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Use of the Polarising Microscope for Classifying Quartzite Artefacts from South Island Sites

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Abstract

FOR determination of the source of the material in stone artefacts examination of hand specimens is unsatisfactory. Some microscopic determinations have, therefore, been made of materials from a number of sites. The problem is mainly one of distinguishing between quartzites from various sources of supply. There is a broad correlation between the archaeological age and the lithology of artefact materials, which could be of importance for dating sites.

INTRODUCTION

IT is important for archaeologists to know the geological source of stone artefacts. Grosser distinctions can often be made by hand specimen examination, for example between baked argillite, basalt, obsidian and greenstone. However, when a collection of fragments is all of the same general rock type distinctions based on hand-specimen characteristics alone become unreliable and more detailed examination is required.

Previous work on this or allied problems is not extensive. The main concern has been with general description of rocks used in a site, e.g., by Coombs (*in* Lockerbie, 1959: 83) with unusual rocks of restricted occurrence (Turner, 1935; Keyes, 1961) or with rocks that can be used directly for dating, like obsidian (Ambrose and Green, 1962; Green, 1962; 1964).

The problem posed here is relatively simple: what petrological differences can be detected among the quartzites used in various archaeological sites? The petrographic microscope has been used to examine this problem, but it must be emphasised that the results presented here are derived from a pilot study. The specimens and thin sections are housed in the Otago Museum and are available for further reference.

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THE SAMPLE

Summary descriptions of the sites from which material was selected for examination are set out below in presumed chronological order*.

1. *Waitaki River Mouth* (S128/1), a large moa-hunting site covering between 75 and 125 acres. It is situated on three terraces a mile from the present river mouth. David Teviotdale excavated part of the site in 1933 (Teviotdale, 1939) and a further exploration was carried out in 1961 by Knight and Gathercole (1961). Recent research suggests that the site can be fairly confidently dated to prior A.D. 1000 (Simmons, 1967).

2. *Pounawea* (S184/1), situated on Pounawea Island in the Catlins estuary of South Otago. Excavated by Lockerbie (1959: 82–85). The site contains three layers: a bottom layer containing moa-hunter material dated *c.* A.D. 1140 ±60, a middle layer dated between A.D. 1400 ±55 and A.D. 1430 ±55, when, according to Lockerbie, moa had become scarce and other food sources were utilised, and a top layer dated between A.D. 1450 ±60 and A.D. 1660 ±60, consisting almost entirely of shell-fish remains.

3. *Papatowai* (S184/5), situated at the mouth of the Tahakopa River in South Otago, is essentially similar to Pounawea. It was excavated by Teviotdale (1938) and Lockerbie (1953; 1959: 80–85).

4. *Shag River Mouth* (S155/5), a large moa-hunter site, situated on the sand spit at the southern side of Shag River estuary. It covers about 4 acres. It was excavated by Teviotdale between 1919 and 1923 (Teviotdale, 1924). Earlier reports (Chapman Manuscript in the Hocken Library) indicate that there were three layers present over most of the site, and occasionally more. The bottom two layers contained moa bone, while the top layer, as at Pounawea, was largely shell. Excavations by Hjarno in 1965 to recover dating material have resulted in dates of A.D. 1127 ±55 and A.D. 1148 ±55 for the bottom layer.

5. *Little Papanui* (S164/1), on Otago Peninsula, near Cape Saunders, at the mouth of Patoki Creek, was excavated by Teviotdale and Skinner (Skinner, 1960). The bottom layer contained some evidence of moa-hunting. The middle layer yielded material showing a later development of the same culture. The top layer is Classic Maori and may be evidence of an invading group from the Canterbury region.

6. *Murdering Beach,* moa-hunter site (S164/16a), situated near the North Head of Otago Harbour on an ancient dune line behind the flat on which the late village was established. It was excavated by Lockerbie (1954: 145; 1959: 90–91) who found a moa-hunter layer characterised by " typical moa-hunter tools ".

7. *Kyeburn* (S135/1), a small site at Kyeburn Diggings, near Naseby, in Central Otago. It was excavated in 1935 by George. The main interest of this site is its position on the Dansey Pass which provided a route through the mountains between the Maniototo Plain and the Waitaki River. This access to plain or river was probably important in prehistoric times.

