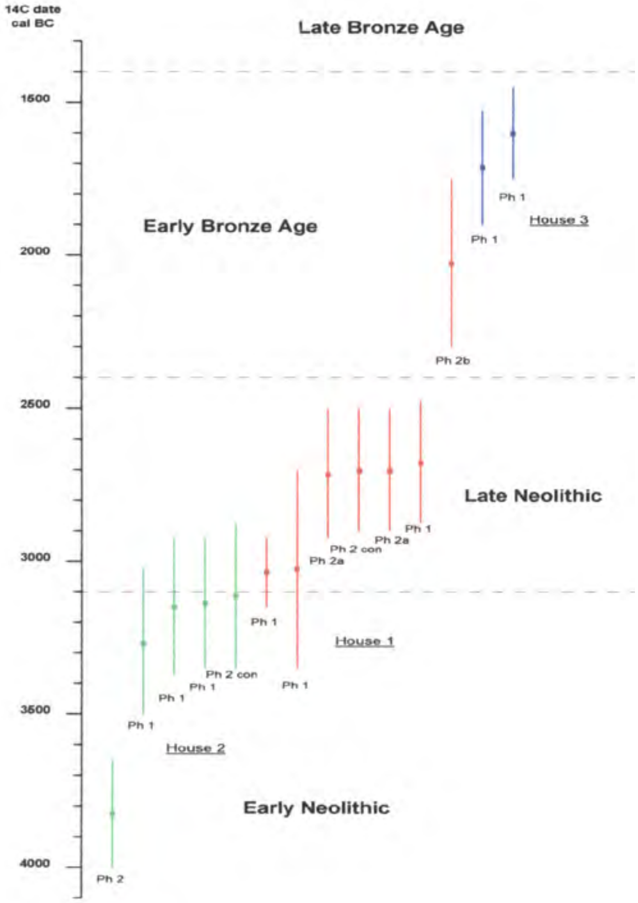
This assemblage was recovered during an excavation of a settlement site in the west mainland of Shetland. The site included three oval or cellular house structures, with one structure probably replacing the other (House 2 ⇒ House 1⇒ House 3). Houses 1 and 2 most likely date to the later part of the Early Neolithic period, whereas House 3 may be of an Early Bronze Age date (illus 54).

In this section, the debitage, core and tool distribution is discussed, as well as the activities suggested by the scattering of artefacts. First, the internal distribution patterns of the three houses is dealt with, followed by the distribution across the three houses. As the principles of recovery and recording of finds differ from house to house, and between layers, the author was incapable of producing standardized distribution maps (point and contour maps) and, in the following discussion, reference will be made to Whittle's general distribution maps. (For a detailed discussion of the three structures see Whittle 1986, 85–90.)

House 2 (Whittle 1986, figs 68–69)

This structure is approximately kidney-shaped, includes two recesses, and has no obvious entrance. The fact that individual finds were recorded in a variety of ways (exact 3D-plotting, per quarter of square metre, and per sector) makes it difficult to get a general picture of the distribution of lithic artefacts. However, it is the author's impression, that the distribution pattern is more or less the same throughout Phases 1 and 2 (pre-house, construction and use-phases) of House 2.

Generally, most quartz artefacts were found in the western half of the house, with fewer finds in the two central sectors, and even fewer in the two eastern sectors and in the north-east recess. Though the



Illus 54 The dates of the three Scord of Brouster houses

majority of finds from Phases 1 and 2 were recorded per sector, the more precisely recorded and plotted finds suggest that the tools were mostly found in the open area around Hearth F4, a possible central fireplace. The cores were partly recovered from areas characterized by knapping and partly from more peripheral areas. Cores from prehistoric sites are frequently found in the peripheral parts of settlements or houses, as they may have been removed ('tossed') from the central zone of sites as part of preventive maintenance (Binford 1983, 189).

The individually plotted quartz objects of Phases 1 and 2 indicate that the northern (F1) and north-eastern (F2/3) recesses were almost, but not entirely, devoid of finds. The larger (F2/3) of the two recesses is approximately 2m long and may have been a sleeping area (cf distribution of lithic finds in the Dalmore house; Ballin forthcoming g). The function of the northern recess is less certain. The quartz distribution in Phase 3 (decay) is probably linked to the use of the location after its general abandonment. Lithics were found evenly scattered across the interior of House 2, but also across the wall tumble and outside the house.

The above distribution patterns only yield little and general information on activities involving quartz use. Knapping was mainly carried out in the western half of the structure, with some knapping and tool use taking place around the central hearth. Clearance of rubbish appears to have taken place, but mainly in the form of preventive, not *post hoc*, maintenance (Binford 1983, 189), leaving large amounts of lithic waste cluttering the floor space. Two areas, Recesses F1 and F2/3, have been kept relatively free of rubbish, and the size of Recess F2/3 would have allowed use as a sleeping area.

House 1 (Whittle 1986, figs 70–74)

This building is oval, with six recesses, and orientated approximately north-west/south-east; it has an entrance to the south-east. In Phase 1 (pre-house), most of the quartz waste, cores and tools were scattered across the southern half of the building, and a large concentration of quartz artefacts was deposited under the southern wall, outside Trench F10, and a small concentration in Recess 1 to the north-east. The quartz distribution was associated with three hearths, F1 in Recess 4 to the south-west, central hearth F2, and the more complex hearth F4–8 in Recess 1 to the north-east. No areas were specialized, and quartz knapping and tool use seem to have taken place throughout the space occupied by lithic debris.

In Phase 2 (main use-phase), there were less quartz and it had a wider distribution. The centre of the building was more or less free of clutter, with most of the lithic finds deriving from either areas along the northern wall, or from a zone just inside the southern orthostats. In the northern half, most of the quartz was found in Recess 6, and small concentrations in Recesses 1 and 2. In the southern half, most of the quartz was recovered from within, or just outside Recess 4, and several pieces from the area surrounding Orthostat 8 (separating Recesses 3 and 4). Again, quartz waste, cores and tools were mixed, with no apparent separation of, for example, knapping floors and areas for tool use. There were a number of hearths (F15 being a central fireplace), or ashy patches, along the central long axis of House 1, the area kept free of lithic waste.

It is possible that some recesses were workspaces, and others sleeping areas, but the quartz concentrations are not dense enough to have prohibited any of the recesses from having been sleeping areas. However, Recess 6 was also associated with a central concentration of coarse stone tools (mainly ard points), suggesting that this particular part of the structure may have been a working area, and the distribution of small scoops and fireplaces in Recesses 1, 5 and 6 makes Recesses 2-4 most probable as 'private quarters', or sleeping areas. In the case of dwellings, traffic in and out of buildings frequently results in a trail of lithic debris in the entrance area, and a solid concentration immediately outside the doorway (cf Dalmore; Ballin forthcoming g). An entrance trail and exterior concentration were not identified in connection with House 1, Phase 2.

Table 30 Scord of Brouster, Houses 1 and 2. The proportions of the main tool categories

	Numbers		%	
	House 1	**House 2**	**House 1**	**House 2**
Arrowheads	2	0	2	0
Knives (incl. truncated piece)	7	7	6	8
Scrapers	91	69	75	77
Piercers	4	2	3	2
Notches and denticulates	2	2	2	2
Pieces with various retouches	12	9	10	10
Fabricators and hammerstones	3	1	2	1
TOTAL	**121**	**90**	**100**	**100**

In Phase 3 (decay), the majority of the worked quartz pieces were found along the walls of the structure, with only a small number of lithic artefacts deriving from the central parts of the building. The discussion of distribution patterns is limited by the retrieval methods, with the findspot of some quartz artefacts having been recorded precisely, and some only by house sectors (each *c* 2–3 x 2–3m). The individually plotted artefacts indicate a concentration in one corner of Recess 1, and the sector-recorded finds suggest the presence of one or more concentrations in the eastern quadrant (possibly the Recess 1 concentration identified by the individually plotted pieces), and outside the entrance. The latter imply either the presence of an entrance trail or a so-called 'door-dump' (Binford 1983, 151), where rubbish was deposited in connection with *post hoc* maintenance.

The distribution of quartz does not allow a more detailed analysis of the activities in House 1. Considerably more quartz blanks, cores and tools were produced during Phase 1 than during Phase 2, but as the exact duration of the individual phases is unknown, it is not possible to infer that more quartz implements were produced and used per time unit (eg per year) in Phase 1. No areas appear to have been used particularly for primary production or tool use, as blanks, cores and tools are generally mixed. The distribution of lithic debris was more widespread in the pre-house phase than in the main occupation phase, with the quartz of Phase 2 respecting and avoiding the central space. Knapping and tool use seem to have taken place mainly in, or just outside, the various recesses (at the Middle Bronze Age site of Bayanne on Shetland no knapping took place inside the dwellings, but only outside the houses or, to a minor degree, in work-sheds; Ballin forthcoming g). A low local density of lithic and stone rubbish suggests that one or more of Recesses 2–4 may have been sleeping areas, with the remaining recesses possibly having been used as work-spaces. The finds of the abandonment phase are not numerous enough to allow detailed inference, but the small concentration of quartz in a corner of Recess 1, and another possibly outside the entrance, suggest that even at this stage of disintegration the structural elements of the building were respected in the organization of activities.

House 3 (Whittle 1986, figs 75–76)

The lithic finds of this structure are too few in number to allow definition of internal spatial patterns.

Lithic artefacts and activities

The sub-assemblages from Houses 1 and 2 are substantial, whereas the material from House 3 is numerically limited: 5688 lithics (59% of the total collection) were recovered from House 1; 3772 lithics (39%) from House 2; and only 227 lithics (2% of the total) from House 3. The proportions of the three main categories, debitage, cores and tools, are roughly the same in Houses 1 and 2, with debitage making up approximately 97% of all lithic artefacts, cores *c* 1% and tools *c* 2%. In House 3, debitage constitutes 99%, and cores and tools each *c* 0.5% (one single-platform core and one retouched piece).

As shown in Table 30, the tool spectra of Houses 1 and 2 are almost identical. In both sub-assemblages scrapers make up approximately three-quarters of all tools, with retouched pieces being the second most common tool group (10%). The relatively large number of curved knives makes knives comparatively numerous in both houses (6–8%). All other tool categories represent proportions of between 0% and 2% of the two sub-assemblages.

In terms of function, the arrowheads were produced either for defensive or hunting purposes; the two types of knives may represent different functional categories: the scale-flaked knife and the truncated piece, with their straight edges, would have been suitable for traditional cutting work, for example butchering, whereas the curved knives may form a separate group of specialized implements – their precise function is presently unknown. The analysis of scraper-edge angles (Ballin 2007b) suggests that the scrapers were manufactured mainly for the processing of harder materials, such as bone, antler and wood. The fact that half of the piercers have almost blunt tips and the other half acutely pointed tips indicate that these may have been used for a variety of tasks – the blunt, more robust pieces may have been involved in the drilling of harder materials, and the more acutely pointed ones may have been used to penetrate softer materials, such as leather and skin. The notched, denticulated and retouched pieces probably represent a number of different functions.

The leaf-shaped arrowhead CAT 2297 from House 1 is a rough-out and proves that arrowheads were produced on site. CAT 2080 (House 2) is most probably a pre-form of a large leaf-shaped arrowhead broken during production, and CAT 2050, 2092 and 2124 (Houses 1 and 2) are probably base-fragments of leaf-shaped arrowheads. They may have broken during use (hunting?) in the field, and the arrows, with the bases of the points still attached to the arrowshaft, were brought back to the settlement for retooling (Keeley 1982).

