RAW MATERIALS WORLDWIDE

*G.P. Bertolotti**

New Techniques of Survey for Ceramic Clays

THE AUTHOR

Gian Paolo Bertolotti is a geologist and free-lance consultant with more than 20 years international experience in raw materials for ceramics and ceramic technology. He worked at various renowned Italian ceramic research centres. His professional experiences include mining evaluation, ceramic compositions as well as the start-up of tile and sanitaryware plants. He is currently working as technical consultant for R.M Ricerche Minerarie s.r.l. (Italy).
E-Mail: geo.bertolotti@libero.it

ABSTRACT

In recent years, the Lozzolo clay deposit in Italy has been thoroughly investigated. Numerous drill sections and geo-electric surveys have been studied in order to map its mineral characteristics in detail and guide exploitation of the excavation. These methods and modern recording of all the collected data in a digital project with G.I.S. software has enabled better understanding of the complex stratigraphy of the mineral deposit. Geophysical studies have also identified the presence of tectonic structures associated with the major concentrations of more valuable kaolinitic clays. These innovative techniques may represent a new methodology for use by the ceramics industry in exploring similar clay deposits elsewhere.

KEYWORDS

clay, Lozzolo, survey, drilling, GPS, GIS, geophysical survey, earth resistivity
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1 Introduction

Ceramic products are becoming more and more complex. To match with exacting product formulations and applications, ceramic minerals must now be submitted to sophisticated methods of analysis. To guarantee required characteristics and consistency, they must be extracted in rigorous fashion, guided by up-to-date criteria and accurate location mapping. The same methods are suitable for exploitation of existing excavations and the search for new deposits. As clays are the most important constituents for correct ceramic formulation, the identification and categorisation of new deposits and better understanding of existing ones are essential and strategic for the industry [1].

2 The kaolinitic clays of Lozzolo

The deposit of Lozzolo, in the north-west part of Italy, has been exploited for more than 100 years. It has recently been the object of a new and more detailed geological survey, mainly in the "Fornaccio" mining tract of R.M. Ricerche Minerarie s.r.l (Fig. 1).

Many geological and mineralogical studies have been made in the past [2, 3]. During 2003, Roberto Gamba, a student of Earth Sciences at the University of Turin drew the first detailed geological map of the area in cooperation with geologists of R.M. (Fig. 2) [4].

The most interesting layers are of Pliocenic age. They are called the "Complesso Inferiore" and are of lake delta origin (Fig. 3). In

Fig. 1 • Aerial overview of the "Fonaccio" mining area (Lozzolo, Northern Italy)

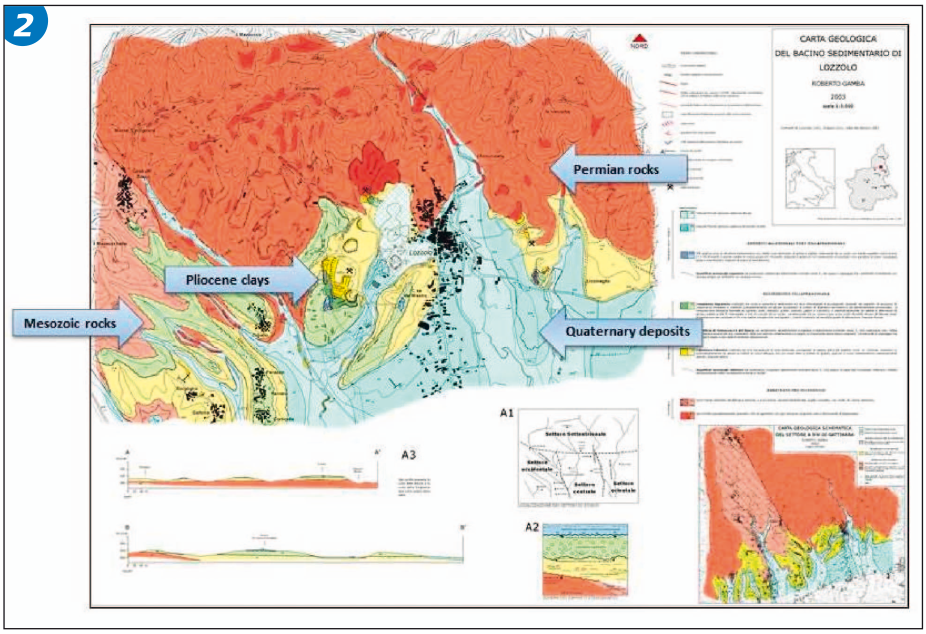

Fig. 2 • Geological map of the Lozzolo area (Gamba, 2003)

