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State of knowledges of the petrography and the diffusion ways of the metamorphic alpine rocks used for the axe blades during the Neolithic in the Rhône basin and the Western Alps.

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Abstract. We present here some new results obtained by laboratory analyses as well as archaeological examinations on the neolithic polished stone axeheads of the Western Alps and the Rhône basin (France, Italie and Switzerland). The main result is the demonstration that the eclogite alpine facies are exploited and diffused strongly in the whole Rhône basin, as it has been demonstrated for the South-East of France and the North Italy. The archaeological work authorize to explain this fact in terms of exchanges networks, progressively constructed through the Western Alps during the Neolithic, with an apogee situated after 4500-4200 B.C. calib., whem the system of production includes the whole Alps, piedmontese as well as french.

Key-words: axeheads, Neolithic, Western Alps, petrography, diffusion

The knowledges on the materials in tenacious rocks used by the Neolithics (from 5500 et 2300 B.C. calib circa) in the french Alps and the Rhône valley have strongly increased during the last five years, thanks to a close collaboration between a prehistorian (E.T.), a petrographers specialised in the metamorphic rocks (Danielle Santallier, University Lyon I, France) and a crystallograph (Ruben Véra, University Lyon I). This contribution aims to present the new knowledges yet established about the stone polished axeheads, which have been fine studied, from the archaeological (Thirault, 2001[1]; Thirault, to publish) and the petroanalytical point of view (Thirault and al., 1999). We'll expound especially the problems of rock caracterization, by a presentation of the history of the researches on the alpine rocks, then our own results on the rocks analyses. After this, we'll explain briefly some significant archaeological results based on this analyses.

1. Problematic and history of the former researches

1.1 Introduction

The analyses of the rocks used by the prehistoric communities are guided by three main goals : characterize the raw materials, try to discover their origin and define the prehistoric criteria of choice. This questions are as old as the prehistoric science, and are organized in two further observation scales:

– ponctual analysis on one precise archaeological site, aimed to define the territorial lithic supplies on the place;

– main enquiries led on a various scale, from a small area to a broad region, which try to characterize on a global way the whole rocks used, to define the productions, and then to localize the supply sources and value the respective importance of wich production.

1.2 Brief history of the alpine researches

In the western Alps, the pioneer works of Franchi on the Alba (Piedmont, Italy; Franchi, 1900) and the Barcelonnette (Alpes de Haute-Provence, France Ricq-de Bouard et al., 1996) collections, and the G. Piolti analyses on the Vaie (Piedmont) artefacts (Bagolini and Biagi, 1977) have established first the importance of the eclogite rocks for the Neolithics. After this, during several decades, for lack of interest, the words "green stone/roche verte/pietra verde", "ophiolite/ofiolite" and "serpentinite" have been considered as synonyms and have been used to refer to the raw materials of the stone axeheads and the bracelets. This confusion is due to a missknowledge of the geological progresses during the 20th century, and the expression "green stone" becamed for the archaeologists a synonym for "stone of green colour" (cf. for a more precised presentation, Ricq-de Bouard et al., 1990; Santallier et al., 1998; Thirault et al., 1999). Moreover, in the South-East of France, the presence of numerous pebbles of green coloured stones in the Durance deposits and the use of some of them for the axeheads (yet identified as pebbles of glaucophanites (Ricq-de Bouard et al., 1990), has led to adopt the imprecise term of "durancian rock" ("roche durancienne").

