Annual of the University of Mining and Geology "St. Ivan Rilski"
vol.44-45, part III, Mechanization, electrification and automation in mines, Sofia, 2002, pp. 33-36

IMPACT OF THE BALL-CRUSHER GRINDING BALL LOAD AND THE NUMBER OF REVOLUTIONS ON THE SELECTIVE GRINDING IN THE PROCESS OF DRESSING OF CHROMITE-BEARING SOILS OF THE VURINOS OTHOLITE COMPLEX, WEST MACEDONIA - GREECE

Kargiotis E.	Godulas K.	Chathtsiavigustis T.	Vatalis K.	Manoliadis O.
TEI of Kavala Greece	Technological Institute West Macedonia Greece	Technological Institute West Macedonia Greece	Technological Institute West Macedonia Greece	Technological Institute West Macedonia Greece

ABSTRACT
The weathering of ultrabasic rocks such as peridotites and dunites as well as the serpentines originating from them has led to a downward enrichment of valuable metals into the Vurinos complex. Nickel and cobalt could be absolutely enriched in certain zones where a weathered laterithic layer is observed while the iron and chrome spinel show a relative enrichment. As the mineralogical study made by X-ray and microscopic analyses as well as by microsounding showed that the more important products of the weathering are composed by ferro-hydroxy limonite and heavy minerals such as chromite and magnetite. The chromite grains are coalesced with the hard limonite aggregates in the soils. Thus they should be preliminary concentrated to have a possibility for their separation. For the purpose the samples are grinded selectively in a ball-crusher. After numerous of tests the following optimal grinding parameters are obtained: grinding ball load of the ball-crusher - 40 volume % and revolutions as of 30 % n_{krit}. The good grinding results are achieved in conditions of grinding ball load of steel balls with diameters 16, 12, 10, 8 и 3 mm respectively. The optimum grinding span is 15 min and in this case a content of 38 % Cr_2O_3 in a class of grading > 100 μm. The chrome loss is 13% in the class of grading <20 μm
Key wards: selective fine grinding, ball-crusher revolutions, chromite.

INTRODUCTION

Geological frame

The Vurinos massif is located in the Northern Greece province of Western Macadonia. It is of the type of "Super-Spreading Zone" (SSZ) otolith (Beccaluva et al., 1984, Pearce et al. 1984). There are number of these otolith which content chromite ore concentrations and thus they represent a scientific interest. That is way the SSZ otolith in that area could be considered as belonging to the world chromite reserves. For the reason the last fact let us have an opinion that the Vurinos massif material is very appropriate for investigations in respect of variability of the oregenetic, magnetic and tectonic processes. The Vurinos massif is considered as composed of three parts: Northern, Southern and Western Vurinos. The massif represents a fully separated ore body. The 12 km long otolith Vurinos vein is composed of a tectonic area which is probably of upper mantle material (shifted up during the time of a new crust formation) and a magmatic area formed by magma intrusion during processes of cumulative crystallization differentiation. Some of the chromite deposits are located in the dunites of the magmatic section.

The Vurinos massif situated on an area of 400 km^2 is separated from the big pindos and the ophiolites by mezzo-folded sediments (Smith, 1979). Ophiolitic rocks are represented in the mean zone of those sediments for which the same obduction direction. Therefore they are considered as co-oceanic (Smith & Moores, 1974; Smith, 1979). In the end, Vurinos has obducted during the Late Jurassic and Early Cretaceous through metamorphosed Lower Jurassic carbonates and Tertiary depositions along the West periphery of the Pelagonian (Moores, 1969). Smith (1979), Nazlor & Harlie (1976) и Rassios et al. (1983) point out that in that direction the obduction has been reoriented to the SSW direction.

Serpentinization and weathering processes of the Vurinos Otholites are investigated by Savvidis (1996), Savvidis & Hovorka (1996) и Savvidis et al. (1997, 2001a, 2001b, 2001c) и Hovorka et al. (1997).

EXPERIMENT FORMULATION

Selective fine grinding

A big amount of the material which is free of slime composed of limonite aggregates. They content also heavy materials such as magnetite and chromite. For achieving a high chromite recovery it should be outcropped. For the reason it was necessary the limonite aggregates to be selectively fine grinded.

