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Effect of firing temperature and atmosphere on ceramics made of NW Peloponnese clay sediments: Part II. Chemistry of pyrometamorphic minerals and comparison with ancient ceramics

C. Rathossi [a,*], Y. Pontikes [b,c]

[a] Section of Earth Materials, Department of Geology, and University of Patras, 26500 Rio, Greece
[b] Laboratory of Materials and Metallurgy, Department of Chemical Engineering, University of Patras, 26500 Rio, Greece
[c] Department of Metallurgy and Materials Engineering, Katholieke Universiteit Leuven, 3001 Leuven, Belgium

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Abstract

The influence of firing conditions on the chemical composition of the major pyrometamorphic phases of Ca-, Fe-rich Plio-Pleistocene sediments of NW Peloponnese is studied. These sediments have been used in the production of ceramic artefacts for a large historical period and are still in use by the local heavy clay industry. Firing conditions were oxidising (CO/CO_2, %, ranging from 0.2 to 4.4) or reducing atmosphere (CO/CO_2, %, ranging from 11.2 to 23.0), for a temperature range 850–1050 °C. At 850 °C, for both atmospheres, fassaite and gehlenite are the predominant new minerals with anorthite and wollastonite also formed in a small quantity. Up to 950 °C, the chemistry of minerals in oxidising and reducing conditions does not exhibit considerable differences. Fe^{3+} is present even in reducing atmosphere entrapped in the structure of fassaite, gehlenite, anorthite. At 1050 °C, in reducing atmosphere, more hedenbergite component ($CaFe^{2+}Si_2O_6$) incorporates in fassaite, whereas the ferrigehlenite component ($Ca_2Fe_2^{3+}SiO_7$) is absent from gehlenite structure. Fe^{3+} is detected only in fassaite and anorthite structure. The work concludes with a summary of the results from Part I and Part II, in the form of a reverse engineering table for the determination of the firing conditions in a ceramic body by using analytical information. Three examples are given that compare ancient ceramic sherds with ones reproduced in laboratory conditions and demonstrate the effectiveness of this approach.

Keywords: Firing; Microstructure-final; Clays; Traditional ceramics; Archaeometry

1. Introduction

The minerals and their particle size distribution in conjunction with the firing conditions (temperature, atmosphere, soaking time, heating and cooling rate) are the main factors which influence the mineralogical and microstructural transformation during ceramic processing.

Focusing on the firing process, the firing atmosphere has often been neglected as one of the most crucial parameters in determining the final body properties. To provide more experimental work in this area, ceramics were fired in oxidising and reducing atmosphere in a propane-firing kiln. Raw materials were collected from local Plio-Pleistocene sediments, close to Patras, prefecture of Achaia, NW Peloponnese. Excavations in this region have demonstrated an activity of ceramic manufacturing during Archaic (6th c. B.C.), Hellenistic (3rd c. B.C.) and Roman (1st–3rd c. A.D.) period.[1] A number of findings, such as the mineralogy and particle size distribution and most notably the geochemistry between ceramics and clay sediments[2–4] has supported that the collected fine wares have been most probably produced from the clay sediments used in this study without any preparation (e.g. levigation, settling, sieving).

In the previous work, Part I, emphasis was placed on unravelling the high temperature reactions that take place, in the qualitative and quantitative determination of the crystalline phases as well as on the analysis of the microstructure. In the second part presented herein, emphasis is placed on an elaborative microchemical analysis and on the comparison of ancient sherds with replicas prepared under laboratory conditions. The latter signifies one of the main tasks of this work which was to provide

* Corresponding author. Tel.: +30 2610997599; fax: +30 2610997560.
E-mail address: C.Rathosi@upatras.gr (C. Rathossi).

