Precambrian Research 246 (2014) 371–372

Contents lists available at ScienceDirect

Precambrian Research

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

Reply to Letter to the Editor

Reply to comment on "New age constraints for the Proterozoic Aravalli–Delhi successions of India and their implications" by Melezhik et al. [Precambrian Res. (2014)]

We thank Melezhik, Purohit, and Papineau for their comment. The authors raise important points regarding the age and nature of the $\delta^{13}C$ isotopic excursion recorded in the Jhamarkotra Formation. Foremost, they question the stratigraphic architecture and continuity of strata within the Aravalli–Delhi Orogenic Belt (ADOB). We agree that the structural and stratigraphic architecture of the region has not been well constrained. Our new geochronologic data clearly illustrate this fact and provided an important step towards resolving some stratigraphic issues within the ADOB; although, the region would benefit from additional detailed geologic investigations in the future. Our interpretations, however, were presented within the context of the current understanding of regional geology. We took a conservative approach when we proposed that the Jhamarkotra Formation might record a previously unrecognized isotope excursion, as indicated by our use of a question mark in the section entitled "*A mid-Proterozoic $\delta^{13}C$ excursion?*" Our discussions of the possible excursion emphasized the need for additional work to explore the validity of the age and nature of the excursion, and we are pleased that our paper has stimulated interest and debate.

While Melezhik and others justifiably highlight some of the uncertainties with the regional geology, they have unfortunately misrepresented some aspects of our manuscript. They comment that our paper "*. . .introduced an unanswered geochemical puzzle by stating that both isotopically normal (0‰ at Jhamarkotra) and ^{13}C-enriched (up to +12‰) values represent synchronous (as opposed to contemporary, i.e., occurring in the same period of time, by* Papineau et al. (2013)*) seawater signals*". We did not suggest synchronous development of both the 0‰ phosphatic horizons and ^{13}C-enriched horizons and we directly acknowledged the difference in stratigraphic position of these horizons on page 124 of the paper by stating: "*The dolostone with isotopically heavy carbon values is considered to sit stratigraphically below the phosphatic horizons (*e.g., Sreenivas et al., 2001)." Ultimately, we followed the arguments of Papineau et al. (2013) who provided an extensive discussion on the potential contemporaneity of deposition of the 13C-rich and phosphatic carbonate units and concluded that strata in all outcrops of the Jhamarkotra Formation were formed within a similar range of depositional ages, and as part of the same sedimentary sequences. This is clearly stated in our paper, e.g., page 125: "*Following the arguments of* Papineau et al. (2013) *for* ***contemporaneous*** *deposition of all Jhamarkotra strata, the ^{13}C-rich Jhamarkotra deposits would have been deposited around ~1.7 Ga.*" It is possible that Papineau et al. (2013) and other workers have been mistaken and that these units instead differ in depositional age by many hundreds of millions of years, but direct evidence for such an arrangement between these units is not presently available. Futhermore, Sreenivas et al. (2001) reported the co-occurrence of both massive isotopically heavy dolostone and phosphatic dolostone within the same sedimentary sequence, with the phosphatic horizon stratigraphically higher in the section.

Aside from the detrital zircon U–Pb data presented by our study, there are few reliable geochronologic constraints for units of the Lower Aravalli Group. We acknowledge that some currently unrecognized structural complexity may complicate the apparent relationship between units associated with the Jhamarkotra Formation, and it is possible that the massive ^{13}C-rich horizons are not part of a continuous succession with the phosphatic strata. However, as no such reliable evidence has yet been presented, we do not agree that in the light of our results it is a simple matter of "*common sense*" to assume drastically different depositional ages (i.e., >300 million years) for horizons of what has generally been considered a single carbonate succession solely on the basis of stratigraphic carbon isotope heterogeneity, as numerous carbonate successions exhibit stratigraphic variation in $\delta^{13}C$ values. Following the recent interpretations made by Papineau et al. (2013), and numerous earlier researchers, the most parsimonious interpretation is that the strata are all part of the Jhamarkotra Formation until adequately shown otherwise, and we strongly advocate additional work on this topic be conducted. It is also noteworthy that recent work has shown that some ^{13}C-enriched carbonate rocks in classic Lomagundi-Jatuli sections in southern Africa have depositional ages younger than ~1.92 Ga (Beukes et al., 2013), which demonstrates that $\delta^{13}C$ values may have been more variable during the Paleoproterozoic than commonly assumed. We feel that the presence of positive $\delta^{13}C$ values alone should not be considered diagnostic of any particular depositional age, and that the utilization of geochronologic data in conjunction with an improved understanding of the regional structural framework will be critical for resolving issues in the ADOB, which is clearly a region of interest that requires additional investigation.

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http://dx.doi.org/10.1016/j.precamres.2014.03.005
0301-9268/

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5 March 2014
Available online 21 March 2014