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Geometry of the contact of the peridotites of Sierra Alpujata with the Sierra Blanca succession (Alpujarride Complex,Betic Internal Zone)

Geometría del contacto de las peridotitas de Sierra Alpujata con la sucesión de Sierra Blanca (Complejo Alpujárride, Zona Interna Bética)

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ABSTRACT

The peridotites of Sierra Alpujata thrust to the north a formation of granitoid gneisses and the succession of Sierra Blanca. This structure led to the individualization of the unit of this name, and thus it is considered to crop out in a tectonic window. Nevertheless, on the western border of Sierra Alpujata the gneisses, in continuity with the formations of Sierra Blanca, are situated over the peridotites. This means that the Sierra Blanca does not crop out in a tectonic window, and that the peridotites, on the whole, are in fact situated in a lower position. This situation has important consequences for the age of their first exhumation and for the geological evolution and structure of the region.

Key-words: *Alpujata peridotites, Sierra Blanca, reverse folds, thrust.*

RESUMEN

Las peridotitas de Sierra Alpujata cabalgan hacia el norte a una formación de gneises granitoides y a la sucesión de Sierra Blanca, lo que condujo a individualizar la unidad de este nombre y a considerarla como aflorante en una ventana tectónica. Sin embargo, en el borde occidental de Sierra Alpujata se observa que dichos gneises, en continuidad con las formaciones de Sierra Blanca, están situados sobre las peridotitas. Esto significa que Sierra Blanca no aflora en una ventana y que las peridotitas están realmente situadas en una posición inferior. Este rasgo tiene importantes consecuencias en lo que concierne a la edad de su primera exhumación y a la evolución y estructura de la región.

Palabras clave: *Peridotitas de Sierra Alpujata, Sierra Blanca, pliegues invertidos, cabalgamiento.*

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Introduction

In the western part of the Betic Cordillera, in the Alpujarride Complex (Fig. 1A), the tectonic position of the Ronda peridotites has been widely debated. Their Tertiary exhumation and thrust is the more accepted hypothesis (Lundeen and Obata, 1977; Sánchez-Gómez *et al*., 1995a, b; Tubía *et al*., 1997, 2013, among many others). These authors considered that the peridotites of Sierra Alpujata thrust the Sierra Blanca succession. According to this interpretation, rocks situated under the peridotites were migmatized by the hot thrust that caused thermal metamorphism during the Oligocene-Early Miocene. This age agrees with the hypothesis that peridotites of the region (the Ronda peridotites) were first exhumed during the Tertiary. The cited thrust is observed in the northern part of Sierra Alpujata (Fig. 1B and cross section 1 in Fig. 2). Other authors (Orueta, 1917, Blumenthal, 1949, Buntfuss, 1970, etc.) indicate that, on the whole, the peridotites are situated at the bottom of the Blanca unit.

In this study, we offer new data of the entire contact existing between the peridotites of Sierra Alpujata, the possible migmatites, and the Sierra Blanca rocks. They lead to a different interpretation discussed in this paper, with important consequences concerning the position of the peridotites and even the age of their first emplacement.

Lithologic sequences of the sierras Alpujata and Blanca

Sierra Alpujata is formed by peridotites situated at the bottom; above, towards the south, there are migmatitic granulites and paragneisses followed by dark schists attributed to the Paleozoic and, only very locally conserved, phyllites and marbles, considered to be Triassic.

To the north and west of the Sierra Alpujata, in contact with the peridotites are granitoid gneisses called granitic gneisses (Platt *et al*., 2013) or diatexitic granitoids (Sánchez-Gómez, 1997), and Tubía *et al*. (1997, 2013) considered them, at least partly, to be migmatites formed by the thermal thrust of the peridotites.

