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Early diagenetic dolomitization and dedolomitization of Late Jurassic and earliest Cretaceous platform carbonates: A case study from the Jura Mountains (NW Switzerland, E France)

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ABSTRACT

Early diagenetic dolomitization is a common feature in cyclic shallow-water carbonates throughout the geologic record. After their generation, dolomites may be subject to dedolomitization (re-calcification of dolomites), e.g. by contact with meteoric water during emersion. These patterns of dolomitization and subsequent dedolomitization frequently play a key role in unravelling the development and history of a carbonate platform. On the basis of excellent outcrops, detailed logging and sampling and integrating sedimentological work, high-resolution sequence stratigraphic interpretations, and isotope analyses (O, C), conceptual models on early diagenetic dolomitization and dedolomitization and their underlying mechanisms were developed for the Upper Jurassic / Lower Cretaceous Jura platform in north-western Switzerland and eastern France. Three different types of early diagenetic dolomites and two types of dedolomites were observed. Each is defined by a distinct petrographic/isotopic signature and a distinct spatial distribution pattern. Different types of dolomites are interpreted to have been formed by different mechanisms, such as shallow seepage reflux, evaporation on tidal flats, and microbially mediated selective dolomitization of burrows. Depending on the type of dolomite, sea water with normal marine to slightly enhanced salinities is proposed as dolomitizing fluid. Based on the data obtained, the main volume of dolomite was precipitated by a reflux mechanism that was switched on and off by high-frequency sea-level changes. It appears, however, that more than one dolomitization mechanism was active (pene)contemporaneously or several processes alternated in time. During early diagenesis, percolating meteoric waters obviously played an important role in the dedolomitization of carbonate rocks that underlie exposure surfaces. Cyclostratigraphic interpretation of the sedimentary succession allows for estimates on the timing of early diagenetic (de)dolomitization. These results are an important step towards a better understanding of the link between high-frequency, probably orbitally forced, sea-level oscillations and early dolomitization under Mesozoic greenhouse conditions.

1. Introduction

Dolomite-capped cycles are common features in shallow-water carbonates and have been reported throughout the geologic record (Goldhammer et al., 1990; Montañez and Read, 1992; Yoo and Lee, 1998; Bosence et al., 2000; Dehler et al., 2001). Their patterns, processes, and timing frequently play a key role in understanding the development of carbonate platforms. Moreover, the usually stratiform dolomite bodies may have economic implications when forming layer-cake hydrocarbon reservoirs (Swart et al., 2005; Borkhataria et al., 2006). At a later stage, dedolomitization (calcitization of dolomites) may happen. One possible mechanism for dedolomitization, that is further explored in this paper, is by contact with percolating meteoric waters during subaerial exposure (Cantrell et al., 2007; Nader et al., 2008).

The goal of this study is to further the understanding of the links that exist between dolomitization and dedolomitization patterns, vertical facies distribution/cyclicity, the architecture of depositional sequences, and high-frequency oscillations of relative sea-level. Upper Kimmeridgian to Middle Berriasian carbonates of the Jura platform (NW Switzerland and E France) were recently subject of a detailed study, focussing on their sedimentology, sequence stratigraphy, and cyclostratigraphy (Rameil, 2005). On the basis of excellent outcrop conditions and detailed logging/sampling, conceptual models on dolomitization and dedolomitization patterns as well as their underlying mechanisms were developed for this example platform. Additionally, the application

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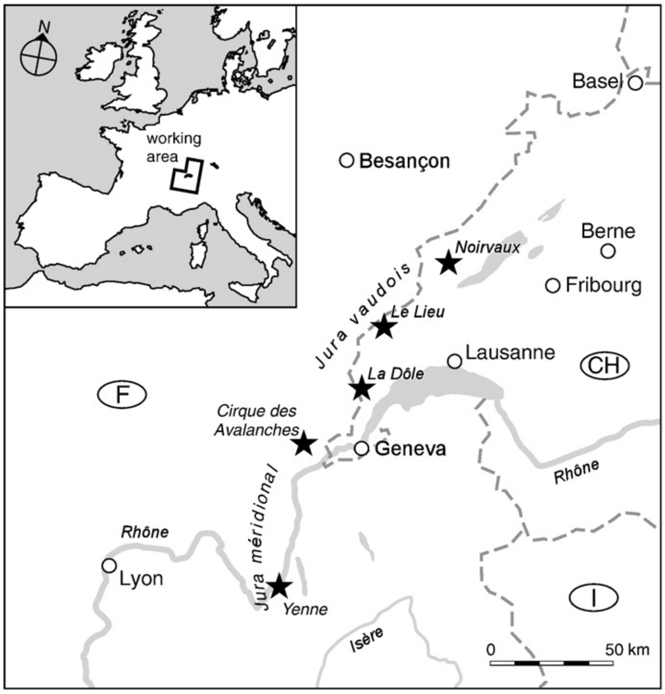

Fig. 1. Geographic overview of the working area with locations of measured sections.

of the proposed cyclostratigraphic timeframe (Rameil, 2005) allows for estimating the duration of the time interval during which early diagenetic processes were active.

