MINERALOGICAL, CHEMICAL AND TECHNOLOGICAL CHARACTERIZATION OF KAOLINITIC SANDS FROM DEPOSIT VYŠNÝ PETROVEC (SOUTH SLOVAKIA)

I. KRAUS[1], T. MANFRENDINI[2], P. UHLÍK[1], P. HVOŽĎARA[3], M. DUBÍKOVÁ[1], T. GRYGAR[4], V. STREŠKO[5], J. PAVLÍKOVÁ[1] and M. HANÚSKOVÁ[6]

[1] Department of Geology of Mineral Deposits, Comenius University, Mlynská Dolina G, 842 15 Bratislava, Slovakia
[2] Universita di Modena e Reggio Emilia, Via S. Eufemia 19, 41100, Modena, Italy
[3] Department of Mineralogy and Petrology, Comenius University, Mlynská Dolina G, 842 15 Bratislava, Slovakia
[4] Institute of Inorganic Chemistry, Academy of Science CR, 250 68 Řež, Czech Republic
[5] Geological Institute, Comenius University, Mlynská Dolina G, 842 15 Bratislava, Slovakia
[6] Demo Center, Modena, Italy

Abstract: Kaolinitic sands from deposit Vyšný Petrovec represent tree component system comprised of quartz (60-70 %), Fe-bearing muscovite (15-25 %) and kaolinite (12-18 %). The aim of the study is to define mineralogical and chemical composition of different fractions between 0.1 and 0.8 mm before and after electromagnetic and gravity separation as well as indication of perspective utilization of the 0.1-0.8 fraction for glass industry and ceramics.

Key words: Vyšný Petrovec, kaolinitic sands, heavy fraction, free Fe oxides, thermal treatment

INTRODUCTION

The deposit of sedimentary origin Vyšný Petrovec is situated in 10 km long and up to 1.5 km width belt of kaolinitic sands with the maximum thickness of 80 m in the northwest part of Lučenská fold (Hano et al., 1973; Hroncová and Sýkora, 1990). It could be considered as the most perspective source of domestic raw material for both ceramics and glass industry.

RESULTS AND DISCUSSION

Grain size analysis revealed that the 0.1-0.8 mm fraction represents almost 40 weight % of the bulk rock. The 0.1-0.8 mm fraction was divided into five fractions (Fig. 1), which were further characterized, by XRD, chemical analysis, gravimetric and electromagnetic separations of heavy, paramagnetic and diamagnetic fractions.

Along with detailed mineralogical studies, some technological investigation and testing was performed determining a possible and more effective utilization of kaolinitic sands in glass industry. These studies included the examination of a colour development after thermal treatments in heating conditions very similar to the industrial ones (to simulate industrial firing in roller kiln), as well as the effects of quartz sands (quartz fractions) addition into higher quality glass and ceramic bodies and aesthetical and microstructural characteristics of the obtained materials mixtures.

Mineralogical analysis confirmed that quartz is a major mineral in all separated fractions. Other minerals identified by XRD were Fe-bearing muscovite, siderite and rutile. The quantity of Fe-bearing muscovite decreased from finer to coarser fractions.

Extracted heavy and paramagnetic fractions did not exceed 2.5 % of any separated fraction. Mineralogy of these fractions was determined by combination of morphology observations using binocular magnification and XRD. Fe-oxyhydroxides appeared mostly as coatings on siderite grains and could be considered as a weathering product of siderite. The amount of Fe-oxyhydroxides and leucoxene was higher in the heavy and paramagnetic fractions extracted from the course-grained fractions. On the other hand, the amount of Fe-bearing muscovite, rutile, tourmaline slightly increased from the coarser to the finer fractions. The volume of Fe-bearing muscovite significantly increased (from 5-10 % to 30-50%) after change of current from 1.2 to 2.5 A. About the same amount of ilmenite was identified in all heavy and paramagnetic fractions.

According to chemical analysis of the quartz fractions the content of SiO_2 increased from 93.32 % in the fine fraction up to 97.88 % in the coarsest fraction. On the other hand, with increasing grain size the content of Al_2O_3 and K_2O decreased. The amounts of Fe_2O_3 and TiO_2 were relatively high in all studied fractions (Fig. 1). In general, the presence of colouring Fe and Ti oxides reduces the quality of a raw material used for production of glass, therefore the attention was paid to detail characterization of Fe and Ti mineral phases.

The amount of free Fe oxides in the whole as well as in the diamagnetic fractions was determined by dissolution in dithionite citrate bicarbonate solution (Mehra and Jackson, 1960) (Fig. 2). The proportion of free Fe oxides to the total Fe content decreased about two-thirds after electromagnetic separation. The results of the selective dissolution treatment were in a good agreement with quantification by voltammetric method (Grygar et al., 2002). Chemical analysis of diamagnetic fraction revealed that in spite of electromagnetic separation of colouring oxides the quantities of Fe and Ti still exceeded the Slovak Technical Norm (STN) for production of table and container glass (T_{40}, T_{25}, Fig.1).