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* Relative sequences of sites have been established by the independent analysis of the typological variation in certain artefacts (e.g., adzes, fish hooks, and flake material) which form continuous sequences, and other elements in material culture (e.g., ornaments, musical instruments, weapons, and faunal remains) which are discontinuous. The latter items are usefully compared on a presence/absence basis, as information on quantities is not always available. A fairly close correspondence has been found between the relative sequences established. This in turn has been correlated with radiocarbon dates. The information obtained by classifying the quartzites was not available and has not been used to place the sites in chronological order.

8. *Murdering Beach* (S164/16b), presumed to be a Classic Maori village. It was excavated by Skinner in 1929-1930 (Skinner, 1960) and Lockerbie in 1952 (Lockerbie, 1954: 145; 1959: 91–93). The culture is late Maori and appears to be mainly intrusive from Canterbury. In 1817, when the site was visited and probably destroyed by the whaler Kelly, the inhabitants were growing potatoes for trade to Europeans.

9. *Anita Bay* (S105/1), situated on the West coast of Otago. The collection was made from a bowenite-working floor discovered by MacKenzie when he was making the garden for Milford Sound Hotel.

10. *The Becker Quarry, Oturehua* (S134/1), a quarry and working floor. Outcropping quartzite boulders lying on schist were utilised, cores being struck off and tools made at the site. The boulders do not exceed 4ft across. The site, discovered in 1966, is not yet fully recorded.

11. *Gray's Hills Quarry,* in the MacKenzie Country of South Canterbury, was discovered by McCully in 1930. The site consists of small boulders of quartzite and much working debris in a dish-shaped hollow.

12. *Nenthorn* (S145/1), inland from Waikouaiti and north of Middlemarch, in Central Otago, is a quarry and working floor. Excavated by Trotter (1961), it consists of a 20ft-high outcropping boulder, one surface of which may have been quarried, and small separated blocks or boulders which were more commonly utilised for making blade tools.

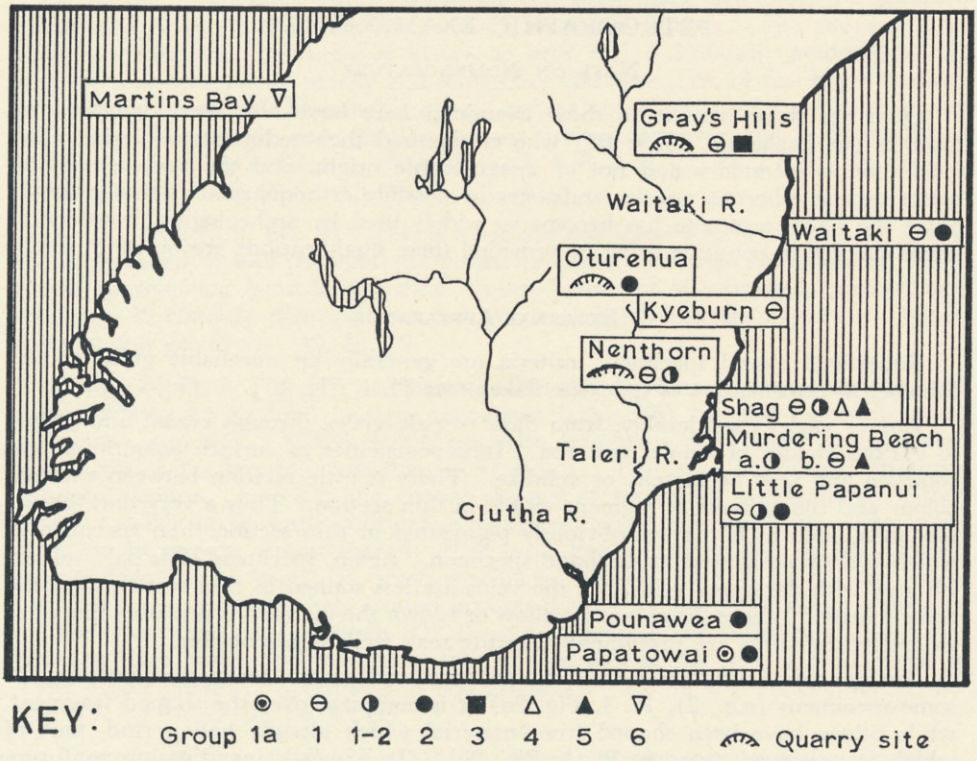


FIG. 1.—Distribution of quartzite and non-quartzite groups.
For Martins Bay read Anita Bay.

