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Contextualising the Onset of the Great Ordovician Biodiversification Event

DAVID A.T. HARPER and THOMAS SERVAIS

Harper, D.A.T. & Servais, T. 2018: Contextualising the Onset of the Great Ordovician Biodiversification Event. *Lethaia*, xx, xx-xx.

We introduce and briefly summarize a collection of papers contextualising the onset of the Great Ordovician Biodiversification Event, initiated during the first meeting of IGCP project 653 at Van Mildert College, Durham University in September 2016.

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The Ordovician radiation was not recognized in any of the major studies of the 19th Century, probably because the system was split between the Cambrian and Silurian systems. It was not until the later part of the 20th Century that John (Jack) Sepkoski established, in the 1970s and 1980s, the statistical reality of the Ordovician radiation, a term subsequently promoted by Droser et al. (1996) in their key paper 'The Ordovician Radiation'. But there was a clear need to dissect this game-changing event in much more detail. Consequently three colleagues, Barry Webby (Sydney, Australia), Mary Droser (Riverside, California, USA) and Florentin Paris (Rennes, France), proposed the International Geological Correlation Programme (IGCP) project entitled '*The Great Ordovician Biodiversification Event: Implications for Global Correlation and Resources*'. This project was accepted and supported by UNESCO and the IUGS (International Union of Geological Sciences) and ran from 1997 to 2001, with an additional year (or extended term) in 2002, under the banner of IGCP 410. The term '*Great Ordovician Biodiversification Event*' thus became firmly entrenched and used by many scientists, particularly those participating in project 410, although variants such as Ordovician biodiversification and Ordovician radiation persisted (e.g. Harper 2006). This project provided the framework and impetus for two subsequent IGCP projects, IGCP 503 and now IGCP 653, both led by Thomas Servais (Lille, France). IGCP 503 *'Ordovician Palaeogeography and Palaeoclimate'* (Harper *et al.* 2011) unleashed some of the many challenges around Ordovician Earth Systems, solved a number of questions in a range of publications (e.g. Munnecke & Servais 2007, Owen 2008, Munnecke *et al.* 2010, Servais & Owen 2010, Harper and Servais 2013), and inevitably raised many, emphasizing the need for further investigation by the international community.

This special issue captures many of the talks and posters presented during the 1st meeting of the new IGCP project, 653 *'the Onset of the Great Ordovician Biodiversification Event'* launched at Van Mildert College in Durham University, in September 2016. The issue is supplemented by a number of other key and related papers solicited by the editors. This issue exposes some of the large volume of research, directly and indirectly related to this and previous projects and helps place the GOBE in context with respect to the start and finish of the event. The issue contains 15 contributions including our introduction. We have organized the papers around three main themes: global challenges, important taxonomic groups and key regional successions. These three themes strike at the heart of the challenge, understanding the regional and taxonomic dimensions of the event and how they interacted to generate global ecosystem change.

Global challenges

Before we can focus on the causes and consequences of this transformative event, there should be clarity on its scope and the accurate communication on what precisely it includes. Servais and Harper (2018) address the history together with the concept and duration of the Great Ordovician Biodiversification Event, noting variants in its definition; understanding the scope of the GOBE is crucial to exposing its causes and consequences. Stigall (2018) investigates the various speciation processes that allow the accumulation of biodiversity and the critical role of biogeography through dispersal and vicariance; such processes are inevitably linked to climatic, oceanic and tectonic processes operating during the GOBE. John (Jack) Sepkoski not only established the statistical reality of the Ordovician radiation, but also established the concept of the five big mass extinctions in Earth history. The Permian mass extinction is still considered the most significant, 'the great dying', followed by the Ordovician extinction event. Isozaki and Servais (2018) have compared these two major extinction events, but conclude that the end Ordovician extinction is more comparable to the extinction that occurred during the middle Permian, rather than the end Permian extinction. The understanding of the Ordovician radiation requires better knowledge of the oceanographic circulation patterns and biomass production in the oceans. The innovative study by Pohl *et al*. (2018), modelling belts of high primary biological productivity, highlights the relationships between upwelling zones and the numerical abundance of some taxa, their diversity and the characteristic sediments that enclose them.

