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# The Neolithic greenstone industry of Brignano Frascata (Italy): Archaeological and archaeometric study, implications and comparison with coeval sites in the Grue, Ossona and Curone valleys

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1 2	The Neolithic <i>greenstone</i> industry of Brignano Frascata (Italy): archaeological and archaeometric study, implications and comparison with coeval sites in the Grue. Ossona and Curone valleys
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10	
11	Adstract
12	The Neolithic greenstone industry of Brignano Frascata (Province of Alessandria, Piemonte
14	Region Northern Italy) was investigated with an archaeometric approach involving both morpho-
15	typological and mineral-petrographic methods, in order to reconstruct the manufacturing
16	techniques/habits and locate the supply sources of the raw materials. The outcomes were compared
10	with those collected on similar tools from other sites of the same region, namely in the Grue
18	Ossona and Curone valleys, as well as others resulting from a nilot comparative study on analogous
10	geological speciments from close Quaternary alluvial and/or Qligocene conglomeratic denosits. This
20	survey proved that Brigmano Frascata should be considered as a local <i>atelier</i> for the
20	production/trade of polished stone implements in Neolithic, devoted to daily uses with no ritual
21	purposes. Several indicators point to an <i>in situ</i> manufacturing (high number of retrieved
22	roughouts/fragmented tools, broken during production/use), which also fed trade/exchange forms on
25	short to modium distances. Although displaying gross processing features and lask of finishing
24	these tools show on eventhering solution of lithols size, worked by production of (No eventsed)
25	realse'. Several mineral netrographic recemblenees are cheered with analogous geological semples
20	from local sources, as well as with appendimentaries are observed with analogous geological samples
27	from local sources, as well as with coeval implements from other Northern flary sites, suggesting a
28	for the suppry source of the existence of a trade channel. By considering the initial chemical
29	features of the rocks used to produce these tools, referred to the particular geologic context of
30	discovery (eastern part of the voltri Group), the chance for the raw materials to derive from
31	secondary deposits of close conglomeratic formations and/or alluvial beds of streams flowing in the
32	adjoining valleys is proposed.
55 24	Kay wards: Naalithia areanstana implement: calasita: Na pyravanita: indaitita: ampleasitita:
54 25	<b>Ney-worus</b> . Incontine greensione implement, eclogite, ina-pyroxemite; jadentite; ompnacifite;
35	riemonte Zone meta-opniontes and calc-schists; western Alps.

### **1. Introduction**

39	Polished stone implements dating from the Neolithic to the Copper Age (mostly axes, chisels
40	and hatchets) were found in archaeological sites spread all over the Western Europe –
41	especially in the Po plain, Northwestern Italy (Ricq-de-Bouard, 1993; D'Amico & Starnini,
42	2011). Most of these tools were obtained by the manufacturing of <i>alpine greenstones</i> – rocks
43	with peculiar colour and provenance, at times commonly referred to as 'Jades', characterized
44	by a wide variety of microstructure, grain-size, deformation and retrogression alterations
45	(D'Amico et al. 2004, D'Amico and Starnini, 2006a, 2012b; Giustetto et al., 2016). The term
46	greenstone includes precious and valuable lithologies; consistently with the classification
47	proposed by Giustetto and Compagnoni (2014), these rocks can be divided into two main
48	groups:
49	i) 'Na-pyroxene rocks' (the real 'Jades'), including three lithotypes:
50	a) jadeitite (consisting of jadeite up to 95-100 vol. %);
51	b) omphacitite (consisting of omphacite up to 95-100 vol. %);
52	c) mixed Na-pyroxenite (with intermediate modal compositions of jadeite/omphacite).
53	ii) 'Na-pyroxene+garnet rocks', comprising other three lithotypes:
54	a) eclogite (consisting of omphacite and garnet up to 25-75 vol. %);
55	b) garnet-omphacitite (mainly consisting of omphacite, with garnet between 5-25 vol. %);
56	c) omphacite-garnetite (mainly consisting of garnet, with omphacite between 5-25 vol. %).
57	However, it is to remark that other lithologies, characterized by green colour but different
58	mineralogy (e.g. serpentinite, amphibolite and prasinite), have also been included under the
59	greenstone term. The non-petrographic term 'Jade', traditionally used in trade and gemmology,
60	includes two different rock types: i) 'jadeite jade', mainly consisting of jadeite (NaAlSi <sub>2</sub> O <sub>6</sub> );
61	and ii) 'nephrite jade', usually consisting of an amphibole of the tremolite-ferro-actinolite
62	series [Ca <sub>2</sub> (Mg,Fe) <sub>5</sub> Si <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub> ]. Only the former will be considered in this study. Besides, in
63	addition to 'jadeite jade', another similar phase was identified in archaeological implements -
64	namely 'omphacite jade', mostly consisting of omphacite [(Ca,Na)(Mg,Fe <sup>2+</sup> ,Al)Si <sub>2</sub> O <sub>6</sub> ]
65	(D'Amico et al., 2004; Ou Yang, 2006; Ou Yang et al., 2011; McClure, 2012).
66	The pioneering studies of Gastaldi (1871), Damour (1881) and Franchi (1900) first established
67	that these greenstone lithotypes occur in the metamorphic ophiolites (meta-ophiolites) and calc-
68	schists of the Piemonte Zone, in the Western Alps. A more precise location is troublesome, as
69	these rocks occur either as small (few m <sup>3</sup> ) primary outcrops at high altitude (D'Amico, 2005;
70	Pétrequin et al., 2005a, 2005b, 2006; Compagnoni et al., 2012) or boulders in secondary clastic
71	deposits downhill, derived from erosion of the formers (Compagnoni et al., 2006; D'Amico and
72	Starnini, 2006a; D'Amico and De Angelis, 2009). Few greenstone outcrops/deposits were

73 discovered so far and the detailed petrographic studies are scarce. However, the occurrence of 74 eclogite/omphacitite boudins was reported from the Pellice Valley, in the Monviso metaophiolite Massif (Borgogno, 2000; Giustetto et al., 2016). Primary outcrops of jadeitite, 75 omphacitite and fine-grained eclogite were also identified in the same massif (Pétrequin et al., 76 77 2005a, 2005b, 2006c; Compagnoni et al., 2012). Recently, an attempt to set up an adequate reference collection was made by analyzing with various techniques more than 500 specimens 78 79 of presumed alpine greenstones (mainly 'Jades'), collected as raw materials or working debris during prolonged prospections in the Monviso area of Piemonte, and in the Beigua area of the 80 81 Voltri Group in Liguria ('JADE' project; Pétrequin et al., 2012b; 2012c). The in-depth archaeometric – especially mineral-petrographic – study of these implements is of paramount 82 83 importance to achieve information about their manufacturing techniques and material quality (Chiarenza and Giustetto, 2010; D'Amico et al., 1992; 1997; 2013). A precise location of the 84 supply sources of raw materials, inferred by means of comparative studies with geological 85 samples of known provenance, might help in reconstructing the migratory/trade routes haunted 86 by our ancestors – an aim pursued also in other famous 'Jade' localities (e.g., the Caribbean: 87 Garcia-Casco et al., 2013). These greenstone tools underwent vast circulation all over the 88 Western Europe – i.e., in Southern France and along a corridor running from Southern Italy to 89 Great Britain (Pétrequin et al., 2002). Similar tools of presumed alpine origin were also found 90 in Slovakia and Czech Republic (Spišiak and Hovorka, 2005; Pétrequin et al., 2011). 91 This study deals with the characterization of the polished greenstone industry from the site of 92 93 Brignano Frascata (Italy). Over 300 stone implements were investigated with a dual archaeologic and archaeometric approach, aimed at reconstructing their manufacturing 94 techniques and locating the raw materials supply sources. Partly presented in a preliminary 95 96 report by Giustetto and Compagnoni (2004), these data are detailed here for the first time. Moreover, this work integrates the study of D'Amico et al. (2000), expanding the survey to the 97 whole Brignano Frascata lithic lithological types and also taking into account implements from 98 coeval sites from the nearby Curone, Grue and Ossona valleys (see square in Fig.1). 99 100 2. Materials and methods 101

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- 103
- 104
- 105

3

(INSERT FIGURE 1)

2.1 Archaeological case study and materials

The Brignano Frascata site - in the Curone Valley near Alessandria, Piemonte region, 106 located to the northeast of the Beigua massif, Voltri Group (Fig. 1) – is positioned on an 107 orographic terrace 300 m a.s.l. on the right side of the Curone stream, with prolonged 108 insolation and excellent water supply. The area was systematically excavated by 109 archaeologists, uncovering several occupational phases from the ancient Neolithic (5400-110 4900 B.C., Venturino Gambari, 2004) to the Roman Age (1<sup>st</sup> century A.D.; Nebiacolombo, 111 2004). A first excavation in 1984 uncovered remains of ancient Neolithic ceramic and lithic 112 industries, typical of the Vhò Group (Bagolini and Biagi, 1975; Tiné, 1993). Among these, 113 34 greenstone implements - including axes, hatchets, chisels, strikers recycled from worn 114 cutting tools and disc-ring roughouts - completely or partly polished (on sharp edges), were 115 studied by D'Amico et al. (2000). Presence of splinters, scraps or roughouts - probably due 116 to defects/breakages – led to consider this as a possible manufacturing site for the 117 production of cutting implements. A second, systematic superficial search led to recover 118 more than 2000 ceramics and lithic implements, dating from the ancient Neolithic to the first 119 phase of the 'Vasi a Bocca Quadrata' (VBQ; Square Mouth Jars) culture, as certified by 120 presence of disc-rings and chisels. 185 stone implements - mostly cutting tools and disc-121 rings at different stages of their manufacturing process, a sample of which is shown in Fig. 2 122 - were studied. Finally a third excavation, in 'S. Giorgio' hamlet, uncovered 12 greenstone 123 implements (mostly for cutting) represented by fragmented roughouts (axe butts and cutting-124 edges) broken during manufacture or re-used as strikers. All 231 specimens - mostly in 125 greenstone - including those studied by D'Amico et al. (2000), were taken into account for 126 127 analysis (Table 1).

#### (INSERT FIGURE 2)

In addition, 79 Neolithic implements (mostly in *greenstone*) from the nearby and coeval archaeological sites of Momperone (34 tools), Casalnoceto (6 tools), Gremiasco (5 tools), Fabbrica Curone (2 tools), Pozzol Groppo (2 tools) and Volpeglino (1 tool) in the Curone Valley; Villaromagnano (23 tools) in the Ossona valley; Viguzzolo (5 tools) in the Grue valley; Sale (1 tool) in the plain between the Scrivia and Tanaro rivers (see the small blue rectangle in Fig. 1 and details in Fig. 16a), were also studied.

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128

136 2.2 Methods

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A dual approach – both archaeological (morpho-typological) and scientific (mineral petrographic) – was adopted to study these implements (Chiari et al., 1996; Compagnoni et

al., 2006; Giustetto et al., 2008). The latter involved a global screening with non-destructive 140 methods (i.e., stereo-microscopic observations and density measurements) for a preliminary 141 lithotype screening. Further in-depth analyses were then performed on selected specimens -142 basing on lithotype distribution and recurring mineral-petrographic features – with X-ray 143 powder diffraction (XRPD), optical microscopy with plane-polarized light and scanning 144 electron microscopy with energy dispersion spectrometry (SEM-EDS). Small cores (6 mm 145 in diameter), obtained by drilling broken tools/splinters with a diamond corona barrel, were 146 used to prepare both 30 µm-thick polished thin sections and rock powders. XRPD data were 147 collected in the 3-70° 20 range using an automated Siemens D-5000 diffractometer with 148  $\theta/2\theta$  setup in Bragg-Brentano geometry, Cu-K $\alpha$  radiation and zero-background sample 149 holder. Data were processed with the Diffrac Plus (2005) software (EVA 11,00,3). A Zeiss 150 WL Pol optical polarizing microscope was used for optical observations. Electron 151 microscopy was performed with a SEM Stereoscan-360, Cambridge Instrument on polished, 152 carbon-coated thin sections. Chemical analyses were collected with an EDS Link-Pentafet, 153 Oxford instrument (operating conditions: 50 s counting time, 15 kV accelerating voltage, 25 154 mm working distance, 300 pA beam current). Data were processed with the INCA-200 155 156 Microanalysis Suite Software, version 4.08, calibrated on mineral standards using the ZAF correction method. 157

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#### 159 **3. Results**

160 161

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#### 3.1 Morpho-typological examination

The 231 finished tools and roughouts from Brignano Frascata (Table 1) can be classified, 163 basing upon their functionality and traces of manufacture/use, as implements for cutting 164 (138 axes, hatchels and chisels; 60 %), striking (21 percussors; 9 %), abrading (9 165 grindstones and millstones; 4 %) and ornamental tools (6 disc-rings; 3 %). The rest (24 %) is 166 represented by (57) splinters. Implements for cutting are mostly axeheads roughouts or 167 fragments; small chisels with distinctive short and linear cutting-edge also appear. Their raw 168 processing state and/or fragmentary conditions (especially axes and hatchels) allow only 169 preliminary typological considerations, due to difficulties in checking their dimensions 170 (length, width and thickness) upon which the existing classifications are based (Pedrotti, 171 1996). Few complete and finished implements were found, mainly small axes completely 172

polished, whose shape was obtained by splintering and bush-hammering (a further stage, in 173 which another tool is used to texturize the stone). The original stone surface is still visible on 174 several implements. Seldom, a limited smoothing of the cutting-edge is observed. Several 175 axe butts and cutting-edge fragments, related also to medium-to-large specimens, were 176 recovered with chisel roughouts and other pieces, thus testifying the frequent breakings 177 occurred during manufacture or use. Axe butts are mostly triangular, edged or rounded, with 178 179 linear or slightly convex borders; cutting edges, when preserved, are curved. Several discring roughouts were recovered in different steps of their production chain; 6 of them were 180 181 studied, allowing to understand their manufacturing phases: i) a discoidal, not-too-thick greenstone pebble is progressively splintered refining its shape; ii) a central, bilateral hole is 182 dug by fine-hammering with tough and sharp strikers, while adjusting the circular shape by 183 184 exploiting the rock schistosity; iii) the surface is then polished by gentle abrading (Venturino Gambari, 2004). 185 The survey involved also those implements from Momperone (34 tools; Table 2) and 186

186 The survey involved also mose implements from Moniperone (54 tools, 1 able 2) and
187 Villaromagnano (23 tools; Table 3), due to their significant statistics. In Momperone, cutting
188 instruments (axes edges/butts) prevail, mostly broken during manufacture/use with traces of
189 bush-hammering. Several splinters and some disc-ring roughouts, similar to those described,
190 were also found. Implements from Villaromagnano are mostly axes or fragments
191 (edges/butts), broken during use for tree felling, with trapezoidal shapes and medium
192 size/thickness (10-12 and 2 cm, respectively). Butts are flat and rounded; edges (the only
193 polished portions) narrow and almost linear.

- 194
   (INSERT TABLE 1)

   195
   (INSERT TABLE 2)

   196
   (INSERT TABLE 3)
- 197

198 3.2 Density measurements and stereomicroscopy examination

199 200

(INSERT FIGURE 3)

201The Brignano Frascata greenstone specimens (density determined for 206 out of 231 total202tools; Table 1) can be divided (Fig. 3a) in lower density ( $\approx$  2.6-2.7; serpentinites) and higher203density rocks ( $\approx$  3.2-3.5, including 'Na-pyroxene rocks' and 'Na-pyroxene+garnet rocks').204A certain degree of overlapping within the latter group prevents a sharper lithotype205discrimination. A third group with intermediate density is also identified ( $\approx$  2.9-3.0),206consisting of prasinite. Stereomicroscopy in reflected light, performed on the polished

207 surfaces of the implements, allowed for each specimen to evaluate the mineral grain-size range, heterogeneities and microstructural features (e.g., presence of veins). By combining 208 209 the density values with these observations, a preliminary lithotype determination was achieved (Fig. 3b). 'Na-pyroxene rocks' (jadeitite + omphacitite + mixed Na-pyroxenite) are 210 the most significant fraction (42 %), followed by 'Na-pyroxene+garnet rocks' – especially 211 eclogite (37 %). Serpentinites and prasinites are scarcer (7 and 4 %, respectively); non-212 greenstone lithotypes are the residual 10 %. The same approach was used on those 213 implements from Momperone (density determined for 32 out of 34 total tools; Table 2) and 214 215 Villaromagnano (density determined for 22 out of 23 total tools; Table 3), statistically significant. The related distribution (Fig. 3c and 3d, respectively) shows that in the latter site 216 serpentinites become preponderant. No further study was performed on serpentinites, due to 217 their monotonous mineralogical composition, being mostly composed of antigorite, 218 occurring all over the internal Piemonte zone (Giustetto et al., 2008). Similar conclusions 219 220 may be drawn for prasinite. Further analyses were instead performed on representative 'Napyroxene rocks' and 'Na-pyroxene+garnet rocks'. Contrarily to serpentinites, in fact, which 221 are very common rocks all over the region, jadeite and/or omphacite-rich rocks are quite rare 222 in the field and thus represent an ideal geologic material for provenance studies. 223 Archaeological and archaeometric data for these tools, photographed in Figs. 4 through 7, 224 are reported in Tables 4 through 6. 225 (INSERT TABLE 4) 226 (INSERT TABLE 5) 227 228 (INSERT TABLE 6) (INSERT FIGURE 4) 229 230 (INSERT FIGURE 5) (INSERT FIGURE 6) 231 232 (INSERT FIGURE 7)

233 234

3.3. X-ray powder diffraction

235

XRPD analyses were performed on 24 implements mainly in *greenstone* from Brignano
Frascata, allowing a detailed study of their mineralogical composition. In addition, 16 tools
from other sites (Momperone, Villaromagnano, Casalnoceto, Gremiasco, Fabbrica Curone
and Pozzol Groppo) were also analyzed (Tables 4-6). These rocks may contain more than
one Na-pyroxene: usually both jadeite and omphacite, and seldom even aegirine-augite

241(Schmidt and Stelcl, 1971; Woolley, 1983; D'Amico et al., 1995). If a single pyroxene242occurs, its characteristic reflections are sharp and well defined (Fig. 8a). When two or more243pyroxenes coexist in relevant amounts (such as in mixed Na-pyroxenite), their peaks are244split due to slight  $d_{hkl}$  differences (Fig. 8b). The mean composition of pyroxenes could be245estimated by plotting the  $d_{hkl}$  values of the most intense jadeite and omphacite reflections246[(221); (310); (002)] on a grid conceived by Giustetto et al. (2008), superposed to the247diagram of Morimoto et al. (1988).

