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Research paper

Petrography and geochemistry of fault-controlled hydrothermal dolomites in the Riópar area (Prebetic Zone, SE Spain)

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ABSTRACT

The present paper reports the first detailed petrographical and geochemical studies of hydrothermal dolomites related to MVT Zn-(Fe–Pb) deposits in the Riópar area (Mesozoic Prebetic Basin, SE Spain), constraining the nature, origin and evolution of dolomitizing and ore-forming fluids. Mapping and stratigraphic studies revealed two stratabound dolostone geobodies connected by other patchy bodies, which replace carbonate units of Upper Jurassic to Lower Cretaceous ages. These dolostones are associated to the W–E trending San Jorge fault, indicating a main tectonic control for fluid flow. Seven different dolomite types were identified: i) matrix-replacive planar-s (ReD-I); ii) matrix-replacive planar-e (ReD-II); iii) planar-e sucrosic cement (SuD); iv) non-planar grey saddle dolomite cement (SaD-I) pre-dating Zn-(Fe–Pb) sulfides; v) non-planar milky to pinkish saddle dolomite cement (SaD-II) post-dating Zn-(Fe–Pb) ores; vi) ore-replacive planar-e porphyrotopic (PoD); and vii) planar-s cloudy cement (CeD). Meteoric calcite types were also recognized. The different dolomite types are isotopically characterized by: i) depleted $\delta^{18}O$ (from +25.1 to +27.6‰ V-SMOW) and $\delta^{13}C$ (from −2.3 to +0.9‰ V-PDB) values compared to Upper Jurassic to Lower Cretaceous limestone signature ($\delta^{18}O$: +27.6 to +30.9‰ V-SMOW; $\delta^{13}C$: +0.5 to +3.2‰ V-PDB); and ii) $^{87}Sr/^{86}Sr$ ratios for the main dolomitization phases (ReD and SuD: 0.70736–0.70773) close to the Jurassic and Cretaceous carbonate values (0.70723–0.70731) whereas more radiogenic values (0.70741–0.70830) for saddle dolomites (SaD) related to the Zn-(Fe–Pb) sulfide mineralization prevailed after fluid interaction with Rb-bearing minerals. Microthermometrical studies on two-phase liquid and vapor fluid inclusion populations in planar and non-planar dolomites and sphalerite show homogenization temperatures between 150 and 250 °C. These data indicate that both planar and non-planar dolomite textures formed at high-temperatures under hydrothermal conditions in deep-burial diagenetic environments. The main dolomitizing phase (ReD-I/ReD-II and SaD-I) shows low to moderate fluid inclusions salinity (5–14 wt.% eq. NaCl), whereas the dolomitization related to ore precipitation (sphalerite and SaD-II) spreads to higher salinity values (5–25 wt.% eq. NaCl). These data may respond to a mixing between a low salinity fluid (fluid A, less than 5 wt.% eq. NaCl) and a more saline brine (fluid B, more than 25 wt.% eq. NaCl) at different fluid proportions.

1. Introduction

The study of dolostones and dolomitizing processes is of a great interest as the resulting rocks may host economic base-metals Zn–Pb–F ore-deposits (i.e. Mississippi Valley-Type (MVT) and Sedimentary Exhalative (SEDEX); Leach and Sangster, 1993; Muchez et al., 2005) and more than half of the world's hydrocarbon reserves (e.g. Zenger et al., 1980; Warren, 2000; Davies and Smith, 2006). Actually, more than 80% of recoverable oil and gas of North American reservoirs occur in dolomitized carbonates (e.g. Braithwaite et al., 2004). Due to intense hydrocarbon subsurface exploration, examples of oil and gas reservoirs in Paleozoic dolomitic rocks are well known (e.g. Davies and Smith, 2006; Hannigan et al., 2006; Morrow, 2014), but fewer cases hosted in Mesozoic dolomites have been studied (e.g. Ameen et al., 2010; Swart et al.,

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2005). The key factors controlling the occurrence and distribution of viable Mesozoic dolostone reservoirs remain insufficiently understood and their outcrop analogues are poorly studied.

Most of the known burial dolostone occurrences have an important tectonic control: extensional and/or transtensional faults are particularly common geodynamical settings (e.g. Duggan et al., 2001; Sharp et al., 2010). Structurally-controlled dolostones commonly involve hot fluids, defining the so called hydrothermal dolomites (HTD) (e.g. Davies and Smith, 2006; Smith and Davies, 2006), formed when the temperature of the dolomitizing fluid is 5 °C or higher than that of the host rock (White, 1957). The HTD geobodies can result in a variety of geometries, but the most common are: i) stratabound and tabular-shaped dolostone bodies which extend away from fault zones following suitable layers (e.g. Sharp et al., 2010; Lapponi et al., 2011; Martín-Martín et al., 2015, 2013; Dewit et al., 2014; Gomez-Rivas et al., 2014); ii) fault-related irregular dolostones distributed in patches along fault traces (e.g. Duggan et al., 2001; Wilson et al., 2007; López-Horgue et al., 2010); and iii) Christmas-tree like morphology, that results from stratabound end members and a patchy combination in individual dolostone bodies (e.g. Sharp et al., 2010).

