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Sedimentology of resedimented carbonates: Facies and geometrical characterisation of an upper Cretaceous calciturbidite system in Albania

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ABSTRACT

Carbonate turbidite systems are not as well studied as their siliciclastic counterparts, resulting in a lack of knowledge on their vertical and lateral organisation. Thus, a preliminary detailed sedimentological study was undertaken in the upper Cretaceous limestones of Albania, which have been described as brecciated limestones and, more recently, as calciturbidites. The sedimentological study of three outcrops (Piluri, Vanister and Muzina) allows the definition of different lithologies grading from fine- to coarse-grained sequences representing the calciturbidites, intercalated with debris flow deposits and thick slumped levels. The thin-section examination of several facies defined in the field shows a dominance of mud-rich microfacies with variable granulometry, texture (mainly wackestone to packstone and floatstone), and the mixing of bioclastic and lithoclastic grains from both shallow-water (intertidal/infratidal) and deep-water settings (slope/basin). The microfacies description and fauna determination support the gravity origin of these calciclastic limestones. According to previous studies of the Ionian Basin and the surrounding platforms, the upper Cretaceous calciturbidite system could be reasonably linked to regional tectonic instabilities in relation to the beginning of the convergence between the Africa and Eurasian plates. The lateral and vertical organisation of these carbonate gravity deposits favours a depositional model over the apron model and that these deposits were fed by material derived from either the Apulian or the Kruja platform, through faulted shelf breaks.

1. Introduction

Siliciclastic turbiditic systems have been widely studied over the last fifty years in both ancient and modern settings (Bouma, 1962; Mutti and Ricci Lucchi, 1978; Normark, 1978; Mutti, 1992; Shanmugan, 2000; Posamentier and Kolla, 2003; Mulder et al., 2010), motivated by the hydrocarbon and source rock potentials of these deep-water environments (Shanmugan and Moiola, 1988). In contrast to siliciclastic systems, carbonate gravity flow deposits have been less studied. Nevertheless, the few studies published on modern and ancient gravity-redeposited carbonates have permitted to precise definition of the facies, the depositional models, and the controlling factors (Mullins and Cooks, 1986; Eberli, 1987; Haak and Schlager, 1989; Betzler et al., 1999; Vigorito et al., 2005; Payros and Pujalte, 2008).

The global morphologies of carbonate and siliciclastic turbidite systems have been compared by several authors, such as Colacicchi and Baldanza (1986) and Eberli (1991). The study of the internal sequence of calciturbidite beds (Meischner, 1964) revealed sedimentary characteristics similar to their siliciclastic counterparts (Bouma, 1962), such as the grading and the succession of sedimentary structures indicating a decelerating turbiditic current. Some other features are proper to calciturbidites, such as the poorer sorting, the local inverse grading, the secondary silicification (occurring as silica nodules or layers), and the presence of an underbed (a diagenetic micritic layer welded to the base of a turbidite) (Eberli, 1991). Geometrical analysis of carbonate turbidite systems resulted in two main models of deposition: (i) the slope and base-of-slope apron model fed by a multiple linear source (Mullins and Cooks, 1986) and (ii) the calciclastic submarine fan model fed by a localised source through a main feeder channel system (Cook and Egbert, 1981; Payros and Pujalte, 2008). The major factors controlling carbonate gravity systems are sea level fluctuations (Shanmugan and Moiola, 1984; Eberli, 1991; Bernet et al., 2000), regional basin tectonics (Eberli, 1987), source area (origin and nature of transported elements), and slope declivity (Eberli, 1991; Payros and Pujalte, 2008). Authors, however, agree that calciclastic systems remain under-investigated and that their general geometry, internal organisation and petrophysical parameters lack good constrains, as calciclastic systems usually are studied along sparse outcrops or seismic profiles (Mullins and Cook, 1986; Betzler et al., 1999; Savary and Ferry, 2004; Vigorito et al., 2005). However, resedimented carbonates

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have been described as potential reservoir rocks (Mullins and Cook, 1986; Casabianca et al., 2002; Van Geet et al., 2002) and should constitute future exploration targets for petroleum exploitation.

