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Research paper

Origin of the Breno and Esino dolomites in the western Southern Alps (Italy): Implications for a volcanic influence

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ABSTRACT

The Esino Limestone of the western Southern Alps represents a differentiated Ladinian-Lower Carnian (?) carbonate platform comprised of margin, slope and peritidal inner platform facies up to 1000 m thick. A major regional subaerial exposure event lead to coverage by another peritidal Lower Carnian carbonate platform (Breno Formation). Multiphase dolomitization affected the carbonate sediments. Petrographic examinations identified at least three main generations of dolomites (D1, D2, and D3) that occur as both replacement and fracture-filling cements. These phases have crystal-size ranges of 3–35 μm (dolomicrite D1), 40–600 μm (eu-to subhedral crystals D2), and 200 μm to 5 mm (cavity- and fracture-filling anhedral to subhedral saddle dolomite D3), respectively.

The fabric retentive near-micritic grain size coupled with low mean Sr concentration (76 ± 37 ppm) and estimated $\delta^{18}O$ of the parent dolomitizing fluids of D1 suggest formation in shallow burial setting at temperature ~ 45–50 °C with possible contributions from volcanic-related fluids (basinal fluids circulated in volcaniclastics or related to volcanic activity), which is consistent with its abnormally high Fe (4438 ± 4393 ppm) and Mn (1219 ± 1418 ppm) contents. The larger crystal sizes, homogenization temperatures (D2, 108 ± 9 °C; D3, 111 ± 14 °C) of primary two-phase fluid inclusions, and calculated salinity estimates (D2, 23 ± 2 eq wt% NaCl; D3, 20 ± 4 eq wt% NaCl) of D2 and D3 suggest that they formed at later stages under mid-to deeper burial settings at higher temperatures from dolomitizing fluids of higher salinity, which is supported by higher estimated $\delta^{18}O$ values of their parent dolomitizing fluids. This is also consistent with their high Fe (4462 ± 4888 ppm; and 1091 ± 1183 ppm, respectively) and Mn (556 ± 289 ppm and 1091 ± 1183 ppm) contents, and low Sr concentrations (53 ± 31 ppm and 57 ± 24 ppm, respectively).

The similarity in shale-normalized (SN) REE patterns and Ce $(Ce/Ce^*)_{SN}$ and La $(Pr/Pr^*)_{SN}$ anomalies of the investigated carbonates support the genetic relationship between the dolomite generations and their calcite precursor. Positive Eu anomalies, coupled with fluid-inclusion gas ratios (N_2/Ar, CO_2/CH_4, Ar/He), high F^- concentration, high F/Cl and high Cl/Br molar ratios suggest an origin from diagenetic fluids circulated through volcanic rocks, which is consistent with the co-occurrence of volcaniclastic lenses in the investigated sequence.

1. Introduction

This study has been focused on the dolomites that might have formed from diagenetic fluids derived from magma or from the interaction between volcaniclastic deposits and water circulating thorough them. To investigate the possible causal relationship between volcanic activity and dolomitization, it is important to identify successions where the dolomites occur in carbonate facies having volcanic or volcaniclastic deposits. The presence of these deposits may affect the composition of the fluids responsible for dolomitization and the geochemical fingerprints are expected to be

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recorded in the dolomites. A favorable scenario for this type of dolomites is presented by the Triassic succession of the Southern Alps of Italy (Fig. 1), where dolomitized platform facies are associated with volcaniclastic deposits (Fig. 2).

In the Southern Alps, crustal movements and volcanic activity took place during Middle and Late Triassic (Castellarin et al., 1979; Pisa et al., 1979; Brusca et al., 1981), and volcanogenic sediments (volcaniclastic sandstones, volcanic conglomerate and tuffs) have been extensively preserved within Anisian - Carnian carbonate sequences (Jadoul and Rossi, 1982; Crisci et al., 1984; Obenholzner, 1991). The carbonate units of the western Southern Alps (Esino Limestone, Calcare Rosso, Breno Formation and Calcare Metallifero Bergamasco) coeval with the volcaniclastic inputs are locally dolomitized and host important Pb–Zn mineralization (Assereto et al., 1979; Brusca et al., 1981). Therefore, the study of petrography and geochemistry of these dolomites is ideal to understand the possible role of volcanic activity in the development of the associated dolomites. The current investigation is a multi-approach study focused on the evaluation of possible contribution of volcanic activity to dolomitization of carbonates via petrographic and geochemical examination including microthermometry, fluid-inclusion gas ratios, stable isotopes, major and minor and rare earth elements (REE), and halogens.

