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Eclogites, jades and other HP-metaophiolites employed for prehistoric polished stone implements in Italy and Europe

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ABSTRACT. — Prehistoric polished stone tools are now fairly well-known from a petrographic point of view in Northern Italy. Many more than one thousand implements sampled from the most important sites and collections (axes, adzes, chisels, some ornaments and various tools fragments), have been analysed. These artefacts were commonly employed from the Neolithic period onwards for working wood and cutting the forest trees. Surface optical observations, density, thin sections, XRD, microprobe analyses and bulk chemistry have been employed, alone or in combination, for petrographic study oriented to archaeometric interpretation.

Alpine eclogites, jades (Na-pyroxenites) and other minor HP (High Pressure) metaophiolites dominate the polished stone lithology of Northern Italy, being at least 70% and often surpassing 90% of stone materials in single sites. Petrographic, geochemical, minerochemical, textural data of the studied rocks are described and discussed in some detail. A number of new definitions are introduced.

The provenance of the raw material is identified as being NW Italy, essentially Piedmont and Liguria. These regions represent one of the few geological zones in the world where alpine eclogites and jades occur, both as primary outcrops in the High Alps, alluvial and morainic deposits along the valleys, and Oligocene conglomerates in the Northwestern Apennines.

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The dominance of eclogites and jades among the prehistoric polished stone tools represents a lithic selection of cultural significance. This selection seems to be justified by litho-technological (best mix of hardness, toughness and density) and aesthetic (fine green colours, translucency) reasons, which caused the exclusion of other, elsewhere common, lithologies.

The remarkable presence of jade and alpine eclogite lithologies among the Western and rarely Central European axe blades (mostly status symbol or ceremonial axes) gives evidence of a relevant long distance exportation of HP metaophiolite materials from NW Italy to France, Germany, Benelux, Great Britain, etc., up to1000-1500 km far from the source areas. The still unsystematic petrographic knowledge of the HP-metaophiolitic stones of the axe blades in Europe, as well as in the Italian Peninsula, allows only a preliminary comparison with the better known Northern Italian implements.

RIASSUNTO. — La pietra preistorica dell'Italia settentrionale è ora abbastanza ben conosciuta da un punto di vista petrografico. Ben oltre mille strumenti sono stati campionati e analizzati da raccolte di molti siti importanti (lame di asce e accette, scalpelli, ornamenti e vari frammenti). I più comuni manufatti sono asce/accette che furono comunemente utilizzate dal Neolitico per lavorare il legno e tagliare gli alberi. Osservazioni ottiche delle superfici, densità, sezioni sottili, XRD, analisi di microsonda e chimica totale sono state usate, da sole o in combinazione, per studi petrografici orientati all'interpretazione archeometrica.

Eclogiti alpine, giade (Na-pirosseniti), e minori HP-metaofioliti dominano la litologia della pietra levigata dell'Italia del Nord, essendo almeno il 70% e spesso superando il 90% dei materiali in pietra nei singoli siti. Dati petrografici, geochimici, minerochimici e tessiturali sono presentati e discussi con qualche dettaglio. Qualche nuova definizione è stata introdotta.

La provenienza della materia prima è identificata con il NW Italiano, essenzialmente Liguria e Piemonte. Queste regioni rappresentano una delle poche aree geologiche al mondo dove affiorano eclogiti alpine e giade, sia come masse geologiche primarie nella Alte Alpi, sia come depositi morenici ed alluvionali lungo le valli, sia come conglomerati oligocenici nell'Appennino di NW.

La dominanza di eclogiti e giade nella pietra levigata preistorica rappresenta una selezione litica di significato culturale. Tale selezione sembra giustificata da ragioni litotecnologiche (la migliore associazione di durezza, tenacità e peso specifico) ed estetiche (bel colore verde, tranlucidità), che provocarono l'esclusione d'uso di altre litologie, che pure sono comuni in altre aree.

La rimarchevole presenza di giade ed eclogiti alpine nella litologia di lame d'ascia nell'Europa occidentale (spesso in forma di oggetti di status symbol e asce cerimoniali) e, in minor misura, centrale mette in evidenza una rilevante esportazione su lunga distanza di materiali HP-metaofiolitici dall'Italia di NW verso la Francia, la Germania, Il Benelux, la Gran Bretagna ecc. fino a 1000-1500 km dalle aree di provenienza. La conoscenza petrografica non ancora sistematica delle lame d'ascia modellate in HP-metaofioliti in Europa, come pure nella penisola italiana, permette per ora solo un confronto preliminare con i meglio conosciuti manufatti nord-italiani.

KEY WORDS: *Polished stone implements, Greenstones, Eclogites, Jades*

GENERAL AND PETROGRAPHIC INTRODUCTION

The presentation of the subject necessarily starts from Northern Italy, where the great majority of polished stone tools from Neolithic times are represented by eclogites, Na-Px-jades and other high-pressure (HP) metaophiolitic lithologies (Table 1). Important, although less numerous artefacts of the same lithologies are also found, singularly or as hoards, frequently as ceremonial and ritual axes («Jade axes», «Prunkbeile», «Haches d'apparat») in France, Germany, Luxemburg, Belgium, the Netherlands, Great Britain, and less commonly or occasionally, in Scandinavia, Northern Germany, Czech Republic, Slovakia, Austria, Croatia and Southern Italy.

All these finds are attributed a NW- Italy provenance, exploited from geological occurrences in Liguria, Piedmont, Aosta Valley, marginally SW Lombardia and worked out by several ateliers in the same areas. The petrography of the prehistoric polished stones artefacts made of HP-metaophiolites is well known in Italy but less in other countries. This is the reason why this paper, devoted to the petrographic characterization of the HP-metaophiolites polished Neolithic stone implements has to consider mainly the Italian materials.

In the North-Italian context the Neolithic polished stone assemblages are dominated (up to 90% and more in single sites) by *eclogite-facies metaophiolitic lithologies* strictly connected with each other in terms of geological relationship and geographical provenance. They are mostly *alpine-type (HP-LT) eclogites, jades (Na-pyroxenites)* and, to a lesser extent, *serpentinites, omphacite-jadeite schists, glaucophane rocks, greenschists retromorphic from eclogites* and some minor lithologies. The list of references is wide; just mentioning the most significant: Bernabò Brea *et al.*, 2000; Chiari *et al.*, 1996; Compagnoni *et al.*, 1995; D'Amico, 1995, 1998, 2000, 2002; D'Amico and Ghedini, 1996; D'Amico and Starnini, 2000; D'Amico *et al.*, 1991, 1995, 1997, 1998a, 2000a, 2000b, 2002; Perrone *et al.*, 2002; Pessina and D'Amico, 1999; Ricq-de-Bouard and Fedele 1993, various papers in Venturino Gambari ed., 1996.

The comprehensive term of *HP-metaophiolites* is justified by the association of lithologies having a strong similarity to rocks of the Pennidic metaophiolitic masses outcropping in the Western Alps: metabasitic composition with ophiolitic precursors; some compatible magmatic relict structures; metamorphic equilibration under high pressure (HP) conditions (for references, Morten ed., 1993, Messiga, 1987, Compagnoni *et al.*, 1995, D'Amico *et al.* 1999, Perrone *et al.*, 2002, and citations therein).

Most rock terms (e.g. *eclogites, glaucophane rocks*, *serpentinites* and *paragonite schists*) are employed in this paper according to the common use and do not need any further specification. On the contrary, two terms need some explanation: *Jade* is used here as a synonym of *Na-pyroxenite;* and *Omphacite (-jadeite) schists* for lithologies chemically similar to eclogite, but lacking in garnet (see below).

The implement stones considered in this paper have all been examined in surface microscopy, about 90% with XR Diffraction, more than 60% in thin section, less than 10% sampled for chemical analysis as total rock in XRF and AAS, and less than 5% for minero-chemical analysis in SEM-EDS.

An overall picture of the presence and the relative frequency of the Neolithic polished stone in Northern Italy is expressed in Table 1, in the whole population and in single sites or areas. The data seem to be statistically well stabilized at this stage, thus being worthy of discussion and synthesis.

Eclogites are the dominant rocks, followed by *jades*, whereas the other lithologies are represented in minor or sporadic quantities.

This is not so obvious in relation to geology because, for example, jades are very rare and only occasionally described in geologic literature (e.g. Franchi, 1900; Novarese, 1903; Stella, 1903; Fornaseri and Bensa, 1939; Griffin and Mottana, 1982), whereas serpentinites and glaucophane schists are much more common. The inverse occurs among the polished tools. Based on this observation, not only *geological provenance but also cultural selection* cooperate to determine the quantity and distribution of polished stone tools.

The petrography of the HP-metaophiolites examined here is briefly considered below.

The provenance of raw materials is interpreted *as being derived from the Western Alps region* by all Authors cited above and by researches studying the Neolithic stone axes in Europe, that are lithologically similar (e.g., Bishop *et al.*, 1977; Campbell Smith, 1963, 1965, 1972; Cassen and Pétréquin, 1999; D'Amico *et al.*, 1998b; Goër de Herve *et al.*, 2002; Jacobs and Loehr, 1993; Jones *et al.*, 1977; Overwell, 1983; Pétréquin *et al.*, 1997, 1998a, 1998b, 2002, 2003; Ricq-de-Bouard, 1996; Ricq-de-Bouard *et al.*, 1990, 1996; Shut *et al.*, 1987; Surmely *et al.*, 2001; Surmely and Santallier, 2001; Wolley, 1983, Wolley *et al.*, 1979). The same raw material is frequently identified from secondary deposits, *in Liguria, Piedmont, Val d'Aosta and SW Lombardy* (D'Amico 2000, D'Amico and Starnini 2000; D'Amico *et al.*, 2000a, 2000b, 2003, Ricq-de-Bouard *et al.*, 1990, 1993).

