Nature and provenance of Montilier-Platzbünden Horgen pottery (3179-3118 calendar years BC, western Switzerland)

M.-A. RODOT[1] R. MARTINEAU[1] J. BONVALOT[1] G.GALETTI[2]

ABSTRACT This study deals with the petrological and chemical analyses of 40 Horgen pots (3179-3118 av. J.-C.) from Montilier-Platzbünden (western Switzerland). The petrographical analyses show the use of a paste with natural and added inclusions of granitic origin. These crystalline materials comprise quartz, feldspar, micas, epidote, sphene, amphibole, zircon, rutile, stilpnomelane and carbonate as mineralogical inclusions, and slightly metamorphic granite, granodiorite and diorite as rock fragments. Stilpnomelane is a fingerprint of Mont Blanc granite, transported by the Rhône ice field. In the studied area, these materials exist only in moraines. There is more variability in sediment than in temper. The most homogeneous parameter in the pastes of this corpus is the added granite inclusions. Therefore, the local moraines are the most probable provenance of both the sediments and of the temper.

1. Introduction

Montilier-Platzbünden is located in the Three Lakes Region (Switzerland) on the southern shore of Lake Morat. This archaeological station is a Neolithic village occupied between 3179 and 3118 calendar years BC (Ramseyer, 1985). The study of the ceramic typology shows that the pots (Fig. 1: flat-bottomed, with straight or sub-conical profile) are characteristic of the Horgen culture (Ramseyer and Michel, 1990). The Three Lakes Region is located on the Switzerland Molassic Basin (Tertiary) between the Jura Belt and the Alps. This basin is mainly composed of sandstone and marls, and is in part covered by Quaternary formations: alluvium, lake sediments, fluvial gravels and sands (Riss-Wurm), moraines

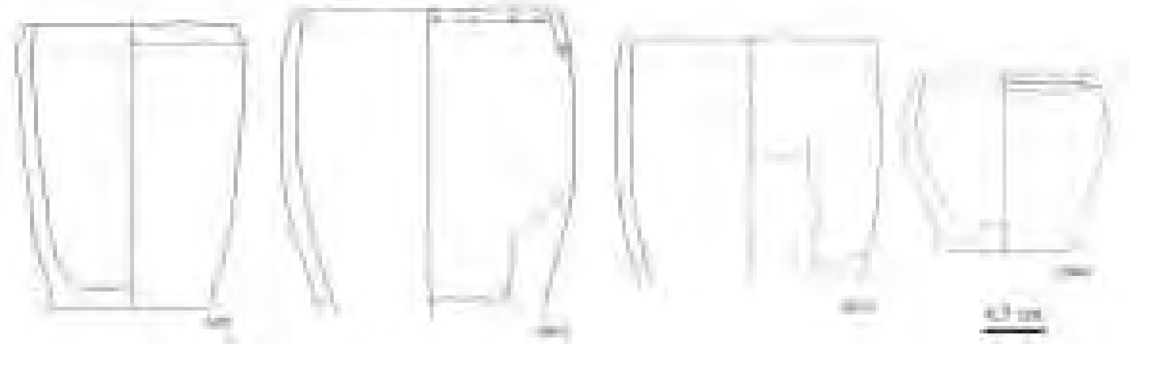

FIG. 1 – Typology of Horgen pots (Michel, 1990). Flat-bottomed with straight or sub-conical profil.

left by the Rhône ice field (Wurm), and other formations (Fig. 2) (Becker, 1973). The main moraine deposits are chiefly granite, quartzite and gneiss (Di Pierro, 2002).

The aims of this study are: 1) to establish the nature and geological provenance of the ceramic raw materials by petrographical and chemical analyses; 2) to determine the technological parameters of paste preparation, and the nature of the inclusions whether natural or/and added; 3) to estimate the number of potential sources for the ceramic raw materials. The objective is to compare these results with those of other Horgen settlements. Finally, possible socio-economic interpretations are suggested.

