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The ultrabasic rocks of the Castillo de las Guardas massif (Seville)

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RESUMEN

Cuerpos decamétricos de rocas ultrabásicas aparecen en el interior de los gabros del Macizo de Castillo de las Guardas (Zona Surportuguesa). Los datos de campo, petrografía, química mineral y geobarometría muestran como estas rocas son acumulados máficos, los cuales han sido reemplazados a ambientes subvolcánicos como un sólido o «mush» desde niveles profundos.

Palabras clave: *Zona Surportuguesa, Castillo de las Guardas, Roca acumulada, Roca ultrabásica, Gabro pegmatoide, Geobarometría.*

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Introduction

The South-Portuguesse Zone (Julivert *et al.,* 1974) is characterized by felsic and mafic elongate plutonic bodies, following the trend of regional structures. At the Castillo de las Guardas massif (fig. 1) the mafic rocks have essentially gabbroic composition with pegmatoid facies in pods or subhorizontal, irregular bands. The contact between the pegmatoid and host gabbro may be gradual or sharp. The development of pegmatite in the felsic rock induced a subhorizontal laminar complex with alternating bands of aplite-pegmatite.

Ultrabasic, cumulate-like rock bodies of decametric size appear inside the gabbros, showing a typical cumulate texture. The ultrabasic rocks have apparently sharp contacts with the host gabbro (pegmatoid or not), although alteration obliterates relations at the contacts. It is very common the pegmatoid gabbro/cumulate rock association on the highs. The petrogenesis of pegmatoid gabbros has been attributed to crystallization at shallow crustal levels with high f_{H_2O} (Beard & Day, 1986; Schwidinger & Anderson, 1987; Pe-Piper, 1988), wile the cumulate rocks has been related to insitu crystallization or crystal settling at the floor of the magma chamber (Wager & Brown, 1968). At this notice, we apply amphibole geobarometry to the cumulate and host gabbros to know the respective depths of crystallization.

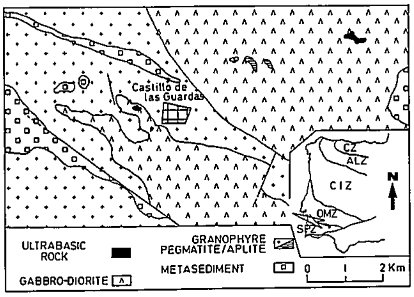

Fig. 1.—Geological map of the Castillo de las Guardas Massif.

Cumulate rocks

Two major cumulate rock types are distinguished: the first has heteroadcumulate texture with olivine, plagioclase as cumulus and poikilitic clinopyroxene and amphibole. The second type contains olivine as cumulus and ortopyroxene, clinopyroxene and amphibole as postcumulus. Its texture is orthocumulate to heteroadcumulate. The first type shows an olivine gabbro-norite composition on the Streckeisen's (1976) classification diagrams, while the olivine cumulate rock is a lherzolite. The residual porosities (Campbell, 1987) of the cumulate rocks are lesser than 25% for the orthocumulate type and more than 40% for the heteroadcumulate rock. They contain green spinel, as fine grain sized cumulus crystals and as inclusions in olivine, associated with cromite.

Anhedral olivine shows fine to medium grain size. In the lherzolites, olivine is more magnesian than in the grabbronorite, ranging in composition from Fo84-85 at the first to Fo75-80 in the gabbronorite (from microprobe data). It is very frequent the magnetite+serpentine alteration along fractures.

Subhedral plagioclase is of fine to coarse grain size and only occurs in gabbro norites. It is zoned (core An90 and rim An70).

Poikilitic clinopyroxenes of the lherzolite (Di44-En49-Fe7) are very similar to the gabbronorite clinopyroxenes ranging from Di48-En47-Fe5 to Di45-En48-Fe7 (from microprobe data). Clinopyroxene forms symplectite at the edge with pleochroic amphibole.

Ortopyroxene is Di1-En85-Fe14, only appearing in the lherzolitic rocks.

Pleochroic amphibole encloses olivine plus plagioclase in the gabbronorites, and is interstitial in the lherzolites. Amphiboles of gabbronorite extent from hornblende (after the Leake's (1978) nomenclature) with $\Sigma(A)>0.3$ and $Si<6.6$, to pargasitic hornblende.

The host gabbro

The textural and compositional features of the host gabbro are very variable. The gabbro ranges from pyroxene-amphibole gabbronorite to amphibole gabbro. Pegmatoid gabbros with plagioclase and amphibole of coarse grain size are very frequent.

Common accessory minerals are sphene, apatite, opaque minerals and quartz.

