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Global carbon cycle and climate change interactions during the Neoproterozoic

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Carbon isotope excursions have long been associated with glaciation during the Neoproterozoic, but teasing apart cause from effect is difficult. One model invokes the existence of a large 'dissolved' organic carbon reservoir in the deeper parts of the world's oceans, which when oxidized can cause negative carbon isotope excursions, but once exhausted could leave the Earth vulnerable to extreme climate change. One test of this model would be to establish whether carbon isotope events and glacial onset are temporally related. In the case of low-latitude Cryogenian glaciations, which began at about 715 Ma, the pre-glacial 'Garvellach' (previously named 'Islay') negative C-isotope anomaly clearly preceded the onset of low-latitude early Cryogenian 'Sturtian' glaciation in Scotland (and elsewhere). In this presentation, an apparently transitional succession on Garbh Eileach in Scotland and related isotope data will be discussed. The late Cryogenian 'Marinoan' glaciation is preceded by the extremely negative 'Trezona' anomaly, which recovers to normal values during the transition to low-latitude glaciation in Australia. The relative timing of isotopic and climatic events is consistent with the exhaustion of a vast organic carbon reservoir due to excess oxidant production. Although it is widely thought that increased organic burial would counteract the effect of DOC oxidation, low C-isotope values do not necessarily imply lower rates of organic burial because erosion forcing can overcome the effect of organic burial on the carbon isotope mass balance. In addition, eutrophication of a largely anoxic ocean can lead to euxinic conditions at productive margins, causing both oxidant imbalance and a weakening greenhouse blanket. Several researchers consider that the c. 580 Ma Gaskiers glaciation coincided with a relatively small, negative C isotope excursion in the Yangtze Gorges area of South China. This may explain why the Gaskiers glaciation was of only regional important, because oxidation of the DOC reservoir acts as a negative feedback on atmospheric greenhouse gas levels, thus reversing cooling. The end-Ediacaran Shuram anomaly, however, is much larger, but apparently unassociated with glaciation, although there are several well-described glaciogenic deposits around the world, e.g. on the North China craton, that could have an Ediacaran-Cambrian age. The recovery from the Shuram anomaly is associated with global ocean oxygenation, which is also consistent with oxidation of a DOC reservoir because excess oxidant production would no longer be buffered once the reservoir became exhausted. This presentation will explore the climate relationships of anomalous carbon isotope excursions, both positive and negative, and asks why they bracket such an extraordinary interval of climatic and environmental revolution.