During the seventies, some enquiries have pointed the complexity hidden by this vague words. We know three examples of them. The laboratory analysis of the stone axeheads discovered on the excavation carried on the Charavines/Les Baigneurs dwelling site (Isère, France) as demonstrated that the rocks (piedmontese ophiolites)

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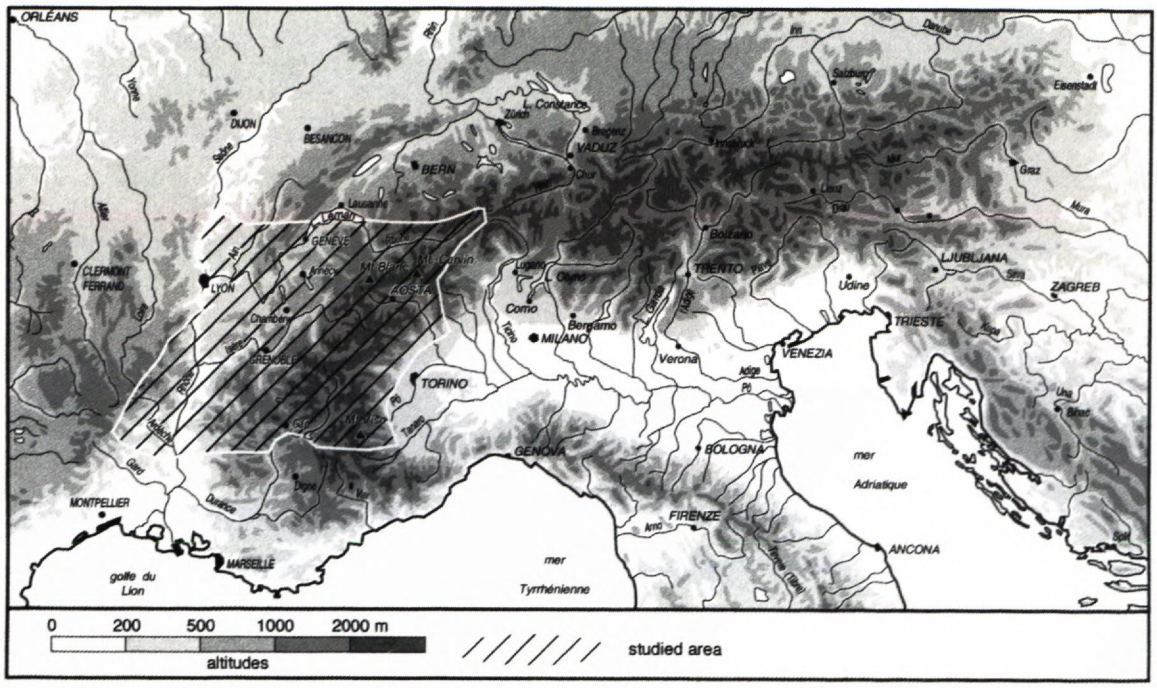

Fig. 1. The area concerned by our study.

came from the italian Alps (Bocquet, 1984). A. Masson, in a petrological study on thin sections (unpublished) about collections coming from the Forez (Loire department, France), as defined several rock groups. One of them (group n° 3) gather exogen alpine rocks (in the geological way), called by the author jadeitites and eclogites (Masson, 1977). C. Buret, in her unpublished thesis on the polished artefacts of the Auvernier excavations (Neuchâtel Lake, Switzerland), has underlined the fact that several metamorphic rocks were used, reflecting the regional morainic composition (Buret, 1983; Buret and Ricq-de Bouard, 1982).

On the same time, M. Ricq-de Bouard began her analyses on the south-eastern french series, and demonstrated quickly the reality of long-distance circulations from Liguria to Provence (Ricq-de Bouard, 1981). The progressive integration of the whole collections of the stone axeheads known in Provence and Languedoc, based on new studies at the alpine metamorphism, led this author to propose a diffusionist model (Ricq-de Bouard et al., 1990), in which the high pression/low temperature (HP/LT) metamorphic facies where mainly used. Among this rocks, the eclogites facies are preferred, coming from Liguria and/or the internal Alps. The still-known exploitation of the durancian pebbles, especially the glaucophanitic ones, has been confirmed but this appears as a regional phenomenon, linked to the western Provence and the low Rhône and Durance valleys.

In the northern part of Italy, the Ricq-de Bouard's researches have pointed the necessity of studying the regional artefacts, so new petrological investigations started under her impulse. The fundamental importance of the alpine rocks (in a geological way) of HP/LT appears clearly now, in Piedmont and Liguria (Ricq-de Bouard and Fedele, 1993; Compagnoni et al., 1995) as well as in the whole northern Italy (D'Amico et al., 1995, 1998; Venturino Gambari dir., 1996).

