Magnetic enhancement of clay materials by heat treatment: role of environmental conditions

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Abstract: The demonstration of increased magnetic properties of pottery (Raymond, 1904) or soil burn (LeBorgne, 1955) allowed to propose methods of investigation to determine if a soil had already heated (Crowther, 2003) or to determine the firing temperature of clay materials such as pottery (Rasmussen *et al*., 2012). Various processes have been invoked to explain the increase of the magnetic properties (iron hydroxide dehydration, reduction of iron oxides by the combustion of organic matter ...). The comparison of the effect of heat treatment in an oven or with experimental camp fire, with samples of soil or clay materials from prehistoric cave , dried or still wet, demonstrates the influence of the water content of the samples, not taken into account in the studies cited .

On samples of cave, the presence of goethite is identified by Raman spectroscopy. Thermodynamic calculations show that the dehydration of Goethite in the presence of a partial pressure of water vapor promotes the formation of magnetite instead of hematite by decreasing the oxygen partial pressure in atmosphere. Moreover, the temperature increase also promotes the magnetite formation instead of hematite. Then, the synergy between temperature and water vapor increases tends towards magnetite formation. The role of reducing the water vapor can therefore be considered as a key parameter. This parameter would explain the variations of magnetic properties observed in a same amphora, reflecting the drying heterogeneity of the state of the walls before firing. In the same vein, the differences in intensity of magnetic anomalies associated with archaeological hearth, could correspond to fire

under a shelter, with dry soil, or outdoors with moist soil for low and strong anomalies respectively.

Keywords: firing, magnetic enhancement, clayed material, soil

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