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Predicting fluvial suspended sediment discharges in the geologic past — examples from the Cenomanian and Turonian North American continent

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Fluvial sediment discharges are governed by tectonic and climatic boundary conditions, which influence spatio-temporal patterns in sediment routing, as well as denudation rates in upland source regions. Depositional stratigraphy represents the only physical archive of ancient source-to-sink systems, which limits palaeo-sediment routing system analyses both spatially and temporally. Therefore, understanding how, when and where sediment was delivered from the continents to the oceans in the geologic past remains a prominent research challenge in Earth science. In this study we use new high-resolution palaeogeographies, which have been digitised as palaeo-digital elevation models (palaeoDEMs), and HadCM3L climate data to predict the configurations, geometries and climates of large continental catchments in the Cenomanian and Turonian North American continent. Moreover, we use the BQART sediment discharge model to make first-order estimates of fluvially-derived suspended sediment discharges in catchments, and we assess their spatial distribution across the North American continent.

We analysed palaeoDEMs in ArcGIS and reconstructed over 1500 North American catchments with areas greater than 500 km2 for both Cenomanian and Turonian time slices. Using BQART, we predicted fluvial sediment discharges in each catchment and mapped their spatial distribution across the continent. Total continental suspended sediment discharges are projected to be 3.5 GT/yr and 3.1 GT/yr in the Cenomanian and Turonian stages, respectively. This implies that continental sediment discharges in the late Cretaceous may have been a factor of 2 bigger than estimated Holocene pre-anthropogenic continental discharges of 1.7 GT/yr. To validate our results, we compared BQART estimates with published constraints from the Cenomanian Dunvegan Formation in Alberta, Canada, and the Turonian Ferron Sandstone in Utah, USA. In each case study, BQART estimates are the same order of magnitude as published constraints, which were derived from previous field-based approaches, and most lie within a factor of 2. Finally, we evaluated and quantified the univariate and multivariate sensitivity of our sediment discharge estimates to a range of uncertainty margins on BQART input parameters, which includes palaeogeographic and palaeoclimatic boundary conditions.

Our results demonstrate that high-resolution palaeogeographies can be used to make first order estimates of fluvial sediment discharges in the geologic past on a variety of spatial and temporal scales. We consider our approach particularly useful where stratigraphic records are incomplete. Moreover, we highlight the potential to use this approach to address big picture research questions, such as the global spatio-temporal response of sediment supply to major tectonic and climatic events in the geologic past.