248 249

#### (INSERT FIGURE 8)

250

251

#### 3.4. Optical polarizing-microscopy and SEM-EDS

These techniques represent by far the most suitable approach to study these HP meta-252 ophiolites – as far as provenance studies are concerned (Giustetto and Compagnoni, 2014; 253 Giustetto et al., 2016). The pronounced structural and compositional heterogeneity of these 254 rocks (D'Amico, 2012; D'Amico and Starnini, 2012b), often observable even in the same 255 sample (Compagnoni et al., 2007), prevents such a goal to be consistently obtained by 256 means of simpler approaches, merely based on visual appearances (naked eye) or less 257 invasive methods (Pétrequin et al., 2012b). Spectroscopic methods, such as infrared, 258 Raman or even UV-visible-NIR spectroscopy in diffuse reflectance mode (also termed 259 spectroradiometry; Errera et al., 2012a), though at times allowing mineral identification, 260 lack the required accuracy for a thorough characterization of these greenstones. Despite 261 their flaws, due to their (micro) destructiveness, these microscopic techniques - whenever 262 applicable and eventually coupled to other approaches – represent so far the only viable 263 264 approach capable of providing reliable mineral-petrographic data, essential to make lithologic comparisons. In particular, the petrographic study of rocks in thin section allows 265 266 the identification of main, minor and accessory minerals, the estimate of their modal amounts, the evaluation of microstructural heterogeneity and chronological mineral 267 relationships, while quantitative EDS analyses define the real composition and zoning of 268 clinopyroxenes and garnets. Chemical data are plotted in the Morimoto et al. (1988) 269 270 classification diagram for pyroxenes, and in the almandine (Alm)+spessartine (Sps) grossular (Grs) – pyrope (Prp) diagram for garnets. 64 thin sections (including 34 sections 271 already examined by D'Amico et al., 2000) were obtained from representative implements 272 of the Brignano Frascata site. The results are the following: 273

274	• 29 are ' <u>Na-pyroxene rocks'</u> [13 jadeitites, 10 omphacitites (including 2
275	omphacite/chlorite schists studied by D'Amico et al., 2000) and 6 mixed Na-
276	pyroxenites];
277	• 20 are ' <u>Na-pyroxene+garnet rocks'</u> (all eclogites);
278	• 8 are low-density <i>greenstone</i> lithotypes (7 antigoritic serpentinites; one prasinite);
279	• 3 are mafic granulites;
280	• 4 are other HP lithotypes (3 glaucophanites; one albite-lawsonite fels).
281	In addition, the examination of six tools from Momperone, Villaromagnano and
282	Casalnoceto led to recognize the following lithologies:
283	• 1 'Na-pyroxene rock' (jadeitite);
284	• 4 'Na-pyroxene+garnet rocks' (2 eclogites and 2 garnet-omphacitites – 1 of which
285	even with scarce jadeite)
286	• 1 quartz-arenite.
287	The 20 more representative samples were also analyzed by SEM-EDS – i.e., 9 'Na-
288	pyroxene rocks' (4 jadeitites, 3 omphacitites and 2 mixed Na-pyroxenites), 9 'Na-
289	pyroxene+garnet rocks' (7 eclogites and 2 garnet-omphacitites), one granulite and one
290	quartz-arenite (Tables 4-6). EDS spot analyses for 'Na-pyroxene rocks' and 'Na-
291	pyroxene+garnet rocks' are shown in Figs. 9 and 10, respectively. Tables 7 through 9
292	provide the mineralogical composition for 57 samples (serpentinite, prasinite,
293	glaucophanite, quartz-arenite and albite-lawsonite fels excluded), as resulting by
294	combining XRPD, optical polarizing-microscopy and SEM-EDS data. Selected chemical
295	analyses for pyroxene and garnets are reported in the Supplementary Material (Tables S1
296	through S16).
297	(INSERT FIGURE 9)
298	(INSERT FIGURE 10)
299	
300	3.4.1 Na-pyroxene rocks
301	
302	3.4.1.1 Jadeitites
303	
304	In thin section, these rocks mostly consist of colourless-to-light-green jadeite,
305	forming granoblastic aggregates with squat-prismatic habit or having fine grain-
306	size and mylonitic microstructure, often crossed by veins with similar

307	mineralogy (BF-230-II; Fig. 11a). A metamorphic foliation is often observed,
308	defined by linear aggregates of rutile, titanite or zircon or by preferred
309	orientation of jadeite crystals. Occasionally, jadeite porphyroclasts with relict
310	appearance are observed with a dark/bluish core, due to tiny titanite/chlorite
311	inclusions and/or high Ti-content. Jadeite usually shows quite a complex,
312	oscillatory zoning. Most specimens analyzed by SEM-EDS show the presence of
313	pure jadeite (Jd $\geq$ 90%; Fig. 9), but also exhibit domains with Ca-richer and Fe-
314	poorer pyroxenes [40% $\leq$ (Wo+En+Fs) $\leq$ 60%; Ae < 20%]. The microstructural
315	relationships among pyroxenes are quite complex: sometimes, idioblastic jadeite
316	overgrows small aggregates/domains of zoned omphacite (C-MP-CA/128; Fig.
317	11b); in other cases, a granoblastic jadeite matrix is crossed by tangled
318	omphacite aggregates with different Ca/Mg contents. White mica porphyroblasts
319	(paragonite) are often observed (Table 7); well-shaped domains, consisting of
320	white mica associated to clinozoisite, are interpreted as pseudomorphs after
321	former lawsonite.
322	(INSERT FIGURE 11)
323	
324	3.4.1.2 Omphacitites
325	
326	Under the polarizing microscope, pyroxenes form aggregates with a typical
327	light-to-dark-green hue and variable grain-size. Fine-grained areas with
328	mylonitic microstructure often alternate with granoblastic portions in the same
329	sample. Seldom a lineation appears, defined by the preferred orientation of
330	pyroxene prismatic blasts or by discontinuous chains of lenticular titanite
331	aggregates and opaque ores. At SEM-EDS, small jadeitic domains show
332	complex relationships with the surrounding omphacitic matrix. Omphacite is
333	always zoned, with a Fe-content significantly higher than that of the analogous
334	mineral observed in some jadeitites (even >30%, C-BR-CV/12; Fig. 9).
335	
336	3.4.1.3 Mixed Na-pyroxenites
337	
338	These rocks, where jadeite and omphacite coexist in almost equivalent modal
339	amounts, show variable grain-size, colour and isotropic-to-foliated
340	microstructure (C-FR-SO/90; Fig. 12a). The mutual relationships among

341	pyroxenes are variable and complex. Sometimes granoblastic jadeite, including
342	tiny omphacite exsolution blebs, is crossed by aggregates of strongly zoned
343	omphacite crystals; the related analyses plot in two separate areas in the
344	triangular diagram (e.g., C-FR-SO/90; Fig. 9). In other cases, the rock consists
345	of an irregular aggregate of pyroxenes whose composition covers an almost
346	continuous range between jadeite and omphacite (e.g., C-FR-O/11, Fig. 9 and
347	12b). Frequently, bluish/green omphacite blasts are observed, characterized by
348	high TiO <sub>2</sub> -content (3-5 wt. %).
349	(INSERT FIGURE 12)
350	(INSERT TABLE 7)
351	
352	3.4.2 Na-pyroxene+garnet rocks
353	
354	3.4.2.1 Eclogites
355	
356	Under the polarizing microscope, omphacite forms a fine-to-medium-grained
357	matrix with mylonitic or granoblastic microstructure, in which locally green-to-
358	bluish-coloured patches are evident (Fig. 13a). Relict omphacite porphyroclasts
359	with darker cores are also observed, containing tiny chlorite and zoisite
360	inclusions. Lineation is marked either by alignments of small rutile/ilmenite
361	aggregates or by preferred orientation of omphacite nematoblasts. Garnets are
362	fine-grained, tens of $\mu m$ up to few mm across, at times with atoll-like
363	microstructure. Usually they form aggregates or chains, aligned parallel to
364	foliation. EDS analyses sometimes reveal an extreme compositional zoning of
365	pyroxenes in the ternary diagram (Fig. 10). The omphacite composition may be
366	either homogeneous (e.g., C-FR-O/14 and C-FR-SOS/8) or covering a scattered
367	range (e.g., C-FR-SO/48). Two pyroxenes often appear: an almost pure jadeite (C-
368	FR-SO/12, C-MP-CA/2, O-VR-CR/1) coexisting with a more heterogeneous
369	omphacite, occasionally extending into the aegirine/Ae-augite fields (Ae <sub>50</sub> , C-MP-
370	CA/2, Fig. 10). The subordinate jadeite domains show complex microstructural
371	relationships with the other 'coexisting' pyroxenes: seldom, they occur amidst a
372	zoned omphacite matrix (Fig. 13b); sometimes, jadeite veins appear to replace the
373	omphacite matrix. Garnets are mainly almandine-rich (until Alm <sub>65</sub> ) with
374	subordinate grossular ( $\leq 40\%$ ), minor pyrope ( $\leq 10\%$ ) and spessartine ( $\leq 20\%$ )

375	components. Usually, a typical growth zoning is observed, with a systematic
376	decrease in grossular component from core to rim (Fig. 10).
377	(INSERT FIGURE 13)
378	
379	3.4.2.2 Garnet-omphacitites
380	
381	The two analyzed samples (Table 8) belong to the sites of Casalnoceto and
382	Momperone. Garnets are scarce, with idioblastic to skeletal habit and an unusual
383	composition for eclogites (Grs $\geq$ 80%); their compositions are more typical for
384	rodingites.
385	(INSERT TABLE 8)
386	
387	3.4.3 Other lithotypes
388	
389	Three axehead roughouts in glaucophanite and three disc-ring roughouts in mafic
390	granulite (the latter also described by D'Amico et al., 2000) were studied in thin
391	section. Fine-grained glaucophane aggregates are observed in the former, with a very
392	modest retrogression into chlorite+albite. Granulites, on the other hand, consist of
393	Ca-plagioclase locally transformed into epidote or pumpellyite, ortho- and
394	clinopyroxene, olivine and spinel (Fig. 14, Table 9).
395	(INSERT FIGURE 14)
396	(INSERT TABLE 9)
397	
398	3.5. Comparative analyses on geological samples
399	
400	Despite their renowned rarity and preciousness, greenstone HP-metaophiolites are still
401	found nowadays. Primary outcrops are scarce, but secondary deposits have been identified
402	in the Voltri massif – westbound (high Erro valley), in the centre (high Orba valley) and
403	eastbound (Lemme and Ardana valleys) (Pétrequin et al., 2012c). Masked by a thick
404	vegetation, these rocks occur in the alluvial beds of streams, together with other more
405	common lithotypes (Pétrequin et al., 2012b; D'Amico and Starnini, 2012b).
406	Some dozens of greenstones rocks – in the form of pebbles/cobbles/blocks deriving
407	directly from the metamorphic substrate or the reworking of greenstone clasts from
408	Oligocene conglomerate units located upstream – have been collected during field

prospections within stream beds and in alluvial terraced deposits in the Curone, Grue, 409 Ossona and adjacent valleys - i.e., Staffora (running parallel to the Curone, on the eastern 410 side), Scrivia and Lemme (on the western side) – all positioned on the eastern side of the 411 Voltri massif. These geological samples were investigated with the same mineral-412 petrographic approach used for the Neolithic tools. The results of such a survey, limited to 413 the blocks with dimensions comparable to the Neolithic artifacts (feasible raw materials for 414 their production), will be exhaustively detailed in a forthcoming paper. Some interesting 415 outcomes, however, are anticipated here. 416

- 417 Several 'Jade' lithotypes (i.e., jadeitite, omphacitite and mixed Na-pyroxenite) and eclogite have been identified so far among the geological specimens, most having not only 418 macroscopic - but also microscopic and compositional features comparable to those of the 419 Neolithic tools from Brignano Frascata (and other close sites). Geologic jadeitites, for 420 example, not only show mineral-chemical analogies inferred by XRPD and EDS 421 techniques, but when observed under the polarizing microscope and SEM also have 422 microstructures akin to those observed in some implements of the same lithotype. In 423 particular, some jadeitites of prehistoric artifacts (i.e., BF-230-II and C-MP-CA/128; Figs. 424 9 and 11b) are very similar to geological specimens collected among the Quaternary 425 boulders of the Val Lemme stream (e.g., VL14; Fig. 15a and b). These common traits, 426 more than others, should be considered reliable 'markers' attesting a common origin. Other 427 similarities, systematically recurring in most eclogite prehistoric tools, refer to the presence 428 of a fine grain-size and of jadeite domains in a prevailing omphacite matrix. Moreover, 429 430 high aegirine contents (up to  $Ae_{50}$ ) are at times observed both in omphacitites and in eclogites, which are consistent with those detected on some analogous implements from 431 432 Brignano Frascata (see Section 3.4; D'Amico et al., 2000). As to the 'Na-pyroxene rocks', significant analogies are also observed in the distribution of some minor and/or accessory 433 434 minerals (e.g., white mica, zircon and titanite). (INSERT FIGURE 15) 435
- 436

437 4. Discussion

438

439 4.1 Archaeological aspects

440

441 The typological features of the Brignano Frascata implements for cutting, though vague due 442 to their often fragmentary conditions, indicate an ancient (excavations; Tiné, 1993) to

middle (superficial collection; Nebiacolombo, 2004) Neolithic style. This is consistent with 443 the dating of the site resulting from studies on ceramics and splintered stone. A clear 444 445 distinction between the two chronological/cultural horizons is not always possible. Some considerations emerge from the study of chisels, possibly obtained by thin slivers (scraps 446 447 resulting from the manufacturing of bigger instruments) and polished only on the cuttingedge (linear with plane-to-convex section), the rest being splintered or bush-hammered. 448 Although this shaping apparently differs from that of middle Neolithic – in which chisels are 449 bigger and improved – the studied context does not allow a sharp chronological attribution. 450 451 As no certain acknowledgement exists for chisels in ancient Neolithic, probably both typologies existed at the same time (Padovan et al., 2004). Several morphological affinities, 452 evidencing a similar occupational period, also occur in the tools of the other sites in the 453 454 Curone Valley (Casalnoceto, Momperone and Villaromagnano).

For what concerns the disc-rings, the predominance of roughouts and fragments at different 455 working stages (in Brignano Frascata and Momperone) testifies the difficulties encountered 456 for their manufacture, which is confirmed by comparison with the reports of experimental 457 archaeologists. This procedure provides a gradual increase in the percussion of the centre of 458 the discoid, where the risk of breakings is higher (Delcaro, 2004). By comparing the studied 459 disc-ring roughouts with analogous complete implements from other sites, the central hole 460 appears smaller. This suggests that – in addition to drilling by hammering – another step in 461 the production chain was represented by the hole widening/finishing using abrasive polissoir 462 in sandstone, while polishing the surface. Some disc-rings are in serpentinite, a common 463 lithotype probably fitting better than others to manufacture. A single jadeitite disc-ring was 464 found, unique from a petrographic point of view, though analogous objects in HP lithotypes 465 466 (Na-pyroxenite or paragonite) were described from other Neolithic sites (Alba, Torino, Vho and near Bologna: Traversone, 1996; Zopfi, 1996; D'Amico et al., 1996). The provenance of 467 the raw materials is still under discussion. Some authors suggested a possible exploitation of 468 cobble/blocks from alluvial deposits of rivers flowing into the Po plain or morainic deposits 469 accumulated at the outlet of Alpine valleys (Ricq-de-Bouard and Fedele 1993; Ricq-de-470 Bouard 1996; D'Amico et al. 2004; Giustetto et al., 2016). Others, however, have objected 471 472 that at least the larger (15-36 cm long), ultra-polished jade ceremonial axes found in France, Germany, Benelux, and Great Britain - whose dimensions exceed those of clasts derived 473 from fragmentation of the primary outcrops – should have a different origin (Pétrequin et al. 474 2005a, 2005b). Basing on ethnographic studies, a possible exploitation of quarries in the 475 476 Western Alps at high altitudes in Neolithic was proposed (Pétrequin and Pétrequin 1993,

477 Pétrequin et al. 2006a). This is also supported by signs of extraction found on presumed
478 jadeitite and eclogite boulders – especially in the Monviso area of Piemonte and, at a minor
479 extent, in the Voltri Group (Pétrequin et al. 2005b, 2006b, 2008).

The moderate dimensions ( $\leq 10-13$  cm) of the few finished tools from Brignano Frascata 480 481 indicate that they were probably used for everyday requirements (i.e., woodworking or other tasks) and not for ritual purposes (such as, for example, the large greenstone axes dated to 482 483 the V-IV millennium BC, manufactured for prestige and symbolic use; Pétrequin et al., 1998). The morphological study of the many excavated fragmented roughouts (mostly 484 485 axeheads) indicates that while some breakings occurred when splintering during manufacture, most happened while bush-hammering. This latter step represents, therefore, 486 487 the production phase with the higher risk of accidents. Fractures occurring during use are instead certified by cutting edges showing traces of regrinding (suggested by tiny 488 discontinuities on the polished surface) or visible damages. These lines of evidence - and 489 490 the recognition of raw surfaces on some axehead roughouts broken during manufacture, with shapes reminiscent of fluvial pebbles (a feature observed also by Pétrequin and Pétrequin, 491 2017) - suggest that Brignano Frascata, similarly to the Rivanazzano workshop (D'Amico 492 and Starnini, 2012b; Pétrequin et al., 2012a), should be considered a local atelier for the 493 production of greenstone implements in Neolithic. In addition to scraps and fragments, the 494 manufacturing in situ is also supported by the recovery of spheroidal strikers (for 495 splintering) and recycling of broken roughouts/apprenticeships attempts marked by hollows, 496 due to their use as anvils (Bernabò Brea et al., 1996, and parallel ethnographic studies: 497 498 Petrequin and Jeunesse, 1996; Pétrequin and Pétrequin, 2012). A recent technological study (Mancusi, in the press) confirmed the occurrence in Brignano Frascata of an unspecialized 499 manufacture, certified by the many implements obtained after reuse of wastes. In Northern 500 Italy, these technological needs might have conditioned the choice of rough material during 501 the Early-to-Middle Neolithic, favouring the gathering of cobbles and blocks from alluvial 502 deposits (D'Amico and Starnini, 2012b). Conversely, during the Middle-Late Neolithic-503 Chalcolithic - when the flux of ritual axes outside the Po plain became relevant - the choice 504 of the materials (also for export) may have followed a more esthetical selection, dictated by 505 506 larger size, elegant shape and mineral features more suitable to polishing. This sample selection might have favoured, in later times, the quarrying of larger blocks from primary 507 outcrops at higher altitudes, potential supply of raw materials for ceremonial axes destined 508 to the Western and Northern Europe. 509

510 All these outcomes suggest for the studied sites a supply of raw materials from secondary conglomeratic deposits and/or alluvial deposits - as no evidence about recovery/mining 511 512 from primary outcrops was found, consistently with the geological remarks (see Section 4.2). Brignano Frascata, therefore, should be considered a 'second-order' site, solely 513 514 operating on secondary supplies (Mancusi, in the press). All other steps of the production chain (rough-hewing, splintering and bush-hammering) were performed in situ, as further 515 516 hinted by the medium-to-small dimensions of the tools and the recovery of few polished specimens. The presence of a stable settlement on the plain level is confirmed by the 517 518 recovering of grindstones or smoothers made in sandstone or serpentinite, respectively, related to sedentary activities such as corn grinding and ceramics processing. This local 519 520 production might also imply that these implements could partly be addressed to trading or exchange purposes – though limited to short-to-medium distances – as even supported by 521 the great number of tools at different steps of their production chain (elsewhere found as 522 523 finished objects; Pessina and D'Amico, 1999).

