A Pleistocene coastal alluvial fan complex produced by Middle Pleistocene glacio-fluvial processes

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A coarse-grained alluvial fan sequence at Lipci, Kotor Bay, in western Montenegro, provides a sedimentary record of meltwater streams draining from the Orjen Massif (1,894 m a.s.l.) to the coastal zone. At Lipci sedimentary evidence and U-series ages have been used alongside offshore bathymetric imagery and seismic profiles to establish the size of the fan and constrain the nature and timing of its formation. Establishing the depositional history of such coastal fans is important for our understanding of cold stage sediment flux from glaciated uplands to the offshore zone, and for exploring the impact of sea level change on fan reworking.

There is evidence of at least four phases of Pleistocene glaciation on the Orjen massif, which have been U-series dated and correlated to MIS 12, MIS 6, MIS 5d-2 and the Younger Dryas. A series of meltwater channels delivered large volumes of coarse- and fine-grained limestone sediment from the glaciated uplands into the Bay of Kotor. At the southern margin of the Orjen massif, a series of large (>700 m long) alluvial fans has developed. Some of these extend offshore for up to 600 m. Lipci fan lies downstream of end moraines in the valley immediately above, which were formed by an extensive outlet glacier of the Orjen ice cap during MIS 12. The terrestrial deposits are part of the fan apex (50 m a.s.l.) that lies at the foot of a steep bedrock channel, but the majority of the fan is now more than 25 m below sea level. The terrestrial fan sediments are strongly cemented by multiple generations of calcite precipitates: the oldest U-series ages are infinite indicating that the fan is >350 ka in age. These ages are in agreement with alluvial sedimentary evidence and U-series ages from other fluvial units on Mount Orjen. The terrestrial portion of the Lipci fan surface contains several channels. These are well preserved due to cementation with calcium carbonate. Submarine imagery indicates that the now submerged portion of the fan also contains deeply incised (up to 10 m) channels which are similar in morphology to those exposed onshore. It is likely that strong cementation of the fan sediments, and associated channel forms, has protected them from coastal erosion during several regression-transgression cycles. These records provide important opportunities to correlate the Pleistocene terrestrial glacial and fluvial records with the marine archive.