2. Recent works in the Rhône valley and the french Alps

In the middle Rhône Basin and the french Alps (fig. 1), the lack of precise petrographical investigations, parallel to the real need of studies about the circulation ways of goods in the rhodanian Neolithic (Beeching, 1991), led us to organize an analytical programm to caracterize the tenacious rocks used for making polished tools (axeheads, hammers, ...), weapons (arrowheads), jewels (pearls, bracelets, ...) and other enigmatic objets (marbles, ...). We expound here only the results concerning the stone axeheads. This research took part in a larger programm called "*Circulations et identités culturelles alpines á la fin de la Préhistoire*" ("Circulations and alpine cultural identities at the end of Prehistory"), coordinated by A. Beeching and financed by the Région Rhône-Alpes and the Centre National de la Recherche Scientifique (Beeching dir., 1999).

The study has been organized in three analytical scales:

– on the neolithic sites scale, a complete laboratory investigation of the artefacts coming from A. Marguet's recent propections and excavations on about ten lakeshore sites on the Annecy and Léman lakes (Marguet, 1995).

– on a regional scale, a selection of axeheads coming from well excavated sites and stray finds, choosen to cover, as well as possible, the whole regional Neolithic.

– on the western Alps scale, we've examined ourselves, during our archaeological work on the axe blades, all the objets studied, with a binocular or with naked eye (Thirault, 2001). We've estimated the fiability of this method at a rate of circa 90 %.

At last, nearly 150 axeheads and tools associated (hammers, roughouts, flakes, ...) have been determinated in laboratory, by thin section (petrography) after sampling, or by X-Ray (cf. Thirault et al., 1999, for a more detailed presentation), and nearly 2500 objets have been studied by us. The rate of laboratory analysis seems low, but we've estimated that it is a good sample of the productions. Nevertheless, extensive laboratory inquiries aren't realisable yet, due to the cost of each of them, and it seems to us that a good preliminary knowledge of the rocks used authorizes to realise a first classification and then a sampling for the laboratory. After the first laboratory determinations, we've done another sampling considering the results obtained and the new questions posed.

3. Petrographical and mineralogical laboratory results

The whole laboratory analytical results and their commentary have been recently published (Thirault et al., 1999). For this reason, we only present here the main results on a synthetical way, as we've exploited them as an archaeologist. For the polished axe blades, we introduce the rock families in their numerical importance order.

3.1 Eclogites

Under this word, we join three lithotypes clearly distinguished on the petrographical and mineralogical point of view, but which can be closely associated in the alpine metamorphic series. They are linked to the alpine high pression/low temperature (HP/LT) metamorphism, and are not or poorly retromorphosed. There are the eclogites sensu stricto, with the typical association of a sodic pyroxen and a garnet; the pyroxenic rocks type omphacite; and few cases of pyroxenites type jadeite with some garnets. This rocks are broadly identified in the ophiolitic series of the Western Alps and the Liguria (Droop et al., 1990). We don't go further in the question of the precise geographical provenances of this rocks, still debated by other authors (Ricq-de Bouard et al., 1990; D'Amico et al., 1995).

3.2 Jadeitites

We call jadeitites acid rocks metamorphized under HP/LT conditions, where the mineral jadeite is the only identified. Such pure rocks are uncommon at the alpine outcrops and can be associated with the metabasic series of the eclogitic and glaucophanitic facies (Ricq-de Bouard et al., 1990).

3.3 Glaucophanites

Well identified by M. Ricq-de Bouard, the alpine matabasites of HP/LT composed mainly by the blue amphibole glaucophane come from the eclogitic facies retromorphose. They are common in the ophiolitic alpine outcrops, but are less known in the archaeological series. The glaucophanites identified by D. Santallier in thin sections have another origin : they can be localized in the cristalline external massifs of the french Alps.

