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The provenance and setting of the Mesoproterozoic Dala Sandstone, western Sweden, and paleogeographic implications for southwestern Fennoscandia

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ABSTRACT

The Mesoproterozoic (Jotnian) Dala Sandstone, western Sweden, is investigated using zircon U-Pb SIMS. The Dala Sandstone was deposited in a gentle sag basin and underwent post-depositional downfaulting and local deformation along the Sveconorwegian Frontal Deformation Zone. The maximum depositional age is lowered to 1.58 Ga, lending support to a suggested 1.5 Ga maximum age from regional basement age considerations. Associated 1.46 Ga volcanism (Öje basalt) indicates that the 1.5–1.4 Ga Hallandian-Danopolonian event triggered basin formation; in addition, repeated local magmatism and deformation over several 100 m.y. hint at the presence of a crustal weak zone. Provenance data indicate sediment sources in surrounding Svecofennian, Transscandinavian Igneous Belt and Gothian domains; age peaks coinciding with early Gothian phases suggest that older inboard parts of the orogen shielded the Dala region from the younger outboard parts. Decreasing input from the Gothian orogen after 1.46 Ga suggests changing regional drainage patterns. Archaean/Paleoproterozoic zircon in pre-Sveconorwegian sediments in southern Norway is proposed to reflect sediment routing from the north, or significant sinistral Sveconorwegian displacement of southern Norway along the Fennoscandian margin. The latter would potentially juxtapose the Dala basin and the Rjukan rift in southern Norway, however, these formed two distinct and separate basins.

1. Introduction

The Dala Sandstone is a well-preserved Mesoproterozoic sandstone covering large areas of the Dalarna region in western Sweden (Fig. 1). It is mainly exposed in waterfalls, quarries and steep hill sides since much of the area is covered by glacial till. It is a typical continental red sandstone, and imparts a characteristic red colour to the glacial till in Dalarna. Though the Dala Sandstone is a well-known rock in Swedish geology and commonly used in the construction industry, it has been relatively little studied. It belongs to the "Jotnian sandstones" (≈ Mesoproterozoic low-grade siliciclastic rocks) found across the Fennoscandian Shield (Sederholm, 1897), and is as such one of the keys to understanding the development of the shield in the Mesoproterozoic. The Dala Sandstone provides a sedimentary archive on the western Fennoscandian Shield at the time of the poorly understood Hallandian-Danopolonian orogeny along the southern Fennoscandian margin (Bogdanova et al., 2014; Roberts and Slagstad, 2014; Ulmius et al., 2015), to which the Dala Sandstone has been proposed to be related (Brander and Söderlund, 2009), and at the time of deposition of the geographically nearby volcano-sedimentary rift successions in Telemark, southern Norway, a crustal domain of disputed origin (Berthelsen, 1980; Bingen et al., 2005). A proposed correlation between the Dala Sandstone and the rift-successions in Telemark, southern Norway (Torske, 1985), the latter containing a locally important Archaean component (Bingen et al., 2001), is of particular interest in this context.

The objectives of this study are to tighten constraints on the depositional age, the sediment provenance and the structural/tectonic setting of the Dala Sandstone, and allow a better understanding of the relation to the pre-Sveconorwegian sediments in southern Norway. This has important implications for erosion and sediment dispersion on the scale of the Fennoscandian Shield, and for models of the origin of southern Norway as an autochthonous or allochthonous part of Fennoscandia, or as an exotic terrane, "Telemarkia" (e.g. Andersen, 2005; Bingen