524

526

#### 525 4.2 Mineral-petrographic considerations and geological issues

The Brignano Frascata lithic industry shows a marked predominance of greenstone HP 527 metamorphic lithotypes, consistently with the outcomes of most coeval sites of Northern 528 Italy, whereas other rocks are only 10% of the lithological types. However, while most of 529 these sites (Alba, Castello di Annone, Gaione, Ponte Ghiara, Rivanazzano, Rocca di Cavour, 530 Sammardenchia and San Lazzaro di Savena; Mannoni and Starnini, 1994; D'Amico et al., 531 1995; 1997; 2013; D'Amico and Ghedini, 1996; D'Amico and Starnini, 2000, 2012b; Andò, 532 1998; Bernabò Brea et al., 2000; Borgogno, 2000; Giustetto et al., 2016; Fig. 1) show 533 dominance of 'Na-pyroxene+garnet rocks' (eclogites even up to 66%), in Brignano Frascata 534 'Na-pyroxene rocks' (jadeitites + omphacitites + mixed Na-pyroxenites) slightly prevail 535 (42% of the lithological types; Fig. 3b). Such values are high, if compared to other sites 536 (e.g., Sammardenchia and Rivanazzano) where these 'Jades' seldom reach 10%. The Monte 537 Savino/Sassello site, where omphacitite is the prevailing lithotype (Garibaldi et al., 1996), 538 539 represents an exception. Comparative studies with close and coeval settlements were also made with Momperone and Villaromagnano, in the Curone and Ossona valleys respectively, 540 where despite the necessary caution due to a non-homogeneous sampling (excavation, 541 surface recovering, harvesting), the statistics of the analyzed specimens is significant (Figs. 542 543 3c and 3d). Only greenstones were recovered in Momperone, with 'Na-pyroxene+garnet

rocks' (44%, all eclogites) prevailing over 'Na-pyroxene rocks' (30%). In Villaromagnano, 544 'Na-pyroxene+garnet rocks' (all eclogites) and 'Na-pyroxene rocks' (26% each) are 545 subordinate to serpentinites (44%), a trend opposite to that usually observed. 546 For what concerns the origin and provenance of the raw materials, two main geological 547 sources of 'Na-pyroxene rocks' and 'Na-pyroxene+garnet rocks' have been so far identified 548 in Northwestern Italy, namely in the Monviso and Monte Beigua (Voltri) massifs (D'Amico 549 550 and Starnini, 2012b; Errera et al., 2012b; Pétrequin et al., 2012c; Fig. 1). Though separated by slightly more than 100 km as the crow flies, these regions underwent – between 5500 and 551 3500 B.C. - a very different cultural history, each characterized by a peculiar evolution and 552 different contacts with neighboring peoples (Pétrequin et al., 2012b). From a geological 553 point of view, the Monviso and Voltri regions, each divided into different subareas, belong 554 to a common stump of HP-meta-ophiolites and share the same lithologies. Some 555 peculiarities, however, can be pointed out and emphasized in the discussion that follows -556 by relating the mineral-petrographic features of the investigated Neolithic tools with those of 557 geological specimens of known provenance. The individuation of sharp correspondences 558 and geologic 'markers' is known to represent a hard task. These lithotypes, in fact, show a 559 wide variety of grain size, microstructure, deformation features and compositional zoning -560 quite difficult to standardize (Giustetto and Compagnoni, 2014; D'Amico and Starnini, 561 2012b). This is the reason why only an in-depth mineral-petrographic exam (on both tools 562 and geological samples) is the only viable method to pursue sharp and reliable provenance 563 information. Such a goal may be achieved by combining accurate analytical methods 564 (density, XRPD, optical polarizing, electron microscopy and even spectroscopic techniques) 565 that – if considered alone – might lead to gross oversights. With the above in mind, some 566 567 peculiar mineral-petrographic features about greenstones and/or other lithologies distinctive of the Monviso or Voltri massifs were extrapolated by the few previous coherent studies 568 (Compagnoni et al., 2012; Giustetto et al., 2016) and by the reference collection for Project 569 'JADE' (Pétrequin et al., 2012b). Obviously, accurate comparisons could be performed only 570 by referring to rigorous mineral-petrographic approaches - consistent with those adopted 571 here (D'Amico, 2012). Moreover, the preliminary results of the pilot comparative study on 572 573 greenstone conglomerate clasts from the eastern side of the Voltri area (see Section 3.5) have also been considered. On the other hand, spectroradiometric outcomes - a poor 574 identification technique for minerals and rocks, applicable only to (possibly overestimated) 575 jadeitites (Errera et al., 2012a) – were disregarded, as well as those resulting from sheer 576 577 visual appearances (to the naked eye; Pétrequin et al., 2012b; Pétrequin and Errera, 2017).

Basing on these approaches, a pilot provenance study on a selection of greenstone artifacts 578 from Brignano Frascata (26; eight of which also investigated here) was recently issued by 579 580 Pétrequin and Pétrequin (2017), comparing them with about 1500 raw material specimens from known locations in the high Alps. Such an investigation apparently proved that while 581 582 most roughouts and axeheads might originate from the secondary deposits of the Monte Beigua (Voltri) massif, a subordinate number (10) might instead derive from exploitations of 583 584 primary outcrops and/or secondary deposits on the Monviso massif - located mostly on the Southern spurs. Despite their unequivocal appeal, these results appear arguable: the dubious 585 586 consistency of these approaches in rendering the mineral-chemical complexity of these heterogeneous rocks, in fact, may dangerously bias the related characterizations. For 587 instance, several lithotype determinations, achieved with spectroradiometry and/or sheer 588 visual appearances, do not correspond to those inferred by means of strict mineral-589 petrographic methods. Moreover, other incongruities exist - and will be listed, whenever 590 necessary, in the discussion that follows. All these limitations, in our opinion, may seriously 591 undermine the reliability of any conclusion deduced by using these approaches. 592

#### (INSERT FIGURE 16)

593

By comparing the mineral-petrographic features of the Brignano Frascata implements (and 594 closer findings; Fig. 16a) with those of other tools from coeval sites, as well as with those of 595 consistent geologic specimens from traced sources, both analogies and differences are 596 observed. The analogies refer to eclogites always being fine-grained and often containing 597 subordinate jadeite domains in a prevailing omphacite matrix, a feature observed also in 598 several geological samples collected from secondary deposits fed by the erosion of the 599 Voltri Massif rocks (see Section 3.5). This aspect, therefore, should not be considered 600 601 exclusive of the Monviso area – as hastily hinted by Errera et al. (2012b) and Pétrequin et al. (2012b). Also, pyroxenes show a complex and variable zoning, with exsolution omphacite 602 'blebs' in jadeite - as observed in some tools from Castello di Annone (Giustetto et al., 603 604 2016). Such a heterogeneity was seldom reported in analogous geological specimens, due to lack of detailed petrologic studies (Compagnoni et al., 1995). Though a rich literature exists 605 on the Monviso eclogites (Rubatto and Hermann, 2003; Groppo and Castelli, 2010; Spandler 606 607 et al., 2011; Castelli et al., 2014, with refs. therein), primary outcrops of 'Napyroxene+garnet'/'Na-pyroxene rocks' with features comparable to those observed in these 608 implements are small and scarce (Pétrequin et al., 2013). Presence of omphacite blebs, 609 ubiquitous zircon and accessory Ti-bearing phases (especially rutile) in jadeite was 610 described in jadeitite outcrops from the Monviso massif (Compagnoni et al., 2007; 2012). 611

Similar jadeitite boulders (up to one m<sup>3</sup>) were reported from the Po valley Quaternary 612 succession, thus reinforcing the hypothesis for a supply of raw materials from secondary 613 deposits (Forno et al., 2015). Presence of different pyroxenes, exsolutions and overgrowths 614 were also described in jadeitites from Cuba (García-Casco et al., 2009), Antigua, Guatemala 615 (Harlow et al., 2006; 2011) and Dominican Republic (Schertl et al., 2012). For what 616 concerns the differences, the Brignano Frascata implements contain, both in eclogite and 617 omphacitite, clinopyroxenes with a high aegirine content (up to Ae<sub>50</sub>). Such unusual Ae 618 values, reported also by D'Amico et al. (2000), are not typical of other 'alpine' recoveries 619 620 (e.g., implements from Eastern Europe: Spišiak and Hovorka, 2005; Hovorka et al., 2008) attributed to a Monviso provenance, nor other 'Jade' localities (e.g., Caribbean geological 621 samples/artifacts: Garcia-Casco et al., 2009, 2013; Harlow et al., 2004). Similar Ae contents, 622 however, have been occasionally observed in some omphacitites and eclogites from 623 secondary deposits around the Voltri Massif (see Section 3.5) – and may therefore represent 624 a distinctive 'marker' in comparative studies aimed at pinpointing the raw materials sources. 625 On this basis, the presumed attribution of some Ae-rich eclogites in prehistoric tools (e.g., 626 C-FR-SO/48; Fig. 10) to a Monviso provenance, based on spectroradiometry and 627 macroscopic approaches, sounds misleading (Pétrequin and Errera, 2017; Pétrequin and 628 Pétrequin, 2017). A typical richness in aegirine (distinctive also of the Momperone tools, 629 e.g., C-MP-CA/2; Fig. 10) was even observed in some Castello di Annone specimens 630 (Giustetto et al., 2016), whose garnet composition and zoning are also similar to those 631 reported here. Furthermore, in both sites high percentages of broken/fragmented implements 632 633 were retrieved. The marginal importance attributed to Castello di Annone in the production network of greenstone tools during Neolithic (Giustetto et al., 2016), coupled with the local 634 635 atelier nature of Brignano Frascata (Section 4.1), may imply that a trade channel existed between these settlements. Alternatively, these common traits may also suggest a common 636 637 material supply, reinforced by the tools of both sites occasionally containing pyroxene blasts with a bluish, Ti-rich core (similar to those reported by Harlow et al., 2003; 2004) and 638 639 pseudomorphs after original lawsonite porphyroblasts (observed also in the Rivanazzano implements; D'Amico and Starnini, 2012a). This latter feature, due to the many similarities 640 641 (both archaeological and mineral-petrographic) found between the Brignano Frascata and Rivanazzano *ateliers*, is probably not exclusive of *greenstones* from the Monviso area – as 642 supposed by Pétrequin et al. (2012b). On the contrary, these features – and the presence of 643 pyroxene porphyroclasts sporadically coupled with strong deformation, in the so-called 644 645 'omphacite schists' described by D'Amico et al., 1997 (i.e., BF20.1 and BF27; Table 7) -

further indicate a possible origin of the raw materials from the meta-ophiolites of the Voltri 646 Group (D'Amico, 2012) - e.g. those exposed in the Staffora hydrographic basin (Mannoni et 647 al., 1996), possibly drawn from an equivalent palaeo-unit dismantled after erosion (see 648 below). This assumption contradicts the presumed provenance of these 'omphacite schists' 649 650 from the Monviso massif, hastily hypothesized by Pétrequin and Pétrequin (2017) basing on spectroradiometry and visual appearance. Sporadic detection of Qtz/Ab in some jadeitites 651 (i.e., BF 230 II and BF25; Table 7), a feature rare in Neolithic artifacts but found in some 652 rocks from the eastern part of the Voltri massif ('Qtz-Ab-jades'; D'Amico, 2012; Pétrequin 653 654 et al., 2012b), even reinforces such a belief. For what concerns garnets, despite moderate fluctuations in the (Alm+Sps) content, most Brignano Frascata eclogites show similar core-655 to-rim compositional variations (Fig. 10). This trend, coupled with the unusually high Ae-656 content of pyroxenes, may suggest that these rocks had a similar geologic history - and thus 657 a common source. Garnet-omphacitites, instead, have quite a different garnet composition 658 (Fig. 10). Minor and accessory minerals show a heterogeneous distribution, quite difficult to 659 interpret. Recurring presence of white mica (paragonite) and titanite prevailing over rutile in 660 many 'Na-Pyroxene rocks' (Table 7), observed also in the geological specimens from the 661 close secondary deposits (see Section 3.5), may support an origin from the Voltri massif 662 (D'Amico, 2012) instead of the Monviso (as inaccurately hinted for BF20.1 by Pétrequin 663 and Pétrequin, 2017). Detection, in some eclogites, of significant glaucophane (e.g., 69361 664 and BF24) or apatite amounts (C-FR-SO/12, BF14.1, BF17 and BF22; Table 8), further 665 supports this assumption (Pétrequin et al., 2012b). 666

Establishing the origin of the raw materials for manufacturing the implements – whether 667 from primary outcrops at high elevation (Pétrequin et al., 2002) or from alluvial, downhill 668 669 secondary deposits – also represents a fundamental archaeometric issue. The first hypothesis needed the community to dispose of skilled gatherers, whose hard task - besides locating the 670 distant primary outcrops on the mountains - was that of tearing off and bringing back raw 671 stone boulders to be worked. The second option would have involved less effort, since these 672 deposits were closer to the settlements and contained blocks already fragmented and 673 selected by erosion and transport. The morphological examination of axehead roughouts, 674 675 abundant in Brignano Frascata, proves that most have rounded shapes, typical of pebbles of Oligocene or Quaternary deposits – some even showing raw surfaces (Section 4.1). The 676 performed geologic survey and ensuing petrographic study show that the conglomeratic 677 horizons intercalated in the Tertiary Piemonte basin successions contain pebbles of both 678 679 metamorphic and non-metamorphic ophiolites. Meta-ophiolites should have derived from

the dismantlement, about 30 My ago, of the palaeo-Voltri Massif (or a possible equivalent 680 unit, disappeared because of long lasting erosion), located to the west of the considered area. 681 682 On the contrary, the non-metamorphic ophiolites should have derived from the Ligurids, i.e., the present-day Apennine exposed to the southeast. Therefore, the pebbles of HP meta-683 684 ophiolites collected by prehistoric men might not derive from the present Voltri Massif because the present-day trend of the streams in the considered area (i.e., Lemme, Scrivia, 685 Grue, Ossona, Curone and Staffora) is roughly from S/SE toward N/NW. Instead, these 686 pebbles should have originated from the 'secondary' deposits of either the Tertiary 687 688 conglomeratic horizons or the re-sedimented Quaternary alluvium. A geological sketch is presented here, based on the most recent geological maps and stratigraphic data, showing the 689 690 location of the closer Oligocene conglomerate and Quaternary alluvial deposits, possible sources of raw materials for these Neolithic tools (Fig. 16a,b). The Oligocene stratigraphic 691 succession of the Tertiary Piemonte Basin includes some lithostratigraphic units containing 692 conglomerate bodies with clasts of meta-ophiolites. The closest ones are the Savignone 693 Conglomerate (sav) and the Monastero Formation (mst), few km far from Brignano Frascata 694 and the other investigated sites. The first, Rupelian in age, is a thick (up to 2200 m) unit 695 made up of continental-to-shallow-water conglomerates and arenites, with subordinate marls 696 and pelites. In its lower part (Monte Rivalta and Val Borbera Members), the conglomerate 697 clasts essentially derive from Ligurian Helminthoides Flysch Units; in the upper part (Persi 698 Member, savc; Fig. 16b), they also derive from continental crystalline basement and meta-699 700 ophiolites with very low-grade, greenschist-facies or high-pressure metamorphic overprint. 701 The Monastero Formation (also Rupelian) consists of sandy-muddy turbidites, followed by hemipelagic marls. In its lower part, a conglomerate lithozone is present (mstc; Fig. 16b) 702 703 containing clasts from Ligurian Helminthoides Flysch Units (Antola Unit) and ophiolitic sequences, overprinted by high-pressure metamorphism (Marroni et al., 2010). The 704 conglomerate bodies containing meta-ophiolitic clasts have been mapped in the Cabella 705 Ligure sheet of the Geological Map of Italy at 1:50.000 (Marroni et al., 2010), 706 corresponding to the southeastern part of the study area (Fig. 16b). In the rest of the area 707 (comprised in the Voghera sheet at 1: 50.000 – Vercesi et al., 2014 – and the 708 709 Alessandria/Voghera sheets at 1:100.000 of the Geological Map of Italy - Servizio Geologico d'Italia, 1969a; 1969b), these conglomerates have not been distinguished from the 710 formations they are included in. To the southwest of the study area (west of the Scrivia 711 valley), a thick succession of continental to shallow-water conglomerates and arenites, with 712 713 subordinate marls and pelites, crops out (mor: Costa Cravara Breccia and Molare Formation;

714 Fig. 16b). These deposits, mainly Rupelian in age, contain abundant clasts of meta-ophiolitic rocks derived from their metamorphic substrate represented by the Voltri massif (Capponi 715 716 and Crispini, 2008; d'Atri et al. 2016 and references therein). From these beds, greenstone cobbles and blocks are released as detrital materials into the Quaternary alluvial deposits in 717 718 the adjoining valleys – e.g., the Curone, Grue and Ossona, as well as Staffora (on the eastern side of the Curone), Scrivia and Lemme (on the western side) valleys - and outlets in the 719 720 plain. These alluvial deposits also gather clasts resulting from the dismantling of the primary 'Jade' and/or eclogite blocks, located at higher altitudes in the eastern area of the Voltri 721 722 massif. In addition to our surveys (see Section 3.5), presence of greenstone secondary blocks of presumed jadeitite, omphacitite and eclogite in the high Lemme valley - about 20 km as 723 724 the crow flies from Brignano Frascata – was also signaled by Pétrequin et al. (2012c). These updated geologic/stratigraphic data, coupled with the wide range of lithotypes found in the 725 tools of Brignano Frascata, further support the hypothesis of a secondary supply source. 726 Such a heterogeneity, in fact, implies presence of an extensive choice/selection, similar to 727 that available in an alluvial deposit gathering pebbles from higher and distant areas. This 728 assumption is definitely strengthened by the outcomes of the ongoing pilot comparative 729 study, performed on geological greenstones from these areas (see Section 3.5). These results 730 undoubtedly show that some typical micro-structural and compositional features recur both 731 in the studied prehistoric tools and in analogous greenstones collected from conglomerate 732 deposits and/or alluvial beds in the adjoining valleys and streams. All these lines of evidence 733 point to a feasible supply of raw materials from the local Quaternary alluvial deposits in the 734 lower course of the nearby streams (e.g., Curone, Grue, Ossona, Staffora, Scrivia and 735 Lemme), and from the lower Oligocene formations cropping out few km far as the crow 736 737 flies – an opportunity already hinted by D'Amico (2012) and D'Amico and Starnini for the site of Rivanazzano (2006b, 2012b). The geological features of the few known primary 738 outcrops at higher altitudes - scarce, small and distant - further reinforce the presumable 739 belonging of these roughouts to secondary deposits, in which erosion imposes a natural 740 selection causing the tougher, less-alterable lithotypes (e.g., 'Na-pyroxene rocks' and 'Na-741 pyroxene+garnet rocks') to undergo an enrichment. A direct supply source from primary 742 743 outcrops at higher elevation seems even more unlikely by considering the scarcity of such blocks, limited to few jadeitite (Celle Ligure), eclogite (Urbe) or amphibolite (Sassello, 744 Chapel of Rocca Colombo) boulders, with poor traces of exploitation (Pétrequin et al., 745 2012). Besides, a similar origin from boulders of the Monviso massif (Western Alps, at a 746 747 distance of approximately 150 km as the crow flies; Errera et al., 2012b; Pétrequin et al.,

