New lithologic and structural data of the central and eastern part of Ceuta (Rif Cordillera)

Nuevos datos de la litología y de la estructura de los sectores central y oriental de Ceuta (Cordillera Bético-Rifeña)

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ABSTRACT

In the central and eastern parts of Ceuta two tectonic units are differentiated: a) the Hacho unit, formed by two groups of orthogneisses which foliation permits to establish the structure: an anticline with a periclinal end at its western edge, and b) the Istmo unit, with peridotites at the bottom, followed by migmatitic granulites, gneisses, and dark mica schists. The thrust of the peridotites over the orthogneisses of the Hacho unit occurred under fragile conditions. For the first time several types of rocks, not previously described, have been localized: dark mica schist and phyllites and quartzites, these two last perhaps corresponding to the Federico units. With the new data, these units can be better compared, with those Alpujárride/Sebtide in the sectors of Jubrique-Guadaiza-Benahavís.

Key-words: *Alpujarride/Sebtide, peridotites, migmatites, orthogneisses.*

RESUMEN

En los sectores central y oriental de Ceuta se diferencian dos unidades: a) la unidad del Hacho, formada por dos grupos de ortogneises cuya foliación permite establecer su estructura: un anticlinal que tiene una terminación periclinal en su parte occidental, y b) la unidad del Istmo, con peridotitas en la base seguidas por granulitas migmatíticas, gneises y esquistos oscuros. El cabalgamiento de las peridotitas sobre los ortogneises ocurrió en condiciones frágiles. Por primera vez se han localizado afloramientos de rocas no descritos previamente: esquistos oscuros y filitas y cuarcitas, estas dos últimas quizás correspondientes a unidades de tipo Federico. Con los datos presentados, estas unidades pueden compararse mejor con las del Alpujárride/Sébtide en los sectores de Jubrique-Guadaiza y Benahavís.

Palabras clave: *Alpujárride/Sébtide, peridotitas, migmatitas, ortogneises.*

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Introduction

The area of Ceuta (Spain), in the N of the Rifian Internal Zone (Fig. 1A), provides a link with equivalent Betic units. In this area, the Sebtide and the Ghomaride complexes (Alpujárride and Maláguide, respectively, in the Betics) crop out. Particularly, the Sebtide Complex occupies the central and eastern parts of Ceuta, being the Ghomaride Complex situated immediately to the west. This area began to be studied during the 19th century and it is particularly interesting the description of Dupuy de Lôme and Milans del Boch (1917) of "calizas sacaroideas" (saccharoidal limestones) in a quarry in the area of San Amaro now disappeared. More detailed studies were made by later authors, as Durand-Delga and Kornprobst (1963), who described the rocks of this area and named "gneisses oeillés", augen gneisses, to the rocks of the Hacho Mountain. Nevertheless, they did not differentiated units, considering that all this area corresponded to the "Ceuta unit". Bernard-Griffiths *et al.* (1977), based on Rb/Sr determinations in whole-rock, attributed a Variscan age (290±4 Ma) to the orthogneisses (this is the name used by these authors) of Hacho Mountain. Sánchez-Gómez *et al.* (1995) and Azañón *et al.* (2004) described the existence of mica schists enclaves in the area of the Desnarigado, in the SE of the Hacho Mountain. They consider the rocks of this unit as migmatites (not as orthogneisses), even passing to form granitoids. They used the name of Monte Hacho unit, while gave the names of "Istmo de Ceuta" or "Filali" gneisses for the rocks situated in the central part of Ceuta (Fig. 1A). Ruiz Cruz *et al.* (2011) identified the existence of microdiamonds in the migmatitic granulites situated over the serpentinites in the Sarchal bay, indicating an old stage of UHP metamorphism.

The aims of this study are: a) to describe for the first time new rocks in the central and eastern part of Ceuta that complete the knowledge of the lithologic sequences and permits a better comparison with other areas of the Rif and the Betics, b) to provide some precisions about the structure, particularly that of the Hacho Mountain, till the moment considered as an undifferentiated mass, and c) to afford new data for the correlations of these units with others in the Betics.

