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Variable scale channel avulsion history using fan architecture and stratigraphy, and sediment provenance of Sutlej-Yamuna fans in northwest Gangetic plains during Late Quaternary

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Channel avulsion during fan development controls distribution and deposition of channel sandbodies and hence alluvial architecture of a fan system. Variable scale spatio-temporal information of fluvial responses to past climate changes is stored in these channel sandbodies. Further these channel sandbodies form fluvial aquifers in alluvial fans and therefore understanding of alluvial architecture and stratigraphy of a fan is crucial for development of groundwater management strategies. In this study we used multiple approaches to map subsurface fluvial aquifer architecture and alluvial stratigraphy, and to estimate sediment provenance using U-Pb dating of detrital zircon grains of Sutlej-Yamuna fan system in northwest India. Satellite imagery based geomorphic mapping shows two large fan system with interfan area. The fan surfaces show presence of major and minor paleochannels. 2D resistivity tomography along several transects across fan surfaces shows distinct layers with contrasting resistivity values. These geo-electric facies corresponds to presence of channel sandbodies beneath surface signature of paleochannels and finer floodplain deposits useful to demarcate lateral extent of subsurface channel sandbodies. A more detailed subsurface stratigraphy using ∼50m deep sediment cores and their luminescence ages from across fan surface shows presence of multi-storey sandbodies (MSB) separated by floodplain fines. Within the MSB, individual channel deposits are identified by presence of channel scour surfaces located at coarse sand overlying fine sand layer. Depositional ages of MSB's ranges from ∼81 ka (late MIS5) to ∼15 ka (MIS2) with major depositional break during MIS3 in parts of the fans. Sediment aggradation rate varies laterally across fan surface as well as vertically down the depth with an average rate of 0.54 mm/year. Fluvial channel persistence for studied time interval (about last 81 ka BP) shows major depositional breaks (and possible incision) at ∼41 ka (mid MIS3) and ∼31 ka (late MIS3). U-Pb age patterns of detrital zircon grains from cores located at paleochannels on the fan system show prominent age peaks at ∼480 Ma and ∼1800 Ma that respectively corresponds to modern Sutlej and Yamuna rivers. Luminescence ages of these samples suggest that major channel activity of Sutlej river at its fan system ceased around ∼15 ka (post last-glacial maxima) and thereafter it avulsed to its modern course. Our surface study results clearly show that alluvial fan system have well developed longitudinal channel sandbodies that may or may not have surface expression in the form of paleochannel and/or longitudinal ridges. However our geophysical studies show that such channel sandbodies can be delineated in shallow surface on the basis of characteristic resistivity values. The subsurface stratigraphy results show development of MSB possibly due to series of small scale (intravalley) avulsion punctuated by large scale (intervalley) avulsion across the fan surface. Our provenance studies clearly identifies two major large scale channel avulsions of Sutlej and Yamuna rivers. Our study has importance for groundwater management policies in this water–stressed agricultural hotspot of India. Thus, understanding the variability in sand body stratigraphy, channel avulsion history, and aggradation rates is important for understanding aquifer geometry of alluvial fan system.