The provenance interpretation from NW Italy dates back to the turn of the nineteenth and twentieth centuries (e.g. Mayer, 1882; Piolti, 1898, Franchi, 1900; Colomba, 1901; Novarese 1903). It is based on two independent but converging reasons:

1) archaeological/logistic reason: in NW Italy, 90% and more of the Neolithic implements are made of HP-metaophiolite lithologies, suggesting a nearby geological source. Moving far away from this region, the percentage of HP-metaophiolites occurring in stone tools assemblages gradually decreases and is mostly limited to symbols of prestige objects, according to a *down-the-line pattern of distribution*.

2) geological reason: the Italian watershed of the Western Alps (Fig. 1) is one of the very rare regions in the world and the only one in Europe in which HP-metaophiolites identical or similar to those of the Neolithic polished stones artefacts primarily outcrop (cfr. also Morten ed., 1993), whereas similar HP- metaophiolitic cobbles/pebbles in Oligocene conglomerates occur in the NW Apennines (e.g. Dalla Giovanna *et al.*, 1984; Federico *et al.*, 2002, Scambelluri, pers. comm.) and in all regional waterstreames.

TABLE 1

General lithology of Neolithic polished stone tools in Northern Italy, as total and in single sites.

Lithogical group	no. of samples	%	Range % of common occurrence in various sites	*Lithological Supergroup*
Eclogites	525	44.3 %	(20) 30 - 60	*HP metaophiolites*
Jades (Na-pyroxenites)	262	22.1 %	12 - 30	*HP metaophiolites*
Omph-Jd schists	47	4.0 %	0 - 6 (- 18)	*HP metaophiolites*
Glaucophane rocks	66	5.6 %	0 - 3 (- 23)	*HP metaophiolites*
Other HP metaophiolites	34	2.9 %	0 - 7	*HP metaophiolites*
Serpentinites	93	7.9 %	1 - 13 (- 35)	*HP metaophiolites*
Paragonite schists	6	0.5 %	0 - 3	*HP schists*
Other lithologies	151	12.7 %	0 - 12 (- 28)	*Various, local or imported*
Total	**1184**	**100.0%**	——	——

		HP – METAOPHIOLITES						OTHER LITHOLOGIES			
Sites/ areas	*No. Samples*	Eclog- ites. %	Omp. schists %	Jades %	Glauc. schi. %	Other M-oph %	Serpen- tinites %	Neph -rites %	Chl.- schists %	Parag. schists %	Other/ Local %
Alba	*115*	35.6	2.6	36.5	3.5	6.1	7.0	0.9	—	0.9	7.0
Bri F.	*34*	29.4	5.9	29.4	—	2.9	20.6 *	—	—	—	11.8
Rivan.	*182*	54.4	6.0	11.5	23.1	0.5	1.1	—	—	—	3.3
P. Gh.	*39*	35.9	20.5	15.4	2.6	2.6	20.5 *	—	—	—	2.6
Gaione	*261*	48.7	5.7	21.8	5.0	5.0	6.9 *	—	0.4	—	6.5
S. Laz.	*36*	63.9	5.6	13.9	2.8	—	5.6 *	—	—	—	8.3
Vho	*30*	36.7	—	40.0	—	—	13.4	—	3.3	3.3	3.3
Ost.	*44*	45.4	2.3	22.7	2.3	4.6	11.4	—	—	—	11.4
MN-BS	*47*	53.2	6.4	19.1	2.1	2.1	8.5	2.1	—	—	6.3
VR	*96*	60.4	—	19.8	—	—	6.3	—	—	—	13.5
Fimòn	*24*	58.3	—	25.0	8.3	4.2	4.2	—	—	—	
TN	*80*	20.0	2.5	16.2	1.3	—	32.5**	2.5	—	—	25.0
SAM	*291*	36.1	1.3	22.3	0.7	—	7.0***	0.7	2.7	1.4	27.8

Alba (D'Amico *et al.*, 2000a), *Brignano Frascata* (D'Amico *et al.*, 2000b), *Rivanazzano* (D'Amico *et al.*, 2003), *Ponte Ghiara* (Bernabò Brea *et al.*, 2000), *Gaione* (Bernabò Brea *et al.*, 1996; Andò, 1998), *S. Lazzaro di Savena* (Fabris, 1996)), *Vhò* (Starnini *et al.*, 2004 in press), *Ostiano* (D'Amico, 1995, Starnini *et al.*, 2004 in press), *MN-BS*, , Provinces Mantova and Brescia (Pitti, 2000, Starnini *et al.*, 2004 in press), *VR*, Province Verona (Lunardi, 2003), *Fimòn* (D'Amico and Lunardi, work in progress), *TN*, Trentino (D'Amico, work in progress), *SAM*, Sammardenchia (D'Amico *et al.* 1997).

* Probable Apennine total or partial provenance

** Many pebbles from Adige river, local/regional contribution

*** At least partial provenance from Easternmost Alps.

+ *VR*, only expeditious examinations. Others 13.5% are undefined green stones: probably some type of HP-metaophiolite.

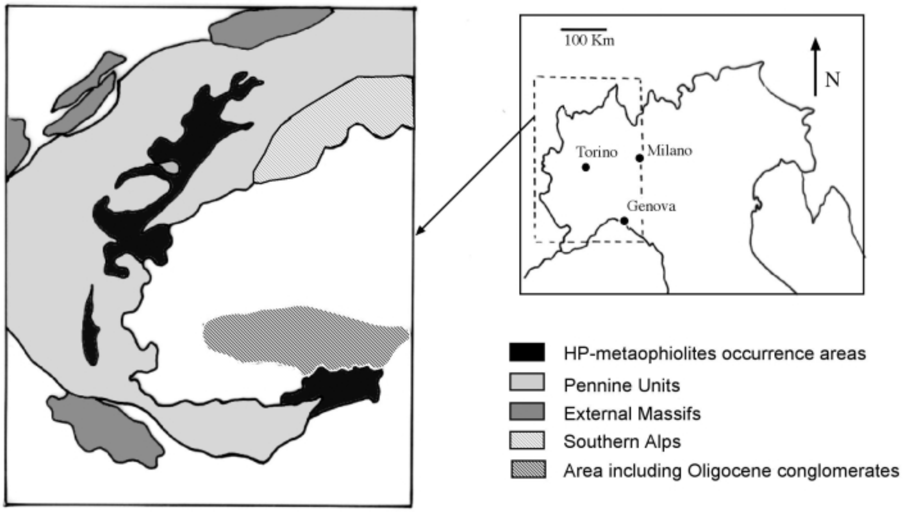

Fig. 1 – Schematic map of the HP-metaophiolitic masses in NW Italy

From a typological point of view, most of the Italian prehistoric implements are axe/adze blades, with a functional use, i.e. cutting/working wood, often being broken and worn-out; ritual or ceremonial axes are much rarer. Other less frequent artefacts are chisels and ring bracelets, whereas burnishers, polishers, rough-outs, reused instruments, pebbles and unidentifiable fragments are commonly present in the various assemblages in different proportions.

The dominance of eclogites and jades and other HP-metaophiolites, exploited for the production of axe blades, extends from NW Italy to the whole of Northern Italy. This lithic selection has a cultural significance, justified by i) *litho-technological reasons*, expressed by the best mix of hardness, toughness and density, searched for working wood and cutting the forest trees during the Neolithic period, and ii) *aesthetic choices*, based on the nice green colours and translucency. Both reasons probably justify the nearly general exclusion of other, elsewhere common, lithologies for manufacturing stone axe blades in Northern Italy.

Essential petrographic information on the North-Italian Neolithic stone implements

Eclogites and Omp-Jd schists

These two lithotypes were mostly used for manufacturing axe/adze blades of various sizes and chisels. Worn cutting-edge implements reused as hammer, pestles, burnishers or polishers are also present in some collections, and some rough-outs in production sites. Both rock types are omphacite-rich terms: the most common *eclogites* (Table 1) always contain garnets and /or secondary chlorite from garnets (± other mineral phases), whereas the less common *omphacite (-jadeite) schists* do not contain any garnet or secondary garnet-derived aggregates.

Eclogites display a broad compositional and textural range. Their mineralogical composition (semiquantitative estimates from XRD and thin sections) is characterized by:

– Na-pyroxenes, ranging from 40% to 90%, mostly 65-75%. Omphacite is the only or the dominant phase, minor jadeite and/or Fe-jadeite may be present (Fig. 2a). Late neoblastic omphacite needles may be present in strongly sheared samples.

– Garnets and/or derived retromorphic chlorites range from < 5% to 45%, usually 10-20%. They are commonly rich in inclusions and frequently atollar. Composition is relatively rich in Ca almandine (Fig. 2b) and with various content in Mn in some zoned individuals. Eclogites may be rarely very poor in garnet, grading towards jades.

– all other mineral phases are usually less than 10%: rutile and/or ilmenite and/or minor sphene are always present; frequent mostly secondary chlorite; zoisite and/or epidotes and/or paragonite not infrequently associated within the form of previous insets; infrequent secondary glaucophane, actinolite, albite, rarely analcite; quartz, phengite and chloritoid very sporadic; zircon and apatite variously present, more sporadic allanite, monazite and pyrite.

The bulk chemical composition (Table 2 and Fig. 5), is metabasitic, characterized by high values of Na_2O, and the presence of two or even three compositional lines based on different Mg/Fe ratio, thus defining three groups: Fe-eclogites, prevailing in quantity, Mg-eclogites and minor «intermediate» eclogites.

The chemical composition has a constant relation to the stone colour, the Fe-eclogite being dark to very dark green and Mg- eclogite medium-to-light green, with various shading. This corresponds with some different mineralogical features: coloured and pleochroic Na-Px and Chl, abundant ilmenite and apatite in Fe-eclogites vs. uncoloured Na-Px and Chl, lack of Ilm and scarcity of Ap in Mg-eclogites.