3.4 Ultrabasites

Two mineralogical types have been identified: the rocks mainly composed by antigorite, one of the two minerals of the serpentinites, and the rocks mainly composed of chloritites. The chlorite is sometimes also recognized in the serpentinites, so we can consider that the chloritites are a pure facies inside the serpentinites series. The serpentinites outcrops are numerous and ubiquist in the internal Western Alps, in the "*schistes lustrés*" zone, so the origin of the archaeological objets can't be established on a petrographical basis.

3.5 Epi- and mesozonal metabasites

We name here a list of various metamorphic rocks associated at the archaeological point of view. There are, for the low metamorphic facies, amphibolites and/or prasinites, and metadolerites. The more metamorphized facies are some hornblende amphibolites, amphibolo-pyroxenites and eclogites retromorphosed under medium pression/medium temperature conditions, i.e. non alpine facies. All this rocks can be alpine in the geographical way, or come from another metamorphic reliefs. Here, the archaeological analysis is the only way to discrimine their origin.

3.6 Various rocks

There are ubiquist rocks in the Alps or stranger to the alpine context : some cataclasites, fibrolites (sillimanites), vosgian metapelites, one cinerite from the Massif Central and some flints not coming from the South-East France formations (not analysed in thin sections). We can indicate too that a fibrous metamorphic rock, non identified yet, is common in the valesian stone axes.

4. The naked eye analyses and the map of the results

The laboratory analyses are a partial sample of the polished tools, because we've ourselves selected the objets to analyse after a first diagnosis to the naked eye. A notable exception is given by A. Marguet's excavations artefacts, which have been analysed *in extenso*. So it is necessary to integrate the whole laboratory results and the naked eye observations before a complete archaeological investigation. This have been done with the help of a spatial analysis of the whole petrographical results on our area of work (Fig. 1). The results are establish from all the archaeological series studies, coming from collections without chronological references as well as dated sites.

4.1 The eclogites supremacy

If the HP/LT metabasites are the most aboundant rocks in the polished axe blades, the alpine eclogites are

