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Sedimentary Geology 175 (2005) 459–477

Sedimentary Geology

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Research paper

Quartz cementation and related sedimentary architecture of the Triassic Solling Formation, Reinhardswald Basin, Germany

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Received 30 March 2004; received in revised form 8 December 2004; accepted 8 December 2004

Abstract

The Olenekian Solling Formation of the Reinhardswald Basin was studied with the aim to examine the dependency of the degree of silica diagenesis on the sedimentary architecture. The Solling Formation is composed of stacked sandstone/clay–siltstone cycles deposited by braided (i.e., subarkoses) and meandering (i.e., subarkosic wackes) river systems. The sand-dominated braided rivers of the Lower Solling Formation are characterized by channels and downstream accretion, whereas mixed load meandering rivers of the Upper Solling Formation are represented by lateral accretion and laminated sands. Diagenetic processes which modified the sandstone–siltstone successions include compaction, feldspar alteration, and cementation. Sandy, clay-poor successions are highly quartz cemented (i.e., silica importers), whereas clay- and mica-rich successions are more compacted (i.e., silica balanced or silica exporters). Three quartz cement generations with a total volume of up to 18% indicate that silica from several different sources cemented the sandy fluvial architectural elements of the Lower Solling Formation. Cementation includes silica supply from internal and external to the sandstone layers, which are silica from grain margin dissolution, from feldspar alteration, silica released from clay–siltstones and silica precipitated from basinal brines. This cementation history is supported by cathodoluminescence observations and fluid inclusion studies, and a consistent burial history was successfully modeled by simulation of the thermal subsidence. In contrast to the Lower Solling Formation, the fluvial architectural elements of the mixed load systems of the Upper Solling Formation contain only one quartz cementation phase with a total volume up to 8%. The Reinhardswald Basin shows a dependency of the fluvial architecture and the diagenetic features. For that we define the term “diagenetic architecture”.

Keywords: Sandstone fluvial architecture; Diagenetic architecture; Quartz cementation; Silica sources and importers; Burial history

1. Introduction

Ancient lithified clastic sediments are the result of numerous diagenetic processes. Initial textures, compositions and volumes are modified by compac-

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0037-0738/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.sedgeo.2004.12.019

tion, dissolution and transformation of detrital phases. Transformed and dissolved phases are often reprecipitated as authigenic phases (Barnes et al., 1992; Dutton, 1993; Gaupp et al., 1993; Bjørlykke, 1994; Oelkers et al., 1996; Marfil et al., 2000; Chuhan et al., 2001). The interrelationship between diagenesis, the depositional system and basin fill facies, however, has been addressed in a more limited number of studies (Burley and McQuaker, 1992; Cord, 1995; Lynch, 1996). The emphasis of our investigation was the relationship between silica diagenesis and the distribution of depositional systems on a basin-wide scale. In order to reach this goal one 3rd-order cycle of a siliciclastic basin fill that is composed of stacked fluvial sandstone cycles was analyzed.

The investigated sequence belongs to the Solling Formation and is part of the Triassic Middle Buntsandstein, a well-known sandstone interval of the German Basin. The German Basin comprises several smaller subbasins, including the Reinhardswald Basin, where the Solling Formation is well exposed. Here the diagenetic processes that modify initial textures, compositions, and volumes by mechanical and chemical compaction, and the cementation of the lithified sandstone layers are described.

The following specific issues are addressed in this paper:

(i) The depositional architecture of braided versus meandering rivers and their related diagenetic history;
(ii) the estimated degree of silica transfer between sandstone layers;
(iii) the diagenetic architecture in the Reinhardswald Basin; and finally
(iv) the burial history and fluid evolution of the Solling Formation.

A close relationship between the different fluvial architectural elements is observed in the Solling Formation of the Reinhardswald Basin. We define the word "diagenetic architecture" to show a predictive relationship between the fluvial lithologic variation and the diagenetic overprint. During diagenesis the depositional architecture in the basin is sensitively translated into the degree and type of silica transfer. Section 5.5. does refer to the term diagenetic architecture.

2. Geological setting

The Solling Formation belongs to the Buntsandstein, the lowermost part of the classical Germanic Triassic. The Olenekian Buntsandstein is dominated by epicontinental clastic sequences of fluvial, aeolian and evaporite to lacustrine origin (Wycisk, 1984; Bindig, 1991; Aigner and Bachmann, 1992; Lepper and Röhling, 1998). Sediment transport under generally semi-arid climate conditions was perennial, suggesting rare events of heavy rain periods in the crystalline source areas to the south. The clastic sediments were transported into a major playa system located in the northern part of the German Basin (Bindig, 1991).

The Reinhardswald Basin, a smaller subbasin of the entire Mid European Basin (Fig. 1a), is located between the source area in the south and the northern playa facies. It is 50 km in diameter and has a length of 100 km. The Solling Formation in the Reinhardswald Basin is characterized by massive sandstone layers and covers one interval of the Upper Olenekian. As one of the most characteristic formations of the Middle Buntsandstein (Fig. 1b), the Solling Formation represents one 3rd-order filling cycle of the Reinhardswald Basin (Wright and Marriot, 1993). Paleocurrent measurements of cross bedded units indicate a dominantly south to north transport along the former basin axis (Fig. 2). During deposition of the Solling Formation, the fluvial environment changed from braided to meandering river systems (Bindig, 1991). Changing deposition style may be governed by climatic and tectonic influences, which indicate a rise in base level (Wright and Marriot, 1993; Weber, 2000). In the depocenter of the Reinhardswald Basin, the Solling Formation reaches a maximum thickness of 120 m, whereas in paleohigh positions (i.e., the Eichsfeld Altmark Swell), condensed thicknesses of 10–30 m are observed (Fig. 2).

From Triassic to Jurassic times the Reinhardswald Basin was subjected to about 2 km of subsidence. Later, during the Cretaceous, the rate of subsidence decreased and the basin fill was