Eclogites are mostly fine-grained (<0.01–0.5 mm), seldom medium-grained (0.5 – >1 mm), usually heterogranular and variously affected by shear/flaser deformation of a previous blastic texture, of which some relics are common. Mylonitic, rarely pseudotachylitic, as well as blastic textures are singularly present. Garnets vary from tiny (<0.01 mm) to holoblastic (> 1 mm) size. No correlation seems to exist between shearing and retromorphosis, retromorphic phases being present in poorly deformed samples or lacking in strongly deformed ones.

Protolithic features are represented by a few basaltic ophitic ghosts, occasional metagabbroic textures and more common metaporphyritic textures. These latter are put in evidence by euedral to sheared whitish insets, composed of zoisite/epidotes, paragonite, Na-pyroxenes and sometimes albite, which could be interpreted as plagioclase phenocrysts. Similar textures have also been interpreted as derived from lawsonite laths (e.g. Messiga *et*

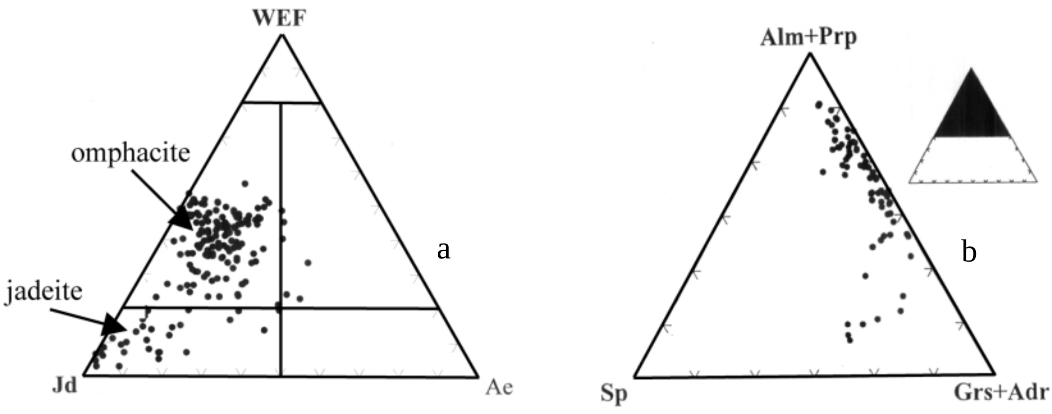

Fig. 2 – Eclogites: in Sammardenchia tools (D'Amico *et al.*, 1997). *2a* - Na-Px composition range, *2b* - Garnet composition range. Similar distribution in all other examined collections.

TABLE 2

Mean geochemical values of eclogites, omphacite schists and other HP- metaophiolites.

	Fe-eclogites	*Mg-eclogites*	*Intermed. eclogites*	*Omphacite schists*	*Jd- Gln-metabasalts*	*Glaucoph-ane schist*	*Green schists*
Samples, *n*	*32**	*21***	*6****	*9*****	*3 ^*	*1 ^*	*3 ^*
SiO_2 %	48.88 ± 4.29	49.81 ± 2.08	48.76 ± 1.37	48.38 ± 1.44	51.39 ± 0.53	47.64	52.25 ± 2.89
TiO_2	2.45 ± 0.92	1.28 ± 0.33	2.37 ± 1.09	1.24 ± 0.40	1.86 ± 0.31	1.83	1.22 ± 0.50
Al_2O_3	12.19 ± 1.55	13.77 ± 1.90	12.07 ± 1.41	15.27 ± 0.50	13.76 ± 0.56	15.14	14,45 ± 0.83
Fe_2O_3tot	15.05 ± 2.91	8.70 ± 1.31	12.94 ± 0.98	8.23 ± 1.12	10.55 ± 1.10	9.81	8.08 ± 1.57
MnO	0,29 ± 0.11	0.18 ± 0.08	0.28 ± 0.09	0.15 ± 0.02	0.13 ± 0.03	0.16	0.14 ± 0.02
MgO	4.68 ± 2.00	10.20 ± 2.06	8.18 ± 0.44	10.08 ± 2.53	5.54 ± 1.09	8.14	6.24 ± 3.00
CaO	7.06 ± 2.29	8.59 ± 1.10	9.23 ± 1.09	8.37 ± 0.94	7.44 ± 2.35	7.48	7.62 ± 1.57
Na_2O	7.41 ± 2.22	5.65 ± 1.00	5.42 ± 0.76	5.27 ± 1.08	4.96 ± 1.29	3.98	3.67 ± 0.57
K_2O	0.07 ± 0.08	0.09 ± 0.08	0.05 ± 0.03	0.12 ± 0.12	0.10 ± 0.09	0.36	0.32 ± 0,39
P_2O_5	0.82 ± 0.69	0.14 ± 0.15	0.08 ± 0.10	0.12 ± 0.08	0.22 ± 0.05	0.22	0.16 ± 0.03
LOI	1.32 ± 1.10	1.78 ± 0.85	1.16 ± 1.02	2.82 ± 0.87	4.03 ± 2.87	5.24	5.85 ± 3.12
V *ppm*	204 ± 206	218 ± 54	361 ± 198	207 ± 48	270 ± 36	277	202 ± 73
Cr	14 ± 16	237 ± 108	115 ± 108	266 ± 58	209 ± 56	285	192 ± 143
Ni	21 ± 20	113 ± 48	53 ± 23	143 ± 46	102 ± 18	113	84 ± 55
Zn	157 ± 195	59 ± 24	68 ± 31	65 ± 24	98 ± 7	101	90 ± 16
Y	107 ± 44	41 ± 23	78 ± 35	28 ± 8	32 ± 2	28	28 ± 6
Zr	356 ± 469	146 ± 121	291 ± 149	115 ± 51	166 ± 75	168	126 ± 12
Ce	57 ± 21	23 ± 14	43 ± 27	18 ± 9	20 ± 14	41	27 ± 19

* Alba (13), Sammardenchia (11), Brignano Frascata (3), Vhò (1), Mantova-Brescia provinces (3) S. Lazzaro (1).
** Alba (7), Sammardenchia (6), Brignano Frascata (2), Vhò (1), Ostiano (1), Mantova-Brescia provinces (3) S. Lazzaro (1).
*** Alba (5), Vhò (1).
**** Alba (2), Sammardenchia (1), Brignano Frascata (2), Mantova-Brescia provinces (2), S. Lazzaro (1).
^ Alba.
References D'Amico *et al.* (1997, 2000a, 2000b), D'Amico (1995), Viroli (1995), Fabris (1996), Pitti (2000).

al., 1993; Compagnoni *et al.*, 1995). Dusted cores, rather common in large omphacite crystals, have been interpreted (Compagnoni *et al.*, 1995, Perrone *et al.*, 2002) as due to rutile or sphene exsolutions indicating derivation from magmatic Ti-rich pyroxenes. Rarer augite relics or altered pyroxenic aggregates are interpretable as ghosts of igneous augite phenocrysts.

All the properties described above are characteristic of «Alpine» eclogites, such as the NW-Alps geological eclogites discussed for example by Messiga *et al.* (1993) and Mottana (1993). The only discrepancy is that metagabbroic textures are rather widespread in the geological bodies, but no more than 1% within the eclogites of the tools in Table 1.

Omphacite (-jadeite) schist is a conventional term introduced by D'Amico *et al.* (1997) to describe some heterogeneous lithologies, for which no name is at hand in geological literature, except for generic terms like «metagabbros» with local specification (e.g. Cortesogno and Haccard, 1984). They have a chemical composition similar to eclogites (Table 2), are rich in Na-pyroxenes like the eclogites (Omp ± Jd = 80-90%), but without garnet or pseudomorphic chlorite. Epidote, zoisite, chlorite, paragonite and albite are present in various proportions. Jadeite is not infrequently found together with omphacite.

Chemical analyses show a high Mg/Fe ratio (Table 2), although Fe-rich types cannot be excluded, as darker specimens have not been sampled yet for conservation reasons.

Jades (Na-pyroxenites)

Jade is used here a synonym of Na-pyroxenite, having Na-Px (jadeite, Fe-jadeite, Mg- and Fe-omphacite or a mix of them) as the most abundant phase. It corresponds only in part to the gemmological term «jade» (Webster R., 1983, Hurlbut and Kammerling, 1991), in which nephrite is also included. In archaeometry nephrite and Px-jade need to be distinguished, having different meanings in terms of provenance and regional use.

Similarly to eclogites, *Na-Px jades* have been mostly used for producing any type of cutting-edged tools, rarely for ornaments (D'Amico *et al.*, 2000a; Venturino Gambari ed., 1996), occurring also in the assemblages as reused implements in the form of burnishers, polishers and hammer stones, or as pebbles.

Jades contain more than 90% Na-Px (range 85-99%). The very wide range of solid solutions in the Na-Px mineralogical system is shown in Fig. 3, in which the main compositional terms *Jadeite*, *Fe-jadeite*, *Omphacite* (*Mg*- and *Fe-Omphacite*) may be conventionally defined.

Other minerals are Ti-minerals, nearly always present as *rutile* and/or *sphene*, and/or *ilmenite*; not infrequently p*aragonite*, very occasionally *phengite; quartz* in sporadic quartz-jades. Among secondary minerals, a*lbite* and *analcite*, usually as submicroscopic dusted aggregates detectable through XRD, are relatively frequent within jadeitites, whereas *chlorite*, *glaucophane* or *actinolite*, *zoisite/epidotes* are sporadic. *Zircon* is often abundant as an accessory mineral, *apatite*, *allanite*, *monazite* and *pyrite* are more occasional.

