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On the Lomagundi-Jatuli carbon isotopic event: The evidence from the Kalix Greenstone Belt, Sweden

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ABSTRACT

We report a significant new database on the carbon and oxygen isotopic analyses (233 whole-rock, and 43 microcored samples) obtained from sedimentary dolostones in the Kalix Greenstone Belt from the Fennoscandian Shield of Sweden. This characterises the second half of the prominent Palaeoproterozoic Lomagundi-Jatuli positive carbon-isotope excursion. Within a 600 m-thick succession of alternating volcanic, volcaniclastic, siliciclastic and dolomitic rocks from greenschist–epidote-amphibolite metamorphic facies, the least altered dolostone samples show a gentle oscillation between +2‰ and +4‰ throughout stratigraphy with a second-order positive excursion from +4‰ through +8‰, and gradually back again to +4‰ in the c. 150 m-thick unit in the middle and upper parts of the succession. This second-order excursion is superimposed on the general relatively rapid $\delta^{13}C$ decline at the second half of the Lomagundi-Jatuli isotopic event and coincides with the transition from a marine-influenced rift to a passive margin setting. If the excursion is global, it would reveal internal fine structure of the Lomagundi-Jatuli isotopic excursion; if not, basinal local factors are the main players. Lithostratigraphic and C-isotope correlation between Kalix and neighbouring Peräpohja Schist Belt successions, 40-km-apart, suggest an incomplete geological record in both successions despite the absence of obvious non-depositional unconformities.

1. Introduction

Ever since the first reports of extremely positive $\delta^{13}C$ values in sedimentary carbonates in Russia (Galimov et al., 1968) and Africa (Schidlowski et al., 1975, 1976) such values have presented a challenge to our understanding of the global carbon cycle in the Precambrian. Now considered to have global extent and known as the Lomagundi-Jatuli event, this Palaeoproterozoic positive $\delta^{13}C$ excursion in sedimentary carbonates is recognised as the greatest in Earth history. The oldest known ^{13}C-rich carbonates in Fennoscandia are intruded by dykes dated to 2200 Ma (Karhu, 1993), and the youngest known are conformably overlain by volcanic rocks dated to 2058 ± 2 Ma (Melezhik et al., 2007). With a minimum duration of 140 Myr, the internal structure of the isotopic excursion remains poorly constrained. This is due to incomplete preservation of the geological record combined with a limited availability of reliable carbonate-bearing sections and poor age constraints. Consequently each new section containing a substantial carbonate record represents a valuable addition, and may improve our current understanding of the internal structure of the Lomagundi-Jatuli $\delta^{13}C$ excursion, with obvious implications for mechanism.

The Fennoscandian Shield has been for several decades a pioneering area in the development of the Lomagundi-Jatuli $\delta^{13}C$ reference curve (Galimov et al., 1968; Schidlowski et al., 1975; Baker and Fallick, 1989a; Yudovich et al., 1991; Karhu and Melezhik, 1992; Ahmedov et al., 1993; Karhu, 1993, 2005; Tikhomirova and Makarikhin, 1993; Pokrovsky and Melezhik, 1995; Karhu and Holland, 1996; Melezhik and Fallick, 1996, 2001; Kortelainen, 1998; Melezhik et al., 1999, 2005, 2007) and still offers new possibilities. Kortelainen (1998), Karhu (2005), Papineau et al. (2005), and Karhu et al. (2008) reported from the Peräpohja Schist Belt (PSB) in Finland (Fig. 1) a sizable fluctuation of $\delta^{13}C$ towards the end of the excursion. The termination of the excursion coincides in time with initial separation of the late Archean supercontinent, formation of the Kola ocean and Svecofennian sea, and transition to marine conditions for most of the rifts fringing the continent (Gaál and Gorbatchev, 1987; Strand and Laajoki, 1999; Lahtinen et al., 2008). This has been approximately dated to 2100 Ma (Korsman et al., 1999; Hanski and Huhma, 2005; Daly et al., 2006).

Here we present $\delta^{13}C$ data from the Kalix Greenstone Belt (KGB) in Sweden (Fig. 1), which contains a sedimentary-volcanic succession spanning the transition from intracontinental rifting to drifting coincident with the end of the Palaeoproterozoic positive excursion