The number of functions covered by the lithic tools from Houses 1 and 2, and the similarities between the two sub-assemblages, support the notion of the structures as being permanent, or semi-permanent (seasonal), dwellings (cf Whittle 1986, 137). It is a well-known fact that in prehistoric times many, or most, tools were made in perishable materials, and a large number of the lithic tools may have been used for the manufacture of tools and other products in organic raw materials (wooden bowls and spoons, bone piercers and points, clothing and adornments, fish-traps, nets, bows and arrows, shafts and handles, etc). No such objects were recovered at Scord of Brouster, but the excavation of prehistoric settlements from submerged or wetland sites (eg Oakbank Crannog, Loch Tay, Perthshire; Dixon & Cavers 2001, 78–9) demonstrates that implements in organic materials usually made up a large proportion of the tools employed by prehistoric people.

The lithic assemblage from House 3 (practically all from the main Structure 3a) defines this unit as functionally different. As demonstrated by Fischer *et al*, lithic reduction produces much debris in a short span of time (Fischer *et al* 1979, 12). In one experiment at the Lejre Archaeological Research Centre, Denmark, almost 20,000 flakes were manufactured in 2 hours and 40 minutes, and the 170 flakes and indeterminate pieces from House 3 may represent a single brief knapping event. The small amount of lithic rubbish probably represents one of three scenarios: either House 3 was in use for a very short period; it was thoroughly cleared out; or the structure may have had a specialized function (or a combination of the three). The composition of the debitage supports the latter option.

The sub-assemblage from House 3 includes the same proportion of flakes as Houses 1 and 2 (on average 77% of the debitage), but fewer chips (3.5% against *c* 16–20%), and many more natural pieces of quartz (*c* 20% against *c* 3–6%). As suggested above, the flakes of House 3 may derive from a single knapping event, and the large amount of natural quartz is probably a bi-product of the decortication of relatively large numbers of raw quartz blocks. Most of the natural quartz has sandstone adhering to it, and this material had to be removed before the collected quartz was suitable for schematic reduction. The decortication of raw quartz blocks would not produce many chips; they would largely be produced as part of the primary and secondary production sequences. The decorticated core rough-outs were most probably removed from the building for further reduction elsewhere.

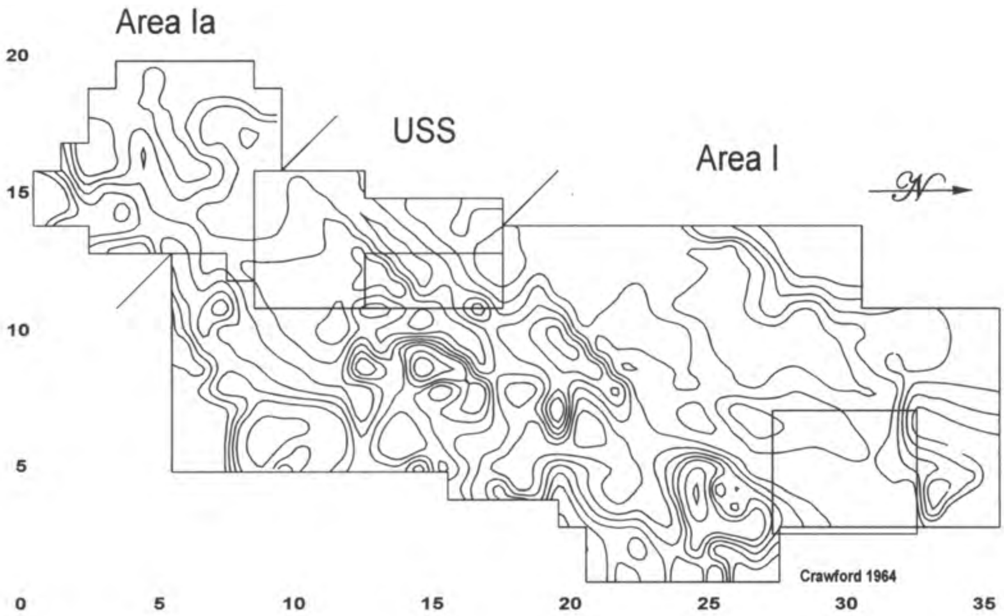
This suggests that House 3 may have had a workshop-like function, though the internal structure of the building, with a central hearth and five recesses or cells, corresponds to the structure of other contemporary Shetland dwellings (eg Calder 1956). As the radiocarbon dates indicate a possible chronological overlap of the use-phases of Houses 1 and 2, but none between House 3 and the other buildings, it is uncertain which settlement the House 3 workshop was linked to.

7.3.5 Rosinish (Ballin forthcoming h)

During the excavation of this wind-eroded machair site, Rosinish was divided into three spatial units: Areas I, II and III. Area I is the main Beaker midden, and includes a U-shaped structure (dwelling?), Area II, north of Area I, is a much smaller Beaker midden, and Area III, south of Area I, constitutes a midden with traces from the Iron Age and Medieval periods (Shepherd 1976; Shepherd & Tuckwell 1977b). A cursory examination of the catalogue showed that the main bulk of the lithics (2746 pieces) were recovered in Area I, with only 818 lithics deriving from Area II, and four from Area III. Most of the finds from Areas II and III were chips from sieved samples. For these reasons, it was decided only to include the lithics from Area I, the main Beaker midden and the U-shaped structure, in the distribution analysis.

A basic distribution analysis showed that most of the artefacts were concentrated in three south-west/north-east oriented bands ('ridges') with find-poor bands ('valleys') separating them (illus 55). The 'valleys' and 'ridges' run perpendicular to the site's main blow-out (Shepherd & Tuckwell 1977b, fig 1), and it is possible that these distributional features owe their existence mainly to wind-erosion/dune-building.

The most important distributional phenomenon is the fact that most of the burnt quartz was recovered from areas to the north, north-west, west and south-west of the post-midden U-shaped structure. The burnt quartz must therefore be associated with this structure and activities in it. A weaker tendency in the distribution of flint artefacts suggests that the flint tools were not produced and used in the same



Illus 55 Rosinish. The distribution of quartz flakes. Contour intervals: 1 piece (0–6), 2 pieces (>6); lowest contour: 1 piece. The location of Crawford's 1964 excavation is indicated (Crawford 1977)

areas, with the unworked flakes mainly deriving from the southern part of area I proper, and the flint scrapers from areas outside this zone. Generally there is very little flint debitage, and most likely the majority of the flint tools were made outside the site.

7.3.6 Summary

The general intra-site spatial patterns revealed by the above presentations are influenced by the fact that all Scottish sites available for this form of analysis are Neolithic/Bronze Age house sites. Open-air Mesolithic and Neolithic/Bronze Age sites were organized in entirely different ways, with more pronounced toss zones (Ballin forthcoming j). However, the identified patterns correspond well with the patterns observed by Binford (Binford 1983, 172–87) in an analysis of the huts, houses and tents of hunter–gatherer groups. For this reason, the structure of the following summary has been based on the spatial elements used in Binford's analysis.

Knapping floors

In general, primary production appears to have been an indoor activity, which mainly took place around indoor hearths, but at Bayanne the actual dwelling structures appear to be completely devoid of lithic production waste. Here, the production of blanks, and possibly tools, seems to have been carried out outside, and between, the various structures, occasionally in combination with preliminary sorting of the produced blanks (sorting was also witnessed at Steinbustølen in the Norwegian High Mountains; Ballin 1998b). These differences may be explained in several ways, such as (i) different yearly cycles of the inhabitants of the structures, and (ii) different abandonment patterns.

As indicated in a forthcoming publication, blank production was generally associated with fireplaces (Ballin forthcoming j), as fire provided light, heating and protection, and '...the domestic hearth was the focal point in the daily life of the inhabitants' (Stapert 1989, 5). It is obvious that, in the cold Scottish winters, quartz knapping would not have been carried out outside the dwellings, whereas, in the summer periods, it could have been. Though there is no definite evidence indicating when the above structures were inhabited, it is possible that they were used at different times of the year, with some house structures representing year-round occupation, whereas others may be shielings (Whittle suggests that Scord of Brouster may represent semi-permanent occupation; Whittle 1986, 133–50). Though the spatial pattern at Bayanne may have been influenced by site maintenance, for example clearing of the houses, the fact that all production waste was found outside the dwellings may be an indication that at least the last (outdoor) knapping events took place in the warmer half-year.

At Kavonkangas, in Finland, the Neolithic Houses 34 and 35 are characterized by the finds mainly being inside (H 35) or outside (H 34) the structures. The excavator interprets these differences as representing different forms of site formation, or modes of abandonment (Rankama 2002, 107; Rankama 2003, 216), where House 34 was cleared, and House 35 not. This may be due to the inhabitants expecting to return to the former site (which, for some reason, they did not), whereas the inhabitants did not intend to return to the latter. However, it is also possible that the two structures were inhabited at different times of the year, allowing quartz knapping to be undertaken outside House 34 (summer?), but making it necessary for primary production to be undertaken inside House 35 (winter?). At Rosinish, disparity between the numbers of blanks and tools indicate that most of the tools may have been imported into the site, and not produced inside or outside the so-called U-shaped structure.

Disposal areas

Disposal areas are known in a number of forms, such as toss zones (preventive maintenance), and proper middens or dumps (*post hoc* maintenance; Binford 1983; Ballin forthcoming j). All these types of waste areas were identified in connection with the above analysis.

At Dalmore and Scord of Brouster, the distribution patterns suggest that preventive maintenance took place, and larger pieces of quartz waste appears to have been tossed from the central parts of the dwellings towards the peripheral areas. When rubbish turned into irritating clutter, occupants in many cases commenced *post hoc*, or actual, clearing, initially in the form of door dumps, immediately outside the house entrance, and, later, in the form of more remotely located middens. At Bayanne, Dalmore and Scord of Brouster, quartz door dumps were identified, and at Bayanne an actual midden was located in an abandoned building. It is possible that, at Rosinish, the concentration of burnt quartz immediately outside the U-shaped structure represents a door dump, but it seems to be a more substantial midden, possibly located at the 'back-side' of the house. The Norwegian Mesolithic 'pit-houses' frequently include a small and a larger outside dump or midden (eg Persmyra 37a and 39; Boaz 1997; also see the distribution of finds at Holter 1; Ballin 1998a, 120), one of which is probably a door dump and one a 'back-side' midden.

As demonstrated by the frequently well-preserved Norwegian house sites, the internal artefact scatter was in many cases linked to the door dumps by a tongue of debris, identifying the house entrance (eg Persmyra 37a, Boaz 1997, fig 30). This is also the case at Dalmore, where an extended tongue of quartz waste connected the interior clutter with two door dumps, and possibly even a small internal door dump, and an 'entrance trail' was identified at Scord of Brouster House 1 (Phase 3).

In some cases, extended occupation at a site allowed the outdoor dumps and middens to grow to impressive sizes and eventually merge into one mound surrounding or covering the building. This seems to be the case at Cruester, where the house site developed into a burnt mound, some of which was quartz. At Persmyra 112 in Hedmark, Norway (Boaz 1997, fig 60), the northern of two pit-houses was completely surrounded by lithic waste and other debris.

It is possible that the various types of waste deposition represent stages in the 'life' of a prehistoric house, giving at least a 'hint' as to the use intensity of the individual building. The development of toss zones is probably the result of an almost automatical behavioural pattern, something 'you just do' because it has proven to be practical: when a piece of rubbish is sizable enough to represent a potential future problem to activities on, or traffic across, the house floor, it is automatically tossed out of the centre. The development of actual dumps or middens, on the other hand, is most likely a result of an extended visit to a location, as it takes some time for rubbish to grow into a problem in need of special attention (formal clearing activities; Binford 1983, 189–90). Probably, door dumps start developing first, middens later, and burnt mounds, such as the one at Cruester, may be the last stage of this process.

