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Precambrian alluvial fan and braidplain sedimentation patterns: Example from the Mesoproterozoic Rjukan Rift Basin, southern Norway

Juha Köykkä

Department of Geosciences, University of Oulu, P.O. BOX 3000, 90014, Finland

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ABSTRACT

An integrated approach of facies analysis, geochemistry and paleohydrology provides new insight into the sedimentology and paleogeography of alluvial sediments in the Precambrian. Here, alluvial fan and braidplain sedimentation patterns are documented in a Mesoproterozoic rift basin, called (known as) the Rjukan Rift Basin in southern Norway. The studied formation (Heddersvatnet Formation) consists of volcanoclastic breccias and conglomerates, cross-bedded sandstones with associated mudstones, and subaerial basaltic lava beds, deposited in a rift basin during the syn-rifting phase. Based on genetically related major lithofacies associations and individual minor lithofacies, the sedimentation is characterized by colluvial and screen apron deposits, subaerial debris flows, hyperconcentrated or sheet flood deposits in the proximal part, representing waning-flood cycles. The distal part contains shallow-water traction current deposits and associated subaerial continental flood basalts that flowed down the rift valleys. The synsedimentary intra-rift faulting formed seasonal or climatically controlled, intrafan ponded-lake with playa lake type cycles and shrinkage cracks.

The geochemical composition of the of the studied sandstones and mudstones suggests a passive rifted continental margin with minor to moderate chemical weathering, possible in a semi-arid/arid paleoclimate. Clastic petrofacies of the sandstones indicate a locally uplifted and syn-rift paleotectonic setting during the main sedimentation stage, passing toward a post-rifting stage of the depositional basin. Small-scale structures within the sedimentary basin affected the depositional patterns of the Heddersvatnet Formation by creating local sites of uplift and erosion, controlling the sediment transport, and defining the accommodation space for deposition. The sedimentation of the Heddersvatnet Formation reflects a tectonic base level fall, which resulted in an accumulation of thick alluvial fan or braidplain sediments near uplifted flank(s) of the sedimentary basin. This was combined with intensive erosion of the basement in the pre-vegetation landscape, which resulted in changes in the hydraulic geometry of flow and sediment discharge of stream channels.

The following criteria, observed from the Heddersvatnet Formation, are suggestive of an ancient alluvial fan and associated braidplain sedimentation: (1) deposition close to the source area; (2) slightly divergent paleoflows; (3) high-energy flows with waning flood-cycles; (4) abundance of poorly sorted and laterally extensive subaerial debris flows, and related streamflows, possible sheetfloods, hyperconcentrated flows, and their associations; (5) great distribution of grain size and lithofacies changes in proximal vs. distal parts; (6) limited suite of sedimentary structures (cross-stratification, ripple-marks, and desiccanation cracks); (7) fault bounded basin (graben) with hanging wall close to uplifted flank(s); (8) paleoslope estimation indicating at least moderate paleotopographic highs; (9) colluvial and scree apron breccias; (10) lack of any typical braided stream channel fill conglomerates and floodplains; and (11) channelized sediment bodies lacking extensive lateral continuity.

1. Introduction

The Precambrian alluvial sedimentation patterns can provide important information about the continental sedimentation systems in non-fossiliferous sediments of the Earth's longest eon (see Eriksson et al., 1998, 2005). Sedimentology of the ancient and recent alluvial fans and braided streams have been described in many studies (e.g. Miall, 1970; Bull, 1972; Cant, 1978; Larsen and Steel, 1978; Rust, 1978; Cant and Walker, 1978; Nemec et al., 1980; Allen, 1983; Strand, 1986; Nemec and Postma, 1993), with other studies describing braidplain sedimentation (e.g. Boothroyd and Nummedal, 1978; Turner, 1983; Rust, 1984; Martins-Neto, 1984; Rust and Gibling, 1990; Rainbird, 1992; McCormick and Grotzinger, 1993). Ancient alluvial deposits can form thick, complex strata, but recognizing and distinguish between alluvial fan, braided fluvial, or braidplain deposits in the sedimentary

E-mail address: juha.koykka@oulu.fi.

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record is often difficult, especially if the channel(s) paleoslope is unknown (e.g. Eriksson et al., 2006; Bose et al., 2008). In fact, braided streams and alluvial fans are not separated in time and space, and braided streams can form a major component of individual fan (cf. Boothroyd and Nummedal, 1978). Recognition of different alluvial systems has been based mostly on physical rock properties, i.e., clast size considerations due to a lack of vertical sequences, which may lead to misinterpretations (Nilsen, 1982; Miall, 1992).