* Ceramin Consulting, Arona, Italy

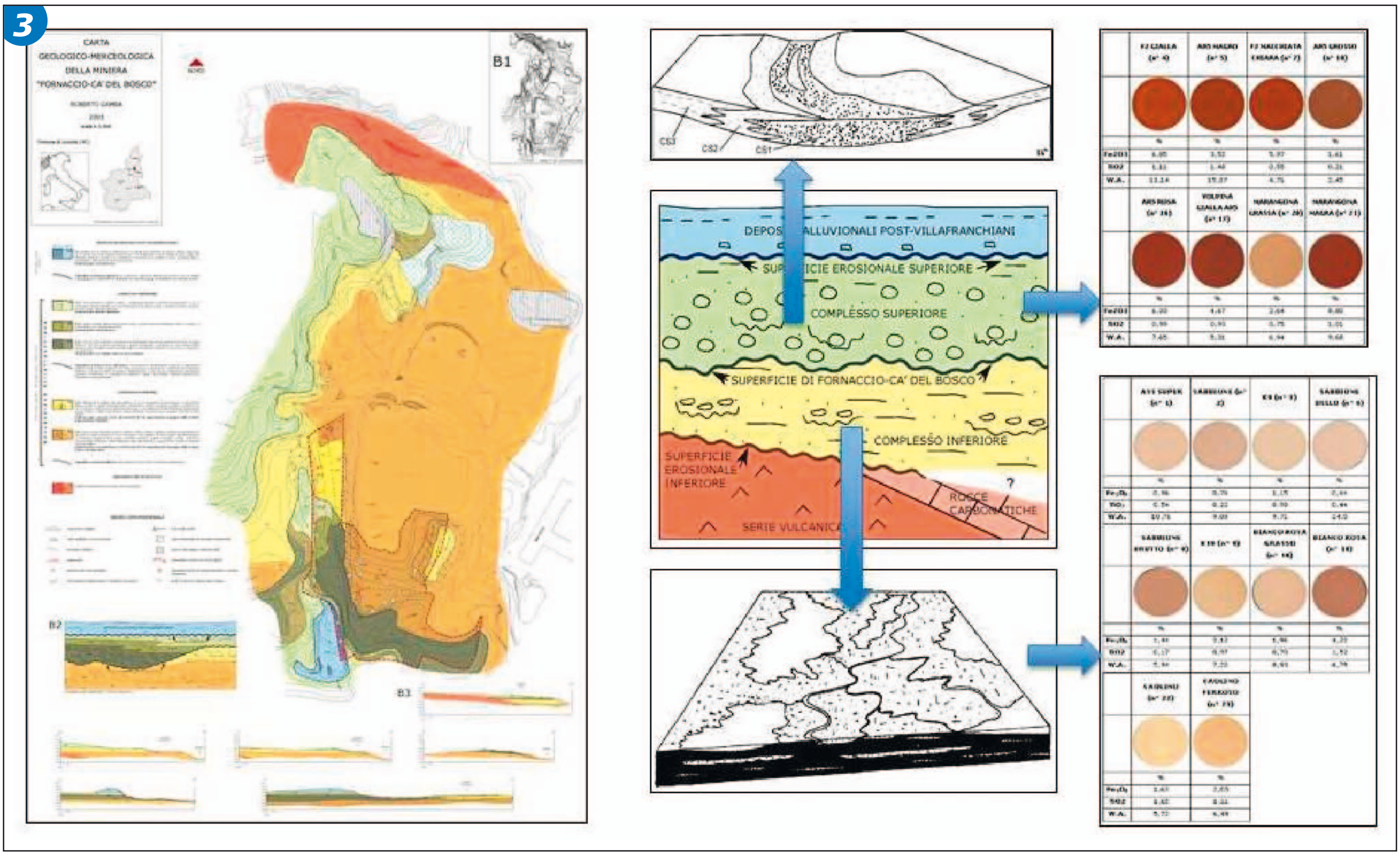

Fig. 3 • Detailed geological map and stratigraphic interpretation of the Lozzolo clay mine. The figure shows that light firing material is associated with a specific geological level (Gamba, 2003)

Figs. 4–5 • Geological prospecting with mechanical auger drilling equipment

Figs. 6–7 • Geological prospecting with rotary core drilling equipment

this level are deposits with lower iron content. These clays have been widely used for many years in the production of refractory tiles and porcelain stoneware.