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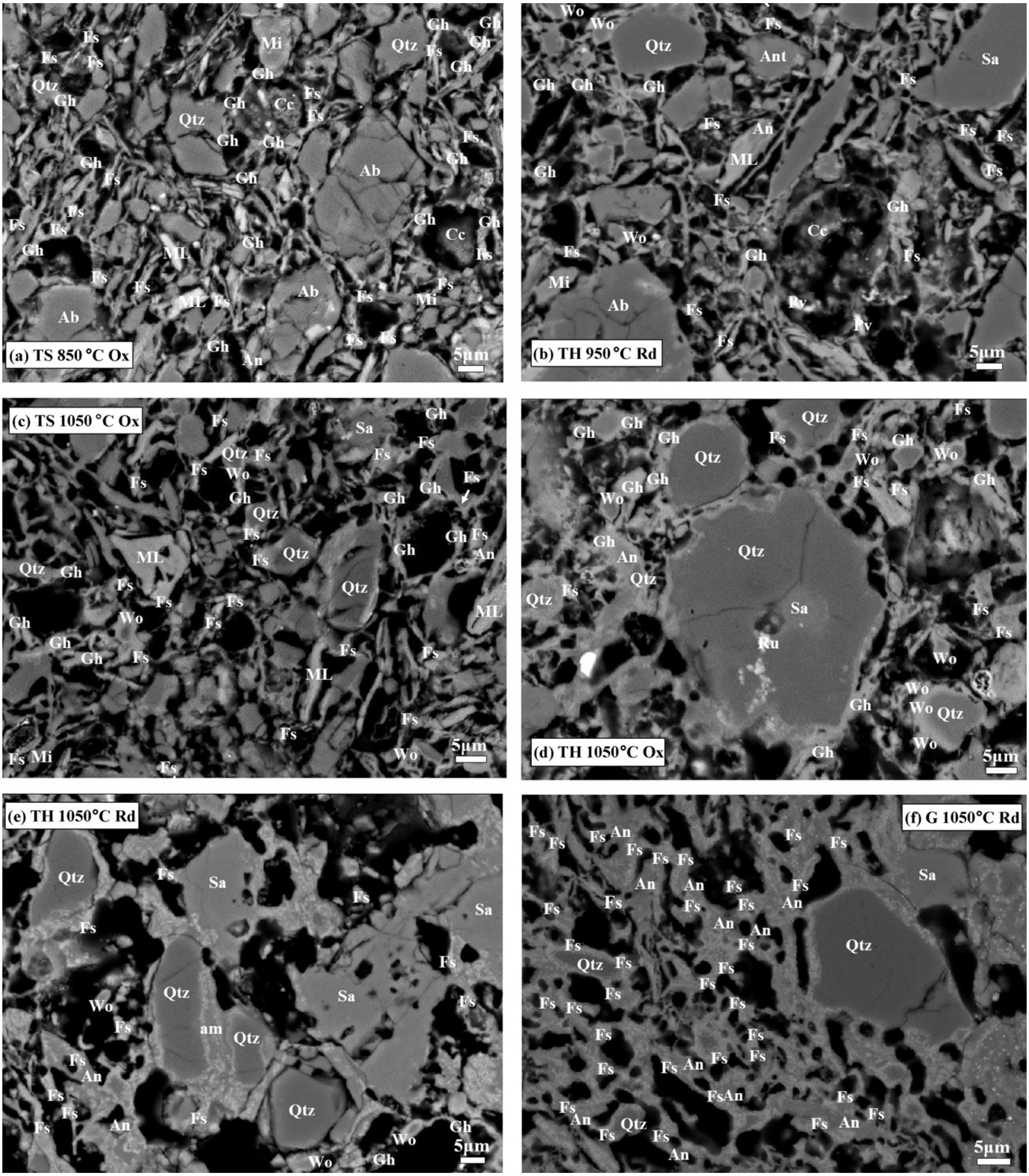

Fig. 1. Backscattered electrons' images of polished surfaces after firing of: (a) TS in oxidising atm., $T = 850\,°C$, (b) TH in reducing atm., $T = 950\,°C$, (c) TS in oxidising atm., $T = 1050\,°C$, (d) TH in oxidising atm., $T = 1050\,°C$, (e) TH in reducing atm., $T = 1050\,°C$, (f) G in reducing atm., $T = 1050\,°C$. *Abbreviations*: Qtz, quartz; Ab, albite; An, anorthite; Sa, sanidine; Fs, fassaite; Gh, gehlenite; Wo, wollastonite; am, amorphous phase; Mi, muscovite; Cc, partially decomposed calcite; Pv, perovskite; Ru, rutile; ML, interstratified muscovite-chlorite.

the tools for a reverse engineering approach: to function as a reference guide after analysis of the ancient body, in order to deduce the firing conditions of the ancient firing and thus duplicate in laboratory conditions (for verification) the ceramic body.

2. Experimental

Three representative raw materials, G, TS and TH, of Plio-Pleistocene sedimentary deposits of NW Peloponnese, have