Palaeogeography, Palaeoclimatology, Palaeoecology 394 (2014) 59–73

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

The Cambrian–Ordovician transition in dysoxic facies in Baltica — diverse faunas and carbon isotope anomalies

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ARTICLE INFO

Article history:
Received 8 March 2013
Received in revised form 6 November 2013
Accepted 22 November 2013
Available online 1 December 2013

Keywords:
Cambrian–Ordovician boundary
Biostratigraphy
Chemostratigraphy
Baltica

ABSTRACT

The Cambrian–Ordovician boundary interval in Scandinavia is characterized by largely endemic trilobite species and fossil-meager intervals within the Alum Shale Formation. Previous investigations of this interval in Scandinavia, based on drill cores, are rather sketchy. In order to characterize the faunal signature in a largely dysoxic setting during this time interval, as well as providing biostratigraphic and chemostratigraphic data valuable for intercontinental correlation, a small strip in the outskirts of the village Södra Sandby in Scania, southern Sweden, was excavated. Nearly 5 m of the Cambrian–Ordovician boundary strata, largely represented by alum shale, were exposed and the profile was meticulously investigated for fossil content and lithological characteristics and sampled for $\delta^{13}C_{org}$ analyses. The uppermost Cambrian in Sweden has previously been described as barren of fossils; however, the present study reveals a rather diverse fauna, including lingulid brachiopods, trilobites, protoconodonts, paraconodonts and euconodonts in the uppermost 1.6 m of the Furongian. The first appearance datum of planktic graptolites is represented by a single shale surface covered by specimens of *Rhabdinopora flabelliforme parabola* at 1.74 m above the base of the section and roughly corresponds to the Cambrian–Ordovician boundary. The conodont fauna includes several cordylodids important for intercontinental correlation. The Södra Sandby section $\delta^{13}C_{org}$ data were coupled with isotope data from two Scanian drill cores, Håslöv-1 and Tosterup-2, in order to compile a composite isotope curve spanning the uppermost *Ctenopyge linnarssoni* Trilobite Zone in the Furongian to the upper *R. flabelliforme parabola* Graptolite Zone in the Lower Ordovician (Lower Tremadocian). Two isotope shifts from baseline values, observed at the base of the *Peltura paradoxa* Trilobite Zone and the lower part of the *Peltura transiens* Trilobite Zone, respectively, can be correlated with contemporaneous shifts in other parts of the world. The former, a negative shift of approximately 0.4–0.7‰, corresponds to the widely documented Top of Cambrian carbon isotope Excursion (TOCE) and the latter, a positive shift of approximately 1‰, corresponds to an as-yet-unnamed excursion at the base of the *Cordylodus proavus* Conodont Zone. In terms of faunal content and isotopic signals, the present study represents the first detailed description of the Cambrian–Ordovician boundary interval in Baltica. The relatively diverse fauna recorded suggests that the dysoxic environment was not a serious inhibitor for marine life. Globally, no isotope values significantly different from background values have been reported at the Cambrian–Ordovician boundary. This is confirmed by the present study; however, as the base of the Ordovician GSSP lacks meaningful isotope data, global correlation of this important boundary is problematic.

1. Introduction

An important step towards today's subdivision of the Lower Paleozoic was taken more than 130 years ago when Charles Lapworth (1879) introduced the Ordovician System. He defined the Cambrian–Ordovician boundary as coinciding with the base of the "Lower Arenig" in Wales, a level roughly coinciding with the base of the modern Migneintian Regional Substage (Upper Tremadocian Stage) of Great Britain (Cooper and Sadler, 2012). The base of the Ordovician as defined today coincides with the base of the Tremadocian Stage and the first appearance datum (FAD) of the conodont species *Iapetognathus fluctivagus* in the Green Point Section, Newfoundland, Canada. The final consensus regarding this boundary was accomplished 25 years after inauguration of the first working group on the Cambrian–Ordovician boundary (Cooper et al., 2001). As a consequence of the intense and prolonged work, the Cambrian–Ordovician transitional interval is among the most thoroughly investigated in the Paleozoic (Terfelt et al., 2012). The spatial distribution and temporal distribution of fossil taxa constitute the most important tool for intercontinental correlations in the Paleozoic; but chemostratigraphy is also of relevance for broad scale correlations. Carbon isotope stratigraphy in combination with biostratigraphy has, during the last three decades, proven to be of great potential for long distance correlations and this is true also for

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0031-0182/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.palaeo.2013.11.021

Cambrian strata (e.g. Brasier, 1993; Montañez et al., 2000; Zhu et al., 2006; Álvaro et al., 2008).

