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Facies-related diagenetic alteration in lacustrine–deltaic red beds of the Paleogene Ergeliin Zoo Formation (Erdene Sum area, S. Gobi, Mongolia)

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Abstract

The Late Eocene Ergeliin Zoo Formation, Mongolia, was subdivided into four facies associations/stratigraphic units which are characterized by various carbonate minerals: (I) mud–sand flat (low-Fe dolomite, high-Mg calcite), (II) delta front (high-Mn dolomite, low-Mg calcite), (III) delta plain (high-Mn calcite, low-Mg and moderate-Fe calcite), (IV) calcretes (high-Mg calcite). Besides carbonate minerals, prevailing among the cement minerals, some sheet silicates (Ca smectite, palygorskite, illite), apatite and Fe oxide-hydroxides occur in the siliciclastics of these lacustrine–deltaic red beds.

The prodelta/mud–sand flat deposits (unit I) were dolomitized and cemented by high-Mg calcite during evaporative pumping at times of low lake-stand under redox conditions greater than 0 and intrastratal solutions of strong alkalinity. Manganoan dolomite is fairly widespread in the delta front sediments (unit II), the Mn content of which is likely to have been derived from decomposition of vertebrate remains. The Mn/Fe ratio in the carbonate minerals was controlled by the redox conditions and the shallow burial depth. In the porous delta front sediments Eh values around zero and pH values slightly above 7 occurred as a result of basinward fluid movements (high-Mn dolomite, high-Fe dolomite, low-Mg calcite). Fluid movement was locally impeded by finer-grained delta plain deposits (unit III), intertonguing with arenaceous aquifers (low Mg-moderate Fe calcite, high-Mn calcite). Higher up on the delta plain with deposits laid down in an environment transitional between distal alluvial and deltaic (unit IV), closed lake basin conditions reappeared as fluids emerged from the distal alluvial–fluvial deposits or were driven by capillary force to ascend and form calcretes

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abundant in Mg-bearing calcite. The climatic conditions in the Erdene Sum area, Mongolia, are likely to have been semi-arid transitional into arid.

Keywords: Lacustrine–deltaic; Carbonate; Phyllosilicates; Diagenesis; Paleogene; Mongolia

1. Introduction

In continental environments the prograding coarse-grained alluvial fans and fan deltas debouching their debris into intercontinental, lacustrine basins have attracted much attention (Nemec and Steel, 1984; Elmore et al., 1989; Dill, 1995; Martins-Neto, 1996; Guocheng Zhang et al., 1998; Anadon et al., 1998; Alonso-Zarza and Calvo, 2000; Benvenuti, 2003). Calcareous minerals cementing red beds have, however, gained not very much attention (Gonçalves and Carvalho, 1996; Khan et al., 1997; Garzanti and Gaetani, 2002). Only a few investigations addressed carbonate mineralization in such red bed depositional systems (South and Talbot, 2000; Wopfner, 2002; Zerfass et al., 2003).

The Paleogene Ergeliin Zoo Formation, well exposed in the southern Gobi desert of Mongolia, offers favorable conditions for the study of carbonate mineralization in red bed series (Fig. 1). Carbonate mineralization in the Ergeliin Zoo Formation is pore- and cavity-filling. Fissure-bound carbonate mineralization does not exist. Nothing has been published so far on the diagenetic alteration of these Paleogene red beds with carbonate minerals making up a large proportion of the rock forming minerals (Table 1). The scope of the present petrographic investigation is to show how cement minerals and their compositions change as a function of lithofacies and how physico-chemical conditions vary along with coarsening-upward/progradation of a sedimentary sequence. Results obtained in the Paleogene Ergeliin Zoo Formation may be taken as a prime example to explain diagenetic alteration of calcareous siliciclastic lacustrine–deltaic deposits in a near-surface environment.

2. Geological setting

The working area, Khoyor zaany ovoo (=Two Elephant Hill), is located near the Mongolian–Chinese border (Fig. 1a). Jamiyandorj and Dagva Ochir (2001) and Badarch (2003) gave the most recent geological account on this part of Mongolia. The basement is made up of different terrains (Enshoo island arc terrane) and basins (Nukhet davaa back arc/forearc basin). Middle to upper Mesoproterozoic metamorphic rocks of the Urgun Formation were intruded by granites and overlain by Mesozoic and Cenozoic sedimentary rocks. The Urgun Formation consists of greenschists, plagiogneiss, metaandesites, marbles, quartzite, granite-gneiss and amphibolites (Fig. 1b,c). It is unconformably overlain by the Cretaceous Baruun Goyot Formation whose age of sedimentation was determined based on dinosaur eggs and bones. Red to gray siliciclastics spanning the full grain size range from gravel to clay make up the Baruun Goyot Formation. The overlying Cenozoic rocks, which cover vast areas around Khoyor zaany ovoo, are represented by the Ergeliin Zoo Formation (Rojdenstvenskii, 1949; Dashzeveg, 1991) (Fig. 1b,d). The Sevkhuul and Ergel members are particularly rich in carbonate minerals and therefore will be dealt with in more detail in the following paragraphs (Fig. 2). The tectonic situation and occurrence of the Ergeliin Zoo Formation may be deduced from Fig. 1b. In the environs of Erdene sum, Dornogovi aimak, the Ergeliin Zoo Formation infills a graben, subsided into Precambrian rocks.

3. Methodology

During the field campaign, mapping and conventional logging were carried out at Khoyor zaany ovoo (Figs. 1 and 2). The stratigraphic cross section was surveyed by a hand-held magnetometer (Kappameter) and a gamma spectrometer for stratigraphic correlation and preselection of samples in the field. Laboratory-based mineralogical investigations involved examination of thin and particulate sections for