2012c; Pétrequin and Pétrequin, 2017), though not completely ruled out (as hinted for some 748 tools from Sammardenchia; D'Amico and Starnini, 2012b), appears even more questionable. 749 750 Not only the covering of such distances would appear senseless – the same materials being available from much closer distances – but all detected mineral-petrographic features 751 752 indicate, for those prehistoric tools investigated with a strict scientific approach, an origin from the Voltri (or palaeo-Voltri) massif. Basing on these evidences, the complex technical 753 754 and economic system proposed for the Brignano Frascata site by Pétrequin and Pétrequin (2017), based on a double supply of raw materials – mainly from regional sources in the 755 756 Voltri massif and secondarily from the Monviso outcrops - is yet to be acknowledged. A simpler single model, solely based on the finding of raw materials from nearby secondary 757 deposits in the Eastern Voltri area, certainly appears more reasonable. While only further 758 and accurate mineral-petrographic analyses could help in improving the statistical weight of 759 this model of supply, particular care must be taken in order to avoid misinterpretations 760 761 and/or overvaluations hinted by approaches that – despite their non-destructiveness – lack in providing a thorough characterization of the rocks. For what concerns lithotypes other than 762 greenstones, moderate presence of glaucophanite among the analyzed artifacts (3 samples; 763 see Section 3.4) strongly supports their origin from the Voltri Group. These rocks, often 764 fine-grained, are in fact quite common all over the Voltri area – reaching nearly 10 % – but 765 are typically lacking in the Monviso massif (D'Amico, 2012). Different considerations 766 involve the significance of the granulite rocks (Table 9; Fig. 14), which certainly belong to 767 the Ivrea-Verbano Zone, an important tectonic unit of the Western Alps located between the 768 town of Ivrea and the Locarno Lake - exposed to the southeast of the Piemonte Zone. The 769 maximum thickness of the Ivrea-Verbano Zone occurs in the Sesia valley, whose Quaternary 770 771 alluvial deposits contain many basic granulites. These rocks might derive from a site downstream the confluence of the Sesia and Po rivers - the closest possible area with respect 772 to the studied archaeological sites (see Fig. 16a). 773

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#### 775 **5.** Conclusions

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The Neolithic *greenstone* industry of Brignano Frascata was studied with an archaeometric
approach, involving both archaeological and mineral-petrographic aspects, supplying
information about the manufacturing techniques and the origin of raw materials. It has been
long ascertained that the '*Jades*' and eclogite of the archaeological implements found all over
the Western Europe derive from the meta-ophiolites of the Piemonte Zone. However, a more

782 accurate location is difficult to determine, due to the scarcity of detailed geological data of primary outcrops. A possible supply source from close secondary deposits is hypothesized here, 783 784 basing on morphological/petrographic features and geological considerations. Although probably both supply models (exploitation of conglomerate deposits and/or alluvial beds vs. 785 786 quarrying of primary outcrops at high altitudes) were exploited in the past, the former was privileged during the early/middle Neolithic, producing not too large, working-wood 787 788 instruments for daily use. This model, recurring in Northern Italian sites, was adopted also in Brignano Frascata, thus satisfying the principle of the cost/benefit ratio (i.e., grabbing the best 789 790 available technological material with the minimum effort). The quarrying of selected outcrops at high altitudes, aimed at obtaining big chunks of first-quality material for the production of 791 792 large ceremonial axes to be exported over long distances, probably became important only later (V and IV Millennium BC) – and apparently did not involve the investigated site(s). Detailed 793 geologic surveys of the surrounding district (Curona, Grue, Ossona and adjoining valleys – e.g., 794 Staffora, Scrivia and Lemme) are at present performed, followed by laboratory analyses on apt 795 geological samples collected from secondary deposits of greenstones - potential sources of raw 796 materials. The preliminary results obtained by such an approach confirm that the greenstones 797 used to manufacture the tools from Brignano Frascata and coeval adjacent sites might have 798 been collected from secondary supply sources located nearby – e.g., close conglomeratic 799 formations and/or alluvial deposits siding the course of the streams crossing the adjoining 800 valleys, originating from the Voltri (or palaeo-Voltri) massif. 801

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814 **References** 

815

Andò M.C., 1998. La pietra levigata neolitica di Gaione (PR). Studio petroarcheometrico dei litotipi. Unpublished
Thesis, Università di Bologna, 1996-97.

819 Bagolini, B., Biagi, P., 1975. Il Neolitico del Vhò di Piadena. Preistoria Alpina 11, 77-121.

Bernabò Brea M., Battiston C., Mazzieri P., Ottomano C., 2000. Un gruppo di figurine fittili dal sito di Ponte Ghiara
(Parma). In: la Neolitizzazione tra Oriente ed Occidente, pp. 269-287.

Bernabò Brea, M., D'Amico, C., Ghedini, M., Ghiretti, A., Occhi, S., (1996). Gaione, loc. Case Catena. In: Venturino
Gambari M (Ed.), Le vie della pietra verde. L'industria litica levigata nella preistoria dell'Italia settentrionale, Omega
Ed., Torino, pp. 122-136.

Borgogno, M., 2000. Petrografia delle asce neolitiche della Rocca di Cavour (TO) e di analoghi litotipi affioranti nel
Massiccio Ofiolitico del Monviso (Alpi Cozie). Unpublished Thesis, Università degli Studi di Torino, 178 p.

831 Capponi, G., Crispini, L., 2008. Carta Geologica d'Italia alla scala 1.50.000 e Note Illustrative. Foglio 213-230
832 (Genova). APAT, Roma.

- Castelli, D., Compagnoni, R., Lombardo, B., Angiboust, S., Balestro, G., Ferrando, S., Groppo, C., Rolfo, F., 2014.
  Crust-mantle interactions during subduction of oceanic & continental crust. Day 1- The Monviso meta-ophiolite
  Complex: HP metamorphism of oceanic crust & interactions with ultramafics. 10<sup>th</sup> International Eclogite Conference,
  Post-Conference Excursion, 9 September 2013, GFT Geological Field Trips, 6 (1.3), 1-73. ISSN: 2038-4947 (DOI:
  10.3301/GFT.2014.03). Available at http://www.isprambiente.gov.it/it/pubblicazioni/periodici-tecnici/geological-fieldtrips/crust-mantle-interactions-during-subduction-of-oceanic-continental-crust.
- Chiarenza, N., Giustetto, R., 2010. L'officina litica di Pertus (Paesana, CN): testimonianze di lavorazione ed analisi
  minero-petrografiche. Quaderni della Soprintendenza Archeologica del Piemonte 25, 13-29.
- Chiari G., Compagnoni R., Giustetto R., Ricq de Bouard M., 1996. Metodi archeometrici per lo studio dei manufatti in pietra levigata. In: Venturino Gambari M. (Ed.), Le vie della pietra verde. L'industria litica levigata nella preistoria dell'Italia settentrionale, Omega Ed., Torino, pp. 5-52.
- Compagnoni, R., Giustetto, R., Ricq-de-Bouard, M., Venturino Gambari, M., 2006. Studio archeometrico di reperti
  neolitici e dell'età del rame in pietra verde levigata: discussione sulle tecniche analitiche ed interpretazione dei risultati.
  Atti XXXIX Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria, Firenze, 25-27 Novembre 2004, 655682.
- Compagnoni, R., Ricq-de-Bouard, M., Giustetto, R., Colombo, F., 1995. Eclogite and Na-pyroxenite stone axes of
  Southwestern Europe: a preliminary petrologic survey. In: B. Lombardo (Ed.), Studies on metamorphic rocks and
  minerals of the Western Alps. A volume in memory of Ugo Pognante, Bollettino del Museo Regionale di Scienze
  Naturali, Torino, 13, suppl. 2, pp. 329-359.
- Compagnoni, R., Rolfo, F., Castelli, D., 2012. Jadeitite from the Monviso meta-ophiolite, western Alps: occurrence and
  genesis from an oceanic plagiogranite. Eur. J. Mineral. 24, 333-343.
- Compagnoni, R., Rolfo, F., Manavella, F., Salusso, F., 2007. Jadeitite in the Monviso meta-ophiolite, Piemonte Zone,
  Italian western Alps. Per. Mineral. 76 (special Issue), 63-82.
- D'Amico, C., 2005. Neolithic 'greenstone' axe blades from North-western Italy across Europe: a first petrographic
   comparison. Archaeometry 47(2), 235-252.
- B'Amico, C., 2012. Jades and other greenstones from the Western Alps. A petrographic study of the geological
  sampling Jade. In: Pétrequin P., Cassen S., Errera, M., Klassen, L., Sheridan A., Pétrequin A.M. (Sous la direction de),
  'Jade. Grandes haches alpines du Néolithique européen', Chapitre 7, Presses Universitaires de Franche-Comté Ed.,
  Besançon, pp. 420-439.
- B72 D'Amico, C., De Angelis, M.C., 2009. Neolithic greenstone in Umbria, from the Bellucci Collection. Petrography,
   B73 provenance, interpretation. Rend. Fis. Acc. Lincei 20, 61-76.
- 874

866

820

827

830

833

840

852

D'Amico C., Ghedini M., 1996. La pietra levigata della Collezione Traverso di Alba nel Museo Etnografico "L.
Pigorini" di Roma, Atti 10° Congresso A.N.M.S., Bologna 1994, Museologia Scientifica 13, Supplemento, 292-312.

B78 D'Amico C., Starnini E., 2000. Eclogites, jades and other HP metaophiolites of the Neolithic polished stone tools from
Northern Italy. Kristallinikum 26, 11-20.

- B21 D'Amico, C., Starnini, E., 2006a. Prehistoric polished stone artefacts in Italy: a petrographic and archaeological
  assessment. In: M. Maggetti and B. Messiga (Eds.), Geomaterials in Cultural Heritage, Geological Society, London,
  Special Publications 257, pp. 257-272.
- D'Amico, C., Starnini, E., 2006b. L'atelier di Rivanazzano (PV): un'associazione litologica insolita nel quadro della
  "pietra verde" levigata in Italia, in : A. Pessina and P. Visentini (ed.), Preistoria dell'Italia settentrionale. Studi in
  ricordo di Bernardino Bagolini. Atti del Convegno, Udine, settembre 2005, Udine, Edizioni del Museo Friulano di
  Storia Naturale, 37-54.
- B'Amico, C., Starnini, E., 2011: Les "Roches Vertes" Alpines. Productions et circulations Néolithique en Italie
  Septentrionales. In: M. Borrello (sous la direction de), Les Hommes Préhistorique et les Alpes. Document du
  Département de géographie et environnement de l'Université de Genève (2011), pp. 125-134. British Archaeological
  Reports, International Series 2476, 2013.
- D'Amico, C., Starnini, E., 2012a. La production d'outils de pierre en Italie du nord vue depuis l'atelier de Rivanazzano (province de Pavie, Lombardie): matières premières et chaîne opératoire. In: P.-A. De Labriffe, É. Thirault (sous la dir. de), Actes de la Table Ronde de Saint-Germain-en-Laye, 16 et 17 Mars 2007, Musée d'Archéologie Nationale, Paris,
- 898 Société préhistorique française, 2012, 235-243, ISBN : 2-913745-47-4.

880

884

889

894

899

915

918

- D'Amico, C., Starnini, E., 2012b. Circulation and provenance of the Neolithic "greenstone" in Italy. In: Pétrequin P.,
  Cassen S., Errera, M., Klassen, L., Sheridan A., Pétrequin A.M. (Sous la direction de), 'Jade. Grandes haches alpines du
  Néolithique européen', Chapitre 12, Presses Universitaires de Franche-Comté Ed., Besançon, pp. 728-743.
- D'Amico, C., Felice, G., Ghedini, M., 1992. Lithic supplies in the early Neolithic to Sammardenchia (Friuli), Northern
  Italy. Science and Technology for Cultural Heritage 1, 159-176.
- 907 D'Amico C., Campana R., Felice G., Ghedini M., 1995. Eclogites and jades as prehistoric implements in Europe. A
  908 case of petrology applied to Cultural Heritage, Eur. J. Mineral. 7, 29-41.
  909
- 910 D'Amico, C., Ghedini, M., Morico, G., 1996. Territorio bolognese. In: Venturino Gambari M. (Ed.) Le vie della pietra
  911 verde. L'industria litica levigata nella preistoria dell'Italia settentrionale, Omega Ed., Torino, pp. 203-204.
  912
- D'Amico C., Felice G., Gasparotto G., Ghedini M., Nannetti M.C., Trentini P., 1997. La pietra levigata neolitica di
  Sammardenchia (Friuli). Catalogo petrografico. Mineralogica et Petrografica Acta 40, 385-42.
- D'Amico, C., Nenzioni, G., Fabris, S., Ronchi, S., Lenzi, F., 2013. Neolithic tools in S. Lazzaro di Savena (Bologna). A
  petro-archaeometric study. Rend. Fis. Acc. Lincei 24(1), 23-38.
- D'amico C., Starnini E., Gasparotto G., Ghedini M., 2004. Eclogites, jades and other HP-metaophiolites employed for
   prehistoric polished stone implements in Italy and Europe. Periodico di Mineralogia 73, Special Issue (3), 17-42.
- D'Amico C., Starnini E., Voytek B.A., 2000. L'industria litica di Brignano Frascata (AL): dati paleoeconomici di un
   insediamento del Neolitico Antico attraverso l'analisi tipologica, funzionale e lo studio della provenienza delle materie
   prime, Preistoria Alpina 31, 91-124.
- Damour, M.A., 1871. Analyse du jade oriental : réunion de cette substance à la tremolite. Ann. Chim. Phys., 3<sup>rd</sup> ser., 17, 469-474.
- d'Atri, A., Irace, A., Piana, F., Tallone, S., Varrone, D., Bellino, L., Fioraso, G., Cadoppi, P., Fusetti, E., Morelli, M.,
  Lanteri, L. Paro, L., Piccini, C., Trenkwalder, S., Violanti, D., 2016. Carta Geologica d'Italia alla scala 1.50.000 e Note
- 931 Illustrative. Foglio 194 (Acqui Terme). ISPRA, Roma.932
- 933 Delcaro, D., 2004. Analisi tecnologica dell'industria in pietra levigata. In : Venturino Gambari M. (Ed.), Alla Conquista
  934 dell'Appennino, le Prime Comunità della valli Curone, Grue e Ossona. Omega Ed., Torino, pp. 61-68.

## 936 Diffrac Plus Evaluation Package, 2005. Copyright © SOCABIM 1996-2005.937

935

942

946

950

963

967

973

982

989

Berrera, M., Pétrequin, P., Pétrequin, A.M., 2012a. Spectroradiométrie, référentiel naturel et étude de la diffusion des
haches alpines. In: Pétrequin P., Cassen S., Errera, M., Klassen, L., Sheridan A., Pétrequin A.M. (Sous la direction de),
'Jade. Grandes haches alpines du Néolithique européen', Chapitre 8, Presses Universitaires de Franche-Comté Ed.,
Besançon, pp. 440-533.

943 Errera, M., Pétrequin, P., Pétrequin, A.M., 2012b. Origine des jades alpins entre Provence et Adriatique. In: Pétrequin
944 P., Cassen S., Errera, M., Klassen, L., Sheridan A., Pétrequin A.M. (Sous la direction de), 'Jade. Grandes haches alpines
945 du Néolithique européen', Chapitre 13, Presses Universitaires de Franche-Comté Ed., Besançon, pp. 750-821.

947 Forno, M.G., Avondetto, S., Groppo, C.T., Rolfo, F., 2015. The Quaternary succession of the Bulé and Alpetto valleys
948 (Monviso Massif, Piedmont) as possible supply for prehistoric jade axes raw material. Rend. Fis. Acc. Lincei, DOI
949 10.1007/s12210-015-0464-8.

951 Franchi, S., 1900. Sopra alcuni giacimenti di rocce giadeitiche nelle Alpi Occidentali e nell'Appennino Ligure. Boll. R.
952 Comit. Geol. It. 4, 119-158.
953

García-Casco, A., Knippenberg, S., Rodriguez Ramos, R., Harlow, G.E., Hofman, C., Carlos Pomo, J., BlancoQuintero, I.F., 2013. Pre-Columbian jadeitite artifacts from the Golden Rock Site, St. Eustatius, Lesser Antilles, with
special reference to jadeitite artifacts from Elliot's, Antigua: implications for potential source regions and long-distance
exchange networks in the Greater Caribbean. Journal of Archaeological Science 40, 3153-3169.

García-Casco, A., Rodríguez Vega, A., Cárdenas Párraga, J., Iturralde-Vinent, M. A., Lázaro, C., Blanco Quintero, I.,
Rojas Agramonte, Y., Kröner, A., Núñez Cambra, K., Millán, G., Torres-Roldán, R. L., and Carrasquilla, S., 2009. A
new jadeitite jade locality (Sierra del Convento, Cuba): first report and some petrological and archeological
implications. Contributions to Mineralogy and Petrology 158, 1-16.

Garibaldi, P., Isetti, E., Rossi, G., 1996. Monte Savino (Sassello) e Appennino ligure-piemontese. In: Venturino
Gambari M. (Ed.), Le Vie della pietra Verde, L'industria litica levigata nella preistoria dell'Italia settentrionale, Omega
Ed., Torino, pp. 113-119.

Gastaldi, B., 1871. Studi geologici sulle Alpi Occidentali. Mem. Descr. Carta Geol. Italia 1, 1-36.

970 Giustetto, R., Compagnoni, R., 2004. Studio archeometrico dei manufatti in pietra levigata del Piemonte sud-orientale:
971 valli Curone, Grue ed Ossona. In: M. Venturino Gambari (Ed.) Alla conquista dell'Appennino. Le prime comunità delle
972 valli Curone, Grue e Ossona", Omega Ed., Torino, pp. 45-59.

974 Giustetto R., Compagnoni R., 2014. Petrographic classification of unusual high-pressure metamorphic rocks of
975 archaeometric interest. Eur. J. Mineral. 26(5), 635-642.
976

Giustetto, R., Chiari, G., Compagnoni, R., 2008. An easy non-invasive X-ray diffraction method to determine the
composition of Na-pyroxenes from high-density 'greenstone' implements. Acta Crystallographica A64, 161-168.
979

Giustetto, R., Perrone, U., Compagnoni, R., 2016. Neolithic polished greenstone industry from Castello di Annone
 (Italy): minero-petrographic study and archaeometric implications. Eur. J. Miner., DOI: 10.1127/ejm/2016/0028-2558.

983 Groppo, C., Castelli, D., 2010. Prograde P-T evolution of a lawsonite eclogite from the Monviso meta-ophiolite
984 (Western Alps): dehydration and Redox reactions during subduction of oceanic FeTi-oxide gabbro. Journal of Petrology
985 51(12), 2489-2514.
986

Harlow, G.E., Murphy, A.R., Hozjan, D.J., de Mille, C.N., Levinson, A.A., 2006. Pre-Columbian jadeite axes from
Antigua, West Indies: description and possible sources. Can. Mineral. 44, 305-321.

Harlow, G.E., Quinn, E.P., Rossman, G.R., Rohtert, W.R., 2004. Blue omphacite from Guatemala. Gem News
International section, Gems and Gemology 40, 68-70.

Harlow, G.E., Rossman, G.R., Matsubara, S., and Miyajima, H., 2003. Blue omphacite in jadeitites from Guatemala and
 Japan. 2003 Annual Meeting, Geol. Soc. Amer., Abstracts with Programs, 35(6), 620 (CD-ROM 254-1).