These rocks vary greatly in thickness, being larger towards the NW border of the Sierra Alpujata, where they may reach 300-400 m, while at other points they are absent. In their western and northwestern outcrops, the gneisses include lenses of metabasites, which are also present within the metadetrital formation (schists and quartzites) that appears in

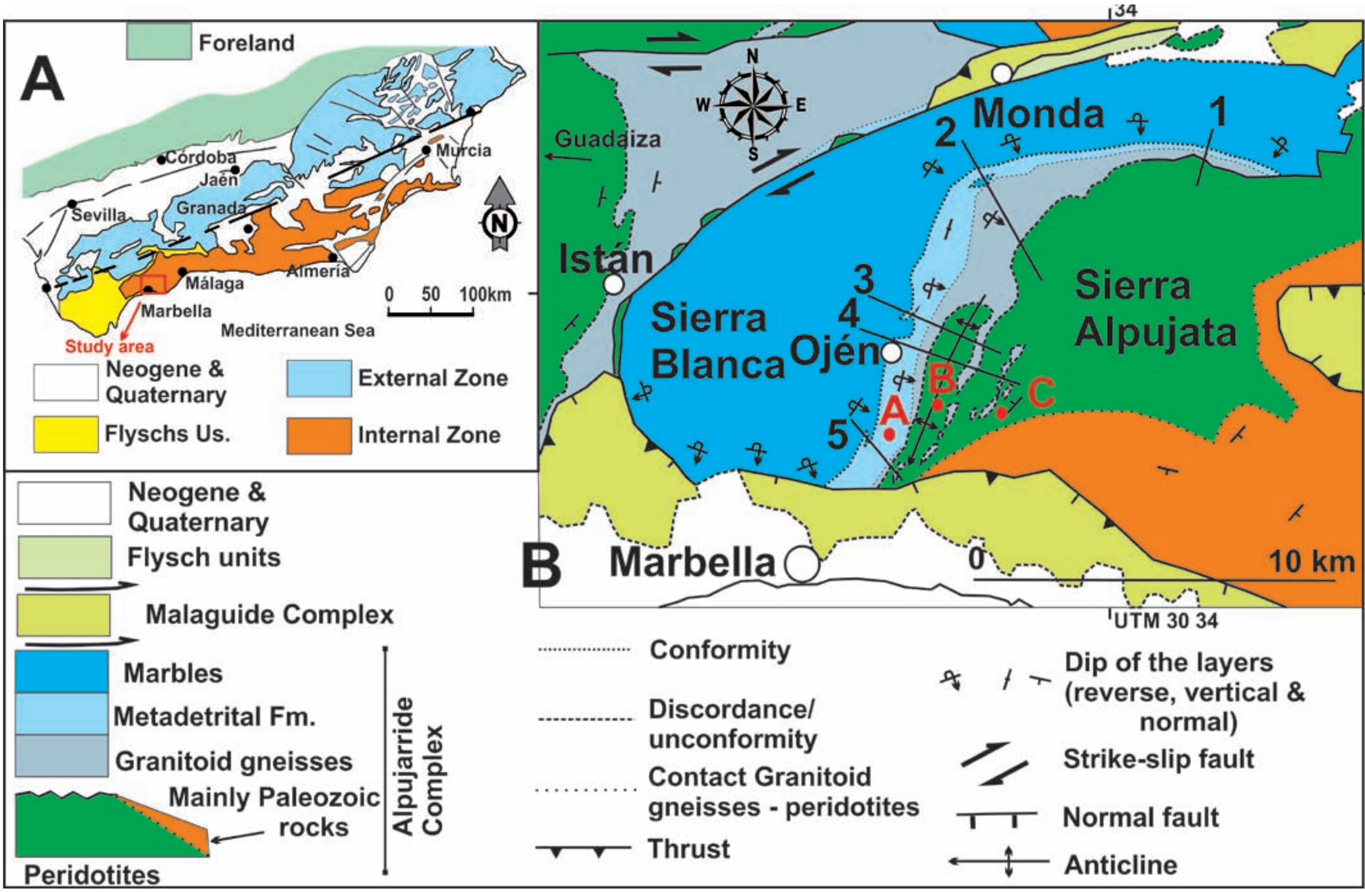

Fig. 1.- A) Regional setting of the study area in the Betic Cordillera. The rectangle indicates the position of inset B. B) Geologic sketch of the Sierra Blanca and Sierra Alpujata area, with location of the cross sections of Fig. 2 and the sketches of Fig. 3 (red points).

