

## COMMENTS AND REPLIES

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## Reply

## No Late Cambrian shoreline ice in Laurentia

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Landing's Comment (2011) offers traditional arguments to support the conventional view of sustained warmth during the latter part of the Cambrian, most of which were already addressed in Runkel et al. (2010). We add here that evaporite deposition is not restricted to warm climatic conditions (Warren, 2010). Furthermore, the intractable problem of establishing depositional synchronicity of presumed warm-water facies elsewhere, to the sandstone intraclasts we described, renders the potential climatic significance of such facies irrelevant if cold conditions were episodic (Runkel et al., 2010).

The alternative sedimentologic processes offered by Landing (2011) to account for the features described in Runkel et al. (2010) are all well-known binding agents, some of which have ductile properties, others brittle, and none of which account for the complex rheological behavior we documented, which is why we tested and rejected them. The specific examples cited by Landing (2011) from clay- (Knight, 2005) and carbonate-dominated (Alsharhan and Kendall, 2003) modern peritidal

environments are unacceptable analogues to the sandstone intraclasts and associated features described in Runkel et al. (2010), both because of the fundamental difference in material properties of the sediment as well as the characteristics of the cementing agents. In contrast, modern ice-cemented, sandy shorelines provide a complete analogue.

Landing (2011) argues that the Cambrian features we described cannot be explained by ice-cement because traditional measures of Cambrian climate have already unequivocally established a history of sustained global warmth. We instead contend that the features we documented demonstrate that the conventional view is wrong.

We were unaware of Landing and MacGabhann (2010) at the time we published Runkel et al. (2010), and agree that the early Cambrian, Avalonian sedimentologic features they describe are at least suggestive of the former presence of ice. If their interpretation of these features is correct, paleogeographic evidence for a temperate-latitude Avalonia (e.g., Cocks and Fortey, 2009) at this time raises the possibility that at least brief episodes of globally cold conditions may have also occurred during the early Cambrian.

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