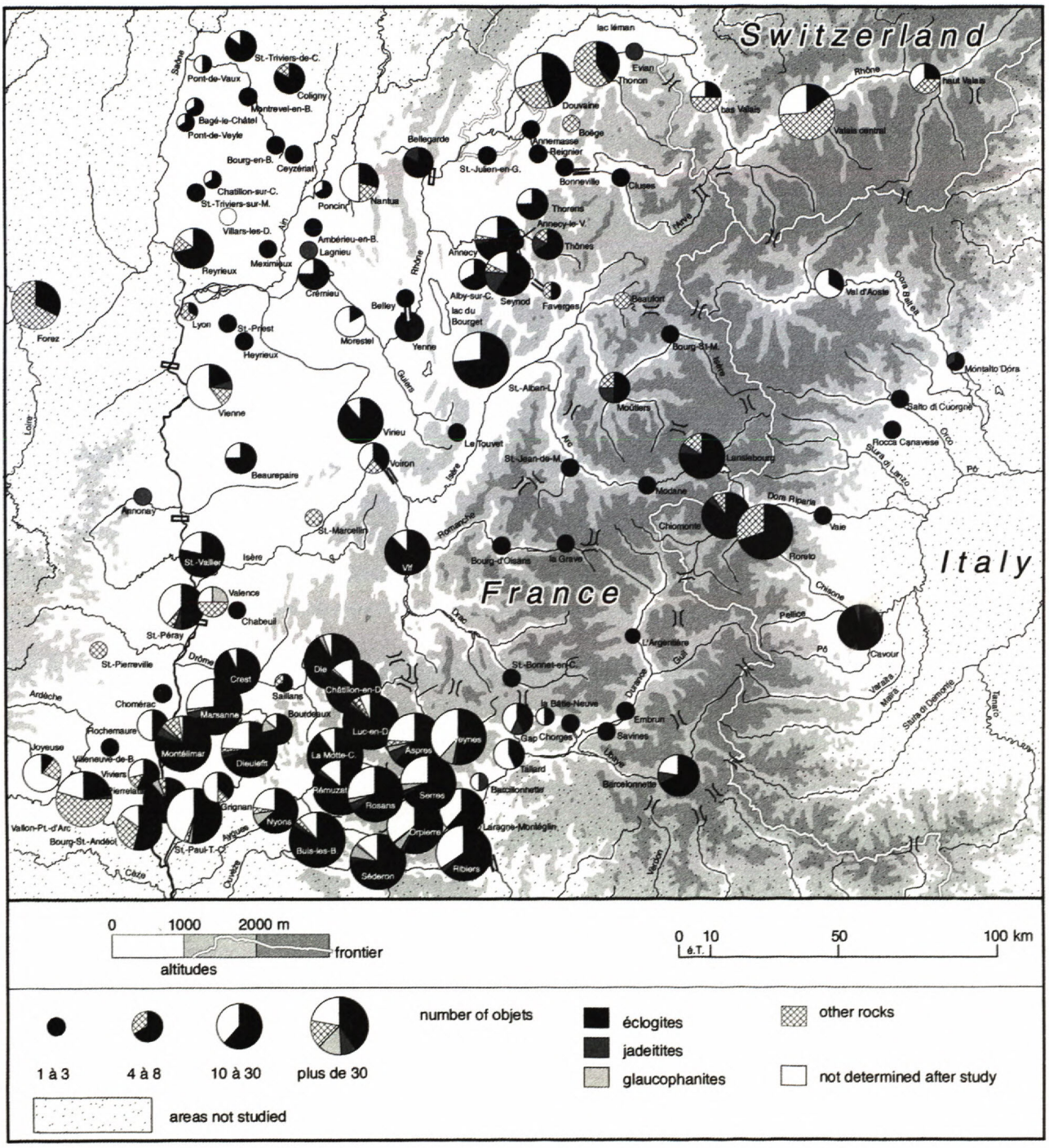

Fig. 2. Spatial distribution of the stone axeheads in HP/LT alpine metamorphic facies rocks (eclogites, jadeitites and glaucophanites). Each dot correspond to a district (in France), a geographical unity (Switzerland and Val d'Aoste) or a site (Piedmont).

dominant inside this rock group (Fig. 2). This report has still been established in Provence (Ricq-de Bouard et al., 1990) and in North Italy (D'amico et al., 1998). However, this supremacy isn't absolute, and variations can be recognized, linked to the source distance. In Piedmont (Venturino Gambari, 1996) and in the french intra-alpine valleys, the eclogites are nearly the only rocks used. This fact is linked to the exploitation of most of the alpine eclogite sources in the whole alpine dorsal. To the west, in the alpine forelands, the french Prealps and to the Rhône river, i.e. between 100 to 200 kms from the nearest stone sources, the eclogites remain dominant : the presence rate is never below 50 %, and is frequently above 75 %. Considering the spatial distribution, we propose to associate the jadeitites to the eclogites, at least for the diffusion, because there isn't any significant difference in their respective distributions.

So the eclogites and the jadeitites form the reference rock till 200 kms from their piedmontese outcrops. They remain aboundant far away, in the upper Loire valley (1/3 of the stone axe blades; Masson, 1977) and in the Ardeche Basin (Ricq-de Bouard et al., 1998). The eclo-