TABLE I

The sites and specimen numbers used for this study.

Site	*Number of specimens examined*	*Specimen numbers*
Waitaki River Mouth	5	25–29
Pounawea	1	80
Papatowai	6	49–54
Shag River Mouth	20	5–24
Little Papanui	5	63–66, 78, 79
Murdering Beach, moa-hunter	2	55, 77
Kyeburn	4	42–45
Murdering Beach, Classic Maori	3	56–58
Anita Bay	1	46
Oturehua	6	81–86
Gray's Hills Quarry	4	3, 4, 73, 74
Nenthorn	4	1, 2, 75, 76

Specimens identified as quartzite from external appearance were selected from a very large collection of implements and waste flakes in the Otago Museum by sorting flakes from each locality into groups of superficially similar aspect. The criteria applied for this were grain size, presence or absence of glassy inclusions, and colour, i.e., exclusively lithological criteria. Representatives from each of these hand-specimen groups were selected for sectioning.

PETROGRAPHIC EXAMINATION

NOTE ON NOMENCLATURE

Quartzite flakes similar to those examined here have also been described by Coombs (*in* Lockerbie, 1959: 83) who emphasised their sedimentary origin. The induration is secondary and not of metamorphic origin, and the rocks would be better termed siliceous quartz sandstones or possibly orthoquartzites (cf. Coombs). Since the name quartzite has become so widely used by archeologists, however, it seems simpler to continue using it, provided these qualifications are borne in mind.

EXTERNAL APPEARANCE

Superficial (hand specimen) criteria are generally an unreliable guide to the lithological classification of quartzite flakes—see Pl. 1, Fig. 1.

Colour varies considerably, from dark to pale greys, through cream and yellow to various shades of brown and red. Inhomogeneities of surface colouration are common and may be blotchy or veinlike. There is little relation between external colour and the amount of pigment visible in thin section. Thus a very dark-brown specimen, such as 65, is less obviously pigmented in thin section than specimen 2, which is cream-coloured in the hand specimen. Again, specimen 27 is pale yellowish grey with dark-grey veins, but the veins are less stained in thin section than the paler matrix. Where the colour is yellow or brown the pigment is probably limonite; where reddish tints are prominent hematite may well be responsible.

Surface-weathering rinds are quite common and present features of interest. On some specimens (e.g., 21, Pl. 1, Fig. 2a) it is complete over the shaped fragment, while others have been shaped from material which already had a rind, part of which is preserved (e.g., 9, Pl. 1, Fig. 2b). It is worth investigating in future studies the possibility that worked fragments with complete weathering rinds are of significantly greater age (archaeologically) than the rest.

