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From seasons to centuries: activity of sedimentary processes on alpine alluvial fans (Planica Valley, NW Slovenia)

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Alluvial fans are sedimentary environments where sedimentary processes ranging from dilute water flows to dense mass flows occur. These processes are controlled by factors such as bedrock geology, morphometry of alluvial fan and its catchment, hydrology, local and regional climatic conditions, vegetation, and anthropogenic activity. Usually, but not exclusively, they are triggered by intense rainfall events. The study site of the Planica valley (NW Slovenia) is covered by several active Holocene alluvial fans, while the steep slopes are composed predominantly of Upper Triassic carbonates, with some scattered outcrops of claystone, mudstone, and marl layers. A detailed analysis of sedimentary processes documented in outcrops and on the surface of fans was performed. Analysis of sediment structure and texture was used to identify the predominant building process of the fans. Dendrogeomorphological dating of deposits enabled to produce spatio-temporal chronology of events covering the whole 20th century, while a few centuries old deposits were dated using ^{14}C dating of paleosoil. Dendrogeomorphologically dated events were linked to triggering precipitation records from a nearby meteorological station to determine the exact triggering meteorological event. Seasonal depositional activity was monitored using Unmanned Aerial Vehicle (UAV).

Based on sedimentary analysis the deposits were categorised as debris floods, fluvial deposits, sieve-lobe deposits, hyperconcetrated flows and debris flows. Majority of the fans are built by debris floods, fluvial deposits, and sieve-lobe deposits, which are typical for locations where bedrock is composed of carbonates, which do not weather into fine-grained particles (silt and clay). Debris-flood deposits are characterised by crudely stratified closed-framework sandy-gavels containing cobbles and boulders. Fluvial deposits are characterised by up to 20 centimetres thick layers of either imbricated open-framework gravels or closed-framework sandy-gravels, containing less than 1% of mud fraction. Several sieve-lobe deposits are present on the surface of fans. Sporadic and rare debris and hyperconcentrated flows occur where bedrock weathers into fine grains. Debris flows consist of massive matrix- to clast-supported muddy-sandy-gravel packages containing up to 16% of mud fraction. Hyperconcentrated flows consist of a few centimetres thick layers of sandy mud.

The oldest ^{14}C dated debris-flow event occurred in the 17th century AD. A hyperconcentrated event occurred in the 7th century AD. More than 60 debris-flood events spanning from 1897 to 2011 were dendrogeomorphologically dated with an annual precision. Precipitation records enabled to pinpoint the exact date and amount of triggering rainfall. Further on we establish the magnitude of debris flooding by comparing the number of trees affected by sedimentary processes to the return period of individual triggering meteorological events. More than 5 years of UAV monitoring depicted seasonal activity of sedimentary processes on fans which were linked to triggering precipitation events. Monitoring concluded that at least one event with over 1000 m^3 of sediment transport occurs annually, which is triggered by rainfalls exceeding 50 mm of precipitation in 24 hours.

The results of the multimethod research offer a reconstruction of complex alluvial fan sedimentation and erosion activities on different temporal scales, which are strongly related to the bedrock geology and triggering precipitation events.

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