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Were transgressive black shales a negative feedback mechanism modulating glacio-eustastic cycles in the Early Palaeozoic Icehouse?

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The Early Palaeozoic Icehouse (Late Ordovician-Early Silurian) is a unique event in the Earth's climatic history, marked by extensive glaciations occurring at a time when atmospheric CO2 concentration was 15-20 times its present level (GEOCARB I-III). Unlike the modern oceans, where short term changes in atmospheric CO2 are accommodated by a carbonate buffer and long term changes in atmospheric CO2 are reflected in carbonate sedimentation, the palaeoceanography of the Early Palaeozoic Icehouse was markedly different. Elevated atmospheric CO2 prohibited carbonate formation consistent with the paucity of carbonates found in deep water successions from this interval. However, periods of marine anoxia, marked by the deposition of graptolitic black shales, are common in such successions, and, having elevated organic carbon concentrations, represent the most likely sink for atmospheric CO2 in this interval.

Though the extent of ice formation during this glaciation remains poorly constrained, relative to that of the Pleistocene, however, several major tillites were deposited, and there is good evidence of global sea-level variation of a presumably glacio-eustatic origin. Rather than dealing with the forcing mechanisms related to onset or termination of Icehouse conditions, this paper aims to address the role of black shale deposition and CO2 draw-down with regard to glacio-eustatic cycles within the relatively stable Icehouse environment.

Sequence stratigraphy shows that graptolitic black shales tend to be deposited during transgressions, (e.g. the earliest Silurian), global regressions (such as the Silurian

sedgwickii Biozone event) correspond to the deposition of oxic facies in shelf successions, marking periods of reduced carbon burial. If global temperature was controlled by atmospheric CO2 concentration at this time, then the deposition of graptolitic black shales during transgressions should act as a negative feedback mechanism, drawing down CO2 and preventing runaway melting. A simple box model has been developed to establish if transgressive black shales could plausibly draw-down sufficient CO2 to modulate glacio-eustastic cycles in the Early Palaeozoic Icehouse.