The results of the technological testing found two possible applications of quartz sands. All five quartz fractions (between 0.1-0.8 mm) are suitable for production of common glasses (probably not in special optical and functional glasses) when they are added as an admixture into a high quality row material. The addition of about 20 % of quartz sands into a glass matrix produced results comparable to addition of the same amount of a standard quality Italian sand. During melting all iron and titanium minerals were dissolved in the amorphous glass matrix so the more suitable fractions are those containing the lowest amount of iron and titanium minerals (the coarsest fraction).

The quartz fractions added as a filler instead of a standard quartz sand did not change the sintering mechanism of bodies and the microstructure of the ceramic products. The coarsest fraction seems to be acceptable in formulation uncoloured bodies only in a small amount. The other smaller fractions are suitable and acceptable in general in all the ceramic body formulations.

The amount of colouring oxides is not always decisive for estimation of raw material availability. The important is also the form of bond, if Ti and Fe are bind in oxides, carbonates or silicates. As an example is a comparison of results obtained after firing of two fractions with a different distribution of free Fe-oxides and Fe-bearing minerals.

The 0.1-0.16 mm fraction contains less than 14 % of free Fe oxides from the total Fe content (0.45 %) and the main admixture is Fe-bearing muscovite. The content of free Fe oxides is about 30 % of the total Fe (0.31%) in the 0.63 - 0.8 mm fraction. In addition, the amount of siderite increased in this fraction. It can be concluded, that fractions containing Fe bound mostly in silicates are more suitable for glass industry despite a higher content of total iron.

CONCLUSION

The results showed that quartz sands from Vyšný Petrovec deposit have an application in both glass and ceramic industry. The economic rentability can be achieved only by parallel utilization of quartz sands together with the finer fraction containing kaolinite and operation of a suitable flotation.

References

Grygar T. et al. 2002: MECC'01, Geologica Carpathica, 53.

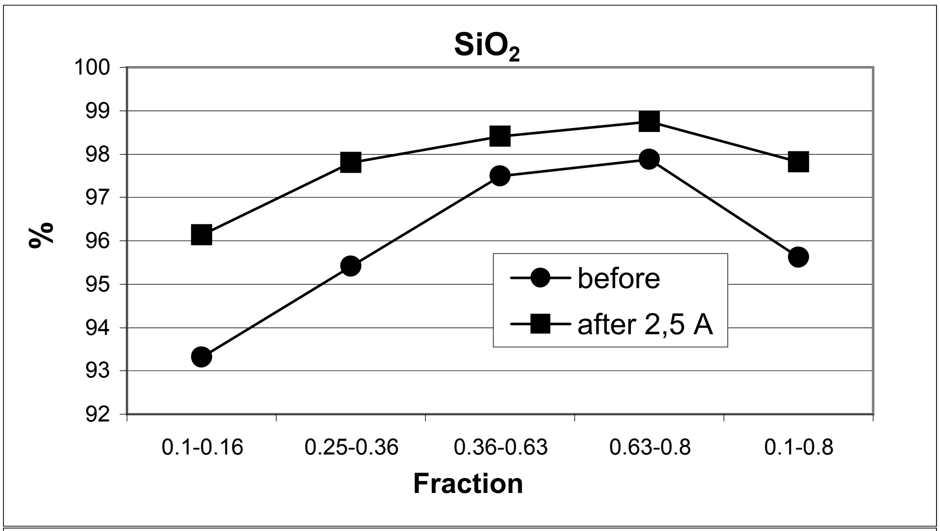
Hano V, Hasch J., Lukaj M., Bondarenková A., Vondráček 1973: Vyšný Petrovec – kaolinitic sands. Spišská Nová Ves, Geological survey, Geofond Bratislava, 74 p. (in Slovak)

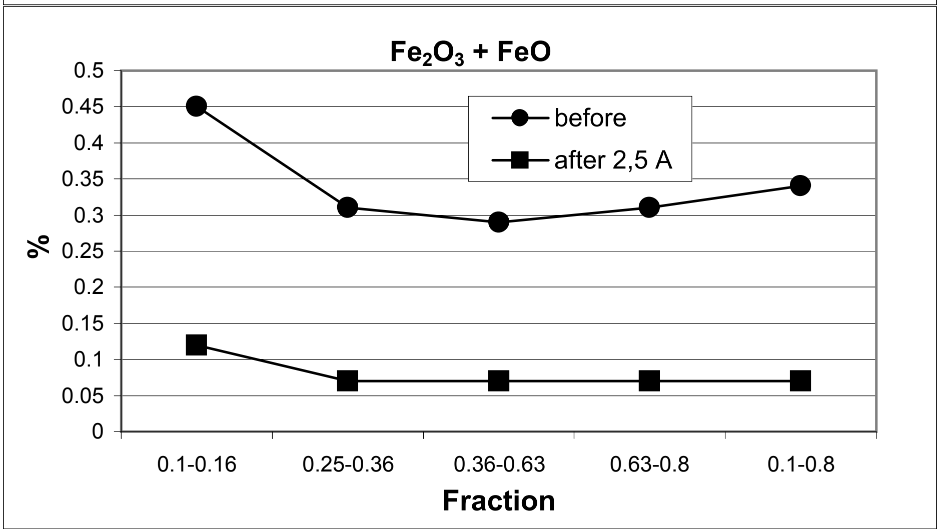
Hroncová Z., Sýkora J., Oško Ľ., 1990: Poltár V. - Vyšný Petrovec - Tovík - II. Stage, Raw material: Kaolinitic sands. Spišská Nová Ves, Geological survey, Geofond Bratislava, 71 p. (in Slovak)