With a detailed geological map it was then possible to efficiently organize all subsequent prospecting activities in the mining area. In the first phase of those studies, classical methods for the clay research were used, including mechanical auger drilling and rotary core drilling.

3 Survey methods

3.1 Mechanical auger drilling

In this technique, a simple drill with a diameter of 70 mm operated by a four-stroke engine brings up ground of different layers (Figs. 4–5). The benefits of such a device are low cost and greatest operational ease. The disadvantages are low achievable depth (a maximum of 15 m) and inaccurate stratigraphic correlations.

3.2 Rotary core drilling

Hydraulic coring machines were utilized to collect cores with a diameter of 10 cm (Figs. 6–7). Between 2003 and 2012, 18 core drillings were done in the "Fornaccio" permit area, producing core samples to depths greater than 240 m.

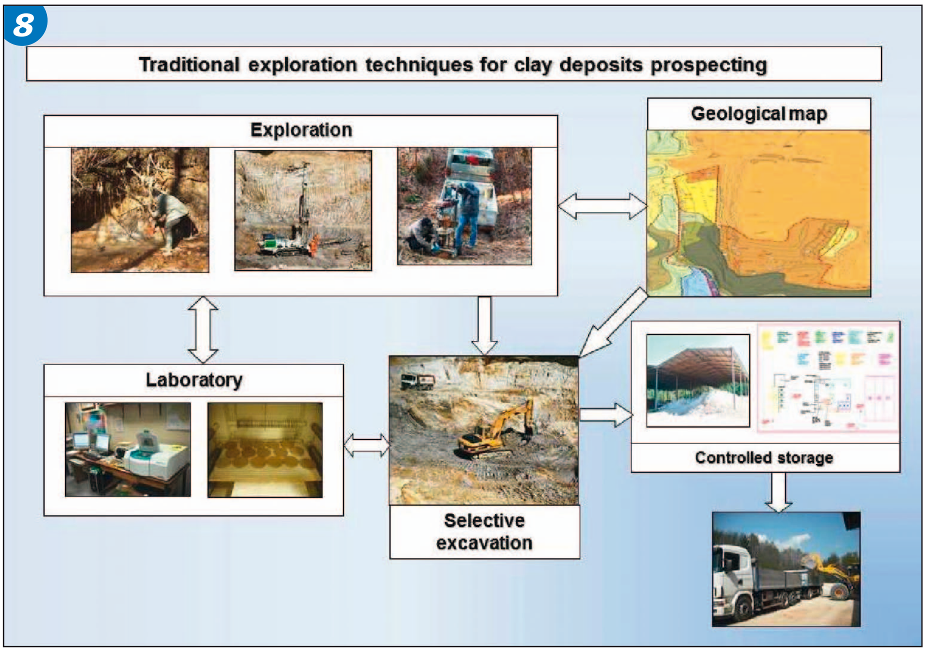

Fig. 8 • Summary of traditional methods of prospecting in the study of clay deposits

Figs. 9–10 • Geological anomalies in Lozzolo clay deposits: steeply inclined strata (Fig. 9, on the left), sharp contrast between different lithologies (Fig. 10)