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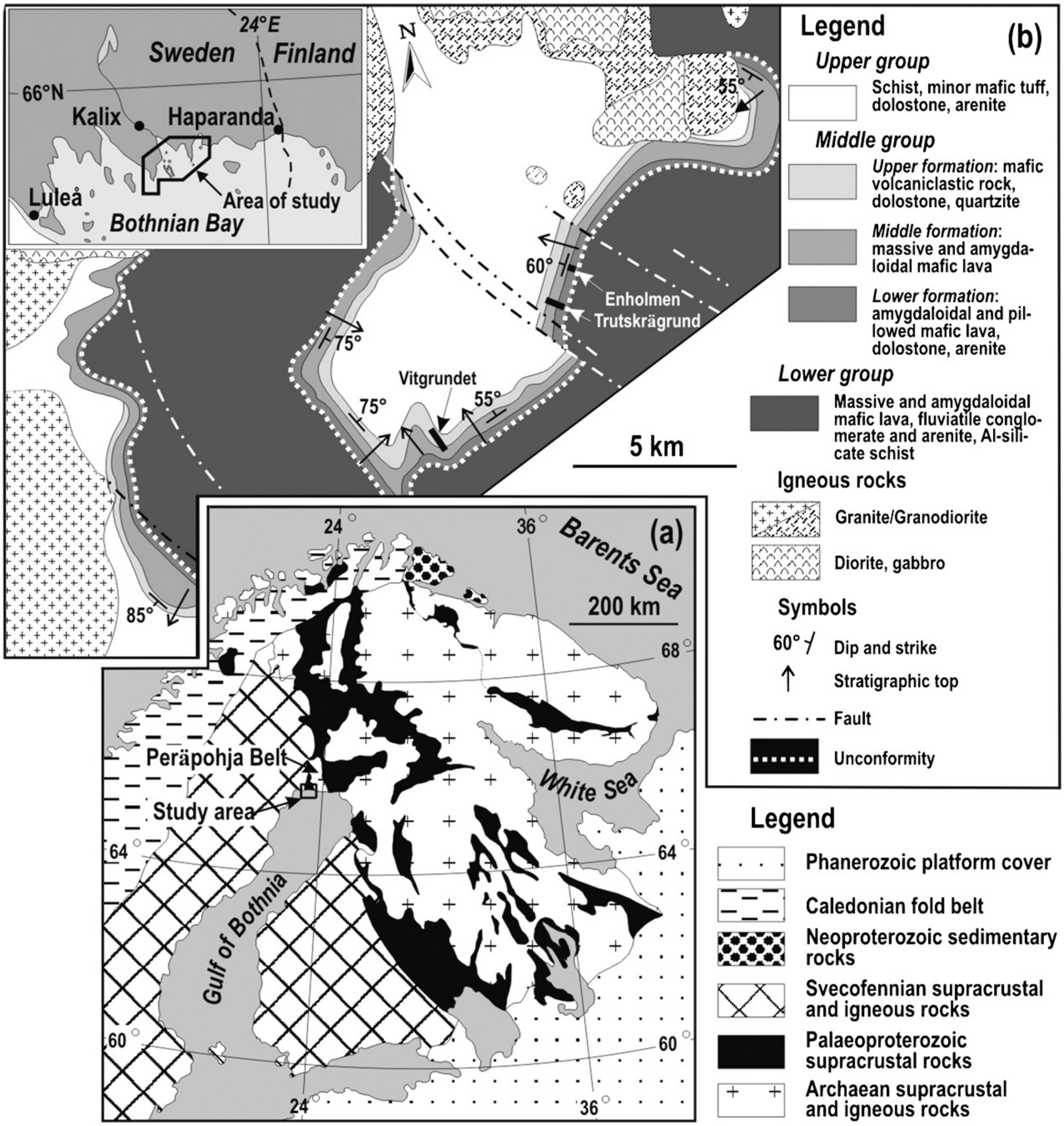

Fig. 1. Overview (a) and detailed map (b) of the study area. Detailed map is based on data from Lager and Loberg (1990).

of $\delta^{13}C$ in sedimentary carbonates (Wanke and Melezhik, 2005). The succession has been lithostratigraphically correlated with that of the PSB (Lager and Loberg, 1990; Öhlander et al., 1992). These two belts are only 40 km apart and are separated from each other by a synorogenic granitoid intrusion, and a north–south trending strike-slip fault. The main objectives of this study are (*i*) to document $\delta^{13}C$ fluctuation towards the end of the Lomagundi-Jatuli excursion in the Kalix sedimentary carbonates, and (*ii*) to compare $\delta^{13}C$ temporal trends in Peräpohja and Kalix successions that represent two adjacent and supposedly correlative sites.

2. Geological settings and lithostratigraphy

The Palaeoproterozoic KGB (Öhlander et al., 1992) is located within the Swedish portion of the Fennoscandian Shield at the northern end of Bothnian Bay (Fig. 1a). The supracrustal sequence has been informally subdivided into *Lower*, *Middle* and *Upper groups* (Lager and Loberg, 1990). Carbonate rocks occur only in the 1200 m-thick *Middle group* which is separated from the underlying rocks by a regional unconformity and a weathering crust. The group comprises a sequence of volcanic, volcaniclastic, siliciclastic and carbonate rocks, and has been subdivided informally by Lager and Loberg (1990) into the *Lower*, *Middle* and *Upper formations*. The *Lower* and *Upper formations* have been further subdivided into several members showing distinct lithologies (Fig. 2). The 2000 m-thick Upper group comprises mainly shales.

Depositional ages of the sedimentary and volcanic rocks of the KGB are poorly constrained. Öhlander et al. (1992) reported a 2100 ± 200 Ma Pb–Pb age obtained from *Lower formation* carbonate rocks. Two suites of granitoids (1890–1860 and 1800–1770 Ma, Skiöld, 1987) cutting the supracrustal rocks provide an upper age limit for deposition. Based on a few $\delta^{13}C_{carb}$ values from the *Middle*