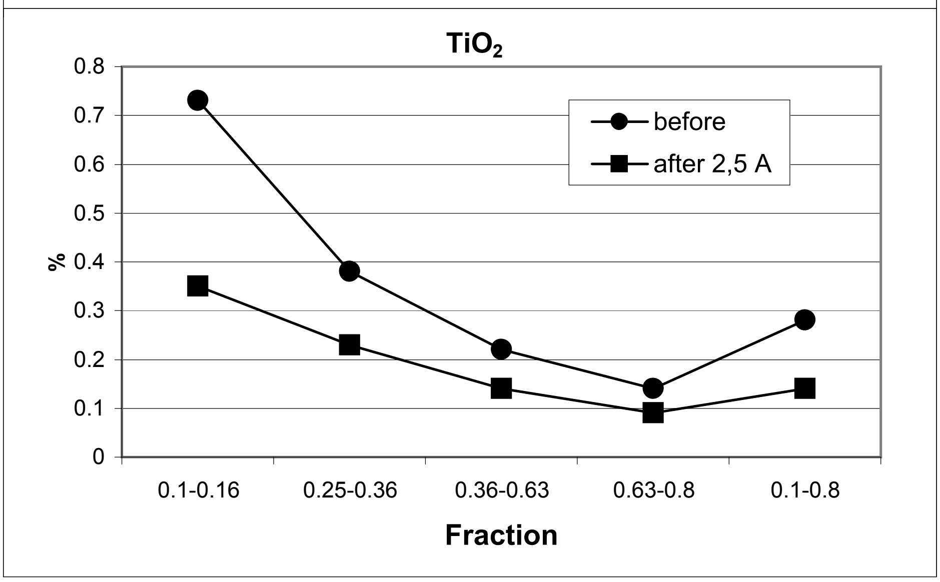
Mehra, O.P., Jackson, M.L., 1960. Iron oxide removal from soils and clays by a dithionite-citrate system buffered with sodium bicarbonate. 7th Nat. Confer. Clays and Clay Miner., Pergamon, Oxford, pp. 317-327.

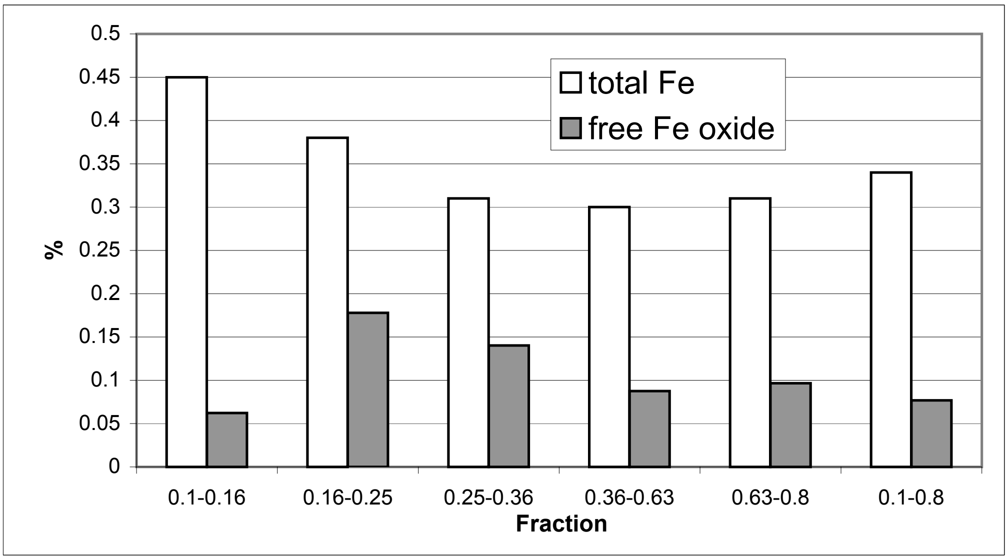
Fig. 1. Content of selected oxides in sand fractions before and after electromagnetic separation.

Fig. 2. Comparison of total Fe content and free Fe oxides in partial fractions.


SiO2
%
100
99
98
97
96
95
94
93
92
before
after 2,5 A
0.1-0.16
0.25-0.36
0.36-0.63
0.63-0.8
0.1-0.8
Fraction


Fe2O3 + FeO
%
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
before
after 2,5 A
0.1-0.16
0.25-0.36
0.36-0.63
0.63-0.8
0.1-0.8
Fraction


TiO2
%
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
before
after 2,5 A
0.1-0.16
0.25-0.36
0.36-0.63
0.63-0.8
0.1-0.8
Fraction


total Fe
free Fe oxide
%
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1-0.16
0.16-0.25
0.25-0.36
0.36-0.63
0.63-0.8
0.1-0.8
Fraction