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Paleocurrent variability in meandering and braided river systems: Modern calibration and stratigraphic case studies spanning the Paleocene-Eocene Thermal Maximum

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Meandering and braided river systems display a range of morphologic, dynamic, and lithologic characteristics. They also display differing degrees of channel sinuosity, which may induce differences in the variability or dispersion of paleocurrent directions obtained from dune cross-stratification in the stratigraphic record. To assess this hypothesis, "synthetic" paleocurrent measurements were taken from 6 modern rivers (3 braided and 3 meandering) by determining the azimuth of flow direction (i.e. perpendicular to channel cross-section) at 1000 locations in rivers in segments that were as long as the channel is wide. From these current measurements we determined a dispersion value for each river. Dispersion values for braided rivers ranged from 0.78 to 0.89 whereas values for meandering rivers ranged from 0.39 to 0.55. We then subsampled this large dataset to assess any changes in the dispersion values with sample size. The subsampling routine suggests accurate dispersion values can even be recovered in small sample sizes ($n \approx 20$-25), and that meandering and braided river morphologies may, in part, be identified by paleocurrent dispersion. Twelve additional rivers were analyzed with 250 current measurements each to better define the dispersion value fields and boundary between meandering and braided.

These results were applied to the stratigraphic record to investigate whether the changes in the hydrologic cycle and vegetation regimes during the Paleocene-Eocene Thermal Maximum (PETM) altered the morphology of river systems in sedimentary basins. The Paleocene-Eocene Thermal Maximum (PETM) was a massive global warming event that occurred approximately 56 Ma, which altered terrestrial vegetation density as well as sediment transport in rivers and their morphodynamics. We compiled and determined new paleocurrent measurements for three Laramide basins in North America where the PETM has been identified, the Bighorn Basin (n=397) and Hanna Basin (n=280) of Wyoming, and the Piceance Basin of Colorado (n=209). Data were pooled into bins before, during, and after the PETM. Overall the fluvial sandbodies during the PETM displayed higher average dispersion values (0.7) than rivers before and after (0.5 and 0.6, respectively). In the Bighorn and Hanna basins there are no associated changes in lithofacies with the PETM, suggesting the change in dispersion may be due to a reduction channel sinuosity, potentially related to increased sediment flux or reductions in bank stability linked to a more open vegetation regime. In contrast, the Piceance Basin displays lithofacies consistent with a shift from meandering to braided fluvial deposition as well as an increase in paleocurrent dispersion values. This finding is consistent with previous hypotheses suggesting greater sediment flux, channel mobility, and planform morphology due to hydrologic variability and sediment flux.