Activity areas

The definition of activities on Scottish quartz-bearing sites is supported by the distribution of quartz on the sites of Bayanne, Dalmore, Scord of Brouster and Cruester. At Bayanne and Scord of Brouster, the activity patterns are influenced by the presence of more than one structure, and apparent specialization between the various buildings. At Bayanne, quartz tools were probably used between the main structures and the smaller 'sheds' or workshops, or within the sheds. At Scord of Brouster, House 3 may have been a workshop, associated primarily with the decortication of the collected or quarried quartz (in this case, mainly the removal of excess sandstone remains from the local bedrock).

At Dalmore, Scord of Brouster and Cruester, most quartz tools were used within the dwellings. Some degree of specialization seems to have taken place between the various sub-areas of the houses, such as the central parts, and the bays or cells. At Cruester, Cell A (characterized by robust chunks and cores) may have been set aside for primary production, whereas Cell D (characterized by flakes and thinner chunks) may have been used mainly for tool using activities (cutting?). At Scord of Brouster, a division of labour is not clearly defined by the quartz, and knapping and tool use may have been spatially overlapping activities. There does, however, seem to have been a separation of quartz and stone production, as in Recess 6 of House 1 mainly sandstone ard points were found.

The quartz tools from Bayanne, Dalmore and Scord of Brouster were distributed slightly differently in relation to the centre of the houses. At Bayanne, practically no tools at all were found in the dwellings; at Dalmore, most tool use may have taken place around the central hearth; and at Scord of Brouster, tool use appears mainly to have taken place either around a central hearth (House 2), or at some distance from the central area (partly within the recesses), with the centre being reasonably free of clutter (House 1).

Most of the prehistoric houses include either 'clutter-free' areas along the walls or, in the cellular structures, in one or more cells. These parts may have been sleeping areas, where no primary or secondary production took place, but occasionally these areas are associated with small caches (see below), or they may be paved (at Dalmore, a paved area is associated with a possible cache). Similar arrangements are known from several of the Scandinavian dwellings, such as the almost archetypal distribution of finds in the house of Persmyra 37a (Boaz 1997, fig 30), with its internal production waste, entrance trail, door dumps, 'back-side midden' and 'clutter-free' sleeping area.

Burnt quartz

As indicated in Section 4.4.3, Scottish quartz assemblages are generally characterized by high ratios of burnt quartz, and particularly the house sites have high ratios (*c* 40–65%; Table 17). The general tendency for this burnt quartz waste is to either indicate the position of shifting hearths, or dumps/middens. At Dalmore, burnt quartz pinpoints the location of a number of, probably not contemporary, hearths, with one relatively weak concentration indicating the slab-build central hearth (illus 53). At Rosinish the bulk of the burnt quartz was found in a midden outside the U-shaped structure.

The investigation of burnt quartz is still in its infancy, and much research needs to be carried out to reach an answer to the question of the activities creating this burnt waste. Some of the burnt quartz may be rubbish from cooking ('potboilers') or saunas, or possibly from attempts at heat-treating quartz, as indicated by one invasively retouched curved knife with scorched faces (Scord of Brouster). The different types of burnt quartz (yellow and white, dull and shiny) may characterize waste from different activities, but these differences may also have been caused, at least partly, by post-depositional factors, such as soil conditions.

Caches and stores (in bays/cells etc)

Possible caching is suggested by quartz finds from Bayanne and Dalmore. At Bayanne, the quartz from Events 6 and 9 (superimposing Structures 5 and 6) indicates that sorting of the produced blanks may have taken place, and the sorted and collected blanks may be defined as caches. In the peripheral parts of the Dalmore house (Phases II/III), two small tool concentrations (each including a hammerstone) may be caches. This interpretation is supported by the fact that they were found in the relatively clutter-free part of the house in close association with the paved possible sleeping area.

Small caches are occasionally found on prehistoric sites, and frequently in possible dwelling structures. On Storsand 53, in the Norwegian Oslofjord area (Ballin 1998a, 43), a number of collected quartz crystals were recovered within an area interpreted by the author as a possible dwelling (?hut, ?tent). In Finland and northern Sweden caches of quartz chunks have been identified in connection with quartz quarries (eg Broadbent 1979, 102; Alakärppä *et al* 1998, 11). In his report on the Richburgh Quartz Quarry, South Carolina, Cantley suggests that '… once a small or sufficient quantity of early stage biface blanks were produced, they were curated to other nearby habitation or special purpose sites where they would be finalized into finished tool forms' (Cantley 2000, 103, quoting House & Ballanger 1976, 128). Most probably, caches of raw material, prepared cores, blanks and preforms are to be expected at quartz quarry sites.

7.4 Burial and ritual sites

In Scotland, quartz has been recovered from several burial or ritual sites. These sites are usually either cairns, megalithic graves or cist burials, and the quartz may take different forms, probably relating to the specific function of the deposited quartz, or the place and date of the monuments (different perceptions of quartz and different cultural traditions). In some cases, the quartz is in the form of raw pebbles or cobbles, in other cases it has been crushed, or it has been transformed into blanks, cores and tools.

At the Calanais ritual complex, on Lewis, a quartz assemblage was recovered, including blanks, cores and tools. Most of this material was found in association with the central cairn, but it is thought (Ballin forthcoming a), that the majority of the finds represent on-site activity prior to or following the cairn's construction. However, the distribution of quartz within the cairn, with most trenches including *c* one-third burnt quartz and Trench H *c* 80% burnt quartz, indicates that activities at the cairn may have included fire – although it cannot be ruled out that this pattern simply reflects the scooping up of soil for the cairn from different parts of an underlying or nearby settlement. A small number of mainly quartz arrowheads were recovered from the chamber.

At the Olcote kerbed cairn, also on Lewis and a few km north of the Calanais ritual complex, a huge assemblage of quartz was recovered (Neighbour 2005). Warren & Neighbour describe the site's complex formation processes, with some residual worked quartz deriving from contexts beneath the cairn, finer pieces were deposited within the monument, and it may have been carpeted in crushed quartz (Warren & Neighbour 2004).

As mentioned above (Section 4.3.3), several of the arrowheads found at Calanais are in 'greasy' quartz, which may have been imported into the island. Outside the assumed source area, near Shieldaig on the mainland, this resource may have been saved for the production of more prestigious objects, such as arrowheads and other sophisticated forms. It is not possible to assess how many of the artefacts deposited in the Olcote cairn are in this material, as the quartz was classified according to a different type schema (ie not corresponding to that presented in Table 16).

The carpeting of the Olcote cairn in quartz is thought, by the excavators, to reflect the striking visual attributes of this material. In this case crushed quartz was used, but in other cases raw pebbles were used. Worked quartz or raw pebbles have been used in burial/ritual contexts throughout the western and northern parts of the British Isles as either capping/revetment of chambered tombs (eg Newgrange: O'Kelly 1982, plate VII), kerbing of cists (eg Glen Luce, Galloway: Lebour 1914, 121), interior paving of chambered tombs (eg Nether Largie, Argyll: Henshall 1972, 97) or cists (eg Burgie near Forres, Moray: Lebour 1914, 123), or quartz may have been deposited as small caches (eg Walton Farm, Dunbartonshire: Henshall 1972, 422).

In a number of cases, quartz, or quartz-rich boulders, formed structural elements of monuments: on Man small mounds consisting almost exclusively of quartz are common (Pitts 1999), and at Glecknahavill and Clach na Tiompan, both Argyll, quartz-rich boulders were incorporated into the monuments (Henshall 1972, 97), as was also the case at Balnuaran of Clava in Inverness-shire (Bradley 2000, 126). At the latter site, two different lithic industries, both dominated by quartz, were identified (Bradley 2000, 85). Stratigraphical observations suggest that at least the quartz from the north-east passage grave was deposited after the erection of the monuments, probably as part of rituals carried out around the megalithic graves.

Though most of these quartz-bearing Scottish, Manx and Irish sites are of Neolithic or Early Bronze Age dates, later prehistoric British and European monuments with quartz deposits are also known. A possible Later Bronze Age or Iron Age mortuary house was investigated at An Dunan on Lewis, and during the investigation unmodified quartz pebbles were recovered (Burgess *et al* 1997; Warren & Neighbour 2004). At Lilla Sylta 87 in central Sweden (Andersson 2004), a number of Migration Period graves were unearthed, many with crushed quartz. Apparently, the quartz was incorporated into the grave fill, and in one case as much as 59kg of this material was recovered from a single burial. In historic times, pebbles were placed in graves in south-west Scotland (Lebour 1914).

Most analysts favour the interpretation that quartz was used in burial or ritual contexts because of its striking visual attributes (Lebour 1914; Bradley 2000; Darvill 2002; Warren & Neighbour 2004), that is, its whiteness. That the colour white had particular importance to prehistoric people is supported by the fact that, in areas where quartz is rare, such as Denmark, white-burnt flint may have been used in the same manner. In the megalithic chamber of Klokkehøj near Bøjden, on Funen (Thorsen 1980, 112), burnt flint formed a thin layer on top of a paved floor. The question, then, is what the white quartz symbolized, to make it particularly suitable for deposition in graves and ritual contexts?

There is probably little doubt that the moon and its cycle played an important part in the belief systems of many prehistoric peoples, and it is thought that many stone circles ('plain', as well as recumbent) were orientated in a way that allowed them to be used as a form of lunar calendars (Bradley 2004). Burl suggests that the quartz may itself have been associated with the moon as prehistoric people possibly:

> ...saw, in the litter of quartz that glittered so brilliantly in the moon light fragments of the moon itself. The same connections between quartz, moon and death may have led to the frequent deposits of quartz and white pebbles with burials in prehistoric Britain (Burl 1980, 196).

Warren & Neighbour support this interpretation, and they refer to the recumbent stone circle at Strichen, Aberdeenshire (Warren & Neighbour 2004), where a crescent-shaped deposit of quartz pebbles was placed opposite the recumbent stone (also see Burl 1995, 107–9).

8 Recovery, Analysis and Storage of Quartz Assemblages – Recommendations

8.1 Introduction

The research into archaeological quartz has three main stages, namely:

- recovery of quartz artefacts and assemblages in the field
- analysis of the recovered quartz finds in the laboratory
- storage of the recovered quartz.

The three elements of quartz research are interconnected, in the sense that the initial choice of recovery policy defines which inference may be made at a later stage, and how detailed this inference can become, and it defines the museum storage requirements. Each of these stages is characterized by its own set of methodologies, and, due to the notable differences in appearance, availability, and flaking properties (see Section 4), archaeological quartz research has been less fruitful than the research into worked flint. To a degree this may be perceived as a historical problem, as the output level of quartz research, as well as the quality of this output, has been improving steadily. However, quartz research is still affected by quartz-specific problems, such as the recognition of quartz in the field, interpretation of the recovered finds, and storage of the frequently very large quartz assemblages. These problems are addressed in this section.

8.2 Recovery policies

As mentioned above, many of the difficulties relating to archaeological quartz research are historical by nature. In terms of recovery policies, these problems may be sub-divided into two groups, namely, (i) difficulties relating to the more lax recording procedures of early archaeology, such as, limited stratigraphical observation and recording of finds either by site or by trench, rather than by grid unit or context (as, for example, in the case of most quartz assemblages from Jura; eg Mercer 1968; Mercer 1971; Mercer 1972), and (ii) quartz-specific problems relating to the recognition of worked quartz (causing the introduction of selective recovery of formal core and tool types; eg Hamilton 1956; Calder 1956; Calder 1964).

General excavation procedures have improved over the years, with quartz artefacts now being recorded meticulously by layer and grid unit, or by context. The second problem, however, still remains. Archaeological quartz is as difficult to recognize as ever, and it must be assumed that, even today, a proportion of the archaeological sites' content of worked quartz is not being collected. As a consequence, quartz assemblages, or sub-assemblages, may still be less representative than flint assemblages.

