GEOLOGICAL RESEARCH OF BALL CLAYS FOR CERAMIC INDUSTRY

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Introduction

Ceramic industry accompanied man in his daily activity since the beginning of his social evolution.

In the last century and mainly in the last 30 years, ceramic industry showed an important technical development in typologies and applications. In Italy, ceramic tile production in the '90 modified the traditional red body compositions (red single firing) improving vitrified white body compositions as unglazed porcelain tiles (granito tiles) and glazed porcelain stoneware tiles. These developments required a radical modification of previous ceramic recipes and the research of raw materials with chemical and mineralogical characteristics more controlled and suitable for these new productions.

In body composition the most important feature for a correct formulation and the most difficult to find is the plasticity.

In Europe clay minerals are mainly supplied by important mining companies well organized to produce and control constant high quality clay blends. In the last few years the crisis of the market has been asking for a deep attention in raw materials costs and actually technical departments of ceramic producers are very oriented to find cheaper raw materials with characteristics suitable for porcelain tile production although not so pure as required before the crisis.

In this situation geological research is strategically important for mining companies and also for ceramic producers to reduce body composition costs.

This paper wants to show some of the main aspects regarding the geological research of clay minerals.

White firing clays

The most suitable clay minerals for white firing ceramic industries are fine-grained sedimentary plastic clays in which the Kaolinite Group minerals are predominant.

They are usually known as "Ball clays" because in the early 18th century in England cubic lumps of clay exploited using hand tools when moved became rounded and "ball" shaped.

These clays usually show in nature grey-dark grey colour and in some cases black because of organic impurities, but after firing at temperatures over 1200 °C they change in white or light grey colour.

Although we can include in this group many different raw materials, in typical ball clays there are usually three dominant minerals: Kaolinite (25-50 %), Illite/Mica (15-40 %) and Quartz/Feldspar (10-30 %). Although Kaolinite is determinant to reach a very good behaviour in firing at higher temperatures, Illite content is very important because it gives the material the good plasticity required during shaping operations.

In some cases a small presence of Montmorillonite or mixed-layer clays also helps to reach an higher plasticity behaviour. On the other hand an higher presence of these kind of minerals can be dangerous in industrial production.

In some volcanic districts kaolinitic deposits also show the presence of minerals dangerous for their emissions during firing as Alunite or Fluorite.

Carbonates are present in a very small percentage or absent in best clay qualities.

Ball clays are sedimentary basins, originated from primary Kaolinite deposits. For this reason the first step of a new ball clay geological research is to identify igneous or metamorphic rocks rich in silica and alumina and with low presence of iron and magnesium minerals. Typical mother rocks derived from granitic magmas and their presence could be helpful to select areas of interest for further geological research.

Clay deposits require a long geological time where weathering or hydrothermal processes altered the original rocks transforming feldspar in clay minerals and water transported and settled out clay components in lakes, swamps or basins with low energy transportation.

Picture n. 1 : kaolinized granite rock (Cornwall, U.K.)

Picture n. 2 : ball clay mine (Donbas, Ukraine)

Geological prospecting

An area is considered potentially interesting for clay minerals, when around primary mother rocks there is evidence of the typical morphologies of hills with low angle of inclination. Topography linked to aerial or satellite photos can be very useful to identify areas where to start field evaluation.

During preliminary geological prospection a detailed geological research must be done near all the rivers and streams present in the area. In fact it's difficult to find clear evidence of clay deposits on outcrops except in areas interested by landslides or excavated by roads or human activities.

Picture n. 3 : ball clay outcrop along a river (Lozzolo, Italy)

Of course it's important to know if in these areas have been found archeological evidences of potteries or if in historical periods local handicraft activities were present or recorded in the past.The second step is to make a very detailed field geological prospecting in the coldest months of the year when vegetation is absent.

During this exploration phase it's very useful to record the right position of any collected samples and GPS systems can be very helpful to find the precise topographic position.

Without geological outcrops for a right sampling it's necessary to move in areas normally covered by woods or lawns using hand auger equipments to reach clay levels under the soil.

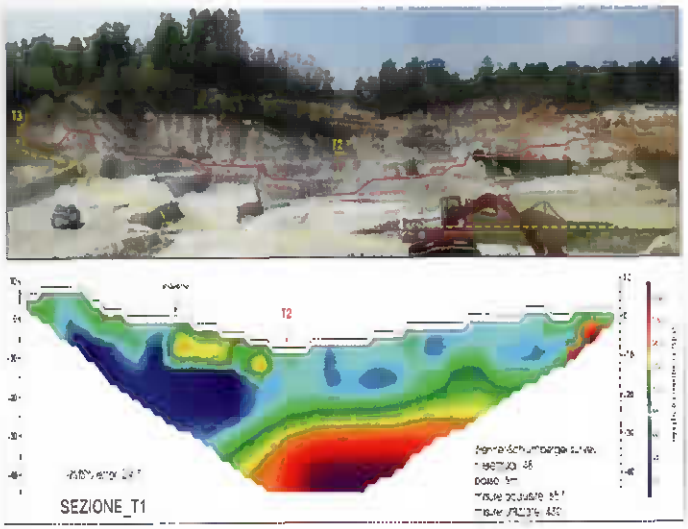
Picture n. 4 : hand auger equipment (Lozzolo, Italy)

Geological field prospecting should be integrated by preliminary drilling operations with a mobile equipment to confirm the presence of good clay deposits. In soft clay sediments mobile drilling can reach more than a 10 meters depth.