As it was shown by the microscopic investigations of Hovorka et al. (1996) the chromite grains are very often aggregate with oxidized iron in such a way that it is impossible

to obtain a valuable chromite concentrate by using of density separation which is usually applied for dressing of the primary ores. The Cr_2O_3 content in the concentrates of the laterite chromite ores which are recovered in a washed ore mass amounts of about 41 % at ratio of Cr - Fe equal to 1,4. The Cr_2O_3 content of the concentrate recovered from the primary chrome ores located in the same area and which Cr - Fe ratio were higher than that of the chrome spinels, amounts of about 50 % in conditions of the ratio 2,3 (Oh, 1984; Korn, 1970). A high quality dressing of the latherite chrome ores by using of the ore dressing methods is possible only in that case when a preliminary separation of the accreted grains has taken place. As the zones accreted with the chromite have a high content of FeO and substantially lower hardness than the chromite it is possible to obtain a better chromite product by using of selective fine grinding.

After considering of an investigation conception it was choosen the method of J. S. Oh (1985).

Grinding parameters influence

The ball-crusher was selected on the base of the more specific properties of the materials to be undergone to a selective fine grinding. Experiments related to the change of the different grinding parameters were performed aiming an optimization of the grinding conditions.

Ball-crusher parameters:

External diameter:	189 mm
Internal diameter:	175 mm
Ball-crusher length:	269 mm
Ball-crusher volume:	6470 ml

A smooth revetment ball-crush was chosen on the base of the theoretical and the reference data.

Diameter, mm	Weight ratio,%
16	30
12	23
10	19
8	16
6	12

Influence of the number of the revolutions and ball load of the ball-crusher

The chromite shows a brittle behavior during its processing so it is necessary to avoid the blow activity of the balls in the ball-crusher. For the reason the ball-crusher revolutions and the grade of its filling with grinding bodies should be determined very well. The optimal ranges of the revolutions and the grade of grinding ball filling were determined on the base of the results obtained by the performed tests. These values are as follow: the number of the revolutions are in a range between 20 and 40 % of n_{crit} and the degree of ball-crusher filling with ball load varying between 30 и 50 %. Different grinding time intervals ranging between 5 and 20 min were chosen to be possible a clarifying of the grinding kinetics. The result of the grinding allowed the bolting of the result product by screens of 100, 63 и 20 μm respectively and the four classes obtained were undergone to chemical analyses. The results are shown on a table. It was turned out that the number of the revolutions exert stronger influence on the results than the grade of the ball-crusher filing with grinding bodies. The last one proves the fact that the material fine grinding is relatively slightly influenced by the different forces of blow which depends on the grade of the filling mentioned above.

An increased chromite enrichment at number of revolutions as of 30 % of n_{crit} as well as a slight decrease of the Cr_2O_3 recovery were established for the solids of grinding size higher than 100 μm. It was established also that in the case of a higher number of revolutions - 40 % of n_{crit} the quality of the enrichment process become less and in the same time the recovery process was accelerated. It showed that at this number of the revolutions the selective action of the grinding balls was significantly decreased.

The results obtained by using of the finest class < 20 μm compared to the results related to the class > 100 μm were as follow: the content and the recovery of the Cr_2O_3 was increased rapidly at number of the revolutions as of 30 % n_{crit} . It was established that for obtaining of a better result of the grinding the grinding time should not to be more than 15 min. The grinding results obtained for a grinding time of 15 min are presented in the Figures 1 - 4.

As it is shown in the Figure 1 the grade of ball-crusher filling with grinding bodies exert a monotonic influence on the Cr_2O_3 content in the class > 100 μm when the number of the revolutions is 20 % of $n_{крит}$.

