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Mineralogical-Petrographical Study of the Clayey Matrix in the Gravels from Nedelea Gravel Pit

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Abstract

The gravels in Nedelea gravel pit (Aricestii Rahtivani, Prahova county) from the left slope of Prahova river, exploited by S.C. Lafarge Agregate-Betoane S.A. for the preparation of concrete, present an atypical clayey matrix, hard to be removed by a usual wash with a water jet, this having unfortunate implications for the preparation of concrete. The detailed mineralogical-petrographical study revealed the presence in a great quantity of chlorites with an ionic content that favors the electrochemical adherence to the gravel clastes.

Key words: *optical microscopy, X-rays diffraction, chloritic clays, Prahova valley*

Introducere

The paper presents the mineralogical-petrographical study of the clayey matrix in the gravels from Nedelea gravel pit which is being exploited by S.C. Lafarge Agregate-Betoane S.A. for the preparation of concrete. The matrix of these gravels is an atypical clayey one, hard to be removed by a usual wash with water jets, this having unfortunate implications for the preparation of concrete. The need to identify solutions that may lead to a most efficient removal of the matrix from the clastes of gravels imposed the establishing of the mineralogical composition of the clayey matrix, in order to explain its atypical behavior after having being washed with water jet.

Nedelea gravel pit area is situated in the flood plain and in the lower terrace of the left slope of Prahova river and belongs, from an administrative point of view, to Aricestii Rahtivani commune, Nedelea village, Prahova county.

Geomorphologically, Nedelea area is situated in the alluvial plain of Prahova river, known as Ploiesti Plain; it has a complex micromorphology, represented by two or three terrace levels.

From a geological-structural point of view Nedelea site is situated in the internal folded side of the Carpathian Foredeep being included in the stratigraphical context of the Quaternary-Holocene deposits (figure 1) which include the recent alluviums of Prahova river, from the minor and major river bed, as well as from the lower terrace (1-3m relative altitude).

The alluviums of the terrace contain gravels and sands with clayey-sandy intercalations, the source of this material being secondary, resulted after repeated taking-over of a primary material originated in the internal Carpathian units. The thickness of the deposits according to drilling data from the area reaches 20-25m. The considerable thickness of the Pliocene-quaternary

formations in the area is due to the general subsidence at the curvature of the Carpathian units. The Holocene deposits are generally horizontal, discordantly over older formations, slightly declining south, according to the slope gradient of Prahova river.