Picture n. 5 : mobile drilling operations (Lozzolo, Italy)

It's required to operate making regular square grids on the prospecting area. The spacing interval between drilling must be defined considering local geology but usually can be at least 100 m for a preliminary evaluation and about 25 metres for a further detailed evaluation.

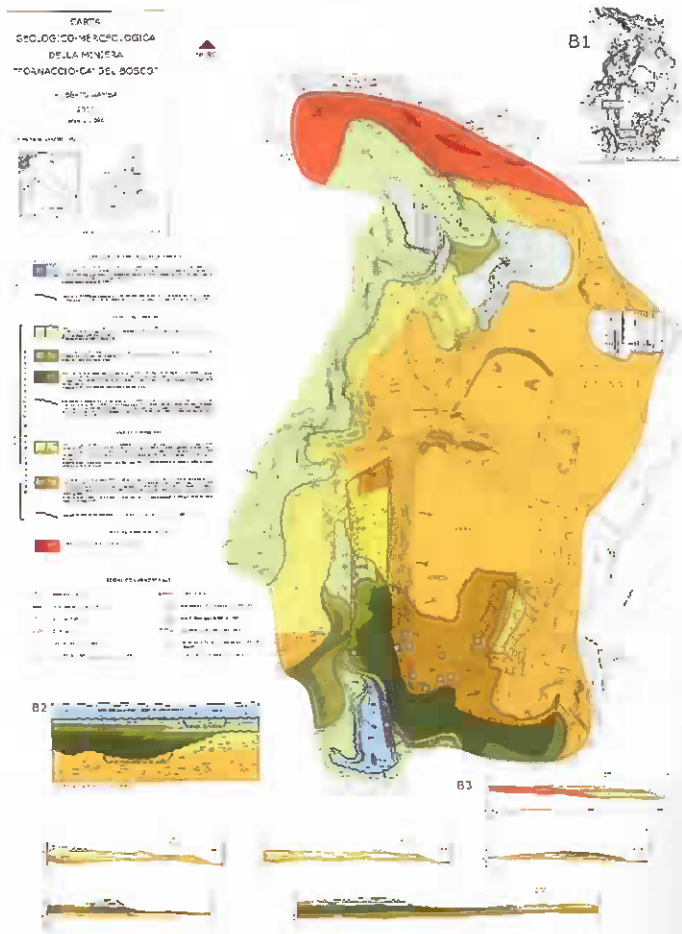
In many cases low quality sediments are present over the interesting ones. therefore it's important to have a right idea of their thickness and evaluate some possible low cost applications to reduce mining costs. After this preliminary geological prospecting and after laboratory results of the collected samples it would be very helpful to integrate the previous data with geophysical prospecting work. Electrical methods (resistivity, induced polarization) can be a cheap method to explore new promising areas. Electrical conductivity isn't linked only to mineralogy of sediments but also to their grain size and their water content and for this reason it's necessary to "tune" the results with drilling operations or relate results outcrop evidences.



Picture n. 6 : electrical geophysical exploration on a clay mine (Lozzolo, Italy) Different colours show different clay or sand layers.

The geological prospecting will define the more important points where to make boreholes with core sampling (10-30 meters depth). Although these operations are expensive they are determinant to have a clear idea of the stratigraphy of sedimentary layers and the thickness of the overburden. Chemical, mineralogical analysis and ceramic tests will allow to define the characteristics of future clay blends and allow also to study the real possibilities for the new products to be utilized in a future ceramic market.

At the end of the geological prospecting it will be very important to have a clear idea on the quantities available of any quality of clay. Actually to be interesting for ceramic industry a clay deposit must be able to supply production for many years. For this reason its size must be not lower than one million tons. Geological prospecting will also collect all the necessary information to present a project of recovery of the area at the end of clay mining



Picture n. 9 : geological map of a mining area (R.M. Ricerche Minerarie. Gamba, 2003)

Picture n. 7-8 : borehole with core sampling operations

and it must study the future impact on the environment. A final detailed geological map of the prospecting area (scale 1:2000 / 1:5000) will allow a correct development of future mining operations. The understanding of a correct geological model of the clay deposit will also help successful researches in areas with similar sedimentary conditions.

