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Forum

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COMMENT

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Sephton et al. (2002) reported a complex isotopic event, marked by a positive $\delta^{13}C_{org}$ excursion and an initially positive $\delta^{15}N_{org}$ excursion, from a Triassic-Jurassic boundary succession at Black Bear Ridge, Williston Lake, northeastern British Columbia, corresponding to the level of disappearance of abundant monotid bivalves. They interpreted this event as occurring at the Norian-Rhaetian boundary, thus preceding the Rhaetian-Hettangian (end-Triassic) isotopic excursions now known to occur at several other localities, but which apparently were absent in this section (Sephton et al., 2002, their Fig. 2). They then suggested that the Late Triassic was marked by more than one extinction event.

In the section at Black Bear Ridge, Sephton et al. placed the Norian-Rhaetian boundary at the level of disappearance of abundant *Monotis* bivalves and the Rhaetian-Hettangian (Triassic-Jurassic) boundary 9.0 m higher (Sephton et al., 2002, their Fig. 2), coinciding with the first recorded occurrence of the ammonite genus *Psiloceras*. As they indicated, the end-Triassic negative $\delta^{13}C_{org}$ excursion should have been recorded somewhere within this 9 m sequence, in their samples numbered BBR39–BBR45 (Sephton et al., 2002), but it was apparently absent.

In the following discussion, all stratigraphic levels we refer to correspond to the measured stratigraphic section of Sephton et al. (2002, their Fig. 2). A more complete summary of new Hettangian ammonite faunas from the Black Bear Ridge section is found in Hall and Pitaru (2003). The lowest Jurassic ammonites occur at 63.4 m on their section, so that the Triassic-Jurassic boundary is at, or even possibly below, this level and the Rhaetian is represented by a maximum of 2.3 m of section; fossils are extremely rare in this interval. Orchard et al. (2001, their Fig. 3, p. 15–16) showed occurrences of the bivalve *Monotis subcircularis*, conodonts *Neogondolella steinbergensis* (Mosher), *Epigondolella* ex. gr. *bidentata* (Mosher), and elements resembling *E. mosheri* (Kozur and Orchard) ''sitting immediately above the youngest bedding surface of *Monotis.*'' They suggested that this indicated the presence of Rhaetian strata. They also recorded several lower Hettangian ammonites, *Primapsiloceras*? sp. (from GSC loc. 98871 at 63.4 m), *Psiloceras calliphyllum* (Neumayr) with phylloceratids (from GSC loc. 98531 at 70.1 m), and middle Hettangian genera at several higher levels. Our collections include the impression of a single *Monotis* valve in a siltstone bed at 62.4 m and two conodont ramiform elements (*Epigondolella*) from thin calcareous beds at 62.6 m and 62.8 m (C.M. Henderson, 2003, personal commun.).

The lowest Hettangian (Jurassic) ammonite in the section at Black Bear Ridge is *Psiloceras plicatum* (Quenstedt) at 63.4 m (Fig. 1A), cited in Orchard et al. (2001) as *Primapsiloceras*? sp. This specimen was collected by Tozer, and his original field note placed it five feet above the fibrous calcite bed, which occurs 0.8 m above the top surface of the *Monotis* beds. The genus *Primapsiloceras* was described from Russia and thought to come from the ''pre-*planorbis* beds'' (i.e., pre-Hettangian), but that stratigraphic level has been questioned (Guex and Rakus, 1991). The next highest psiloceratids in this section are two slightly flattened lateral impressions of *Psiloceras majus* (Neumayr) at 64.1 m (Fig. 1B), followed by *Psiloceras* cf. *planocostatum* (Hillebrandt) at 65.1 m (Fig. 1C), *Psiloceras plicatum* (Quenstedt) at 67.6 m and 68.4 m (Fig. 1D), *Psiloceras* cf. *rectocostatum* Hillebrandt at 69.4 m, and *Psiloceras calliphyllum* (Neumayr) at 69.6 m. The last specimen was initially recorded by Tozer (1982) and used by Sephton et al. (2002) to define the base of the Jurassic in their section. Other ammonites in this part of the section are ?*Kammerkarites* sp. between 67.3 m and 69.7 m and phylloceratids at 69.4 m and 72 m.