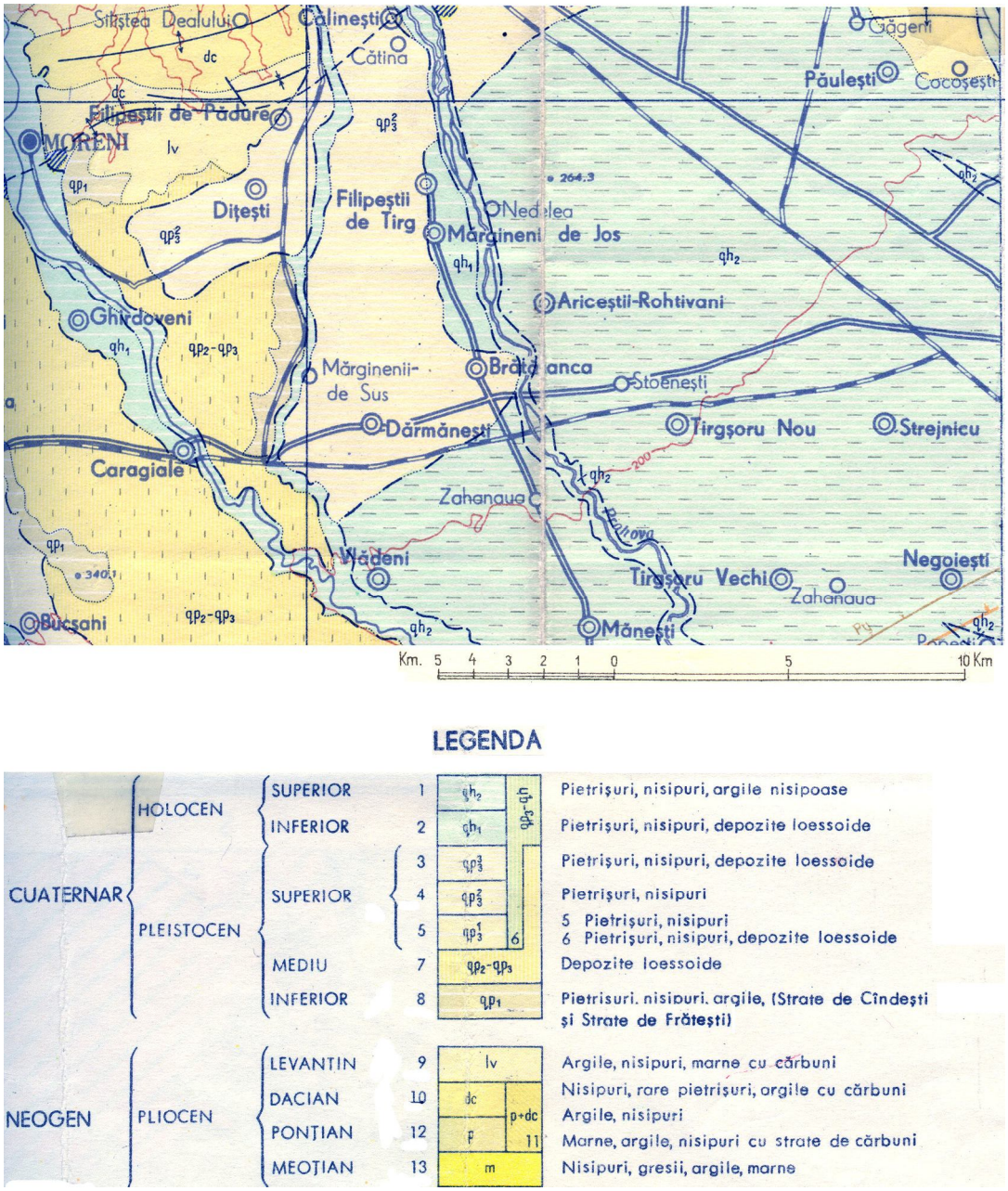

Fig. 1. Geological map fragment in the studied area
(after Geological Map of Romania, scale 1:200.000, Târgoviște sheet, 1968)

The deposits of natural river aggregates from Nedelea area is represented by an alluvial complex made up of gravels and boulders with sand from the Holocene age, quasi-horizontally disposed on the Upper Romanian and Pleistocene formations, which are in their turn made up of alohtone polygene clastes of rudites of a sedimentary origine (a source area in the internal Carpathian units). The mineral resource has the characteristics of the fluviatile deposits with current oblique stratification and with an accumulation of the point-bar type (lateral accretion at the interior of the meander, with frequent structures of the channel filling type, or of crevasse fan). In the

series of Holocene deposits there appear clayey lens-shaped intercalations, with a thickness varying from centimeters to decimeters, more frequently appearing as pellicles in the rudite fraction. The cover of the deposits is very thin, almost inexistent, the process of turning into soil being reduced, this cover being less than a decimeter thick, made of clayey sands and sandy clays with a reduced content of organic substance.

Mineralogical-petrographical investigations

Mineralogical-petrographical characteristics

The natural river aggregates from Nedelea zone form a detrital complex of rudites and arenites, disposed in layers or lens, with a cross-bedding structure and having a predominantly grey or grey-yellowish colour. The mineralogical-petrographical study was carried out in the speciality laboratory of Petroleum-Gas University in Ploiesti. The mineralogical-petrographical constituents of the useful complex are represented by calcareous and siliceous sandstones, limestones, marly-limestones, quartzites, micaschists and green schists.