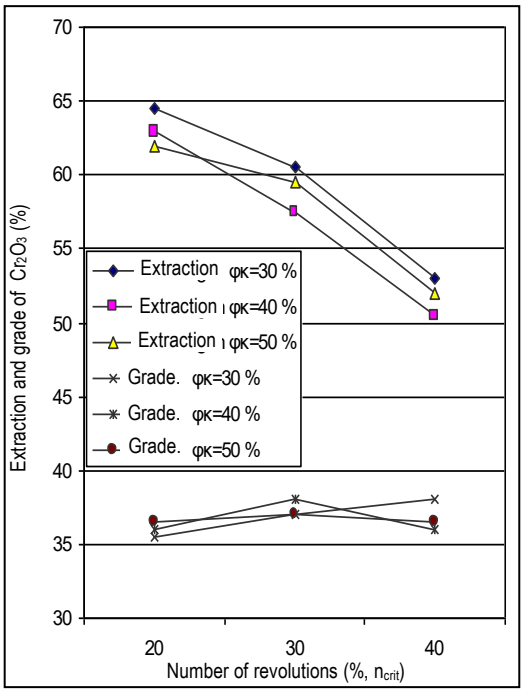

Figure 1. Results for the grinding of the class $>10^{-4}$mm depending on the number of the revolutions n_{crit} the ball-crusher grinding ball load. Grinding span - 15 min

When the ball-crusher filling with grinding bodies is increased the Cr_2O_3 content was increased from 35,5 to 36,3 %.

However, that result could be not established at a higher number of the revolutions. The highest Cr_2O_3 content – 37,2 % was established at number of revolutions 30 % of n_{crit} and filling grade of 40 %.

The grinding results was carried out further by using of microscope. There was not at all limonite aggregates. Nevertheless, the vein minerals such as quartz, piroxene and so on wich are still presented in the material should be separated.

The grinding results obtained at number of revolutions of 40 % of n_{crit} showed a highly undesired fine grinding of the chromite. As the best conditions for the fine grinding of the class of grinding size > 100 μm were established: number of the revolutions - 30 % of n_{crit} and grade of ball-crusher filling with grinding balls - 40 %.

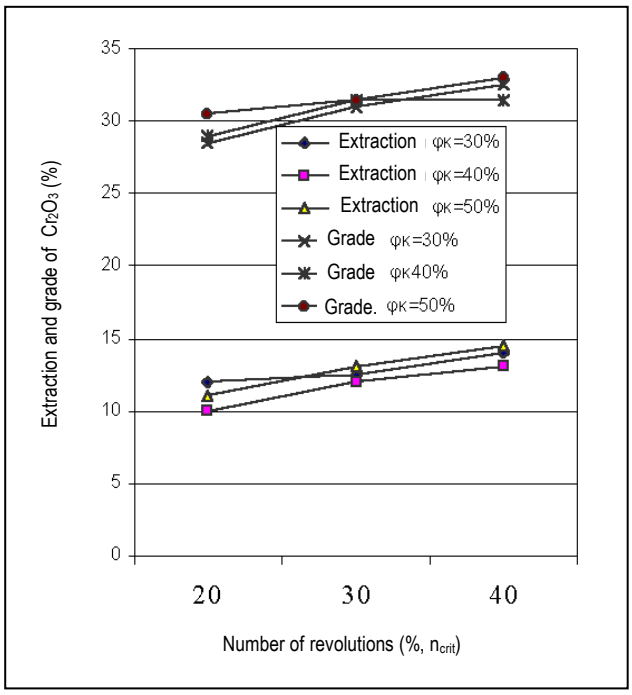

Figure 2. Results for the grinding of the class 100 -63 mm depending on the number of the revolutions n_{crit} the ball-crusher grinding ball load. Grinding span - 15 min

It could be seen from the Figure 2 that the desired dressing of the limonite aggregates in the medium class could be not achieved yet. The Cr_2O_3 content was still in the interval 29,1 - 32,5 %. The last fact could be explained as follow: the light limonite aggregates are so mobile in these conditions that they pass easy among the grinding balls and in that way they are not influenced by the last ones. In the limonite aggregates of the class of size > 100 μm as by-elements are most often observed fine heavy minerals and silicate minerals. Those inhomogeneous aggregates have a less hardness compared with the homogeneous aggregates which are composed only of agglomerated limonite and in that way they are being quite easily fine grinded in the ball-crusher. A high percent of limonite aggregates are presented in the class of the grinding size of 100 - 63 μm - about 70 % while heavy and silica minerals are not presented. Those aggregates are very stabile in respect to the crushing activity of the balls and that is why they are slightly fine grinded in these conditions.

