Completing the Permian time scale: Progress on Cisuralian GSSP definitions

C.M. Henderson¹, S. Shen² & J. Chen²
¹Department of Geoscience, University of Calgary, Alberta, Canada T2N 1N4
²Nanjing Institute of Geology and Palaeontology, Nanjing, China 210008

GSSPs for the base of the Permian, and for Guadalupian and Lopingian stages are all ratified; only three Cisuralian stage GSSP proposals (Sukmarian, Artinskian, and Kungurian) remain. The Permian Time Scale will be complete when these are ratified. Two alternative definitions for the base-Sakmarian (295 Ma) GSSP have been considered, including the chronomorpholine from Sweetognathus expansus to Sw. merrilli at 115 mab of the Kondurovsky section in the Urals. Sweetognathus merrilli is widespread and its first occurrence in Kansas in the upper part of the Eiss Limestone Member is well constrained, but the presence of associated Streptognathodus spp. indicates diachrony within this “lineage”. As a result, a second definition at the FAD of Mesogondolella uralensis within the chronomorpholine of M. pseudostriatum to M. arcuata to M. uralensis at 51.6 mab of the Usołka section is now preferred. This taxon is present at Kondurovsky at 104.2 mab. The best GSSP section for the base-Artinskian (290 Ma) is the Dal'ny Tulkus section in Russia, at a point defined by the FAD of Sweetognathus “whitei” within the chronomorpholine Sw. binodosus to Sw. anceps to Sw. “whitei” at 2.7 mab of bed 4. The succession of Sw. binodosus to Sw. “whitei” can also be recognized in the lower Great Bear Cape Formation, southwest Ellesmere Island and in the Luodian Section in South China. The defining species is in quotes because Sweetognathus whitei from the Schroyer–Florence limestone cyclothem of the Chase Group, Kansas, co-occurs with species of Streptognathodus suggesting an older Late Asselian age. Specimens of Sw. “whitei” in the Canadian Arctic and in the Urals are found above high frequency cyclotherms indicating a post-glaciation interval. A Kungurian (282 Ma) GSSP located near Mecheetino on the Yuryuzan River has been considered as a possible stratotype for the base-Kungurian at the FAD of the conodont Neostreptognathodus pnevi in bed 19, but subsequent tests found very few conodonts and ash beds did not yield useful dates. Therefore the Rockland section in the Pequop Mountains, Nevada, which also demonstrates the chronomorpholine from N. pequoensis to N. pnevi, is now under study. Neostreptognathodus pnevi was thought to be absent from the Tethys, but specimens have now been recovered from the Luodian section of South China; the lack of a chronomorpholine suggests that this is a migration event, indicating only proximity to the Kungurian boundary. Carbon isotopes, strontium isotopes from conodonts and geochronologic dates provide important additional correlation tools.

Clumped isotope geochemistry of Carboniferous brachiopods: Early lessons from a novel paleothermometer

G.A. Henkes¹, B.H. Passey¹, E.L. Grossman² & T.E. Yancey²
¹Johns Hopkins University, Baltimore, MD, USA
²Texas A&M University, College Station, TX, USA

Carbonate clumped isotope geochemistry is based on the temperature sensitivity of the relative abundance of carbonate ions containing $^{13}$C-$^{18}$O bonds. This emerging method has applications in paleoaltimetry and paleothermometry, and has the potential to elucidate past relationships among temperature, ice volume, and the global carbon cycle. The clumped isotope temperature signal is independent of the isotopic composition of seawater and can be used with traditional oxygen isotope paleotemperature equations to calculate the isotopic composition of ancient seawater. Isotope values of marine carbonates serve as a baseline for evaluating the physical and biogeochemical evolution of Earth, and calcitic brachiopods are a standard material for Paleozoic paleoceanography because of their ability to retain original isotopic compositions and their widespread distribution in the sedimentary record. Here we present carbon, oxygen, and clumped isotope data from Carboniferous brachiopod shells from North America and Russia. The shells were screened for diagenesis by a combination of elemental and textural analysis and cathodoluminescence microscopy. Inferring paleotemperatures from shallow, hypersaline North American epicontinental seas during the late Tournaisian (Iowa) were ~40°C, while early Viséan paleotemperatures (Missouri) were somewhat cooler (~35°C). Calculated seawater $\delta^{18}$O values are ~1%, consistent with evaporation in restricted, low-latitude seas. In contrast, Serpukhovian paleotemperatures from the Moscow Basin average 26 to 33°C with calculated seawater values of ~2.1 to -0.8%. The warm temperatures for North American seas are problematic, and partial closed-system redistribution of clumped isotopes cannot be ruled out. Early Pennsylvanian brachiopods from Arrow Canyon, Nevada have anomalously low clumped isotope values (though high $\delta^{18}$O) that suggest high-temperature (~100°C), closed-system alteration during burial. Thus, independent burial history data are essential for clumped (as well as stable) isotopes. Conversely, clumped isotope thermometry may be a powerful tool for evaluating basin-scale burial histories. We also present results from a clumped isotope calibration study for modern mollusks which shows that mollusks deviate from clumped isotope calibration curves developed for other biogenic carbonates (e.g. corals, foraminifers, otoliths). Differences between these calibrations have implications for brachiopod and mollusc-based clumped isotope palaeothermometry as well as assumptions of equilibrium isotope fractionation during shell precipitation.