The main objectives of this study are to:

1. Investigate the petrographic and geochemical characteristics and diagenetic evolution of the Esino and Breno dolomites, which are associated with volcaniclastic sandstones and volcanic deposits (mostly tuffs), in the western Southern Alps of Italy.
2. Identify and characterize (petrographically and geochemically) the dolomitization phases and investigate the characteristics and nature of their parent dolomitizing fluids.

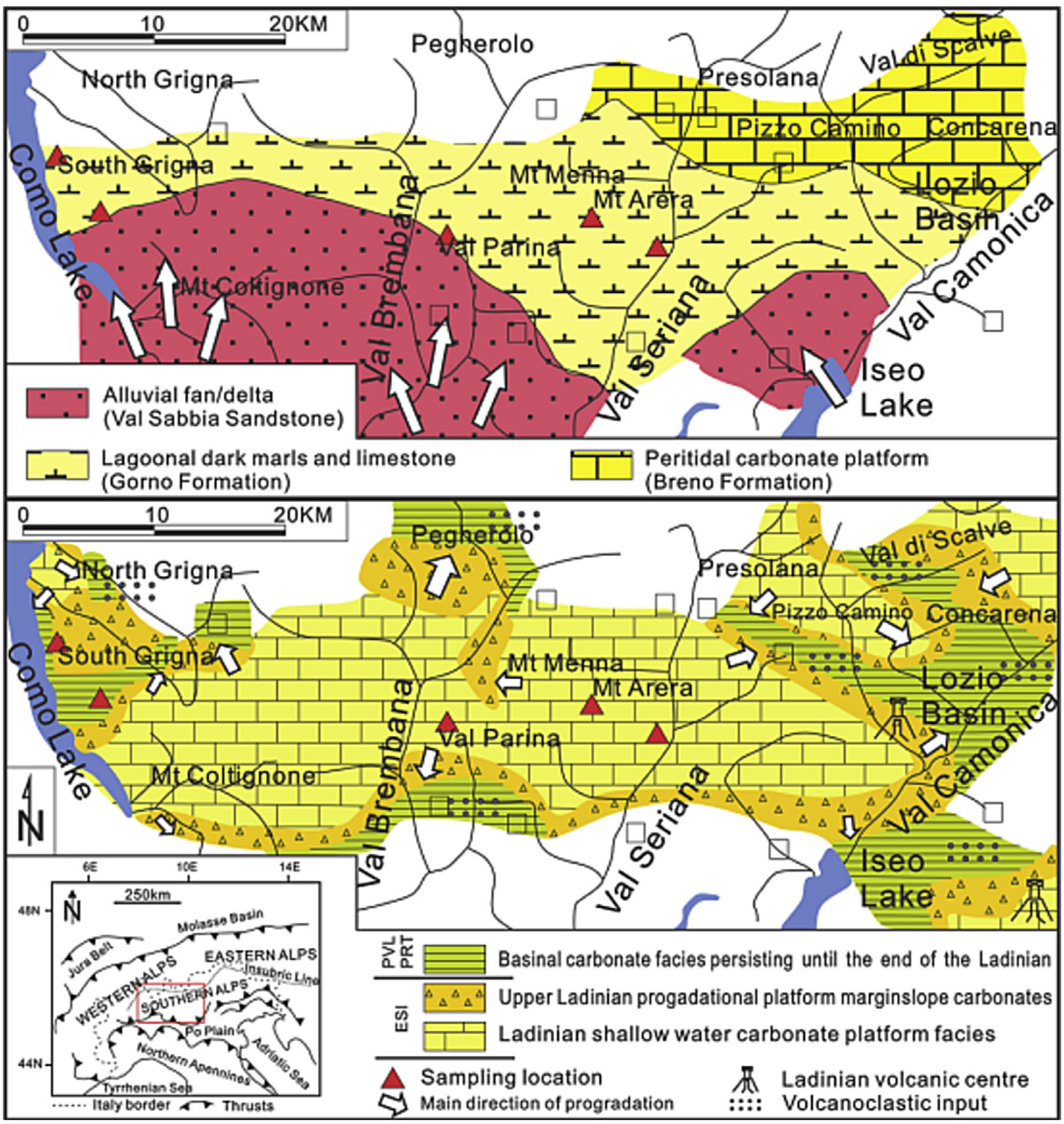

Fig. 1. Late Ladinian (below, modified after Berra et al., 2011) and early Carnian (above, modified after Brusca et al., 1981) palaeogeography of the western Southern Alps with inset of simplified tectonic map of Northern Italy (modified from Ronchi et al., 2011).