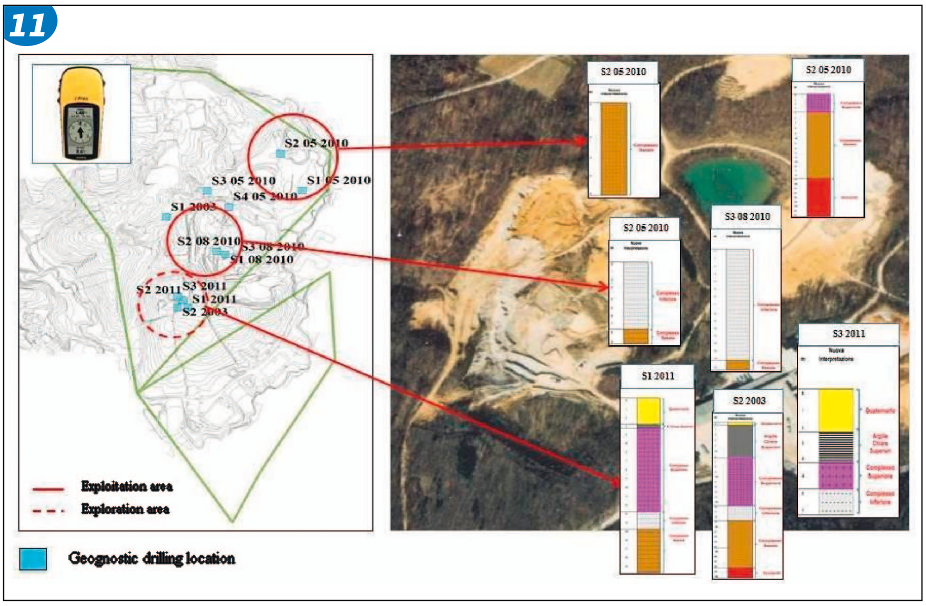

Fig. 11 • Georeferencing using GPS topographic positioning of core drilling

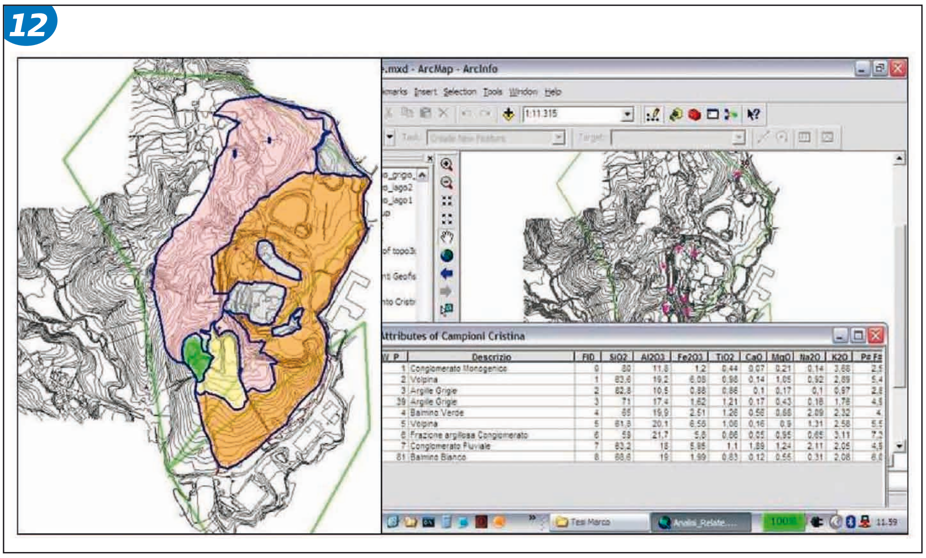

Fig. 12 • Geological information and analytical data recorded by the G.I.S. project

Coring is more precise than simple drilling as it allows collection and study of better condition samples. On the other hand, costs are much higher and specialised workers are required to operate the equipment.

Figure 8 schematically summarises the methodology traditionally used for exploration of ceramics clay deposits. They are typical of the techniques applied in the first phase studies at the Lozzolo mine.

For correct interpretation of collected data that will be used in mining exploitation, it is of great importance to have a modern laboratory close to the mining area. It can provide controlled storage of different types of technical information and support selective excavations. A new R.M. analytical and technological laboratory has improved overall knowledge of the deposits and been very useful in finding the best quality clays. Thanks to its assistance, it has been possible to develop improved clay blends with consistent physical and chemical characteristics.

Progressive improvement of mining operations and geological prospecting has identified various geological anomalies in the deposit, including existence of layers inclined more than 40 degrees, sharp lateral variations in lithology, inversion of stratigraphic series and sudden deepening of the whitest layers (Figs. 9–10). All this was in clear

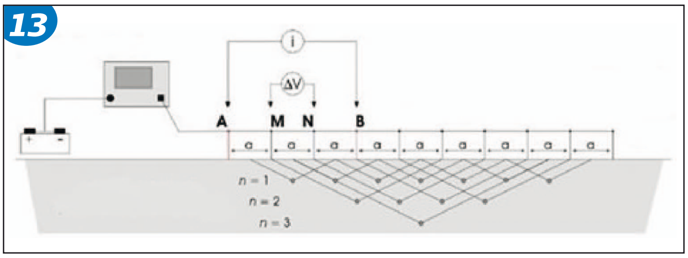

Fig. 13 • Operating diagram of a geo-electric method with Wenner-Schlumberger geometry (courtesy of i. Geo)

Fig. 14 Location of geo-electric profiles in the mining area "Fornaccio", Lozzolo