996 Harlow, G.E., Sisson, V.B., Sorensen, S.S., 2011. Jadeitite from Guatemala: Distinctions among multiple occurrences. 997 Geologica Acta 9(3), 363-387. 998 999 Hovorka, D., Spišiak, J., Mikuš, T., 2008. Aeneolithic jadeitite axes from Western Slovakia. In: Archäologisches 1000 Korrespondenzblatt 38(1), 33-44. 1001 1002 Mancusi V.G., in the press. Produzione, funzione e circolazione degli abbozzi di asce in pietra verde nel territorio 1003 piemontese durante il Neolitico, Quaderni della Soprintendenza Archeologica del Piemonte, 31. 1004 1005 Mannoni, T., Starnini, E., 1994. Il contributo delle analisi petrografiche nello studio dell'officina litica di Rivanazzano 1006 (PV). In: C. D'Amico and R. Campana (Eds.), Le scienze della terra e l'archeometria, Università di Bologna, 21. 1007 1008 Mannoni, T., Starnini, E., Simone Zopfi, L., 1996. Rivanazzano In: M. Venturino Gambari (Ed.), Le vie della pietra 1009 verde. L'industria litica levigata nella preistoria dell'Italia settentrionale, Omega Ed., Torino, pp. 119-122. 1010 1011 Marroni, M., Ottria, G., Pandolfi, L. 2010. Carta Geologica d'Italia alla scala 1.50.000 e Note Illustrative. Foglio 196 1012 (Cabella Ligure). ISPRA, Roma. 1013 1014 McClure, S., 2012. Jadeite/omphacite nomenclature question. GIA News from Research, April 10, 2012: 1015 http://www.gia.edu/research-resources/news-from-research. 1016 1017 Morimoto, N., Fabries, J., Ferguson, A.K., Ginzburg, I.V., Ross, M., Seifert, S.A., Zussman, J., Aoki, K., Gottardi, G., 1018 1988. Nomenclature of pyroxenes. American Mineralogist 73, 1123-1133. 1019 1020 Nebiacolombo, F., 2004. Le ricerche di superficie nelle valli Curone, Grue e Ossona. In: M. Venturino Gambari (Ed.), 1021 Alla conquista dell'Appennino. Le prime comunità delle valli Curone, Grue e Ossona. Omega Ed., Torino, pp. 15-24. 1022 1023 Ou Yang, M.C.M., 2006. The development of Fei Cui's study in China. Proceedings of the First International Gem and 1024 Jewelry Conference, Gemological Institute of Thailand, Bangkok, December 6-9, 2006, p. 44. 1025 1026 Ou Yang, M.C.M., Yen, H.K., Ng, M.F.Y., Chan, S.Y., 2011. Nomenclature and classification of Fei Cui (pyroxene 1027 jade). Proceedings of International Symposium on Jade, Peking University, 1-2 Sept. 2011, Beijing, pp. 23-34. 1028 1029 Padovan, S., Salzani, P., Venturino Gambari, M., 2004. Brignano Frascata, Loc. Frascata. In: M. Venturino Gambari 1030 (Ed.), Alla conquista dell'Appennino. Le prime comunità delle valli Curone, Grue e Ossona. Omega Ed., Torino, pp. 1031 15-24. 1032 1033 Pedrotti, A., 1996. La pietra levigata nei corredi delle sepolture neolitiche dell'Italia Settentrionale. In: M. Venturino 1034 Gambari (Ed.) Le vie della pietra verde. L'industria litica levigata nella preistoria dell'Italia settentrionale, Omega Ed., Torino, pp. 150-164. 1035 1036 1037 Pessina, A., D'amico, C., 1999. L'industria in pietra levigata del sito neolitico di Sammardenchia (Pozzuolo del Friuli, 1038 Udine). Aspetti archeologici e petroarcheometrici. In: A. Ferrari and A. Pessina (a cura di), Sammardenchia Cûeis. 1039 Contributi per la conoscenza di una comunità del primo Neolitico. Udine, pp. 23-92. 1040 1041 Pétrequin, A.M., Pétrequin, P., 2012. Les modèles ethnoarchéologiques de Nouvelle-Guinée. In: Pétrequin P., Cassen 1042 S., Errera, M., Klassen, L., Sheridan A., Pétrequin A.M. (Sous la direction de), 'Jade. Grandes haches alpines du 1043 Néolithique européen', Chapitre 1, Presses Universitaires de Franche-Comté Ed., Besançon, pp. 27-45. 1044 Pétrequin, P., Errera, M. 2017. Spectroradiométrie, approches macroscopiques et origine des jades alpins: Viso ou 1045 1046 Beigua? In: Pétrequin P., Gauthier E., Pétrequin A.M. (Sous la direction de), 'Jade. Objets-signes et interpretations 1047 sociales des jades alpins dans l'Europe néolitique', Tome 3, Chapitre 4, Presses Universitaires de Franche-Comté Ed., 1048 Besançon, pp. 75-86. 1049 1050 Pétrequin, P., Jeunesse, C., 1996. La hache de pierre. Carrières vosgiennes et échanges de lames polies pendant le Néolithique (5400-2100 av. J-C.). Bulletin de la Société Préhistorique Française, Paris 93(1), 15-16. 1051 1052 1053 Pétrequin, P., Pétrequin, A.M., 1993. Ecologie d'un outil: la hache de pierre en Irian Jaya. Monographie du CRA, 12,

1054 Paris, CNRS Editions (réédition complétée, 1999).

- 1057 B., Venturino, M.). À l'origin des routes du jade alpin: regional specialization and initial transfers. In: Pétrequin P., 1058 Gauthier E., Pétrequin A.M. (Sous la direction de), 'Jade. Objets-signes et interpretations sociales des jades alpins dans 1059 l'Europe néolitique', Tome 3, Chapitre 14, Presses Universitaires de Franche-Comté Ed., Besancon, pp. 323-361. 1060 1061 Pétrequin, P., Bontemps, C., Buthod-Ruffier, D., Le Maux, N., 2012a. Approche expérimentale de la production 1062 des haches alpines. In: Pétrequin P., Cassen S., Errera, M., Klassen, L., Sheridan A., Pétrequin A.M. (Sous la direction 1063 de), 'Jade. Grandes haches alpines du Néolithique européen', Chapitre 5, Presses Universitaires de Franche-Comté Ed., 1064 Besançon, pp. 258-290. 1065 1066 Pétrequin, P, Cassen, S., Errera, M., Klassen, L., Pétrequin, A.M., Sheridan, A., 2013. The value of things: the production and circulation of Alpine jade axes during the  $5^{\text{th}} - 4^{\text{th}}$  millennia in a European perspective. Economic 1067 1068 Archaeology: from structure to performance in European archaeology. Bonn, Habelt ed., 65-82. 1069 1070 Pétrequin, P., Croutsch C., Cassen S., 1998. A propos du dépôt de La Bégude : haches alpines et haches carnacéennes pendant le Ve millénaire, Bulletin de la Société Préhistorique Française 95 (2), 239-254. 1071 1072 1073 Pétrequin, P., Errera, M., Cassen, S., Croutsch, C., 2002. Les Matières Premières Lithiques en Préhistoire, 253-275. 1074 Aurillac: Table Ronde Internationale. 1075 1076 Pétrequin, P., Errera, M., Cassen, S., Billand, G., Colas, C., Maréchal, D., Prodéo, F., Vangele, F., 2005a. Des Alpes 1077 italiennes à l'Atlantique: les quatre grandes haches polies de Vendeuil et Maizy (Aisne), Brenouille (Oise). Hommage à 1078 Claudine Pommepuy. Revue archéologique de Picardie 22 (numéro spécial), 75-104. 1079 1080 Pétrequin, P., Errera, M., Cassen, S., Gauthier, E., Hovorka, D., Klasen, L., Sheridan A., 2011. From Mont Viso to 1081 Slovakia: the two axeheads of Alpine jade from Golianovo. Acta Archaeologica Academiae Scientiarum Hungaricae 1082 62, 243-268. 1083 1084 Pétrequin, P., Errera, M., Pétrequin, A.M., Allard, P., 2006b. The Neolithic quarries of Mont Viso (Piedmont, Italy). 1085 Initial radiocarbon dates. European Journal of Archaeology 9/1, 7-30. 1086 1087 Pétrequin, P., Errera, M., Rossy, M. (avec la collaboration de C. D'Amico et M. Ghedini), 2012b. Viso ou Beigua : approche pétrographique du référentiel des "jades alpins". In: Pétrequin P., Cassen S., Errera, M., Klassen, L., Sheridan 1088 1089 A., Pétrequin A.M. (Sous la direction de), 'Jade. Grandes haches alpines du Néolithique européen', Chapitre 6, Presses 1090 Universitaires de Franche-Comté Ed., Besançon, pp. 292-419. 1091 1092 Pétrequin, P., Pétrequin, A.M., Errera, M., Cassen, S., Croutsch, C., 2006a. Complexité technique et valorisation 1093 sociale: haches polies de Nouvelle-Guinée et du Néolithique alpin, in : L. Astruc, F. Bon, V. Léa, P.Y. Milcent and S. 1094 Philibert (ed.), Normes techniques et pratiques sociales : de la simplicité des outillages pré- et protohistoriques. XXVIe 1095 Rencontres internationales d'Archéologie et d'Histoire d'Antibes, Juan-les-Pins, Editions APDCA, 419-433. 1096 1097 Pétrequin, P., Pétrequin, A.M., Errera, M., Cassen, S., Croutsch, C., Klassen, L., Rossy, M., Garibaldi, P., Isetti, E., 1098 Rossi, G., Delcaro, D., 2006b. Produzione e circolazione delle asce in rocce alpine nel Neolitico dell' Europa 1099 occidentale. Verso un approcio pluridisciplinare, in : Materie prime e scambi nella Preistoria italiana. XXXIX Riunione 1100 scientifica, Istituto Italiano di Preistoria e Protostoria (Firenze, 25-27 novembre 2004), Firenze, 629-639. 1101 1102 Pétrequin, P., Pétrequin, A.M., Errera, M., Cassen, S., Croutsch, C., Klassen, L., Rossy, M., Garibaldi, P., Isetti, E., 1103 Rossi, G., Delcaro, D., 2005b. Beigua, Monviso e Valais. All'origine delle grandi asce levigate di origine alpina in Europa occidentale durante il V millennio. Rivista di Scienze Preistoriche 55, 265-322. 1104 1105 1106 Pétrequin, P., Pétrequin, A.M., Errera, M., Jaime Riveron, O., Bailly, M., Gauthier, E., Rossi, G., 2008. Premiers 1107 épisodes de la fabrication des longues haches alpines : ramassage de galets ou choc thermique sur des blocs, Bulletin de
- 1108 la Société Préhistorique Française 105(2), 309-334.1109
- 1110 Pétrequin, P., Pétrequin, A.M., Errera, M., Prodéo, F., 2012c. Prospections alpines et sources de matières premières.
- 1111 Historique et résultats. In: Pétrequin P., Cassen S., Errera, M., Klassen, L., Sheridan A., Pétrequin A.M. (Sous la
- direction de), 'Jade. Grandes haches alpines du Néolithique européen', Chapitre 2, Presses Universitaires de Franche Comté Ed., Besançon, pp. 46-183.
- 1114

Pétrequin, P., Pétrequin, A.M., 2017 (avec la collaboration de Chiarenza, N., Cinquetti, M., Mancusi, V.G., Zamagni,

Piana, F., Fioraso, G., Irace, A., Mosca, P., d'Atri, A., Barale, L., Falletti, P., Monegato, G., Morelli, M., Tallone, S., Vigna, G.B., in the press. Geology of Piemonte Region (NW Italy, Alps-Apennines junction zone). Journal of Maps. Ricq-de-Bouard, M., 1993. Trade in Neolithic jadeite axes from the Alps: new data. In: Scarre C. and Healy F. (Eds), Trade and Exchange in Prehistoric Europe, Oxford Monographs 33, pp. 61-67. Ricq-de-Bouard, M., 1996. Pétrographie et sociétés Néolitiques en France méditerranéenne. L'outillage en pierre polie. Monographie du CRA 16, CNRS Editions, Paris, 272 p. Ricq-de-Bouard, M., Fedele, F.G., 1993. Neolithic rock resources across the Western Alps: circulation data and models. Geoarchaeology 8, 1-22. Rubatto, D., Hermann, J., 2003. Zircon formation during fluid circulation in eclogites (Monviso, Western Alps): Implications for Zr and Hf budget in subduction zones. Geochimica et Cosmochimica Acta 67(12), 2173-2187. Schertl, H.P., Maresch, W.V., Stanek, K.P., Hertwig, A., Krebs, M., Baese, R., Sergeev, S.S., 2012. New occurrences of jadeitite, jadeite quartzite and jadeite-lawsonite quartzite in the Dominican Republic, Hispaniola: petrological and geochronological overview. Eur. J. Mineral. 24, 199-216. Schmidt, J., Stelcl, J., 1971. Jadeites from Moravian Neolithic period. Acta Univ. Carolinae, Geol. 1-2, 141-152. Servizio Geologico d'Italia, 1969a. Carta Geologica d'Italia, Foglio 70 (Alessandria), 2<sup>nd</sup> ed., Roma. Servizio Geologico d'Italia, 1969b. Carta Geologica d'Italia, Foglio 71 (Voghera), 2<sup>nd</sup> ed., Roma. Servizio Geologico d'Italia, 1969c. Carta Geologica d'Italia, Foglio 83 (Rapallo), 2nd ed., Roma. Servizio Geologico d'Italia, 1971. Carta Geologica d'Italia, Foglio 82 (Genova), 2nd ed., Roma. Spandler, C., Pettke, T., Rubatto, D., 2011. Internal and external fluid sources for eclogite-facies veins in the Monviso meta-ophiolite, Western Alps: implications for fluid flow in subduction zones. Journal of Petrology 52(6), 1207-1236. Spišiak, J., Hovorka, D., 2005. Jadeite and Eclogite: peculiar raw materials of Neolithic/Aeneolithic stone implements in Slovakia and their possible sources. Geoarcheology 20(3), 229-242. Tiné, S., 1993. Una capanna del Neolitico a Brignano Frascata. Archeologia nella Valle del Curone, 21-26. Traversone, B., 1996. Oggetti ornamentali. In: M. Venturino Gambari (Ed.), Le vie della pietra verde. L'industria litica levigata nella preistoria dell'Italia settentrionale, Omega Ed., Torino, pp. 197-207. Venturino Gambari, M., 2004. Dalla pietra al metallo. Il Neolitico e l'età del Rame nelle valli Curone, Grue ed Ossona. In: M. Venturino Gambari (Ed.), Le vie della pietra verde. L'industria litica levigata nella preistoria dell'Italia settentrionale, Omega Ed., Torino, pp. 25-44. Vercesi, P.L., Falletti, P., Pasquini, C., Papani, L., Perotti, C., Tucci, G., 2014. Carta Geologica d'Italia alla scala 1.50.000 e Note Illustrative. Foglio 178 (Voghera). ISPRA, Roma. Woolley, A.R., 1983. Jade axes and other artefacts. In: D.R.C. Kempe and A.P. Harvey (Eds.), The petrology of Archaeological Artefacts. The Clarendon Press, Oxford, pp. 256-276. Zopfi, L.S., 1996. Vho (Piadena), loc. Campo Costiere. In: M. Venturino Gambari (Ed.), Le vie della pietra verde. L'industria litica levigata nella preistoria dell'Italia settentrionale, Omega Ed., Torino, pp. 202-203. 

#### Tables

	State Inventory	Excavation inventory	Other inventories	Label	Implement description	Lithotype	Notes (stereomicroscopy in reflected light/density)	Weight in air	Weight in H <sub>2</sub> O	Density	Sampling
1			C-FR-NO/1		axehead roughout	(undefined lithotype)	weighing not reliable	62.1	38.9	2.68	
2			C-FR-SO/50		grindstone fragm.	sandstone	low density	451.9	277.3	2.59	
3			C-FR-SO/21		smoothing pebble	sandstone	low density	191.4	119.8	2.67	
4	69367		C FR SO		grindstone	sandstone	too heavy for reliable weighing	Ш	II	Ш	
5			C-FR-SO/ 8		grindstone fragm.	sandstone	too heavy for reliable weighing	Ш	Ш	Ш	
6		1900/43	C-FR-SO/97		file	sandstone	===	=	=	Ш	
7	69263	BF 422 31 III			sharpening stone	sandstone	===	=	=	=	
8	69260	BF 89 II			whetstone	sandstone	===	=	=	=	
9			C-FR-NO/3		grindstone fragm.	diabase	porphyiric diabase (basalt)	402.3	262.7	2.88	
10			C-FR-SOS/2-3		two slivers	eclogite	evident garnets; weighing not reliable	2.3	1.2	2.09	
11			C-FR-S/3		sliver	eclogite	red crystals (garnets/sulfides?), quartz and zoisite	68.4	45.4	2.97	
12			C-FR-SO/35		axehead cutting edge	eclogite	slightly regressed eclogite	13.1	8.7	2.98	
13			C-FR-SOS/11		sliver	eclogite	quite heterogeneous eclogitic rock	8.8	5.9	3.03	
14			C-FR-SO/3		sliver	eclogite	regressed eclogite, with amphibole and epidote	98	66.1	3.07	
15			C-FR-SO/83		sliver	eclogite	eclogite with many garnet and amphibole	12	8.2	3.16	
16			C-FR-SO/81		sliver	eclogite	eclogite with pale green omphacite and blue amphibole	19.3	13.2	3.16	
17		BF 4/5 II		BF24	pebble	eclogite	===	324.8	223.5	3.21	
18			C-FR-SO/70		axe butt fragment	eclogite	===	59.8	41.2	3.22	
19			C-FR-SO/92		sliver	eclogite	===	10	6.9	3.23	
20			C-FR-S/2		sliver	eclogite	eclogite with small garnets and possible zoisite	54.2	37.4	3.23	
21			C-FR-SO/77		axe butt roughout	eclogite	presence of whitish pyroxene and garnets	61.3	42.4	3.24	
22			C-FR-O/ 3		axehead roughout	eclogite	banded eclogite with mylonitic structure and sulfides	111	76.9	3.26	
23	69363		C FR SO		axehead roughout	eclogite	eclogite with evident idiomorphic garnets	131.6	91.4	3.27	
24			C-FR-SO/64		axehead fragment	eclogite	fine-grained eclogite	49.6	34.6	3.31	
25			C-FR-SO/52		axehead cutting edge	eclogite	===	12.9	9	3.31	
26			C-FR-N/29		axehead	eclogite	raw-grained eclogite	239.0	166.9	3.31	
27			C-BR-MD/1		axehead fragment	eclogite	raw-grained eclogite	74	51.7	3.32	
28			BR81B/3		sliver	eclogite	levels richer in omphacite or garnet; mica aggregates	22.9	16	3.32	
29			C-FR-SOS/7		striker	eclogite	portions rich in porphyroblastic garnets or pyroxenes	161.8	113.1	3.32	
30			C-FR-O/12		chisel	eclogite	evident garnets	14	9.8	3.33	
31			C-FR-SO/36		axehead fragment	eclogite	presence of carbonates; idioblastic garnets (1 mm)	45.4	31.8	3.34	
32			C-FR/1		ten small slivers	eclogite	===	6.7	4.7	3.35	