The arenitic fraction is represented by clayey sand, from middle to big in size and made up of grey quartz grains from subrounded to rounded, feldspar grains, mica paillettes, fragments of sandstones, limestones, marly-limestones and crystalline schists.

The ruditic fraction has a polimictic character, with a sorting degree from medium to weak and a good rolling. It is made up of calcareous sandstones (55%), quartzitic sandstones (5%), limestones (5%), marly-limestones (23%), quartzites (7%), micaschists (4%), and green schists (1%).

The sandstones are generally polimictic, with calcareous cement, rarely siliceous or ferruginous, grey and with fissures. The white-yellowish limestones are from micritic to sparitic, rarely organogenous (reef-like). The white or white-grey quartzites have a high percent of SiO_2, sometimes looking like the rounded blocks of chalcedony. The crystalline schists, generally represented by muscovitic micaschists or green schists have small dimensions and a reduced weight, being characteristic for the flattened elements.

The detrital part of the useful complex has a low sorting degree, the rolling degree being advanced, the elements having flat surfaces, rarely rugged, covered with clayey pellicles in most cases.

The granulometrical composition

The granulometrical composition of the deposits indicates the presence of accumulations of natural river aggregates and considering the average of the analyzed samples belongs to the domain: clay + silt (<0,05mm) – 16-17%; sand (0,05-2mm) – 9%; gravel (2-20mm) – 40%; boulder (20-200mm) – 35%; parts that can be levigated (>0,05mm) – 17-18%.

After separating the class of the gravel pit the following percents were obtained (according to the analysis paper no 233/05.02 2010 carried out by the central laboratory of S.C.Lafarge Agregate-Concrete S.A. from Ploiesti): class 0-4mm: 15,3%; class 4-8mm: 10,83%; class 8-16mm: 21,2%; class 16-31mm: 27,5%; class > 31,5mm: 25,1%; part that can be levigated: 17,8%.

Morphometrical characteristics

The elements more than 7mm in diameter are generally rounded and subrounded in a percentage of 65% and subangular 35%. The shape of sand clastes (Φ=0,05-2mm) is subangular to subrounded (for about 80%) and rounded (for about 20%).

Referring to the ratio of the geometrical parameters, they have the following values: *b/a*=0,67-0,82; *c/a*=0,40-0,65, values that correspond to the standards from STAS 1667/87 and STAS 662/69. The shape of the grains, according to the ratio of the clastes diameters ranks them in the subisometrical and subflattened domains.

Physical-chemical characteristics

The laboratory observations done on the sandy-clayey fraction offer the following data: (1) the clayey sand has a soily aspect and impurities that surpass the accepted limits of STAS 1667/84; (2) the large amount of clayey minerals (10-11%) imposes an adequate wash/ processing; (3) the clayey minerals cover both the small grains of the arenite type and those with a rudite type granulation; (4) the mica paillettes are up to 1%; (5) the content of soluble salts and sulphates is under 1%, as the standards require.

The X-ray diffraction

The sample was ground in an agate mortar with pestle to particle size smaller than about 20μm. X-ray powder diffraction data were measured at 24ºC using an automated Bruker D8 Advance θ-θ diffractometer, with CuKα radiation (λ = 1,54Å; 40kV; 40mA), a LynxEye solid-state Si detector and Bragg-Brentano geometry. Kβ radiation was eliminated by a Ni filter. Primary and secondary Soller slits were 2.5º. A fixed aperture and divergence slit of 0.6mm, a 0.6mm antidivergence slit and 0.1mm width detector slit were used. Data were obtained using 0.1º 2θ steps from 10º to 60º 2θ counting for 1 s per step. The powder was placed into a cavity mount in an attempt to minimize preferred orientation.

The phase qualitative analysis carried out with the help of DIFFRAC^{plus} EVA soft (figure 2) showed the following composition: quartz, clinochlor, muscovite and calcite.

At a phase quantitative interpretation done with the DIFFRAC^{plus} TOPAS 4.1 soft (figure 3) the minerals had the following percentual composition: quartz – 22,23%, clinochlor – 62,28%, muscovite – 12,94%, calcite – 2,55%.