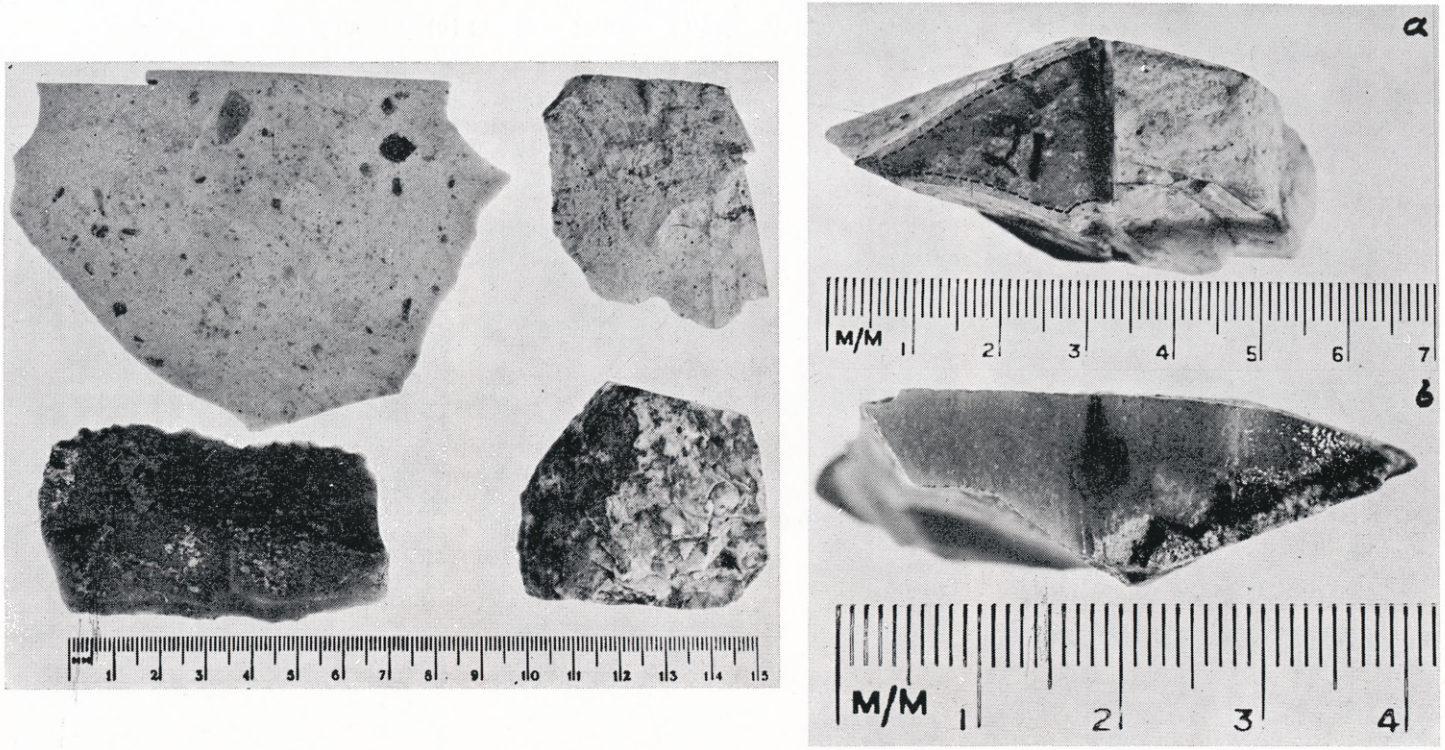
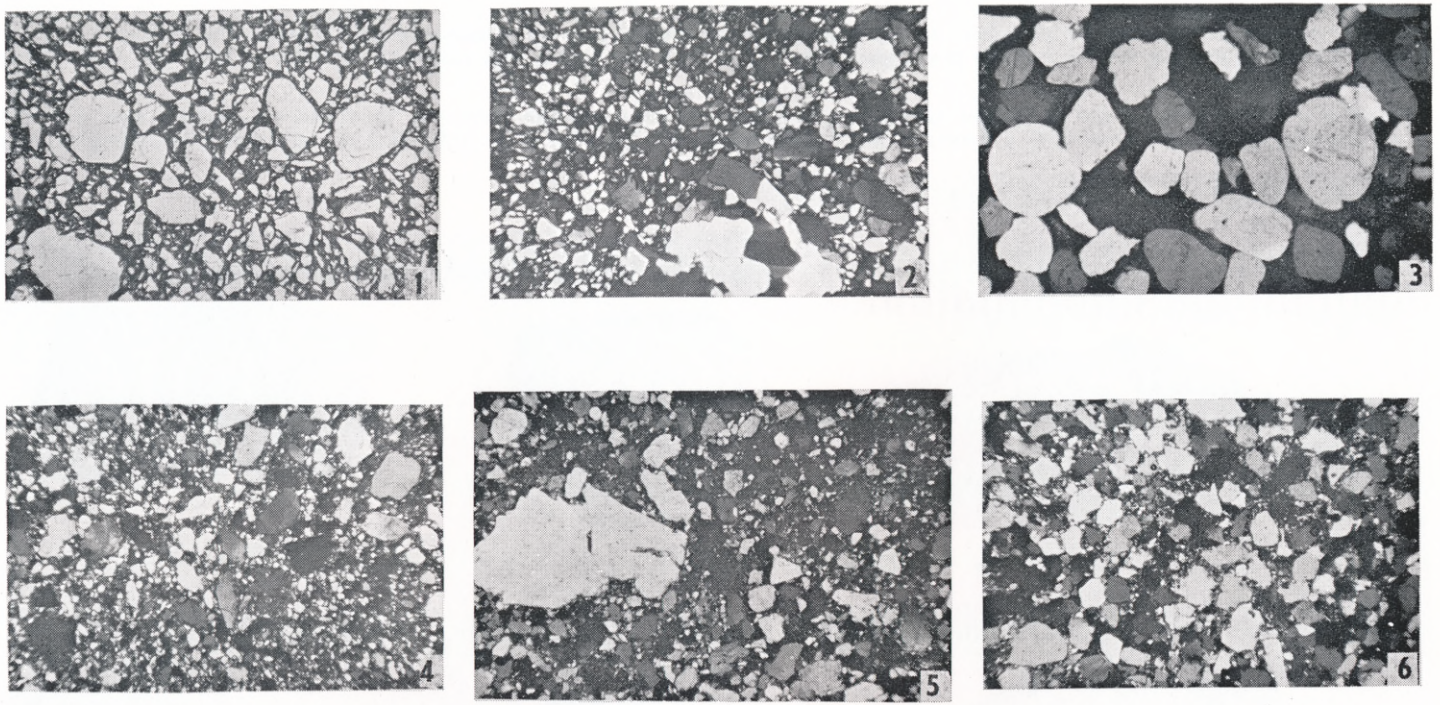