Alluvial sedimentation patterns can display complex interaction between tectonics, different sedimentation processes, climate, and source rock composition. They can be constructed and composed of material of any grain size, depending simply on material availability. Although, they tend to have some recognizable facies assemblages, the recognition of ancient alluvial deposits and its paleotectonic and paleoclimatic setting should be based on a combination of physical features, including textural, compositional, and lithofacies type criteria, in combination with studies of clastic petrofacies and geochemical characteristics. This study contributes to Precambrian alluvial systems by using multifaceted approach to recognize alluvial fan and braidplain sedimentation patterns from a well preserved and

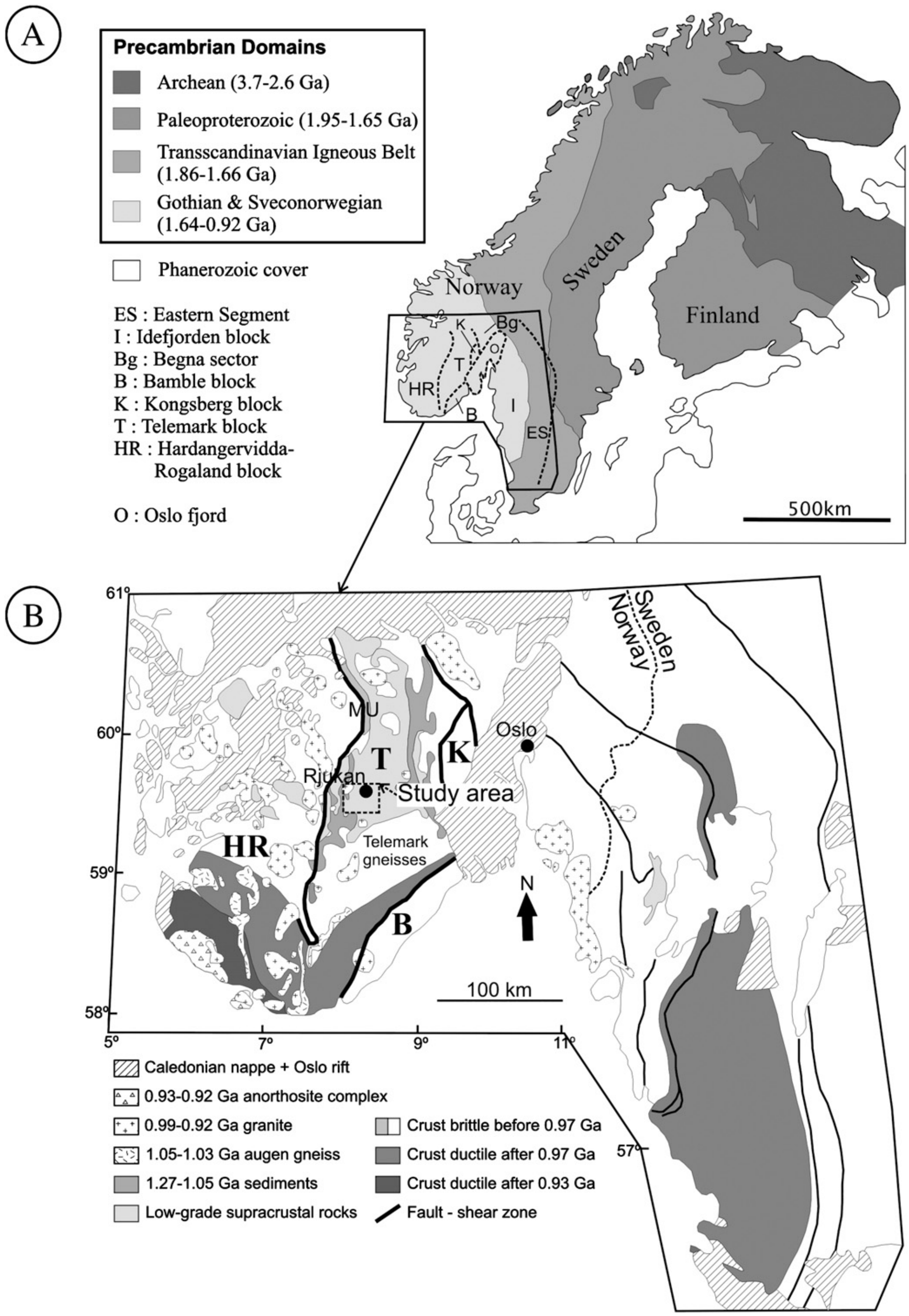

Fig. 1. A) Simplified geological sketch map of Fennoscandia. B) Simplified geological map of the Sveconorwegian belt, and domains affected by ductile deformation after 0.97 Ga (modified from Bingen et al., 2006, 2008b). Study area marked.