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The accretion of foreland basin sediments during early stages of continental collision: Implications for mountain building in the central European Alps

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During early stages of continental collision, peripheral foreland basins are characterized by the deposition of calcareous and siliciclastic marine sediments. With ongoing plate convergence, the weakly consolidated sediments are incorporated into the orogenic wedge and experience diagenesis and metamorphism. Although it was shown that syntectonic sediment alteration (compaction, dehydration, mineral reactions) is important for the tectonics of accretionary wedges at subduction zones, little attention has been paid to this aspect in the tectonic analysis of collisional orogens. Here we present structural observations from foreland basin sediments that were incorporated into the central European Alps during early stages of continental collision. Our analysis focuses on the prograde evolution of the sediments, ranging from their deposition in the basin to deep burial and low-grade metamorphism at ∼320 ºC. The inferred structural and tectonic evolution is matched against constraints on the diagenetic alteration of the sediments. Thereto, we calculate the temperatures and depths of sediment compaction and the smectite-illite transformation, as well as the associated liberation of fluids. The combined datasets suggest that the mechanical behavior of the sediments varied significantly with their diagenetic state and associated water content, which influenced the tectonic evolution. Earliest deformation occurred during the imbrication and frontal accretion of unconsolidated and fluid-saturated sediments. The sediments deformed by independent particulate flow at low background strain rates, which is recorded by a pervasive deformation e.g. by ductile low-temperature folding. At higher strain rates, deformation was localized, e.g. along the imbricate thrust faults or shear veins. With the progressive consolidation of the sediments, deformation by particulate flow ceased and pressure solution of calcite and quartz became active and was associated with the formation of a penetrative cleavage. Simultaneously, the elastic strength of the rocks increased causing an overall embrittlement. This is recorded by the onset of out-of-sequence thrusting, brittle faulting, and the formation of massive extensional quartz-calcite veins, which took place in the approximate temperature range of the seismogenic zone (∼150–350 ºC). Taken together, the inferred structural and tectonic evolution of the frontal Alpine wedge is comparable to the one of accretionary wedges forming at accretion-dominated subduction zones.