

## Secular Variation in Boron Isotopes in the Paleozoic Ocean

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Wally Broecker was quick to recognize the potential for boron isotopes as a proxy for changes in atmospheric pCO<sub>2</sub>. His interest and support in developing the proxy spurred the field. As with every proxy, there are unexpected complications and details to be confronted. In the end, he was a strong supporter of boron isotope research and valued the insights it provided regarding changes in ocean chemistry.

Of particular importance for taking the boron pH/pCO<sub>2</sub> proxy beyond the Neogene is the question of secular variability. In order to estimate pH, the isotope composition of the mineralizing fluid must be known. Insight into secular variability can be established through careful selection of calcitic marine fossils such as brachiopods. Published  $\delta^{11}\text{B}$  of brachiopods, combined with our emerging results from the Paleozoic demonstrate that secular changes in the  $\delta^{11}\text{B}$  of seawater is required. That is, pH alone, with modern ocean  $\delta^{11}\text{B}$  cannot account for the variability found. Several important observations regarding boron secular variability have emerged. One is that changes appear to be relatively rapid (order of 5 m.y.) and are interspersed with intervals of stasis. Another is that these changes tend to covary with other isotope records. A model that accounts for the shared changes will provide an important window into the controls on the processes that control ocean chemistry.