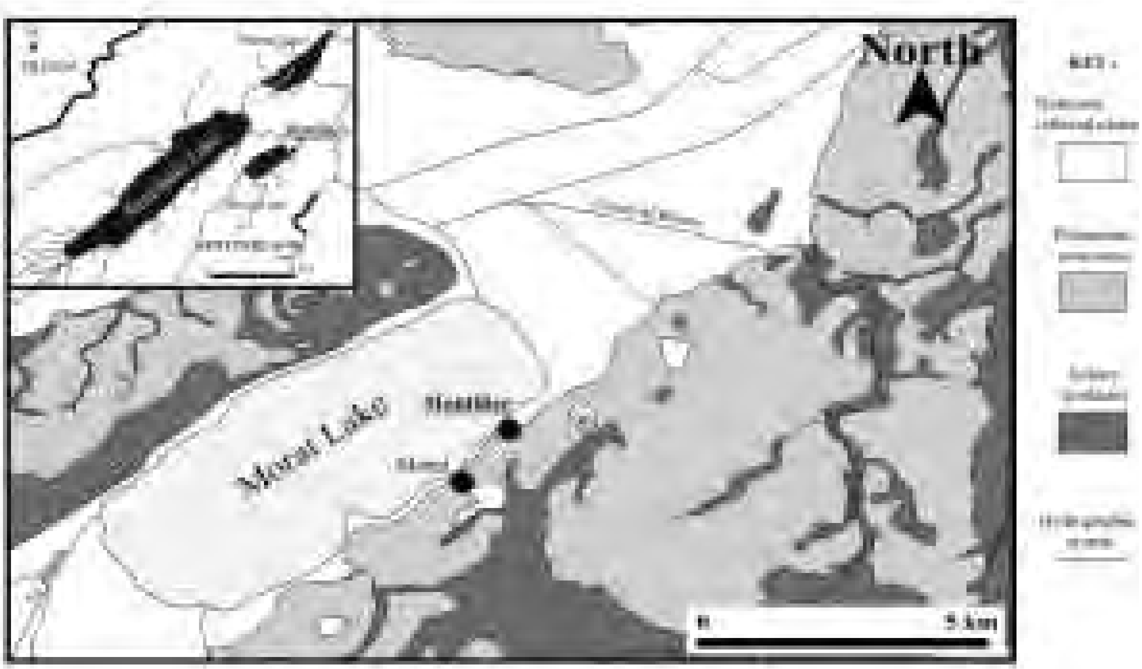

FIG. 2 – Synthetic geological map of the Morat Region (according to Becker and Ramseyer, 1972). Moraines with granitic rocks are present near the Neolithic settlement of Montilier-Platzbünden.

2. Methodology

Earthenware, which is composed of clay minerals (argillaceous matrix) and inclusions (natural and/or added) can be considered as an artificial rock and thus be studied with earth science techniques (Echallier, 1985; Maggetti, 1994).

Petrographical techniques are used to identify the nature of temper, the nature of the rock fragments and minerals in the sediment, and the aspect of the argillaceous matrix. Microscopic analysis allows natural inclusions to be distinguished from added inclusions (temper) on the basis of four criteria: “bimodal distribution of the inclusions, angular outlines of the temper grains, organic material, grog” (Maggetti, 1994, p. 27). Other studies (Constantin and Courtois, 1985; Constantin, 1986; Echallier and Courtin, 1994; Convertini, 1998), also based on technological aspects (grinding, burning, etc.), mineralogical association, and geological context, have shown that materials such as bone, calcite, flint, and some crystalline rocks, were voluntarily added to the paste. The nature of the added inclusions is our criterion for temper groups. Characterisation of inclusions leads to better understanding of paste preparation methods. Temper nature and paste preparation constitute techno-cultural pottery traditions (Constantin and Courtois, 1985). The nature of the inclusions naturally present in the sediment and the aspect of the argillaceous matrix are used to establish sediment groups. Our sediment groups are considered to be representative of sediment variability. Ceramic paste groups correspond to data from sediment and temper groups.

