Quantifying Mineral Raw Materials in Neolithic Knapped Tool Production in the Lake Saimaa Area, Finnish Inland

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Abstract

In Finland, the Neolithic period begins with the appearance of ceramics ca. 5200 calBC and ends at the beginning of the Bronze Age ca. 1800 calBC. The co-occurrence of widespread and abundant flint import and Typical Comb Ware pottery (3900–3400 calBC) has been recognised since the very early days of Finnish archaeology, but so far, only one study has quantified the volume of Neolithic flint import to Finland. In general, the exploitation of domestic lithic raw materials has not been quantified at all. The present study provides an overview of the main trends in the use of mineral raw materials that were exploited in knapped tool production during the Neolithic in the Lake Saimaa area, Finnish inland. Firstly, the results show temporal and spatial variation in the selection of raw materials. As expected, the linkage between the heyday of flint import and Typical Comb Ware pottery is clearly visible. Moreover, during the span from the beginning of the Neolithic to the end of the Typical Comb Ware period, the utilisation of high-quality quartzes was very high. On the contrary, the latter part of the Neolithic was completely dominated by the exploitation of vein quartzes. The results also indicate spatio-temporal changes in the used reduction techniques, as well as in the reduction sequences present at the studied sites.

1 Introduction

Lithics, and particularly debitage, have been an overlooked material in Finnish Neolithic studies. Vein quartz, which has been considered as the prevailing raw material in knapped tool production during the Stone Age, is a difficult material to work with: its fracture is irregular, it has plenty of internal flaws, and the number of typologically distinctive formal artefact types is very limited. Consequently, the traditional tendency towards typological studies in Finnish archaeology and the lack of a theoretical basis for studying quartz have led to a situation where very few studies have been made on the changes in the raw material base.

Since the dawn of fracture analysis (Callahan et al. 1992; Knutsson 1988), lithic studies on quartz have mainly focused on identifying different reduction techniques and the presence or absence of complete reduction sequences at sites (e.g. Rankama 2002). Instead of a detailed technological analysis of singular assemblages, we chose to analyse a larger bulk of material with coarser methods – the study includes altogether 21 separate assemblages

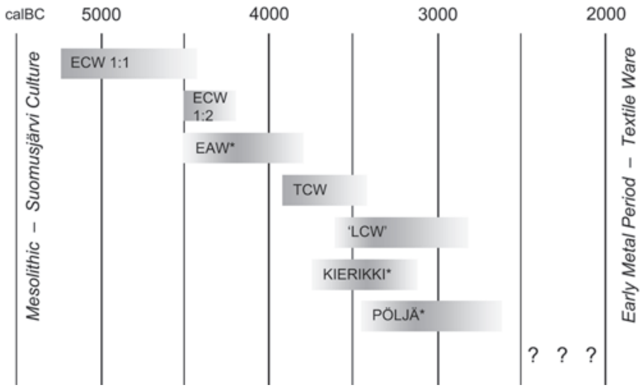

Figure 1. Neolithic chronology of the Finnish inland lake area (schema slightly modified after Pesonen 2004; Pesonen & Leskinen 2011; Pesonen et al. 2012; Oinonen et al. 2014). Abbreviations: ECW 1:1 – Early Comb Ware, older style (a.k.a. Sperrings 1); ECW 1:2 – Early Comb Ware, younger style (a.k.a. Sperrings 2); EAW – Early Asbestos Ware; TCW – Typical Comb Ware; 'LCW' – Late Comb Ware and typologically unspecified Comb Ware -related ceramics; KIERIKKI – Kierikki Ware; PÖLJÄ – Pöljä Ware (including the material previously labelled as Jysmä Ware). * – Mainly asbestos-tempered pottery types. Illustration: T. Mökkönen.

from 18 Neolithic sites in the Lake Saimaa area, eastern Finland (Figs. 1 & 2; Appendix 1). The aim of the study was to identify different profiles of raw material use and to get some idea of the temporal and regional variability of material culture and raw material use during the Neolithic (the Neolithic is customarily seen to start with the adoption of pottery, ca. 5200 calBC, and to last until the Bronze Age / Early Metal Period, ca. 1800 calBC).

This article starts with a short survey of lithic studies made on quartz and on the occurrence of flint in Finnish Stone Age materials. We continue by introducing the aims of the article and the methods used and proceed by presenting the material and the results of the analysis. This is followed by a short discussion of the general trends emerging in the study and their possible implications.

2 Lithic studies in Finland

The research history of knapped tools and debitage, referred to also as lithics, is a short one in Finland. Until recently, the main emphasis has been put on imported flint-like raw materials, and only a few geological analyses have been executed. Technological analyses of quartz, including both knapped artefacts and debitage, were not performed to a large extent until the 1990s (see Räihälä 1999; Rankama 1997; Schulz 1990).

The lack of technological analyses on quartz reflects the lack of proper methods for analysing the material: initial analyses, which followed the methods used in flint analyses (see Luho 1956; 1957), led to erroneous results when applied to quartz material (Siiriäinen 1977; 1981), but for a long time, no alternative method was available (see Knutsson 1998). Since fracture analysis suitable for quartz material was launched some thirty years ago (Callahan et al. 1992; Knutsson 1988), quartz lithics gained new source value and analyses of quartz material were also carried out in Finland (e.g. Räihälä 1999; Rankama 2002).

The last decades are marked by the active analysing of lithics and utilisation of archaeological quartz material in research (Manninen 2003; Pesonen & Tallavaara 2006; Räihälä 1998; 1999; Rankama 2002; 2003; Rankama et al. 2006; Tallavaara 2007; Tallavaara et al. 2010). Even so, the temporal and regional coverage of the published analyses is modest, and only a few analyses have been conducted on Neolithic materials (Hertell & Manninen

2005; Manninen et al. 2003; Rankama 2002; 2003; Tallavaara 2005; 2007). The bulk of the recent technological studies of lithic assemblages –frequently made on flint-like materials – have been put into practice in connection with post-glacial Mesolithic pioneer settlement (Hertell & Manninen 2006; Hertell & Tallavaara 2011; Jussila et al. 2007; 2012; Kankaanpää & Rankama 2005; 2011; Rankama & Kankaanpää 2013; Takala 2004).