The best way to deal with this problem is probably to acknowledge that archaeological quartz is best dealt with by an experienced *quartz* specialist, that is, not simply a general lithics or flint specialist. When consulted by excavators, inquiring about how to best deal with quartz in the field, the author usually suggests the introduction of the following two simple rules:

- *If in doubt, keep everything*, and allow the quartz specialist to sort the finds in the laboratory. It is always possible to discard unworked quartz later, whereas quartz artefacts missed in the field are missed forever.
- If this rule is not practical, for example due to the presence of excessive amounts of quartz, it is suggested to *keep all pieces with one or more sharp edges, and discard all rounded pieces*. The reduction of quartz, even the initial testing of quartz nodules, should lead to the production of at least one sharp edge. This rule is only unsuitable in connection with the excavation of previously transgressed or flooded sites, where post-depositional water action may have abraded the artefacts. In these cases, the first rule should be followed.

Obviously, adhering to these rules has as a consequence that large amounts of quartz may be recovered in the field, with subsequent implications for storage requirements and storage policies (see below).

8.3 Analysis

As mentioned above, the amount, character and quality of information gained from the analysis of quartz assemblages partly depends on the choice of recovery policy, but the experience of the analyst is also important, as is the specific choice of analytical approaches.

In terms of experience, it is crucial that the analyst is familiar with bipolar technology and the variation within bipolar products (cf Ballin 1999a), as this may shed light on the specific operational schemas of industries dominated, or influenced, by bipolar approaches. The analyst should also have a minimum of geological insight:

- to be able to identify the various sub-types of quartz (Section 4)

- to identify the possible sources of these quartz forms
- to distinguish between different sets of flaking properties
- to use this information to estimate the use-value (including symbolic value) of the different quartz forms, and define possible prehistoric territories and exchange networks (techno-complexes and social territories; Ballin 2007b).

The geological differences between quartz and, for example, flint (geological provenance, flaking properties, etc.) makes it imperative to separate the various raw materials and analyse the resulting sub-assemblages individually. Bulk analysis of, for example, quartz and flint artefacts tends to reduce the amount and quality of inference that may be gained from a lithic collection. In the presentation and discussion of the finds from the well-known Mesolithic sites on Jura (eg Mercer 1968; Mercer 1971; Mercer 1972) large sub-assemblages of flint and quartz (as well as some bloodstone and pitchstone) were dealt with as one combined assemblage, making it almost impossible to discuss matters, such as, different technological approaches (were two different operational schemas employed, one for quartz and one for flint and flint-like materials?), procurement strategies, social territories and exchange networks.

It is a well-known fact that burnt flint is a valuable source to the interpretation of intra-site spatial patterns and on-site behaviour (eg Ballin forthcoming j), particularly with regards to the identification of 'latent' hearths (the distinction between 'evident' and 'latent' structures was made by Cziesla 1990, 257, in his dissertation on settlement dynamics; also see Stapert 1987; Stapert 1989; Stapert 1990; Stapert 1992). Burnt quartz is practically never mentioned in reports on quartz-bearing sites, and it does not form an integral part of the interpretation of these sites. This is mainly due to the fact that burnt quartz, due to the specific attributes of this raw material, is much more difficult to identify than burnt flint, and the research into this matter is still in its infancy (eg Gonick 2003; Ballin forthcoming k). Presently it appears that burnt quartz takes two forms, namely, (i) dull, crackled and disintegrating white or grey quartz, and (ii) shiny, yellow-brown quartz with 'peeled-off' surfaces. It is possible that form (i) is connected to ordinary settlement activities, like most crazed flints, whereas the other form may relate to heat-treatment of quartz, or it may be the result of exposure to fire combined with specific soil conditions (particularly the iron-rich, acidic conditions of Scottish peat areas; see discussion in Section 2.4.11). It is hoped that, in the future, the recognition and discussion of burnt quartz may form a standard part of general quartz analysis, as burnt flint does to general flint analysis.

The comparison and interpretation of quart assemblages may be influenced by the analyst's choice of classification system. Any classification system must be tailored to fit the material under investigation, and, to allow comparison between assemblages, a standardized classification system should be employed by all quartz specialists. In central and northern Scandinavia (see Section 3), the difficulties relating to quartz research were largely seen as products of an inappropriate typology borrowed from flint research (Broadbent 1979; Callahan 1987; Knutsson 1998), and it was attempted to develop a specific quartz typology. This, however, had as a consequence that quartz assemblages and flint assemblages were no longer directly comparable (see for example Lehane's 1986 attempt at using a Scandinavian classification system on a Scottish quartz assemblage), and what would one do in cases where a specific assemblage was based on the simultaneous exploitation of equal amounts of different raw materials?

Consequently, the author advices against this practice. As demonstrated in the lithic analyses undertaken as part of the present project (eg Ballin 2002b; Ballin 2007a; Ballin forthcoming j), it is quite practicable to apply the same typology to all raw materials. The difference between quartz and flint assemblages is not so much that other tool types are manufactured in quartz, but that quartz assemblages – due to the different flaking properties of this material – may be based on different blanks, such as a larger proportion of chunks, thick flakes and abandoned cores or core fragments. These differences are revealed by the detailed characterization of the finds, which forms part of the general classification process.

The most central problem to quartz classification – that it is difficult to recognize retouch on quartz tools – is not going to be solved by the development of any new approach or method. It is a consequence of the physical appearance of this material (its shiny, reflective surfaces; in the case of rock crystal, the material's transparency), and the recognition of retouch on quartz is, and will remain, a matter of experience. The author has only made one observation, which may be helpful to lithics analysts, namely that retouch on quartz is much easier to identify when scrutinized from the 'lower face' of the piece (ie the face from which the retouch was initiated), rather than from the 'upper face' (ie the face affected by the removals, the reliefed surfaces of which are usually much more reflective).

8.4 Storage policies

Generally, the storage requirements of quartz artefacts correspond to those of artefacts in flint and flint-like raw materials. Lithic materials are predominantly hardy and durable and, in most cases, they do not require special attention. Consequently, ordinary quartz artefacts do not call for individual packaging, that is, there is no need for acid-free paper, silver foil, bubble-wrap or cling-film, and bulk packaging is acceptable (that is, multiple pieces per bag or box). The only exceptions are (i) artefacts in poorer qualities of quartz, characterized by excessive numbers of cracks and planes of weakness; (ii) burnt quartz artefacts; and (iii) exceptionally thin (mostly the more elegant and well-made) pieces. Burnt quartz, and objects in poor-quality quartz, tend to disintegrate, and the more elegant, thin pieces may break. In these cases, it may be necessary to bag the artefacts individually, occasionally even wrap them in some form of protective material.

The above guidelines may seem obvious to most specialists, but occasionally large quartz assemblages have been stored inappropriately – that is, in an excessively protective manner – which may make later re-examination of the assemblages unnecessarily time-consuming, or even prevent later analytical use of these finds. On one occasion, the author examined a large lithic assemblage which had been wrapped individually in acid-free paper, whereas, on another occasion, an equally numerous assemblage had been wrapped individually, first in silver-foil, and then in cling-film. In both these situations, the 'unwrapping process' required an input of an extra three to five days – which had not been included in these projects' general design or budget.

However, the most important point, in terms of storage policies, is the fact that many quartz assemblages are numerous, and, due to the flaking properties of this raw material, most quartz artefacts are somewhat chunkier than, for example, flint artefacts. As a consequence, archaeological quartz may take up large parts of museum stores. If the excavation of a specific quartz-bearing site was not carried out by a quartz-specialist, and the excavator chose to adhere to the advice given in Section 8.2 (that is, all quartz, or all sharp-edged quartz, was recovered), what would have been large collections if excavated according to standard methodologies, would grow even larger.

Therefore to prevent the storage of considerable amounts of natural quartz from occupying storage space unnecessarily it should be attempted to keep the time from initial storage to final examination and discard of unworked material to a minimum. It is not uncommon that an initial quartz collection is reduced by as much as 50–75%, and if the initial collection numbered, for example, 20 large standard boxes, the savings, in terms of museum storage space, would be considerable.

9 Acknowledgements

The author is most grateful to:

- Historic Scotland for being the main grant-aider of this project
- The National Museums of Scotland for the funding of several sub-projects
- The Society of Antiquaries of Scotland for covering various expenses of the project
- The Russel Trust for funding the examination and analysis of several Mesolithic quartz assemblages
- The Catherine Mackichan Bursary Trust for covering travel expenses in connection with the examination of the Cnoc Dubh quartz quarry
- Shetland Museum for support in connection with the analysis of the Scord of Brouster quartz assemblage
- Principal Monuments Inspector Patrick Ashmore at Historic Scotland for his interest and support, as well as relevant comments to the manuscript
- Senior Curator Alan Saville, the National Museums of Scotland, for his detailed comments to the manuscript
- Beverley Ballin Smith, Glasgow University Archaeological Research Division, for valuable assistance in connection with the illustration of quartz artefacts
- Western Isles Archaeologist Mary MacLeod, Comhairle nan Eilean Siar, and amateur archaeologist Jim Crawford, Lewis, for valuable information on the Cnoc Dubh general environment.

10 References

Abbott Jr, L E 2003 'Quarry studies in North Carolina: what have we learned in the last 30 years?', *J Middle Atlantic Archaeol* 19, 93–112.

Abbott Jr, L E, Cantley, C E & Jones, S forthcoming 'A re-evaluation of quartz and silicate raw material acquisition along the South Atlantic Slope: going beyond the economics of expediency', *South Atlantic Archaeol* 2001.

Alakärppä, J, Ojanlatva, E & Ylimaunu, T 1998 'Raw material sources and use of quartz in the Kemi-Tornio area in the North of the Gulf of Bothnia', *in* Holm, L & Knutsson, K (eds) 1998 *Proceedings from the third Flint Alternatives Conference at Uppsala, Sweden, October 18–20, 1996*. Occasional Papers in Archaeology 16. Uppsala: Department of Archaeology and Ancient History, Uppsala University.

Alsaker, S 1987 *Bømlo–Steinalderens råstoffsentrum på Sørvestlandet*. Arkeologiske Avhandlinger 4. Bergen: Historisk Museum, Universitetet i Bergen.

Andersen, S H 1983 'Stenalderfolk fra Tybrind Vig, Vestfyn', *Fynske Minder* 1983, 7–28.

Andersen, S H 1995a 'Coastal adaptation and marine exploitation in Late Mesolithic Denmark – with special emphasis on the Limfjord Region', *in* Fischer, A (ed) *Man and Sea in the Mesolithic. Coastal Settlement above and below Present Sea Level. Proceedings of the International Symposium, Kalundborg, Denmark 1993*, 41–66. Oxbow Monograph 53. Oxford: Oxbow Books.

Andersen, S H 1995b 'Ringkloster. Ertebølle trappers and wild boar hunters in eastern Jutland. A survey', *J Danish Archaeol* 12 (1994–95), 13–59.

Andersson, G 2004 'Lilla Sylta RAÄ 87 gravfält', *Riksantikvarieämbetets undersökningar, UV:s hemnsida*. http://www.raa.se/uv/norrortsled/lillasylta87/index.htm [accessed 21.03.2005].

Anonymous 2001 'Mesolithic hunting camp found on Scottish mountain', *Br Archaeol* 57. http://www.britarch.ac.uk/ba/ba57/news.html#item6 [accessed 26.02.2005].

Ashmore, P 1995 *Calanais. The Standing Stones*. Edinburgh: Historic Scotland.