The bulk chemical method is used to quantify paste elements by X-Ray Fluorescence technique (XRF conducted at Fribourg University by G. Galetti, Geosciences Department). The XRF analysis gives the bulk chemical composition of ceramic paste, which depends on the raw materials (sediment, temper, water, etc.) processing and even, sometimes, pollution. Twenty-two elements were measured: 10 major (wt%): SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5; and 12 minor (ppm): Ba, Cr, Cu, Nb, Ni, Pb, Rb, Sr, V, Y, Zn, Zr (Table 2). Statistic processing (univariate, bivariate and multivariate methods: cluster analyses with standardised data, unweighted averages, Euclidian distances, and Statistica software) aims to evaluate the degree of homogeneity and allow chemical paste groups to be constituted.

The comparison of these two types of results (petrographical and chemical) allows better understanding of ceramic raw material variability and of the different sources exploited by Neolithic potters.

3. Microscopic analyses

In ceramic thin section, eleven specimens show secondary carbonate (calcite or dolomite) in paste porosity (**2, 10, 11, 12, 17, 20, 24, 26, 30, 33 & 36**), indicating carbonate pollution during utilisation and/or burial. In the text, bold numbers correspond to these contaminated samples.

3.1 Sediment groups

Petrographical analyses (N=40) permit the determination of two matrix groups (Table 1). The first one corresponds to a phyllitic matrix aspect (N = 36), interpreted as clay sediment. The second matrix group shows a phyllito-calcic aspect, interpreted as marl (N=4). In the different sediments, the main minerals and rock fragments are: quartz, feldspar (K-Feldspar and plagioclase), micas, epidote, sphene, amphibole, zircon, stilpnomelane, rutile, carbonate (calcite or dolomite), slightly metamorphic granite, granodiorite and diorite (Fig.3). The associations of some of these minerals and rock fragments allow 4 natural inclusion groups to be composed (Table 1).

FIG. 3 – Examples of different inclusions in ceramic thin section. Granite inclusion is composed of quartz, feldspar, chlorite and epidote. Granodiorite inclusion shows quartz, amphibole and epidote. The stilpnomelane is present in a K-feldspar mineral, which belong to a granite inclusion.

[illegible]

TABLE 1 – Petrographic groups (matrix, sediment, temper, paste) and chemical groups. Mineraligical abreviations: Qz – quartz; F – feldspar; C – carbonate.

On the basis of these four natural inclusion groups, and of the two matrix groups (calcic and phyllito-calcic), we have established five petrographic sediment groups (I to V, Table 1). But no correlation exists with natural inclusion abundance, underlining natural sediment heterogeneity. Three-quarters (75%) of the pots are made of clay sediment with granite rock fragments and minerals (sediment group I); 7,5% are of a clay with granite and carbonate minerals (II); 7,5% show a clay sediment with granite and granodiorite (III), 5% are of a marl with granite and carbonate inclusions (IV) and 5%, a marl with granite, granodiorite and carbonate minerals (V) (Table 1).

3.2. *Temper groups*

Three principal temper groups are identified by petrographic analyses (Table 1). Only one pot contains no temper (2,5%). The different inclusions added are granite in 80% of the

Oxide/Element	Unit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
weight	g	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SiO_2	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TiO_2	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Al_2O_3	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe_2O_3	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MnO	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MgO	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CaO	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Na_2O	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K_2O	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P_2O_5	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUM	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LOI	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ba	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Oxide/Element	Unit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
weight	g	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SiO_2	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TiO_2	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Al_2O_3	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe_2O_3	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MnO	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MgO	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CaO	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Na_2O	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K_2O	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P_2O_5	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUM	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LOI	wt%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ba	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 2 – XRF chemical data of 40 ceramic samples of Montilier. LOI = Loss on ignition.

corpus and granite associated with granodiorite rock fragments in 17,5% (Table 1). Furthermore, some metagranite fragments show stilpnomelane (Fig. 3), as accessory mineral (30%). The temper abundance in paste varies between 0 to 40 vol.%. The nature and the abundance of the temper show no correlation.