The classification of jades (D'Amico *et al.* 1995, 1998a,b, 2000a, D'Amico and Starnini, 2001) is based on XRD patterns (Fig. 4) and their chemical composition (Table 3). Three essential subgroups are distinguished: *Jadeitites*, *Omphacitites* and *Mixed Jades.* Each of them may include cases of different Mg/Fe ratios, making it possible to define Mg- and Fe-rich terms, in such a way that a complex system of *six subgroups* of Na-Px solid solutions, shading into each another, may be conventionally classified. The terms found in previous Authors are *jadeitite*, of general use, less commonly *omphacitite* or *Na-pyroxenites* (e.g. Ricq-de-Bouard *et al.*, 1990; Cabella *et al.*, 1995, Compagnoni *et al.*, 1995; Chiari *et al.*, 1996; Perrone *et al.*, 2002; Thirault, 2001a, b, c; Thirault *et al.*, 1999; Venturino Gambari ed. , 1996).

Jadeitites, Fe-jadeitites and Omphacitites contain jadeite, Fe-jadeite and omphacite respectively as the only or prevalent (conventionally > 90%) Na-Pyroxene.

Jadeitite, a term of common use in archaeological literature (also erroneously *jadeite*), indicates bright green, translucent and strongly polished jade axes (e.g. Campbell

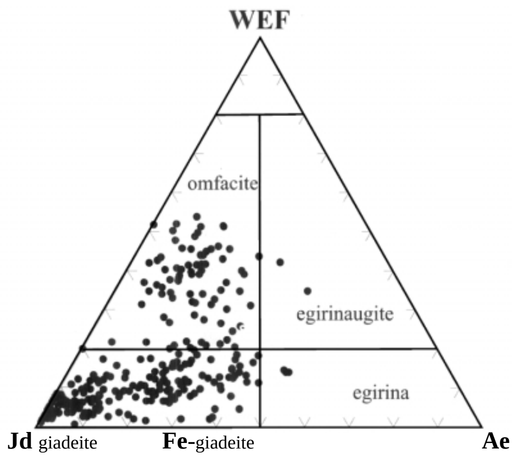

Fig. 3 – Na-Px composition range in Sammardenchia jades (D'Amico *et al.*, 1997). Similar distribution in all other examined collections.

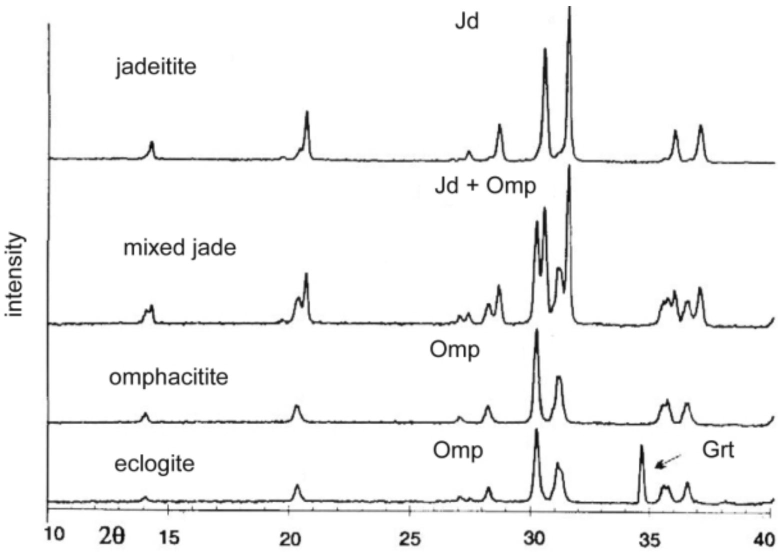

Fig. 4 – XRD pattern for defining the principal solid solutions in the Na-Px jade system.

Smith, 1963, Cassen and Pétréquin, 1999, Jacobs and Loehr, 1993, Pétréquin *et al.*1998 a, 1998b, 2002, 2003; Venturino Gambari, 1996; Wolley *et al.*, 1979, etc.). It may actually include not only true jadeitites, but some other bright green Mg-jades too, all having uncoloured Na-Px in thin section. *Quartz-jadeitites* are very rare and seem rather similar to parts of Jd-Qtz-bearing metaplagiogranites from Monviso (Castelli *et al.*, 2002).

The term *Fe-jadeitite* did not exist in the jade-axes literature before the definition given by D'Amico *et al.* (1997). It is now widely documented (Table 3). In few cases jadeite and Fe-jadeite may coexist and shade into each other. Fe-jadeitites can be distinguished on the basis of their dark to medium-dark green colour, of slightly coloured Na-Px in thin section and chemical characters (Table 3).

Omphacitites, easily distinguishable from jadeitites by means of XRD patterns (Fig. 4), may have a wide range of Al/Fe and Mg/Fe ratio (cfr. Fig. 3), so that *Mg-* and *Fe-omphacitites* can be distinguished, although shading into each other. They can be distinguished by the bright and dark colour respectively, Na-Px colour in thin section and their chemistry (Table 3).

Px-mixed jades contain both jadeite/Fe-jadeite and omphacite/Fe-omphacite in various proportions (each >10%), shading both towards jadeitites or less commonly towards omphacitites. They can be easily distinguished through XRD (Fig. 4). This term was proposed by D'Amico and Ghedini (1996). Several of the so called omphacitites in literature, or simply Na-pyroxenites (Perrone *et al.*, 2002) as well as some jadeitites, should actually be included in this group. *Fe-rich and Mg-rich associations* are present as in the previous groups, distinguishable by chemical analysis, the colour of the stone and of the minerals in thin section.

The old term *Chloromelanite,* used in the past in prehistoric literature for describing dark (Fe-rich) jades and sometimes also eclogites, is no longer used.

The classification of the six jade groups (*Jadeitites, Fe-jadeitites, Omphacitites, Fe-Omphacitites, Mg-mixed Jades, Fe-mixed Jades*) seems more precise in describing the Neolithic jade axe blades raw materials, than the use of only two terms (Jadeitite

TABLE 3

Mean geochemical values of jades, divided into eight subgroups

Mean values % and ppm, standard deviation (±) and number of analysed samples are indicated

Subgroups → **Elements ↓**	*Qtz-jadeitites*	*Qtz- Fe-jadeitite*	*Jadeitites*	*Fe-jadeitites*	*Mixed jades*	*Fe-mixed jades*	*Omphacitites*	*Fe-ompha - citites*
Samples	3 *	1*	16**	15 ***	12 +	7 ++	5 ^	2 ^^
SiO_2%	66.62 ± 2.70	61.17	58.37 ± 1.04	55.99 ± 1.12	56.76 ± 1.12	54.82 ± 2.06	54.63 ± 0.53	54.86 (2)
TiO_2	0.51 ± 0.26	0.86	0.61 ± 0.34	1.07 ± 0.26	0.69 ± 0.39	1.50 ± 0.66	0.93 ± 0.58	1.18
Al_2O_3	16.37 ± 0.40	16.16	19.34 ± 1.05	15.69 ± 1.37	15.19 ± 1.63	13.88 ± 1.51	10.10 ± 1.83	14.30
Fe_2O_3tot	1.84 ± 0.80	6.83	2.61 ± 0.87	9.13 ± 1.88	5.03 ± 1.76	9.38 ± 2.30	7.84 ± 0.96	13.09
MnO	0.04 ± 0.01	0.05	0.06 ± 0.02	0.16 ± 0.03	0.11 ± 0.03	019 ± 0.04	0.13 ± 0.03	0.15
MgO	1.95 ± 1.12	1.63	2.74 ± 1.09	2.16 ± 1.16	5.35 ± 1.79	3.42 ± 0.78	8.29 ± 1.62	1.96
CaO	1.61 ± 0.75	2.38	2.79 ± 0.86	3.19 ± 0.94	5.88 ± 1.71	5.58 ± 1.91	9.96 ± 1.40	5.92
Na_2O	10.06 ± 0.22	10.72	11.90 ± 1.48	11.45 ± 0.70	9.79 ± 1.23	9.54 ± 0.74	6.89 ± 0.95	6.47
K_2O	0.08 ± 0.05	0.02	0.24 ± 0.50	0.07 ± 0.07	0.08 ± 0.09	0.05 ± 0.03	0.13 ± 0.14	0.07
P_2O_5	0.42 ± 0.33	0.19	0.22 ± 0.26	0.32 ± 0.21	0.29 ± 0.85	0.77 ± 0.69	0.09 ± 0.18	0.85
LOI	0.63 ± 0.19	0.18	1.19 ± 0.67	0.83 ± 0.57	0.89 ± 0.62	1.03 ± 0.53	1.21 ± 0.60	1.17
V *ppm*	25 ± 25	37	25 ± 16	31 ± 25	51 ± 48	91 ± 71	152 ± 84	65 (1)
Cr	11 ± 9	8	15 ± 13	18 ± 14	60 ± 74	13 ± 8	203 ± 267	17
Ni	49 ± 25	16	41 ± 32	37 ± 48	69 ± 64	25 ± 18	147 ± 174	15
Zn	5 ± 5	13	25 ± 37	93 ± 50	52 ± 36	61 ± 19	46 ± 17	41
Y	142 ± 23	116	85 ± 40	72 ± 27	74 ± 37	100 ± 46	31 ± 22	54
Zr	793 ± 661	1507	735 ± 467	1045 ± 779	326 ± 390	902 ± 548	546 ± 703	1706
Ce	148 ± 37	70	207 ± 288	482 ± 631	372 ± 549	55 ± 24&	33 ± 23	71

* Alba.
** Alba (5), Sammardenchia (6), Brignano Frascata (3), Vhò (1), Ostiano (1).
*** Alba (5), Sammardenchia (7), S. Lazzaro (1), Vhò (1), Ostiano (1).
\+ Alba (4), Brignano Frascata (2), Sammardenchia (5), Vhò (1).
\++ Alba (4), Vhò (2) Brignano Frascata (1)..
^ Alba (3), Sammardenchia (1), Brignano Frascata (1).
^^ Ostiano (1), S. Lazzaro (1).
& n=6; excluded a sample having value Ce = 6587
References D'Amico *et al.* (1997, 2000a, 2000b), D'Amico (1995), Viroli (1995), Fabris (1996).

and Omphacitite), and is clearly supported by chemical differences (Table 3). All different jades subgroups have very high Na_2O content.