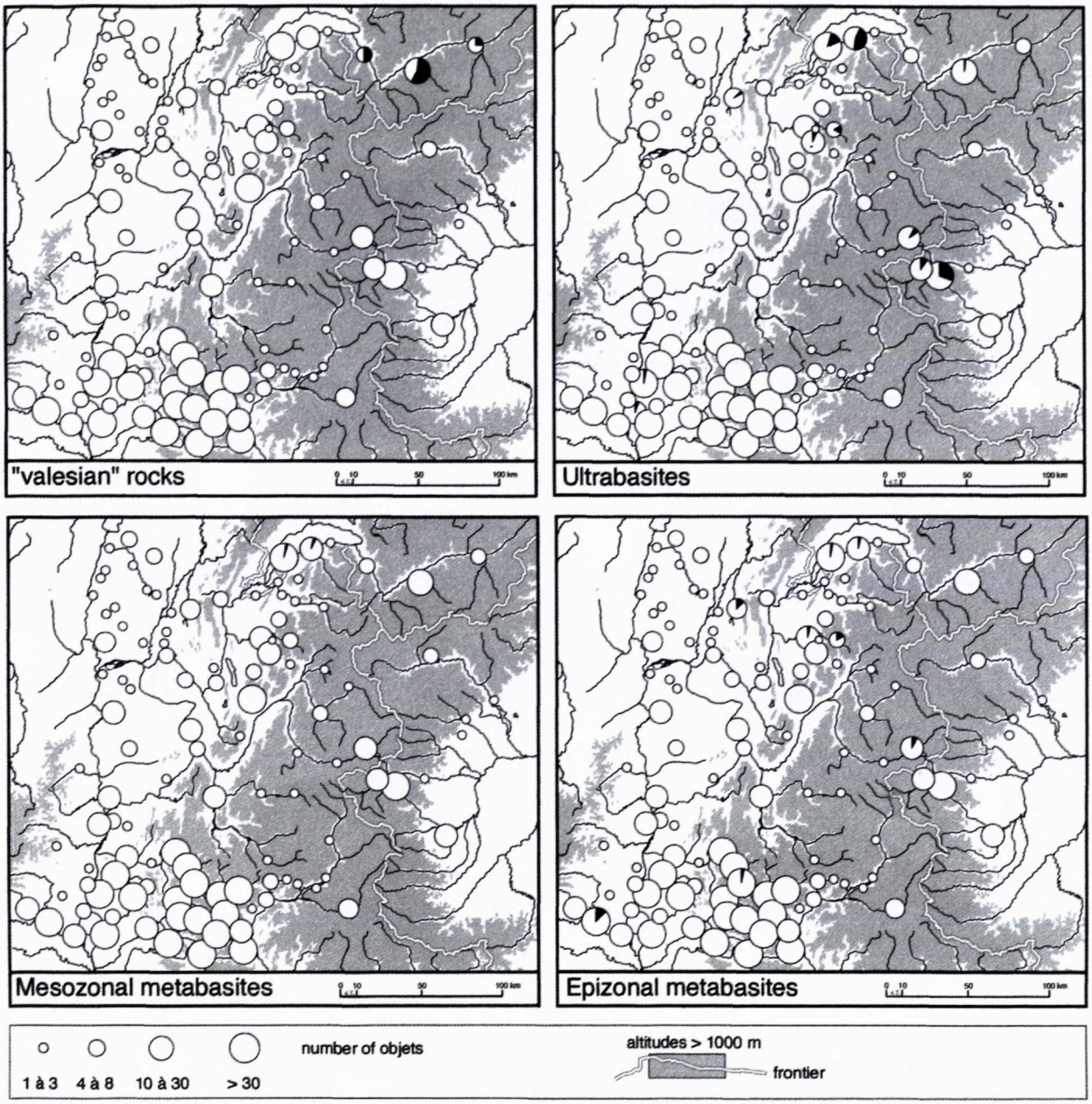

Fig. 3. Spatial distribution of the regionaly used rocks.

gites have been exploited en masse and diffused, and if we add the eastern diffusions, we can conclude that this rocks form one of the most important rock reservoir used for the axeheads in western Europe.

4.2. Regional dominant rocks

Glaucophanites are recognized in two regions : on the southern shore of the Leman lake, and on the Buëch basin (Fig. 2). The first come from the external cristalline massifs metamorphism and can be brought together, considering the neolithic supplying, with the epi- and mesozonal metabasites (see below). The others can be brought with the alpine glaucophanites used in western Provence (Ricq-de Bouard et al., 1990), thanks to two archaeological criteria: their distribution in continuity to the lower Durance and the lower Rhône valley, and the frequent use of pebbles coming from the Durance deposits. The glaucophanites pebbles are a common raw material source in western Provence (ibid.), but they are scarcely diffused more than 50 kms from the proper Durance valley.