The data correlation from the five sediment groups and the four temper groups shows eight paste groups (Table 1) that reflect the paste preparation variability.

3.3. Discussion

Petrographical analyses show five sediment groups (Table 1) suggesting the maximum number of geological sediment sources exploited during the Neolithic occupation is equal to or lower than five. Although variability exists in natural inclusions, the fact that all the sediments contain crystalline inclusions, and that such inclusions are rare in the western Switzerland geological context, may indicate that the raw materials have a common geological origin. The homogeneity of the temper nature (crystalline, chiefly granitic rocks)

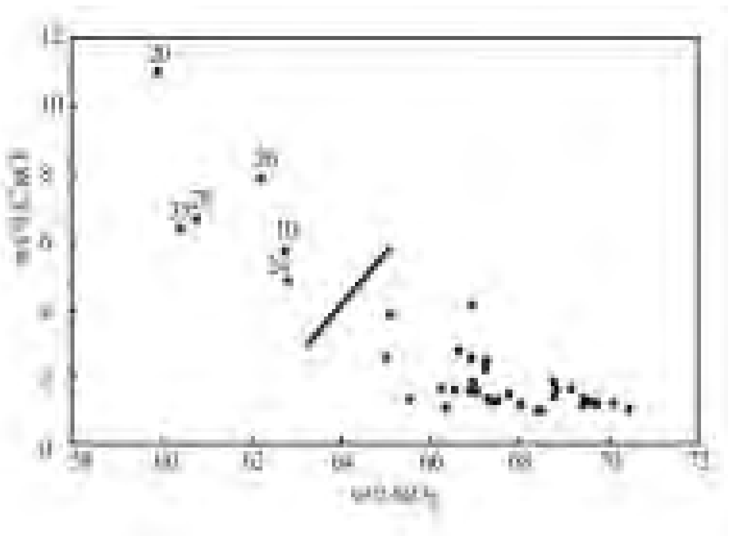

FIG. 4A – CaO-SiO_2 bivariate graph of the 40 Montilier-Platzbünden samples shows two groups of pots.

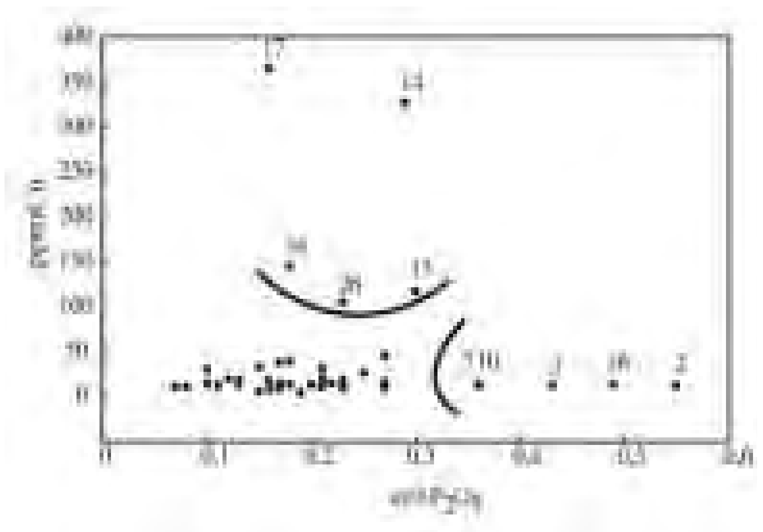

FIG. 4B – P_2O_5-Cu bivariate graph of the 40 Montilier-Platzbünden samples places in a prominent position three groups of pots.

added to the pastes seems to show its common techno-cultural tradition (Constantin and Courtois, 1985; Di Pierro and Martineau, 2002). The fact that sediment and temper groups contain granite and granodiorite inclusions, both of a crystalline nature, suggests a common geological provenance for these two materials. Moreover, stilpnomelane (in metagranite fragments) is a fingerprint mineral of the Mont Blanc granite formation (Von Raumer, 1969). In the Three Lakes Region, crystalline fragments are only present in the Wurmian moraine formations, deposited by the ice field of the Rhône (Di Pierro, 2002). These formations are located near the settlement of Montilier-Platzbünden (Fig. 2) and could have been exploited by the Neolithic population. This provenance hypothesis does not allow us to identify how many sources were exploited (1 to 5). Indeed, the natural heterogeneity of moraine formations is a restrictive factor for provenance studies. It therefore would seem necessary to collect further natural samples from the moraines near the Neolithic Montilier settlement and to compare them with archaeological data.