2. Geologic setting

The study area is located in the central and southern Jura Mountains, the so-called *Jura vaudois* and *Jura neuchâtelois* of north-western Switzerland and the *Jura méridional* of eastern France (Fig. 1). The Jura Mountains are a predominantly calcareous mountain chain of moderate height (~1700 m) that trends subparallel to the northern Alpine Front. They mainly consist of the remains of a Jurassic and Lower Cretaceous carbonate platform that was folded and thrusted during the latest tectonic phases of the Alpine orogeny. Tectonic deformation, however, took place at rather shallow burial depth (thin-skin tectonics) and resulted mainly in wide, open geometries of folds with only a minor thrusting component (e.g. Trümpy, 1980; Sommaruga, 1997). This leads to long, commonly steeply inclined, but relatively undisturbed sections that are accessible in natural gorges cutting into the folds normally to the fold axes and/or along road cuts. The study focuses on rocks of Late Kimmeridgian, Tithonian, and Early Berriasian age (Upper Reuchenette, Twannbach, and Goldberg Formations).

During the Late Jurassic and Early Cretaceous, central and western Europe consisted of a patchwork of low-relief islands in a shallow continental sea at the north-western passive margin of the Alpine Tethys. Here, the Jura platform represented the central part of the North-Tethyan platform. According to palaeogeographic reconstructions (e.g., Ziegler, 1990; Thierry, 2000), the palaeolatitude of the Jura platform was approximately 30° to 35° N (Fig. 2).

Sedimentation from the Late Kimmeridgian to Middle Berriasian was characterized by shallow lagoonal and peritidal carbonates, organized in hierarchically stacked high-frequency sequences ("cycles"). These were most probably generated by orbitally forced sea-level change (Rameil, 2005). The amplitude of high-frequency sea-level changes was most probably very low (m-scale), as the

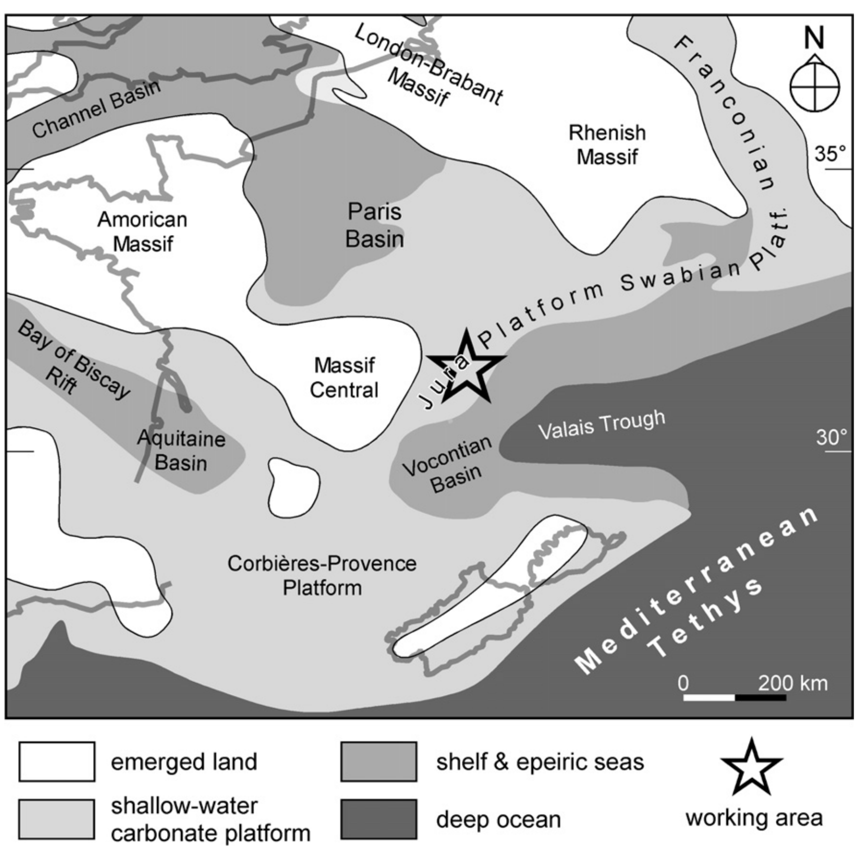

Fig. 2. Early Tithonian (ca. 150 Ma) palaeogeography of western and central Europe. After Thierry (2000).