Taxonomic diversifications

A number of studies are focused on important taxonomic groups. Ernst (2018) provides a new, detailed biodiversity curve for bryozoans through the Ordovician Period. The highest diversities of bryozoan taxa were achieved in the Late Ordovician, possibly mirroring sea-level patterns. Esteve *et al*. (2018) in an analysis of trilobite enrolment using kinematics, clarify and illustrate that although a few structures appeared for the first time during the Ordovician, the majority had already evolved during the Cambrian. The CHITDB, the Chitinozoan Database, has captured detailed range data for these Ordovician and Silurian microfossils from the Baltic region (Hints *et al*. 2018); analysis of the database demonstrates a diversity hike during the Darriwilian to middle Katian and subsequently during the Telychian. Servais *et al*. (2018) provide a detailed review of the biostratigraphy of selected taxa of acritarchs from the large peri-Gondwanan province. The study clearly shows that many taxa appear diachronously, and that international correlations based on these taxa should be drawn with care. Topper *et al*. (2018) have mapped changes in life styles through the Cambrian and Ordovician in the most prolific Palaeozoic benthic group, the Brachiopoda; the majority of life modes evolved rapidly and were already established during the Cambrian.

Regional diversifications

There are a number of regional case histories reported from key Ordovician successions. In Laurentia, Nowak *et al*. (2018) explore the diversity and significance of Small Carbonaceous Fossils (SCFs) associated with the Middle Ordovician Winneshiek Lagerstätte. This study extends the geographic, palaeoenvironmental and temporal range of arthropod microfossils (pancrustacean mandibles or euchelicerate coxae), so far only known from the Cambrian.

Trubovitz and Stigall (2018) investigate the GOBE and its effects in the Ordovician successions of Oklahoma. Changes in body size, evenness and dominance suggest that increasing ecological complexity was coincident with taxonomic diversification in the Oklahoma succession. A common mechanism, such as climate optimization or increased food abundance, was a key local driver.

Around Gondwana, the onset and development of the GOBE is charted in Ordovician successions of the Iberian Peninsula by Colmenar *et al*. (2018), with an initial increase in the diversity of linguliformean brachiopods that culminated as early as the Tremadocian, followed by pulses of rhynchonelliform diversification in the Darriwilian and Katin. Lefebvre *et al*. (2018) describe and illustrate a new integrated biostratigraphy through the succession of exceptionally-preserved biotas in the Lower Ordovician Fezouata Formation in Morocco. The famous Fezouata Biota is actually present at two horizons, a lower of late Tremadocian age, and an upper that can now be correlated with the middle Floian. Zhang *et al*. (2018) have developed a new biostratigraphy for the Upper Ordovician in parts of South China to identify a stratigraphical gap resulting mainly from the abrupt sea-level drop driven by the Late Ordovician glaciation.

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References

Ernst, A. 2018: Diversity dynamics of Ordovician Bryozoa. *Lethaia* (this issue)

Esteve, J., Gutiérrez-Marco J.C., Rubio, P. & Rábano, I. 2018: Evolution of trilobite enrolment during the Great Ordovician Biodiversification Event: insights from kinematic modelling. *Lethaia* (this issue)

Harper, D.A.T. 2006: The Ordovician biodiversification: setting an agenda for marine life. *Palaeogeography, Palaeoclimatology, Palaeoecology 232*, 148–166.

Harper, D.A.T. & Servais, T. (eds). 2013: Early Palaeozoic biogeography and geography. *Memoir, Geological Society, London 38*, 1-490.

Harper, D.A.T., Li Jun, Munnecke, A., Owen, A.W., Servais & Sheehan, P.M. 2011: Concluding IGCP 503: Towards a holistic view of Ordovician and Silurian Earth systems. *Episodes 34*, 32-38.