Laboratory

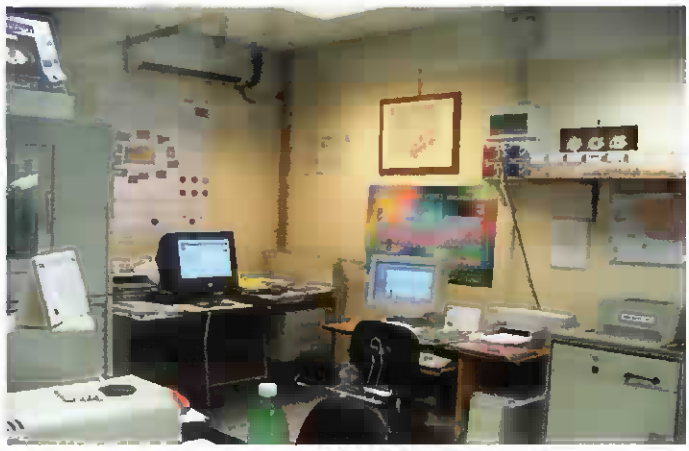
For a correct evaluation of geological prospecting and for a constant production control during future mining operations it's necessary to organize a suitable analytical and technological laboratory.

X-ray equipments are very expensive but they are absolutely determinant to control in a right way the daily exploitation work.

X-ray fluorescence (XRF) and X-ray diffraction (XRD) are widely utilized for they speed and reliability.

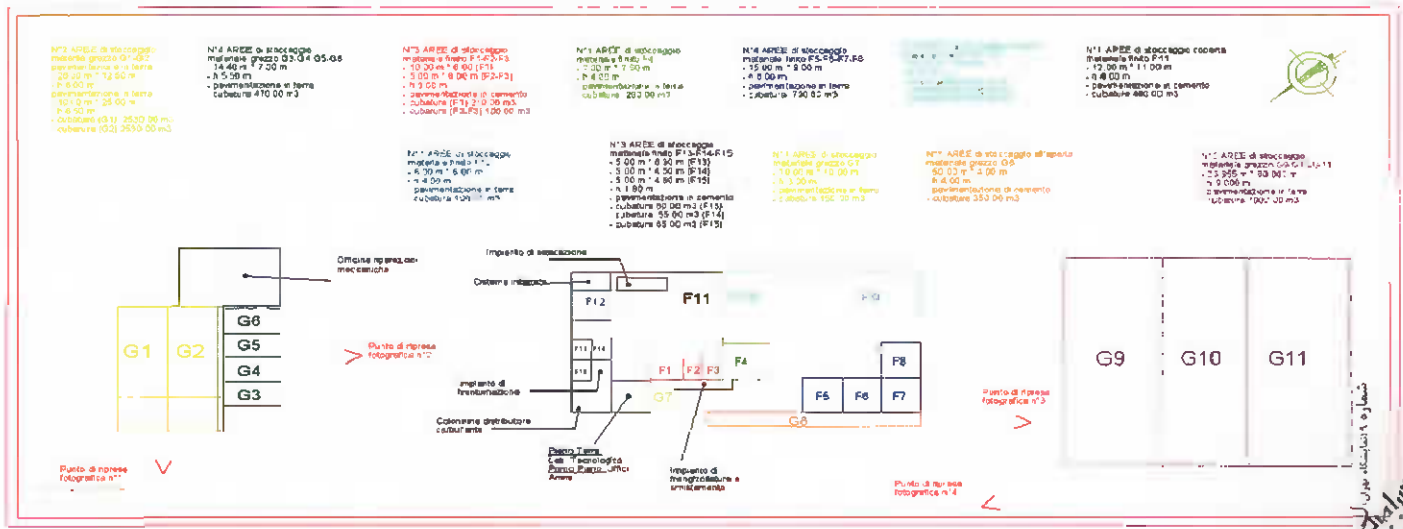
The limit of XRF analysis is that it can't evaluate elements with atomic number lower than 11 (Na) therefore it cannot evaluate a possible presence of Li or F oxides and C content.

XRD will help to understand the mineralogy content of the exploited raw materials. Any laboratory must have available muffle kilns to calculate loss of ignition after firing and to evaluate the characteristics of clay samples before and after firing (colour, water absorption, shrinkage).



Picture n. 10-11 : analytical laboratory for clay mining control (R.M. RIcerche Minerarie s.r.l, Lozzolo, Italy)

Picture n. 12-13 covered storage area and storage area lay out (R.M. RIcerche Minerarie s.r.l, Lozzolo, Italy)



Other very important instruments for a well equipped lab are : grain size analyser, DTA/TG equipment, TE thermal expansion dilatometer, combustion analyser and heating microscope.

Anyway the most important thing is to organize a methodology allowing to obtain in a very short time a correct answer on the production problems. A good method will be able to give results at least in 24-48 hour time.

During mining operation all the exploited different clay quality must be collected covered storage areas.

The laboratory will deeply monitor the first phases of the industrial production to confirm the preliminary results of clay blend formulation.

One of the most important characteristics of an high quality clay is its constancy in time. Natural variability of clay blends must be carefully monitored by the lab in each phase of the exploitation.

A technical data sheet of each clay blend indicating the maximum tolerance for each chemical element and mineral must be defined with the final client before the supply.

Conclusions

Geological research is today very important to define up to date raw materials after continuous ceramic product developments.

Field work and laboratory controls are of paramount importance to discover new mineral sources and to define the most suitable clay blends for the ceramic market.

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