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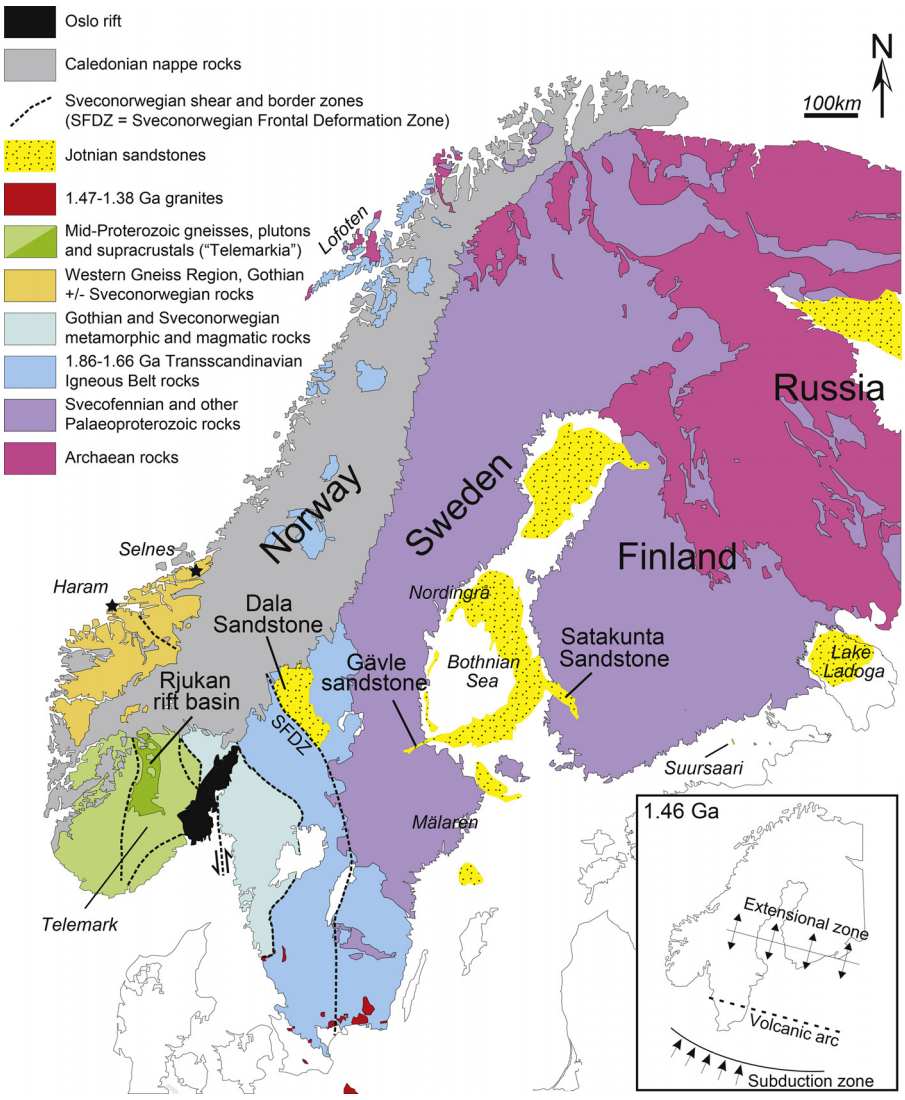

Fig. 1. Overview of Fennoscandia with the main occurrences of Jotnian sandstone (cf. Koistinen et al., 2001). Inset shows the inferred tectonic setting at c. 1.46 Ga (modified from Brander, 2011). In the Western Gneiss Region a rough indication of the Sveconorwegian border is indicated, with Sveconorwegian influence present to the south, and lacking to the north (Tucker et al., 1990). Arrows showing sinistral displacement along Sveconorwegian shear zones after Bingen et al. (2008). Haram and Selnes gabbros are marked with stars after Robinson et al. (2003) and Tucker et al. (1990), respectively.

et al., 2005). Results from this study will also aid investigations of recycling effects in younger sandstones, since Neoproterozoic rift basins along the Baltoscandian margin contain conglomerates with pebbles of Dala Sandstone (e.g. Pease et al., 2008).

2. Geological background

The Fennoscandian Shield becomes progressively younger towards its south-western margin, reflecting continental growth through subduction and terrain accretion interspersed with periods of rifting or quiescence. Major crustal growth took place in the Archaean at about 2.9–-2.6 Ga, during the Svecofennian orogeny at c. 2.0–1.75 Ga, through the formation of the Transscandinavian Igneous Belt at c. 1.86–1.66 Ga, the Gothian orogeny at c. 1.66–1.52 Ga (that potentially includes the Telemarkian event at c. 1.52–1.48 Ga), with extensive crustal reworking during the Sveconorwegian orogeny at c. 1.25–0.9 Ga (Fig. 1; Gáal and Gorbatschev, 1987; Roberts and Slagstad, 2014). Along the western Fennoscandian margin, west of the Transscandinavian Igneous Belt, the fault bounded or overprinted contacts between different crustal domains have led to contrasting interpretations of their origins as either accreted micro-continents, displaced parts of the Fennoscandian Shield, or the result of in situ growth of the shield (Fig. 1; e.g. Andersen, 2005, and references therein).

The Dalarna and Trysil area in central Sweden and eastern Norway are characterized by red coloured sandstone of Mesoproterozoic age, the Dala Sandstone, which overlies Transscandinavian Igneous Belt basement. The sandstone was deposited on a subaerial unconformity, the Fennoscandian sub-Jotnian peneplain, testifying to a long period of denudation prior to its deposition (Högbom, 1910; Olivecrona, 1920; Lidmar-Bergström, 1996). The sandstone stretches from Malung in the south to Idre at the Caledonian front in the north, and extends westwards into the Hedmark region in eastern Norway where it is referred to as Trysil sandstone. It has also been observed in drill cores penetrating the Caledonian nappes, testifying to its continuation below the thrust sheets (Tegengren, 1962). The Dala Sandstone is typically approximately horizontal and largely undeformed. Overall it forms a gentle northwest-striking syncline (Fig. 2; Törnebohm, 1896 in Högbom, 1910). The south-western margin of the Dala Sandstone parallels (Berthelsen, 1980; Wahlgren et al., 1994) and is partly deformed in the Sveconorwegian Frontal Deformation Zone (Hjelmqvist, 1966;