



## **IAS Postgraduate Grant Scheme**

Lauren P. Birgenheier

Scientific Report:

### **Global climatic implications of a Permian organic carbon isotope curve constructed from the high-latitude, ice-proximal record of glaciation from eastern Australia**

#### **Background**

Our understanding of global climatic fluctuations through the late Paleozoic has relied heavily on inferred relationships between shifts in carbon and oxygen stable isotope records constructed from paleoequatorial localities and Gondwanan glaciation. However, these isotopic records have yet to have been tied directly to the stratigraphic record of high-latitude late Paleozoic glaciation in order to test inferred paleoclimatic relationships. The Permian stratigraphic record of glaciation from eastern Australia reveals four discrete episodes of glaciation (P1-P4), ranging from ~5 to 8 m.y. in duration, separated by periods of distinctly non-glacial deposition. This is the most highly resolved late Paleozoic glacial record available, which makes it an ideal locality to test the relationship between climatic and carbon isotopic fluctuations during a critical icehouse period in earth's history.

#### **Objectives**

This study aims to:

- 1) Construct a high-resolution Permian organic carbon isotope record using samples of organic-rich glacial and non-glacial facies across eastern Australia, which lay at high latitudes during the Permian.
- 2) Compare the organic carbon isotope curve to climatic fluctuations observed from sedimentologic indicators of glacial facies in the eastern Australian stratigraphic record. Are positive organic carbon isotope shifts coeval with the onset of documented glacial episodes, and vice versa?

- 3) Compare the organic carbon isotope curve constructed from high-latitude, eastern Australian localities with published paleoequatorial isotopic,  $p\text{CO}_2$  records, and the stratigraphic record of Permian glaciation from other high-latitude localities. Are the organic carbon isotope shifts global in nature? What can they tell us about the mechanisms driving late Paleozoic climate change?

## Results

Distinctly glacial and non-glacial organic-rich facies from the Permian (mid-Sakmarian to basal Wuchiapingian) of eastern Australia have been sampled and geochemically analyzed for total organic carbon content (%  $\text{C}_{\text{org}}$ ), total nitrogen content (%  $\text{N}_{\text{tot}}$ ), and  $\delta^{13}\text{C}_{\text{org}}$ .  $\text{C}_{\text{org}}/\text{N}_{\text{tot}}$  and  $\delta^{13}\text{C}_{\text{org}}$  values indicate a fully terrestrial to mixed terrestrial/marine organic matter source through the succession. Changes in  $\delta^{13}\text{C}_{\text{org}}$  values through time display shifts that are similar to and coeval with those from isotopic datasets constructed from paleoequatorial latitudes, which suggests  $\delta^{13}\text{C}_{\text{org}}$  shifts observed in the curve are global in nature.

The Permian  $\delta^{13}\text{C}_{\text{org}}$  curve is compared to the stratigraphic record of glaciation from eastern Australia, which comprises four discrete Permian glacial intervals (P1-P4) separated by periods of distinctly non-glacial deposition. The onset of each glacial episode (P2-P4) is marked by a positive  $\delta^{13}\text{C}_{\text{org}}$  shift (magnitude: 1 to 3.2‰), which is interpreted to be a result of a global decrease in atmospheric  $p\text{CO}_2$ . This indicates that  $p\text{CO}_2$  and glaciation were coupled throughout the Permian and that mid- to late Permian glacial events in eastern Australia were of global significance. Global negative  $\delta^{13}\text{C}_{\text{org}}$  shifts are interpreted to be the result of a rise in  $p\text{CO}_2$  and may be coincident with deglaciation events evident in the sedimentary record from eastern Australia, such as the middle and upper Pebbley Beach formations. Alternatively or additionally, the global negative  $\delta^{13}\text{C}_{\text{org}}$  shifts may be coeval with mid- to late Permian glaciation evident from other southern and northern hemisphere high latitude localities, such as Southern Africa, Antarctica, Tasmania, and northeastern Asia. This study confirms the traditional relationship between late Paleozoic climate and carbon cycling in which a positive carbon isotope shift is associated with the onset of glaciation.

Past late Paleozoic climate studies using isotopic data have relied heavily on purely marine records. The results of this study assert that mixed terrestrial/marine to fully terrestrial isotopic records also record global climatic variations. Direct sampling and organic carbon isotopic analysis of glacial and non-glacial facies combined with detailed sedimentologic and stratigraphic study of the Permian of eastern Australia have allowed for a more precise understanding of late Paleozoic climate, offering further evidence that Permian glaciation was quite dynamic in nature.

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