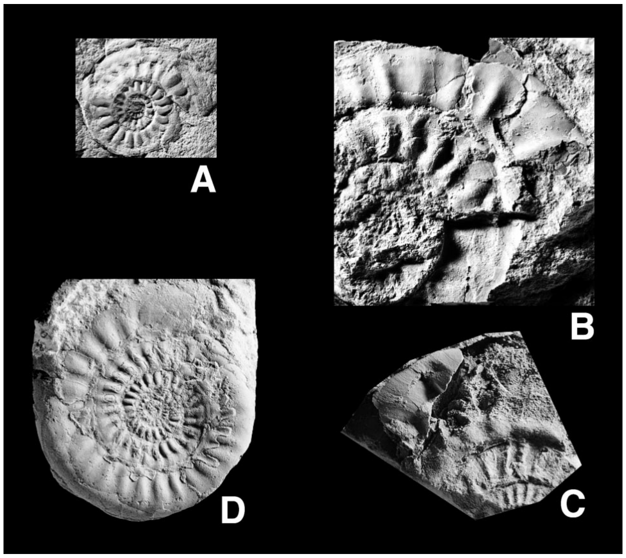

Figure 1. Selected lower Hettangian ammonites, Black Bear Ridge: (A) *Psiloceras plicatum* (Qu.) from 63.4 m (specimen identified as *Primapsiloceras*? sp. in Orchard et al. [2001]); (B) *Psiloceras majus* (Neumayr) from 64.1 m; (C) *Psiloceras* cf. *P. planocostatum* Hillebrandt from 65.1 m; and (D) *Psiloceras plicatum* (Qu.) from 67.6 m.

Thus, the apparent absence of the expected end-Triassic $\delta^{13}C_{org}$ excursion at Black Bear Ridge within the stratigraphic interval beginning just below 64.6 m (sample BBR40; the level of their sample BBR39 is not given in their data table, GSA data repository item 2002131) up to 70.9 m (sample BBR45) is, we believe, explained by the fact that this interval lies entirely within the Hettangian. If the conodonts and monotid bivalve found above 61.1 m, where abundant monotids suddenly disappear, were reworked specimens, then this part of the section could also already be Hettangian, meaning the Rhaetian is absent in this section. It must be noted that the species of *Psiloceras* reported here from Black Bear Ridge are not the earliest known species of this genus. At most, the Rhaetian is represented by 2.3 m of section (61.1–63.4 m), in contrast to just over 100 m in the boundary sequence at Kennecott Point, Queen Charlotte Islands (Ward et al., 2001, their Fig. 1). The Rhaetian at Black Bear Ridge is represented either by a hiatus, an extremely condensed sequence, or a marine flooding event occurring in the latest Rhaetian.

We suggest, then, that the carbon and nitrogen isotopic excursions recorded in the Black Bear Ridge section by Sephton et al. (2002) actually approximate the anticipated Rhaetian-Hettangian (end Triassic) event as recorded at other localities.

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REPLY

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We thank Hall and Pitaru for their comments and look forward to the publication of their work on the ammonites of the Black Bear Ridge section. This will undoubtedly provide much-needed details on this important Triassic-Jurassic boundary section. However, for now, the information they provide indicates that the Triassic-Jurassic boundary is lower than the level we chose, which was based on the published work of Tozer (1982). The first occurrence of *Psiloceras* is at 64.1 m and seems a reasonable choice for the placement of the boundary. This is 2.9 m above the top of the Norian stage, which is characterized by prolific *Monotis.* The affinity of the *Primapsiloceras*? at 63.4 m is debatable; it could be a true *Psiloceras* but it is also extremely similar to the Triassic taxon *Rhacophyllites*.

Despite this readjustment of the boundary level, we do not concur with Hall and Pitaru's proposal that the Rhaetian may be entirely absent at Black Bear Ridge. The strata between the last abundant *Monotis* and the first *Psiloceras* contain unequivocal Triassic taxa, as listed in Orchard et al. (2001) and noted by Hall and Pitaru. The suggestion that *Monotis* is reworked is not supported by any sedimentological data and is highly unlikely for such a thin-shelled taxon. Neither do we agree that the carbon and nitrogen isotope excursions we record are equivalent in time to end-Triassic carbon isotope excursions observed in other sections. Consider that Ward et al.'s (2001, their Fig. 1) data have a base Rhaetian $\delta^{13}C_{org}$ positive excursion of similar magnitude and direction to ours (at a level that is also marked by the abrupt disappearance of *Monotis*) and, at a higher level, a negative excursion at the Triassic-Jurassic boundary. Hesselbo et al.'s (2002, their Fig. 3) data also have positive $\delta^{13}C$ values within the lower Rhaetian followed by a complex negative anomaly beginning at a higher level taken to be the Triassic-Jurassic boundary. Thus, the Triassic-Jurassic boundary is marked by a negative, not a positive, excursion. The main contention of our paper, that a pre–end Triassic positive $\delta^{13}C_{org}$ excursion is associated with an extinction of deep-water taxa is therefore unchanged.

Further clarification of the complex series of events that occurred during the Late Triassic will undoubtedly come from the study of other sections on Williston Lake. Our recent field investigations indicate that the top *Monotis* surface at Black Bear Ridge records an interval of early Rhaetian condensation, with much thicker Rhaetian successions present in sections to the west of this location.

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