33			C-FR-SO/67		axe butt fragment	eclogite	===	93.5	65.6	3.35	
34		17	C-FR-SO/76		axe fragment/roughout	eclogite	===	61.1	42.9	3.36	XRPD
35			C-FR-SO/62		axehead fragment	eclogite	===	48.7	34.2	3.36	
36			C-FR-SO/17		axehead roughout	eclogite	eclogite with mylonitic structure and garnets in bands	118	83	3.37	
37			C-FR-NE/6		axehead roughout	eclogite	presence of pure pyroxene levels, lacking garnets	52.3	36.8	3.37	
38			C-BR-CV/10		axe butt roughout	eclogite	eclogite with mylonitic structure	65.8	46.3	3.37	
39			C-FR-SO/84		big sliver	eclogite	===	83.1	58.5	3.38	
40			C-FR-SO/85		sliver	eclogite	rare garnets	29.4	20.7	3.38	
41			C-FR-SO/34		chisel/striker fragm.	eclogite	presence of amphibole	23	16.2	3.38	
42			C-FR-SO/19		axe roughout fragment	eclogite	very small garnets; possible pseudomorphosis on lawsonite	35.2	24.8	3.38	
43			C-FR-SO/15		axe roughout fragment	eclogite	banded eclogite with pure omphacite levels	54.9	38.7	3.39	
44			C-FR-SO/12		axehead roughout	eclogite	eclogite with jadeitic portions	228.6	161.2	3.39	thin section
45	69358		C FR SO		axehead roughout	eclogite	stricto sensu eclogite with homogeneous garnets	196.2	138.4	3.39	
46	69373		C FR SO		axehead	eclogite	stricto sensu eclogite with small garnets	106.8	75.4	3.40	
47			C-FR-SO/26		axe butt fragment	eclogite	===	149.7	105.7	3.40	
48			C-FR-SOS/6		sliver	eclogite	banded eclogite with jadeite veins	16	11.3	3.40	
49			C-FR-SO/42		axe roughout fragment	eclogite	very fine-grained garnets	64.7	45.7	3.41	
50			C-FR-SO/27		axehead fragment	eclogite	===	31	21.9	3.41	
51	69371		C FR SO		axehead fragment	eclogite	stricto sensu eclogite with porphyroblastic garnets	112.1	79.2	3.41	
52			C-FR-N/2		axe butt roughout	eclogite	===	53.5	37.8	3.41	
53			C-FR-NE/2		axehead fragment	eclogite	possible presence of white mica porphyroblasts	33.4	23.6	3.41	
54	69253	BF 279 III		BF26.1	axehead	eclogite	eclogite/serpentinite schist	54.9	38.8	3.41	
55			C-FR-SO/56		axe butt fragment	eclogite	===	50.5	35.7	3.41	
56			C-BR-CV/3		axehead	eclogite	===	70	49.5	3.41	
57			C-FR-SO/44		axehead roughout	eclogite	evident presence of garnets	112.8	79.8	3.42	
58			C-FR-SO/14		axe butt roughout	eclogite	===	96.1	68	3.42	
59			C-BR-CV/5		axehead roughout	eclogite	big garnets	79.1	56	3.42	
60			C-FR-SOS/8		sliver	eclogite	===	50.4	35.7	3.43	thin section
61			C-FR-SO/29		axe butt fragment	eclogite	very fine-grained garnets	34.3	24.3	3.43	
62			C-FR-SO/40		axe butt fragment	eclogite	small garnets	63.9	45.3	3.44	
63			C-FR-SO/88		sliver	eclogite	===	24.4	17.3	3.44	
64			C-FR-O/9		sliver	eclogite	evident euhedral garnets	16.2	11.5	3.45	
65			C-FR-SO/59		axe fragment/roughout	eclogite	===	109	77.4	3.45	thin section
66			C-FR-SO/48		axe butt fragment	eclogite	===	346.4	246	3.45	thin section

67			C-FR-SO/16		axe butt fragment	eclogite	abundant, pale garnets	77.4	55	3.46	
68			C-FR-O/4		axe butt fragment	eclogite	lineated omph. and big garnets; porphyrocl. magmatic pyrox.	66.4	47.2	3.46	
69			C-FR-SO/101		sliver	eclogite	small, pale garnets aligned in chains; big vein of omphacite	18	12.8	3.46	
70			C-FR-O/8		axe butt roughout	eclogite	very fine-grained garnets	46.1	32.8	3.47	
71			C-FR-N/6		sliver	eclogite	= = =	76.4	54.4	3.47	
72			C-FR-SO/47		axe butt fragment	eclogite	abundant garnets (two kinds: pale and dark) and rutile	99.9	71.3	3.49	
73			C-FR-SO/89		sliver	eclogite	= = =	19.6	14	3.50	
74			C-BR-CV/9		axehead recycling	eclogite	= = =	92.7	66.3	3.51	
75			C-FR-0/14		axehead fragment	eclogite	= = =	60.1	43	3.51	thin section
76			C-FR-O/10		axehead fragment	eclogite	very fine-grained garnets	46.4	33.2	3.52	
77			C-BR-CV/11		axehead roughout	eclogite	mylonitic structure, garnet porphyroblasts and white mica	182.8	131	3.53	
78		BF 102 IV/14.1		BF14.1	axehead roughout	eclogite	raw-grained eclogite	106.7	76.8	3.57	
79	69370		C FR SO		axehead roughout	eclogite	===	394.5	284	3.57	
80	69351		C FR NE		axehead roughout	eclogite	stricto sensu eclogite with abundant garnets	121.8	87.8	3.58	
81			C-FR-SO/37		axe butt fragment	eclogite	small idiomorphic garnets, amphibole and glaucophane	22.6	16.3	3.59	
82	69355		C-FR-O	PIEM 30	axehead roughout	eclogite	presence of chloritoid; weighing not reliable	106.8	75.4	3.40	thin section
83	69362		C-FR-SO	PIEM 34	axehead roughout	eclogite	lato sensu eclogite; weighing not reliable	96.1	68.0	3.42	thin section
84	69361		C-FR-SO	PIEM 33	axehead roughout	eclogite	possible zoisite and glaucophane crystals; relict omphacite	83.1	58.5	3.38	thin section
85	69356		C-FR-SO	PIEM 31	axehead	eclogite	fine-grained, regressed omphacite, atoll-like garnets and rutile	99.9	71.3	3.48	thin section
86	69353		C-FR-SO	PIEM 28	chisel roughout	eclogite	with chloritoid porphyroblasts, chlorite, epidote and ilmenite	52.3	36.8	3.37	thin section
87			C-FR-SO/7		big sliver	eclogite	containing lineated amphibole	=	=	=	
88			C-FR-SO/24		small chisel	eclogite	===	20.3	=	=	
89			C-FR-SO/61		axehead fragment	eclogite	euhedral garnets; too small for reliable weighing	=	=	=	
90	69254			BF30 (agg.)	striker	eclogite	===	76.4	54.4	3.48	
91	69250			BF22 (agg.)	axehead	eclogite	===	99.9	71.3	3.49	
92	69249			BF35.1(agg)	striker	eclogite	===	46.1	32.8	3.47	
93	69248			BF17 (agg.)	striker	eclogite	===	46.4	33.2	3.52	
94		BF 420-429/10		BF10	sliver	eclogite	weighing not too reliable	6.7	4.7	3.35	
95	BF163-164.17	79-180 III/35.2		BF35.2(agg.)	sliver	eclogite	===	19.6	14.0	3.50	
96	BF227-228	3 243-44 III/13		BF13 (agg.)	striker	eclogite	===	63.9	45.3	3.44	
97	BF	262 IV-V/20.3		BF20.3(agg.)	small pebble	albite/lawsonite fels	===	=	=	=	
98			C-FR-SOS/5		sliver	jadeitite	prysmatic crystals/veins with Jd and Omph; unreliable weighing	6.9	4.7	3.14	
99	69251	BF E3 1		BF25	pestle	jadeitite	===	215.3	147.2	3.16	thin section
100	69364		C-FR-SO		axehead fragment	jadeitite	folded mylonitic structure	9.5	6.5	3.17	

1 1	1	1	1	1	1					1
101		BF-3		axehead fragment	jadeitite	light green colour	5.2	3.6	3.25	XRPD
102		GG81		axehead fragment	jadeitite	===	11.4	7.9	3.26	
103		C-FR-NO/2		big sliver	jadeitite	===	294.7	204.5	3.27	thin section
104		C-FR-SO/65	PIEM 24	striker fragment	jadeitite	===	52.4	36.5	3.30	
105 69366		C FR SO		ascia abbozzo	jadeitite	===	14.3	10	3.33	
106		C-FR-SO/68		ascia abbozzo fr.	jadeitite	===	34.3	24	3.33	
107		C-FR-SO/23		axe butt fragment	jadeitite	small elongated glaucophane crystals	45	31.5	3.33	
108		C-FR-O/2		axehead roughout	jadeitite	presence of omphacite in veins or portions	108.8	76.4	3.36	
109		C-FR-SO/41		striker fragment	jadeitite	===	168.2	118.3	3.37	thin section
110		BR81B/2		small sliver	jadeitite	dark green	2.8	2	3.50	XRPD
111		C-FR-NE/7	PIEM 25	axehead fragment	jadeitite	relicts of magmatic pyroxene	66.4	47.2	3.46	thin section
112		C-FR-SO/57	PIEM 23	axehead roughout	jadeitite	===	161.5	113.0	3.33	
113		C-FR-SO/66		striker fragment	jadeitite	===	=	=	=	thin section
114		C-FR-SO/94	PIEM 20	disc-ring roughout	jadeitite	===	131.6	91.4	3.27	
115 69262	BF 230 II			grindstone	jadeitite	===	239	167	3.30	thin section
116 74918			BF21 (agg.)	axehead	jadeitite	===	34.3	24.3	3.43	
117	BF 161-178 II/19		BF19	axehead fragment	jadeitite	===	30.6	21.1	3.22	
118	BF 454-463 I/23		BF23	cutting edge fragment	jadeitite	===	22.9	16	3.32	
119	BF 89 II/32		BF32	sliver	jadeitite	too small for reliable weighing	6.7	4.7	3.34	
120	BF268 II/20.2		BF20.2 (agg.)	axehead fragment	jadeitite	===	111	76.9	3.26	
121		BR81B/1		axehead roughout	glaucophanite	other phases in addition to glaucophane	44.6	29.9	3.03	
122 69357		C FR SO	PIEM 32	axehead roughout	glaucophanite	omphacitite turned into glaucophanite; epidote, rutile, garnet	323.4	=	=	thin section
123 69354		C FR SO	PIEM 29	axehead roughout	glaucophanite	===	=	=	=	thin section
124		C-FR-SO/60	PIEM 21	axe fragment/roughout	glaucophanite	schist with glaucophane, jadeite and quartz	=	=	=	thin section
125		C-FR-SOS/10		sliver	glaucophanite	presence of glaucophane	29.2	19.8	3.11	
126	BF 263 II/29.1		BF29.1	disc-ring roughout	basic granulite	===	52.2	33.7	2.82	
127	BF 310 II/34		BF34	disc-ring roughout	basic granulite	===	101.3	66	2.87	
128	BF263 II/29.2		BF29.2 (agg.)	disc-ring roughout	basic granulite	===	144.5	94.0	2.85	thin section
129		BF-4		axehead fragment/sliver	mixed Na-pyroxenite	too small for reliable weighing	5.2	3.6	3.26	XRPD
130		C-FR-SO/11		axe butt fragment	mixed Na-pyroxenite	mixed Na-pyroxenite with glaucophane	135.1	91	3.06	
131		C-BR-CV/8		axe butt roughout	mixed Na-pyroxenite	===	73.9	50.3	3.13	
132		C-FR-SO/13		axehead fragment	mixed Na-pyroxenite	pale green jadeite crystals, wrapped in an omphacite matrix	26.7	18.3	3.18	
133		C-FR-SO/86		big sliver	mixed Na-pyroxenite	presence of pseudomorphosis on possible lawsonite	222.2	152.5	3.19	
134		C-FR-SO/82		axe butt roughout	mixed Na-pyroxenite	slightly altered mixed Na-pyroxenite	30.6	21.1	3.22	

135		C-FR-SO/95	1	polished sliver	mixed Na-pyroxenite	possible presence of epidote	26.8	18.5	3.23	
136		C-FR-SO/28		axehead roughout	mixed Na-pyroxenite	slightly regressed mixed Na-pyroxenite	244.2	168.7	3.23	
137		C-BR-CV/1		axehead/striker	mixed Na-pyroxenite	===	150.3	103.9	3.24	
138		C-BR-CV/4		axe butt fragment	mixed Na-pyroxenite	===	109.7	75.9	3.25	
139		C-BR/1		chisel roughout	mixed Na-pyroxenite	presence of both jadeite and omphacite; possible garnets	28.9	20	3.25	
140		C-BR-CV/6		axehead fragment	mixed Na-pyroxenite	partially chloritized garnet porphyroblasts; zoisite aggregates	102.6	71.2	3.27	
141		C-FR-N/4		sliver	mixed Na-pyroxenite	===	4.1	2.85	3.28	
142		C-FR-SO/18		striker fragment	mixed Na-pyroxenite	===	23	16	3.29	XRPD
143		C-FR-SO/49		striker roughout	mixed Na-pyroxenite	pale green jadeite crystals, wrapped in an omphacite matrix	185.4	129.1	3.29	
144		C-BR-CV/2		axehead roughout	mixed Na-pyroxenite	===	93.2	64.9	3.29	
145		C-FR-SO/91		sliver	mixed Na-pyroxenite	===	14.5	10.1	3.30	
146		C-FR-SO/93		sliver	mixed Na-pyroxenite	===	13.2	9.2	3.30	
147		C-BR-CV II/1		axehead/striker	mixed Na-pyroxenite	===	140.4	98	3.31	
148		C-FR-SO/96		polished sliver	mixed Na-pyroxenite	===	27.5	19.2	3.31	
149		C-FR-O/ 6		axehead/striker	mixed Na-pyroxenite	heterogeneous and atypical rock	161.5	113	3.33	
150		C-FR-N/1		axehead fragment	mixed Na-pyroxenite	===	110.9	77.6	3.33	
151 69255	BF84 193-194 II	1	BF9	axehead fragment	mixed Na-pyroxenite	===	95.3	66.8	3.34	
152		C-FR-SO/32		small axehead roughout	mixed Na-pyroxenite	===	24.8	17.4	3.35	
153		C-FR-SO/43		small axehead roughout	mixed Na-pyroxenite	===	29.9	21	3.36	
154		C-FR-SO/69		axe butt fragment	mixed Na-pyroxenite	bright green crystals coupled to pale green ones	36.3	25.5	3.36	
155		C-FR-SO/46		axe butt fragment	mixed Na-pyroxenite	===	50.5	35.5	3.37	
156		C-FR-SO/9		pebble fragment	mixed Na-pyroxenite	===	61	42.9	3.37	thin section
157		C-FR-O/11		axe butt fragment	mixed Na-pyroxenite	===	105.5	74.2	3.37	thin section
158		C-FR-SO/1		axehead roughout	mixed Na-pyroxenite	jadeite aggregates in an omphacite matrix; quartz	51.7	36.4	3.38	
159		C-FR-S/1		axehead fragment	mixed Na-pyroxenite	heterogeneous rock; presence of both jadeite and omphacite	24	16.9	3.38	
160		C-FR-N/5		axehead	mixed Na-pyroxenite	presence of both jadeite and omphacite; possible garnets	118.8	83.8	3.39	
161		C-FR-NE/1		axehead fragment	mixed Na-pyroxenite	===	19.7	13.9	3.40	XRPD
162		BF-2		axehead fragment/sliver	mixed Na-pyroxenite	===	5.2	3.7	3.47	XRPD
163		BR81B/4		sliver	mixed Na-pyroxenite	rutile and ilmenite define lineation; unreliable weighing	2.9	2.1	3.63	
164		C-FR-NE/3		axehead fragment	mixed Na-pyroxenite	too small for reliable weighing	=	=	=	
165		C-FR-SO/78	PIEM 18	big sliver	mixed Na-pyroxenite	===	79.1	56.0	3.42	thin section
166		C-FR-SO/87	PIEM 17	big sliver	mixed Na-pyroxenite	===	51.7	36.4	3.38	thin section
167 69257	BF235 IV/28		BF28 (agg.)	pestle	mixed Na-pyroxenite	===	45	31.5	3.33	
168		C-FR-SO/90		pebble fragment	mixed Na-pyroxenite	===	33.8	23.7	3.35	

169		C-FR-SOS/12		grindstone	(undefined lithotype)	===	=	=	=	
170		C-FR-SOS/12		(undefined artifact)	(undefined lithotype)	===	=	=	=	
171		C-FR-SOS/14		(undefined artifact)	(undefined lithotype)	===	=	=	=	
172		C-FR-SOS/15		(undefined artifact)	(undefined lithotype)	===	=	=	=	
173		BF-1		axehead fragment	omphacitite	weighing hardly reliable	8.8	5.9	3.06	XRPD
174		C-FR-SO/2		sliver roughout	omphacitite	partially regressed omphacitite, covered by carbonates	61	40.1	2.92	
175		C-FR-SO/10		small axehead roughout	omphacitite	several reddish veins with possible quartz	48.6	32.2	2.96	
176	C-FF	R-SO/53-54-55		three small slivers	omphacitite	with mylonitic structure; too small for reliable weighing	3	2	3.00	
177		C-FR-SO/73		axehead roughout	omphacitite	strongly regressed omphacitite with epidote	177.8	118.7	3.01	
178		C-FR-SO/4		sliver	omphacitite	Binoc.: omphacitite a quarzo ed anfibolo	201	136.2	3.10	
179 69360		C FR SO		chisel	omphacitite	omphacitite with chloritoid	7.3	5	3.17	
180		C-FR-NE/5		axehead fragment	omphacitite	presence of zoisite	8.6	5.9	3.19	
181		C-FR-SO/80		sliver	omphacitite	presence of zoisite	12.5	8.6	3.21	
182		C-FR-SO/71		axe fragment/ roughout	omphacitite	===	312.7	215.3	3.21	thin section
183		C-FR-O/ 7		axe butt roughout	omphacitite	regressed omphacitite, with chlorite aggregates	65.4	45.2	3.24	
184		C-FR-SO/20		small axe roughout	omphacitite	===	49.1	34.1	3.27	
185		C-FR-SO/22		small axe roughout	omphacitite	possible presence of zoisite in pale plagues	22.3	15.5	3.28	
186		C-BR-CV/12		big axe roughout	omphacitite	===	534	371.2	3.28	thin section
187		C-FR-SO/38		axe butt fragment	omphacitite	presence of superficial carbonate crusts	12.8	8.9	3.28	
188		C-FR-SO/63		axehead fragment	omphacitite	quite homogeneous rock	45.9	32.2	3.35	
189		C-FR-SO/25		small axe roughout	omphacitite	presence of pseudomorphosis on probable lawsonite	29.5	20.7	3.35	
190		C-FR-O/ 1		striker	omphacitite	===	205	144	3.36	
191 69372		C FR SO		axehead fragment	omphacitite	===	37.2	26.2	3.38	XRPD
192		C-FR-SO/100		striker/cobble	omphacitite	pyroxene with dark green colour	54.2	38.2	3.39	
193		C-FR-SO/30		recycled axe fragment	omphacitite	===	43.4	30.6	3.39	
194		C-FR-SO/6		axe cutting edge draft.	omphacitite	===	55.5	39.2	3.40	XRPD
195		C-FR-SO/39		axehead fragment	omphacitite		52.6	37.3	3.44	
196		BF-5		axehead fragment/sliver	omphacitite	pyroxene with dark green colour	3.9	2.8	3.55	XRPD
197 69350		C FR NE	PIEM 27	axehead roughout	omphacitite	partly regressed fine-grained omphacitite, altered on the border	52.4	36.5	3.30	
198 69349		C-FR-SO	PIEM 26	axehead roughout	omphacitite	presence of subordinate jadeite and ilmenite	161.8	113.1	3.33	thin section
199		C-FR-SO/58	PIEM 22	axehead roughout	omphacitite	===	74	51.7	3.32	thin section
200		C-FR-SOS/1		axe cutting edge fragm.	omphacitite	too small for reliable weighing	=	=	=	
201	BF229 IV/11		BF11 (agg.)	axehead	omphacitite	= = =	22.3	15.5	3.28	
202	BF422-31 III/33		BF33 (agg.)	axehead roughout	omphacitite	= = =	28.9	20.0	3.26	