Fig. 1.- A) Situación general del área estudiada dentro de la Cordillera Bética. El rectángulo indica la posición de B. B) Esquema geológico del área de las sierras Blanca y Alpujata, con situación de los cortes de la Fig. 2 y los esquemas de la Fig. 3 (puntos rojos).

direct contact with them towards the N and NW (the metapelitic sequence of Tubía *et al.*, 1997). The maximum thickness of this metadetritic formation is around 300 m, while it is absent at other points.

The metadetrital formation gradually changes to the carbonates of Sierra Blanca by including progressively more abundant interlayered marbles (Fig. 3A), which also metabasite lenses at least up to the first 20 m of the marble succession. The marbles constitutes a thick formation (around 700 m) that is generally attributed to the Triassic in age.

Structure

Southwards, Sierra Alpujata has a simple structure, with its lithological sequence generally dipping towards the S or SE, although it is affected locally by recent faults. Towards the N and W of Sierra Alpujata the tectonic structure is, however, much more complicated.

In the NE part of the Sierra Alpujata, the peridotites thrust onto the granitoid gneisses, and partially onto the Sierra Blanca succession (Fig. 2, cross section 1). To the west, the thrust progressively diminishes its displacement so much that the contact between the peridotites and the gneisses progressively becomes vertical, without evidence of thrusting (for the following descriptions, see Fig. 2, cross sections 2 to 5).

Westwards, the contact between the peridotites and the gneisses strikes approximately N-S following the same orientation of the Sierra Blanca succession (Fig. 1B). Here, the presence of a long cartographic band of the gneisses extending to the south is particularly striking. This band, according to the compiled field data, corresponds to a very tight N-S synform, whose eastern limb is practically vertical, dipping to the west or the east at some points. The western limb dips steeply generally with the peridotites underlying the gneisses, but locally above them.

Such attitudes in the contact with the peridotites along the aforementioned band of gneisses cast doubts on the general geometric relation originally existing between both types of rocks. To clarify them it is useful to continue the study of the gneissic outcrops towards the south. There, the gneisses occupy the higher parts of a N-S line of hills surrounded by peridotites situated in the lower slopes of the hills and at the bottom of the small valleys. In the places where fluvial incision is sufficiently deep, the cartographic continuity of the gneissic outcrops is lost and they form isolated hills resting directly on the peridotites (Fig. 3B). This same disposition is visible to the east (Fig. 3C). These two lines of hills of gneisses overlying the peridotites actually corresponds to two parallel perched synclines separated by an anticline cored by peridotites (Fig. 2, section 4).

Another anticline separates the western line of hills from the SE border of Sierra Blanca (Fig. 1B). On this border, the contact between the peridotites and the gneisses generally dips 60 to 80° to