The textures of the jades cover a wide range of cases. *Jadeitites* have a very common (about 2/3 of the samples) granoblastic texture, the remaining 1/3 being strongly sheared or mylonitic, sometimes shown by dark, thin mylonitic stripes. On the contrary all other jades are commonly and variously *deformed*, more than 3/4 of them being sheared/flasered/mylonitic and less than 1/4 granoblastic or moderately deformed. This feature is common to eclogites.

In many jades of all type, dusted cores within larger individuals, are more common than in eclogites and should be interpreted in the same way as ghost relics. Very thin veinlets of Na-pyroxenes, and some rare Na-Px needles crossing the sheared textures suggest, as in eclogites, HP conditions during and after deformation.

Some relations between eclogites and jades

Table 4 shows a schematic summary of eclogites + jades *(E+J)* occurrences in comparison to all other lithologies and eclogites/eclogite+jades ratios *(E/E+J)* in a number of Neolithic Italian sites, including omphacite schists among eclogites.

In general, the dominance of eclogites and jades over any other rocks is evident (usually > 50% up to over 80%). The case of Trentino is biased, because of sampling in favour of serpentinite objects; by taking into account only axe blades and chisels the eclogites + jades dominance is similar to the other cases. The prevalence of eclogites over jades is also clear, E/E+J grading from 50% to 80%.

The petrological relations between jades and eclogites are rather complex (Fig. 5), and need to be examined elsewhere. Both lithologies participate in series different in Mg/Fe ratios.

TABLE 4

(E + J) % and E/E+J ratio of Eclogites and Jades within HP-metaophiolites artefacts in various Italian sites.

(References as Table 1)

Site	*Age*	*E + J %**	*E/E+J***
Alba (CN)	Early – Middle Neolithic	72.1 %	49.4
Brignano Frascata (AL)	Early Neolithic	58.8 %	50.0
Rivanazzano (PV)	Neolithic	65.9 %	82.5
Ponte Ghiara (PR)	Initial Middle Neolithic	53.9 %	71.4
Gaione (PR)	Middle Neolithic	72.5 %	67.9
San Lazzaro di Savena (BO)	Neolithic	77.8 %	82.1
Vhò (CR)	Early Neolithic	64.7 %	64.0
Ostiano (CR)	Early and Middle Neolithic	65.2 %	64.3
Mantova-Brescia Provinces	Early Neolithic to Bronze Age	70.8 %	82.6
Verona province	Neolithic to Bronze Age	80.2 %	75.3
Fimòn (VI)	Neolithic	83.3 %	70.0
Trentino	Neolithic to Bronze Age	37.5 %	53.3
Sammardenchia (UD)	Early and Middle Neolithic	58.4 %	61.8

* *E + J %* = Sum of Eclogites and Jades as % of all lithologies.
** *E/(E+J)* x 100.

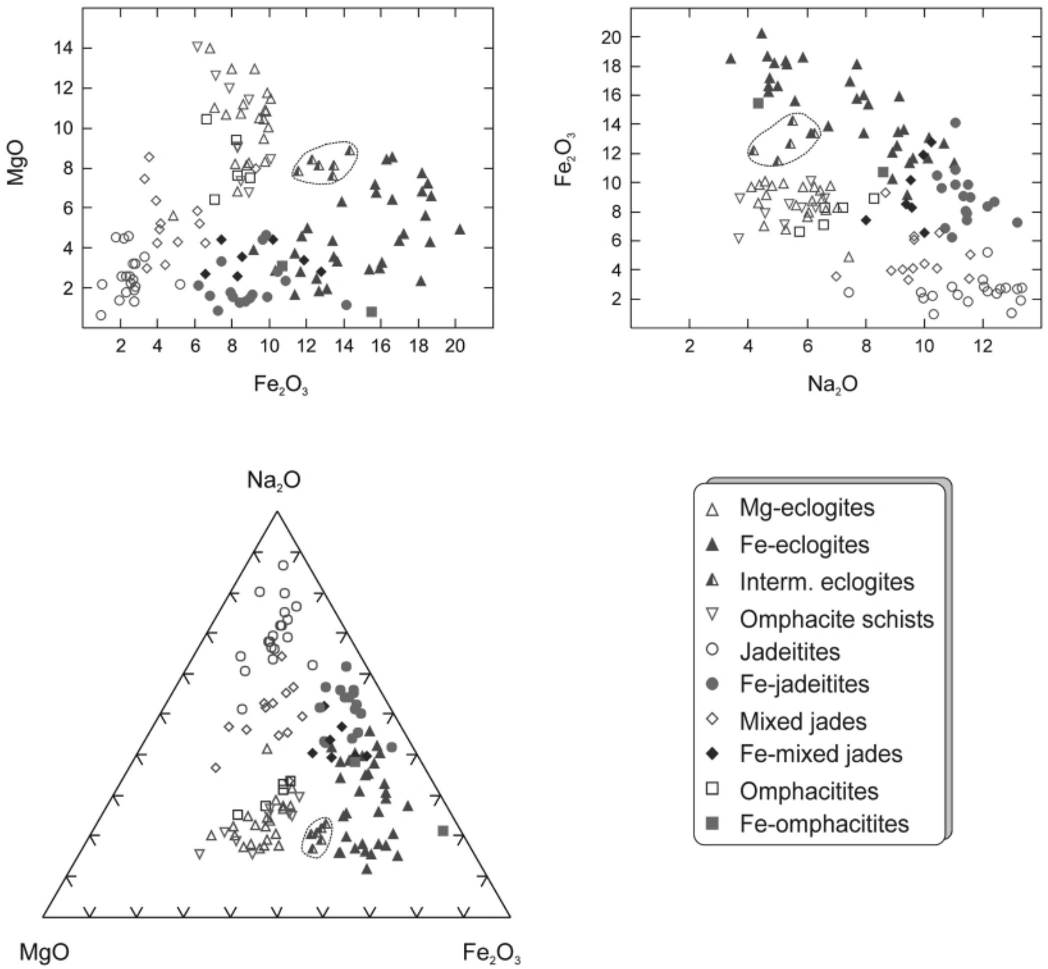

Fig. 5 – Some petrochemical relations between and within eclogites and jades. The three diagrams separates the samples into two supergroups with some overlapping; the minor group of intermediate eclogites in contoured. Omphacite schists fall in the Mg-eclogites fields. Jadeitites unclude also Qtz-jadeitites. The jadeitite with low Na_2O (<8%) is the sole phengite-bearing jadeitite found (Brignano Frascata, K_2O = 2.10%).

Other lithologies in Northern Italy implements

Serpentinites are present in all collections, but usually they are less than 10% in average (Table 1 and 2). They have been exploited more for ornaments or other working implements rather than for cutting-edged tools.

Many of them are characterized by mineral relics of diopside, tremolitic amphiboles and forsterite (rare) and occasionally by chlorite. Serpentinites interpreted as deriving from the Western Alps and serpentinites from different provenances, such as the South Tyrol and Eastern Alps (D'Amico *et al.*, 1997; Pessina and D'Amico, 1999; D'Amico and Starnini, 2000, D'Amico, 2002) and possibly the Apennines (Andò, 1998; Bernabò Brea *et al.*, 2000) have been recognized. The attribution of single serpentinite samples to a definite source is often uncertain.

The use of serpentinite for making artefacts strongly increased (up to 50% of finds) during the Chalcolithic period, for the production of hammer axes in the North-easternmost part of Italy and in Slovenia (D'Amico *et al.*, 2001, Montagnari Kokelj, 2001). These serpentinites usually contain many relics. Their sources are probably located in the Easternmost Alps or Dinarides.

Glaucophane(-crossite) rocks are poorly represented, except for the axe-workshop of Rivanazzano (PV) (Minale, 1997-98; D'Amico and Starnini, 2001; D'Amico *et al.*, 2003), where more than 20% of the finds (all rough-outs at different stages of manufacture) are made from this lithology. In the other collections (Table 1) glaucophane rocks are absent or present in low quantities as chisels, axes, undefined tool fragments and pebbles. This suggests that glaucophane rocks were tentatively exploited (e.g. in Rivanazzano) but mostly discarded for the manufacture of Neolithic instruments throughout Northern Italy. A different situation exists in Southern France around Marseille-Avignon (Ricq-de-Bouard *et al.*, 1990; Ricq-de-Bouard, 1996), where glaucophane lithologies have been widely used.

Glaucophane (and/or crossite) rocks are highly diversified in texture and mineralogical composition. They range from a few *glaucophanites* (*Glf* ca. 70-80 %) to various *glaucophane schists* (glaucophane around 50%): a few *omphacite-glaucophane schists* (omphacite as relics); rather abundant g*arnet-rich glaucophane rocks; lawsonite-glaucophane schists* (with relics of magmatic augite); e*pidote-rich glaucophane schists; a few fine-grained glaucophane metabasalts*; one *glaucophane-zoisite-tremolite schist;* some *glaucophanic green schists* (D'Amico *et al.*, 2003).

Green schists are present only a few sites, used for axes/adzes and chisels.

They are characterized by an ultrafine grained matrix, defined by means of XRD analysis as an association of *chlorite, actinolite, albite* and *epidote*, containing a few optically detectable microblastic nests of the same minerals. Other sporadic components are *omphacite* or *augite* as relics, very small *garnets*, occasional *glaucophane*, s*phene, ores, paragonite, pyrite and* rarely *quartz*. The texture is usually strongly sheared, sometimes crenulated and microfolded, and indicates a mylonitic nature of these rocks and an incomplete low-grade metamorphism.