FIG. 1.—Specimens 2 (top left), 21 (top right), 9 (bottom left), 6 (bottom right), all of Group 1 (sub-group with stained matrix). 2 is pale grey with "glassy" inclusions. 21 is creamy with yellowish blotches, 6 is brown with whitish to yellow blotches, and 9 is medium brown to grey.

FIG 2.—(a) Specimen 21, showing weathered skin formed over shaped fragment (visible and outlined only on left half of specimen, where sawn for thin section). (b) Specimen 9, showing original weathering skin (lower right) partly removed by working.

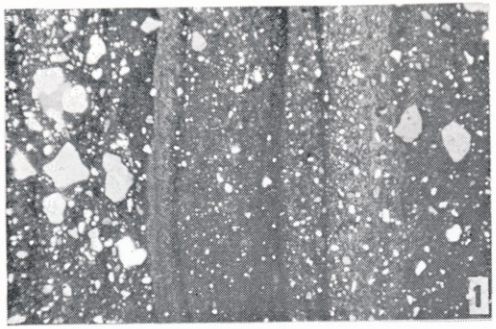


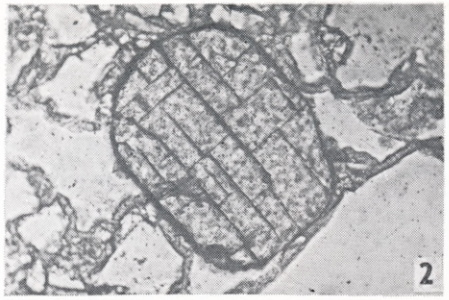
FIGS. 1–2.—Group 1. Picture lengths = 2mm. (1) Specimen No. 2, plane light, showing grain size range, embayment of grains and stained intergranular silica (dark). (2) Specimen No. 22, crossed nicols, field with more uniform and finer grain size, but showing also large composite mosaic fragment of metamorphic quartzite (lower centre-right).

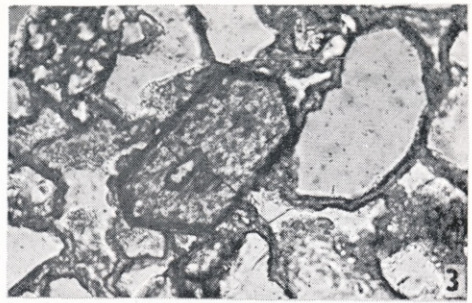
FIG. 3.—Group 1A. Picture length = 2mm. Specimen 51, crossed nicols, showing overall larger, more uniform grain size and more rounded grains than Group 1.