203		BF 90 I/15		BF15	pebble	prasinite	prasinitic micaschist	164.9	104.2	2.72	
204			C-FR-SO/75		axe roughout/fragment	prasinite	very heterogeneous rock	175.9	115.9	2.93	
205			C-FR-SO/ 5		fragmented pebble	prasinite	===	91.8	60.8	2.96	
206			C-FR-SO/33		axe cutting edge draft.	prasinite	===	67.4	44.8	2.98	
207	69352		C FR SO		axehead roughout	prasinite	strongly regressed, with abundant albite	84	56.4	3.04	
208			C-FR-SO/98		axe roughout/fragment	prasinite	===	214.9	144.4	3.05	
209			C-BR-CV/7		axe cutting edge draft.	prasinite	prasinite crossed by veins of possible albite	48	32.3	3.06	
210			C-FR-N/3		axe butt fragment	prasinite	===	127.4	86	3.08	
211			C-FR-SO/79		sliver/axe roughout	prasinite	too small for reliable weighing	=	=	=	thin section
212			C-FR-SO/31		axehead roughout	aegirin-augite and chlorite schist	===	133.2	93.5	3.36	thin section
213		BF 404 II/27		BF27	axe butt fragment	omphacite/chlorite schist	===	60.5	41.2	3.13	
214		BF 252 III/20.1		BF20.1	axe butt fragment	omphacite/chlorite schist	===	44.5	30.5	3.18	
215			C-FR-NE/4		axehead fragment	serpentinite	===	16.3	9.8	2.51	
216	69258	BF 163-164/17	9-180 III	BF31	axehead	serpentinite	antigoritic serpentinite	21.9	13.3	2.55	
217			C-FR-SOS/4		axe cutting-edge fragm.	serpentinite	altered serpentinite	27.6	17	2.60	
218			C-FR-SOS/9		sliver	serpentinite	===	12.5	7.7	2.60	
219			C-FR-SO/45		axehead roughout	serpentinite	===	50.9	31.5	2.62	
220			C-FR-SO/72		smoother/grindstone	serpentinite	===	85	52.7	2.63	
221			C-FR-SO/99		sliver	serpentinite	===	16.9	10.5	2.64	
222			C-FR-O/5		disc-ring roughout	serpentinite	===	230.9	144	2.66	
223			C-FR-O/13		pebble fragment	serpentinite	= = =	73	46.3	2.73	
224			C-FR-SO/74		axe roughout/fragment	serpentinite	===	144.5	94	2.86	
225		BF 247 IV/14.2		BF14.2	small sliver	serpentinite	antigoritic serpentinite; too small for reliable weighing	=	=	=	
226		BF 279 III/26.2		BF26.2	sliver	serpentinite	antigoritic serpentinite; too small for reliable weighing	=	=	=	
227		BF131-132 147	7-148-II/12	BF12 (agg.)	disc-ring roughout	serpentinite	===	118.2	72.7	2.58	
228		BF163-180 II/16		BF16 (agg.)	disc-ring roughout	serpentinite	===	84.7	52.3	2.62	
229		BF235 II/18.1		BF18.1 (agg.)	sliver	serpentinite	too small for reliable weighing	=	=	=	
230		BF266 III/18.2		BF18.2(agg.)	sliver	serpentinite	too small for reliable weighing	=	=	=	
231	69261	BF 159 IV			axehead	steatite	too small for reliable weighing	=	=	=	

Table 1. Inventory codes, label, typology, preliminary lithotype determination and density value of the 231 polished stone implements and artefacts coming from the<br/>archaeological site of Brignano Frascata, based on density measurements and stereo-microscopy observations in reflected light of the tools polished or raw surfaces; the<br/>related treatments for analytical purposes are also indicated. 

	State	Excavation	Other	Labol	Implement	Lithotypo	Notes (staroomiaroscopy in reflected light/density)	Weight	Weight	Donsity	Sompling
1	Inventory	inventory	C-MP-I/ 7	Laber	striker fragment	serpentinite	===	82 5	51.4	2 65	Samping
2			C-MP-CA/37		disc-ring roughout	serpentinite	===	76.9	48.0	2.65	
3			C-MP-CA/126	C-MP-C/1	ascia abbozzo	serpentinite	===	146	91.2	2.66	
4			C-MP-CA/1		anellone fr.	serpentinite	===	83.7	52.3	2.67	
5			C-MP-CV/6		discoidal pendant	serpentinite	===	10	6.3	2.70	
6			C-MP-CA/131	C-MP-C/6	axehead fragm./roughout	serpentinite	===	20.6	13	2.71	
7			C-MP-CA/133	C-MP-C/8	pebble/disc-ring roughout	serpentinite	===	305.3	196.4	2.80	
8			C-MP-CA/132	C-MP-C/7	sliver	prasinite	===	20.3	13.4	2.94	
9			C-MP-CA/3		axehead fragm./roughout	prasinite	= = =	36.9	24.5	2.98	
10			C-MP-CA/129	C-MP-C/4	big sliver	omphacitite	possible presence of zoisite	158.2	105.7	3.01	
11			C-MP-CA/135	C-MP-C/10	sliver	omphacitite	possible presence of zoisite	65.3	44.9	3.20	
12			C-MP-CA/127	C-MP-C/2	axehead fragment.	omphacitite	===	140.2	97.2	3.26	
13			C-MP-I/1		axehead/striker fragment	garnet-omphacitite	presence of rare garnets	108.3	75.8	3.33	thin section
14			C-MP-I/3		ascia fr. tagliente	garnet-omphacitite	presence of rare garnets; too small for reliable weighing	=	=	=	
15			C-MP-CV/3		axehead fragment.	mixed Na-pyroxenite	presence of rare garnets	55.7	38.4	3.22	
16			C-MP-CA/39		axe butt fragment	mixed Na-pyroxenite	presence of both jadeite and omphacite	127.2	88.7	3.30	
17			C-MP-I/4		axe butt fragment	mixed Na-pyroxenite	no garnets are observed	25.7	18.1	3.38	
18			C-MP-CA/130	C-MP-C/5	axe/sliver fragment	mixed Na-pyroxenite	===	7.6	5.5	3.62	
19			C-MP-CA/128	C-MP-C/3	axehead fragment.	jadeitite	===	183	128.2	3.34	thin section
20			C-MP-CV/4		striker fragment	eclogite	banded eclogite, with garnet-rich and omphacite-rich levels	86.5	58.5	3.09	
21			C-MP-CA/134	C-MP-C/9	sliver	eclogite	presence of zoisite aggregates	68.1	46.8	3.20	
22			C-MP-CV/2		axehead roughout	eclogite	===	96.1	66.1	3.20	
23			C-MP-CA/7		axehead roughout	eclogite	===	492.8	339	3.20	
24			C-MP-CA/6		sliver	eclogite	presence of zoisite	165.3	114.4	3.25	
25			C-MP-CV/5		chisel roughout/fragm.	eclogite	fine-grained eclogite with oriented omphacite crystals	55.3	38.8	3.35	
26			C-MP-CA/38		small sliver	eclogite	===	11.5	8.1	3.38	
27			C-MP-CA/2		axehead fragment	eclogite	===	63.2	44.6	3.40	thin section
28			C-MP-CA/5		sliver	eclogite	===	10.2	7.2	3.40	
29			C-MP-I/ 5		striker fragment	eclogite	===	53	37.6	3.44	
30			C-MP-I/6		striker fragment	eclogite	===	36.7	26.1	3.46	XRPD
31			C-MP-I/2		striker	eclogite	eclogite with mylonitic structure; 2 different pyroxenes	30.4	21.8	3.53	
32			C-MP-CV/1		axe butt fragment	eclogite	===	70.3	50.6	3.57	XRPD

	33	C-MI	P-CA/4		small sliver	eclogite	too small for reliable weighing	3.7	2.7	3.70	
	34	C-MI	P-CA/136	C-MP-C/25	axehead fragment	eclogite	too small for reliable weighing	=	=	=	
L179	Table 2. Inver	ntory codes, label,	, typology	y, prelimina	ry lithotype determ	nination and der	nsity value of the 34 polished stone implements and	d artefacts	coming fro	om the	
1180	arch	naeological site of	f Mompei	rone, based	on density measure	ements and ster	eo-microscopy observations in reflected light of th	e tools pol	ished or ra	w surface	s; the
1101	Tela	ted treatments for	anarytica	ai puiposes	are also mulcated.						
1102											
1103											
1125											
1186											
1187											
1188											
1189											
1190											
1191											
1192											
L193											
L194											
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197											
L198											
1199											
1200											
201											
1202											
203											
L204											
205											
1206											
1207											
1208											
1209											

	State	Excavation	Other		Implement				Weight		
	Inventory	inventory	inventories	Label	description	Lithotype	Notes (stereomicroscopy in reflected light/density)	in air	in H <sub>2</sub> O	Density	Sampling
1			VRM/10		axehead roughout	serpentinite	===	118.2	72.7	2.60	
2			VRM/11		pebble/smoother	serpentinite	===	67.5	42	2.65	
3			VRM/13		pebble/smoother	serpentinite	=	46.5	29	2.66	
4			VRM/15		(undefined artifact)	serpentinite	===	144.9	90.4	2.66	
5			VRM/14		pebble/sliver	serpentinite	===	75.8	47.3	2.66	
6			VRM/2		grindstone fragment	serpentinite	===	218.4	136.3	2.66	
7			VRM/5		flat pebble/axe roughout	serpentinite	=	307.5	192.5	2.67	
8			VRM/12		pebble/smoother	serpentinite	=	13.2	8.4	2.75	
9			VRM/1		grindstone fragment	serpentinite	=	598.4	387	2.83	
10			VRM/9		axehead roughout	serpentinite	===	131.6	85.2	2.84	
11			VRM/6		axehead fragment	mixed Na-pyroxenite	===	28	19.6	3.33	XRPD
12			VRM/16		axehead fragment	mixed Na-pyroxenite	===	48.1	33.7	3.34	XRPD
13			O-VR-CR/3		axehead fragment	mixed Na-pyroxenite	===	21.2	14.8	3.31	
14			VRM/8		axe	jadeitite	===	189.8	130.9	3.22	
15			VRM/20		axe	jadeitite	===	140.7	98.7	3.35	XRPD
16			VRM/4		axe	eclogite	banded eclogite, with garnet-rich and omphacite-rich levels	236.9	164.7	3.28	
17			VRM/19		big axe	eclogite	presence of very small garnets	529.8	375.3	3.43	
18			VRM/3		axehead fragm./roughout	eclogite	presence of rutile and/or ilmenite	130.8	93	3.46	
19			VRM/18		axe	eclogite	===	323.6	231.4	3.51	
20			O-VR-CR/2		axehead fragment	eclogite	===	56.5	39.8	3.38	
21			O-VR-CR/1		axehead fragm./roughout	eclogite	===	261.7	186.5	3.48	thin section
22			VRM/7		axehead fragment	(undefined lithotype)	too small for reliable weighing	=	=	=	
23			O-VR-CR/4		striker fragment	omphacitite	===	120.7	84.6	3.34	

Table 3. Inventory codes, label, typology, preliminary lithotype determination and density value of the 23 polished stone implements and artefacts coming from the

archaeological site of Villaromagnano, based on density measurements and stereo-microscopy observations in reflected light of the tools polished or raw surfaces; the 1212 related treatments for analytical purposes are also indicated

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Inventory	Sample	Sample Site Typology Notes						1	Pictu
code	code/label				(g/cm³)	XRPD	О.М. 9	SEM	
JADEITIT	ES: 17								
69262	BF 230 II	Brignano Frascata	grindstone	irreg. spheroidal morphology; flat-convex sect.	3.30	Х	Х	Х	(1)
=	C-FR-NO/2	Brignano Frascata	big sliver	strong zoning of Na-Pyroxenes	3.27	Х	Х	Х	(2)
=	C-FR-SO/41	Brignano Frascata	striker fragment	=	3.37	Х	Х	Х	(3)
=	C-FR-SO/94	Brignano Frascata	disc-ring roughout	granoblastic structure	3.27		Х		(4)
=	C-FR-SO/57	Brignano Frascata	axehead roughout	=	3.33		Х		(5)
=	C-FR-SO/65	Brignano Frascata	striker fragment	accessory: white mica	3.30		Х		(6)
=	C-FR-NE/7	Brignano Frascata	axehead fragment	igneous cpx relicts; granoblastic structure	3.46		Х		(7)
=	BF-3	Brignano Frascata	axe roughout/sliver	pale green hue	3.25	Х			(8)
=	BR81-B/2	Brignano Frascata	small axe sliver	dark green hue; accessory: Fe-glaucophane	3.50	Х			=
BF161-17811/19	BF19*	Brignano Frascata	axehead fragment	accessory: white mica	3.22		Х		(9)
BF26811/20.2	BF20.2*	Brignano Frascata	axehead fragment	=	3.26		Х		=
74918	BF21*	Brignano Frascata	axehead	Ti-rich Na-pyroxene	3.43		Х		=
BF454-4631/23	BF23*	Brignano Frascata	axehead fragment	rich in phengite	3.32		Х		(10)
BF-E31	BF25*	Brignano Frascata	striker	parallelepiped-shaped; flat-convex section	3.16		Х		(11)
BF89II/32	BF32*	Brignano Frascata	manufacture sliver	=	3.34		Х		(12)
C-MP-C/3	C-MP-CA/128	Momperone	axehead fragment	homogeneous rock	3.34	Х	Х	Х	(13)
=	VRM/20	Villaromagnano	axe		3.35	Х			(14)
OMPHAC	TITES: 17								
=	C-BR-CV/12	Brignano Frascata	big axe roughout	=	3.28	Х	Х	Х	(15)
=	C-FR-SO/71	Brignano Frascata	axe fragment/roughout	arched cutting edge	3.21	Х	Х	Х	(16)
=	C-FR-SO/58	Brignano Frascata	axe fragment/roughout	acc: Mg-chlorite probably after garnet	3.32		Х		(17)
69349	69349	Brignano Frascata	axehead roughout	isosc. triangshaped, flat-convex sect.; ilmenite	3.33		Х		(18)
69350	69350	Brignano Frascata	axehead roughout	triangshaped, biconvex sect.; omph. regressed	3.30		Х		(19)
=	BF-1	Brignano Frascata	axe fragment/sliver	=	3.06	Х			(20)
=	BF-5	Brignano Frascata	axe fragment/sliver	dark green hue	3.55	Х			(21)
69372	69372	Brignano Frascata	axehead fragment	indef. shape, biconvex sect., arched cutting edge	3.38	Х			(22)
=	C-FR-SO/6	Brignano Frascata	axe cutting edge draft.	homogen. omphacite; acc. nepheline	3.40	Х			(23)
=	C-FR-SO/31	Brignano Frascata	axehead roughout	Ae-augite-chlorite schist	3.36	Х	Х	Х	(24)
BF229 IV/11	BF11*	Brignano Frascata	axehead	=	3.28		Х		=
BF422-31111/33	BF33*	Brignano Frascata	axehead roughout	=	3.26		Х		=
BF 252111/20.1	BF20.1*	Brignano Frascata	axe butt fragment	omphacitic-chloritic schist; abundant omphacite	3.18		Х		(25)
BF 404 II/27	BF27*	Brignano Frascata	axe butt fragment	omphacite-chlorite schist; partly regressed omph	. 3.13		Х		(26)
=	C-GR-III/5	Gremiasco	sliver	=	3.45	Х			(27)
=	GG56/834	Gremiasco	axe	zoisite pseudom. after laws.;calcite, quartz acc. min	. 3.24	Х			=
=	CSN93/1	Casalnoceto	axehead fragment	=	3.36	Х			=
MIXED Na	-PIROXENITE	S: 12	1 0			•••		•••	(20)
=	C-FR-O/11	Brignano Frascata	axe butt fragment	accessory: magnetite and hematite	3.37	X	X	Х	(28)
=	C-FR-SO/90	Brignano Frascata	pebble fragment	=	3.35	Х	Х	Х	(29)
=	C-FR-SO/87	Brignano Frascata	big sliver	isolated garnet (?)	3.38		Х		(30)
=	C-FR-SO/78	Brignano Frascata	big sliver	=	3.42		Х		(31)
=	C-FR-NE/1	Brignano Frascata	axehead fragment	=	3.40	Х			(32)
=	C-FR-SO/18	Brignano Frascata	striker fragment	=	3.29	X			(33)
=	BF-2	Brignano Frascata	axe fragment/sliver	accessory: hematite	3.47	X			(34)
= DE84 102 104UL	BF-4	Brignano Frascata	axe fragment/sliver	=	3.26	Х	37		(35)
DE325 TV/20	BF9*	Brignano Frascata	axehead tragment	Indet. shape, flat-convex sect., linear cutting-edg	e 3.34		X		(36)
df233 1V/28	BF28*	Brignano Frascata	pestle	=	3.33	37	Х		=
=	VRM/6	Villaromagnano	axehead tragment	=	3.33	X			(37)
=	VRM/16	Villaromagnano	axehead tragment	=	3.34	X			(38)
Table	4. Minero-petr	ographic characteri	zation of 46 polished s	tone implements (12 of which, marked)	у '*',	also			
)	described	by D'Amico et al., 2	2000) in 'Na-pyroxene	rocks' from Brignano Frascata and/or o	ther co	beva	1		
	archaeolog	gical sites in the Gru	ie, Curona and Ossona	valleys, analysed by XRPD, optical pol	arizing	3			
	microscop	e and/or SEM-EDS.	, as indicated. In the las	st column, numbers refer to pictures in I	Figs. 4	and	5.		