4. Chemical analysis

4.1. Bivariate analysis

Among all the bivariate graphs correlating the 22 chemical elements analysed, only two graphs show distinct chemical groups (SiO_2-CaO and P_2O_5-Cu).

- The SiO_2-CaO graph places 2 groups of ceramic samples in a prominent position (Fig. 4a). One group (**10, 20, 24, 26**, 28 & 35) shows relatively high values for CaO (> 4wt%) and low values for SiO_2 (< 64wt%). It contains the samples with a phyllito-calcic matrix aspect (**20, 26**, 28 & 35) and some samples that show petrographic carbonate pollution (**10, 20, 24 & 26**). But no correlation with nature and abundance of temper exists (Table 1). The other group (N=34) shows relatively high values for SiO_2 (≥ 64wt%) and low values for CaO (≤ 4wt%).
- The P_2O_5-Cu graph shows 3 groups of pots (Fig.4b). The first group (7, **10**, 3, **36** & **2**) is relatively rich in P_2O_5 (> 0,3wt%), the second group (**17**, 14, 34, **26** & 15) is rich in Cu (> 50ppm) with values higher than average environmental values (Wedepohl, 1995), and the third group (N=30) is relatively poor in P_2O_5 (≤ 0,3wt%) and Cu (≤ 50ppm).

4.2. Discussion concerning CaO, P2O5 and Cu

Chemical analysis shows that the bulk chemical composition of the pottery corpus is relatively homogeneous. Ceramic groups are prominent in only two graphs. But there is no correlation between the groups placed in a prominent position in the 2 graphs (SiO_2-CaO & P_2O_5-Cu, Fig. 4). Ceramic paste chemical variability can be explained by the use of different materials, by the natural heterogeneity of the geological formation exploited, by the use of different quantities of material, or by pollution during utilisation or burial. In all cases, no relation exists between chemical paste groups and temper nature or abundance, which allows the exclusion of the hypothesis that different quantities of material have been used. Moreover, the P_2O_5-rich group and the Cu-rich group show no correlation with petrographical parameters. The CaO-rich group (N=6) is explained by sediment variability (phyllito-calcic matrix aspect) and/or pollution (secondary carbonate in porosity). The P_2O_5-rich group (N=5) may indicate a particular provenance for ceramic materials or more probably pollution during utilisation or burial of pots (Picon, 1982). The Cu-rich group (N=5) may indicate a particular raw material source or human pollution corresponding to metallurgic activity (either Late Neolithic or Bronze Age).

4.3. Cluster analysis and chemical groups

All samples present in the three rich groups (Cao-rich, P_2O_5-rich and Cu-rich groups) must be considered as "contaminated" samples. For this reason, these samples, and those showing secondary carbonate in petrography, are not taken into account in the cluster analysis. Therefore, analysis was performed with only 22 samples. This analysis (Fig. 5) shows a heterogeneous group constituted of two chemical subgroups and three out-layer