Throughout the Stone Age, with occasional exceptions, local lithic raw materials have dominated knapped tool production. Vein quartz, which occurs widely as rounded cobbles in moraines and as veins in bedrock, has been the primary raw material in Finland (Rankama 2003; Rankama et al. 2006). It may be that vein quartz has been considered so common in nature that it has not inspired archaeologists to map the raw material sources (however, see Alakärppä et al. 1998; Rajala 1999). Quartz is commonly classified as a local raw material, the knapping properties of which are notably inferior to those of flint. However, there are different varieties of quartz, and the finer variants, such as the colour variants of rock crystals, are (on rare occasions) recognised in literature as domestic, nearly flint-like raw materials (Rankama et al. 2006). In contrast to vein quartz, the deposits of some varieties of rock crystals might have a rather limited geographical distribution: for example, the Morion type of smoky quartz is a very black variety of quartz, which can be found in crystal cavities particularly in the area of the Vyborg Rapakivi Massif in south-eastern Finland (Kinnunen et al. 1987; Poutiainen 1991; Simonen 1987).

3 Flint in Stone Age assemblages

Flint cannot be found in Finnish geological deposits, and its appearance in archaeological materials provides evidence of (long-distance) contacts between Finland and the main flint sources in Russia, in the southern part of the Baltic States, and in Belarus, situated at a distance of ca. 350–700 km from the Finnish borders (Gurina 1976; Hertell & Tallavaara 2011; Kinnunen et al. 1985; Manninen et al. 2003; Vuorinen 1982; Zhuravlev 1982). Smaller flint deposits are present (mainly as pebbles) in sedimentary layers in the Baltic States (Kriiska et al. 2011: 67) and in the Kola Peninsula, Russia (Gurina 1987: 43; Muzhikov 1996: 45; Shumkin 1986: 31). Some flint-like materials can be found in Finland, too, such as northern Finnish jasperoids (Kinnunen et al. 1985: 24–25).

There are two major periods in Finnish prehistory with a higher share of flint in their lithic assemblages: the first is the Early Mesolithic post-glacial pioneer settlement phase (ca. 9000–8500 calBC) and the second is the Middle Neolithic Typical Comb Ware period (hereafter TCW; 3900–3400 calBC). The contacts between Finland and the flint sources may have been direct, as proposed in the case of pioneer migration, or indirect (Edgren 1984: 22; Jussila et al. 2012: 20–21; Kankaanpää & Rankama 2014; Takala 2004: 169–170). In the latter case, the factors that maintained the flint import might have been commercial relations, gift exchange, marriage networks, or some other cultural reasons (Hertell & Manninen 2006; Jussila et al. 2007; 2012; Manninen et al. 2003; Vuorinen 1982). Even though some rapid pioneer migration evidently occurred (Kankaanpää & Rankama 2014), a recent study of the Early Mesolithic flint-like materials concluded that the distribution of these materials in Finland was, for the most part, also due to the work of exchange networks, that is, indirect contacts (Hertell & Tallavaara 2011). According to Vuorinen (1982: 91), the TCW flint import included both gift exchange of large ready-made objects and exchange of flint nodules as raw material.

Finnish Stone Age flint, including all flint-like materials such as cherts, has been studied in terms of petrology. According to Kinnunen et al. (1985), both flints from eastern Carboniferous and southern Cretaceous/Tertiary deposits were imported to Finland in varying amounts during different periods, although the eastern materials dominate the picture. The latest analyses from the Middle–

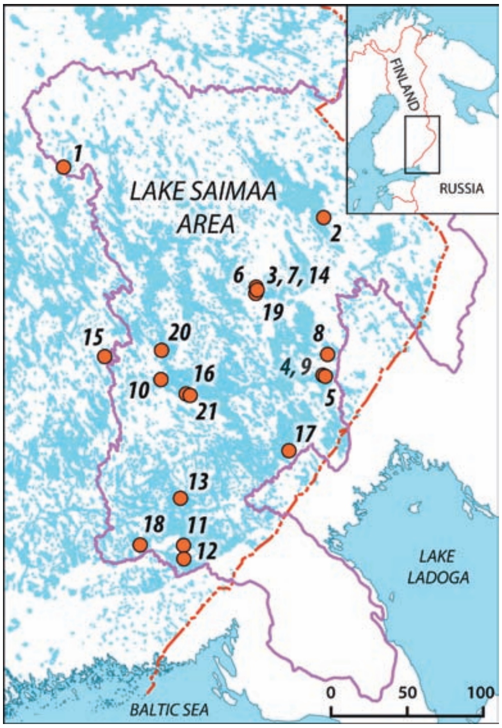

Figure 2. The Lake Saimaa area and sites included in the study. The numbering of sites refers to Table 2 and Appendix 1. Illustration: K. Nordqvist.

Late Neolithic site of Råvåsen (ca. 3400–2000 calBC) in Southern Ostrobothnia (western Finland) showed that flint-like materials were mainly of eastern Carboniferous origin, while the provenance of some artefacts remained unspecified (Kinnunen 2005; see also Costopoulos 2003). The geological results are pretty much in line with the previous assumptions based on macroscopic observations, in which the eastern flint deposits, and especially the Valdai area, have been seen as the main source for flint, at least during the TCW period (e.g. Ailio 1921: 6; Torvinen 1979: 69; Vuorinen 1982: 77–78; cf. Manninen et al. 2003: 172).

The high magnitude of flint import into Finland during the TCW period has long been a commonly accepted fact in Finnish archaeology (e.g. Ailio 1921: 6–7; Europaeus-Äyräpää 1930: 210; Pälsi 1915: 122). Still, only one study has quantified the volume of this import in relation to other mineral raw materials: based on Vuorinen (1982: 80, Maps 3–7; 1984), the TCW flint import is most abundantly visible in the Lake Saimaa area and on the Karelian Isthmus in Russia. After this study, the magnitude of flint import has not been reapproached.

4 Aims and methods

The quantification of materials is one of the basic tasks of archaeological research. However, not too much effort has been put into understanding the temporal changes in Finnish Stone Age lithic raw materials in general. The aim of this study is to draw temporal profiles of lithic raw material use during the Neolithic in the Lake Saimaa area, eastern Finland. By creating these profiles, our study aims to produce quantitative data of Neolithic lithic raw material use in the Lake Saimaa area, which further allows us to observe chronological and regional tendencies and most probably cultural trends, too. In order to understand what other changes took place in relation to changes in raw material use, we provide some simple ratios between different artefact types. This study is also intended as comparative data for upcoming studies in other geographical areas.

Recovery techniques employed in archaeological excavations have improved greatly since the early 1980s, which has resulted in a more accurate picture of the find material, especially in the case of the smallest items. In addition, the excavations made during the 1990s narrowed down the gap in the archaeological data from the Lake Saimaa area, which previously concerned especially the periods following TCW (see e.g. Karjalainen 1999; Katiskoski 2002). Therefore, data and material facilitating a broad understanding of the actual volume of archaeological lithic assemblages, as well as their volume of change, have not been available for long.