Results and discussions

In order to determine the degree of cohesion of the clayey fraction there were carried out some lab tests which permitted to estimate the cohesion as having values of *c*=36-38kPa and a friction angle Φ=23°, which are high values, corresponding to some clean clays but not typical for clayey sands. These values increase the adhesion of clay minerals sheets to detrital grains, making harder their complete wash and consequently reducing the quality of concrete resulted from the use of these aggregates.

In order to establish the causes of these phenomena there were carried out mineralogical analyses by X-ray diffraction with a Bruker AXS type D8 Advance diffractometer on the fine, silty-clayey fraction. The interpretation of diffractograms indicated a mineralogical composition of immature diagenetic clays, made up of phyllosilicates of the clinochlore type which resulted from the chemical alteration of some silicates of the magnesian amphiboles, the biotite or the pyroxenes type from the Carpathian crystalline rocks.

The chlorites (clinochlore) from the clayey matrix of the gravels from Nedelea gravel pit could result most probably from reactions of chemical alteration of the above mentioned types:

$5Ca_2Mg_3Al_2[Al_2Si_6O_{22}](OH)_2+2CaAl_2Si_2O_8+10H_2O\rightarrow$

hornblende anortite

$\rightarrow 3Mg_5Al[AlSi_3O_{10}](OH)_8+6Ca_2Al_3Si_3O_{12}(OH)+7SiO_2$

chlorite epidote

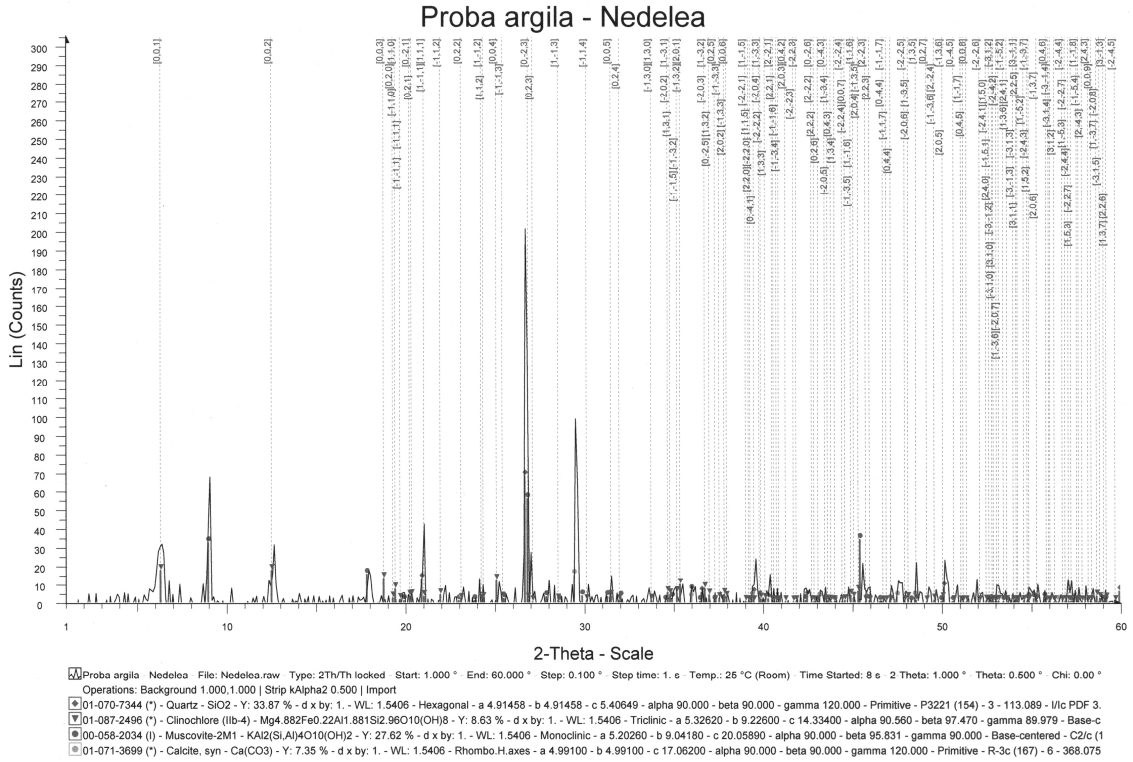

Fig. 2. Qualitative interpretation of the diffractogram of the clay sample from Nedelea gravel pit.