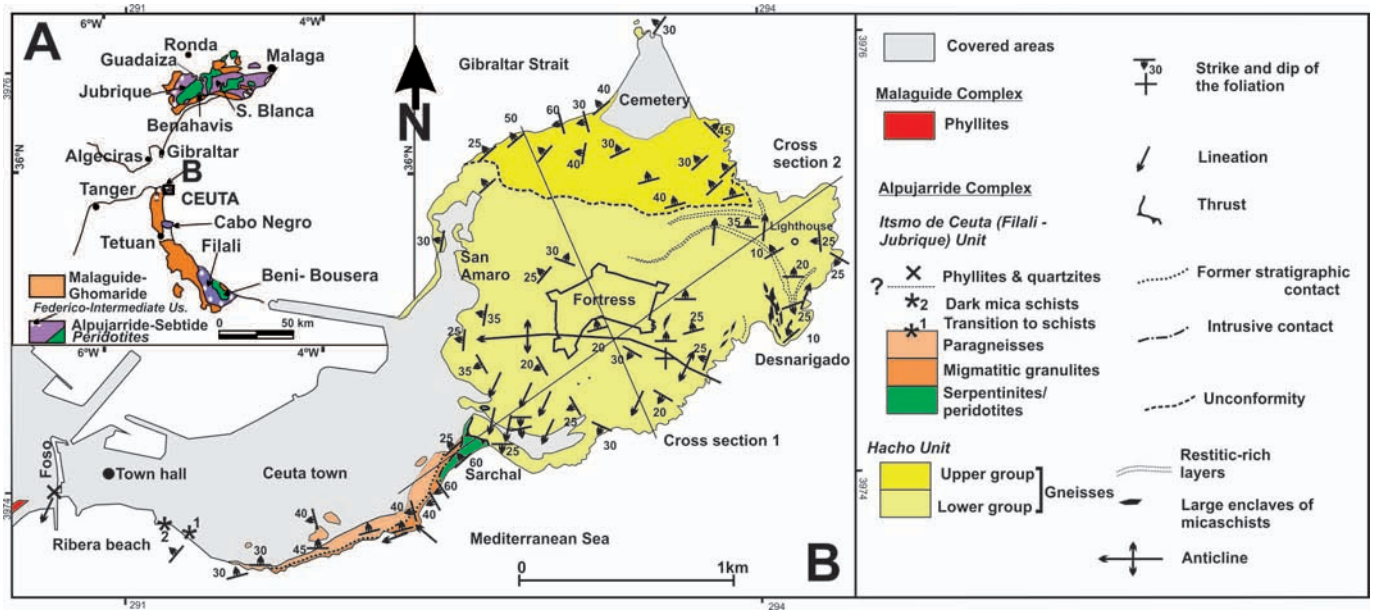

Fig. 1.- A) Geologic sketch of the Alpujarride and Malaguide Complexes in the area of the Strait of Gibraltar. The rectangle indicates the position of B. B) New geological map of the central and eastern parts of Ceuta. The location of the cross sections of figure 2B is indicated.

Fig. 1.- A) Esquema geológico de los complejos Alpujárride y Maláguide en el área del Estrecho de Gibraltar. El rectángulo indica la posición de B. B) Nuevo mapa geológico de los sectores central y oriental de Ceuta. Se indica la posición de los cortes de la figura 2B.

Lithologic series of the differentiated units

We distinguish two units in the study area, the Hacho unit and the overthrusting Istmo unit. Their cartographic shapes and lithologic columns can respectively be seen in figures 1B and 2A.

Hacho unit

According to Bernard-Griffiths *et al.* (1977) the rocks forming this unit correspond to orthogneisses, although Azañón *et al.* (2004) considers them as migmatites. But our data agree with the interpretation of the first authors. These rocks are arranged in two groups (Fig. 2A).

The lower group of orthogneisses. This formation includes fine-grained rocks interpreted as derived from rhyolites, which are mainly located in the westernmost part of the Hacho Mountain; porphyritic granites particularly located in the central and eastern part of this mountain; and leucocratic meta-granites, located in the innermost zone of the outcrop. In general, the rocks contain variably sized porphyroclasts of K-feldspar, plagioclase, quartz, and altered cordierite, and a fine-grained matrix of quartz, white mica, and biotite or chlorite. The rocks are characterized by the abundance of phases inherited from the source (restites), such as apatite, zircon, and small, corroded garnets.