Amphibole and plagioclase are dominant phases. There is also clinopyroxene with reemplacement textures to amphibole.

Subhedral plagioclase is zoned (core An90 rim An30).

Amphibole is also zoned with a pargasitic-edenitic hornblende core to actinolitic hornblende-actinolite rim. Note as the microprobe analyses show an increase of Mg/(Mg+Fe2+) ratio from the core to the rim which implies an increase of f_{O_2} in the magma as the crystallization proceeded (Yamaguchi, 1985; Pe-Piper, 1988).

Geobarometry of cumulate rocks and host gabbros

In the last years it is very frequent the utilization of hornblende as geobarometer in the plutonic rocks to know the pressures under which the rocks were emplaced (e.g. Beard & Day, 1986; Hammarstrom & Zen, 1986; Hollister *et al.,* 1987; Pe-Piper, 1988). We can apply the hornblende geobarometer for cumulate rocks to know if final crystallization occurred at depth or at the actual level of emplacement with the host gabbros.

The Hammarstrom & Zen's (1986) geobarometer (confirmed by Hollister *et al.,* 1987), in which the crystallization pressure is calculated from the Al content of hornblende, has been used so hornblende is a common phase in the studied rocks. Chemical analysis were made using electron microprobe. Structural formulae have been calculated according to Deer *et al.* (1966). The Fe3+ content has been considered to be the average between the maximum (total cations=13, excluding K, Na and Ca) and minimum (total cations=15, excluding K and Na) according to stoichiometry, following the method by Droop (1987) based on Stout (1972). The resulting Mg/(Mg+Fe2+) ratios are listed in table 1.

Figure 2 shows as the host gabbro hornblendes crystallized at low pressure (less than 2.6 kbar) and at high oxygen fugacity as deduced from the high values of the Mg/(Mg+Fe2+) ratio at the external rim of zoned crystals. The cumulate rock hornblende crystallized at pressure more than 5 kbar. It is possible that several cores of the host gabbro amphiboles crystallized at pressures similar to the cumulate rocks (note the analysis of edenitic hornblende core near the group of the cumulate rock amphiboles).

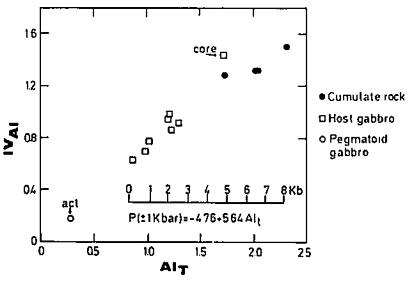

Fig. 2.—Plot of^{IV}Al vs. Al total. The crystallization pressures are based on regression equation by Hollister *et al.* (1987). Note as the cumulate rock hornblendes crystallized at greater pressure than the host gabbro hornblendes. It is possible that the hornblende cores of the gabbros crystallized at more depth.

Discussion

The differences in mineral compositions between the host gabbros and cumulate rocks, and the values of pressure calculated from the hornblende geobarometer, show that the intercumulation process (and accumulation) occurred at more depth than that of the host gabbro crystallization, which was developed at shallow levels at different physical conditions (e.g. high f_{O_2} and f_{H_2O}), as noted by Bear & Day (1986), Schwidinger & Anderson (1987) and Pe-Pipper (1988) in others pegmatoid gabbros. This implies that the cumulate rock of the Castillo de las Guardas massif was re-emplaced as a solid or mush to subvolcanic levels.

In another way, the existence of different residual porosities (Campbell, 1987) in the cumulate rocks supports the important role of accumulation to produce efficient fractional crystallization in the petrogenesis of the Castilllo de las Guardas Complex.

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Table 1.—**Representative microprobe analysis of hornblendes from the gabbros and cumulate rocks**

