Chromite Deposits from Western Sahara: Textures, Composition and Platinum Group Minerals

/ SALEH LEHBIB (1, *), ANTONIO ARRIBAS (2), JOAN CARLES MELGAREJO (1), JOAQUÍN A. PROENZA (1), FEDERICA ZACCARINI (3), OSKAR THALHAMMER (3), GIORGIO GARUTI (3,4)

(1) Departament de Cristal·lografia, Mineralogia i Dipòsits Minerals. Facultat de Geologia. Universitat de Barcelona, C/ Martí i Franquès s/n, E–08028 Barcelona (Spain)
(2) Escuela Técnica Superior de Ingenieros de Minas, C/Ríos Rosas, 21. 28003 – Madrid (Spain)
(3) Department of Applied Geological Sciences and Geophysics, The University of Leoben, P. Tunner Str, 5, A–8700 Leoben (Austria)
(4) Department of Earth Sciences, The University of Modena and Reggio Emilia, S. Eufemia 19, I–41100 Modena (Italy)

INTRODUCTION.

The basement rocks of the Western Sahara contains small deposits of podiform chromitite. The political situation of the area prevented since many years ago a detailed study of these bodies. Fortunately, a very detailed sampling of the basement of this area was performed 50 years ago by one of us (Arribas, 1968). This collection of rocks and thin sections has been used for this study. The present work gives for first time data on the textures, composition and platinum group minerals in the Western Sahara chromitites.

GEOLOGICAL BACKGROUND.

The study area is found in the Mauritanide belt domain of the Western Sahara (Figs. 1 and 2).

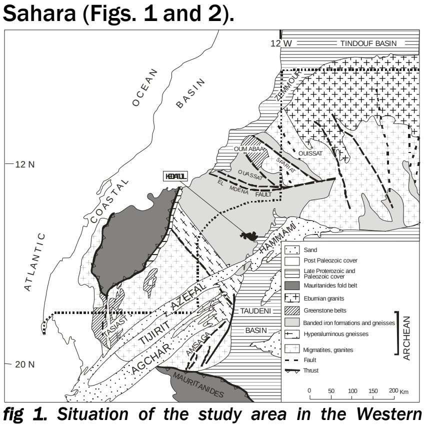

fig 1. Situation of the study area in the Western Sahara and the Mauritanide fault belt (Rocci et al., 1991).

The Mauritanide fault belt is the result of polycyclic tectonic events, first the Panafrican orogeny (680-525 Ma) and later the Hercynian orogeny (325-300 Ma), and was produced by the Gondwana-Laurentia collision. This fact has been proved by the occurrence of hercynian eclogites (Le Goff et al., 2001) and the ophiolites of the study area.

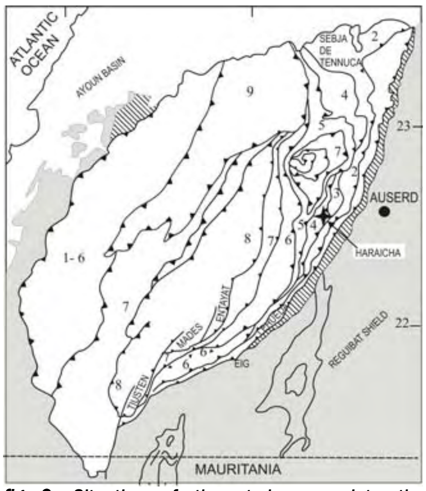

fig 2. Situation of the study area into the Mauritanide fault belt (Rocci et al., 1991). 1, metasedimentary rocks in greenschist facies; 2, banded iron formations, schists, gneisses, amphibolites, leptinite, serpentinites; 3, granites; 4, amphibolites, marbles, schists; 5, quarzites and micaschists; 6, sheared granites; 7, amphibolites and gneisses I granulitic facies; 8, metabasites (Adrar Sutuf range); 9, greenschists. Modified after Lécorché et al. (1991).

CHROMITITE OCCURRENCE.

Chromitite pods occur as small lenses embedded into serpentinites. The ensemble is strongly affected by shear bands dipping to the NW, in some cases enriched with fuchsite. Chromitite pods are massive, and chromite constitute more than 90% of the rock. Accompanying minerals include fine-grained magnetite, chlorite and serpentine.

MINERALOGY AND TEXTURES.

Chromitite textures are predominantly massive, and locally grading to disseminated. The primary spinel corresponds to chromite s.s. and it is extensively replaced along the borders of the grains by a second generation of Cr-rich spinels. Backscattered-electron images have shown that chromite grains are predominantly composed of two zones (fig. 3): (i) Al-rich chromites (dark appearance, lower atomic number) and (ii) Fe-rich chromites (light appearance, high atomic number).

