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Evaluating compositional turnover of brachiopod communities during the end-Triassic mass extinction (Northern Calcareous Alps): Removal of dominant groups, recovery and community reassembly

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Abstract

This study highlights the role of large-scale physical perturbations in mediating biotic replacements and shows that an environmental disturbance at the Triassic/Jurassic (T/J) boundary correlates with abrupt and substantial changes in the composition of brachiopod communities. Disturbance changed the phylogenetic structure of Early Jurassic brachiopod communities owing to a removal of higher taxa that were abundant in the Late Triassic. A replacement of brachiopod communities through the Rhaetian in the Kössen Basin (Northern Calcareous Alps), related to a combination of habitat tracking and immigration/local extinction events, indicates a high compositional turnover. This turnover is of local nature only because Early Rhaetian communities migrated or tracked their habitats beyond the Kössen Basin and persisted through to the Late Rhaetian in other regions. A siliciclastic interval that is several meters thick with rare brachiopods dated as the earliest Hettangian marks the extinction–survival interval. This interval is coeval with a negative carbon isotope anomaly, implying a correlation with global perturbation of carbon cycle. A rapid brachiopod recovery is indicated by a presence of several distinct communities in late Early and Middle Hettangian that show onshore–offshore differentiation and beta diversity comparable to pre-extinction levels. Analyses of similarities demonstrate that (1) the compositional turnover of brachiopod communities on generic level at the T/J boundary ($R=0.83$) is substantially higher than turnovers between the Rhaetian zones ($R=0.28$–0.57) and between the Hettangian zones ($R=0.28$–0.53), and (2) the turnover at superfamily level at the T/J boundary accounts for differential composition of Rhaetian and Hettangian communities. A global extinction of athyridoid, spondylospiroid and dielasmatoid superfamilies characterized by high-community level abundances during the Late Triassic led to a new assembly of Jurassic brachiopod communities from surviving superfamilies. In addition to persisting rhynchonellids and zeillerioids, Hettangian brachiopod communities were dominated by terebratuloids, spiriferinoids and pennospiriferinoids. These superfamilies were characterized in the Late Triassic by low community-level abundance. We argue for tracking the phylogenetic structure of communities across mass extinction events because a measurement of the turnover in community-level abundance of higher taxa can be highly relevant for estimating the ecologic impact of mass extinctions. Taxonomic extinction rate metrics or diversity measures can be depressed by surviving taxa that do not re-attain their pre-extinction community-level abundance.

Keywords: Triassic; Jurassic; Northern Calcareous Alps; Mass extinction; Brachiopoda; Communities

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1. Introduction

One of the main interests in analysing variations in diversity, extinction rates, extinction selectivity, community attributes and morphologic disparity across mass extinctions is to assess the effects of environmental disturbances on evolutionary pathways and ecology, and to understand how ecosystems respond to large-scale environmental perturbations (Erwin, 2001). In the last years, a strong emphasis has been placed on ecologic changes during mass extinctions (Jablonski and Raup, 1995; McRoberts and Newton, 1995; Harries et al., 1996; Droser et al., 1997; Harries and Little, 1999; Lockwood, 2003; Hansen et al., 2004; Kiessling and Baron-Szabo, 2004; McGhee et al., 2004; Twitchett et al., 2004). These analyses indicate that effects of mass extinctions are more diverse and complex than indicated by taxonomic extinction metrics at boundary intervals (Jablonski, 2002). One of the most profound effects is that mass extinctions remove successful incumbents (Rosenzweig and McCord, 1991; Jablonski, 2001). Extensive environmental perturbations leading to mass extinctions thus have a strong impact on evolutionary trajectories because taxonomic survivorship may differ from that operating during "background" times.

In this study we analyze a compositional turnover – the change in species composition and relative abundances – to evaluate the effects of environmental perturbation on brachiopod ecology at the end of the Triassic and across the Triassic/Jurassic boundary. To exclude biogeographic effects, the study area is restricted to the intra-platform Kössen Basin (Northern Calcareous

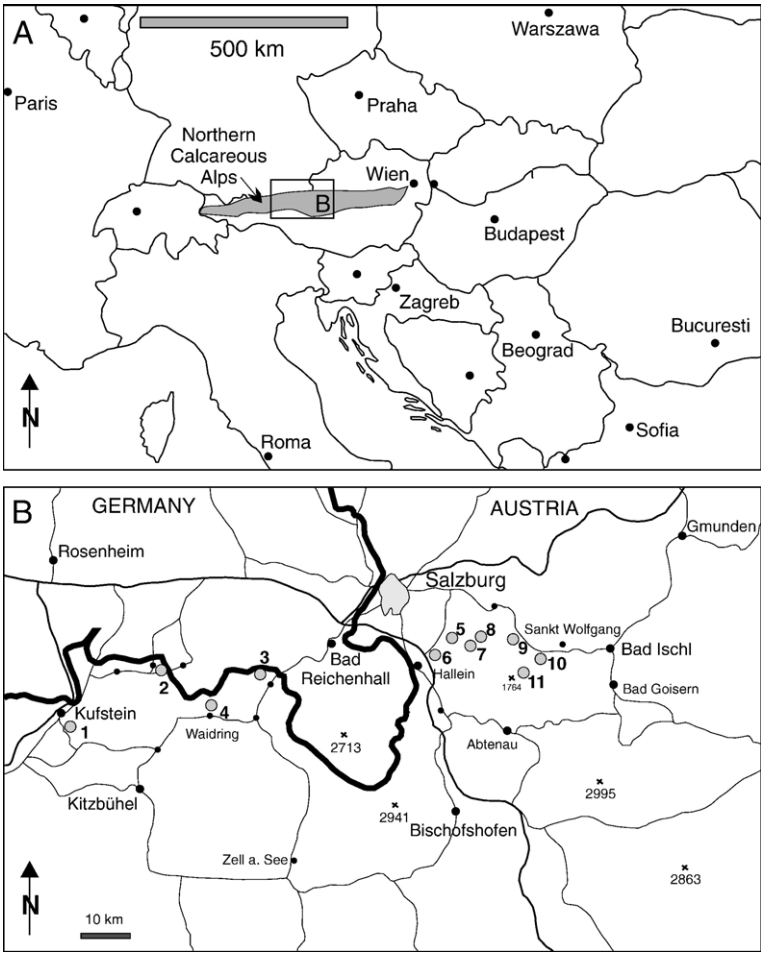

Fig. 1. (A) Geographic position of the Northern Calcareous Alps. (B) Geographic position of Rhaetian and Hettangian sections between Kufstein and Bad Ischl. Some of these sections are shown in Figs. 4 and 6. 1 — Eiberg (Rhaetian–Hettangian), 2 — Kössen–Weissloferbachgraben (Rhaetian), 3 — Hochalm–Sonntagshorn (Rhaetian), 4 — Steinplatte (Rhaetian–Hettangian), 5 — Gaissau–Mörtlbachgraben (Rhaetian), 6 — Adnet (Rhaetian–Hettangian), 7 — Hochleitengraben (Hettangian), 8 — Rötelwand (Rhaetian), 9 — Saubachgraben (Hettangian), 10 — Breitenberg (Hettangian), 11 — Kendlbachgraben (Rhaetian–Hettangian).