In the southwestern part of Albania, the upper Cretaceous deep marine limestones cropout as a result of uplift linked to the Tertiary Alpine orogeny. These limestones were described as calciturbidites (Meço and Aliaj, 2000; Van Geet et al., 2002), but little is known about their detailed stratigraphic organisation and facies variation. In the central part of Albania, mainly under the Peri-Adriatic depression and adjacent areas, some of these upper Cretaceous carbonate successions form hydrocarbon reservoirs in sub-thrust plays (Xhavo, 2002). This study focuses on resedimented carbonates deposited from the Santonian to the Maastrichtian in the Albanian area of the Ionian Basin, whose overall palaeogeographical and structural evolution are well constrained. These carbonate gravity deposits are remarkably well exposed in the Piluri, Muzina and Vanister sites, allowing for a detailed facies analysis. Based on a combined field and petrographical study, this paper aims to unravel the different facies and their associated microfacies and to analyse the geometrical organisation of this calciturbidite system. These interpretations will be integrated in a regional framework to address the main controlling factors triggering the carbonate gravity flows. A comparison with proposed depositional models will also be made.

2. Geological setting

The tectonic map of Albania (Fig. 1A) shows a general NNW–SSE trending succession of thrusts limiting W-verging tectonic nappes (Moisiu and Gurabardhi, 2005) (Fig. 1B). This nappe stacking constitutes the Albanides belt formed during the Tertiary Alpine orogeny. In the southwestern part of Albania, the Krasta–Cukali, the Kruja, and the Ionian tectonic zones correspond to the external Albanides. The Sazani zone is autochthonous and belongs to the Apulian domain (Fig. 1A). The thrusted formations of the external nappes are Triassic to Eocene in age. Northward, the Ionian and Kruja nappes are buried under the post-Eocene sediments of the peri-Adriatic depression, under which some formations constitute reservoir rocks for current petroleum exploitation (Xhavo, 2002) (Fig. 1B). The evolution of the Ionian region is marked by a Triassic-to-Eocene phase of passive margin conditions followed by an Oligocene-to-Quaternary phase of orogeny (Fig. 2). The Early and Middle Triassic correspond to intracontinental rifting related to the Neo-Tethysian rifting (Stampfli and Borel, 2002). In the Sazani and Ionian zones, the Late Triassic sediments consist of dolomites and evaporites deposited in a lagoonal/shallow-water environment (Meço and Aliaj, 2000). The Liassic formations display variations in facies and thickness, marking the former tilted fault block system (Roure et al., 2004). From the Middle Jurassic to Eocene, the sedimentation of the Ionian basin reflects a deep-water carbonate depositional system limited on the both sides by the Sazani and Kruja platforms (Figs. 2 and 3). The Middle Jurassic-to-Early Cretaceous Ionian deposits constitute a monotonous succession of pelagic limestone and cherts. The Late Cretaceous-to-Eocene sediments correspond to allochthonous turbidites, breccias, debris flows, and slumps (Bosellini et al., 1993; Borgomano, 2000; Meço and Aliaj, 2000; Heba and Prichonnet, 2009).

During Tertiary times, the African and Eurasian plate convergence involved the closure of the Neo-Tethysian Ocean and the formation of the Albanides belt (Kilias et al., 2001). In the Ionian zone, the Oligocene sediments consist of synflexural flysch. From Miocene to Quaternary times, synkinematic molassic sediments were deposited into