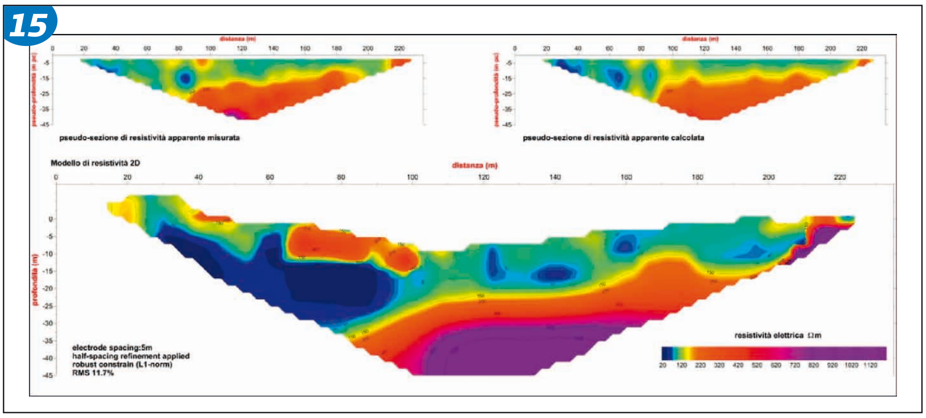

Fig. 15 • Example of geo-electric section with recorded electrical resistivity (in Ω · m)

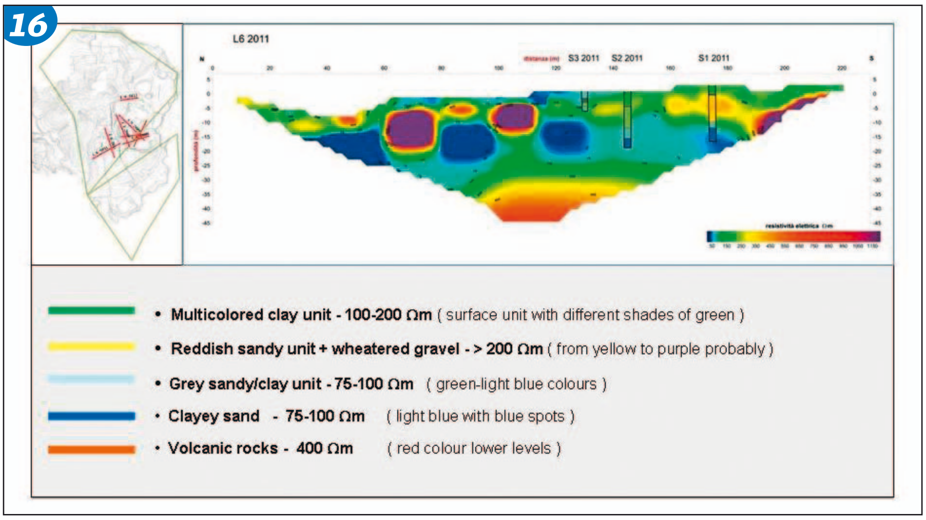

Fig. 16 • Electro-stratigraphic section and geological interpretation resulting from correlation of geophysical data with the results of geological surveys

contrast with previous knowledge that suggested only lateral discontinuities and a weak E-NE inclination.

To further improve operations, other new methods were applied. The first was a digital model of the mining area, constructed with the help of GPS positioning. A detailed sampling in near and more remote untouched areas was performed and all samples were assigned a GPS position on a digital map. The GPS positions of all previous drill and coring locations were put on the map as well (Fig. 11).

Using these new elements and software resources as a foundation, the map has been incorporated into a dedicated graphical information system (GIS). This archive is continually monitored and updated with the progress of new excavations and research. It is now possible to access a detailed digital archive of geological information and view the location and characteristics of all samples collected for analysis (Fig. 12).

3.3 Geophysical survey: Geo-electric 2D earth resistivity imaging

This survey method, conducted with the assistance of Italian company i.Geo s.n.c. (Cassano d' Adda), has been of great importance in clarifying aspects of the local geology.

In geo-electric methods, electric power is applied to the ground by means of elec-

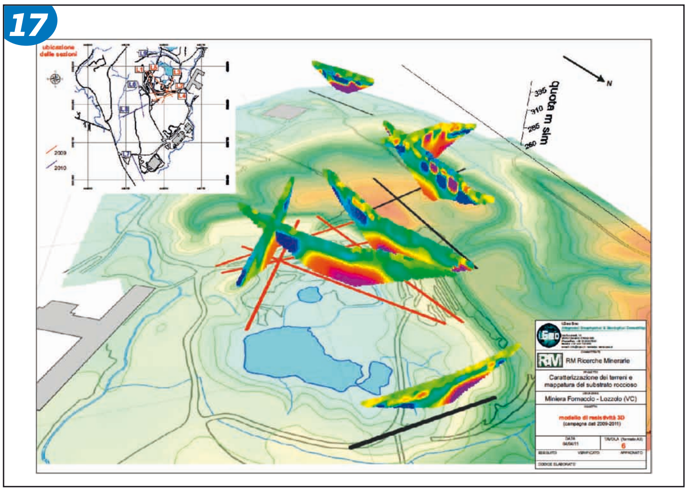

Fig. 17 • Digital mapping project with locations of electro-stratigraphic sections resulting from geo-electric prospecting

