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Apport de la cathodoluminescence à haute résolution à l'étude de la diagenèse météorique dans les formations sédimentaires carbonatées

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Résumé

Cet article présente une étude des différentes transformations diagénétiques et de leur chronologie relative intervenues en milieu météorique et affectant le calcaire de la plate-forme carbonatée Oligocène supérieur au Nord du Bassin aquitain (France), en combinant des données de cathodoluminescence (imagerie et spectroscopie haute résolution) et de microsonde de Castaing. Plus de 128 analyses ponctuelles par la microsonde électronique (WDS) et plus de 60 analyses par cathodoluminescence (CL) ont été effectuées sur les différents ciments carbonatés identifiés préalablement par les méthodes classiques de microscopie optique. En fonction de l'intensité relative des bandes CL observées (350, 380, 430, 500 et 620 nm), il a été possible de classer les ciments en trois types. Grâce à ces investigations au sein de chaque ciment météorique, ce sont des successions de phases de croissance cristalline et de dissolution que l'on a pu identifier finement, et ainsi de proposer une séquence diagénétique météorique beaucoup plus réaliste exprimant les passages cycliques de la zone vadose (non saturée) à la zone météorique d'eau douce (saturée). ***Pour citer cet article : R. Chapoulie et al., C. R. Geoscience 337 (2005).***

Abstract

Contribution of high-resolution cathodoluminescence to the meteoric diagenesis in sedimentary carbonates. Different diagenetic transformations and their relative chronological sequence are studied in the meteoric diagenetic zone from the Upper Oligocene limestone at the North of the Aquitaine Basin (France), by combining high-resolution cathodoluminescence spectroscopy and electron-microprobe analyses. More than 128 spot analyses by electron microprobe and 60 analyses by cathodoluminescence spectroscopy are done on different meteoric cements firstly identified by classic optical microscopy. Three cement types are identified according to the relative intensity of the bands of their respective cathodoluminescence spec-

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tra (350, 380, 430, 500, and 620 nm). From these investigations, we could identify for each meteoric cement different phases of crystalline growth and crystalline dissolution. As a result, a better and more realistic meteoric diagenetic model is proposed. It illustrates the cyclic transformations from vadose zone (unsaturated) to meteoric zone (saturated). ***To cite this article: R. Chapoulie et al., C. R. Geoscience 337 (2005).***

Mots-clés : Cathodoluminescence ; Calcaire ; Diagenèse météorique ; Ciments

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Abridged English version

1. Introduction

During the last decade, high-resolution cathodoluminescence (CL) has been widely used for the study of the genesis and diagenesis of carbonated sedimentary formations. The contribution of high-resolution CL proves to be particularly important for a detailed knowledge of the sequences of crystalline growth, processes of crystalline dissolution and the understanding of some diagenetic physicochemical conditions of the cement formation [7,12,14,15]. Some authors have introduced the notion of 'cement stratigraphy', based on the appearance of some zonations into carbonated cements (zonal stratigraphy). They use in particular the variations of colour and intensity of luminescence versus the concentric zonations in a crystal, dependent on a variation of Mn^{2+} and Fe^{2+} concentration [2,6,8,11].

Cement characterization through high-resolution cathodoluminescence methods proves to be particularly helpful for the understanding of the meteoric diagenetic influence on the sedimentary evolution of a carbonate platform during LST (Lowstand System Track) period. The objective of this paper is to apply the results of the experimental evaluation of the role that Fe^{2+}, Fe^{3+}, Mn^{2+} cations play in the cathodoluminescence of calcite for studying different cements due to the meteoric diagenesis of a limestone. The main interest in using CL, lies in the knowledge improvement of the diagenetic transformation sequence in meteoric zone.

2. Object and samples choice

A hundred and twenty samples taken in three underquarries Aquitaine Oligocene carbonate were first investigated by petrographical and mineralogical analyses. These analyses showed an important variation of the texture and of the sedimentary and diagenetic facies. This limestone is characterised by four sedimentary textures: mudstone–wackestone, packstone, packstone–grainstone and grainstone. It is mainly composed of red algae, oncolithes and miliole.

CL-study of carbonate cements was made on grainstone textures considered to represent the diagenetic transformations. The Aquitaine Oligocene limestone was laid during the transgression of the Oligocene. It belongs to a carbonate sedimentary system of a stable marine platform located in the North of the Aquitaine Basin.

Since its deposition (32 Myr), the carbonate platform has remained permanently emerged in a meteoric diagenetic environment. It thus constitutes a sound example of carbonate platform deeply transformed by meteoric dissolution.

3. Methods

The CL image is made using an OPEA system linked to an optical microscope Olympus Bx51 and a DP50 camera with a 3CCD. The CL image is obtained under an accelerating voltage of 10 kV, with electric intensity between 150 and 200 μA. Optimum conditions of reproductiveness were obtained.

The CL spectrometry is made in a SEM (JSM820) under acceleration tension of 20 kV and electric intensity of 70 nA.

More than 128 spot analyses using an electron microprobe (CAMECA SX50) and a detection threshold at 0.01% have been made on carbonate cements, with the following parameters: acceleration tension of 15 kV, beam intensity at 10 μA and spot size 10 μm^2.

4. Results and discussions

The CL spectra decomposition led to the identification of several emission bands at 350, 380, 430, 500,