No primary silicates were found. The most abundant silicate is chlorite, accompanied by minor titanite. Fe-rich chromite is porous and contain numerous chlorite inclusions. Fractures in the chromitites are filled with chlorite.

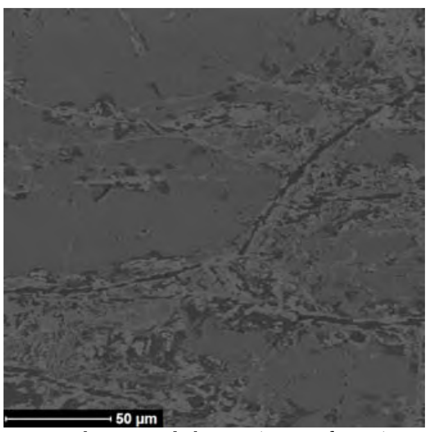

fig 3. Back-scattered electron image of massive chromitite sample. Primary chromite (slightly darker) is replaced by a more Fe-rich Cr-spinel (light) around grain borders and cracks.

Laurite was the only platinum-group mineral found as euhedral inclusions in chromite or as individual crystal

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* corresponding author: slehbib@yahoo.es

attached to chromite grains, generally up to 10 mm across (Fig. 4). The textural position and shape suggest a primary origin, formed at high temperature as pristine liquidus phase and mechanically collected in crystallizing chromite. Together with laurite, chromite grains contain Ni sulfides and awaruite.

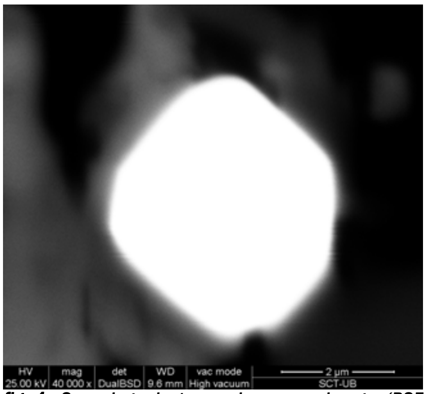

fig 4. Scanning electron microscope image (BSE mode) of laurite [Ru,Os,Ir)S2] in chromite from Haraicha.

MINERAL CHEMISTRY.

Al-rich chromite records igneous (primary) composition. This magmatic origin is supported by the low SiO_2 (<0.1 wt %), Fe_2O_3 (< 0.5 wt%) contents and high MgO contents (up to 17 wt%), which are characteristics of primary chromite. Cr# varies from 0.44 to 0.59. Mg# ranges from 0.59 to 0.8, and the TiO_2 content is very low (TiO_2 < 0.25 wt%). Sahara chromitites plot within the podiform (ophiolitic) chromitite field (Fig. 5), with compositions located mainly in the Al-rich part (#Cr < 0.6) of this field.

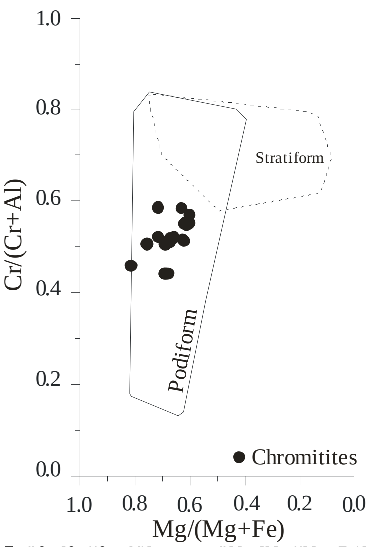

fig 5. #Cr [Cr/(Cr+Al)] versus #Mg [Mg/(Mg+Fe)] for chromite in chromitites from Western Sahara. The podiform and stratiform fields are from Leblanc and Nicolas (1992).

Mineral chemistry shows that the chromite composition records a metamorphic trend characterized by a depletion in Al and an enrichment in Fe^{2+}; Fe^{3+} remains relatively constant (Fig. 6). These chemical variations are typical of chromite altered mainly within the greenschist facies metamorphism (Evans and Frost, 1975).

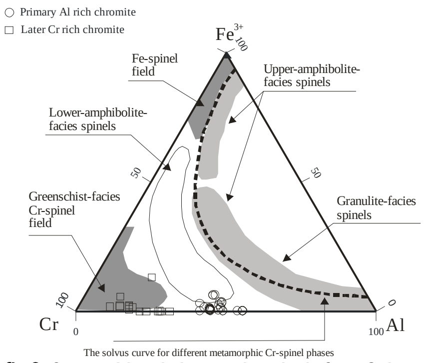

fig 6. Compositional changes in spinels from Sahara chromitite (primary and secondary chromite) expressed in a triangular Fe^{3+}-Cr-Al plot. Spinel compositional fields from different metamorphic facies were compilated by Proenza et al. (2004).

