

Abstract

Limited studies exist on the downstream variation of grain size in sand-bed rivers, particularly in natural sediment regimes. The impact of local grain-size variability, lateral tributaries, and bedrock confined zones on the downstream trend remains underexplored. The work of first objective of this thesis examined 54 sediment samples from the sandbars of the Brahmaputra main trunk, analyzing grain-size and bulk mineralogy, along with selected samples for clay mineralogy. End-member modeling was applied to the grain-size data, and existing depth profile data were used to propose a transport mechanism. Results corroborate previous studies indicating limited chemical weathering in the Brahmaputra basin. Additionally, diverse median grain sizes ranging from 17 μm to 356 μm was observed, with a notable scarcity of samples having dominant mode in intermediate range of approximately 63-172 μm . This study reveals that local flow conditions and selective transportation and deposition of sediments in specific size classes drive the grain-size variability. The grain-size gap is explained by proposed transport mechanism, with sediments within the gap selectively transported during peak monsoon periods, resulting in coarser deposits on riverbed and depleting sediments within the 63-172 μm range over repeated annual floods. Sediments below 63 μm are consistently present in the water column and can be deposited in low-flow zones within floodplains. Evolution of downstream grain-size variation is influenced by low width bedrock confined zones, characterized by increased grain-size. The findings contribute to understanding sediment transport and deposition in river floodplains, with implications for downstream fining and grain-size gap formation in sand-bed rivers.

Sediment composition in modern fluvial settings is commonly assessed regarding spatial but rarely temporal variability, potentially leading to a bias of unknown extent. The second objective of this thesis present the grain-size distribution, bulk chemical and mineralogical composition of a time-series set of 36 suspended sediment samples from the Brahmaputra river, as well as clay and heavy mineral analysis of selected samples. Sampling covers the June to November 2021 period, which included two major flooding events. Results show that the two flooding events are characterized by contrasting grain size, with the first event characterized by a grain-size minimum and the second by a grain-size maximum. Although grain sizes of the first flood and the period after the second are similar, their compositions differ significantly, highlighted by a factor-two decrease of biotite largely compensated by an increase in quartz. By contrast, the content of garnet, clinopyroxene, sillimanite, and rutile

increased compared to epidote and amphibole during the second flood event. By relating the results to spatio-temporal rainfall and discharge patterns and basin morphology, it is concluded that the first flooding primarily mobilized hydraulically pre-sorted sediments from the exposed sandbars of the floodplains, while those sandbars are already submerged during the second flooding in a single-channel system, resulting in higher sediment contributions from highland tributaries draining igneous and high-grade metamorphic rocks. Such temporal variations pose constraints on the interpretation of compositional differences between individual samples regarding sediment provenance and dispersal and, should be considered in studies of modern drainage basins as well as ancient sediment routing systems.

The third objective is designed to test the hypothesis proposed in the second objective and identify the controls of sediment transport in a series of unsteady events. Furthermore, understanding sediment transport mechanisms during unsteady events is crucial for accurately assessing the dynamics of sediment movement in rivers. While the transport of bed load on coarse-grained mobile beds has been studied for a single unsteady event at flume scale, the role of fine-grained suspended sediment as well as sedimentary response of multiple unsteady events, has often been overlooked. This work investigate sediment transport dynamics in response to a series of three unsteady events through numerical simulation. The results are interpreted with field observations presented in previous objectives and optical and microwave satellite data. Our findings reveal that the transport of coarse-grained sediments is primarily controlled by bed shear stress. However, the transport of fine-grained sediments is more intricate, governed not only by bed shear stress but also by the armor-ing and morphological effects. To validate simulation results, they were compared with field observations and complement the analysis with optical and microwave satellite data. It is concluded that the initial flood event plays a significant role in generating a higher proportion of fine-grained sediments. This is attributed to the selective transport of fine material facilitated by the interaction between the flood and exposed bedforms containing these fine sediments. As the fine sediments are either flushed away or armored by the coarser particles, the supply of fine-grained sediment diminishes in subsequent floods within less morphologically active channels. These findings have implications for understanding the dynamics of fine-grained sediments, which are often sampled and studied for sediment flux calculations, sediment provenance determination, and environmental quality assessment.