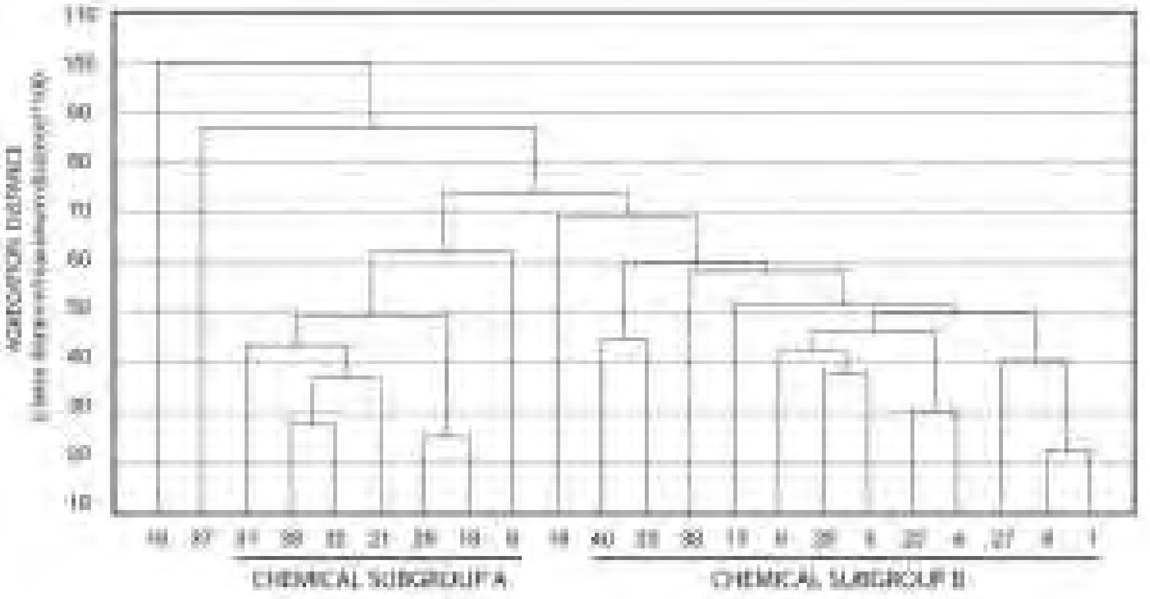

FIG. 5 – Cluster analysis of the compositional data (N=22, Table 2) using standardised data, unweighted averages and Euclidean distance shows two chemical subgroups.

pots (16, 18 and 37). Subgroup A is composed of 7 samples (31, 39, 32, 21,29, 19 and 6) and subgroup B of 12 samples (40, 23, 38, 13, 9, 25, 5, 22, 4, 27, 8 and 1). This result suggests that two principal chemical paste subgroups exist in the ceramic corpus.

4.4. Discussion

The cluster analysis (N=22) shows two chemical paste subgroups and three out-layers. Petrographical paste group 1 is present in chemical subgroups A and B, whereas paste group 2 is only present in chemical subgroup B, and paste groups 4 and 5 are only present in chemical subgroup A (Table 1). The paste groups 3, 6, 7 and 8 have not been taken into account in the multivariate analysis because of sample contamination. Petrographical sediment group I is present in chemical subgroups A and B, whereas sediment group III is only present in chemical subgroup A (Table 1). These comparisons underline the fact that the nature and abundance of paste group 1 and sediment group I are not correlated with the chemical groups. For the other numerically minor paste and sediment groups, it is not possible to conclude if correlation exists or not. The two principal temper groups (granite, granite and granodiorite) are present in the two chemical subgroups A and B (Table 1). Chemical variability is thus the result of sediment variability. However, the fact that the two chemical subgroups (A and B) are present in sediment group I probably suggests that these chemical subgroups reflect the chemical variability of a single geological formation.