DISCUSION AND CONCLUSIONS.

Primary chromites from the chromitite bodies from Sahara are of Al-rich type (Cr#<0.6) and have a chemical composition similar to that expected to be found in an ophiolitic environment. This chemical composition is similar to other Proterozoic Al-rich ophiolitic chromitites, such as those in Pan Africa ophiolite complexes of Egypt (Ahmed et al., 2001), and western ophiolitic belt of Pampean Ranges of Córdoba, Argentina (Proenza et al., 2008). The high-Al (Cr#<0.6) composition of primary chromite in Western Sahara chromitites suggest formation from BABB-type melts in a backarc basin tectonic setting. The occurrence of these ophiolitic outcrops is helpful in the paleogeographic reconstruction of this segment of the Mauritanides.

The alteration trend is usually characterized by a decrease in the Al and Mg contents, coupled with an increase in Fe^{2+}. Hence, these chromitites have been affected by low-grade greenschist metamorphism accompanying shearing during the Panafrican or Hercyniain orogenies. This thermal history is different as that reported in southern areas of the Mauritanides, where chromite is replaced by ferrian chromite (Kane, 1987).

Ophiolite chromitites can be expected in other areas of the Mauritanide belt, as well as concentrations of PGE minerals of the association Ir-Ru-Os. The rule of these mineralizations as possible preconcentrations for further enrichments due to residual or hydrothermal processes must be considered for further mineral exploration in the Mauritanides.

ACKNOWLEDGMENTS.

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REFERENCES.

Arribas, A. (1968): El Precámbrico del Sahara español y sus relaciones con las series sedimentarias más modernas. Bol. Geol. Min., LXXIX-V, 445-480.

*Ahmed, A.H., Arai, S., Kadar, A.. (2001): Petrological characteristics of podiform chromitites and associated peridotites of the Pan Africa Proterozoic ophiolite complexes of Egypt. Mineral. Deposita, **36**, 72-84.*

*Evans, B.W., Frost, B.R., (1975): Chrome-spinel in progressive metamorphism – a preliminary analysis. Geochim. Cosmochim. Acta, **39**, 959-972.*

Kane, M. (1987) : Evidence for an ultrabasic-basic complex with ophiolitic characteristics in the central part of the Panafrican Mauritanides. Abst. Progr. Tectonothermal evolution of the West African orogens and Circum-Atlantic terrane linkages, Nouakchot, Mauritania, 113-115.

*Leblanc, M., Nicolas, A. (1992): Les chromitites ophiolitiques. Chron. Rech. Minière, **507**, 3-25.*

Lécorché, J.P., Bronner, J., Dalmeyer, R.D., Rocci, G., Roussel, G. (1991) : The Mauritanide orogen and its Northern extension (Western Sahara and Zemour), West Africa. In R.D. Dallmeyer, J.P. Lecorché (eds.): The West African orogens and Circum-Atlantic correlatives, 187-225.

*Le Goff, E., Guerrot, C., Maurin, G., Joahan, V., Tegyey, M., Ben Zerga, M. (2001) : Découverte d'éclogites hercyniennes dans la chaîne septentrionale des Mauritanides (Afrique de l'Ouest). C.R. Acad. Sci. Paris, Sci. Terre Planètes **333**, 711-718.*

*Proenza,J.A., Ortega-Gutiérrez. F., Camprubí, A., Tritlla, J., Elías-Herrera, M., Reyes-Salas, M. (2004): Paleozoic serpentinite-enclosed chromitites from Tehuitzingo, (Acatlan complex, southern Mexico): a petrological and mineralogical study. J. South Am. Earth Sci., **16**, 649-666.*

*Proenza, J.A., Zaccarini, F., Escayola, M., Cábana, C., Shalamuk, A., Garuti, G. (2008): Composition and textures of chromite and platinum-group minerals in chromitites of the western ophiolitic belt from Córdoba Pampeans Ranges, Argentine. Ore Geology Reviews, **33**, 32-48.*

Rocci, G., Bronner, G., Deschamps, M. (1991) : Crystalline basement of the West Africa Craton. In R.D. Dallmeyer, J.P. Lecorché (eds.): The West African orogens and Circum-Atlantic correlatives, 31-61.