In this paper we report on a chronostratigraphic study of the Cambrian–Ordovician transition interval in an alum shale setting in Scania, southern Sweden. The Alum Shale Formation and its fauna have been the subject of numerous investigations, e.g., Westergård (1922, 1944), Henningsmoen (1957), Gee (1972), Bergström and Gee (1985), Buchardt et al. (1997), Terfelt (2006), Eriksson and Terfelt (2007), Nielsen and Schovsbo (2007, 2013), Terfelt et al. (2008, 2011), Ahlberg et al. (2009), and Weidner and Nielsen (2013). This study provides a meticulous documentation of the fossil assemblages and a detailed $\delta^{13}C_{org}$ chemostratigraphic profile through a section excavated in the outskirts of the village Södra Sandby in Scania, southernmost Sweden (Fig. 1), comprising strata

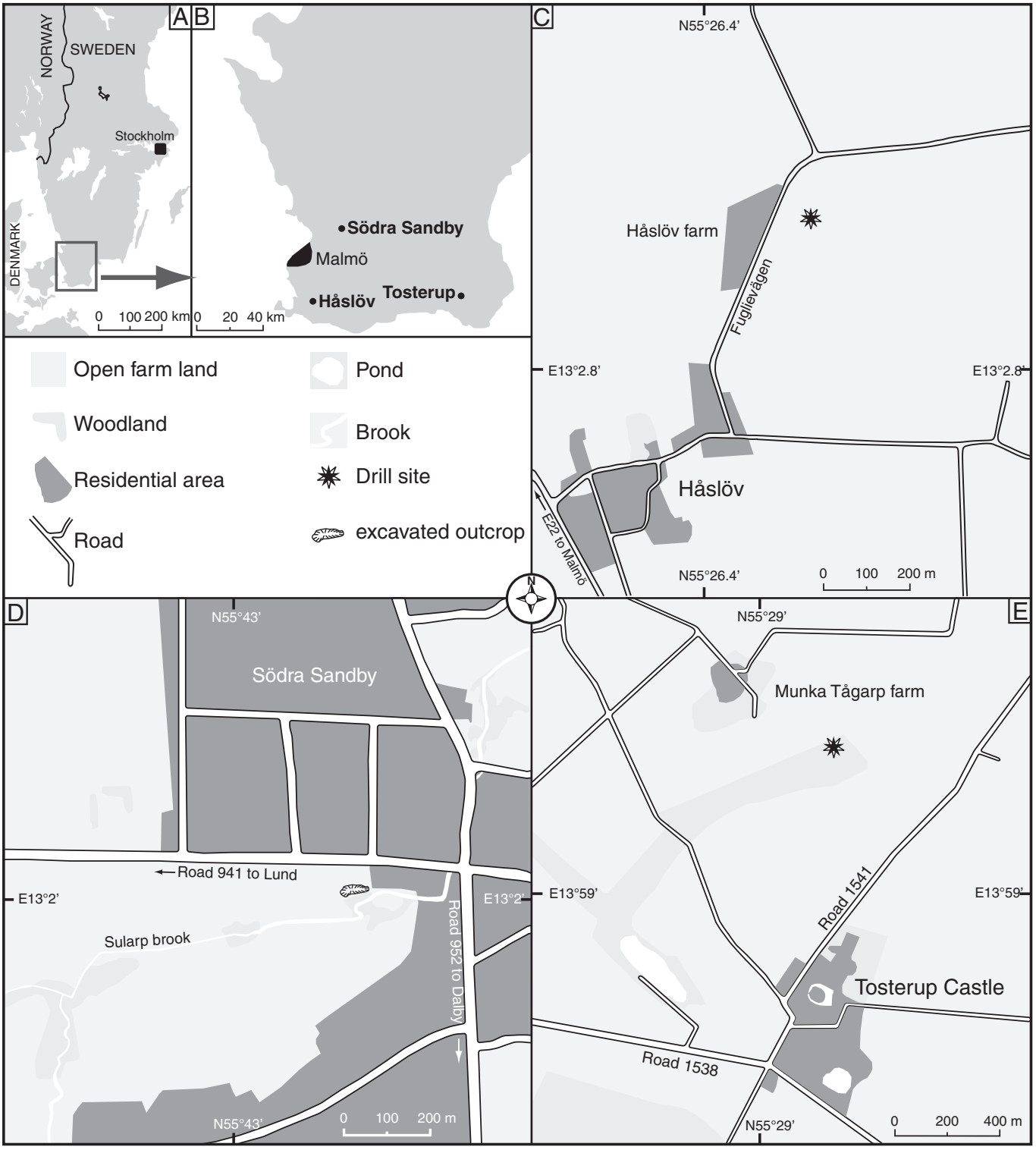

Fig. 1. A. Orientation map of southern Scandinavia. B. Map of Scania showing the location of Södra Sandby, Håslöv, and Tosterup. C. Detailed map of the Håslöv area showing the location of the Håslöv-1 drill site. D. Detailed map of the Södra Sandby area showing the location of the excavated outcrop. E. Detailed map of the Tosterup area showing the location of the Tosterup-2 drill site.