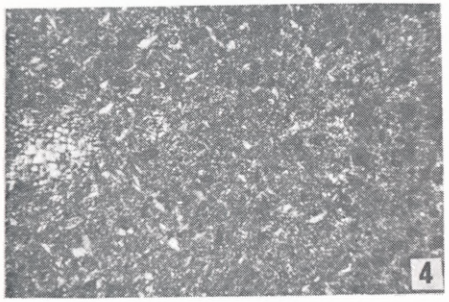
FIGS. 4–5.—Group 2. Picture length = 2mm. (4) Specimen 28, crossed nicols. Virtually all the intergranular space is filled with comminuted quartz. (5) Specimen 79, crossed nicols. As (4), showing large angular quartz grain.

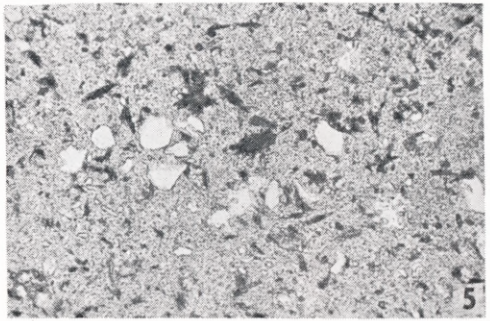
FIG. 6.—Transitional Group 1–2. Picture length = 2mm. Specimen 23, crossed nicols, showing comminuted quartz in intergranular spaces in addition to secondary silica.











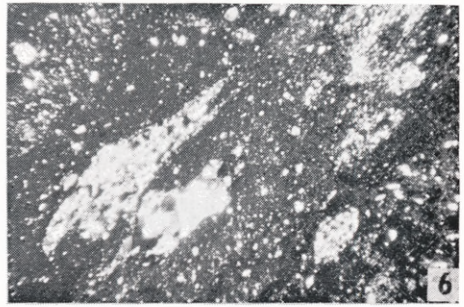


FIG. 1.—Group 3. Picture length = 2mm. Specimen 74, crossed nicols, showing variable grain size and one of the chalcedonic bands.

FIGS. 2–3.—Accessory zircon in quartzites of Groups 1, 2 and 3. Plane light. (Specimen 2) Picture length = 0.3mm. (2) Basal section showing two cleavages at right angles. (3) Prismatic section, showing good euhedral form, and possibly an apatite inclusion.

FIG. 4.—Group 4. Picture length = 2mm. Specimen 7, crossed nicols, showing very fine spherulitic chalcedonic groundmass with local patches of coarser spherulitic development (left), and abundant lozenge-shaped calcite (white to grey). At right of picture can be seen the darker amorphous pseudomorphs after calcite produced in the weathered skin.

FIG. 5.—Group 5. Picture length = 0.75mm. Specimen 13, plane light, very fine cristobalite-rich(?) groundmass with disseminated quartz grains and altered pyroxene prisms (black).

FIG. 6.—Group 6. Picture length = 2mm. Specimen 46, crossed nicols, showing very fine groundmass, evidence of preferred orientation (foliation), top right to bottom left, composite (porphyroblastic?) quartz aggregates and scattered epidote and quartz grains, mutually indistinguishable in the photograph.

One fairly reliable deduction that can be made from the hand specimens is that where small, sub-rounded *vitreous inclusions* are seen (e.g., 2, Pl. 1, Fig. 1), the microscope shows them to be fragments of metamorphic quartzite. Exceptionally such fragments may reach 1cm in length (specimen 22).

MICROSCOPIC EXAMINATION

The sample has been divided into two main groups, *quartzites* (by far the most abundant) and *non-quartzites*. Each main group has been further subdivided, but it must be emphasised that, for the quartzites, classification is to some degree subjective, since transitional varieties occur.