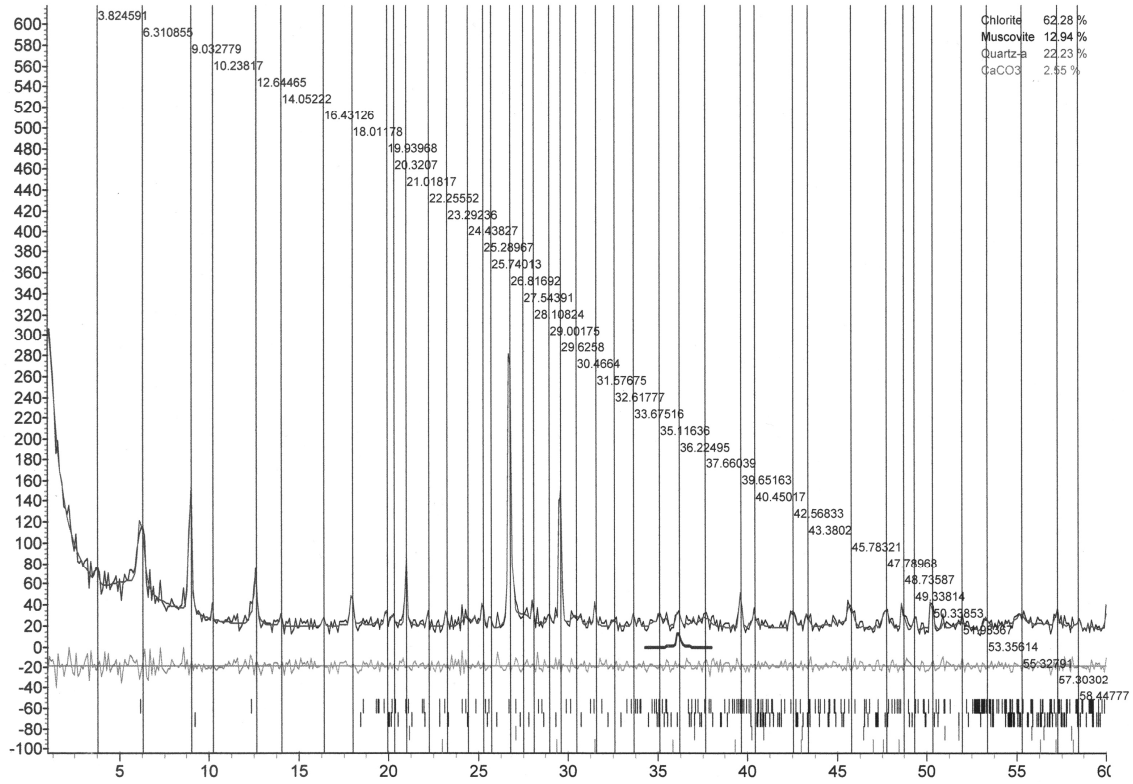

Fig. 3. Quantitative interpretation of the diffractogram of the clay sample from Nedelea gravel pit.

