Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 123

The Mid-Caradoc Carbon Isotopic Event and its Expression in Siljan District, Central Sweden – Offshore Area of the Balto-Scandian Palaeobasin

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The mid-Caradoc carbon isotopic event is one of the best-documented Ordovician excursions after the end-Ordovician glacially induced event. A nearly coeval positive shift in marine stable carbon isotopic composition is described up to now in two palaeo-continents: Laurentia (Patzkowsky et al., 1997) and Baltica (Ainsaar et al., 1999). Dating of the isotopic event in both palaeo-continents is based on correlation of the K-bentonite beds and on biostratigraphy. For the Baltica palaeo-continent, the mid-Caradoc carbon isotopic event was still recorded only in the East Baltic part of the palaeobasin, in epi-continental carbonates of Estonia and Latvia (Ainsaar et al., 1999). Recently a coeval shift was established in the western offshore part of the palaeobasin, in the Fjäcka sections of the Siljan District (central Sweden). The beds at Fjäcka are inverted and penetrated by small faults, as a result of the Devonian Siljan impact, but the preservation of primary marine isotopic values in these carbonates was suggested already by Marshall & Middleton (1990).

Stable isotopic composition of bulk carbonates was recorded in the Skagen, Moldå and Slandrom formations (Caradoc) of the Fjäcka section (Figure1). The positive $\delta^{13}C$ shift of the mid-Caradoc excursion is recorded throughout the Skagen Limestone, with a small decline in its top part. A new rise of $\delta^{13}C$ values at the base of the Moldå Limestone is followed by a gradual decrease through the Moldå Formation and lower part of the Slandrom Limestone.

The $\delta^{13}C$ curve of the Fjäcka section is greatly similar to curves from the southern Estonian core sections (Figure 1). Comparison of the isotopic curves supports the biostratigraphical correlation of the East Baltic area and Sweden in this particular interval (Nõlvak & Grahn, 1993). The isotope shift in Fjäcka section begins above the Kinnekulle K-bentonite whereas in Estonian sections that change occurs 6-7m higher of this marker, suggesting a gap at the lower part of the Skagen Limestone in Fjäcka section, probably due to local faulting.

The mid-Caradoc carbon isotopic event, well expressed in offshore and transitional sections (central Sweden, southern Estonia), is not recorded from the onshore area of the basin (northern Estonia; Kaljo et al., 1999). This may be due to the hiatus in the upper shelf area, but may also refer to the particular isotopic composition of the seawater in shallow onshore area, like suggested for the Caradocian basin in North America by Holmden et al. (1998).

The beginning of the mid-Caradoc carbon isotopic excursion in offshore of the Balto-scandian palaeobasin approximately coincided with the first appearance of warm-water carbonates in the upper shelf area and with breaks in sedimentation, suggesting a relationship to the climatic and sea level changes. Unlike in case of most other Lower Palaeozoic isotopic events, the peak of this particular excursion preceded the biotic crisis (extinction event at the boundary of the Oandu Stage) and maximum black shale accumulation in Baltoscandia.

The mid-Caradoc events could be caused by ventilation of the ocean and influx of nutrients to surface waters. Influx of nutrients raised primary productivity on the shelf and led to enrichment of the seawater in ^{13}C during the eustatic lowstand episode. Subsequent return into the stratified state, expansion of anoxic bottom waters and black shale accumulation were responsible for major faunal changes in the Balto-scandian shelf basin. Although the mid-Caradoc environmental and isotopic events have some unique features, they are more similar to the thermohaline circulation events related to eustatic sea level fall (end-Ordovician and Silurian cases) than to the warm anoxic events related to eustatic sea level rise (late Cambrian example). Fluctuations of the sea level and changes in ocean stratification propose a relationship to glacial event, the fluctuations of the continental ice sheet in Gondwana, perhaps marking the first shift from the Ordovician greenhouse Earth to the end-Ordovician icehouse world.

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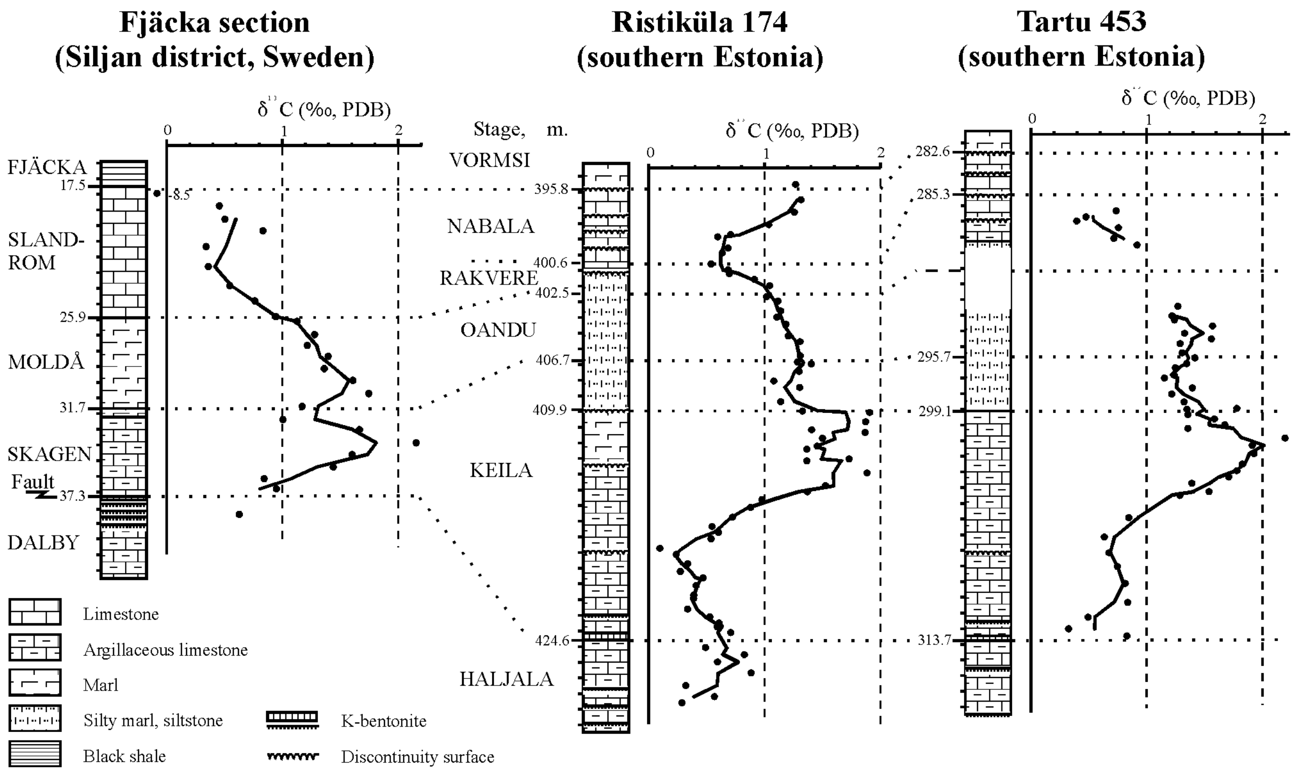

Figure 1: $\delta^{13}C$ data on the carbonates from Fjäcka section (Siljan, central Sweden) and Estonian core sections (Ainsaar et al., 1999). Biostratigraphical correlation of stratigraphical units according to Nõlvak & Grahn (1993). Raw data (solid circles) have been filtered with three-point moving average (solid line).

This study was supported by Estonian Science Foundation grants Nos. 3011 and 3751.

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