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Research paper

Occurrence and origin of pore-lining chlorite and its effectiveness on preserving porosity in sandstone of the middle Yanchang Formation in the southwest Ordos Basin

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ABSTRACT

The occurrence and origin of pore-lining chlorites in sandstone were studied using mineralogical and crystal chemical analysis and their effectiveness on preserving porosity was discussed. During the sedimentary period of the middle Yanchang Formation, the two provenance and sedimentary systems of the southwest and northeast developed in the southwest Ordos Basin. In the Northeast of the study area, the content of biotite flakes is approximately 10 vol%. Pore-lining chlorites prefer to grow on the surfaces of fine-grained detrital quartz and feldspar but not on ductile grains such as biotite. Pore-lining chlorites that developed during the early stage of eodiagenesis (< 90 °C) probably locally increased the compressive strength of the rock, in places with residual intergranular pores. The chlorites within different sand bodies show slight variations in their chemical composition. After initial mechanical compaction, the formation of authigenic chlorites (brunsvigite and diabantite) was probably related to the hydrolysis and alteration of biotite fragments and the migration of diagenetic fluid. In the Northeast, only 2 vol% of the chlorite rims significantly inhibited quartz overgrowth, preserving the primary porosity. However, they probably blocked and delayed the dissolution of acids to feldspar. The porosity probably decreased when the authigenic chlorite content exceeded 9.38 vol%. In the Southwest, the authigenic chlorite is rare and quartz-overgrown cement is widespread, causing poor reservoir quality. Authigenic chlorites increase with the content of biotite flakes in the northeast and southwestern parts of the study area, but excess ductile biotite flakes and authigenic chlorites have negative effects on reservoir quality.

1. Introduction

Grain-coating and pore-lining chlorites are significant for porosity preservation in siliciclastic and volcaniclastic sandstones (e.g. Boles and Franks, 1979; Bjørlykke, 1994; Ehrenberg et al., 1998; Pe-Piper and Weir-Murphy, 2008; Ajdukiewicz and Lander, 2010). Infiltrated chlorite coating is mainly caused by mechanical processes during deposition and is commonly found in fluvial facies (Wilson, 1992; Bloch et al., 2002; Berger et al., 2009; Morad et al., 2010). Authigenic chlorite coating, which formed in the early diagenetic stage, and pore-lining chlorites, which emerged after the initial mechanical compaction, are both commonly found in delta facies and turbidite sandstone (Hakimi et al., 2012; Friis et al., 2014; Wilson et al., 2016). Grain-coating and pore-lining chlorites could protect the primary pores by inhibiting quartz (or possibly other phases) precipitation (Ehrenberg, 1993; Anjos et al., 2003; Lander et al., 2008; Berger et al., 2009); however, some scholars consider that authigenic grain-coating and pore-lining chlorite can enhance the compressive strength of rock (Clough et al., 1981; Karig et al., 1993; Schnaid et al., 2001; Saidi et al., 2003; Spinelli et al., 2007).

Predecessors have carried out qualitative discussions on authigenic chlorite coats and rims. They considered that the early, adequate, continuous coats and rims have positive effects on the reservoir protection (Bloch et al., 2002; Taylor et al., 2010; Bahlis and De Ros, 2013). Regardless of their origin, the effectiveness of the grain coats or rims is a function of their completeness, thermal history, grain size and the abundance of quartz grains (Walderhaug, 1996; Bonnell et al., 1998). The amount of quartz cement shows an overall inversely proportional relationship with the coat completeness. However, there are few reports about negative effects of excess chlorite cement. Additionally, there is a lack of quantitative discussion of the valid thickness and amount of chlorite coats and rims. Therefore, topics that are worth studying include but are not limited to the following: 1) microfacies or sediment units (lamina and rock type) that contain pore-lining