	Na-PYROXENE + GARNET ROCKS									
	Inventory	ory Sample Site		Typology	Notes	Density	A	nalyse	6	Picture
	code	code/label				(g/cm <sup>3</sup> )	XRPE	О.М.	SEM	
	ECLOGIT	ES: 27								
	=	C-FR-SOS/8	Brignano Frascata	sliver	portions richer in garnets and others in pyrox.	3.43	Х	Х	Х	(39)
	=	C-FR-SO/59	Brignano Frascata	axe fragment/roughout	=	3.45	Х	Х	Х	(40)
	=	C-FR-SO/48	Brignano Frascata	axe butt fragment	garnet composition: Grs90 Adr10	3.45	Х	Х	Х	(41)
	=	C-FR-O/14	Brignano Frascata	axehead fragment	garnets also with skeletal habit	3.51	Х	Х	Х	(42)
	=	C-FR-SO/12	Brignano Frascata	axehead roughout	portions with jadeitic composition	3.39	Х	Х	Х	(43)
	69353	69353	Brignano Frascata	chisel roughout	rectang.shape, biconv.sect; chloritoid, chlorite, epidote	3.37		X		(44)
	69355	69355	Brignano Frascata	axehead roughout	indef. shape, arched cutting-edge; chloritoid rich	3.40		X		(45)
	69356	69356	Brignano Frascata	axehead	isosceles triang.shape; atoll-like garnets & rutile	3.48		X		(46)
	69361	69361	Brignano Frascata	axehead roughout	trapez.snape, nat-convex sect.; zoisne, lawson.; glaucopil.	3.38		X		(47)
	69362	69362	Brignano Frascata	axehead roughout	trapezoidal snape, biconvex section, arched cutting-edge	3.42	v	Х		(48)
	1/	C-FR-SO//6	Brignano Frascata	axe fragment/roughout		3.30	А	v		(49)
	BF420-429/10	BF10* DF12*	Brignano Frascata	manufacture silver	retrogressed garnet, zoisite	3.33		A V		(30)
E	3F227-8 243-4III/1 BF 102IV/14 1	BF13" DE1/1*	Brignano Frascata	striker	=	3.44 2.57		A V		(51)
	60249	DF14.1 '	Drignano Frascata	axenead roughout	coarse-grained eclogite	2.57		л v		(51)
	69248	DF1/*	Drignano Frascata	surficer	_	5.52 2.40		л v		(52)
	09230 DE 4/5 II	DF22* DF2/*	Drignano Frascata	nabhla	-	2.49		л v		(52)
	BF 4/3 II	DF24 DF26 1*	Drignano Frascata	evolution	trapezoidal shape flat-convex sect thinned cutting-edge	3.21		л v		(53)
	69253/BF 279 III	DF20.1*	Brignano Frascata	striker		3.41		л V		(54)
	6024	DF35 1*	Brignano Frascata	striker	_	3.40		л V		=
	07247 DE162 170m25 2	BF35.2*	Brignano Frascata	manufacture sliver	=	3.50		л Х		=
	=	$C_{-}FB_{-}C/1$	Fabbrica Curone	ave fragment/roughout	=	3 55	x	Λ		=
	=	C-MP-CA/2	Momperone	axeheah fragment	Ae-rich Na-pyroyene	3.40	x	x	x	(55)
	=	C-MP-CV/1	Momperone	axe hutt fragment	=	3 57	X	Λ	1	(56)
	=	C-MP-I/6	Momperone	striker fragment	=	3 46	X			(57)
	=	S-BI-I/2	Pozzol Groppo	axe fragment/roughout	=	3.31	X			(58)
	=	O-VR-CR/1	Villaromagnano	axe fragment/roughout	=	3.48	X	Х	х	(59)
	GARNET-0	ОМРНАСІТІТ	TES: 2							. ,
	69238	69238	Casalnoceto	axe fragment/roughout	sub-trapezoid.shape; arched cutting-edge; rare garnets	3.38	Х	Х	Х	=
	=	C-MP-I/1	Momperone	axe/striker fragment	rare garnets and pumpellyite	3.33	Х	Х	Х	(60)
1228	3 Table	5. Minero-pet	rographic characteriz	ation of 29 polished s	tone implements (10 of which, marked b	ov '*'.	also	)		
1229	)	described	by D'Amico et al., 2	000) in 'Na-pyroxene	+ garnet rocks' from Brignano Frascata	and/o	r otł	ner		
1230	)	coeval arc	chaeological sites in t	he Grue Curona and (	Ossona vallevs analysed by XRPD onti	cal nc	lariz	vino		
1231		microscor	he and/or SFM-FDS	as indicated. In the la	st column numbers refer to nictures in F	ios 5	and	6		
1727	)	meroseo	be and/or bein ebb,	as maleated. In the la	st column, numbers refer to pretures in r	155. 5	ana	0.		
1222	-									
1200										
1234	+									
1235	2									
1236	)									
1237	/									
1238	3									
1239	)									
1240	)									
1241	L									
1242	<u>)</u>									
1243	3									
1244	L									
1245										
1245										
1240	, 1									
124/	)									
1240	) )									
1249	1									
1250	J									
1251	<u>l</u>									
1252	2									
1253	3									
1254	ļ									
1255	5									

1256	0									
	OTHER I	ITHOTYPES				<b>N</b> 1.				<b>D</b> .
	Inventory	Sample	Site	Typology	Notes	(g/cm <sup>3</sup> )	AI	alyses		Picture
	OUADTZ	ADENITE: 1					XRPD	О.М. 3	SEM	
		$CN 91_{-102}$	Casalnoceto	millstone fragment	=	_	x	x	x	=
	GLAUCO	PHANITES (BL	UESCHISTS) · 3	ministone nugment			21	21	11	
	=	C-FR-SO/60	Brignano Frascata	axe fragment/roughout	acc. minerals: garnet, jadeite and quartz	=		Х		(61)
	69354	69354	Brignano Frascata	axehead roughout	isosc.triangshaped, irreg.sect, large talon; albite	=		X		(62)
	69357	69357	Brignano Frascata	axehead roughout	indef. shape; irreg. sect.; acc.epidote,garnet,rutil	e =		Х		=
	BASIC GI	RANULITES: 3		6						
	BF 263 II/29.	<sup>1</sup> BF29.1*	Brignano Frascata	disc-ring roughout	=	2.82		Х		=
	BF263 II/29.2	<sup>2</sup> BF29.2*	Brignano Frascata	disc-ring roughout	=	2.85		Х	Х	(63)
	BF 310 II/34	BF34*	Brignano Frascata	disc-ring roughout	=	2.87		Х		(64)
	ANTIGO	RITIC SERPENT	<b>FINITES: 7</b>							
	BF131/2-147/8-II	1 BF12*	Brignano Frascata	disc-ring roughout	=	2.58		Х		(65)
	BF 247IV/14.	<sup>2</sup> BF14.2*	Brignano Frascata	manufacture sliver	=	=		Х		(66)
	BF163-180II/1	6 BF16*	Brignano Frascata	disc-ring roughout	=	2.62		Х		=
	BF235 II/18.1	BF18.1*	Brignano Frascata	manufacture sliver	=	=		Х		=
	BF266 III/18.	<sup>2</sup> BF18.2*	Brignano Frascata	manufacture sliver	=	=		Х		=
	BF 279 II/26.2	<sup>2</sup> BF26.2*	Brignano Frascata	manufacture sliver	magnetite aggregates	=		Х		(67)
	BF 163/4-179/80	n BF31*	Brignano Frascata	axe	irreg.triang-shaped; flat-convex sect.;linear cutting-edg	e 2.55		Х		(68)
	PRASINI	FIC MICASCHI	ST: 1							
	BF 90 I/15	BF15*	Brignano Frascata	pebble	=	2.72		Х		(69)
	LAWSON	ITE-ALBITE FI	ELS: 1							
	BF262 IV-V/20.	3 BF20.3*	Brignano Frascata	small pebble	=	=		Х		=
125	/									
1258	s Table	e 6. Minero-petr	ographic characteriz	zation of 16 polished	stone implements (12 of which, marked)	by ••´,	also	desc	crib	ed
1259	)	by D'Amico	et al., 2000) made (	of lithotypes different	than 'Na-pyroxenites' and 'Na-pyroxen	e + gas	rnet 1	rocks	s' fr	om
1260	)	Brignano Fra	ascata and/or other o	coeval archaeological	sites in the Grue, Curona and Ossona va	lleys,	analy	/sed	by	
1261	L	XRPD, optic	cal microscopy in pl	ane-polarized light ar	nd/or SEM-EDS as indicated. In the last of	colum	n, nu	mbei	s re	efer
1262	2	to pictures ir	n Fig. 7.							
1263	3	1	e							
1264	1									
126	;									
126	5									
1200	7									
1207	, ,									
1200	5									
1265	1									
12/(	)									
1271	L									
1272	2									
1273	3									
1274	1									
1275	5									
1276	5									
1277	7									
1278	2									
1070	2									
12/3										
120	)									
1281	L									
1282	2									
1283	3									
1284	1									
1285	5									
1286	5									
1287	7									
1288	3									
1289	-									
1200	, 1									
1204	, I									
1291	L									
1292	<u> </u>									

Na-PYROXENE	E RO	CKS	5																		
Legend:	0	<50	%				5%	- 20	%			٠	20%	6 - 60	)%					>60	%
JADEITITES	mnhacita	andoite iadoite	aucite	garnet	chloritoid	quartz olanconhane	saucopuano muhihala		clinozoisite-	epiaote t.t.at.o.	winte inica	UL:12	albite sufile	l uure Imanita	ullenuc itanita	uranuc zirean	anafite	apauto Nonito	ananuc sulabidae	upinucs vidae	S Notes
C-FR-SO/41	0				Ĭ	Ī	~ ·	ľ		Ĭ	<u> </u>	Ĭ			0	0					
C-FR-NO/2																		0			access. crystals with Y/Ir
BF 230 II	0				0										0						accessory: native Cu
C-MP-CA/128	Ο														0	0					From Momperone
C-FR-SO/94	0							0					0			0					
C-FR-SO/57	Ο															0					
C-FR-SO/65	0																				
C-FR-NE/7	0														0						
BF19	0																				lescr. D'Amico et al.2000
BF20.2	0															0					lescr. D'Amico et al.2000
BF21	0														0						lescr. D'Amico et al.2000
BF23	0															0					Гi-rich pyroxene
BF25	0				0							0									lescr. D'Amico et al.2000
BF32	0															0					lescr. D'Amico et al.2000
OMPHACITIT	ES																				-
C-BR-CV/12	$\bullet$	0																0		0	
C-FR-SO/71	$\bullet$	0													0						
C-FR-SO/58	$\bullet$													0							
69349														0							
69350	$\bullet$																				
C-FR-SO/31	•										•				0		0				
BF11							0									0					lescr. D'Amico et al.2000
BF33	•					-			-				0						0		lescr. D'Amico et al.2000
BF20.1	•										•										by D'Amico et al.2000
BF27	•										$\bullet$										by D'Amico et al.2000
MIXED Na-PYI	ROX	ENI	TES	1		1		<u> </u>	1	-	1	-	1		1	1	1	1		-	1
C-FR-O/11	•				+						<u> </u>		+	0						0	Ti-rich pyroxene
C-FR-SO/90	•	•			-											0			-		
C-FR-SO/87			0		-	-															
C-FR-SO//8				-		<u> </u>			<u> </u>							0					
ВГУ				-		<u> </u>			<u> </u>		-	-			0		0				lescr. D'Amico et al.2000
$\begin{bmatrix} \mathbf{DF} 2 \mathbf{\delta} \\ 0 2 \\ \mathbf{T} 1 1 1 7 \\ \mathbf{M}^{2} \end{bmatrix}$						 		- 6 2				1	<b>₽</b>	 :			  :+`		 1 '	·	plescr. D'Amico et al.2000

Table 7. Mineralogical composition (vol. %) of 30 'Na-pyroxene rocks' (jadeitite, omphacitite and mixed Na-pyroxenite) studied in thin section by means of the optical polarizing microscope and/or SEM-EDS. All samples are from Brignano Frascata, except when otherwise indicated.



#### 1323 Figure Captions

#### 1324

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- 1325 Figure 1. Map of Northern Italy: main towns are indicated, as well as the location of the Monviso 1326 (Vi) and Voltri (Vo) massifs – possible sources for the supply of raw materials. The 1327 location of the archaeological site of Brignano Frascata and other close ones in the 1328 Curone, Grue and Ossona valleys (Momperone, Villaromagnano, Casalnoceto, 1329 Gremiasco, Fabbrica Curone, Pozzol Groppo, Volpeglino, Viguzzolo and Sale) is 1330 indicated by the small blue rectangle (more specific information about the position of 1331 each site is provided in Fig. 16a). The location of eight coeval archaeological sites [1] 1332 Alba, 2) Castello di Annone, 3) Gaione; 4) Ponte Ghiara; 5) Rivanazzano; 6) Rocca di 1333 1334 Cavour; 7) Sammardenchia; 8) San Lazzaro di Savena)], taken into account for 1335 archaeometric comparison, is also shown.
- Figure 2. Neolithic polished greenstone implements (all from Brignano Frascata, except when otherwise indicated); a) instruments for cutting (axehead roughouts and/or fragments): i)
  C-FR-O/6, ii) C-FR-O/1, iii) C-FR-N/5, iv) C-FR-SO/48, v) C-FR-SO/45, vi) C-FRSO/20; b) disc-ring roughouts and fragments at different working steps: i) C-MP-CA/133
  (from Momperone), ii) C-FR-O/5, iii) BF29.2, iv) BF12, v) C-FR-SO/94.
- Figure 3. a) Density histogram and b) lithotype distribution of 231 archaeological implements from
   Brignano Frascata, obtained by combining density measurements and stereo-microscopic
   observations. Lithotype distribution of similar implements from the sites of c)
   Momperone (34 tools) and d) Villaromagnano (23 tools).
- Figure 4. Photographs of Neolithic greenstone implements in 'Na-pyroxene rocks' from Brignano
   Frascata and other nearby sites in the Curone, Grue and Ossona valleys, investigated with
   an in-depth mineral-petrographic approach; numbers refer to the last column of Table 4.
- Figure 5. Photographs of Neolithic greenstone implements in 'Na-pyroxene rocks' (21-38) and
  'Na-pyroxene+garnet rocks' (39-40) from Brignano Frascata and other nearby sites in the
  Curone, Grue and Ossona valleys, investigated with an in-depth mineral-petrographic
  approach; numbers refer to the last column of Tables 4 and 5.
- Figure 6. Photographs of Neolithic greenstone implements in 'Na-pyroxene+garnet rocks' from
   Brignano Frascata and other nearby sites in the Curone, Grue and Ossona valleys,
   investigated with an in-depth mineral-petrographic approach; numbers refer to the last
   column of Table 5.
- Figure 7. Photographs of Neolithic implements in lithotypes different than 'Na-pyroxene rocks' and 'Na-pyroxene+garnet rocks' from Brignano Frascata and other nearby sites in the Curone, Grue and Ossona valleys, investigated with an in-depth mineral-petrographic approach; numbers refer to the last column of Table 6.
- Figure 8. X-ray powder diffraction pattern of: a) a jadeitite (BF-230-II) and b) a mixed Na pyroxenite (C-FR-SO/90) from Brignano Frascata. While in the former the reflections
   typical of clinopyroxenes i.e., Z21, 310 and 002 are single, in the latter they are split
   (magnification in the upper right square) due to the presence of both jadeite (Jd) and
   omphacite (Omph) (wavelength: Cu-Kα radiation).

1373 1374	<b>Figure 9</b> . Compositional variation of pyroxenes in 'Na-pyroxene rocks' analyzed by SEM-EDS (4 jadeitites, 3 omphacitites and 2 mixed Na-pyroxenites plotted in the ternary diagram of Maximute at al. 1099)
1375	Morimoto et al., 1988).
1376	Figure 10. Compositional variation of 'Na-pyroxene + garnet rocks' analyzed by SEM-EDS
1378	[pyroxenes and garnets, plotted in the ternary diagram of Morimoto et al., 1988 and in the
1379	grossular (Grs) – pyrope (Prp) – almandine + spessartine (Alm+Sps) diagram,
1380	respectively; arrows indicate the compositional zoning from core (C) to rim (R) of 7
1381	eclogites and 2 garnet-omphacitites].
1382	
1383	Figure 11. Thin section photomicrographs of jadeitite: a) squat, prismatic jadeite blasts (Jd)
1384	containing small inclusions with omphacitic composition (Omph); euhedral zircons (Zrn)
1385	are also observed (BF-230 II; photomicrograph, plane-polarized light); b) granoblastic
1386	aggregates of idioblastic jadeite crystals (dark grey: Jd) surrounding small plagues with
1387	omphacitic composition (light grey: Omph); zircons (Zrn) are also observed (C-MP-
1388	CA/128; SEM image, BSE).
1389	<b>F</b> '
1390	Figure 12. This section photomicrographs of mixed Na-pyroxenite: a) whitish pyroxene matrix in
1391	which line-grained jadelle aggregates (Jd.1), alternating to bigger Jd crystals (tens of $\mu m$
1392	mutile gruetals (Pt) are also observed (C EP SO/00; optical polarizing microscope, plane
1204	nolarized light) b) pyrovene matrix in which an omnhacitic weave (light gray: Omnh)
1205	surrounds and crosses fragmented indeite blasts (dark grey: Id) which contain small
1206	suffounds and crosses fragmented factor offsts (dark grey. $Jd$ ), which contain small
1390	omphaene merusions (C-1 K-0/11, 5EW mage, B5E).
1398	<b>Figure 13</b> . Thin section photomicrographs of eclogite: <b>a</b> ) small garnet (Grt) with tiny inclusions in
1399	the core surrounded by a zoned pyroxene matrix. composed of prismatic Fe-rich
1400	omphacite (Omph.1) with vellow-to-bluish pleochroism (Ti up to 5%) and less coloured.
1401	fine-grained Fe-poorer pyroxenes (Omph.2): opaque ores (Op) are sulphides (C-FR-O/14:
1402	optical polarizing microscope, plane-polarized light). b) pyroxene matrix where small
1403	jadeite domains (dark grey: Jd) appear amidst a prevailing Fe-rich, zoned omphacite
1404	(light grey: Omph). Foliation is defined by alignments of small titanite crystals (Ttn) (O-
1405	VR-CR/1; SEM image, BSE).
1406	
1407	Figure 14. Photomicrograph of a mafic granulite, made of Ca-plagioclase (Pl) (partially regressed
1408	to zoisite and rarer pumpellyite), orthopyroxene (Opx), clinopyroxene (Cpx), green
1409	hercynitic spinel (Hc) and brown hornblende (Ho) (BF29.2; optical polarizing
1410	microscope, crossed polarizers).
1411	
1412	Figure 15. Geologic jadeitite from the Val Lemme (VL14): a) thin section photomicrograph, in
1413	which granoblastic aggregates of idioblastic jadeite crystals (dark grey: Jd) surround
1414	small plagues with omphacitic composition (light grey: Omph; SEM image, BSE –
1415	compare with Fig. 11b); b) compositional variation of pyroxenes, analyzed by EDS and
1416	plotted in the ternary diagram of Morimoto et al. (1988).
1417	
1418	Figure 16. a) Map of the southeastern part of Piemonte region with the location of the investigated
1419	archaeological sites (related numbering proceeding from Fig. 1): 9) Brignano Frascata,
1420	10) Momperone, 11) Villaromagnano, 12) Casalnoceto, 13) Gremiasco, 14) Fabbrica
1421	Curone, 15) Pozzol Groppo, 16) Volpeglino, 17) Viguzzolo, 18) Sale. The red polygon

corresponds to the area represented in Fig. 16b. b) Geological scheme of the southeastern

1423	part of the study area (see red polygon in Fig. 16a). The distribution of the
1424	lithostratigraphic units of the Tertiary Piemonte Basin succession containing meta-
1425	ophiolitic pebbles (mor: Costa Cravara Breccia and Molare Formation; sav: Savignone
1426	Conglomerate; mst: Monastero Formation) is shown, as well as the distribution of
1427	Quaternary alluvial deposits (tal; all). Geological boundaries redrawn from Piana et al.
1428	(in the press), for the Piemonte part, and from Servizio Geologico d'Italia (1969a, b, c;
1429	1971), Marroni et al. (2010), and Vercesi et al. (2014), for the Liguria and Lombardia
1430	part. Within the Savignone Conglomerate and the Monastero Formation, the distinction
1431	of the conglomerate bodies containing meta-ophiolitic clasts (savc; mstc) has been
1432	possible only for the area delimited by the dashed line, corresponding to the northwestern
1433	part of the Cabella Ligure sheet of the Geological Map of Italy at 1:50.000 (Marroni et
1434	al., 2010).