The last grinding size class ore grinded during time of 15 min was bolted by screen of 80 μm. It turned out that the limonite aggregates are presented mainly in the class of grinding size of 80 - 63 μm.

The results of the grinding of the grinding class of size 63 - 20 μm are shown on the Figure 3. The Cr_2O_3. content increased contemporary with the increase of the number of the revolutions. The highest content of Cr_2O_3 was achieved at number of revolutions as of 40 % of n_{crit} and 50 % of the ball-crusher filling with the grinding bodies. That value amounts of 21,3 % in conditions of recovery of 18,8 %. The content obtained shows that a big part of that class is still assembled by limonite aggregates.

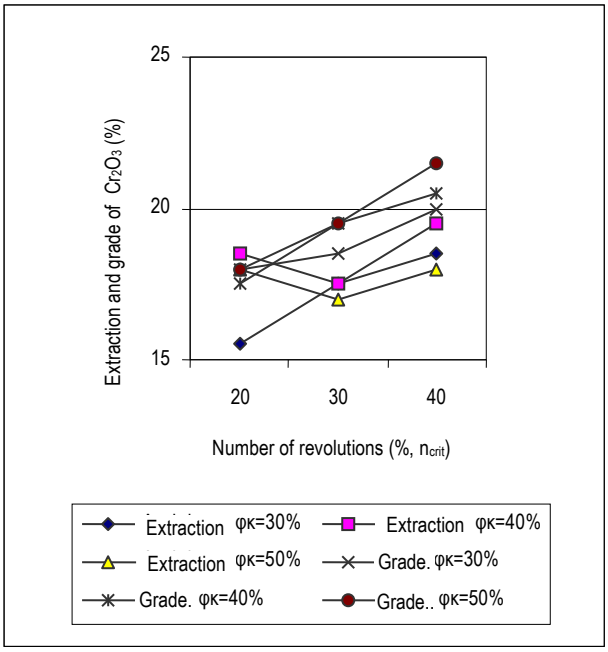

Figure 3. Results for the fine grinding experiments of the class 63 – 20 mm depending on the number of the revolutions n_{crit} the ball-crusher grinding ball load.

The finely grinded chromite is a premise for an increase of the Cr_2O_3 content and its recovery for the class of grinding size less than 20 μт. According to the curves shown in the Figure 4 it could be established that the Cr_2O_3 recovery depends more on the revolutions than on the grade of the ball-crusher filling with balls. A higher increase is observed when the number of the revolutions is 40 % of n_{crit}.

DISCUSSION OF THE RESULTS

After numerous of tests the optimal parameters of the grinding in respect to the grade of ball-crusher filling with balls as well as the number of the revolutions of the last one were found. As the most advantageous conditions among the all grinding conditions mentioned above were established the following ones: ball-crusher revolutions 30 % n_{crit} and the

grade of ball-crusher grinding ball load as of 40 % because they could provide the best enrichment of the chromite high classes of grading.

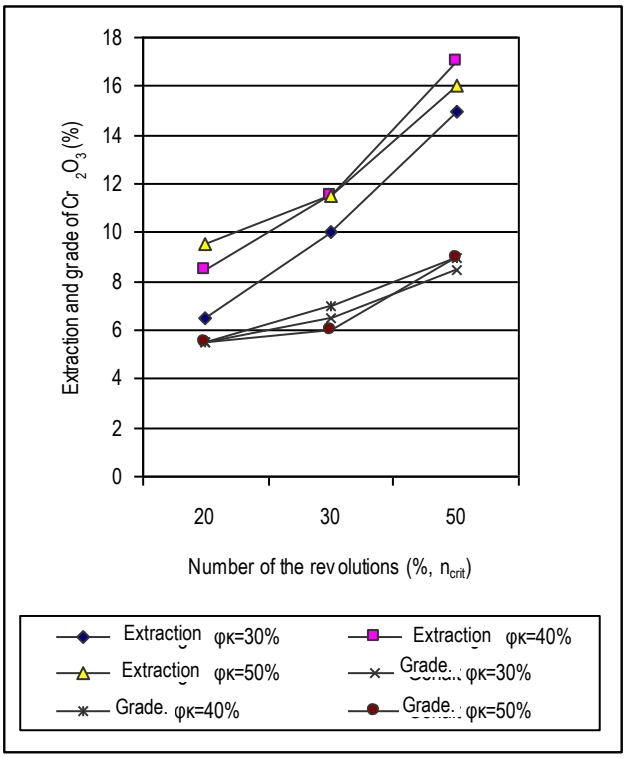

Figure 4. Results for the grinding of the class 63 - 20 mm depending on the number of the revolutions n_{crit} and the ball load of the ball-crusher; Grinding span - 15 min