Normal crystalline greenschists (prasinites) seem to be practically absent from the Neolithic stone tools.

Other less used lithologies are:

Epidote-albite zoisitite, one occurrence (D'Amico *et al.*, 1997) as a fragmented axe.

Chlorite-schists and –felses, felty and very pure, used for ring bracelets (D'Amico *et al.*, 1997), and *albite chlorite-schists* (Starnini *et al.*, 2004, in press). Their sources are not yet known.

Paragonite schist (about 100% paragonite) used for ring bracelets, are found in many places (D'Amico *et al.*, 1997, 2000a; Venturino Gambari ed., 1996). This particular lithology was probably exploited from the Piedmont HP-metamorphic areas, possibly the «zona Sesia-Lanzo» (Traversone, 1996).

Nephrite (nearly 100% tremolite) as fine-grained to felty schists with occasional diablastic tremolite, are occasionally present as axes. They are clearly different in mineralogy and texture from the nephrites described by Kalkowsky (1906) in Liguria and cannot have this origin. The only sporadic presence of nephrite implements suggests a possible importation from Switzerland, Grisons, where both nephrite outcrops and its local use for neolithic tools are well documented (Giess, 1994; Mutschlechner, 1948).

Actinolite-hornblende schists, with Amph>>Ab, Ep, ores etc., in the shape of shoe-last adzes of danubian typology, are sporadic finds (border zone of Trento and Friuli, D'Amico *et al.*, 1991, 1997), and testify, according to their morphology and petrography, occasional exchange with transalpine cultures.

Many ***other lithologies***, usually occurring in small quantity, have nothing to share with the HP-metaophiolites: *cinerites, andesite-dacites, porphyries, basalts, gabbros, granites, limestones, sandstones, silexites, vitric tuffs, cherts, spotted slates*. Most of them have been used for non cutting-edged tools, such as burnishers, polishers, pestles, or occur as pebbles or unidentifiable tools fragments. Only a few of them have been used for axe blades or axe/adzes rough-outs (e.g. Pessina & D'Amico, 1999) or ornaments or ring-bracelet roughs-outs (Fabris, 1995-96; D'Amico *et al.*, 2001; D'Amico *et al.*, 2003).

A short mention of *lithologies used for manufacturing prehistoric polished stone artefacts during the Copper Age* in *Northern Italy*, which are completely different in typology (i.e. shaft holed hammer-axes and rectangular axe blades) and petrography from the Neolithic tradition, may be given. Two areas are known. One is the Bologna area, where nearly all implements are made of magmatic rocks (mostly *dolerite-diabases* with minor *basalts, gabbros and microgabbros*) having some imprint of oceanic metamorphism (D'Amico *et al.*, 2000b), typical of the Apenninic LT- LP-ophiolite suite. In the N-Easternmost part of Italy and Slovenjia (D'Amico *et al.*, 1996a, 2001; Montagnari Kokelj, 2001), hammer-axes and rectangular axe-blades are manufactured from *serpentinites* (nearly. 50%), Px-Ol-Amph-Chl-*metaultramafites, amphybolites and heterogeneous volcanics* (each ca. 14%), and gabbros (ca. 10%). Similar ratios were observed in the Chalcolithic Lubljiana collection (work in progress).

HP-METAOPHIOLITES IN OTHER PARTS OF EUROPE

Moving farther away from Northern Italy (except South-eastern France), polished cutting-edged instruments worked from Italian HP-metaophiolites gradually become less frequent and less used as functional tools. Axe blades increasingly assume a non-functional use as ritual, symbolic and prestige objects, often reaching a very high aesthetic value like the so called «*Jade axes*», «*Haches d'apparat*» and «*Prunkbeile*» in Great Britain, France and Germany, which are characterized by unusual large dimensions, often coupled with extremely thin sections and a very accurate mirror-like polishing.

The rest of Italy

In Central, Southern and Insular Italy the situation is not yet clear because of the lack of petrographic studies. In general, the use of HP-metaophiolites for the manufacture of polished artefacts became, in theses areas, less common or absent. Table 5 groups all up-to-date information, based on literature or just expeditious examinations (surface microscopy and partly XRD) except for some materials from Sardinia, analyzed by Bertorino *et al.* (2002). The data in Table 5 should be considered with some caution in terms of statistical representation, being unsystematic.

In Central Italy, single well preserved artefacts made of HP-metaophiolites are found in Tuscany.

Eclogites have been found in one of the examined collections and a few jade axes from Northern Tuscany are present in the collection of the Mineralogical Museum of Bologna University (Campana *et al.*, 1996).

Among the axe blades and chisels belonging to the «Bellucci» collection in Umbria (D'Amico & De Angelis, work in progress) HP-metaophiolites of NW-Italian provenance are rather abundant. However, unlike the collections examined in chapters 1 and 2, which are currently representative of single sites, the ancient (19th to 20th century) Bellucci collection is surely a selective gathering of axe blades from a large area, mostly out of context. The dominance of HP-metaophiolites is evident, if compared to other lithologies which are present in the

TABLE 5

Distribution of HP-metaophiolites and other lithologies of the polished stone from Central and Southern Italy.

Lihology	**Tuscany** *	**Umbria** **	**Lazio** ***	**S. Italy Museums &LD**	**S. Italy Museums &O'H**	**W-Sicily &&**	***W* -*SARDINIA* +**	**N -Sardinia ++**
Eclogites	7	32	2	2	—		—	1
Jades	2	27	2	9	7	-	—-	9
Nephrites	—	—	1	2	—	1	16	8 ?
Serpentinites	5	1	—	5		4	—	—
Other Metam.	—	—	—	18	8	-	1	6
Volc/Plutonic	—	3	28	7	123	68	2	10
Sedimentary	5	3	14	4	77	4	3	—

* D'Amico and Tozzi,unpubl. Site La Queciolaia (Livorno). Campana et al., 1996.
** D'Amico De Angelis and Ghedini, unpubl., from Collezione Bellucci.
*** D'Amico, Fugazzola and Ghedini, unpubl., site La Marmotta
&LD Southern Italy implements from English and Italian Museums, Leighton&Dixon, 1992; Leighton, 1992
&O'H From Southern-Italian Museums, O'Hare, 1990. Numerous uncertainties in interpretation. +27 unidentified
&& Leighton&Dixon, 1989
+ Bertorino et al, 2002, W- central Sardinia, and D'Amico and Tozzi, unpubl., Contragudas.
One metamorphite is a blue schist.
++ Lovisato, 1886. Some doubtful interpretation of lithological descriptions. Eclogites and jades seem correctly described.

neighbouring areas, such the volcanites from the nearby Roman quaternary K-rich lavas. The E/E+J ratio is similar to that of Northern Italy, only a little richer in jades. Nearly all the Umbrian artefacts examined are complete and several of them are perfectly polished, thus suggesting a prevalent use for prestige/ritual/cultural purposes, but no true «ceremonial axe» is present. It cannot be excluded, however, that the representativeness of the collection is low, because at that time only complete artefacts with a high aesthetic value were appreciated and collected.

A similar situation is probably represented in Abruzzo, according to a first insight into the old collections in the Perugia deposits of the local Soprintendenza Archeologica. This does not seem to be the case of Latium, where some information can be given only from one site, albeit very important (Marmotta, Early Neolithic, north of Rome), where HP-metaophiolites are really very scarce and consisting, at present, of only two axes (D'Amico & Fugazzola, work in progress).

In Southern Italy and Sicily (grouped in Table 5 under Museum collections – a few come from Sicily) the proportion of HP-metaophiolites seems very scanty and it is limited to objects for prestige/ritual purpose (Leighton, 1989, 1992; Leighton and Dixon, 1992; O'Hare, 1990). The sporadic HP-metaophiolites are nearly all jades, suggesting a selection of jades with respect to eclogites. This selection could be linked with the great distance from Northern Italy.

In Northern Sardinia, a number of HP-metaophiolites outside any context have been known since the 19th century (Lovisato, 1886), but not studied since then. These old descriptions seem accurate and, as the Sicilian and Southern Italy collections, they indicate a strong selection of jades *versus* eclogites.

In conclusion, an important circulation of HP-metaophiolites, mostly for non-functional artefacts, seems to have occurred in the Italian Peninsula and major Islands, in particular towards the Central Apennines. The importation of HP-metaophiolites becomes gradually poorer, according to the well-known down-the-line distribution model, in parallel with a strong preference for jades in comparison to eclogites.

Table 5 shows that nephrite objects are not absent, although rare, in Central-Southern Italy. The high quantity of nephrite objects in Sardinia is worth of note, representing a unique case in Italy. A zone with dominant presence of *nephrite* axe blades in central-western Sardinia was discovered (Bertorino *et al.*, 2002) and similar stones were found in another area of north-western Sardinia (D'Amico and Tozzi,work in progress). The petrography of the Sardinia nephrite artefacts seems rather different from the few Northern Italian ones, because they contain chlorite and epidotes as important components associated with Ca-amphiboles, and are more crystalline in some parts. The source of nephrite is still unknown.

The special case of South-eastern France

Provence may be considered a continuation of the North-Italian region, its polished stone distribution pattern being about the same as in Piedmont and Liguria (Ricq-de-Bouard *et al.*, 1990; Ricq-de-Bouard and Fedele 1993; Ricq-de-Bouard, 1996). This sort of unique Neolithic macroregion regarding the manufacture and use of polished stone implements tends to partly extend to the Rhône-Alps region, thus involving the whole of South-eastern France (Thirault *et al.*, 1999; Thirault, 2001a, b, c).

