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Cosmogenic nuclide concentrations in Neogene rivers of the Great Plains reveal the evolution of fluvial storage and recycling

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The measurement of the duration of near surface residence of sediment grains from the stratigraphic record has the potential to quantitatively reconstruct processes such as stratal condensation, sediment recycling and the exposure histories of unconformities. Geomorphological measurements of dates and rates of surfaces and erosion respectively has enabled significant advances in understanding, however, the radiogenic half life of typical cosmogenic nuclides such as 10Be and 26Al means they are not suitable for the stratigraphic record. Instead, we have applied the stable cosmogenic nuclide of 21Ne to quartz-rich sediment to quantify the routing history of the river systems that have drained the southern Rockies of Wyoming and Colorado during Neogene times.
The Neogene sediments of Nebraska record fluvial systems of the Great Plains that flow from the Rockies towards the east and into the Mississippi catchment. This succession is <300 m thick, and records successive episodes of fluvial incision and aggradation associated with regional tilting from 6 to 4 Ma and periods of climate change. As part of an evaluation of the application of 21Ne to the stratigraphic record, we sampled quartzite pebbles from an Upper Miocene, Pliocene and modern river channel of the North Platte approximately 400 km from their mountainous source. The quartzite is derived from a single exposure of the Medicine Bow quartzites in Wyoming, therefore all three intervals recorded the same travel distance from source. Additionally, we know the erosion rate of the Medicine Bow quartzites from detrital 10Be analyses, and we also sampled shielded bedrock samples from the quartzite to evaluate for any non-cosmogenic 21Ne. This means that the concentrations of 21Ne in detrital pebbles >400 km from their source could be corrected for both inherited non-cosmogenic and erosion induced accumulation at source. Therefore, any additional amounts of 21Ne must record storage and exposure during transport down the river systems.
Based on 40 analyses of pebbles from these intervals, we are able to demonstrate that approximately half of the pebbles record significant excess 21Ne resulting from storage and transport, indicating a mixing of first generation and recycled pebbles throughout the succession. Furthermore, the numbers and concentrations of excess 21Ne in the pebbles are comparable between the three time intervals indicating little change in the extent of storage and recycling of river sediment from late Miocene to present. These results represent the first application of stable cosmogenic nuclides to the stratigraphic record and point to a significant development in our ability to quantify sediment routing systems.