Ashmore, P forthcoming 'Calanais, Isle of Lewis, Western Isles', *Proc Soc Antiq Scot*.

Ashton, N, Dean, P & McNabb, J 1991 'Flaked flakes: what, when and why?', *Lithics* 12, 1–11.

Atkinson, J, Donelly, M & MacGregor, G 1998 'Ben Lawers Historic Landscape Project', *Disc Excav Scot* 1997, 63.

Atkinson, J, Donelly, M, Lelong, O & MacGregor, G forthcoming *Ben Lawers Historic Landscape Project, the pilot seasons, 1996-98*. Tayside and Fife Archaeological Committee Monograph. Perth: Tayside and Fife Archaeological Committee.

Baker, C M 1983 'Some technological considerations of quartz as a raw material for flaked stone implements: experiments and applications', *in* Marquardt, W H (ed) *Proceedings of the Thirty-third Southeastern Archaeological Conference*, 5–16. Gainesville: Florida State Museum.

Ballin, T B 1996 *Klassifikationssystem for Stenartefakter*. Universitetets Oldsaksamling, Varia 36. Oslo: Universitetets Oldsaksamling.

Ballin, T B 1998a *Oslofjordforbindelsen - Arkæologiske undersøgelser ved Drøbaksundet*. Universitetets Oldsaksamling, Varia 48. Oslo: Universitetets Oldsaksamling.

Ballin, T B 1998b 'Steinbustølen. Quartzite Reduction in the Norwegian High Mountains', *Universitetets Oldsaksamling, Årbok* 1997/1998, 83–92.

Ballin, T B 1999a 'Bipolar cores in Southern Norway: classification, chronology and geography', *Lithics* 20, 13–22.

Ballin, T B 1999b *Kronologiske og Regionale Forhold i Sydnorsk Stenalder. En Analyse med Udgangspunkt i Bopladserne ved Lundevågen (Farsundprosjektet)*. Unpublished PhD thesis, Institute of Prehistoric Archaeology, Aarhus University.

Ballin, T B 1999c 'Tanged arrowhead from the Biggings, Papa Stour', *in* Crawford, B & Ballin-Smith, B 1999 *The Biggings, Papa Stour, Shetland*, 172–3. Edinburgh: Society of Antiquaries of Scotland.

Ballin, T B 2001a *Kilmelfort Cave, Argyll – a re-evaluation of the lithic assemblage.* Unpublished report.

Ballin, T B 2001b *The Quartz Assemblage from Lealt Bay, Isle of Jura, Argyll*. Unpublished report.

Ballin, T B 2001c *Quartz Technology in Scottish Prehistory: Pilot Project*. Edinburgh: unpublished report commissioned by Historic Scotland and the National Museums of Scotland.

Ballin, T B 2002a 'Later Bronze Age flint technology: a presentation and discussion of post-barrow debitage from monuments in the Raunds area, Northamptonshire', *Lithics* 23, 3–28.

Ballin, T B 2002b *The Quartz Assemblage from Lussa River, Isle of Jura, Argyll*. Unpublished report.

Ballin, T B 2003a *The Quartz Assemblage from Barvas 2, Lewis, Western Isles*. Unpublished report.

Ballin, T B 2003b *St Fergus to Aberdeen Natural Gas Pipeline (FERG), Aberdeenshire.* Unpublished report.

Ballin, T B 2004a *The Lithic Assemblage from Chest of Dee, Crathie & Braemar, Aberdeenshire.* Unpublished report.

Ballin, T B 2004b 'The Mesolithic Period in Southern Norway: material culture and chronology', *in* A Saville (ed) *Mesolithic Scotland and its Neighbours. The Early Holocene Prehistory of Scotland, its British and Irish Context, and some Northern European Perspectives*, 413–38. Edinburgh: Society of Antiquaries of Scotland.

Ballin, T B 2004c *Site 4. St Fergus to Aberdeen Natural Gas Pipeline (FERG), Aberdeenshire – the lithic assemblage*. Unpublished report.

Ballin, T B 2004d *Site 5. St Fergus to Aberdeen Natural Gas Pipeline (FERG), Aberdeenshire – the lithic assemblage.* Unpublished report.

Ballin, T B 2004e 'The worked quartz vein at Cnoc Dubh, Isle of Lewis, Western Isles. Presentation and discussion of a small prehistoric quarry', *Scottish Archaeological Internet Reports (SAIR) 11*. http://www.sair.org.uk/sair11/index.html [accessed 11.02.2005].

Ballin, T B 2005 'The quartz assemblage', *in* Ballin-Smith, B 2005 'Catpund: a prehistoric house in Shetland', *Scottish Archaeological Internet Reports (SAIR) 7*. [http://www.sair.org.uk/sair7/index. html].

Ballin, T B 2005c 'Lundevågen 31, Vest-Agder, SW Norway. The spatial organization of small hunter-gatherer sites – a case study (or: Binford in Practice)', *in* C Bond forthcoming *Lithic Technology: Reduction and Replication*. Occasional Paper for the Lithic Studies Society. Oxford: Oxbow Books.

Ballin, T B 2007a 'The lithic assemblage from Scord of Brouster, Shetland: a re-examination', *Scottish Archaeological Internet Reports (SAIR) 17*.

Ballin, T B 2007b 'The territorial structure in the Stone Age of Southern Norway. A comparative analysis of selected lithic assemblages from Southern Norway, Western Sweden and Southern Scandinavia', *in* Waddington, C & Pedersen, K (eds) *The Late Palaeolithic and Mesolithic of the North Sea Basin and Littoral*, Proceedings from a Conference at the University of Newcastle-upon-Tyne, 17 May 2003, 114–36. Oxford: Oxbow Books.

Ballin, T B forthcoming a 'The lithic assemblage', *in* Ashmore, P forthcoming 'Calanais, Isle of Lewis, Western Isles', *Proc Soc Antiq Scot.*

Ballin, T B forthcoming b 'The lithic assemblage', *in* Cox, A (ed) *Achnahaird Sands, Highland*. Edinburgh: Society of Antiquaries of Scotland.

Ballin, T B forthcoming c 'The lithic assemblage', *in* Johnson, M forthcoming 'A Bronze Age cremation cemetery at Skilmafilly, Aberdeenshire, and other prehistoric sites. Excavations 2001', *Proc Soc Antiq Scot*.

Ballin, T B forthcoming d 'The lithic assemblage', *in* Moore, H & Wilson, G forthcoming 'Burland, Trondra, Shetland', *Proc Soc Antiq Scot.*

Ballin, T B forthcoming e 'The lithic assemblage', *in* Moore, H & Wilson, G forthcoming 'Cruester, Bressay, Shetland', *Proc Soc Antiq Scot.*

Ballin, T B forthcoming f 'The lithic assemblage', *in* Proudfoot, E & Turner, R 'Fordhouse Barrow, House of Dun, Angus', *Proc Soc Antiq Scot*.

Ballin, T B forthcoming g 'The lithic assemblage', *in* Sharples, N forthcoming *Dalmore, Isle of Lewis, Western Isles*.

Ballin, T B forthcoming h 'The lithic assemblage', *in* Shepherd, I & Shepherd, A forthcoming *Rosinish, Benbecula, Western Isles*.

Ballin, T B forthcoming i 'The lithic assemblage', *in* Suddaby, I forthcoming 'Stoneyhill Landfill Site, Peterhead, Aberdeenshire', *Proc Soc Antiq Scot.*

Ballin, T B forthcoming j 'The quartz assemblage', *in* Moore, H & Wilson, G forthcoming *The Bayanne Project, Shetland*. Lerwick: Shetland Amenity Trust.

Ballin, T B forthcoming k 'Recognition of burnt quartz and its relevance to the interpretation of prehistoric sites', *Lithics*.

Ballin, T B & Johnson, M 2005 'A Mesolithic chert assemblage from Glentaggart, South Lanarkshire, Scotland: chert technology and procurement strategies', *Lithics* 26, 37–86.

Ballin, T B & Lass Jensen, O 1995 *Farsundprosjektet - stenalderbopladser på Lista*. Varia 29. Oslo: Universitetets Oldsaksamling.

Ballin, T B & Saville, A 2003 'An Ahrensburgian-type tanged point from Shieldaig, Wester Ross, Scotland, and its implications', *Oxford J Archaeol* 22(2), 115–31.

Ballin, T B, Saville, A & Walker, M forthcoming *The Lithic Assemblage from Shieldaig, Wester Ross, Scotland*.

Ballin-Smith, B 2005 'Catpund: a prehistoric house in Shetland', *Scottish Archaeological Internet Reports (SAIR) 7*. [http://www.sair.org.uk/sair7/index. html].

Bang-Andersen, S 1998 'Why all these white and shiny stones? On the occurrence of non-flint lithic material on Mesolithic inland sites in south-western Norway', *in* Holm, L & Knutsson, K (eds) *Third Flint Alternatives Conference at Uppsala*, 39–54. Uppsala: Uppsala University, Department of Archaeology and Ancient History, Occasional Papers in Archaeology 16.

Barber, M, Field, D & Topping, P 1999 *The Neolithic Flint Mines of England*. London: English Heritage.

Barclay, G J, Brophy, K & MacGregor, G 2002 'Claish, Stirling: an Early Neolithic structure in its context', *Proc Soc Antiq Scot* 132, 65–137.

Binford, L R 1976 'Forty-seven trips: a case study in the character of some formation processes of the archaeological record', *in* Hall, E S (ed) *Contributions to Anthropology: The Interior Peoples of*

Northern Alaska, 299–351. National Museum of Man, Mercury Series 49. Ottawa.

Binford, L R 1978 'Dimensional analysis of behaviour and site structure: Learning from an Eskimo hunting stand', *Am Antiquity* 43(3), 330–61.

Binford, L R 1979 'Organization and formation processes: looking at curated technologies', *J Anthropol Res* 35, 255–73.

Binford, L R 1980 'Willow smoke and dogs' tails: hunter–gatherer settlement systems and archaeological site formation', *Am Antiquity* 45(1), 4–20.

Binford, L R 1983 *In Pursuit of the Past. Decoding the Archaeological Record*. London: Thames & Hudson.

Boaz, J 1997 *Steinalderundersøkelsene på Rødsmoen*. Varia 41. Oslo: Universitetets Oldsaksamling.

Bodu, P, Karlin, C & Ploux, S 1990 'Who's who? The Magdalenian Flintknappers of Pincevent (France)', *in* Cziesla, E, Eickhoff, S, Arts, N & Winter, D (eds) 1990 *The Big Puzzle. International Symposium on Refitting Stone Artefacts, Montrepos, 1987*, 143–63. Bonn: Holos.

Bradley, R 1986 'Microwear analysis [Tougs, Burra Isle, Shetland]', *Glasgow Archaeol J* 13, Microfiche M9–M32.

Bradley, R 2000 *The Good Stones. A new investigation of the Clava Cairns*. Edinburgh: Society of Antiquaries of Scotland.

Bradley, R 2004 *The Moon and the Bonfire: an investigation of three stone circles in NE Scotland*. Edinburgh: Society of Antiquaries of Scotland.

Bridgeland, D R, Saville, A & Sinclair, J M 1997 'New evidence for the origin of the Buchan Ridge Gravel, Aberdeenshire', *Scott J Geol* 33(1), 43–50.

Broadbent, N 1973 'Prehistoric quartz quarrying in Norrland. A preliminary report of finds at Gummark in Västerbotten and some observations concerning quartz technology', *Fornvännen* 3, 129–37.

Broadbent, N 1979 *Coastal Resources and Settlement Stability. A Critical Study of a Mesolithic Site Complex in Northern Sweden*. Aun 3. Uppsala: Archaeological Studies, Uppsala University Institute of North European Archaeology.