As previously indicated, in the Desnarigado area (Fig. 1B) many enclaves are present, in some cases of decametric size. The enclaves show a typical foliated texture, dominated in some cases by biotite. In other cases, the xenoliths represent true restites with variable amounts of pinnitized cordierite, staurolite, red biotite, apatite, and garnet. Sillimanite is also abundant in some of these bodies, as a product of the transformation of biotite.

These rocks are locally crossed by acidic dykes, some of which also contains small enclaves of schists. According to the structure deduced from the foliation, the visible thickness of this gneissic formation is about 300 m.

The upper group of orthogneisses. This group occupies the northern part of Hacho Mountain (Fig. 1B). Generally, they form a more subdued relief, the arrangement in layers is well developed, and generally they do not show the porphyritic texture characterizing the lower group. The rocks consist of dominant magmatic phases (e.g. K-feldspar and red biotite). Nevertheless, some levels of these rocks also contain grains with textural characteristics of detrital phases, such as the shape of the grains and the clayed or Fe-oxide coatings, suggesting a possible volcano-sedimentary origin. Phases showing these textural characteristics, such as large fractured garnets and angular quartz grains have not been identified in the rocks of the lower group of orthogneisses. The estimated thickness of this group is about 100 m.

Istmo unit

The serpentinites/peridotites. They crop out only in the Sarchal Bay. These ultramafic rocks have been described by Sánchez-Gómez (1995), among others. Where serpentinites are not tectonically disturbed, the foliation is well conserved although no more than 50 m of thickness are visible.

The migmatitic granulites. These rocks are situated directly over the peridotites and crop out along more than a kilometre in the coast (Fig. 1B). They range from migmatites with banded texture, in which thin leucosomes are derived locally from in situ melting, to rocks with larger leucosomes recording evidence of melt mobilization. Among their minerals, the large garnets and also microdiamond inclusions stand out. The visible thickness is about 20 m.Locally, these rocks are cross cut by aplitic dykes.

The paragneisses. They are situated over the migmatites with a short transition between the two types of rocks. The town covers up the greater part of their outcrops. These rocks are quite similar to those lying several km south of Ceuta (in Cabo Negro), and also to those overlying the migmatitic granulites in the Jubrique zone (in the Alpujarride Complex, in the western Betics) (Fig. 1A). These gneisses are characterized by the presence of small,

