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What classic greywacke (litharenite) can reveal about feldspar diagenesis: An example from Permian Rotliegend sandstone in Hessen, Germany

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ABSTRACT

Rotliegend siliciclastic sediments in southern Hessen (Germany) are a good example of dissolution of detrital feldspars, which is a common feature in many sandstones. Dissolution occurred after mechanical compaction of the lithic-rich sandstone, which experienced framework collapse with pores and pore connections filled and obstructed by deformed ductile lithic grains (pseudomatrix) thereby reducing pore space to microporosity., The advanced degree of compaction and reduced porosity caused low permeability and low hydraulic conductivity of the rock mass. This is further reduced by the presence of wackes and shales that occur intercalated with the sandstones. Feldspar dissolution thus took place in low permeable sediments when large-scale flow of meteoric or acidic fluids is ruled out as a cause of feldspar dissolution. Mineral precipitation (illite, kaolinite, and albite) took place within pseudomatrix and detrital matrix as well as in secondary pores created by feldspar dissolution. Feldspar was the source for the authigenesis. The system was thus closed during burial after framework collapse, and diagenetic reactants in the form of detrital components were already present within the system. The original mass was preserved, but redistributed and diagenetic minerals were the local sinks for the dissolved reactants, precipitating within the system. This also suggests that burial diagenesis in general might be more mass conservative than usually assumed.

Rotliegend sandstones thus form a case where, despite of the lack of external exchange of mass by fluid flow, major diagenetic processes did take place and significantly modified the original mineralogy and texture. Feldspar diagenesis can take place from other processes than mere large-scale flushing of open systems as often supposed. It implies that the volumes of rock affected by feldspar diagenesis may be much larger than anticipated based upon the common hold believe that feldspar diagenesis is linked to unconformities and surface weathering or dissolution in near-surface aquifers.

1. Introduction

Rotliegend sandstone forms the main reservoir for numerous gasfields in the Netherlands, Great Britain, Poland, and Germany (Gaupp et al., 1993). It is mainly composed of quartzose sandstone, as are also most of the gas and oil reservoir sandstone in the North Sea (e.g., Gaupp and Okkerman, 2011; PanTerra confidential Rotliegend database). This sandstone type has therefore strongly influenced diagenetic modelling (e.g., Ajdukiewicz and Lander, 2010), which thus might be based on data derived from a kind of end-member detrital mode that is not representative for the whole spectrum of sandstone types. Existing diagenetic models might thus be based upon biassed suppositions. For example, proximal areas usually contain sandstone with a lithic composition but are rarely included in models of sandstone diagenesis. However, this type of sandstone is interesting because it may be a potential reservoir for unconventional plays and geothermal applications.

Quartz-rich detrital compositions are problematic for the reconstruction of the development of porosity through diagenesis. The relative timing of diagenetic processes, which is often based on the spatial relationships between detrital and diagenetic components, is difficult to estimate in detail. There are two major reasons for that. Quartz grains are rigid and only indicate mechanical compaction until the maximum degree of grain packing is reached (Paxton et al., 2002) while pressure dissolution between grains is rather uncommon (Houseknecht, 1988;

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