The archaeological material used in this research derives from altogether 18 sites (Fig. 2; Appendix 1), and was studied piece by piece at the National Board of Antiquities, Helsinki, by the authors. The lithics were first classified according to the raw material, and, secondly, according to their type, the latter meaning a simple division into flakes, cores, and major artefact types (scrapers, knives, burins, etc.), as well as raw material pieces. Also additional information, like the reduction technique of cores and the presence of cortex, was recorded. The analysis was done with the naked eye only, and no detailed technological analysis of debitage, in the meaning of fracture theory, was executed.

The quartzes were divided into ordinary vein quartz and high-quality quartzes (hereafter H-Q quartzes). The division was based on colour and grain size, determined again with the naked eye. Coarse-grained whitish-grey quartzes with internal flaws were classified as vein quartz, while fine-grained quartzes, like rock crystals and their different colour variants (smoky quartz, rose quartz etc.), were classified as H-Q quartzes. A similar classification has been used in some recent studies on quartz materials (see Driscoll 2010; Sandquist 2013).

The variables concerning the raw material were not quantified on a piece-by-piece level. Rock crystals and other H-Q quartzes are easily recognisable, but there is often much variation both in colour as well as in grain size, even within one piece. Also tiny flakes present challenges, which make a definite classification of every single piece quite impossible. Therefore the presence of H-Q quartzes was recorded only on the level of catalogue subnumber (present/absent). This is, of course, a less accurate way to quantify material use, but the outcome is reliable enough, as the finds have been collected and catalogued in fairly uniform ways (see below).

Other rocks were also quantified. Rocks that were not identified with the naked eye, as well as singular pieces of particular stones, such as the only piece of lydite in our materials in a Phase 3 (4000–3500 calBC) assemblage from Rääkkylä Vihi 1, were combined into the ‘Other’ category.

5 Material

The Neolithic lithic material analysed in this study consists of 21 separate assemblages in the Lake Saimaa area (Figs. 1 & 2; Appendix 1), which derive from 18 sites: five of them originate from two larger sites with several dwelling areas, namely Outokumpu Sätös and Rääkkylä Pörrinmökki (one assemblage includes all analysed material from one site belonging to one temporal phase). All sites can be classified as larger dwelling sites, and in two cases the settlement is accompanied by a cemetery. Nevertheless, there is considerable variation in the volume and representativeness of available assemblages, both within and between different temporal phases. The whole material consists of ca. 41,000 pieces, with a total weight of some 148 kg (Fig. 3).

Based on pottery and radiocarbon dates, each of the assemblages is supposed to represent a single cultural component and/or limited time span. Mixed contexts were avoided, and in order to escape biases caused by different excavation methods, sites excavated during the 1990s or later were prioritised. However, due to problems in finding clean sites with single cultural components, some assemblages include parts that were produced with slightly less accurate recovery techniques and cataloguing methods (see Appendix 1). Nevertheless, as most of the material has been collected with fairly uniform precision (pinpointed find recovery and use of screens), there should be no significant biases caused by differences in data collection.

The studied materials and contexts date between ca. 5000 and 2000 calBC. In order to observe temporal variation in the material culture, the assemblages were divided into five phases (Table 1; Fig. 2), which follow the dating of different pottery types (Fig. 1) quite smoothly. However, as the study area roughly equals the Ancient Lake Saimaa, a great inland lake that existed in the region prior to the outbreak of the current outflow channel, the Vuoksi River (ca. 4100–3800 calBC; Delusin & Donner 1995; Mökkönen 2011a), the hy-

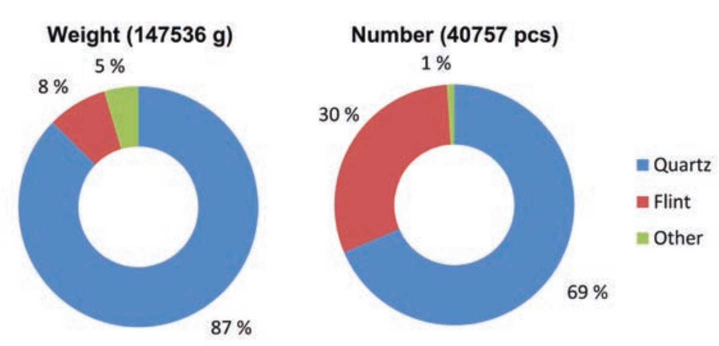

Figure 3. Overview of the analysed lithic materials in the Lake Saimaa area.

drological history of this basin imposes some restrictions on the spatio-temporal coverage of sites. Before the formation of the Vuoksi River, the southern parts of the lake area were transgressive. The speed of isostatic land uplift, which was higher in the north than in the south, and the consequent effects on water bodies also contributed to the formation of multi-period dwelling sites. At least partly because of these environmental causes, the southernmost part of the lake system is beyond the regional coverage of assemblages during Phases 2 and 5 (5000–4000 calBC and 3000–2000 calBC). Further, the original idea was to analyse also Late Mesolithic materials, but only a few sites dating to 6000–5000 calBC (Phase 1) are known in the Lake Saimaa area, and none of them have been excavated (Phase 1 was not totally discarded, since the same periodisation will be used in studies concerning other regions). Finally, Phase 4 (3500–3000 calBC) is represented by one assemblage only, because new radiocarbon dates acquired during this research (which will be published separately) proved some sites to date to both Phases 4 and 5. In other words, Phase 4 is not comparable alone.

6 Results and discussion

The results show that there is significant variation in the amount of lithics per excavated area (Table 1). Some of the variation is due to the uneven quality and size of the available assemblages, but the results generally reflect wider trends in raw material utilisation. The lithic raw materials are dominated by quartz throughout the Neolithic, with the high tide in flint use during Phase 3 being the only obvious exception (Fig. 4).

The share of flint in the studied assemblages confirms the long-known phenomenon of flint import during TCW (Phase 3) in the Lake Saimaa area, but also reveals the paucity

	calBC	Assemblages	Lithics (g/pcs)	Excavated area (m²)	Lithics per m² (g/pcs)
Phase 1	6000–5000	0	0	0	0
Phase 2	5000–4000	5	31,143 / 7024	401.5	77.6 / 17.5
Phase 3	4000–3500	7	36,376 / 21,564	1313.25	27.7 / 16.5
Phase 4**	3500–3000	1	6762 / 816	244	27.7 / 3.3
Phase 4/5	3500–3000/3000–2000	5	23,444 / 4234	471.5	49.7 / 9.0
Phase 5	3000–2000	3	29,812 / 7119	328	151.9 / 21.7
		21	147,536 / 40,757	2352.25	

Table 1. Materials and phases used in the study. For detailed information on the sites, see Table 2 and Appendix 1. ** – Sieved material not included in the figures.