REFERENCES

Beccaluva, L., Ohnenstetter, D., Ohnenstetter, M and Paupy, A., 1984: Two magmatic series with island-arc affinity within the vourinos ophiolite. Constr. Min. Petr. 85, 253-271.

Hovorka, D., Savvidis, S., 1997: Serpentinites in the Ophiolite complexes of the Vourinos and Kamvounia Mts. (Northern Greece). Geologica Carpathica, 48, 18 – 26.

Korn, M., 1970: Aufbereitungstechnik, S. 713-729.

Moores, E., 1969 : Petrology and structure of the vourinos ophilite complex of northern Greece. Geol. Soc. Am. Spec. Pap 118, 65 pp.

Mountrakis, D., 1985: Geologie Griechenlands. University Studio Press, Thessaloniki.

Naylor, M., Harle, T., 1976: Paleogeographic signifigance of rocks and structures beneath the vourinos ophiolite, northern Greece. Jour. Geol. Soc. London 132, 667-682.

Oh J.S., 1985: Untersuchungen zu Entwicklung eines verfahrens zur Trennung von chromit aus laterit unter besonderer Berucksichtigung der rohstofflichen Beschaffenheit. Dissertation RWTH Aachen.

Oh, J.S., 1984: BMT-Bericht, Nr 213, unveröffentlicht.

Pearce, J., Lippard, S. and Roberts, S., 1984: Characteristics and tectonic signifigance of subra-subduction zone ophiolites. In Kokellar, B. and Howels, M., eds. Marg basin Geology, Blackwell Scien. Publ. 77-94.

Rassios, A., Moores, E. and Green D. H., 1983: Magmatic structure and stratigraphy of the vourinos ophiolite cumulate zone, Northern Greece. Ophioliti 8 (3), 377-410.

Savvidis, S., 1996: Resultate geochemischer, petrologischer, lagerstättenkündlicher und mineralogischer Studien am Vourinos Ophiolith-Komplex, Griechenland. Dissertation, Comenius Universität Bratislava, 1996.

Savvidis, S., Hovorka, D., 1997: Vourinos Complex (Greece) – An example of eastern mediterranean Ophiolite. Geologica Carpathica, 48, 11 – 18.

Savvidis, S., Kargiotis, E., 1997 : Die Serpentin - Gruppe Minerale im Vourinos Ophiolith-Komplex, Nord Griechenland. Oberhessische Naturwissenschaftliche Zeitschrift ISSN 0340 - 4498, Band 59, S. 91 –101.

Savvidis, S., Kargiotis, E., 2001c : Mikrostruktur der Chromite und ihrer Nebengesteine im Vourinos Ophiolith – Komplex, West Makedonien, Nord Griechenland. Oberhessische Naturwissenschaftliche Zeitschrift ISSN 0340 - 4498, in Print.

Savvidis, S., Vatalis, K., Kargiotis, E., Charalampidis, G., and Zissopoulos, D., 2001a : Die Geochemie des Ursprungsmagmas und die Chromiterzbildung im Vourinos – Ophiolith Komplex, Nord Griechenland. Mineralia Slovaca, Vol 33, No 2.

Savvidis, S., Vatalis, K., Kargiotis, E., Charalampidis, G., and Zissopoulos, D., 2001b : Der Einfluss des Schaumssystems auf die Selektivität des Flotationsprozesses bei der zinnsteinflotation. Mineralia Slovaca, Vol 33, No 4.

Smith, A.G., 1979: Othris, Pindos and Vourinos Ophiolites and the pelagonian zone. Proc. Colloq. Geol. Aegean Region. 6, 1369-1374.

Recommended for publication by Department of Mineral Processing, Faculty of Mining Technology