	Ultrabasic rock				Host gabbro								Pegamatoid gabbro
SiO2	46.228	46.637	47.132	45.719	48.531	49.032	48.967	51.188	49.242	51.926	49.540	44.998	54.072
TiO2	0.246	0.066	0.066	0.106	1.160	1.150	1.497	0.391	0.358	0.515	0.108	2.096	0.167
Al2O3	10.160	12.115	12.084	13.824	5.824	7.093	7.178	5.875	7.654	5.195	7.262	10.044	1.673
FeOt	8.124	6.603	6.636	7.248	12.732	8.896	10.219	9.247	9.909	9.031	11.785	9.818	11.115
Cr2O3	0.367	0.095	0.035	0.083	0.000	0.702	0.394	0.315	0.234	0.220	0.000	0.988	0.107
MnO	0.118	0.114	0.133	0.167	0.238	0.139	0.103	0.255	0.171	0.171	0.171	0.218	0.269
NiO	0.050	0.079	0.078	0.000	0.000	0.000	0.000	0.013	0.000	0.025	0.084	0.109	0.000
MgO	17.124	17.198	17.809	16.972	14.588	16.605	16.476	17.433	17.477	17.521	15.609	14.774	16.255
CaO	11.514	11.500	11.306	11.167	10.749	11.890	11.353	11.420	10.640	12.140	12.123	12.006	12.444
BaO	0.000	0.000	0.000	0.000	0.014	0.000	0.036	0.030	0.053	0.018	0.000	0.025	0.026
Na2O	2.067	1.881	1.905	2.154	1.052	1.425	1.519	1.260	1.051	1.018	1.189	2.159	0.341
K2O	0.171	0.027	0.009	0.023	0.130	0.250	0.280	0.154	0.139	0.117	0.173	0.149	0.059
Total	96.170	96.320	97.190	97.460	95.020	97.180	98.020	97.580	96.930	97.900	98.040	97.380	96.530
AK(IV)	1.276	1.312	1.309	1.497	0.767	0.941	0.977	0.698	0.915	0.627	0.864	1.435	0.175
Al(total)	1.742	2.048	2.023	2.318	1.023	1.204	1.214	0,988	1.298	0.870	1.233	1.728	0.285
Mg/(Mg+Fe2+)	0.889	0.913	0.946	0.932	0.726	0.792	0.788	0.822	0.905	0.806	0.767	0.744	0.719

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Estudio de los contenidos de estroncio en las rocas carbonatadas del Cretácico Inferior del Noroeste de Cantabria (España)

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ABSTRACT

This paper tries to determine the strontium contents in different types of carbonated rocks thus setting up a series evolutionary patterns related to the dolomitization process.

The evolution of these processes causes a strontium content decrease and, contrasting with our data shown in the paper, it must be concluded that the low contents of this element in the dolomites are related to the late diagenetic dolomitization processes. All this being in agreement with the petrological studies carried out on this king of lithology.

Key words: *Strontium, Carbonated Rocks, Dolomitization, Evolutionary Models, Lower Cretaceous.*

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Introducción

El trabajo objeto de este estudio, trata de establecer un modelo geoquímico evolutivo según los contenidos de estroncio en las rocas carbonatadas del Cretácico Inferior del NO de Cantabria, y así poder determinar el carácter diagenético-epigenético de estas litologías en el entorno de las mineralizaciones Pb-Zn.

En todas las muestras tratadas —calizas y dolomías—, se han realizado análisis por absorción atómica así como los correspondientes estudios petrológicos de manera que todas se han cogido en dominios inmediatos a las mineralizaciones Pb-Zn; algunas series se tomaron en afloramientos aunque la mayoría corresponden a muestras de testigos de sondeos.

De todos los elementos traza viables de analizar en este tipo de litologías (calizas y dolomías), son pocos los que ofrecen gran interés destacando sobre todos ellos el estroncio que se utiliza ligado al estudio de los procesos diagenéticos. Trabajos relacionados con esta línea, han tenido un gran desarrollo a partir de los años setenta, destacan sobre todo los de Kinsman (1969); Veizer y Demovic (1974); Jacobson y Usdowski (1976); Baker *et al.* (1982) y Bustillo y Fort (1986).

Situación del área estudiada

Las cuatro zonas estudiadas 1. La Florida, 2. Novales, 3. Reocín y 4. Santander se localizan dentro del área comprendida entre los paralelos 42°30'42" y 43°17'40" y los meridianos 3°46'12" y 4°31'10", ver fig. 1, en donde además de aparecer una relación de las Hojas de escala 1:50.000 se expone la columna tipo del área estudiada correspondiente a la facies urgoniana (Aptiense-Albiense). Todas las muestras tratadas en el presente trabajo (576) están contenidas en estos dos pisos, y el número de las mismas correspondiente a las cuatro zonas estudiadas es de 126, 47, 311 y 92, respectivamente.

Modelos evolutivos

Estos pueden ser de dos tipos:

a) Penecontemporáneos. Aquí los carbonatos pueden tener una composición muy variada. Por un lado podemos tener *precipitación de lodos aragoníticos* que si le quitamos el contenido de Sr en los fósiles, tendremos valores de 5.800 ppm (Milliman, 1974). Por otro lado, tenemos los *procesos de dolomitización penecontemporánea* en donde los contenidos de este elemento según Jacobson y Usdowsky (1976) son de 324 ppm.