Broadbent, N & Knutsson, K 1975 'An experimental analysis of quartz scrapers. Results and applications', *Fornvännen* 70, 113–28.

Brockington, P E 1992 *Historical and Archaeological Investigations in Support of a Proposed Historic Properties Management Plan for John H Kerr Dam and Reservoir near Boydton, Virginia*. Atlanta, Charleston: Brockington and Associates Inc.

Brown, J F 1992 'Flint as a resource for Stone-Age Orcadians', *Orkney Field Club, Bulletin* 1992, 21–8.

Bruen Olsen, A & Alsaker, S 1984 'Greenstone and diabase utilization in the Stone Age of Western Norway: technological and socio-cultural aspects of axe and adze production and distribution', *Norwegian Archaeol Rev* 17(2), 71–103.

Burdukiewicz, J M 1986 *The Late Pleistocene Shouldered Point Assemblages in Western Europe*. Leiden: EJ Brill.

Burgess, C, Church, M, Flitcroft, C & Gilmour, S 1997 'An Dunan (Uig parish), utilized natural island', *Disc Excav Scot* 1997, 85.

Burl, A 1980 'Science or symbolism: problems of archaeoastronomy', *Antiquity* 54, 191–200.

Burl, A 1995 *A Guide to the Stone Circles of Britain, Ireland and Brittany*. New Haven: Yale University Press.

Calder, C S T 1956 'Report on the discovery of numerous Stone Age house-sites in Shetland', *Proc Soc Antiq Scot*, 89 (1955–56), 340–97.

Calder, C S T 1964 'Cairns, Neolithic houses and burnt mounds in Shetland', *Proc Soc Antiq Scot* 96 (1963–64), 37–86.

Caldwell, J A 1954 'The old quartz industry of Piedmont Georgia and South Carolina', *Southern Indian Studies* 5, 37–9.

Callahan, E 1987 *An Evaluation of the Lithic Technology in Middle Sweden during the Mesolithic and Neolithic*. AUN 8. Uppsala.

Callahan, E, Forsberg, L, Knutsson, K & Lindgren, C 1992 Frakturbilder. Kulturhistoriska kommentarer till det säregna sönderfallet vid bearbetning av kvarts. *TOR Tidskrift för arkeologi*. 24, 27–63.

Cameron, K 2002 *St Fergus to Aberdeen Natural Gas Pipeline. Archaeological Excavations. Baseline Report*. Report 700. Musselburgh: CFA Archaeology Ltd.

Cameron, I B & Stephenson, D 1985 *The Midland Valley of Scotland. British Regional Geology. 5*. London: British Geological Survey, Natural Environment Research Council/Her Majesty's Stationery Office.

Cantley, C E 2000 *Archaeological Data Recovery at Richburg Quarry Site (38CS217) Chester County, South Carolina*. New South Associates Technical Report 619. Stone Mountain, Georgia: New South Associates.

Clark, J G D 1975 *The Earlier Stone Age Settlement of Scandinavia*. Cambridge: Cambridge University Press.

Clarke, A 1999 'The flaked quartz', *in* Owen, O & Lowe, C (eds) *Kebister. The-Four-Thousand-Year-Old Story of One Shetland Township*. Edinburgh (=Soc Antiq Scot monogr 14), 164–6.

Clarke, A & Griffiths, D 1990 'The use of bloodstone as a raw material for flaked stone tools in the west of Scotland', *in* CR Wickham-Jones 1990 *Rhum. Mesolithic and Later Sites at Kinloch. Excavations 1984-86*. Edinburgh: Society of Antiquaries of Scotland.

Clarke, D V, Cowie, T G & Foxon, A 1985 *Symbols of Power at the Time of Stonehenge*. Edinburgh: National Museum of Antiquities of Scotland.

Clemmer, R 1990 *The Tosawihi Quarry. World Heritage Site and Western Shoshone Monument.*

Prepared by Dr Richard Clemmer, University of Denver. Bureau of Land Management Cultural Resources File 1-1749. Elko, Nevada: Bureau of Land Management, Elko Field Office.

Coles, J M 1983 'Excavations at Kilmelfort Cave, Argyll', *Proc Soc Antiq Scot* 113, 11–21.

Congdon, R 2000 *Cumulative impact analysis of dewatering and water management operations for the Betze Project, South Operations Area Project Amendment, and Leeville Project.* Elko, Nevada: US Department of the Interior, Bureau of Land Management, Elko Field Office.

Crabtree, D E & Gould, R A 1970 'Man's oldest craft re-created', *Curator* XIII(3), 179–98.

Crawford, I A 1977 'A corbelled bronze-age burial chamber and beaker evidence from the Rosinish machair', *Proc Soc Antiq Scot* 108, 94–107.

Cziesla, E 1990 *Siedlungsdynamik auf steinzeitlichen Fundplätzen. Metodische Aspekte zur Analyse latenter Strukturen*. Studies in Modern Archaeology 2. Bonn: Holos.

Darvill, T 2002 'White on blonde: quartz pebbles and the use of quartz at Neolithic monuments in the Isle of Man and beyond', *in* Jones, A & MacGregor, G (eds) *Colouring the Past. The Significance of Colour in Archaeological Research*, 73–91. Oxford: Berg.

David, A 1991 'Late Glacial archaeological residues from Wales: a selection', *in* Barton, N Roberts, A J & Roe, D A (eds) *The Late Glacial in north-west Europe: human adaptation and environmental change at the end of the Pleistocene*, 141–59. CBA Research Report 77. London: Council for British Archaeology.

Dixon, T N & Cavers, M G 2001 'Oakbank Crannog, Loch Tay (Kenmore parish), excavation', *Disc Excav Scot* 2001, 78–9.

Donnelly, M 2003 'The quartz', *in* MacGregor, G 'Excavation of an Iron Age buried mound, Loch Borralie, Durness, Sutherland', *Scottish Archaeological Internet Reports (SAIR) 9*, 10. [http://www.sair.org.uk/sair9/index.html].

Downes, J & Lamb, R 2000 *Prehistoric Houses at Sumburgh in Shetland. Excavations at Sumburgh Airport 1967-74*. Oxford: Oxbow Books.

Eriksen, B V 1999 'Varmebehandling af flint. Et eksperimental-arkæologisk studie', *in* Høiris, O, Madsen, H J, Madsen, T & Vellev, J (eds) *Menneskelivets mangfoldighed. Arkæologisk og antropologisk forskning på Moesgård*, 185–92. Højbjerg: Aarhus Universitet/Moesgård Museum.

Eriksen, B V 2000 'Chaîne opératoire' – den operative proces og kunsten at tænke som en flinthugger', *in* Eriksen, B V (ed) *Flintstudier - en håndbog i systematiske analyser af flintinventarer*, 101–26. Aarhus.

Eriksen, B V 2002 'Fossil mollusks and exotic raw materials in Late Glacial and Early Postglacial find contexts: a complement to lithic studies', *in* Fisher, L E & Eriksen, B V (eds) *Lithic Raw Material Economies in Late Glacial and Early Postglacial Europe*. British Archaeological Reports International Series 1093. Oxford: British Archaeological Reports.

Espenshade, C T 1986 *CRM: Vogtle-Effingham-Thalmann 500 KV Electric Transmission Line GP-SN-13: Data Recovery*. Atlanta: Georgia Power Company.

Fichter, L S 2000 'Metamorphic rocks', *in* Fichter, L S *JMU Geologic Web Sites, Department of Geology and Environmental Science, James Madison University*. http://csmres.jmu.edu/geollab/ Fichter/Fichter/websites.html [accessed 01.03.2005].

Finlayson, B 1992 'Carding Mill Bay: lithic report', *Glasgow Archaeol J* 17, Microfiche M52–M58.

Finlayson, B 1996 'Worked flint and quartz', *in* McCullogh, R P J & Tipping, R *The Lairg Project 1988-1996. The Evolution of an Archaeological Landscape in Northern Scotland*, 132–9. Edinburgh: AOC Archaeology Ltd monogr 3.

Finlayson, B 2000 'Chipped stone assemblage', *in* Downes, J & Lamb, R *Prehistoric Houses at Sumburgh in Shetland. Excavations at Sumburgh Airport 1967-74*. Oxford.

Finlayson, B forthcoming 'The flint and quartz artefacts', *in* Armit, I forthcoming *Excavations at the Neolithic site of Eilean Domhnuill, Loch Olabhat, North Uist*.

Fischer, A, Grønnow, B, Jønsson, JH, Nielsen, FO & Petersen, C 1979 *Stenaldereksperimenter i Lejre. Bopladsernes indretning*. Working Papers, The National Museum of Denmark 8. København: The National Museum of Denmark.

Flennikin, J J 1981 *Replicative Systems Analysis: A Model Applied to the Vein Quartz Artifacts from the Hoko River Site*. Washington State University, Laboratory of Anthropology Reports 59. Ann Arbor: Washington State University.

Fojut, N 1986 *A Guide to Prehistoric & Viking Shetland*. Lerwick: Shetland Times Limited.

Foster, P 1993 Barra 1993 'Interim report on the excavations at Alt Chrysal (Alt Easdeal) Sites T18, T19, T26A and T168, 5–7', *The Western Isles Project 6th Interim Report (SEARCH)*. Sheffield: Department of Archaeology and Prehistory, University of Sheffield.

Gebauer, A B 1988 'Stylistic analysis. A critical review of concepts, models, and interpretations', *J Danish Archaeol* 6, 223–9.

Gonick, K 2003 'Fire-altered rock as artifacts. two experiments – fire and water: their effects on quartz and quartzite', *J Middle Atlantic Archaeol* 19, 151–62.

Gould, R A 1980 *Living Archaeology.* Cambridge: Cambridge University Press.

Gray, A F 1960 'A collection of stone artefacts from Redpoint, Loch Torridon, Ross-Shire', *Proc Soc Antiq Scot* 93 (1959–60), 236–7.

Green H S 1980 *The Flint Arrowheads of the British Isles. A detailed study of material from England and Wales with comparanda from Scotland and*

Ireland. Part I–ii. Oxford (=Br Archaeol Rep, Br Ser 75).

Greig, D C 1971 *The South of Scotland. British Regional Geology. 6*. Edinburgh: Natural Environment Research Council, Institute of Geological Sciences/Her Majesty's Stationery Office.

Haggarty, A 1991 'Machrie Moor, Arran: recent excavations at two stone circles', *Proc Soc Antiq Scot* 121, 51–94.

Halén, O 1994 *Sedentariness during the stone age of northern Sweden. In the light of the Alträsket site, c. 5000 B.C., and the comb-ware site Lillberget, c. 3900 B.C.: Sorce-critical problems of representativity in archaeology*. Acta Archaeologica Lundensia, Series in 4° 20. Lund: C.W.K. Gleerups Förlag.

Hamilton, J R C 1956 *Excavations at Jarlshof, Shetland*. Ministry of Works, Archaeological Reports, I. Edinburgh.

Hayden, B 1984 'Are Emic types relevant to archaeology?', *Ethnohistory* 31(2), 79–92.

Hedges, J W 1986 'Bronze Age structures at Tougs, Burra Isle, Shetland', *Glasgow Archaeol J* 13, 1–43.

Henshall, A 1956 'Appendix II: Pottery and stone implements from Ness of Gruting', *in* Calder, C S T 'Report on the discovery of numerous Stone Age house-sites in Shetland', *Proc Soc Antiq Scot* 89 (1955–56), 381–97.

Henshall, A 1972 *The Chambered Tombs of Scotland, Vol 2*. Edinburgh: Edinburgh University Press.

Higgs, E S & Vita-Finzi, C 1972 'Prehistoric economies: a territorial approach', *in* Higgs, E S (ed) *Papers in Economic Prehistory*, 27–36. Cambridge: Cambridge University Press.