No	Site (n 5)	Phase	Ceramics	Flint (g/pcs)	Quartz (g/pcs)	H-Q quartz (% of cataloque sub-nos)	Other (g/pcs)
1	Pielavesi Kivimäki	2	ECW 1:2	12.6/3	14,096.2/2287	22	2195.7/79
2	Lieksa Haasiinniemi**	2	ECW 1:1	8.0/1	6525/3091	13	1524/44
3	Outokumpu Sätös	2	EAW, ECW 1:2	–	4493/1136	2	175/15
4	Rääkkylä Pörrinmökki**	2	EAW	3.0/1	599/28	0	–
5	Kitee Sarvisuo	2	EAW (TCW)	–	1488.7/329	0	–
No	Site (n 7)	Phase	Ceramics	Flint (g/pcs)	Quartz (g/pcs)	H-Q quartz (% of cataloque sub-nos)	Other (g/pcs)
6	Outokumpu Lintutorni	3	TCW (EAW)	136.3/45	2098.8/475	22	11.3/14
7	Outokumpu Sätös	3	TCW	35.5/39	99.5/58	0	0.5/1
8	Rääkkylä Vihi 1**	3	TCW (EAW, Kierikki, Eastern Pitted Ware)	228.7/241	3103.2/996	9	256.5/33
9	Rääkkylä Pörrinmökki	3	TCW	727/354	5541/910	15	94.5/31
10	Joroinen Kanava	3	TCW	1518.2/5241	5779.3/4771	16	50.4/65
11	Taipalsaari Kujansuu*	3	TCW	331.6/335	388/192	18	7.2/1
12	Taipalsaari Vaateranta	3	TCW	8317.6/6091	7400.2/1624	25	248.2/42
No	Site (n 1+5)	Phase	Ceramics	Flint (g/pcs)	Quartz (g/pcs)	H-Q quartz (% of cataloque sub-nos)	Other (g/pcs)
13	Puumala Kärmelahti**	4	'Comb Ware', Asbes-tos-tempered ware	5.0/2	4864.7/749	1	1892.2/65
14	Outokumpu Sätös	4/5	Pöljä	0.5/4	11,463.6/1972	6	18.4/5
15	Pieksämäki Tahinniemi**	4/5	Pöljä	5.5/2	4114.7/709	1	91.5/10
16	Rantasalmi Ritokangas	4/5	Pöljä	–	3155.1/951	1	–
17	Savonlinna Salkoniemi	4/5	Kierikki	–	1263.2/295	5	–
18	Savitaipale Rovastinoja	4/5	'Comb Ware', As-bestos- and organic-tempered wares	–	3177.6/266	0	154.0/18
No	Site (n 3)	Phase	Ceramics	Flint (g/pcs)	Quartz (g/pcs)	H-Q quartz (% of cataloque sub-nos)	Other (g/pcs)
19	Outokumpu Laavusso	5	Pöljä	0.1/1	7980.8/2204	–	42.1/6
20	Varkaus Konnasalo 3	5 (?)	Asbestos- and orga-nic-tempered wares (Pöljä?)	–	4760.4/967	5	103.2/2
21	Rantasalmi Pirskanlahti B	5	Pöljä	–	35,425.3/3916	1	1499.7/21

Table 2. Volume of analysed lithic materials. The sites are arranged from north to south within each phase (see Fig. 2). * – Includes some material that does not fit the definition of Typical Comb Ware; ** – Sieved material not included in the figures.

of flint raw material during the other phases of the Neolithic (Fig. 4; Table 2). The amount of flint at TCW sites grows from the north to the south, and flint is most abundant in the southern Lake Saimaa area. In the southernmost assemblages, the amounts of flint and quartz (measured by weight) are basically equal (Taipalsaari Kujansuu and Vaateranta). In the central parts of Lake Saimaa, further away from the raw material sources, the share of flint is 6–21% (Joroinen Kanava, Rääkkylä Vihi 1, and Pörrinmökki), and in the north it is 6% (Outokumpu Lintutorni). The strict temporal limits of flint import are illustrated by the fact that the analysed pre-Phase 3 assemblages contained merely five pieces (23.6 g) and the post-Phase 3 assemblages just nine pieces of flint (11.1 g).

Another notable phenomenon is the higher proportion of H-Q quartzes during the earlier part of the Neolithic (Phases 2 and 3). During Phase 2, the northernmost sites, which contain Early Comb Ware, display elevated proportions of H-Q quartzes, while the Early Asbestos Ware sites with a more southern distribution contain only vein quartzes (Table 2). During Phase 3, the TCW sites display even higher proportions of H-Q quartzes than before (up to 25%). In general, rock crystals were the most widely used type of H-Q quartz, while there are some regional changes in the use of other varieties (Fig. 5), apparently following the natural distribution of H-Q quartzes within the research area: blue and snow quartzes are more common in the north, whereas smoky quartz is more characteristic in the south. Interestingly, however, the latter part of the Neolithic (Phases 4 and 5) displays the domination of ordinary vein quartz and a nearly total lack of H-Q quartzes.

The amount of identified major types of quartz artefacts in each phase (1.7–4.8%) corresponds with previously analysed Mesolithic and Neolithic assemblages (see Table 3). The typical proportion of quartz artefacts (implements) varies between 3.4 and 13.4% (Rankama 2002: Fig. 6; Schulz 1990: Fig. 4; Tallavaara 2007: 38), although numbers as large as 23 and 29% have also been presented in microscope-aided analyses (Rankama & Kankaanpää 2011: Fig. 12). The shares given for quartz cores vary between 0.8 and 4.5% (Räihälä 1999: 123; Rankama 2002: Fig. 6; Tallavaara 2007: 38), which is also in line with our observations (2.1–4.7%). The amount of flint tools present in our assemblages is 6.1% of all flint material.