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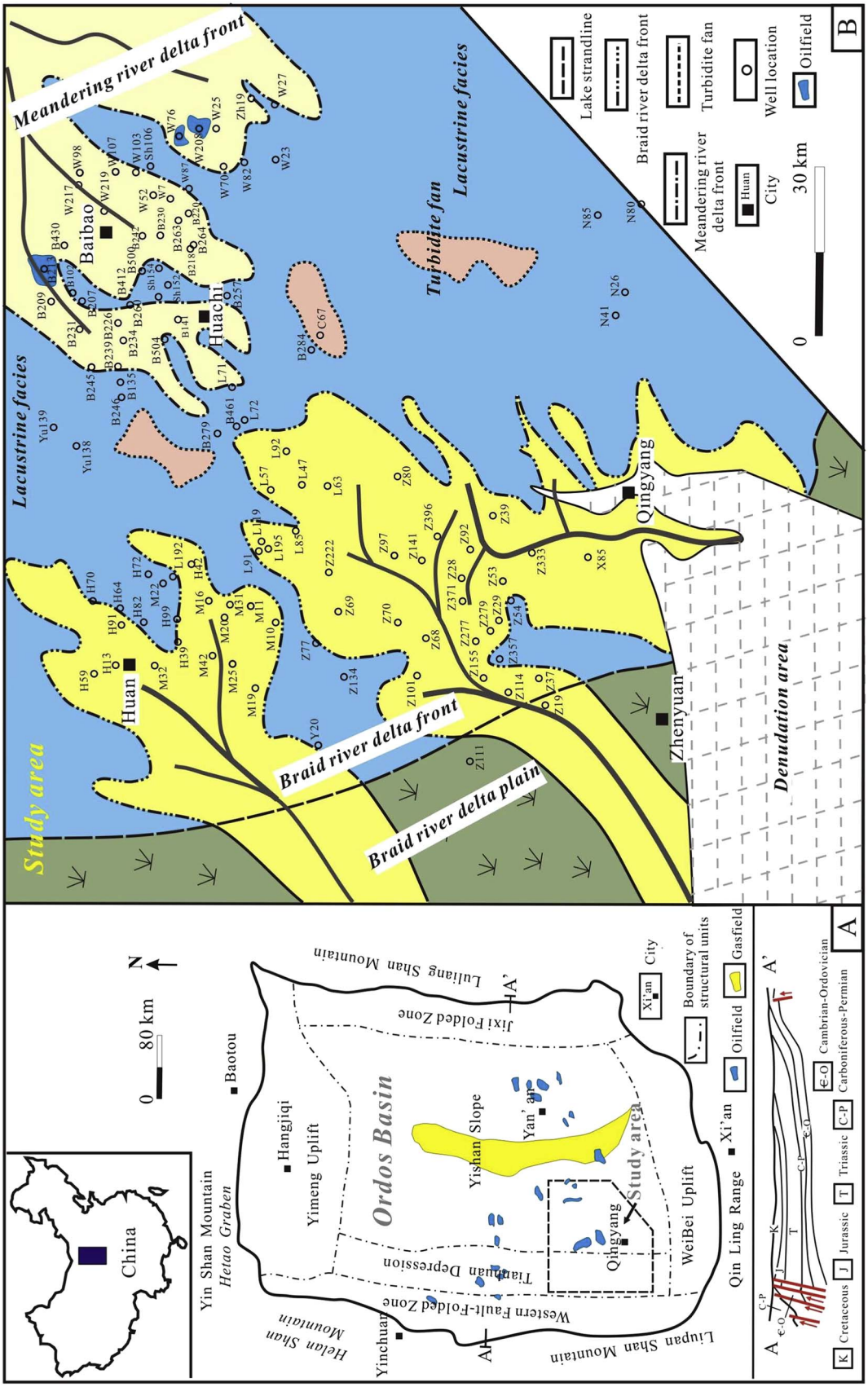

Fig. 1. (A) Location of the study area; (B) The distribution of the deposition facies (after Zhu et al., 2013). Zhenbei region = Zhenyuan + Huan + Qingyang regions; Huaqing region = Huachi and Baibao regions.