$$25Ca_2(Mg,Fe)_3Al_2[Al_2Si_6O_{22}](OH)_2+44H_2O\rightarrow$$

hornblende

$$\rightarrow 14Mg_5Al[AlSi_3O_{10}](OH)_8+24Ca_2Al_3Si_3O_{12}(OH)+ Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2+28SiO_2$$

chlorite epidote actinolite

$$Ca_2Al_3Si_3O_{12}(OH)+Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2+H_2O+CO_2\rightarrow Mg_5Al_2Si_3O_{10}(OH)_8+SiO_2+4CaCO_3$$

epidote actinolite chlorite

$$Ca_2[(Mg,Fe)_4(Al,Fe^{3+})][AlSi_7O_{22}](OH)_2+H_2O+2CO_2=(Mg,Fe^{2+})_5(Al,Fe^{3+})_2Si_3O_{10}(OH)_8+2CaCO_3$$

hornblende chlorite

The biotite releases K^+ and changes to chlorite (possibly goethite) if there remains any available iron:

$$K(Mg,Fe)_3Si_3AlO_{10}(OH)_2 + H_2O + CO_2= (Mg,Fe)_5Al_2Si_3O_{10}(OH)_8 + K^+$$

biotite chlorite

The chemical alteration of the rock fragments into detrital grains of various sizes leads to the transformation of the crystalline lattices by dissociating the molecules into ions with the release of some cations from the crystalline lattice. With the release of these cations (Na, K, Ca, etc) at the surface of the mineral granules there remain in excess negative electric charges, which means that at the rocks surface some unsatisfied negative electric charges will appear. To these electric charges there will stick the sheets of phyllosilicates (chlorites) which also have some unsatisfied positive electric charges, resulted from fragmentation and these will adhere to the mineral granules. The smaller the dimensions of the chlorite sheets and the bigger the need for negative charges, the higher the adherence degree.

From the complex interpretation of diffractograms follows that the dimensions of the chlorite sheets are of 0,1-0,2µm, they have reduced dimensions compared with the common clay minerals (kaolinite, montmorillonite, illite), which increases the adherence degree to the detrital clastes, due to the larger specific surface and consequently due to the larger number of unsatisfied electric charges on the sheet sides. This also explains the high degree of cohesion of the clayey sands in the matrix, which is not typical for this category of rocks and their uneasy separation from the surface of gravels clastes. Consequently, it is necessary to seriously wash of the gravels; that means that a prewash of the gravels has to be done in order to remove the clayey-sandy matrix; this will be followed by a wash with water pressure jets for removing the chlorite sheets (clayey minerals) which adhere to the detrital clastes.

Conclusions

The matrix of the gravels from Nedelea gravel pit, exploited by S.C. Lafarge Agregate-Betoane S.A. for the preparation of concrete, is an atypical clayey matrix, hard to remove from the sides of the gravel clastes with a common wash with water jets, this having unfortunate implications for the preparation of concrete.

The detailed mineralogical-petrographical study revealed the presence in a large amount of chlorites (over 60%), which favours the electrochemical adherence to the gravel clastes.

The interpretation of diffractograms shows a mineralogical composition of diagenetic immature clays, made up of phyllosilicates of the clinochlor type, which resulted from the chemical alteration of some silicates of the magnesian amphiboles, biotite or pyroxenes type from the

Carpathian crystalline rocks. The reduce dimensions of the chlorites sheets (0,1-0,2μm) facilitates the increase of the adherence to the surface of the mineral grains.

As a solution to remove more efficiently the clayey matrix from the gravel clastes a prewash of the gravels is recommended, in order to remove the clayey-sandy matrix, this being followed by washing under pressure, for the removal of the chlorite sheets that adhere to detrital clastes.

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Studiul mineralogo-petrografic al matricei argiloase a pietrişurilor din balastiera Nedelea

Rezumat

Pietrişurile din balastiera Nedelea (com. Ariceştii Rahtivani, jud. Prahova), din versantul stâng al râului Prahova, exploatate de către S.C. Lafarge Agregate-Betoane S.A. pentru preparare betoane prezintă o matrice argiloasă atipică, greu de îndepărtat prin spălare obişnuită cu jet de apă, cu implicaţii nefavorabile în prepararea betoanelor. Studiul mineralogo-petrografic detaliat a relevat prezenţa în cantitate mare a cloritelor cu un conţinut ionic care favorizează aderenţa de natură electrochimică la clastele de pietriş.