Table 4 and Figure 6 display other numeral characteristics of quartz assemblages during Phases 2–5. There are certain trends visible in the data. First of all, the number of formal tools (detectable with the naked eye) in relation to the amount of debitage decreases during the course of the Neolithic. A reversed pattern is seen in the ratio between bipolar and platform quartz cores; the share of bi-

Quartz	Flakes (%, pcs)	Tools (%, pcs)	Cores (%, pcs)	Raw material (%, pcs)
Phase 2	91.5	4.8	3.2	0.4
Phase 3	95.0	2.6	2.1	0.2
Phase 4**	91.6	3.2	4.7	0.5
Phase 4/5	92.4	2.7	3.8	1.0
Phase 5	94.8	1.7	2.9	0.8

Flint	Flakes (%, pcs)	Tools (%, pcs)	Cores (%, pcs)	Raw material (%, pcs)
Phase 3	93.6	6.1	0.2	0.0

Table 3. Percentages of major artefact types present within each phase. ** – Sieved material not included in the figures.

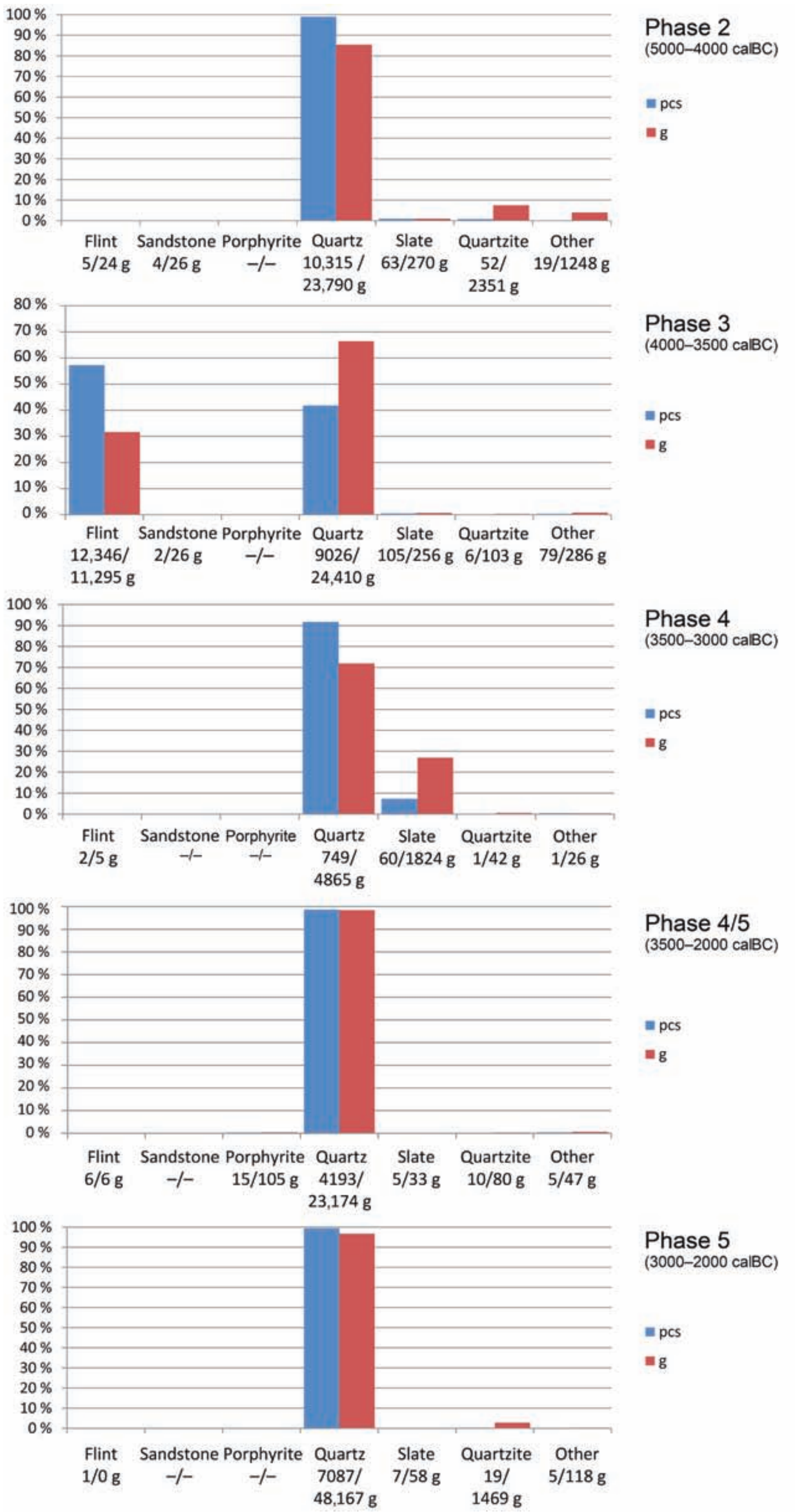

Figure 4. Lithic raw materials used during the Neolithic in the Lake Saimaa area. Note the differing vertical scale in Phase 3.