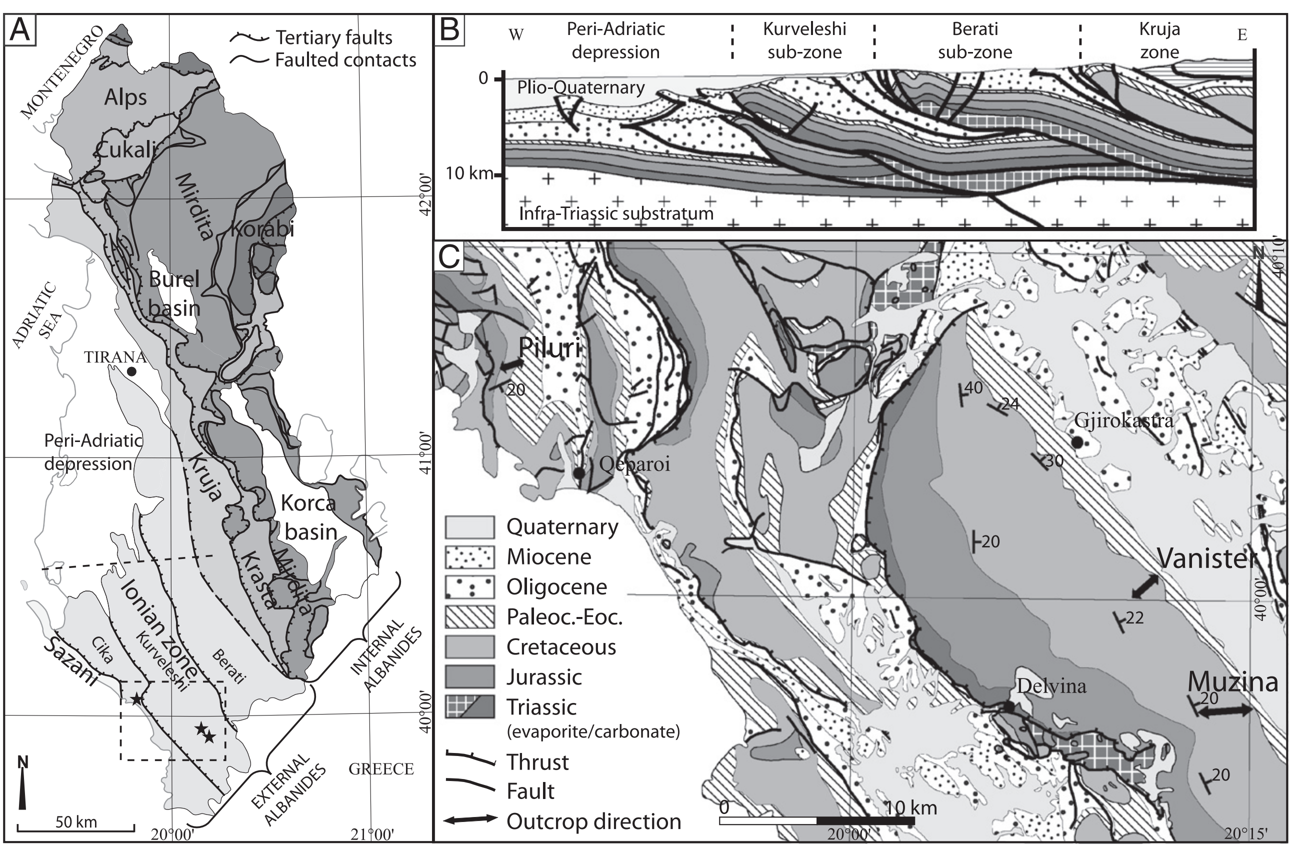

Fig. 1. Geological context of the study. A: Simplified tectonic map of Albania with the different tectonic zones and locations of the studied outcrops (star) (after Moisiu and Gurabardhi, 2005). The dashed line represents the cross-section in B, and the dashed rectangle represents the location of the detailed geological map in C. B: Seismic line interpretation of the external Albanides (after Roure et al., 2004), legend given in C. C: Detailed geological map of southern Albania with the studied Piluri, Muzina, and Vanister outcrops indicated (after Moisiu and Gurabardhi, 2005).