5. Conclusion

The petrographic and chemical analyses of these Horgen pots show temper homogeneity and sediment variability (Table 1). This study places in a prominent position the cultural aspect of the temper, and the exploitation of a single geological formation, with perhaps different sediment sources (probably inferior to 5). All the raw materials (temper and sediments) have a common (crystalline) genetic origin, corresponding to the Wurmian moraine formations. But natural variability of moraines does not allow the determination of the precise number of geological sources exploited, nor their exact provenance. The Montilier petrographic results were compared to the Saint-Blaise Horgen settlement (Benghezal, 1994) in the Three Lakes Region (Switzerland) and to the areas around the Chalain 3 (France; Martineau et al., in press) and Arbon-Bleiche 3 (Switzerland; Bonzon, 2003) Horgen occupations. As already demonstrated by many authors (Benghezal, 1994; Maggetti, 1994; Nungässer and Maggetti, 1978; Nungässer et al., 1985, 1992; Martineau et al., 2000; Di Pierro, 2002; Di Pierro and Martineau, 2002; Bonzon, 2003), the intentional use of granitic rocks for pottery tempering is a cultural regularity. Granitic temper is recognised in Montilier (97,5%) and Saint-Blaise pots (100%; Benghezal, 1994), which indicates a common technical practice in the ceramic "chaîne opératoire", revealing techno-cultural tradition. Moreover, granitic temper is used for the Pfyn/Horgen pots of Arbon Bleicher 3 (73,3%; Bonzon, 2003), underlining the cultural relations between western and eastern Switzerland; but in the Chalain 3 settlement only 15,2% (layer VIII) then 4,5% (layer VI) of the Horgen pots show granitic inclusions, suggesting that contacts were fewer with eastern France (Martineau, 2000). It is interesting to note that all these results underline a common technical practice of tempering, which reveals a common cultural geographical area. In perspective, chemical comparisons with other settlements, and geological prospections will aim to determine if ceramic exchanges existed between settlements. Moreover, these studies could determine if the sediment sources exploited came from a single geological formation (moraine) or from several.

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NOTES

[1] UMR 5594, CNRS/ Université de Bourgogne/culture, Dijon, France.

[2] Geosciences Departement, Fribourg, Suisse.

REFERENCES

BECKER, F. (1973) - Atlas géologique de la Suisse 1/25000, notice explicative de la feuille 1165 Murten (Morat), Commission Géologique Suisse, 2 planches, p. 28.

BECKER, F.; RAMSEYER, R. (1972) - *Atlas géologique de la Suisse 1/25000, Feuille 1165 Murten (Morat), feuille 63 de l'Atlas.* Commission Géologique Suisse.

BENGHEZAL, A. (1994) - *Provenance et technique de la céramique du Néolithique final de stations des trois lacs jurassiens.* Thèse n.° 1062. Fribourg: Faculté des sciences de l'Université de Fribourg, Suisse (unpublished).

BONZON, J. (2003) - Petrographical and Mineralogical Study of Neolithic Ceramic from Arbon-Bleiche 3 (Canton of Thurgau, Switzerland). In DI PIERRO, S.; SERNEELS, V.; MAGGETTI M., eds. - *Ceramic in the Society, Proceedings of the 6th European Meeting on Ancient Ceramics, Fribourg, Switzerland, 3-6 October 2001*. Fribourg: Département de Géosciences, Minéralogie et Pétrographie, Université de Fribourg, p. 25-49.

CONSTANTIN, C. (1986) - La séquence des cultures à céramique dégraissée à l'os. Néolithique du Bassin parisien et du Hainaut. In *Le Néolithique de la France*. Paris: Picard, p. 113-127.

CONSTANTIN, C.; COURTOIS, L.-C. (1985) - Le matériau céramique comme caractéristique culturelle. L'exemple du dégraissant pendant le Néolithique dans le Bassin Parisien. Documents et travaux - Institut géologique Albert de Lapparent. Paris. 9, p. 19-25.

CONVERTINI, F. (1998) - Identification de marqueurs culturels dans la céramique du Néolithique du sud-est de la France. Apports pour une meilleure compréhension du phénomène campaniforme. In D'ANNA, A.; BINDER, D., eds. - *Production et identité culturelle. Deuxièmes rencontres méridionales de Préhistoire récente, Arles 1996*. Juan-les-Pins: APDCA, p. 203-215.

DI PIERRO, S. (2002) - *Domestic production versus pottery exchange during the Final Neolithic: characterization of the Auvernier - cordé ceramics from the Portalban and the St Blaise settlements, Western Switzerland*. Thèse n° 1391. Fribourg: Institut de Minéralogie et de Pétrographie, Université de Fribourg, Suisse.

DI PIERRO, S.; MARTINEAU, R. (2002) - Pottery tempering with Mont-Blanc granite across the Jura belt during French and Swiss final Neolithic. In *33rd International Symposium on Archaeometry*. Amsterdam, p. 75-76 (Abstract).