The petrographic terminology used by Ricq-de-Bouard and the other French Authors is greatly simplified if compared to the classification used in the present paper. Only the terms *eclogite* and *jadeitite*, secondarily *omphacitite*, are used, evidently including all the other rocks distinguished in the present paper. Probably the bright green jadeitites include a few bright-green omphacitites and mixed jades previously distinguished, whereas some dark Fe-omphacitites, Fe-jadeitites and Fe-mixed jades have been possibly included with eclogites. On this basis it is hard to make accurate or detailed comparisons, or to give precise re-attributions, according to the nomenclature used here, for many artefacts. In spite of this uncertainty, the Southern France polished stone tool association may be surely considered, on the whole, similar to the NW Italian one, in terms of petrography and provenance from Liguria – Piedmont, as pointed out also by Ricq-de-Bouard and co-workers.

Glaucophane lithologies in Neolithic tools, particularly abundant in the region of Marseille, have a Southern France source (Durance, Queyras, haute Ubaye) and probably nothing to do with the few glaucophane lithologies observed in Italian artefacts.

The studies cited above clearly demonstrate that moving further from Provence and Rhône-Alps towards western and northern France, the percentage of HP-metaophiolites strongly decreases, according once more to the usual down-the-line pattern.

HP-metaophiolites from Italy to Europe. Summing up the data

The presence of axe blades made of HP-metaophiolite lithologies is well known in many parts of Europe: *in France* –excluding Provence and Rhône-Alps regions (e.g. Cassen and Pétréquin, 1999; Cogne and Giot, 1952; Giot, 1965; Goër de Herve and Surmely, 2000; Goër *et al.*, 2002; Le Roux, 1979, 2002; Le Roux and Cordier, 1974; Pétréquin *et al.*, 1998 a, b, 2002, 2003; Surmely *et al.*, 2001; Surmely et Santallier, 2001; Surmely et Goër de Herve, 2002); *in Great Britain* (e.g. Bishop *et al.*, 1977; Campbell Smith, 1963, 1965, 1972; Coles *et al.*, 1974; Curtis, 1997; Jones *et al.*, 1977; Wolley, 1983, Wolley *et al.*, 1979); *in Germany* and *Luxemburg* (e.g. D'Amico *et al.*, 1998b, 2003 in press; Jacobs and Loehr, 1993, 2003; Le Brun Recalens, 1997; Schwarz-Meckesen and Schneider, 1986; Virchow, 1881); *in Denmark* (Klassen, 1999) *in the*

Netherlands (Overwell, 1983; Shut *et al.*, 1987), *in the Czech Rep.* (Schmidt and Štelcl, 1971), *in Slovakia* (Hovorka *et al.*, 1998; Spišiak *et al.*, 2001), *in Croatia* (Petrič, 1995, Burič, 2000).

Unfortunately several of these artefacts have been defined simply on the basis of a nacked eye exam, or merely by expeditious observations such as surface microscopic examination and density measurements, whereas only a small part of them have been subjected to XRD or thin section analyses. Recently, non-destructive, spectro-radiometric analyses have been performed (Errera, 1999; Pétréquin *et al.*, 2002) on artefacts from HP-metaophiolites and other rocks, but a comparison between the results obtained from this method and the standard petrographic ones has not yet been completely undertaken.

We hope that a petrographic comparison between Italian and European HP-metaophiolites axes will be planned for the future. However, in some papers by the British, French, Dutch, Czech and Slovak Authors cited above, thin section and/or XRD determinations and other data are reported. Moreover, some unpublished data have been obtained by one of the Authors (C. D'A.) for Rhineland, Luxemburg, Saar, Lorraine and Northern France, working in collaboration with some German and French colleagues. An interim first introduction to this theme may therefore be made in the present paper, on the basis of some references, direct observations and expeditious determinations.

Table 6 displays a very schematic picture of the essential knowledge about eclogites and jades, expressed in terms of simple numbers of artefacts in different collections, and their ratio E/E+J, whereas the other lithologies have been grouped into a single class named «others» (see discussion at point 1, below) because of the lack of good descriptions. In spite of these limits, the data in Table 6 merit some preliminary discussion and explanation.

1 – The proportions between HP-metaophiolites, expressed as Eclogites + Jades (E+J), and the other lithologies used for manufacturing implements can be deduced only in Auvergne, Charente-Maritime and Great Britain. In the other columns of Table 6 only selected data of (E+J) axe blades are reported but not their proportion in respect to all different lithologies exploited in the various regions. However, each regional (E+J) presence is presumably of a similar proportion as in Great Britain (2%), Charente-Maritime (2,5 %) and Auvergne (17%) or even less. For example, a stronger divergence is recorded in D'Amico *et al.* (1998, page 163) in a German site, where 4 «jades» in respect of 541 other lithologies (less than 1%) were counted. An evident difference from the Northern Italy situation in Table 4 (>50% up to 80%).

In the class «others», very few and sporadic glaucophane rocks, some greenschists and a number of serpentinites should be mentioned. Potentially, these lithologies could also derive from the NW-Italian HP-metaophiolites, together with the E+J pair, but they could have different provenances too.

2 – The definition of jades or eclogites from the literature in Table 6 can be considered exhaustive in several cases, but doubtful in many others, when thin sections and XRD determinations or minerotextural evidences are lacking. In this respect, numerical data need some caution in interpretation. Doubts can arise from the following points.

– European eclogites have been defined as such by the present Authors in Table 6 only in cases where garnets were named in the bibliographic source or detected in thin section or by XRD determinations. The possibility exists that some retromorphosed eclogites have been classified as greenschists or *«roches verts»* (included in «others» in Table 7).

– It cannot be excluded that a few tools classified as jades, having no clear definition in the literature data or arising from expeditious determination, can actually be eclogites, bearing very small, not detectable garnets or having a complete or advanced garnet chloritization.

– Some European jades and some not perfectly defined greenschists or *«roches verts»*

TABLE 6

Schematic picture of some European collections of axes-blades made of HP-metaophiolites in comparison to the general North- Italian distribution.

(See text for discussion)

Areas	*No. tools*	*Eclogites*	*Jades*	*Other lithologies*	*E/E+J ratio*
Northern Italy	*1275*	*583*	*281*	*411*	*67.5 (49.4–82.6)*
France: W-Alps-Rhone	182	60	47	75	56.1
France : Auvergne	873	107	42	724	71.8
France : Charente-Marit.	320	6	2	312	75.0
France : Charente	40	3	3	34	50.0
France : Lorraine	17	8	9	—	47.1
Germany : Saar	14	9	3	2	75.0
Luxemburg	77	42	31	4	57.5
Germany: Trier	40	15	21	4	41.7
Germany: Bonn	7	3	4	—	42.9
Germany: Mainz-Gonsenheim	6	—	6	—	0
France: St. Germ. en Laye	64	19	39	6	32.8
The Netherland	29	7	15	7	31.8
Great Britain	5994	16	96	5882	14.3
Czech Rep. , Slovakia	11	—	11	— *	0
Croatia	16	—?	16?	—	0?

Northern Italy – see tables 1 and 4.

W Alps – Rhone – Thirault, 2001. Objects tabulated; the total number of eclogites" (eclogites +dark or medium-dark jades) is 491 (p. 112). – Thirault *et al.*, 1999 have similar data, except for a higher number of "Others" implements , many of which are not axes.

Auvergne – Surmely *et al.*, 2001. Some thin section directly examined by one Author (C.D'A.)

Charente-Maritime and **Charente –** Surmely and Santallier, 2001 and pers. comm..

Saar, Lorraine –D'Amico *et al.*, 2003 in press.

Mainz-Gonsenheim – Jacobs and Loehr, 2003.

Luxemburg, Trier, Bonn – D'Amico *et al.*, 1998, 2003 + unpubl.

St. Germaine en Lay, Museum – expeditious determinations by C D'A., collab. Pétréquin and Errera.

The Netherland – Overweel, 1983; Shut *et al.*, 1987.

Great Britain – HP-metaophiolites: Campbell Smith, 1963, 1965, 1972; Coles at al., 1974; Jones *et al.*, 1977; Curtis, 1997; for the evaluation of total tools and "others": Pitts, 1996.

Czech Republic, Slovakia – Schmidt & Štelcl, 1971; Hovorka *et al.*, 1998.

* Spisiak *et al.* (2001) and Hovorka *et al.*(2001), report axe blades made in eclogites different from the Alpine eclogites. They derive from the Bohemian Variscan basement, and are HT- coarse-to-middle grain, symplectitic eclogites having a partial or strong amphybolite facies metamorphic imprint over a previous HT-HP eclogite metamorphism.

Croatia – Petrič 1995. No clear petrographic attribution. Probably all jades.

could possibly actually be omphacite schists or greenschists retromorphosed from eclogites.

– Therefore, the presence of a few more eclogites, perhaps a few less jades and a little higher E+J sum, as well as the presence of a few omphacite schists cannot be excluded, at the present stage, with respect to the picture of Table 6. However, these variations could hardly affect more than 10% of the case. At present the simplified data and ratios in Table 6 can be considered sufficiently correct and reliable for some interim considerations in paragraph 3.4 below.

A short synthesis about HP-metaophiolites in Europe.

With the cautions pointed out above, the E/E+J data of the European collections (Table 6) can be confronted with the Northern Italian ones (Table 4) and briefly discussed, taking into account, for a correct consideration, the variable importance of the collections of Table 6 for the number of finds examined.

The W-Alps-Rhône, Auvergne, Saar and Luxemburg collections have similar (E/E+J) range, that is prevalence of eclogites over jades, as in Northern Italy, and Lorraine an E/E+J ratio about 1/1. Two of these, from Auvergne and the Luxemburg, are large collections, statistically highly representative for their E/E+JO ratio.