In the Riópar area (Prebetic, SE Spain) dolomitization bodies spatially related to Zn-(Fe–Pb) mineralizations are hosted in Upper Jurassic to Lower Cretaceous carbonatic sequences. A first attempt to understand the relationship between dolomitization and mineralization in the area was done by Grandia et al. (2001), which was focused on petrographical studies. In the present paper we provide new petrographical and geochemical data in order to better understand the origin and evolution of dolomitizing fluids and the relationship with Zn-(Fe–Pb) occurrences in the area. Microthermometrical studies to constrain the composition, temperature and origin of dolomitizing fluids are also presented.

2. Geological setting

The study area is located near the Riópar village (Albacete province, SE Spain; Fig. 1), where Mesozoic siliciclastics, limestones and dolostones occur. This area is situated at the limit between the Internal and External Prebetic Zones (Fig. 1), a broad Alpine tectonic unit that corresponds to the outer portion of the fold-and-thrust belt of the Betic Cordillera (e.g. García-Hernández et al., 1980). It comprises Mesozoic to Cenozoic carbonates and clastics sequences up to 2000 m thick, originally deposited in the southern part of the Iberian continental paleomargin (Vera et al., 2004). The foreland NNW-verging Prebetic fold-and-thrust belt became detached from the Variscan basement along Upper Triassic sediments (Fig. 2) during the Miocene main orogenic stage (e.g. Barbero and López-Garrido, 2006). The External Prebetic Zone, dominated by shallow internal platform facies, corresponds to the deformed part of the septentrional basin where frequent stratigraphic gaps are observed.

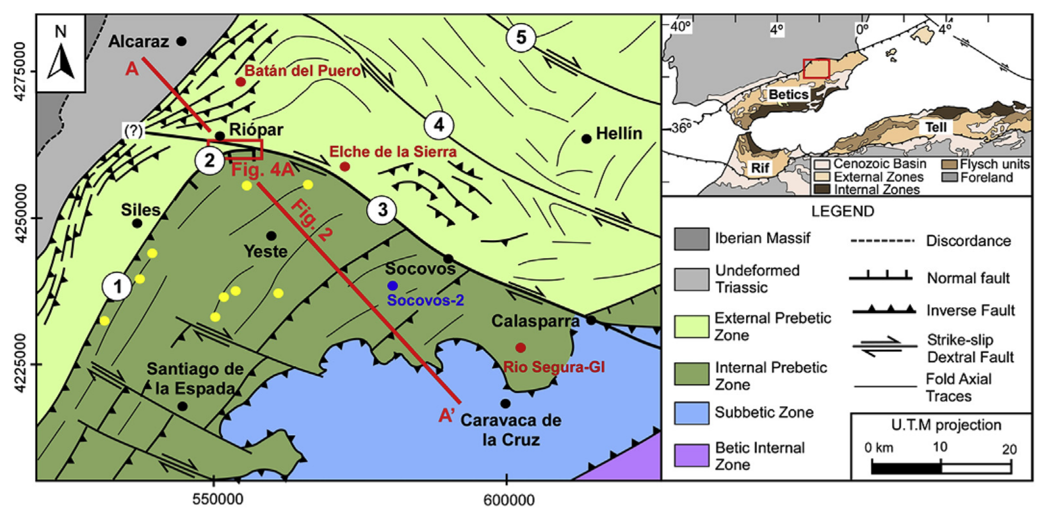

Fig. 1. Geological and tectonic sketch of Prebetic Zone (Betic Cordillera), modified from Pérez-Valera et al. (2010) (see Fig. 2 for geologic cross-section in direction A–A′ and Fig. 4a for detailed geological map of the studied area). The inset in the upper right corner shows the location of the studied area in the Betic Range (Comas et al., 1999). Numbers in circles refer to: (1) Alto Guadalquivir fault; (2) San Jorge Fault; (3) Socovos-Calasparra fault; (4) Liétor fault; and (5) Pozohondo fault. Color dots refer to location of: subsidence analyses performed by Hanne et al. (2003) (red); vitrinite reflectance analyses from Albian sandstones samples conducted by Barbero et al. (2001) (blue); and apatite fission-track thermal model analyses from Cretaceous samples performed by Barbero and López-Garrido (2006) (yellow). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

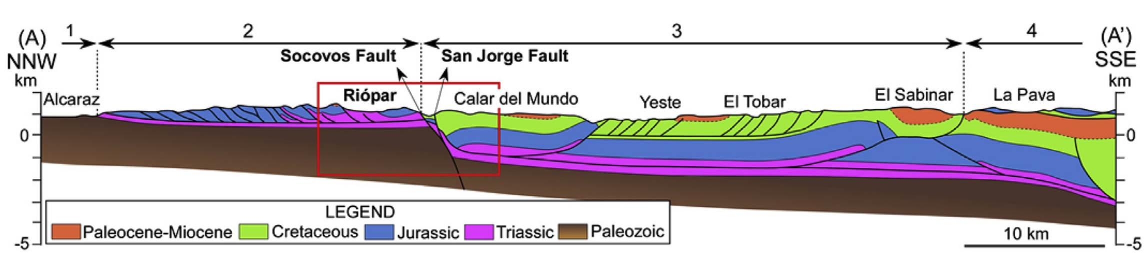

Fig. 2. Geologic cross-section of the Prebetic Zone (see Fig. 1 for location) according to Banks and Warburton (1991). The cross-section part into the red square is modified according our field geologic data. Numbers refer to: (1) Iberian Massif; (2) External Prebetic Zone; (3) Internal Prebetic Zone; and (4) Subbetic Zone. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)