Hiscock, P 2001 *The Ancient Miners of Mount Isa*. http://artalpha.anu.edu.au/web/arc/resources/papers/mi/ancientminers.htm [accessed 16.02.2005].

Hodder, I 1979 'Economic and social stress and material culture patterning', *Am Antiquity* 44(3), 446–54.

House, J H & Ballanger, D L 1976 *An Archaeological Survey of the Interstate 77 Route in the South Carolina Piedmont. Anthropological Studies 3*. Columbia: South Carolina Institute of Archaeology and Anthropology, The University of South Carolina.

Howard, M & Howard, D 2000 *Rockhounding Arkansas. 1. Quartz*. http://rockhoundingar.com/contents.html [accessed 21.05.2004].

Jensen, Aa 1973 *Sten. Mineraler, Ædelsten, Bjergarter, Malme*. Copenhagem: G.E.C. Gads Forlag.

Jeppesen, J 1984 Funktionsbestemmelse af flintredskaber. Slidsporsanalyse af skrabere fra Sarup. *Kuml* 1982/83, 31–60.

Johnson, M forthcoming 'A Bronze Age cremation cemetery at Skilmafilly, Aberdeenshire, and other prehistoric sites. Excavations 2001', *Proc Soc Antiq Scot*.

Johnstone, G S & Mykura, W 1989 *The Northern Highlands of Scotland. British Regional Geology 2*. London: British Geological Survey/Her Majesty's Stationery Office.

Jones, S forthcoming 'Towards an analysis system for quartz artifacts', *in* Abbott, L E Jr, Cantley, C E & Jones, S 'A re-evaluation of quartz and silicate raw material acquisition along the South Atlantic Slope: going beyond the economics of expediency', *South Atlantic Archaeol* 2001.

Juel Jensen, H 1988 *Microdenticulates in the Danish Stone Age: A Functional Puzzle*. Oxford (=Br Archaeol Rep, Intl Ser 411), 231–52.

Juel Jensen, H 1994 *Flint Tools and Plant Working. Hidden Traces of Stone Age Technology. A use wear study of some Danish Mesolithic and TRB implements*. Århus: Aarhus University Press.

Keeley, L H 1982 'Hafting and retooling: effects of the archaeological record', *Am Antiquity* 47(4), 798–809.

Kenworthy, J B 1981 *Excavation of a Mesolithic Settlement Site at Nethermills Farm, Crathes, near Banchory, Grampian, 1978-80; Interim Statement*. Unpublished report.

Kinnunen, K A 1993 'Mineralogical methods applied to the study of Stone Age quartz quarries in Finland', *Fennoscandia archaeologica* X, 9–17.

Knight, J 1991 Vein quartz', *Lithics* 12, 37–56.

Knutsson, K 1978 'Skrapor och skrapning. Ett exempel på artefakt- och boplatsanalys', *TOR* XVII, 1975–77, 19–62.

Knutsson, K 1988 *Making and Using Stone Tools. The Analysis of the Lithic Assemblages from Middle Neolithic Sites with Flint in Västerbotten, Northern Sweden*. Aun 11. Uppsala: Archaeological Studies, Uppsala University Institute of North European Archaeology.

Kourimsky, J 1995 *The Illustrated Encyclopedia of Minerals & Rocks*. London: Sunburst Books.

Lacaille, A D 1933 'Small implements of quartz from Ward Hill, Dunrossness, Shetland', *Proc Soc Antiq Scot* IX.1, 56–74.

Lacaille, A D 1937 A stone industry, potsherds, and a bronze pin from Valtos, Uig, Lewis', *Proc Soc Antiq Scot* LXXI, 279–96.

Lacaille, A D 1938 'Aspects of intentional fracture', *Trans Glasgow Archaeol Soc* IX.II, 313–41.

Lacaille, A D 1944 'Unrecorded microliths from Tentsmuir, Deeside, and Culbin', *Proc Soc Antiq Scot* LXXVIII, 5–16.

Lacaille, A D 1951 'A stone industry from Morar, Inverness-shire; Its Obanian (Mesolithic) and later affinities', *Archaeologia* 94, 103–39.

Lacaille, A D 1954 *The Stone Age in Scotland*. London: Oxford University Press.

Lebour, N 1914 'White quartz pebbles and their archaeological significance', *Trans Dumfriesshire & Galloway Nat Hist Antiq Soc* 1913–14, 121–34.

Lehane, D 1986 'Attribute analysis [Tougs, Burra Isle, Shetland]', *Glasgow Archaeol J* 13, Microfiche M3–M8.

Lemonnier, P 1976 'La Description des Chaînes Opératoires: Contribution à l'Analyse des Systèmes Techniques', *Technique et Culture* 1, 100–51.

Leroi-Gourhan, A 1965 *Le Geste et la Parole II. La Memoire et les Rythmes*. Paris: Albin Michel.

Lindgren, C 1998 'Shapes of quartz and shapes of minds', *in* L Holm & K Knutsson (eds) *Third Flint Alternatives Conference at Uppsala*, 95–103. Uppsala: Uppsala University, Department of Archaeology and Ancient History, Occasional Papers in Archaeology 16.

Luedtke, B E 1992 *An Archaeologist's Guide to Chert and Flint*. Archaeological Research Tools 7. Los Angeles: Institute of Archaeology, University of California.

Luho, V 1956 *Die Askola-Kultur. Die frühmesolitische Steinzeit in Finnland*. Finska Fornminnesförenings Tidskrift 57. Helsinki: Finska Fornminnesförening.

McCullagh, R 1989 'Excavation at Newton, Islay', *Glasgow Archaeol J* 15, 23–51.

McNiven, I 1994 'Technological organization and settlement in southwest Tasmania after the glacial maximum', *Antiquity* 68, 75–82.

Marshall, D N 1978 'Excavations at Auchategan, Glendaruel, Argyll', *Proc Soc Antiq Scot* 109, 36–74.

Marshall, G D 2000a 'The distribution of beach pebble flint in Western Scotland with reference to raw material use during the Mesolithic', *in* Mithen, S J (ed) *Hunter-Gatherer Landscape Archaeology: The Southern Hebrides Mesolithic Project 1988-98*, 75–7. Cambridge: McDonald Institute for Archaeological Research.

Marshall, G D 2000b 'The distribution and character of flint beach pebbles on Islay as a source for Mesolithic chipped stone artefact production', *in* Mithen, S J (ed) *Hunter-Gatherer Landscape Archaeology: The Southern Hebrides Mesolithic Project 1988-98*, 79–90. Cambridge, McDonald Institute for Archaeological Research.

Mercer, J 1968 'Stone tools from a washing-limit deposit of the highest Postglacial transgression, Lealt Bay, Isle of Jura', *Proc Soc Antiq Scot* 100 (1967–68), 1–46.

Mercer, J 1970 'Flint tools from the present tidal zone, Lussa Bay, Isle of Jura, Argyll', *Proc Soc Antiq Scot* 102, 1–30.

Mercer, J 1971 'A regression-time stoneworkers' camp, 33 ft OD, Lussa River, Isle of Jura', *Proc Soc Antiq Scot* 103, 1970–1, 1–32.

Mercer, J 1972 'Microlithic and Bronze Age camps, 75–26ft OD, N Carn, Isle of Jura', *Proc Soc Antiq Scot* 104 (1971–2), 1–22.

Mercer, J 1974 'Glenbatrick Waterhole, a microlithic site on the Isle of Jura', *Proc Soc Antiq Scot* 105, 9–32.

Mercer, J 1980 'Lussa Wood 1: the Late-Glacial and Early Post-Glacial Occupation of Jura', *Proc Soc Antiq Scot* 110, 1–32.

Mercer, J & Searight, S 1987 'Glengarrisdale: confirmation of Jura's third microlithic phase', *Proc Soc Antiq Scot* 116, 41–55.

Mithen, S & Finlayson, B 2000 'Gleann Mor, Islay: test-pit survey and trial excavation', *in* SJ Mithen (ed) *Hunter-Gatherer Landscape Archaeology: The Southern Hebrides Mesolithic Project 1988-98*, 79–90. Cambridge, McDonald Institute for Archaeological Research.

Moore, H & Wilson, G 1999 'Food for thought: a survey of burnt mounds of Shetland and Excavations at Tangwick', *Proc Soc Antiq Scot* 129, 203–37.

Moore, H & Wilson, G 2003a *Cruester Burnt Mound, Bressay, Shetland: Data Structure Report*. Unpublished report.

Moore, H & Wilson, G 2003b *Excavations at Burland, Trondra, Shetland: Data Structure Report*. Unpublished report.

Moore, H & Wilson, G forthcoming a *The Bayanne Project, Shetland*. Shetland Amenity Trust Monograph. Lerwick: Shetland Amenity Trust.

Moore, H & Wilson, G forthcoming b 'Burland, Trondra, Shetland', *Proc Soc Antiq Scot*.

Moore, H & Wilson, G forthcoming c 'Cruester, Bressay, Shetland', *Proc Soc Antiq Scot*.

Morrison, A 1986 'The northward march of Palaeolithic Man in Britain. An Appreciation of Armand Donald Lacaille', *in* Pollard, T & Morrison, A (eds) *The Early Prehistory of Scotland*. Edinburgh: Edinburgh University Press.

Morrow, C A & Jeffries, R W 1989 'Trade or embedded procurement? A test case from southern Illinois', *in* Torrence, R (ed) *Time, Energy and Stone Tools*, 27–33. Cambridge: Cambridge University Press.

Murphy, E & Simpson, D 2003 'Neolithic Northton: a review of the evidence', *in* Armit, I, Murphy, E, Nelis, A & Simpson, D (eds) *Neolithic Settlement in Ireland and Western Britain*. Oxford: Oxbow Books.

Mykura, W 1976 *Orkney and Shetland. British Regional Geology 1*. Edinburgh: Natural Environment Research Council, Institute of Geological Sciences/Her Majesty's Stationery Office.

Neighbour, T 2005 'Excavation of a Bronze Age Kerbed cairn at Olcote, near Calanais, Isle of Lewis', *Scottish Archaeological Internet Reports (SAIR) 13*.

Ness, J & Ward, T 2001 *Pitchstone Seminar held Saturday 30 September 2000. Unpublished report*. Biggar: Biggar Museum Trust.

Neumann, H 1985 *Norges Mineraler*. NGU Skrifter 68. Oslo: Norges geologiske undersøkelse.

O'Kelly, M J 1982 *Newgrange. Archaeology, Art and Legend*. London: Thames and Hudson.

Owen, O & Lowe, C (eds) 1999 *Kebister. The-Four-Thousand-Year-Old Story of One Shetland Township*. Edinburgh: Society of Antiqities of Scotland.

Pannett, A 2002 *Excavations of a Mesolithic Site at Oliclett, Caithness.* Cardiff Studies in Archaeology, Specialist Report 22. Cardiff: Cardiff University.

Paterson, H M & Lacaille, A D 1936 'Banchory microliths', *Proc Soc Antiq Scot* 70, 419–34.

Pellant, C 1992 *Rocks and Minerals. The Visual Guide to Over 500 Rock and Mineral Specimens from Around the World*. Eyewitness Handbooks. London: Dorling Kindersley.

Pigeot, N 1990 'Technical and social actors. Flintknapping specialists and apprentices at Magdalenian Etiolles', *Archaeol Rev Camb* 9.1, 126–41.

Pitts, M B 1999 'Quartz mounds: a preliminary assessment', *in* Davey, P J (ed) *Recent Archaeological Research on the Isle of Man*. Oxford (=Br Archaeol Rep, Br Ser 278), 63–73.