Moreover, in the Auvergne (Surmely *et al.*, 2001), Charentes (Surmely et Santallier, 2002), Dordogne (Surmely, ined., pers. comm., about 192 axe blades), Lorraine and Saar (D’Amico *et al.*, 2003 in press) collections, a high number of eclogite and jade axe blades of various size are broken or worn-out, suggesting a functional use rather than, or complementary to, a symbolic/ritual/ceremonial one. This characteristic makes these collections similar to the Italian ones.

On the contrary, the Luxemburg collection, although bearing more eclogites than jades (Table 6), consists only of complete, unworn and well polished blades and includes some ceremonial axes, clearly interpretable as prestige/ritual/symbolic objects (see cover photo of vol. 17, 1995, of Bull. Soc. Préhist. Luxemb. and D’Amico *et al.*, 1998b). Similar features are shown by the collections of the Museums in Trier and Bonn, although they differ from the Italian collections by containing more jades than eclogites. The small but eminent collection of Mainz-Gosenheim ceremonial axes from a deposit (Jacobs and Loehr, 2003) represents a strong selection of jade (mostly probable jadeitites) in that territory.

The presence of a very small number of generic jade axes is mentioned in Northern Germany (Schwarz-Mackesen and Schneider, 1986) and one big ceremonial axe interpreted here as made of mixed jade in Salzderhelden (Heinrichs, 2003).

In Great Britain (Bishop *et al.*, 1977; Campbell Smith, 1963, 1965, 1972; Coles at al., 1974; Curtis, 1997; Jones *et al.*, 1977; Wolley, 1983, Wolley *et al.*, 1979) and at the Museum of St. Germain-en-Laye (approximately representing NW France, both Bassin Parisien and Bretagne, C.D’A., unpubl. data), the E/E+J ratio is completely different. It must, however, be pointed out that the sampling from the St. Germain-en- Laye Museum was mostly applied to ceremonial axe blades and not stochastically to all the polished stone axes/adzes, thus possibly bearing some bias. The stone blades in the British collections (Table 6) mostly consists of ceremonial axes and unused pieces.

In the N-French and British collections, jades strongly prevail over eclogites, in parallel with the abundance of ceremonial axes having long, thin, elegant morphology and perfect polishing. Eclogites seem to be more frequent among the shorter and thicker axe blades. Morpho-typology, varieties and cultural significance of the ceremonial axes have long been discussed and described by the French and English Authors, in particular by Pétréquin and collaborators.

In the Netherlands (Overweel, 1983, Schut *et al.*, 1987), the prevalence of jades and low (E/E+J) value similar to N France and Great Britain corresponds to common shorter and thicker blades, in the absence of long and thin ceremonial axes.

The few jade axe blades found and studied in the Czech Republic and Slovakia are exhaustively presented by Schmidt and Štelcl (1971) and Hovorka *et al.*, (1998). They are all jades, mostly jadeitites and have the morphotypological and petrographic characteristics of typical Italian axes. Since Neolithic stones are widely studied at present in these countries, these axe-blades probably represent most if not all the jade tools found there. A few jade axes found in Lower Austria, all fragmented (Prichystal and Trnka, 2001) and some ceremonial, completely polished ones (V. Hammer, pers. comm., 1999) are similar. Possibly the same pattern can be presumed for the Croatian axes, whose petrographic attribution is not so sure, because no detailed archaeometric studies on these lithologies are available at present.

Some consideration about the circulation of prehistoric axe blades from petrographic data

Some preliminary conclusions can be attempted on the basis of the albeit unsatisfactory data reported above, while waiting for more systematic petrographic studies, which hopefully make it possible to propose more critical and reliable conclusion on the circulation pattern of the European axe blades.

1 – The high number and variety of axe blades in Western Europe suggests a strategic/industrial importation of Italian artefacts or raw materials, the articulation of which is rather problematic and will be shortly considered below (point 3). On the contrary, the jade axes of Austria, the Czech Republic, Slovakia, Croatia and probably north-central Germany seem to indicate just occasional, and non- strategic imports, which are interpretable as exchanges and/or gifts, surely manufactured in Italy.

2 – The *general trend of an increase in jades implement with respect to eclogites,* gradually moving away from the sources is a clear *cultural selection* already noticed in Italy. In Europe this trend is more emphasized (Table 6) and jades strongly increase with respect to eclogites, both in the presence of a rich production of ceremonial jades and in its absence. An apparently connected change during the Neolithic times is considered by Pétréquin *et al.* (2002, Fig. 7): from dominant eclogite axes to dominant jadeitite and lastly serpentinite axe blades.

3 – The exploitation strategy of axe blades within a radius of 200-500 km from their sources in Piedmont-Liguria, from SE-France, to Auvergne, Lorraine and Saar, seems mostly pivoted upon importation of Italian artefacts and their use more for functional than for ritual/ceremonial objects. It may be defined as an *Italian model:* typically, abundance of eclogites (high to intermediate E/E+J ratio, Table 6), common use of eclogite and jade axes for functional purposes (worn axes), relative scarcity of long axes used for social symbols of excellence.

At a distance of about 600/700 to >1000 km at N and NW, in N-France, the Netherland and Great Britain (§ 3.4, Table 7) jades apparently become prevalent over eclogites. Although great caution is necessary at this stage of research, due to our non-systematic petrographic knowledge, two different trends seem recognizable. In the Netherland the prevalence of jades (low E/E+J) does not correspond to a diffusion of ceremonial thin and long axe blades, but of short and thick axes. In N- France and Great Britain the prevalence of jades corresponds to a great development of the thin and long, beautiful, completely polished, ceremonial axes, so largely discussed by Pétréquin *et al.* (1998b). Clearly, the importation strategy is here prevalently oriented towards obtaining ritual/prestige objects of exotic materials, possibly made more precious by their long-distance provenance and therefore even aesthetically more selected (more jades than eclogites).

At a distance of 500-600/700 km Northward, in Luxemburg, Trier and Bonn the collections represent a somewhat intermediate case: variable E/E+J ratios (both E>J and E<J), practically no functional use(no worn axe blades), presence of both short/thick axe blades and thin/long, carefully polished, beautiful ceremonial axes.

If the clues outlined here, are tested and proved by further petrographic and archaeological studies on axe blades in Europe, the following circulation picture could be suggested.

– Importation of Italian manufactured axe blades along a line (or a belt) SE France – Rhine-Mosel regions to the Netherlands. At short distance (about < 500 km) the Italian axes have also been used for functional use, at longer distance they were probably mostly devoted to non-functional purposes. A similar, although more sporadic circulation model seems valid for Central-Eastern Europe.

– Prevalent importation of Italian raw materials (mostly jades) to N and NW France and Great Britain for manufacturing them according to non-Italian traditions and typological styles, nearly exclusively for ceremonial, *«socialement valorisés»* (Pétréquin *et al.*, 1998b, 2002) axes.

– Probably the two trends are not exclusive in many places and typically they tend to mix in the Rhine-Mosel regions (W-Germany and Luxemburg), where, moreover, some noteworthy diversities between French and German ceremonial axes have been noted (Jacobs, pers. comm.).

4 – Many problems remain open and any conclusion should be considered premature, due to the still insufficient petroarchaeometric studies on stone axes.

For instance, there is an apparent discrepancy between the preliminary data reported here and the Geneva - Le Havre line (Pétréquin *et al.*, 2002, Fig. 4; however already defined by previous Authors) dividing areas with prevalent *«éclogite vert foncé»* to the west, and with prevalent *«jadèitite verdâtre saccharöide»* to the east. The petrographic data presented here suggest instead a different conclusion, because eclogites are certainly not scarce to the east (e.g. Trier, Bonn, Luxemburg) and jadeitites very abundant to the west (Table 7). Further data will clarify this point.

Another example of problematic interpretation may be the case of one Luxemburg axe (L61 Steinsel; D'Amico *et al.*, 1998), having a typical aspect of bright jadeitite, but a density too low (3.04) to be such a lithology. Thin section and XRD exam performed on a too-tiny sample shows a complex rock made of tremolite, zoisite and albite with some relics of omphacite. Apart from the provisional definition given (retromorphic omphacitite), the important point is that a similar lithology is not yet known within the Italian HP-metaophiolites, except possibly and doubtfully in some rare, albeit darker, tools at Gaione (Andò, 1998). The possibility of examining more rocks of this type (for example a similar, not sampled, implement in the Lorraine collection of Table 7), and of having more material available for chemical and minerochemical examinations, could clarify whether a provenance other than Italy could be rationally and critically proposed for these and other cases.

5 – A major problem regards the finest ceremonial axes, which are absent or absolutely rare in Italy and instead relatively abundant in NW-Europe. They are beautiful objects, of elegant, long and thin shapes, always completely polished, mostly bright in colour and translucent, generally defined *jadeitites.* Most of them are surely true jadeitites, but a minor presence of bright Mg-mixed jades or -omphacitites, of middle-dark to dark Fe-rich jades (example in the cover of vol. 17, 1995, of Bull. Soc. Préhist. Luxemb.), as well as of a few garnet-poor Mg-eclogites cannot be excluded without further petrographic studies.

Current knowledge suggests that their raw material very likely came from Italian sources. However similar objects are lacking in Italy, where only sporadic highly polished axe-blades of a different morphology are present. It is thus necessary to presume importation from Italy of raw materials in form of blocks to NW Europe and the manufacture of different forms, according to local, proper traditions and cultural choices for social distinction, as suggested in some cases (Thirault, 2001; Pétréquin *et al.*, 2003, Jacobs, pers, comm.), or a special manufacture in Italy of axes or rough-outs appointed for exportation.

No further contribution may be given here to this problem. It has been widely and very well considered by Pétréquin and collaborators, who provide important information about axes morphology, varieties and distribution. Further research seems necessary for the examination of axes petrography and linking the archaeometric data to the archaeological and logistic context.

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