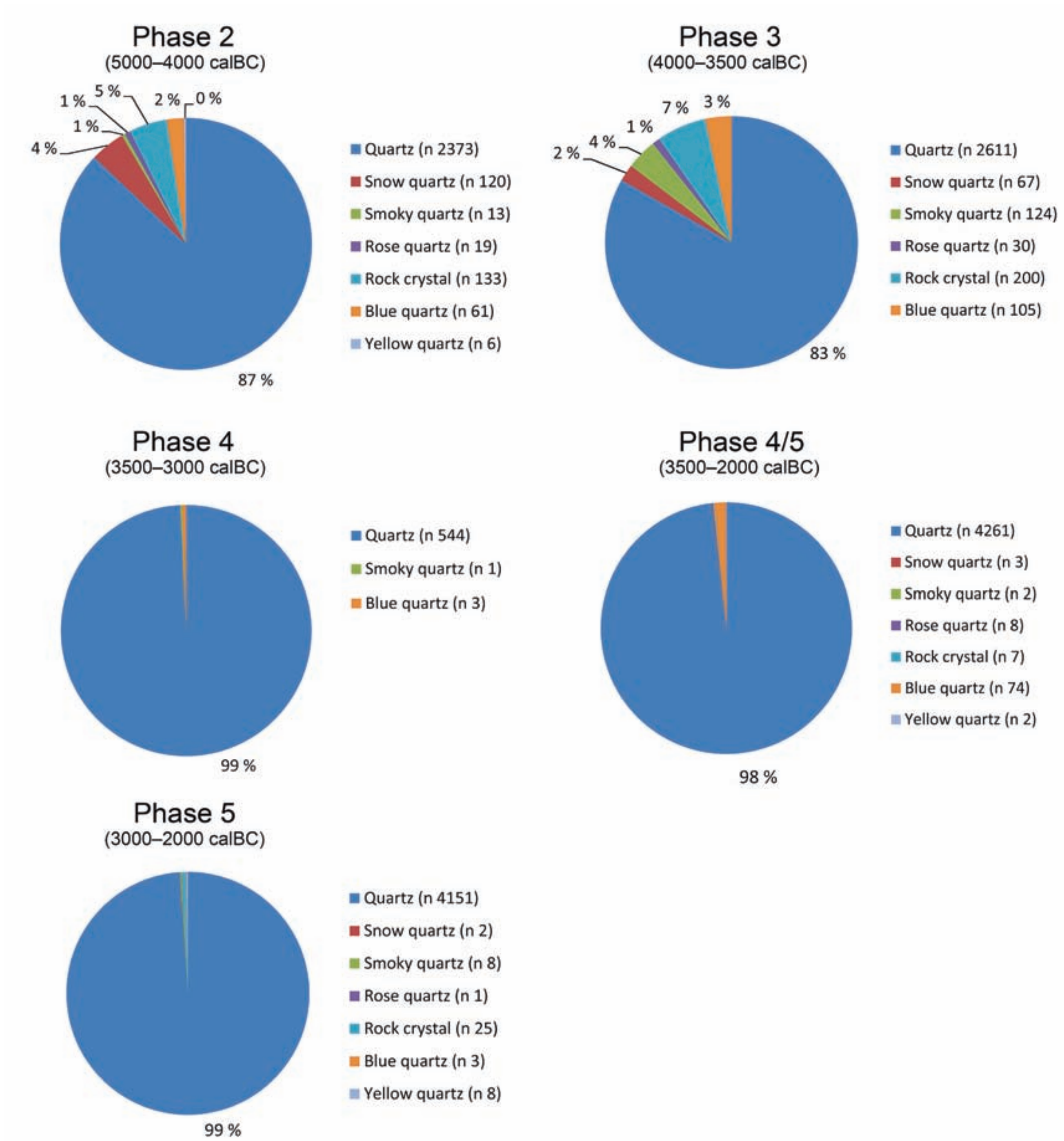

Figure 5. Quartz varieties included in the assemblages. 'Quartz' refers to normal vein quartz, in contrast to a variety of high-quality quartzes (smoky, snow, etc.). The percentages present the prevalence of different variants measured as find catalogue sub-numbers.

polar cores increases towards the end of the Neolithic. During Phase 3, which contains all the flint cores of the analysed assemblages, the share of flint platform cores was 87% against 13% of bipolar cores. During the same period, the shares of platform and bipolar quartz cores were 17% and 83% respectively, which shows that the reduction method has been largely dependent on the raw material at hand. The high share of quartz platform cores during Phase 2 is quite surprising (the three largest assemblages in our material have platform core shares of 41%, 52%, and 80%), since the bipolar reduction of quartz had been very common since the Mesolithic (e.g. Jussila et al. 2012; Schulz 1990), and no clear breaks have been observed in the lithic technologies between the Late Mesolithic and the Early Neolithic in the few earlier studies carried out (see Schulz 1990: 13; cf. Gerasimov 2012: 141–142).

The ratio of quartz cores to flakes does not indicate any clear trends, but the mean size of quartz flakes shows more changes (Table 4; Fig. 6). The mean weight of flakes is at its lowest during Phase 3 (1.59 g) and more than doubles during the latter part of the Neolithic (2.78–4.28 g). The share of quartz raw material chunks in relation to flakes and artefacts displays a similar pattern as the mean weight of flakes and cortex pieces: the minimum shares are reached during Phases 2 and 3 and the maximum during Phases 4 and 5. All in all, it seems that the amount of raw material pieces at sites increases towards the later Neolithic.

The transformation of lithic profiles indicates changes in raw material use, reduction methods, and locations in which the knapping took place. It has been suggested that the proportion of better-quality quartzes should be higher among the assemblages of more mobile people, as better-quality material contains more usable tool edges than lower-quality vein quartz and thus has lower transportation costs (Tallavaara et al. 2010). This might be the case with Early Comb Ware of the Early Neolithic, although the archaeological materials of contemporaneous Early Asbestos Ware, with almost no high-quality raw materials, show no larger signs of sedentism either. Similarly, the elevated share of H-Q quartzes and the higher proportion of quartz tools in relation to debitage during Phases 2 and 3 can be taken to indicate higher mobility. Alternatively, the preparation of tools may not have taken place at the same sites where the tools where used and discarded (see Rankama & Kankaanpää 2011: 248), or part of the knapping sequence took place outside the excavated areas. The latter alternatives seem to be more suitable at least for TCW (Phase 3), which is commonly considered as fairly sedentary (e.g. pit house villages, red ochre cemeteries, see Mökkönen 2011b), and which shows low shares of raw material chunks and cortex pieces in the studied assemblages. On the contrary, during Phases 4 and 5, the low proportion of tools in relation to debitage and the coeval high share of raw material pieces in relation to debris might indicate a situation where whole reduction sequences are present in the assemblages.

The proportion of bipolar and platform cores does not necessarily reflect the dominant reduction method determined through fracture analysis, since the flaking could have begun with the platform method and changed into bipolar reduction when the core became smaller (Callahan 1987; Rankama 2002). On the other hand, reduction methods identified through analyses of quartz flakes and through quartz cores have produced contradictory results: in some cases they have shown similar trends (Rankama 2002), whereas in other cases platform reduction is more pronounced among cores than among flakes (Rankama & Kankaanpää 2011). A recent experimental study proved that variability in the fragmentation of quartz is much higher than what has been assumed, and that this variation is mostly dependent on the knapping styles of individual knappers (Tallavaara et al. 2010). However, the change in the ratio between platform and bipolar cores in the analysed quartz material, showing an increasing popularity of bipolar reduction during the Neolithic, is likely to display real changes in the popularity of reduction methods.