Powell, B W 1965 'An aboriginal quartz quarry at Samp Mortar Reservoir, Fairfield, Connecticut', *Bull Archaeol Soc New Jersey* 22 [http://www.bwpowell. com/archaeology/sampmortar/mortar.html].

Price, T D, Chappell, S & Ives, D 1982 'Thermal alteration in Mesolithic assemblages', *Proc Prehistoric Soc* 48, 467–85.

Rankama, T 2002 'Analyses of the quartz assemblages of Houses 34 and 35 at Kauvonkangas in Tervola', *in* Ranta, H (ed) *Huts and Houses. Stone Age and Early Metal Age Buildings in Finland*, 79–108. Helsinki: National Board of Antiquities.

Rankama, T 2003 'Quartz analyses of Stone Age house sites in Tervola, southern Finnish Lapland', *in* Samuelsson, C & Ytterberg, N (eds) *Uniting Sea. Stone Age Societies in the Baltic Sea Region. Proceedings from the First Uniting Sea Workshop at Uppsala University, Sweden, January 26-27, 2002*. Occasional Papers in Archaeology 33, 204–24. Uppsala: Uppsala University.

RCAHMS 1946 *Twelfth Report with and Inventory of the Ancient Monumenets of Orkney and Shetland*. 1–3. Edinburgh: RCAHMS.

Renfrew, C 1977 'Alternative models for exchange and spatial distribution', *in* Earle, T K & Ericson, J E (eds) *Exchange Systems in Prehistory*. *Studies in Archaeology*, 71–90. New York: Academic Press.

Renfrew, C & Bahn, P 1996 *Archaeology. Theory, Methods and Practice*. London: Thames & Hudson.

Russell, M 2000 *Flint Mines in Neolithic Britain*. Stroud: Tempus.

Sahlins, M 1972 *Stone Age Economics*. Chicago: Aldine.

Sassaman, K E, Hanson, G T & Charles, T 1988 'Raw material procurement and the reduction of hunter–gatherer range in the Savannah River Valley', *Southeastern Archaeology* 7(2), 79–94.

Saville, A 1994 'Exploitation of lithic resources for stone tools in earlier prehistoric Scotland', *in* Ashton, N & David, A (eds) *Stories in Stone*, 57–70. Lithic Studies Society, Occasional Paper 4. London.

Saville, A 1995 'GB 20 Den of Boddam near Peterhead, Grampian Region, Scotland. GB 21 Skelmuir Hill, Grampian Region, Scotland. Prehistoric exploitation of flint from the Buchan Ridge Gravels, Grampian region, north-east Scotland', *Archaeologia Polona* 33, 353–68.

Saville, A 2003a 'Indications of regionalisation in Mesolithic Scotland', *in* Larsson, L, Kindgren, H, Knutsson, K, Loeffler, D & Åkerlund, A (eds) *Mesolithic on the Move. Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000,* 230–8. Oxford: Oxbow Books.

Saville, A 2003b 'Lithic resource exploitation for artefacts in prehistoric and Early Historic Scotland', *in* Stöllner, T, Körlin, G, Steffens, G & Cierny, J (eds) *Man and Mining - Mensch und Bergbau. Studies in honour of Gerd Weisgerber on occasion of his 65th birthday*, 405–13. Bochum.

Saville, A 2005 'Prehistoric quarrying of a secondary flint source: evidence from North-East Scotland', *in* Topping, P & Lynott, M (eds) *The Cultural Landscape of Prehistoric Mines,* 1–13. Oxford: Oxbow Books.

Saville, A & Ballin, T B forthcoming 'Re-examination of the lithic assemblage from Kilmelfort Cave, Argyll', *Proc Soc Antiq Scot*.

Saville, A & Miket, R 1994 'An Corran, Staffin, Skye (Kilmuir parish), rock-shelter', *Disc Excav Scot* 1994, 40–1.

Schwabedissen, H 1954 *Die Federmesser-Gruppen des nordwesteuropäischen Flachlandes. Zur Ausbreitung des Spät-Magdalénien*. Neumünster: Karl Wachholtz Verlag.

Sharples, N 1983a *Dalmore, Isle of Lewis 1983. Report* (unpublished).

Sharples, N 1983b *Dalmore, Isle of Lewis 1983. Stratigraphical report* (unpublished).

Sharples, N forthcoming *Dalmore, Isle of Lewis, Western Isles*.

Shepherd, I A 1976 'Preliminary results from the Beaker settlement at Rosinish, Benbecula', *in* Burgess, C & Miket, R (eds) *Settlement and Economy in the Third and Second Millenia* BC. *Papers delivered at a conference organised by the Department of Adult Education, University of Newcastle upon Tyne, January 1976*, 209–16. Oxford (=Br Archaeol Rep, Br Ser 33).

Shepherd, I A & Tuckwell, A N 1974 'Benbecula, Rosinish', *Disc Excav Scot* 1974, 38–9.

Shepherd, I A & Tuckwell, A N 1975 'Benbecula, Rosinish', *Disc Excav Scot* 1975, 50.

Shepherd, I A & Tuckwell, A N 1976 'Benbecula, Rosinish', *Disc Excav Scot* 1976, 35–6.

Shepherd, I A & Tuckwell, A N 1977a 'Benbecula, Rosinish: Beaker settlement', *Disc Excav Scot* 1977, 18.

Shepherd, I A G & Tuckwell, A N 1977b 'Traces of beaker-period cultivation at Rosinish, Benbecula', *Proc Soc Antiq Scot* 108, 108–13.

Shepherd, I & Shepherd, A forthcoming *Rosinish, Benbecula, Western Isles*.

Siiriäinen, A 1974 'Quartz, chert and obsidian. A comparison of raw materials in a Late Stone Age aggregate in Kenya', *Finskt Museum*, 15–29.

Siiriäinen, A 1977 'Problems of the East Fennoscandian Mesolithic', *Finskt Museum*, 5–31.

Simpson, D D A 1976 'The Later Neolithic and Beaker settlement site at Northton, Isle of Harris', *in* Burgess, C & Miket, R (eds) *Settlement and Economy in the Third and Second Millenia B.C. Papers delivered at a conference organised by the Department of Adult Education, University of Newcastle upon Tyne, January 1976*. Oxford (=Br Archaeol Rep, Br Ser 33), 221–31.

Smith, D I & Fettes, D J 1979 'The geological framework of the Outer Hebrides', *in* JM Boyd 'The Natural Environment of the Outer Hebrides', *Proc Roy Soc Edinburgh* 77B, 75–83.

Stapert, D 1987 *Some Simple Techniques for Intrasite Spatial Analysis of Sites with a Central Hearth. Paper presented to the "Social Space" Congress. An Interdisciplinary conference on human spatial behaviour in dwellings and settlements. Denmark. October 19-21 1987*. Groningen: Biological-Archaeological Institute.

Stapert, D 1989 'The ring and sector method: intrasite spatial analysis of Stone Age sites, with special reference to Pincevent', *Palaeohistoria* 31, 1–57.

Stapert, D 1990 'Within the tent or outside? Spatial patterns in Late Palaeolithic sites', *Helinium* XXX, 14–35.

Stapert, D 1992 *Rings and Sectors: Intrasite Spatial Analysis of Stone Age Sites*. Groningen: Unpublished PhD thesis, Rijksuniversiteit Groningen.

Sussman, C 1988 *A Microscopic Analysis of Use-Wear and Polish Formation on Experimental Quartz Tools*. Oxford (=Br Archaeol Rep, Intl Ser 395).

Taçon, P S C 1991 'The power of stone: symbolic aspects of stone use and tool development in western Arnhem Land, Australia', *Antiquity* 65, 192–207.

Thorsen, S 1980 '"Klokkehøj" ved Bøjden. Et sydvestfynsk dyssekammer med velbevaret primærgrav', *Kuml*, 105–46.

Thorsberg, K 1986 'Myten om eggvinklen', *Fjölnir* 5.1, 4–39.

Tolan-Smith, C 2001 *The Caves of Mid Argyll. An Archaeology of Human Use.* Edinburgh: Soc Antiq Scot.

Veil, S & Breest, K 2002 'The archaeological context of the art objects of the *Federmesser* site of Weitsche, Ldkr. Lüchow-Dannenberg, Lower Saxony (Germany) – a preliminary report', *in* Eriksen, B V & Bratlund, B (eds) *Recent studies in the Final Palaeolithic of the European plain*, 129–38. Højbjerg: Jutland Archaeological Society.

Vita-Finzi, C & Higgs, E S 1970 'Prehistoric economy in the Mount Carmel area of Palestine: site catchment analysis', *Proc Prehistoric Soc* XXXVI, 1–37.

Walker, M 1973 *Archaeological Excavation of a Microlithic Assemblage at Shieldaig, Wester Ross, Scotland. 24/iii/73 – 6/iv/73 : Preliminary Report*. Unpublished report.

Warren, G no date *Hawkhill, Angus. Chipped stone*. Unpublished report.

Warren, G forthcoming Chipped Stone Tool Industries of the Earlier Neolithic in Eastern Scotland. *Scott Archaeol J* 28(1), 27–47.

Warren, G & Neighbour, T 2004 'Quality quartz: working stone at a Bronze Age kerbed cairn at Olcote, near Calanais, Isle of Lewis', *Norwegian Archaeol Rev* 37(1), 83–94.

White, J P 1968 'Fabricators, Outils Écaillés or scalar cores', *Mankind* 6(12), 658–66.

White, J P & Modjeska, N 1978 'Where do all the stone tools go? Some examples and problems in their social and spatial distribution in the Papua New Guinea Highlands', *in* I Hodder (ed) *The Spatial Organisation of Culture*, 25–38. Pittsburgh: University of Pittsburgh Press.

Whittle, A 1986 *Scord of Brouster. An Early Agricultural Settlement on Shetland*. Oxford University Committee for Archaeology Monograph 9. Oxford.

Wickham-Jones, CR 1986 'The procurement and use of stone for flaked tools in prehistoric Scotland', *Proc Soc Antiq Scot* 116, 1–10.

Wickham-Jones, C R 1990 *Rhum. Mesolithic and Later Sites at Kinloch. Excavations 1984-86*. Edinburgh (=Soc Antiq Scot monogr 7).

Wickham-Jones, C R 1997 'The flaked stone', *in* Masters, L 'The excavation and restoration of the Camster Long chambered cairn, Caithness, Highland, 1967–80', *Proc Soc Antiq Scot* 127, 123–83.

Wickham-Jones, C R & Collins, G H 1978 'The sources of flint and chert in northern Britain', *Proc Soc Antiq Scot* 109, 7–21.

Wickham-Jones, C R & Hardy, K 2004 'Camas Daraich: a Mesolithic site at the Point of Sleat, Skye', *Scottish Archaeological Internet Reports (SAIR) 12*. [http://www.sair.org.uk/sair12/ index.html].

Wickham-Jones, C R, Brown, M M, Cowie, T G, Gallagher, D B & Ritchie, J N G 1982 'Excavations at Druim Arstail, Oronsay, 1911–12', *Glasgow Archaeol J* 9, 18–30.

Wiessner, P 1983 'Style and social information in Kalahari San projectile points', *Am Antiquity* 48(2), 253–76.

Williams Thorpe, O & Thorpe, R S 1984 'The distribution and sources of archaeological pitchstone in Britain', *J Archaeol Sci* 11, 1–34.

Wobst, H M 1977 'Stylistic behavior and information exchange', *Museum of Anthropology, University of Michigan. Anthropological Papers* 61, 317–42.

Woodland, A W 1979 *Geological Map of the United Kingdom North (North of National Grid Line 500km N)*. 3rd edn. Southampton: Institute of Geological Sciences.