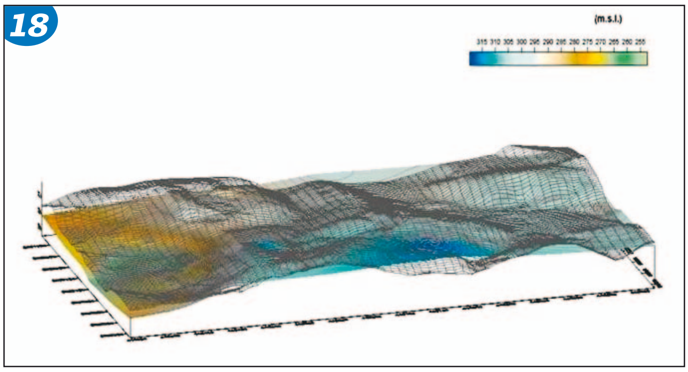

Fig. 18 • Preliminary 3D model of Lozzolo clay deposit

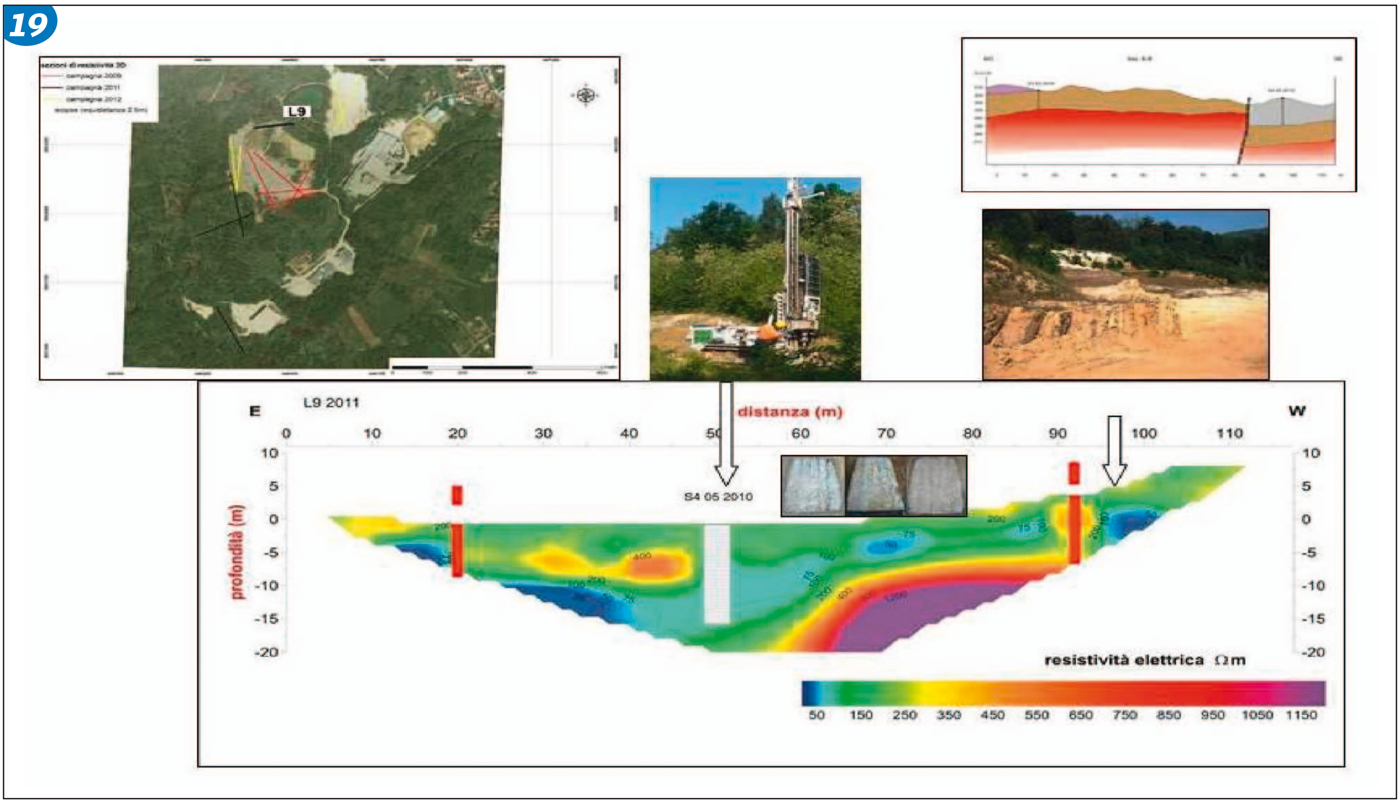

Fig. 19 • Tectonic structures (red lines) in the mine "Fornaccio", recognized by geophysical prospecting associated with geological survey

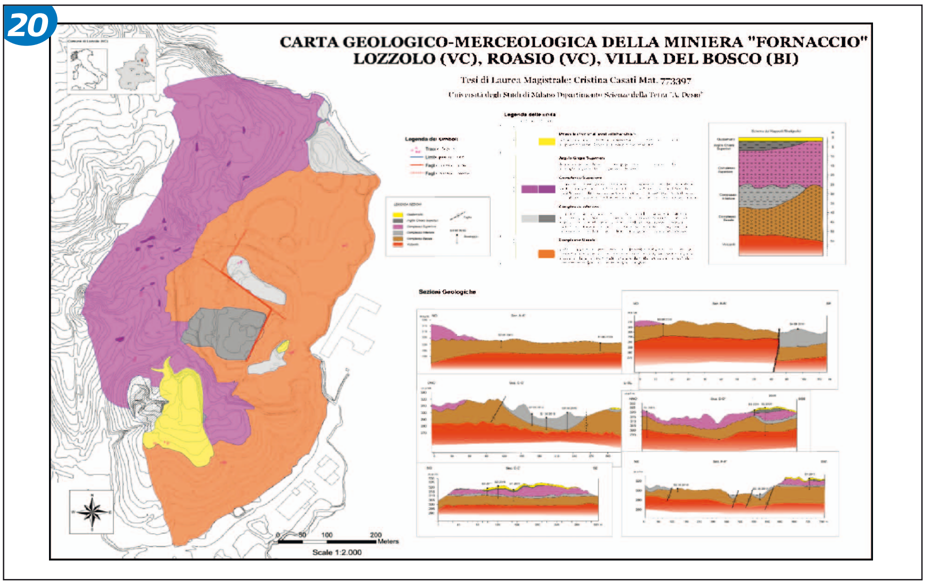

Fig. 20 • Detailed geological map of the Lozzolo clay mine sections and associated stratigraphic interpretations (Casati, 2012)

trodes; the potential difference registered at different electrodes is a function of the resistivity of the layers of ground crossed by electrical current [5]. The results depend on the measuring scheme that is chosen. In Lozzolo, the Wenner-Schlumberger system was adopted (Fig. 13). 13 region profiles were made in the Lozzolo quarry, each 235 m in length (Fig. 14).

By means of special software fed with data coming from electrodes positioned at different distances, it is possible to obtain a bi-dimensional image of variations in electrical resistivity occurring underground (Fig. 15).

The geo-electric survey is an indirect method of detection. Resistivity has to be translated into understandable geological terms. This is done by calibrating against resistivity values corresponding to different types of subsurface layers. The result is a lithology-geo-electric virtual colour plot, which displays correct stratigraphic information (Fig. 16).

The coloured drawings of the different profiles can then been overlaid digitally on a geographic image of the excavation (Fig. 17). A future goal will be to obtain sufficient information to draw a reliable three-dimensional model of the clay deposit (Fig. 18).

Geophysical survey has been very useful in the interpretation of geological anomalies. As an example, it is possible to easily detect the presence of tectonic lines in the mining area (Fig. 19).

Geo-electric survey has many advantages. It can be quickly performed, is economical, does not spoil private property and is easy to integrate with geological-based G.I.S. software. It is limited mainly due to the presence of water in earth layers (which interferes with the accuracy of electrical measurements) and to its limited precision at small scales.

This effort led to the drafting of a new geological map that was the subject of Cristina Casati's thesis at the University of Milan [6]. The map showed the existence of unrecognized tectonic lines in the mining area and has also defined a new stratigraphic scheme (Fig. 20). The tectonic fault lines are now seen as indicators of increased thickness of white clays and are therefore of utmost importance for future mining research.