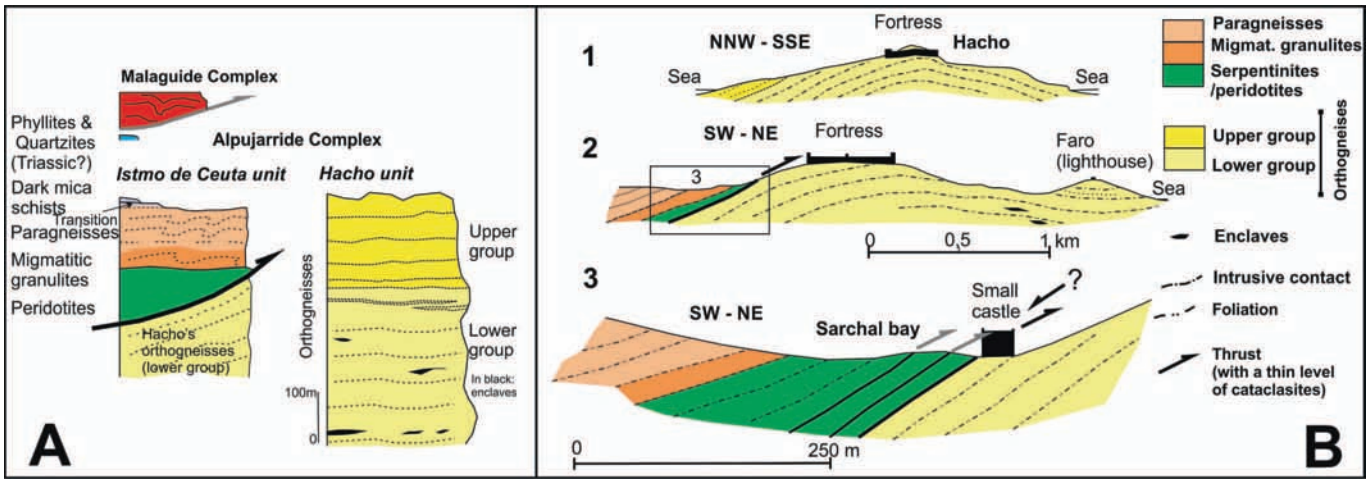

Fig. 2.- A) Lithologic sequences of the central and eastern area of Ceuta. B) Cross sections of the Hacho Mountain. The rectangle of cross section 2 indicates the position of cross section 3. These cross sections are situated in figure 1B

Fig. 2.- A) Secuencias litológicas de los sectores central y oriental de Ceuta. B) Cortes del Monte Hacho. El rectángulo del corte 2 indica la posición del corte 3. Estos cortes se sitúan en la figura 1B.

corroded garnets. Their visible thickness somewhat exceeds 50 m, but may exceed 100.

Dark mica schists. The existence of these rocks has been suspected by comparison with the lithologic sequences of Jubrique unit (and in Morocco with the Filali Schists). Durand-Delga and Kornprobst, 1963) cite the existence of schists without indicating their exact position and could not correspond to these rocks, as is commented in the next paragraph. Azañón *et al.* (2004) supposed their existence, but did not found them. Now, we found them in two small outcrops, both situated in "La Ribera" beach. The first is visible in the city walls, to the east of the south municipal market (Mercado de Abastos) exit. At this point, a transition from paragneisses to dark mica schists can be observed. The second outcrop is formed by some rocks situated at the edge of the sea, rising less than 1 m from the sand of the beach, with an extension of about 7 x 4 m (see the asterisk 2 in Fig. 1B). These schists contain abundant mica (white mica and biotite) and graphite and are characterized by the presence of small, almost black garnets.

Phyllites and quartzites. These rocks crop out only in the south-west end of the Foso de San Felipe, in the city wall, on the steps descending to the beach. Probably they are the rocks cited by Durand-Delga and Kornprobst (1963) as mica schists. They could belong to the Triassic sequences of the Federico units (Didon *et al.*, 1973), also called Intermediate units (between the Alpujárride and Maláguide complexes) by Sanz de Galdeano *et al.* (2001).

The Malaguide/Ghomaride unit

This complex crops out extensively to the west, not in the central and eastern part of Ceuta. It is cited here because some of their outcrops appear nor far from the Foso de San Felipe and consist of Paleozoic lutites -phyllites and sandstones easily distinguishable from the phyllites and quartzites of the Foso de San Felipe.

Structure

Structure of the Hacho unit

Its structure is inferred from the foliation of the orthogneisses (Figs. 1B and 2B). It corresponds to an anticline with a periclinal end situated on its western edge. The foliation is generally well marked. Within the lower group, the levels rich in restites (Fig. 1B) have been also used to highlight the structure. A lineation formed by the preferred orientation of elongated minerals is visible on the foliation surfaces. This lineation maintains a constant NO15ºE strike, with very slight variations.

The contact between the Hacho unit and the serpentines/peridotites of the Sarchal bay

This contact is the thrusting of the peridotites over the orthogneisses of the Hacho unit (Fig. 2B, cross sections 2 and 3). The thrust surface is occupied by a greenish layer of cataclastic aspect, with a visible thickness not greater than 5-6 cm. This band originated from the shearing of the peridotites and includes remains gneisses. Farther away from the contact, the peridotites are strongly deformed, developing shear bands, with almond structures of very different sizes, from millimetres to metres. Locally, pseudo S/C structures mark the sense of displacement, indicating an eastward thrusting of the peridotites, although in other points the sense of displacement is at least dubious.