QUARTZITES (Groups 1, 1a, 2, 1–2, 3)

Group 1 (Pl. 2, Figs. 1, 2): Angular to subrounded quartz grains range in size from 0.05 to (exceptionally) 0.5mm, with rare well-rounded grains up to 1mm in diameter. In the larger composite fragments of metamorphic quartzite (Pl. 2, Fig. 2), individual crystals sometimes show strain extinction and some preferred orientation.

The intergranular spaces are filled with finely crystalline prismatic and mosaic secondary quartz, in part derived by solution of the detrital quartz grains. Most of the latter show evidence of fretting and embayment.

A further subdivision within this group has been made below on the presence or absence of staining in the intergranular secondary quartz. The staining is in various shades and intensities of brown to grey and is generally amorphous. It may be uniform or quite patchy and sometimes takes the form of fine black dusting, probably of hematite. Staining is not at present considered to be a factor of any importance in assessing petrographic type or geological source, but is distinguished in the specimen list as follows: *Stained*: 2, 3, 4, 6, 8, 9, 21, 22, 27, 42, 44, 56, 57, 73; *Unstained*: 1, 5, 10, 11, 15, 43, 45, 75, 78.

Group 1A (Pl. 2, Fig. 3): This is a variant of Group 1 in which all the grains are subrounded to well-rounded and generally larger and more equigranular, many grains approaching $\frac{1}{2}$mm in diameter. A small amount of staining is present, and specimen 49 contains plentiful rounded grains of partly altered magnetite. Specimens in this group are: 49, 51, 52.

Group 2 (Pl. 2, Fig. 4): Angular to subrounded grains are characteristic once more, ranging up to 1mm in some specimens (e.g., 66b) but not exceeding $\frac{1}{4}$mm in others (e.g., 63). Metamorphic quartzite fragments and larger well-rounded quartz grains are less common than in Group 1. The most important difference between Groups 1 and 2 is the virtual absence of secondary quartz in the latter, except possibly as optically continuous overgrowths on grain margins. The intergranular spaces are almost entirely filled with finely comminuted detrital quartz, mostly down to 10^{-3}mm. In some specimens, notably 63 and 81–86, the intergranular material is less finely ground, so that the overall grain-size range is smaller. At the other extreme (specimen 80) there is a greater size difference than usual between large grains and matrix, so that in thin section the rock is gradational to Type 3 (see below). Specimens in this group are: 25, 26, 28, 29, 50, 53, 54, 63, 66B, 79, 80, 81, 82, 83, 84, 85, 86.

Transitional Group 1–2 (Pl. 2, Fig. 6): Some specimens possess features common to Groups 1 and 2, especially intergranular secondary quartz as well as finely comminuted detrital quartz, in varying proportions. The status of this transitional

group is more subjective than any of the others. The specimens have again been subdivided according to whether or not matrix staining is present: *Stained*: 12, 18, 19, 23; *Unstained*: 14, 16, 17, 20, 24, 55, 64, 65, 66A, 76, 77.

Group 3 (Pl. 3, Fig. 1)—specimen 74 only: The rock is grey and flinty in hand specimen, with narrow subparallel bands 1–2mm thick and half a centrimetre or so apart, which are darker grey and of more chalcedonic aspect.

In thin section the dominant feature is the matrix of chalcedonic and finely granular quartz, with scattered larger angular quartz grains. The thin bands of the hand specimen are confirmed by the microscope to be rich in chalcedony, which is spherulitic in places.

Accessory Minerals in the Quartzites

The only significant accessory (detrital) mineral is one having optical properties in thin section consistent with zircon, except that the cleavage is sometimes better developed than appears to be typical for this mineral (Pl. 3, Fig. 2). It is found in varying amounts in almost all specimens of Groups 1 to 3. This tends to confirm that all the quartzite material has been quarried from beds of suitable lithology among pockets of late Cretaceous and Tertiary sediments, which locally overlie the schists and greywackes of Otago (see also Coombs, *in* Lockerbie, 1959). Zircon is universally present in these basement rocks and is the commonest derived detrital mineral in the younger sediments (Hutton and Turner, 1937; Turner, 1943).

The only other detrital accessories found were opaque magnetite, rare crystals of brown tourmaline, brown hornblende, and possibly brown garnet, in specimens 2, 3, and 74. Further search would probably reveal these minerals in other samples also.

