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Deciphering the chronology of internal wedge deformation by means of strontium isotopes of vein carbonates

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The formation and growth of accretionary complexes is accompanied by a suite of deformation processes, ranging from early compaction of unconsolidated sediments near the trench to pervasive visco-plastic deformation of well cemented rocks beyond the down-dip limit of the seismogenic zone. Although the integrated record of previous field studies, seismic surveys and borehole data provided invaluable insights into the architecture of accretionary complexes, the relative timing and precise conditions of different deformation modes have remained largely elusive. Here we present a new approach to decipher the chronology of internal wedge deformation by means of radiogenic strontium isotopes of vein carbonates. Our study area is located within the Paleogene accretionary complex of the central European Alps, comprising a ∼4 km thick sequence of Upper Cretaceous to Eocene shelf sediments and syn-orogenic turbidites. We sampled different types of mineral veins that were formed during sediment compaction, nappe stacking, nappe internal thrusting, folding, layer parallel shear, normal faulting, extensional fracturing and regional out-of-sequence thrusting. We show that the 87Sr/86Sr ratio of these veins record an evolution from initially seawater derived fluids toward diagenetic-metamorphic fluids within the accretionary complex. The combination of structural analysis and Sr isotope geochemistry allows us to resolve the relative timing of different deformation events on a resolution that cannot be assessed by field observations solely. By extending the Sr-record with quartz-calcite oxygen isotope thermometry, we further constrain the temperature range of different deformation processes and demonstrate, how internal wedge deformation differs between the aseimic and seismogenic zone.