The southern shore of the Leman lake is another region where the regional rocks are aboundant. The rocks identified are the glaucophanites still presented, several epi- and mesozonal metabasites, cataclasites and ultrabasites, which are almost known on the Annecy lake sites (Fig. 3). Some of these stone axe blades present a cortical pebble surface, which indicate that the supply is linked to the morainic or the alluvial deposits, as it is recognized on the swiss foreland, at Auvernier for instance (Buret and Ricq-de Bouard, 1982). This explains the presence of a large variety of rocks in the axe blades, partial reflexion

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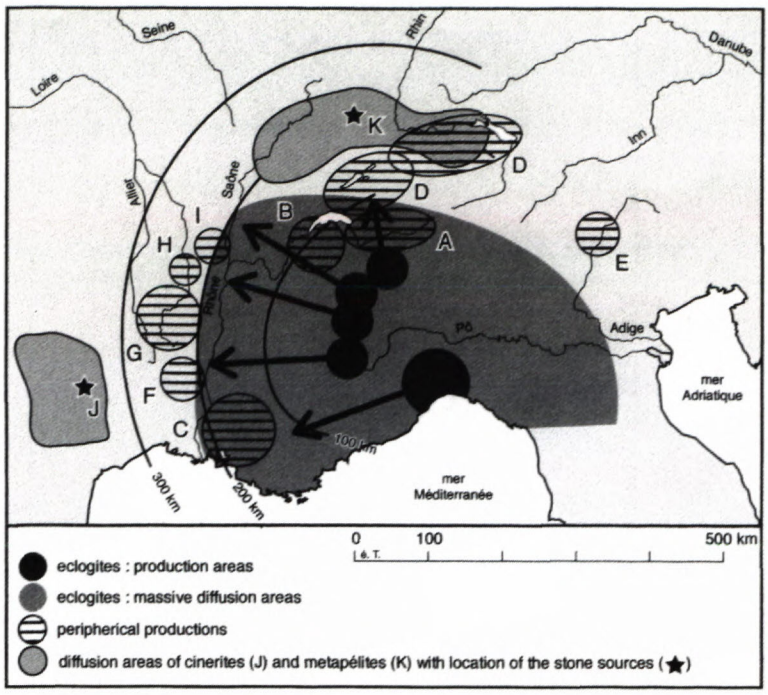

Fig. 4. Schematic distribution of the rocks used for axeheads, showing the process of peripherization around the Western Alps and the eclogite diffusions. A. "valesian rocks". B. Morainic rocks used in the Leman Basin. C. Glaucophanites (Durance pebbles). D. Serpentinites and other morainic rocks. E. Serpentinites. F. Several rocks of the Ardeche Basin (amphibolites, basalts, ...). G. Fibrolites. H. Meta-andesites. I. Amphibolites (actinolites). J. Cinerites (Requista's quarries). K. metapelites (Plancher-les-Mines' quarries).

of the moraines petrographic composition, which is opposite to the strict choice of the eclogites in the other regions. We are here face to two opposite strategies for the supply of raw materials.

In Valais, a similar choice can be recognize but with only one type of rocks, not formaly identified but probably coming from the regional metamorphic series. On the upper valleys of Susa, Chisone and Maurienne, a significant part of the stone axeheads are realised in ultrabasites (serpentinites), extracted from flaked supports.