Hints, O., Antonovitš, L., Bauert, G., Nestor V., Nõlvak, J. and Tammekänd, M. 2018: CHITDB: a database for documenting and analysing diversification of Ordovician–Silurian chitinozoans in the Baltic region. *Lethaia* (this issue)

Isozaki, Y. & Servais, T. 2018: The Hirnantian (Late Ordovician) and end-Guadalupian (Middle Permian) mass-extinction events compared. *Lethaia* (this issue)

Lefebvre, B., Gutiérrez-Marco, J.C., Lehnert, O., Martin, E.L.O., Nowak, H., Akodad, M., El Hariri, K. & Servais, T. 2018: Age calibration of the Lower Ordovician Fezouata Lagerstätte, Morocco. *Lethaia* (this issue)

Munnecke, A. & Servais, T. (eds), 2007: Early Palaeozoic Palaeogeography and Palaeoclimate. *Palaeogeography, Palaeoclimatology, Palaeoecology 245*, 316 pp.

Munnecke, A., Calner, M. & Harper, D.A.T. (eds) 2010: Early Palaeozoic sea level and climate. *Palaeogeography, Palaeoclimatology, Palaeoecology 296*, 213–413.

Nowak, H., Harvey, T.P., Liu, H.P., McKay, R.M. & Servais, T. 2018: Exceptionally preserved arthropodan microfossils from the Middle Ordovician Winneshiek Lagerstätte, Iowa, USA. *Lethaia* (this issue)

Owen, A.W. (ed.) 2008: Ordovician and Silurian environments, biogeography and biodiversity change. *Lethaia 41*, 97-194.

Pohl, A., Harper, D.A.T., Donnadieu, Y., Le Hir, G., Nardin, E. & Servais, T. 2018: Possible patterns of marine primary productivity during the Great Ordovician Biodiversification Event. *Lethaia* (this issue).

Servais, T. & Harper, D.A.T. 2018: The Great Ordovician Biodiversification Event (GOBE): definition, concept and duration. *Lethaia* (this issue).

Servais, T., Molyneux, S.G., Jun Li, Nowak, H., Rubinstein, C.V., Vecoli, M., Wen Hui Wang & Kui Yan 2018: First Appearance Datums (FADs) of selected acritarch taxa and correlation between Lower and Middle Ordovician stages. *Lethaia* (this issue).

Servais, T., Harper, D.A.T., Li, J., Munnecke, A., Owen, A.W. & Sheehan, P.M. 2009: Understanding the Great Ordovician Biodiversification Event (GOBE): Influences of paleogeography, paleoclimate, or paleoecology? *GSA Today 19*, 4-7.

Servais, T. & Owen, A.W. 2010: Early Palaeozoic Palaeoenvironments. *Palaeogeography, Palaeoclimatology, Palaeoecology 294*, 95-247.

Stigall, A.L. 2018: How is biodiversity produced? Examining speciation processes during the GOBE. *Lethaia* (this issue).

Topper, T.P., Zhifei Zhang, Gutiérrez-Marco, J.C. & Harper, D.A.T. (2018). The dawn of a dynasty: life strategies of Cambrian and Ordovician brachiopods. *Lethaia* (this issue).

Trubovitz & Stigall, A.L. 2018: Ecological revolution of Oklahoma's rhynchonelliform brachiopod fauna during the Great Ordovician Biodiversification Event. *Lethaia* (this issue).

Webby, B.D., Paris, F., Droser, M.L. & Percival, I.C. (eds) 2004: *The Great Ordovician Biodiversification Event.* 496 pp. Columbia University Press, *New York, NY*.

Fang Xiang, Ma Xuan, Li Wenjie, Zhang Yuandong, Zhou Zhiqiang, Chen Tingen, Lü Yong, Shenyang Yu Shenyang & Fan Junxuan 2018: Biostratigraphic constraints on the disconformity within the Upper Ordovician in the Baoshan and Mangshi regions, western Yunnan Province, China. *Lethaia*. (this issue).