U/Pb dates for the base of the terminal Proterozoic and Cambrian

Dear Editor,

The recently published Phanerozoic time scale by Gradstein and Ogg (1996) is much welcomed as a basis for comment and discussion. These authors state that a 'GSSP ... for the base of Cambrian is considered in a cap carbonate above Varanger tillites in southern Australia'. Presumably this should read 'for the base of the Terminal Proterozoic', since the GSSP for the base of the Cambrian has recently been defined in Newfoundland (see below).

The authors then go on to imply a date for this Australian cap carbonate by correlation into 'tuffs with U/Pb dates on zircons in Namibia [that] may be near 570 Ma old', citing the presentation and abstract of Grotzinger et al. (1996). But here again, there appears to be a misunderstanding. Grotzinger et al. (1996) were referring to the recently published U/Pb of 548.8 ± 1 Ma from ashes within the Kuibis Subgroup (Grotzinger et al., 1995), broadly within the range of an Ediacarian fauna, and then extrapolating downward to a cap carbonate by means of assumed rates of sediment accumulation. This provided them with an upper envelope for the glacial interval of c. 570 Ma. Obviously, such estimated dates can be questioned for a variety of reasons.

The date of 545 Ma given by these authors for the base of the Cambrian now appears a little too old. The GSSP in south-east Newfoundland, marked by the appearance of a trace fossil assemblage bearing *Phycodes* sp. (Brasier et al., 1994), has recently been correlated into the Nemakit-Daldynian stage of the Olenek region, N Siberia. Volcanic breccias not far beneath *Phycodes pedum* have yielded a U/Pb date of 543.6 ± 0.24 (Bowring et al., 1993). In Namibia, this trace fossil assemblage appears

near the base of the Nomsas Formation, U/Pb dated at 539.4 ± 1 , and above an erosional break at the top of the Schwarzrand Subgroup, whose top contains an Ediacara fauna plus ashes U/Pb dated at 543.1 ± 1 (Grotzinger et al., 1995). Thus the base of the Nemakit-Daldynian stage may lie closer to 543 Ma.

The date of 534 Ma for the base of the Tommotian is also open to question since an important depositional break occurs between this stage and the underlying Nemakit-Daldynian stage on the Siberian Platform. Comparative biostratigraphy and chemostratigraphy suggest that the south-west Mongolian succession is substantially more complete than any Siberian section over this interval (Brasier et al. (1996). In northern Siberia, fluvial conglomerates thought to lie within this problematic interval contain volcanic clasts dated at 534 ± 0.5 Ma (Bowring et al., 1993). Although the latter authors refer overlying skeletal assemblages within the Tyusersk Formation to the upper part of the lowest, *Nochroioecyathus sunnaginicus* Zone of the Tommotian, others regard these faunas as of at least middle Tommotian age (e.g. Vidal et al., 1995) and they could well be younger. The Tyusersk Formation not only contains Tommotian-type early skeletal fossils, it also yields Atdabanian trilobites. Both occur together with acritarchs of the *Heliosphaeridium dissimulare*-*Skiagia ciliosa* Zone which in Baltica are associated with trilobites of the *Holmia kjerulfi* Zone (Vidal et al., 1995). The latter has been correlated, on the basis of trilobites, with the middle to upper Atdabanian of Siberia (Palmer and Repina, 1993) and a medial Atdabanian age now appears possible for this fossiliferous part of the Tyusersk Formation (A R Palmer, pers. comm., 1996). Hence this date of 534 Ma is not well constrained. It suggests an oldest possible age for the Tommotian. But it may span an interval as wide as the late Nemakit-Daldynian to middle Atdabanian.

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The following reply has been received from Felix Gradstein and James Ogg:

We would like to thank Dr Brasier for his correction regarding the proposed GSSP for the latest Proterozoic in our footnote to the 1996 Phanerozoic Time Scale compilation. We are also grateful for his insightful review of ongoing problems in the correlation of lower Cambrian strata. Such appears in line with our comment that the Early Paleozoic Era has '... a general paucity of relatively precise and stratigraphically meaningful ages dates ...' compounded by '... problems in inter-regional stage assignments ...'

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