4.3 Scarce "exotic" rocks

Among the scarce axe blades realised in non alpine rocks (in the geographical meaning), some indicate the diffusion limits of important productions outside the Alps, which cannot penetrate the mighty eclogite diffusion streams nowhere else that on their periphery. The vosgian metapelites, coming from the Plancher-les-Mines quarries (Pétrequin et al., 1996), are known in the middle Saône valley, on the Leman lakeshores, in south Jura (Bugey), in few exemplaries, but they're unknown on the Rhône south bank. On south, a lonely axe blade in cinerite coming from the Réquista quarries in the Rouergue (Servelle and Vaquer, 2000) is recognized in the Drôme valley. Lastly, the fibrolites, used in the Massif Central, are identified in scarce objets in the middle Rhône valley, the lower Dauphiné and in the Savoie forelands.

But all this rocks are only exotic curiosity among the hundreds of stone axeheads in eclogites. It is the same for the flint axe blades, polished or not, known in few exemplaries in the Rhône basin and coming from another sedimentary basin (Jura, Bassin parisien, South-West France ?).

5. Some interpretative archaeological tracks

5.1 The structuration of the diffusions (Fig. 4)

A spatial segmentation of the fabrication processes has been recognized for the eclogites and jadeitites. Indeed, numerous sites in the french Prealps and the large prealpine valleys, in the Buëch, Drôme and Drac valleys, and near by Chambéry, attest that the pecking and polishing stages, or even sometimes the flaking stages, have been realised far from the metabasites outcrops. This means that the piedmontese eclogites have been carried on 100 to 120 kms as roughouts more or less worked, before finishing on this "workshops". The strict distribution of the prealpine "workshops" in a peripherical crown in relation to the internal Alps, and their location in the key-places of the landscape (tophills, confluences, open valleys) indicates that a real control of the materials diffusions have been organized through the Western Alps and their forelands. So the great diffusions on the western side of the Alps are linked to a large spatial scale production system.

5.2 Chronological evolution

This remarkable organization has an history, summarized here under it economical aspects, without considering the important symbolic and functionnal evolutions in the polished tools status, studied otherwise (Thirault, 2001).

In the earlier Neolithic stages, the production sites are linked to the Apennines outcrops (*Groupo di Voltri*). Brignano Frascata is a good example of this sites for the *Neolitico antico*, type Vho (D'Amico et Starnini, 1996). In the Western Alps, the first production sites are related to the *Neolitico medio* (*Vasi a Bocca Quadratta*), for

instance Rocca di Cavour located in front of the lower Pčllice valley (Zamagni, 1996). But we consider, on the base of indices explained otherwise (Thirault, 2001), that the recognizing of the Western Alps eclogite outcrops is earlier and could be related to the transition stages between the *Neolitico antico* and the *Neolitico medio* (Fiorano/VBQ I), maybe even before, as well as the first transalpine diffusions in the Rhône basin (Thirault, 2001). Be that as it may, during the *Neolitico medio/Néolithique moyen I*, the production sites clearly dated are all located on the eastern side of the piedmontese Alps. We propose to attribute the real implantation of the eclogites "workshops" in the french Prealps and prealpine valleys in a more recent stage (*Neolitico recente/Néolithique moyen II*). So there should be a topple over, maybe progressive, dated circa 4500-4200 B.C. calib, from the eastern to the western side of the western Alps, for the control of the most important productions in eclogites. This means that the production control forms really a stake for the alpine neolithic communities, and that a strong link is established between the production and the diffusion. We propose to interpret this fact in terms of strong transalpine exchanges networks linking the communities on several hundreds of kilometers, with a real competition for the supplying in eclogites and the axeheads fabrication. During the latest stages (*Néolithique final/Eneolitico-Calcolitico*), the diffusions remain notable in the french Rhône basin, and some of the production sites are still in activity, but the distant diffusions seems to be less developped. The definitive end of the productions, considering the topical knowledges, can be situated before the earlier Bronze Age, because we don't know any demonstrated production after the end of the second millenium B.-C. calib.

This quick chronological survey put in light the fact that, beyond the fundamental knowledges brought by the material analyses, the stake of the stone axeheads study resides in the comprehension of the technical and social processes who condition the becoming of the productions and the diffusions. The petrographical investigations are the first link in a long work chain, if we want to understand the prehistoric societies through their tools.

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