**Introduction**

U-Pb dating of zircons is the most versatile geochronological method to unravel the tectono-magmatic evolution of the continental crust. Applied in detrital zircon populations, it is an effective method to assess the provenance of metasedimentary sequences through comparison with possible source areas in older continental blocks. In addition, it can provide useful information for investigating geological affinity and possible correlations between different terrains. Another widely used method is $^{40}\text{Ar}/^{39}\text{Ar}$, which determines the age of deformation phases recorded by metamorphic rocks.

In SW Iberia, the Sierra Albarrana Domain (SAD) has traditionally been considered a terrain with a Variscan magmatic and metamorphic history related to the Ossa Morena Zone (OMZ, e.g., González del Tánago, 1995). However, recent works suggest a different scenario. Solís-Alulima et al. (2020) showed that the main tectonic fabrics, metamorphism, and related magmatism are essentially pre-Variscan (Lower Ordovician), and Díez Fernández and Arenas (2015) propose that SAD would be correlated with the Central Iberian Zone (CIZ).

In this study, we review the U-Pb and $^{40}\text{Ar}/^{39}\text{Ar}$ ages obtained from SAD and the ‘La Cardenchosa’ pluton (LCP) with the aim of discussing the origin, geological evolution, and geological affinity of this terrain located in the SW of the Iberian Massif.

**Geological Setting**

This study focuses on the SAD (Fig. 1A), a metasedimentary sequence that defines an anticlinorium (González del Tánago, 1995), and LCP, a granitic body intruding the metasediments. Strati-
Pluton B

de two different concordia ages. The first
ted into two coherent groups that provi-
zircons. The obtained ages can be separa-
from 469 to 498 Ma with no xenocrystic

gle U-Pb analytical results provide ages
matic zircon from acid igneous rocks. Sin-
oscillatory zoning, characteristic of mag-
idiomorphic crystals with well-developed
population of medium size (60–170 μm)
lís-Alulima
Magmatic zircon ages from LCP

U-Pb Geochronology

The zircon grains of LCP (CZ05; So-
Albarrana Domain. (1) Dallmeyer and Quesa-
15 concordant analyses performed on
zircon rims yield a coherent group who-
se concordia age is 478 ± 2 Ma and can be
considered the age of migmatization (Fig 2).
Zircon cores define a zircon po-
be considered the age of migmatization

10 concordant analyses performed on
zircon cores, whose ratio is generally greater
than 0.4 (except in older cores). These
characteristics indicate that the over-
growths are probably products of meta-
morphic recrystallization.

These analyses were compiled from So-
is-Alulima et al. (2022). The Kernel density
estimation plots (KDEs) are drawn in Fig. 2.
The Maximum Depositional Ages (MDA) were
calculated as the weighted average of the
$^{206}$Pb/$^{238}$U age of the youngest con-
cordant grains. Comparison of age distribu-
tions between samples was made using a
Kolmogorov-Smirnov (K-S) test. The mul-
tidimensional scaling analysis plots (3D-MDS)
were obtained using the data from the SAD
and neighbouring areas, with emphasis on the
metasedimentary sequences from the
Ediacaran to the Cambrian (Cambeses et al,
2017 and references therein).

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U-Pb Geochronology

Magmatic zircon ages from LCP

Fig. 1.- A) Geological map of SAD. In the box on the lower left, the location of the domain in
the Iberian Massif is indicated; B) Stratigraphic column, simplified from Insúa et al. (1990).
The sample locations and MDAs are taken from Solís-Alulima et al. (2020, 2022), Dallmeyer and
Quesada (1992) and Azor et al. (2012), reference numbers are shown in Table I.

47 concordant zircons of the Azuaga
Formation (AZ16) yielded concordant ages
between 545 ± 20 and 1928 ± 36 Ma. MDA of 554 ± 8 Ma was obtained.

Fig. 1. - A) Mapa geológico del Dominio de Sierra Albarrana. En el recuadro abajo a la izquierda,
se indica la ubicación del dominio en el Macizo Ibérico; B) Columna estratigráfica, simplificado
por Insúa et al. (1990). Las ubicaciones de las muestras y las MDAs son tomadas de Solís-Alulima
et al. (2020, 2022), Dallmeyer y Quesada (1992) y Azor et al. (2012), los números de referencia se
muestran en la Tabla I.
40Ar/39Ar Ages

We have compiled the ages obtained by this method (Table I) and plotted them together with the U-Pb ages for comparison (Fig. 2).

Discussion

Magmatic and metamorphic ages

The metamorphic and magmatic evolution of the SAD has generally been attributed to the Variscan cycle (e.g. Dallmeyer and Quesada, 1992). Recently, Azor et al. (2012) proposed an older low-pressure metamorphic event related to continental rifting leading to the onset of the Variscan cycle. Based on these results it has been proposed that the main regional fabric in the SAD could be Cambro-Ordovician and related to Cadomian magmatism (Solís-Alulima et al., 2022). Furthermore, the LCP, which is part of the Cambro-Ordovician igneous suite (ca. 478–480 Ma; Azor et al., 2016), crosses a pervasive synmetamorphic cleavage, supporting a Cambro-Ordovician age for SAD metamorphism.