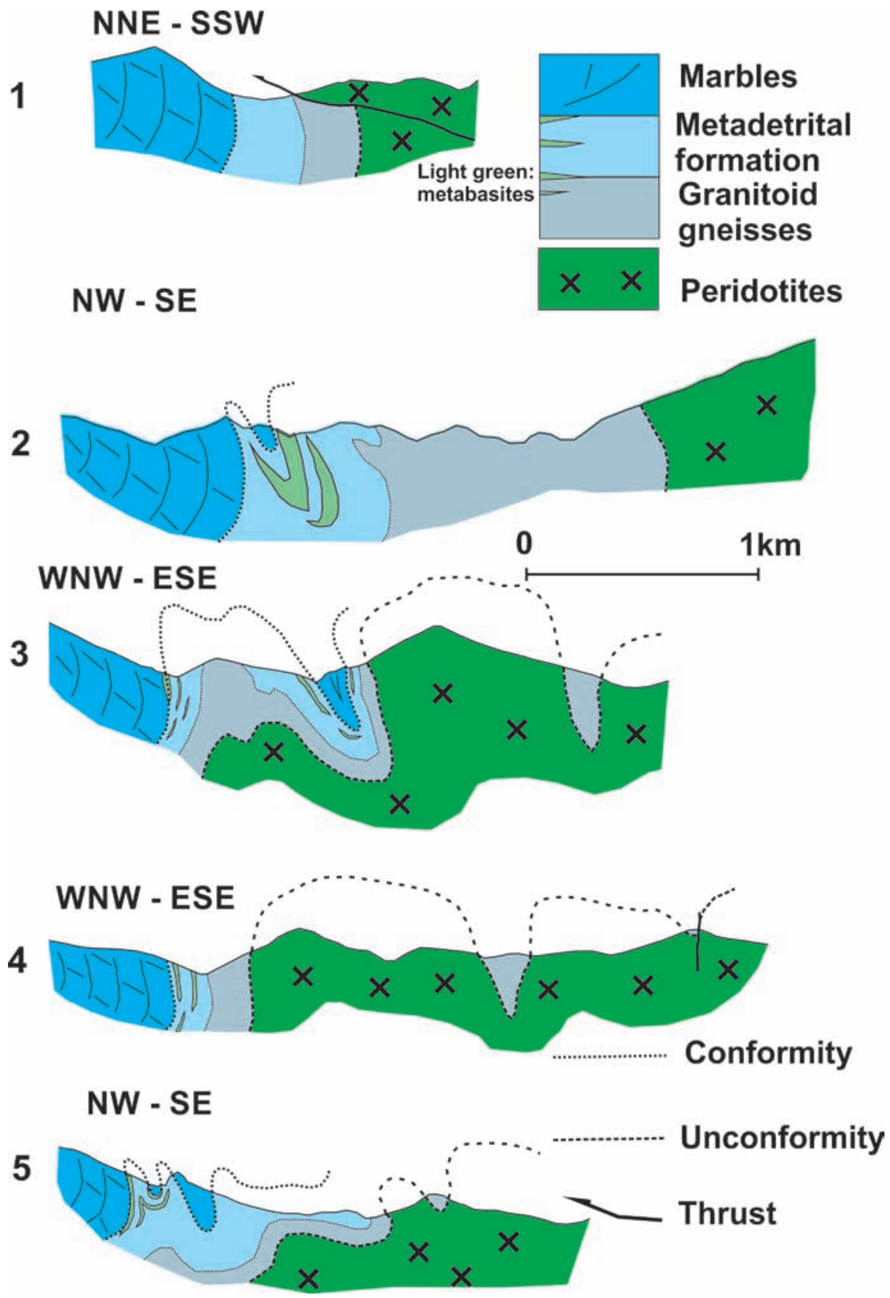

Fig. 2.- Geological cross sections showing the geometry of the contact between Sierra Blanca and Sierra Alpujata. Their positions are marked in Fig. 1B.

Fig. 2.- Cortes geológicos que muestran la geometría del contacto entre las sierras Blanca y Alpujata. Sus posiciones se señalan en la Fig. 1B.

the east, and only locally dips to the west, although steeply. In this area, the slopes of many new roads allow seeing the alternation of metapelites and quartzites with interlayered basic rocks and marbles becoming progressively more abundant towards the west, up to the continuous marble succession of Sierra Blanca (Fig. 3A).

The structure of Sierra Blanca in the neighborhood of Sierra Alpujata, according to Sanz de Galdeano and Andreo (1994, 1995) and Orozco and Alonso-Chaves (2012), is formed by reversed folds verging to the interior of Sierra Blanca. The inversion affects the entire contact between the Triassic (?) marbles and the stratigraphically older metadetrital formation, all along the SE and S border of the sierra. The foliation in both, marbles and metadetrital formation, is parallel.

Discussion

If only the northern border of Sierra Alpujata is considered, the best interpretation is that the peridotites thrust onto the gneisses and the related metadetritic and carbonatic formations of the Sierra Blanca, consequently, the later one, which is situated in a lower position, crops out in a tectonic window. However, following the contact more toward the SW, it is possible to see that the gneisses are situated over the peridotites and consequently, their classical interpretation as formed by the thermal thrust of the peridotites onto the Blanca succession seems less plausible. In this last sector, Sánchez-Gómez (1997) indicated the same position for the gneisses, situated over the peridotites, but he supposed the existence of fragile faults superposed to ductile faults in the contact with the peridotites. Obviously, we agree with this position of the gneisses, but not with his interpretation concerning the faults, which we did not see.