The structure of the Istmo unit

The general structure is simple, mainly dipping to the N and W (Fig. 1B), depending on the place. In detail, there are many decametric to minor folds, generally isoclinal, with NE-SW axis, and dominant vergence to the NW, although in some places, e.g. at the seaside, near the "Mercado de Abastos", they have a nearly E-W strike, with vergence to the N. There is also a lineation but with different directions (see Fig. 1B), generally not coincident with the lineation of the gneisses of the Hacho unit.

The relation between the Istmo unit and the phyllites and quartzites of the Foso de San Felipe cannot be clarified based on the data derived from the preserved outcrops because they are disconnected. The strike and dip of these rocks are similar to that of the dark mica schists.

Discussion and conclusions

According to our interpretation, the rocks of the Hacho unit, divided in two groups, correspond to dominant hypoabyssal acidic rocks and local floods of rhyolites. These rocks have been compared with those of the Sierra Blanca, Guadaiza, Benahavís. (Sánchez Gómez *et al.,* 1995), but there is a problem of attribution of ages: rocks of the Hacho units present Permian ages, while for the other ones the attribution of ages ranges from 19 to 24 Ma (see for instance Tubía *et al*., 2013). With so different ages it is not possible the correlation. But Acosta *et al.* (2015) obtained a Permian age for these rocks in the Alpujarride Complex. In this case the correlation seems correct, although not corresponding to Neogene but to Permian rocks.

The structure of the Hacho unit defines an anticline with a periclinal end on the western edge of the mountain. This structure is presented for the first time.

The ages obtained in the Istmo unit are similar to those of the Jubrique unit (Ruiz Cruz and Sanz de Galdeano, 2014). This, and the existence of dark mica schist in the Istmo unit, reinforces the previously proposed correlation. The location of these schists is provided for the first time.

The phyllites and quartzites situated in the southern part of the Foso de San Felipe are also described for the first time. Their relations with the dark mica schists cannot be seen, but for their light metamorphic aspect, very different to the dark schists, probably they correspond to one of the Intermediate (Federico) units (situated between the Malaguide and Alpujarride complexes).

Even more uncertain are the relations of the previous units with the Malaguide/ Ghomaride Complex cropping out westward. According to the regional geological setting, this complex must occupy the highest tectonic position.

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References

Acosta-Vigil, A., Rubatto, D., Bartoli, O., Cesare, B., Meli. S, Pedrera, A., Azor, A. and Tajcmanova, L. (2015). *Lithos*, doi: 10.1016/j.lithos.2014.08.018.

Azañón, J.M., Balanyá, J.C., García-Dueñas, V., Sánchez-Gómez, M. and Sanz de Galdeano, C. (2004). *In : Geología de España* (J.A. Vera, Ed.), IGME-SGE, Madrid, 444-449.

Bernard-Griffiths, J., Cantargel, J.M. and Kornprobst, J. (1977). *Réunion annuelle des Sciences de la Terre*, Rennes, p. 64.

Didon, J., Durand Delga, M. and Kornprobst, J., (1973). *Bulletin de la Société Géologique de France* 15, 77-105.

Dupuy de Lôme, E. and Milans del Bosch, J. (1917). *Boletín del Instituto Geológico y Minero de España* XVIII, 27-158.

Durand-Delga, M.and Kornprobst, J. (1963). *Bulletin de la Société Géologique de France* 7(V), 1049-1057.

Ruiz Cruz, M. and Sanz de Galdeano, C. (2014). *International Geology Review,* DOI: 10.1080/00206814.2014.904759

Ruiz Cruz, M.D., Sanz de Galdeano, C. and Garrido, C. (2011). *Economic Geology* 106, 1241–1249.

Sánchez-Gómez, M., García-Dueñas, V., Muñoz, M. and Balanyá, J.C. (1995). *Geogaceta* 17, 135-137.

Sanz de Galdeano, C., Andreo, B., García-Tortosa, F.J. and López-Garrido, A.C. (2001). *Palaeogeography, Palaeoclimatology, Palaeoecology* 167, 157-173.

Tubía, J.M., Cuevas, J. and Esteban, J.J. (2013). *Journal of Structural Geology* 50, 148-160.