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Climate controlled, fabric destructive, reflux dolomitization and stabilization via marine- and synorogenic mixed fluids: An example from a large Mesozoic, calcite-sea platform, Croatia

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ABSTRACT

The Jurassic–Cretaceous dolomites, Adriatic platform, Croatia resulted from climate-influenced *post-depositional* reflux dolomitization (as opposed to synsedimentary peritidal- and deeper burial dolomitization), and subsequent stabilization within a Mesozoic, "calcite sea" isolated platform. The dolomites are stratiform (10 to 200 m thick), fabric destructive (20 to over 500 μm crystals), nonluminescent, and zoned with respect to Ca. Bulk dolomites have low Mn (10 to 30 ppm), moderate Sr (60 to over 200 ppm), positive $\delta^{13}C$ and $\delta^{18}O$ values, only moderate ordering (0.25 to 0.6) and single-phase fluid inclusions (temperatures <50 °C). High-Ca dolomite (HCD; ~53 to ~59 mol% Ca; $\delta^{18}O$ + 1 to > + 3‰ VPDB and Sr > 100 ppm) composes most Jurassic and 40% of Cretaceous dolomites, making up turbid dolomite cores and initial clear dolomite rims. A first generation of low-Ca dolomite (LCD-1; 50 to 53 mol% Ca; $\delta^{18}O$ + 1 to > + 3‰ VPDB; 100–180 ppm Sr) forms cement and variably replaces (stabilizes) earlier HCD cores. HCD and LCD-1 formed in refluxing marine-dominated pore waters under semi-arid climate (<300 m depth, 30 to ~40 °C). $^{87/86}Sr$ values of the HCD and LCD-1 dominantly were controlled by the refluxing seawater $^{87/86}Sr$ with minor addition of $^{87/86}Sr$ from ascending cooling fluids. During maturation of HCD, Sr loss was greatest from least stable, more calcic HCD (>55 mol%) phases. A second generation of much younger, low-Ca dolomite (LCD-2; fracture-associated, more negative $\delta^{18}O$ from −1.4 to +1‰ VPDB, Sr <100 ppm, enriched in radiogenic ^{87}Sr) overgrows and variably replaces earlier Cretaceous dolomites. It formed during Eocene–Oligocene deformation and uplift to <1 km burial depths (<50 °C) from synorogenic, mixed marine–meteoric pore fluids, circulating via faults, fractures and local permeable zones. Porosity loss by dolomite cementation coupled with localized, rapid Cenozoic uplift, variably arrested stabilization to LCD.

1. Introduction

Budd (1997) used the term *post-depositional dolomites* for dolomites generated by reflux of normal to slightly evaporative waters on isolated platforms, to differentiate them from typical peritidal fine-grained dolomites formed at or near the sediment–water interface, and from dolomites that form in the deeper subsurface at elevated temperatures. Such post-depositional dolomites can form in marine phreatic zones of active reflux down to 200 m subsurface, and perhaps down to 300 m in marine-dominated mixing zones (Budd, 1997; Cander, 1994; Gaswirth et al., 2007). Little altered, post-depositional dolomites have been widely documented from Late Cenozoic isolated platforms that formed in aragonite seas (Supko, 1977; Saller, 1984; Aharon et al., 1987; Hein et al., 1992; Vahrenkamp and Swart, 1994; Budd, 1997; Stanley and Hardie, 1999; Wheeler et al., 1999; Suzuki et al., 2006; Zhao and Jones, 2012b). Post-depositional dolomites can be partly stabilized in marine fluids via overgrowth of more stoichiometric dolomite rims (Wheeler et al., 1999; Suzuki et al., 2006; Zhao and Jones, 2012b) or in mixing zones in which less stable, early marine dolomite phases are converted into more stable dolomites via replacement and growth of dolomite cements (Cander, 1994; Gaswirth et al., 2007; Li et al., 2015).