Towards the Sierra Blanca foothills, the gneisses –intercalating basic rocks– gradually change to the metadetrital and carbonatic formation of the Sierra Blanca. At the observation points, the shift between the gneisses and the metadetrital formation is marked by basic rocks. Our observations indicate that this succession is generally reversed (with rocks of higher metamorphic grade lying above those of lower metamorphic grade), in agreement with the whole structure, including the general inversion of the SE border of the marbles of Sierra Blanca, but that this inversion disappears to the SSW of Sierra Alpujata. This means that the reconstruction of the former position of the rock succession could be the opposite to that observed today. This interpretation situates the gneisses, the metadetrital formation, and the marbles above the peridotites, in this ascending order.

The thrust situated in the northern border of Alpujata and the inversions in the structure of Sierra Blanca would be due, consequently, to a later deformation that certainly accounted during the Alpine orogeny.

The granitoid gneisses have been correlated with others situated to the west of Sierra Blanca, in the area of Guadaiza (Tubía *et al.*, 2013) and formed during the

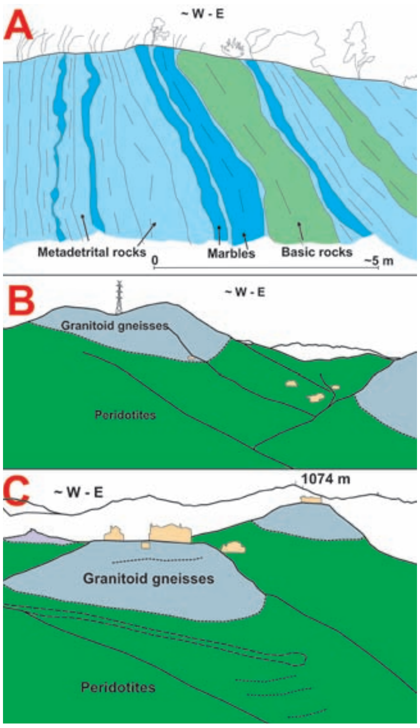

Fig. 3.- A) Detail of the alternation of the metadetritic formation with basic rocks and marbles. B) Panoramic showing the superposition of the gneisses over the peridotites. C) Another panoramic of this same superposition, in this case situated more to the east. The schemes are taken from photos and their position can be seen in Fig. 1B.

Fig. 3.- A) Detalle de alternancia de la formación metadetrítica con rocas básicas y mármoles. B) Panorámica que muestra la superposición de los gneises sobre las peridotitas. C) Otra panorámica de la misma superposición, en este caso localizada más al Este. Los esquemas están sacados de fotos y su posición relativa se puede ver en la Fig. 1B

Tertiary thrust of the peridotites over the so-called Guadaiza unit. We consider that this correlation is adequate. Nevertheless, these gneisses have been dated by Acosta-Vigil *et al*. (2015) and Sanz de Galdeano and Ruiz Cruz (2016) as Permian by U/Th SHRIMP of zircon. This means that they were formed much earlier. Moreover, in this area of Guadaiza, the latter authors also consider the peridotites to be situated under these Permian rocks.

Conclusions

The geometrical relations described, together with the Permian age attributed to the granitoid gneisses, and the general attribution of the marbles to the Triassic, has the following important consequences for regional interpretation:

1) These gneisses do not correspond to rocks formed by the thermal thrust of the peridotites. On the whole, they are situated over the peridotites and, moreover, their attributed Permian age is not consistent with its formation during the generally accepted Tertiary age of the thrust.

2) The formations of Sierra Blanca occupy a higher position than do the gneisses and the peridotites. Consequently, Sierra Blanca does not crop out in a tectonic window, and does not form an individualized tectonic unit, although the peridotites partially overthrust its formations to the N of Sierra Alpujata.

3) The peridotites were exhumed for the first time during the Paleozoic, and partially eroded. Above them formed the magmatic rocks, acid and basic, later the metadetrital formation, and finally the marbles, in a process of extension (with fracturing permitting the extrusion of the igneous rocks) and subsidence that we know that continued regionally into the Cretaceous.

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