Geochronology data presented by Solís-Alulima et al. (2020) confirm the Early Ordovician age (481 ± 2 Ma) previously attributed to LCP and ductile deformation developed under high-grade metamorphic conditions in the SAD. Field cross-cutting relationships suggest that the regional metamorphic fabrics of the SAD are older than the granite emplacement. In addition, the metamorphic ages obtained at the zircon rims of the migmatitic gneisses of the lower SAD successions are identical, within errors, to the age attributed to the LCP emplacement (~481 Ma), suggesting a common origin for the tectonic-metamorphic migmatitic banding in the basal parts of the SAD and the LCP emplacement.

The 40Ar/39Ar ages (Dallmeyer and Quesada, 1992; Azor et al., 2012) represent a very wide age range. The oldest age (ca. 482 Ma), obtained from an amphibolite collected from the Cabrill-Peña Grajera succession, could be related to a Cambro-Ordovician metamorphic event, while the youngest (ca. 337 – 392 Ma) would be related to the Variscan Orogeny and would correspond to reset ages.

Depositional age and stratigraphy

The Albarrana Succession forms the lower part of the SAD. If we consider its MDA, the age of the LCP (481 ± 2 Ma) intruding the Azuaga Formation, as well as a metamorphic age (478 ± 2 Ma) for the migmatites overlying this succession (Cabrill-Peña Grajera), we can conclude that the basin-filling of the SAD began in the middle Cambrian to early Ordovician (Solís-Alulima et al., 2022).

KDEs from SAD (Fig. 2) show a dominant age group in the Ediacaran-Cryogenian (c. 0.54–0.72 Ga), and two minor age groups in the Tonian (c. 0.72–1.0 Ga) and Paleoproterozoic (c. 1.6–2.5 Ga). This suggests that the principal detrital source corresponds to Cadomian magmatism (535–515 Ma). Mesoproterozoic, Paleoproterozoic, and Archean zircons would have been contributed by Paleoproterozoic basement and/or recycled continental crust in the eastern sections of the Gondwana margin.

Sample comparison: multidimensional scaling

Results from the samples of SAD were integrated for comparison by Solís-Alulima et al. (2022). The 3D-MDS plot (Fig. 3) suggests that the Albarrana Succession (AZ01) is regionally akin to the Lower Unit of the Schist Greywacke Complex (SGC–CIZ). The Cabrill-Peña Grajera (AZ03) and the upper part of the Albariza-Bembézar (AZ19–15) show strong resemblances with the Upper Alcadian Formation (CIZ). The lower part of the Albariza-Bembézar (AZ07) has a closer affinity with the Beiras Group (CIZ). Finally, the Azuaga Formation (AZ16) is nearer to the Cándana Formation in the West-Asturian-Leonese Zone (WALZ).

López-Guijarro et al. (2008) proposed that the SAD and the Serie Negra had a common detrital source and linked it to the OMZ. However, considering the possible difficulties in differentiating the OMZ from the Iberian autochthonous based on the age populations of detrital zircons, the comparison diagrams (Cumulative age distribution – CADs, 3D-MDS; Solís-Alulima et al., 2022), together with the Cambrian zircons obtained from SAD, indicate that these domains do not share a common source (Solís-Alulima et al., 2022). In addition, SAD geochemical and isotopic characteristics are very similar to those found in the sedimentary sequences of the autochthonous section of the CIZ (Fuenlabrada et al., 2021). These considerations strongly suggest that SAD could correlate with the autochthonous domains of the CIZ. Furthermore, based on comparison diagrams (3D-MDS), the Azuaga Formation shows a higher affinity with WALZ, also part of the Iberian autochthonous.

Possible settings and sources

According to Fuenlabrada et al. (2021), the SAD has very similar lithogeochemical and Sm-Nd isotopic signatures suggesting...
Conclusions

1. U-Pb ages of magmatic and metamorphic zircon grains indicate that the main tectono-magmatic event in the SAD is Lower Ordovician (granite emplacement; 481 ± 2 Ma and migmatization; 478 ± 2 Ma). This setting and timing are compatible with the late magmatic event defined for the Early Paleozoic rifting (535–460 Ma).

2. The oldest $^{40}Ar/^{39}Ar$ age (ca. 482 Ma) could be related to a Cambro-Ordovician low-pressure metamorphic event, while the young ages (ca. 337-392 Ma) would be related to the Variscan Orogeny.

3. The SAD was deposited in the middle Cambrian. This age is bounded by the MDA of the Albarrana succession (511 ± 21 Ma) and the magmatic age of LCP (481 ± 2 Ma), and the metamorphic age in the migmatites of the Cabril–Peña Grajera Succession (478 ± 2 Ma). The U-Pb zircon data, geochemical and isotopic characteristics, and regional comparisons strongly suggest that SAD is part of the autochthonous section of the CIZ. Zircon age patterns suggest a sedimentary provenance from the Sahara Metacraton and/or the Tuareg Shield.

Authors’ contribution

Solís-Alulima, B.; Paper Structure, methodology, data acquisition, editing, figures, research/analysis.
Abati, J.: Methodology, manuscript review, coordination, supervision.
López-Carmona, A.: Methodology, manuscript review, coordination, supervision.
Gutiérrez-Alonso, G.; Methodology, manuscript review.
Fernández-Suárez, J.: Methodology, manuscript review.

Acknowledgements

This work was supported by projects CGL2016-76438-P, PID2020-112489GB-C21, and PID2021-126347NB-I00. Solís-Alulima is funded by the predoctoral contract CT17/17-CT18/17 (UCM-Santander). We appreciate the constructive reviews from anonymous reviewers that have significantly improved the quality of the manuscript.

References