The variation in the mean sizes of flakes is also likely to reflect changes in the use of raw materials and in knapping techniques. It is known that platform reduction of quartz produces smaller flakes than bipolar reduction (Rankama & Kankaanpää 2011; Tallavaara 2007: 46–48), and bifacial retouching creates even smaller flakes (Manninen et al. 2003). Likewise, the knapping of flint produces smaller flakes than the knapping of quartz (Tallavaara 2007), and the same suggestion fits the less fragmentation-prone H-Q quartzes (see Rankama et al. 2006). Accordingly, the mean size of quartz flakes should be at its lowest during Phase 2, when platform reduction (based on cores) and H-Q quartzes were

	Tool:flake (pcs)		Cores			Cortex	Raw material			Flakes
Quartz	Mean / median (x 100)	Max–min (x 100)	Bipolar / platform (pcs)	Bipolar / platform (%)	Core:flake (x 100)	% of catalogue sub-nos.	Raw:tool (pcs, x 100)	Raw:flake (pcs, x 100)	Mean size (g)	Mean size (g)
Phase 2	5.20 / 4.85	9.01–1.91	91 / 75	55 / 45	3.530	4	8.099	0.427	180	3.06
Phase 3	3.78 / 3.39	11.06–1.07	90 / 18	83 / 17	2.214	6	8.898	0.245	222	1.59
Phase 4**	3.50	–	21 / 3	87 / 13	5.102	6	16.667	0.583	327	3.15
Phase 4/5	2.40 / 3.03	4.33–0.70	105 / 26	80 / 20	4.129	12	38.261	1.135	199	2.78
Phase 5	1.88 / 1.95	2.66–1.02	137 / 15	90 / 10	3.021	10	48.649	0.804	258	4.28

	Tool:flake (pcs)		Cores			Cortex	Raw material			Flakes
Flint	Mean / median (x 100)	Max–min (x 100)	Bipolar / platform (pcs)	Bipolar / platform (%)	Core:flake (x 100)	% of catalogue sub-nos.	Raw:tool (pcs, x 100)	Raw:flake (pcs, x 100)	Mean size (g)	Mean size (g)
Phase 3	28.22 / 20.07	95.65–4.03	2 / 13	13 / 87	0.208	3	0.396	0.026	110	0.68

Table 4. Statistics on studied lithics. The amount of flint was suitable for statistics only in Phase 3. ** – Sieved material not included in the figures.

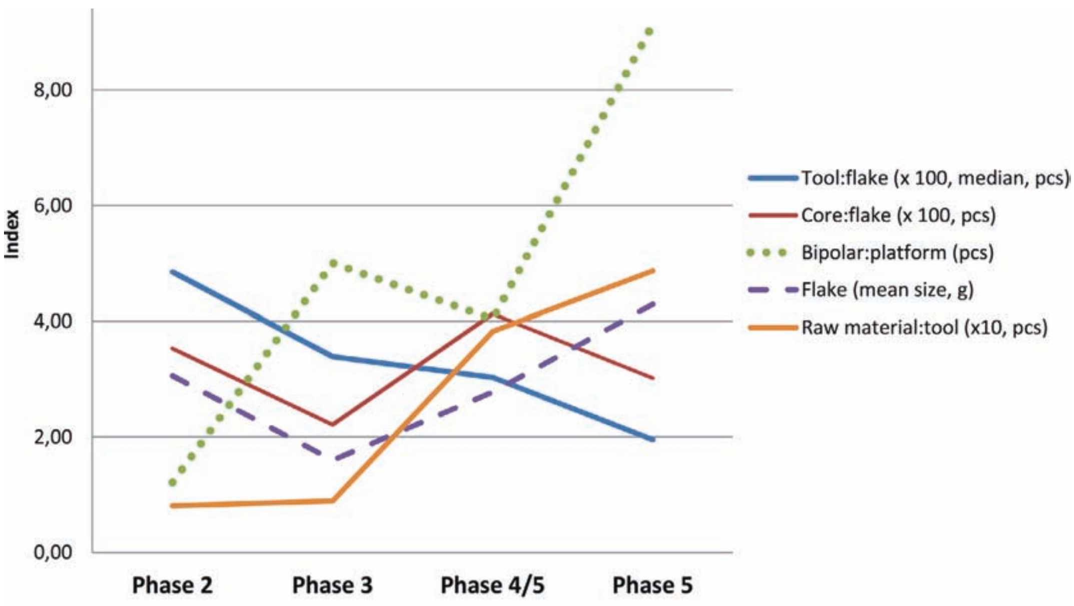

Figure 6. Temporal trends in the analysed quartz assemblages. Numerical values in Table 3.

clearly present. However, the mean weight of the flakes during Phase 2 is at the same level as during Phase 4/5, when bipolar flaking is the prevailing method. This might be due to the combined effect of a few small assemblages and the less accurate excavation methods that resulted in two assemblages in Phase 2.

The ratio of tools to flakes shows the highest proportion of quartz tools during Phase 2, which may indicate that not all knapping took place at the excavated sites. Further, the variation in the ratio of tools to flakes is polarised between assemblages with high values (ratios x 100: 4.85 and 6.21) and those with lower values (1.91 and 4.00). The first are associated with Early Comb Ware and the latter with Early Asbestos Ware. This is, of course, an interesting observation, but it should be remembered that some of the assemblages dating to the Early Neolithic are too small to produce a reliable picture of the material.

The small size of quartz and flint flakes during Phase 3 is, most probably, a product of the coeval use of higher-quality raw material and the production of well-retouched tools. However, when flint and quartz are compared, flint is mainly found in even smaller pieces. A part of this impression may be caused by the good visibility of colourful flint resulting in a high recovery rate, but, supposedly, a more significant effect is caused by the knapping techniques used – bifacial and platform flaking are typically used with flint – and the more economic use of flint compared to quartz, meaning that flint raw material has a longer reduction history than quartz. In addition, vein quartz knapping produces more large pieces of unusable waste than flint reduction (see Manninen et al. 2003; Tallavaara 2007: 46–52).

Even if our analyses provide no direct evidence, it may be proposed that the small size of quartz flakes is connected with the abundant use of flint and the application of similar reduction techniques on finer quartz materials. The H-Q quartzes, also known as quartz gems, actually fracture pretty much like flint, and from a technological point of view, rock crystals cannot be considered as the same raw material as normal vein quartz (Rankama et al. 2006: 248; see also Rodríguez-Rellán & Fábregas

Valcacre 2015). It is probable that a knapper who came from a flint-based knapping tradition to a new area would have sought the most flint-like local raw materials (cf. Meinander 1948: 32), which in Finland would unquestionably be the high-quality quartzes (Rankama et al. 2006: 255).

The shift in reduction methods towards the predominance of bipolar technology and the contemporary changeover from finer to coarser raw materials must largely be explained by cultural preferences. Because vein quartz and H-Q quartzes are local raw materials, the acquisition of particular materials is a question of choice. Just like in lithics, cultural preferences are visible in other archaeological material as well: populations producing asbestos-tempered pottery, both during the Early Neolithic and later, hardly ever utilised high-quality raw materials but preferred ordinary vein quartz. Reversed preferences are observed among the groups producing Comb Ware, who were clearly keen to utilise and value finer raw materials (flint and H-Q quartzes).