NON-QUARTZITES

Group 4—specimen 7 only: Outwardly the rock is of rather mat appearance but not unlike some less vitreous quartzites. In thin section (Pl. 3, Fig. 4), a chalcedonic matrix is seen to be finely spherulitic with abundant lozenge-shaped crystals of (ferruginous?) calcite, replaced by amorphous pseudomorphs in the weathered skin. There is no detrital quartz. Similar rocks were described by Coombs (*in* Lockerbie, 1959: 83), who suggested that they might have originated from Moeraki.

Group 5—specimens 13 and 58: Respectively grey and yellowish-brown very fine-grained rocks of porcellanous aspect, reminiscent in thin section of the porcellanites produced by contact metamorphism of argillite along basalt dyke contacts at Moeraki (C. A. Landis, pers. comm.). Both rocks have a very fine but rather turbid groundmass rich in cristobalite (or opaline silica derived from it), in which are numerous disseminated quartz grains, and in specimen 13 abundant altered prisms probably of clinopyroxene (Pl. 3, Fig. 5) with rare grains of pale-green amphibole. In specimen 58 there are fewer of these prisms, which are more highly altered, and amphibole is not seen. Instead, occasional subspherical aggregates of quartz and calcite occur, and there is plentiful impure (ferruginous?) calcite in veins and patches.

Group 6—specimen 46 only: The grey fine-grained rock is of patchily chalcedonic and sub-conchoidal aspect, which appears in thin section to be a metamorphosed (possibly tuffaceous) argillite, with some semblance of foliation, and lenticular mosaic aggregates of recrystalised quartz (Pl. 3, Fig. 6). There is also abundant epidote and possibly a little detrital zircon.

RESULTS

Fig. 1 and Table II summarise the distribution of archaeological sites and lithological groups recognised here. There is a broad correlation between age and lithological type. This could well be important for indicating the age of a site not dated by other means and for defining trade or access routes and the geographical areas utilised by particular groups. More detailed investigations should be particularly directed towards classification of quartzites from quarry sites to establish additional sources for the different groups. Thus Oturehua is probably only one possible source of the Group 2 artefacts, while there are almost certain to be other quarry sites than Nenthorn for Groups 1 and 1–2. The Gray's Hills Quarry, the most northerly of all the sites represented, is of interest in that, unlike Nenthorn and Oturehua, it is situated on greywacke rather than schist basement. Locally derived quartzose sediments at Gray's Hills might accordingly be expected to possess distinctive features marking them off from similar sediments on schist basement. The single Group 3 specimen is from Gray's Hills and is quite distinctive in hand specimen because of its banded character. It may well be indigenous, because examination of the Gray's Hills collection in the Otago Museum reveals an abundance of the same distinctively banded quartzite.

CONCLUSIONS

1. Microscopic examination provides a sounder basis than hand specimen criteria for classifying artefacts into lithological types.

2. Such a classification facilitates the search for geological sources of worked material.

3. Detailed petrographic analyses could well be important as a tool for dating archaeological sites.

TABLE II

Site and Quartzite Group Correlations

Collection Sites in Chronological Order, oldest at the bottom. (Quarry sites are italicised.)	2*	1A	1-2*	1*	3	4	5	6
Anita Bay								46
Murdering Beach (b) (Classic Maori)				56, 57 42, 43, 44			58	
Kyeburn				45				
Gray's Hills				*3, 4, 73*	*74*			
Nenthorn			*76*	*1, 2, 75*				
Murdering Beach (a) (Moa-hunter)			55, 77					
Shag River Mouth			12, 18, 19, 23 14, 16, 17, 20 24	5, 6, 8, 9, 10, 11, 15, 21, 22		7	13	
Little Papanui (bottom and middle layers)	63, 66B, 79		64, 65, 66A	78				
Papatowai	50, 53, 54	49, 51, 52						
Pounawea	80							
Waitaki River Mouth	25, 26, 28, 29			27				
Oturehua	*81, 82, 83, 84, 85, 86.*							

* No subdivision on basis of staining.

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