4 Conclusions

The results of improved surveys carried out in the "Fornaccio" permit excavation of R.M. Ricerche Minerarie s.r.l. in Lozzolo

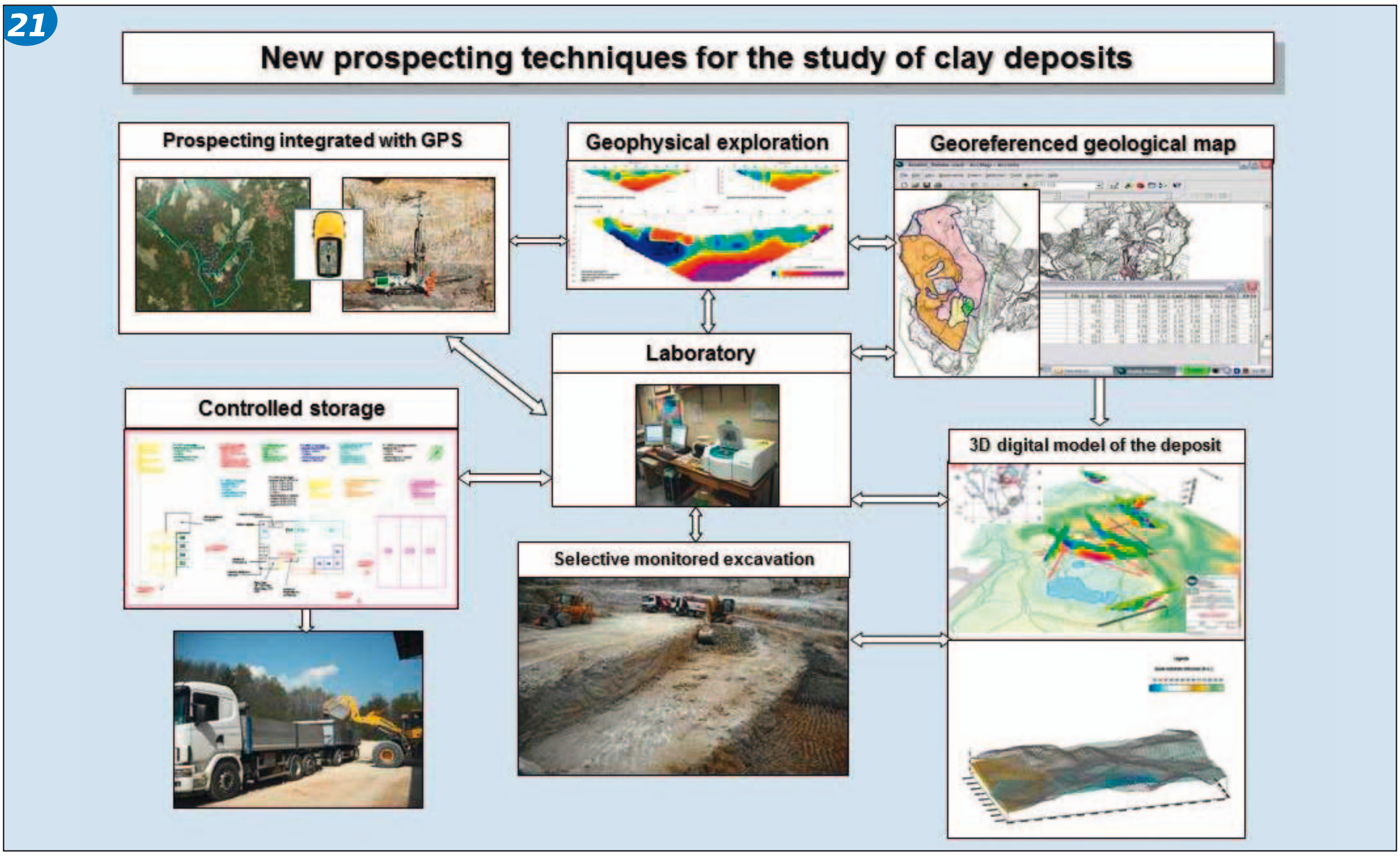

Fig. 21 • Summary of new methods of prospecting applied in the study of the Lozzolo clay deposit (Northern Italy)

have led to new strategies in the search for white firing ceramic clay deposits (Fig. 21). Successful investigation of the complexity of this deposit has led to deeper knowledge of general techniques applicable to geological surveys. It is feasible to apply these methods to any other deposits in the world or to reconsider further exploitation of apparently exhausted mines.

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