Few studies have documented post-depositional dolomites from Mesozoic isolated platforms from calcite seas (Stanley and Hardie, 1999; Galluccio, 2009). Most have focused on syndepositional peritidal, hydrothermal and burial dolomites (e.g., Frisia and Wenk, 1993; Balog et al., 1999; Iannace et al., 2011; Ronchi et al., 2011; Meister et al., 2013). The massive, stratiform to discontinuous, coarse fabric-destructive dolomite units within the Upper Jurassic to Lower Cretaceous carbonates of the Adriatic platform, Croatia (Figs. 1, 2) provide an opportunity to fill this knowledge gap. These were referred to as

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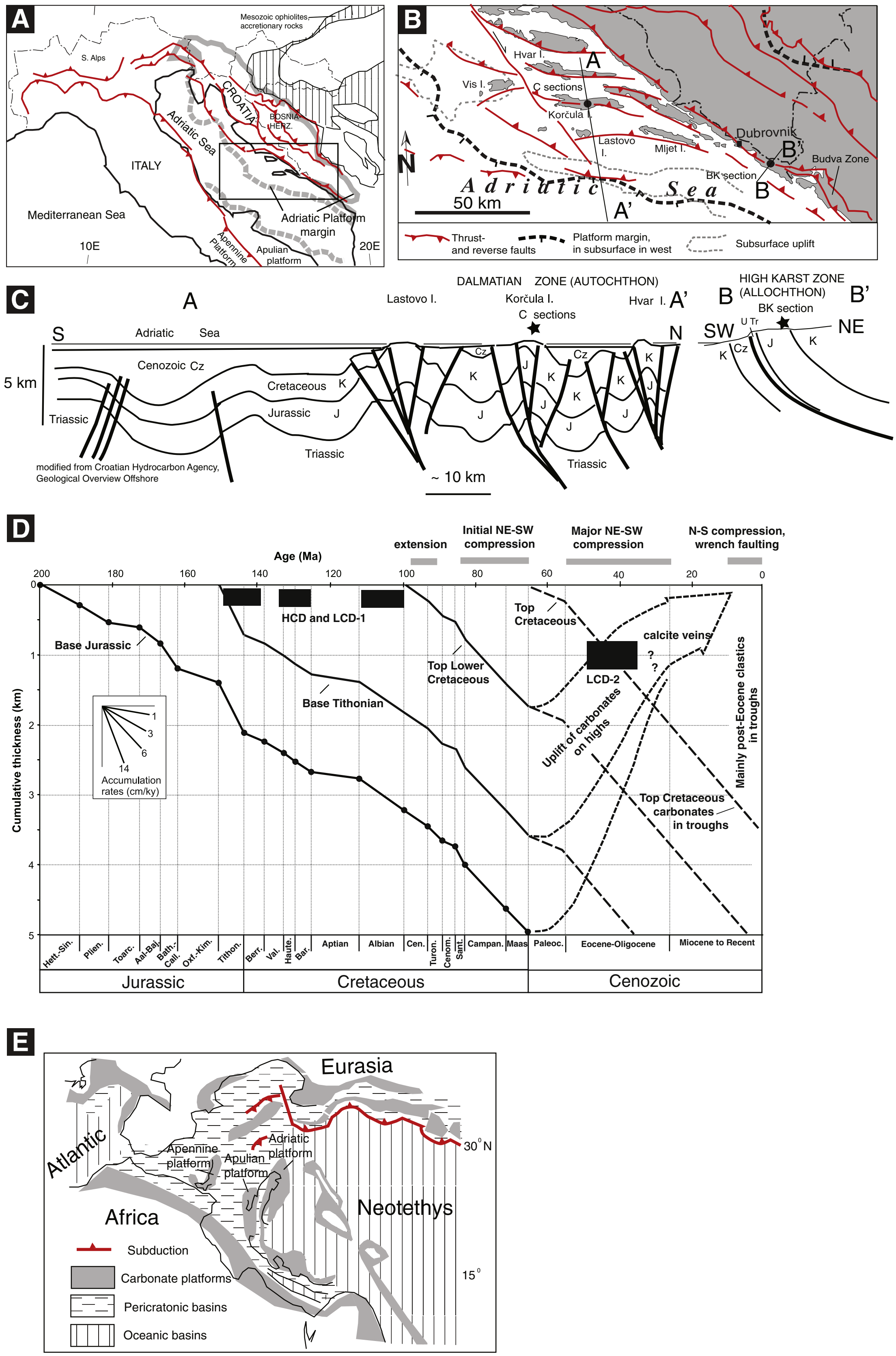

Fig. 1. (A) Map showing location of the Adriatic Platform. (B) Enlarged map of study area in southern Croatia, showing location of sections from which samples were obtained. Faults from Prtoljan et al. (2007) and Črne and Goričan (2008). (C) Cross section of study area, modified from Croatian Hydrocarbon Agency (2016). (D) Subsidence history plot for study area. Modified from Husinec and Jelaska (2006). (E) Simplified latest Jurassic–earliest Cretaceous paleogeographic sketch map showing location of the Adriatic Platform (modified from Golonka, 2002).