7 Conclusions

Our study shows significant fluctuation in raw materials used in knapped tool production during the Neolithic in the Lake Saimaa area. The abrupt changes in the proportions of materials involved both imported and local raw materials. During the earlier part of the Neolithic (Phases 2 and 3), colourful raw materials of better knapping quality were used. H-Q quartzes were exploited during Phases 2 and 3, while flint use peaks distinctively during Phase 3 only. The latter part of the Neolithic (Phases 4 and 5) is merely a one-way parade of ordinary vein quartz utilisation.

Along with the change in raw materials, also other changes are observable in our assemblages. The rise in vein quartz utilisation after Phase 3 is paralleled by the prevalence of the bipolar reduction technique. Simultaneously, the increase in the amount of raw material and cortex pieces present at sites and in the mean size of quartz flakes is likely to imply that the whole reduction sequence is present in the material, contrary to the earlier Neolithic.

The data at hand strongly suggests that the selection of raw materials is evidently dictated by cultural preferences. Asbestos-tempered pottery types are markedly connected with the use of vein quartz, while Comb Ware types are associated with high-quality materials. Since the varieties of quartz are local minerals, this selection is not only a question of the availability of raw materials.

Acknowledgements

This study was produced within the research project *The Use of Materials and the Neolithisation in North-Eastern Europe (c 6000–1000 BC)* (University of Oulu / the Academy of Finland).

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Appendix 1

Material used in the study. Phases: 1 – 6000–5000 calBC; 2 – 5000–4000 calBC; 3 – 4000–3500 calBC; 4 – 3500–3000 calBC; 5 – 3000–2000 calBC. Ceramics: ECW 1–2 – Early Comb Ware, sub-styles 1 and 2; EAW – Early Asbestos Ware; TCW – Typical Comb Ware; Kierikki and Pöljä –Middle and Late Neolithic asbestos-tempered wares. Excavations: researcher and year of investigations, identification of the excavated area(s) included in the study is given in parentheses. Area: acreage of excavated area included in the study (m^2). KM: the studied collection numbers of the National Museum of Finland, sub-numbers are given when only a part of the material catalogued under the given main number is included in the study. * – Includes some material that does not fit the definition of Typical Comb Ware; ** – Sieves not used at the excavations/Sieved material not included in the figures; † – Finds catalogued more coarsely based on layers and grid squares.

No.	Site	Phase	Ceramics	Excavations (included areas)	Area	KM	Site type
1	Pielavesi Kivimäki	2	ECW 1:2	Halinen 1988**†	126	24765:8–1214	Settlement
2	Lieksa Haasiinniemi	2	ECW 1:1	Katiskoski 1993 (A, B, D)**	83	28066	Settlement
3	Outokumpu Sätös	2	EAW, ECW 1:2	Karjalainen 1992 (x 400–415/y 1497–1505); 1993 (1, 3); 1998 (2)	81.5	27704; 28153; 30892	Settlement
4	Rääkkylä Pörrinmökki	2	EAW	Hintikainen 1990 (1)**†	36	25817:1–152	Settlement
5	Kitee Sarvisuo	2	EAW (TCW)	Pesonen 1996 (1, 2) **	75	29714	Settlement
6	Outokumpu Lintutorni	3	TCW (EAW)	Karjalainen 1997 (1)	105	30319	House pit
7	Outokumpu Sätös	3	TCW	Karjalainen 1994 (2)	8	28482:2165–2584, 3456–3547	House pit
8	Rääkkylä Vihi 1	3	TCW (EAW, Kierikki, Eastern Pitted Ware)	Pesonen 2003 (3: x 484–496/y 712–718)**	68.5	30460:4675–11966	House pit
9	Rääkkylä Pörrinmökki	3	TCW	Pesonen 1993 (3E, 3B: x 726–740/y 561–562:, 3C)**; 1996 (3G: x 736–746/y 554–557, 3H: x 740–746/y 562–567)**	242	28013:1–6355; 29713:1–5624	Settlement
10	Joroinen Kanava	3	TCW	E.-L. Schulz 2002 (2, 4); 2003 (6)	138	33822; 33923	House pit, burials
11	Taipalsaari Kujansuu*	3	TCW	Pesonen 1999 (1)**	51	31825:1–1384	Settlement

No.	Site	Phase	Ceramics	Excavations (included areas)	Area	KM	Site type
12	Taipalsaari Vaateranta	3	TCW	Räty 1971**†; Taavitsainen 1978**†; Katiskoski 1997 (A); 1998 (A1); 1999 (1, 4, 6)	700.25	19239:1–841; 20659:1–2079; 30322:1–278; 30887:1–1202; 31494:1–422, 1038–1532, 1705–1961	Settlement, burials
13	Puumala Kärmelahti	4	Comb Ware', Asbestos-tempered ware	Katiskoski 1998**; 1999**	244	31376:1–865; 31879:1–838, 1708–1828	House pit
14	Outokumpu Sätös	4/5	Pöljä	Karjalainen 1998 (1)	87.5	30892:1–2591	House pit
15	Pieksämäki Tahinniemi	4/5	Pöljä	Jussila 1985 (1–3)**; 1986 (4–5)**	193	22955; 23445	House pit
16	Rantasalmi Ritokangas	4/5	Pöljä	Karjalainen 1997 (1)	70	30771:1–512	House pit
17	Savonlinna Salkoniemi	4/5	Kierikki	Lesell 2003 (3)	31	33624:1–927; 34311:1–85	Settlement
18	Savitaipale Rovastinoja	4/5	Comb Ware', Asbestos- and organic-tempered wares	Jussila 1997**	90	30430	House pit
19	Outokumpu Laavusso	5	Pöljä	Karjalainen 1996 (1)	111	29556	House pit
20	Varkaus Konnasalo 3	5 (?)	Asbestos- and organic-tempered wares (Pöljä?)	Pesonen 2007; Kankkunen 2009	69	36703; 37967	Settlement
21	Rantasalmi Pirskanlahti B	5	Pöljä	Karjalainen 1998; 1999**	148	31389:1–707; 32004:1–2593	House pit

Suomen Muinaismuistoyhdistys ry – Finska Fornminnesföreningen rf
The Finnish Antiquarian Society

New Sites, New Methods

Proceedings of the Finnish-Russian Archaeological Symposium

Helsinki, 19–21 November, 2014

Editors:
Pirjo Uino & Kerkko Nordqvist

ISKOS 21

Helsinki 2016