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Climatic control on salinity gradient across the US Midcontinent Sea during Pennsylvanian glacio-eustatic highstands

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The Late Palaeozoic Ice Age (Mississippian to Middle Permian) was characterized by the development of high southern-latitude ice caps resulting in the deposition of glacial deposits in large parts of South America, South Africa, India, Antarctica, and Australia [1]. However, the imprint of glacial conditions was not limited to higher latitudes. Studies of Pennsylvanian sedimentary deposits suggest that the glaciation was characterized by cyclic waxing and waning of Gondwanan glaciers, which produced high-frequency sea-level fluctuations and resulted in the sedimentation of cyclothems, especially during the Pennsylvanian. The Pennsylvanian cyclothems in Midcontinent North America are the most well-known sedimentary successions for this specific time interval [2]. When completely developed, the middle portion of these cyclothems includes a thin transgressive limestone, overlain by thin offshore gray to black phosphatic shales, which are then overlain by thicker regressive limestones. This package of units is under- and overlain by nearshore to terrestrial shales with well-developed paleosols that are commonly capped by coal beds. Pennsylvanian phosphatic “core shales” are interpreted to have been deposited in waters deep enough to produce a pycnocline that may have developed as consequence of increased riverine runoff into the largely landlocked US Midcontinent Sea during the more humid interglacial intervals [3].

We tested whether a gradient in surface water salinity existed in the Late Pennsylvanian Midcontinent Sea during times of maximum flooding by analysing oxygen isotopes of conodont apatite from the maximum flooding surface in black shales of the Midland, Midcontinent, Illinois and Appalachian basins. Samples were collected from the core black shales or the equivalent maximum flooding units of the Verdigris (Oakley Shale, mid-Desmoinesian/middle upper Moscovian), Lost Branch (Nuyaka Creek Shale; uppermost Desmoinesian/upper Moscovian), Swope (Hushpuckney Shale; lower Missourian/basal Kasimovian), and Oread (Heebner Shale; lower Virgilian/lower Gzhelian) cyclothems. In the Midland and Midcontinent basins, average oxygen isotope values for conodonts from the Oakley, Hushpuckney and Heebner shales are 18.8 ±0.3‰, 19.1 ±0.2‰, and 18.9 ±0.1‰, respectively. Conodonts from the Appalachian Basin are generally depleted in ^{18}O. For example, conodonts from the Oakley shale have 2.5‰ lower values compared to conodonts from the Midland and Midcontinent basins. This pattern is also evident for conodonts from the Heebner and Hushpuckney shales, although conodonts from the Appalachian Basin show only a 0.4 to 0.7‰ depletion in ^{18}O compared to conodonts from the Midcontinent Basin. These differences in oxygen isotopes are interpreted as reflecting primarily a salinity, assuming that temperature was relatively constant across the tropical Midcontinent Sea.

Lower salinities in the Appalachian Basin and a significant salinity gradient in the Midcontinent Sea were reconstructed for the Desmoinesian (Oakley shale), supporting the idea that freshwater discharge may have resulted in a salinity-stratified water column during everwet paleoclimate times, at least in the eastern part of the epeiric sea. However, the salinity gradient is considerably reduced during the subsequent periodically dryer Missourian and Virgilian interglacial periods (Hushpuckney, Heebner shale). This suggests that surface

waters in the Midcontinent Sea were not significantly influenced by continental runoff during the Missourian and Virgilian, and calls into question whether a halocline was necessary for the formation of the phosphatic core shales.

References:

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