



## Research paper

# Petrographic and geochemical characterization of the early formative stages of Northern Adriatic shelf rocky buildups



Fulvio Franchi<sup>a,b,\*</sup>, Andrea Bergamasco<sup>c</sup>, Cristina Da Lio<sup>c</sup>, Sandra Donnici<sup>c</sup>, Claudio Mazzoli<sup>d</sup>, Paolo Montagna<sup>b,e</sup>, Marco Taviani<sup>b,f,g</sup>, Luigi Tosi<sup>c</sup>, Massimo Zecchin<sup>h</sup>

<sup>a</sup> Botswana International University of Science and Technology, Private Bag 16, Plot 10071 Palapye, Botswana

<sup>b</sup> Institute of Marine Sciences, National Research Council, Via Gobetti 101, 40129 Bologna, Italy

<sup>c</sup> Institute of Marine Sciences, National Research Council, Arsenale - Tesa 104, Castello 2737/F, 30122 Venezia, Italy

<sup>d</sup> Department of Geosciences, University of Padova, Via Gradenigo 6, 35131 Padova, Italy

<sup>e</sup> Laboratoire des Sciences du Climat et de l'Environnement LSCE/IPSIL, CEACNRS-UVSQ, Université Paris-Saclay, Avenue de la Terrasse, Gif-sur-Yvette, Île-de-France, 91198, France

<sup>f</sup> Biology Department, Woods Hole Oceanographic Institution, 266 Woods Hole Rd, Woods Hole, Ma. 02543, USA

<sup>g</sup> Stazione Zoologica Anton Dohrn, Villa Comunale, 80121 Napoli, Italy

<sup>h</sup> National Institute of Oceanography and Experimental Geophysics, Borgo Grotta Gigante, 42/c, 34010 Sgonico, Trieste, Italy

## ARTICLE INFO

## Keywords:

Temperate carbonates  
Allochemic sandstone  
Beachrock  
Marine diagenesis  
Bio-concretions  
Adriatic shelf

## ABSTRACT

A peculiar type of marine rocky outcrops is generated under temperate conditions through the cementation of carbonate and siliciclastic sediments on the northwestern Adriatic shelf. The lithification process results into the genesis of punctiform outcrops (*tegnùe*) that serve as substrate to substantial coralligenous epibenthic growth. These buildups have been often described as beachrock. More recently, an alternative genetic mechanism, implying precipitation of carbonate cements in the marine phreatic zone, has been hypothesized for the rocky outcrops off the coast of Chioggia (south of Venice). These rocky outcrops are settled along the levee of meandering channels inherited from Pleistocene fluvial systems.

Petrographic analyses of the Chioggia rocky outcrops allowed distinguishing three (3) main lithofacies: 1) biofouled sandstone blocks; 2) cross-stratified slabs and 3) bioclastic carbonates. These lithofacies have a common substrate mainly made by allochemic sandstone and sandy allochem limestone consisting in rounded grains of limestones and dolostones. The host sediments are cemented by a thin micrite coating followed by isopachous rims of scalenohedral and bladed calcite. Geochemical analyses revealed a sensible decrease in Mg contents between the early and late generations of isopachous cements. Vadose cements are missing suggesting that the precipitation of calcite cements occurred in marine phreatic zone without supra-tidal exposure. The lack of aragonite cements suggests that seawater was mixing with meteoric groundwater. The mixing of groundwater induced a partial dissolution of high-Mg calcite and precipitation of a later stage low-Mg calcite.

The lithification of the morphologies inherited from Pleistocene fluvial systems provided the nucleus for the development of the coralligenous buildups observed in the North Adriatic Sea shelf. It is possible that diagenetic processes, other than those normally responsible for the formation of beachrocks worldwide, have been active in the northern Adriatic Sea starting from the post-Last Glacial Maximum transgression. It is therefore likely that these processes are more relevant for the coralligenous epibenthic growth in temperate siliciclastic shelves than previously thought.

## 1. Introduction

The occurrence of rocky outcrops in the Gulf of Venice has been reported in the scientific literature since the 60s (Stefanon, 1966, 1967, 1970). In the past 50 years researchers have demonstrated that the whole northeastern Adriatic Sea is dotted by rocky outcrops in a depth

range of 15–40 m (e.g., Gordini et al., 2012 and references therein). These outcrops are unevenly distributed from Grado in the north (Gardini et al., 2012) to the Po river delta, off Chioggia, in the south (Tosi et al., 2017), where they are named “*tegnùe*” (Fig. 1). To date most work carried on the *tegnùe* focused on their biological and ecological aspects (e.g., Boldrin, 1979; Colantoni and Taviani, 1980; Mizzan,

\* Corresponding author. Botswana International University of Science and Technology, Department of Earth and Environmental Science, Private Bag 16, Plot 10071 Palapye, Botswana.  
E-mail address: [franchif@biust.ac.bw](mailto:franchif@biust.ac.bw) (F. Franchi).