ECHALLIER, J.-C. (1985) - Les techniques des sciences de la terre dans l'analyse des terres cuites archéologiques. Pertinence et limites. Documents et travaux - Institut géologique Albert de Lapparent. Paris. 9, p. 13-14.

ECHALLIER, J.-C.; COURTIN, J. (1994) - Approche minéralogique de la poterie du Néolithique ancien de la Baume Fontbrégoua à Salernes (Var). *Gallia Préhistoire*. Paris. 36, p. 267-297.

MAGGETTI, M. (1994) - Mineralogical and petrographical methods for the study of ancient pottery. In BURRAGATO, F.; GRUBESSI, O.; LAZZARINI, L., eds. - *First European workshop on archaeological ceramics*. Rome: La Sapienza, p. 23-35

MARTINEAU, R.; CONVERTINI, F.; BOULLIER, A. (in press) - Les pâtes céramiques: natures, provenances et dynamiques évolutives. In PETREQUIN, P.; PETREQUIN A.-M., eds. - *Les sites littoraux néolithiques de Chalain et de Clairvaux (Jura), Du Ferrières au groupe de Clairvaux (31e et 30e siècles av. J.-C.), tome IV*. Paris: Maison des Sciences de l'Homme.

MARTINEAU, R. (2000) - *Poterie, techniques et sociétés. Etudes analytiques et expérimentales à Chalain et Clairvaux (Jura), entre 3200 et 2900 av. J.-C.* Thèse de doctorat. Besançon: Université de Franche-Comté, France (unpublished).

MARTINEAU, R.; CONVERTINI, F.; BOULLIER, A. (2000) - Provenances et exploitations des terres à poterie des sites de Chalain (Jura), aux 31e et 30e siècles avant J.-C. *Bulletin de la Société Préhistorique Française*. Paris. 97:1, p. 57-71.

NUNGÄSSER, W.; MAGGETTI, M.; GALETTI, G. (1992) - Analyse der Scherbensubstanz mit Mikroskop und Röntgenlicht. In BILL, J.; GALETTI, G.; NUNGÄSSER, W., eds. - *Liechtensteinische Keramikfunde der Eisenzeit*. Jahrbuch des Historischen Vereins für das Fürstentum Liechtenstein. 91, p. 119-165.

NUNGÄSSER, W.; MAGGETTI, M.; STÖCKLI, W. E. (1985) - Neolithische Keramik von Twann - Mineralogische und Petrographische Untersuchungen. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frügeschichte*. Basel. 68, p.7-39.

NUNGÄSSER, W.; MAGGETTI, M. (1978) - Mineralogisch-petrographische Untersuchung der neolitischen Töpferware vom Burgäschisee. *Bulletin de la Société Fribourgeoise des Sciences Naturelles*. Fribourg. 67:2, p.152-173.

PICON, M. (1982) - La fixation du phosphore par les céramiques lors de leur enfouissement et ses incidences analytiques. *Revue d'Archéométrie*. Rennes. 6, p.101-112.

RAMSEYER, D. (1985) - La dendrochronologie et l'interprétation des structures d'habitats néolithiques. L'exemple de Montilier/Platzbünden (Lac de Morat, Suisse). *Bulletin de la Société Préhistorique Française*. Paris. 82, p.20-31.

RAMSEYER, D.; MICHEL, R. (1990) - Muntelier/Platzbünden, Gisement Horgen. Vol. 1: Rapports de fouille/La céramique. *Archéologie Fribourgeoise*. Fribourg. 6, p. 160.

VON RAUMER, J.-F. (1969) - Stilpnomelan als alpinmetamorphes Produkt im Mont-Blanc-Granit. *Contributions to Mineralogy and Petrology*. Heidelberg. 21, p. 257-271.

WEDEPOHL, H. K. (1995) - The composition of the continental crust. *Geochimica et Cosmochimica Acta*. Washington, DC. 59:7, p. 1217-1232.