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Fault-related progressive unconformities: Growth strata of the transpressive Northern Calcareous Alps (NCA) fold belt (Austria) in field and analogue model

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The thrust sheets of the NCA were stacked during Cretaceous oblique NW-directed convergence, leading to segmentation of the allochthons between km-spaced NW-striking tear faults, which separate anticline segments with different wavelengths and amplitudes and tend to die out toward the thrust. Shortening was accompanied by syn-tectonic, deep marine deposition. The Cretaceous Gosau Group of the western Northern Calcareous Alps at Muttekopf is made up of up to 800m of deep marine sediment gravity flow deposits, preserved in a km-scale syncline.

Growth strata geometry on folds in the blocks between tear faults is characterized by rotational overlap, the rate of deposition being always larger than the rate of vertical growth of the fold. However, the main unconformities in the area show apparent rotational offlap, then onlap and finally overlap. In map view, these unconformities are only found above tear faults and connect to tear faults in the pre-tectonic deposits.

Bedding orientations in the vicinity of the main unconformities show rather changes in strike instead of changes in dip as observed in the classic examples. An outcrop at the southern margin of the syncline within a tear fault zone where offset is large and brings syn-tectonic sediments in contact to pre-tectonic sediments shows subvertical fault scarps and drag of syn-tectonic sediments toward the faults, both onlapped by younger sediments. All fault branches systematically downthrow the eastern block. The observation shows that syntectonic sediments drape a topography created by tear faulting.

Analogue modeling was used to investigate the 3D-geometry of faults and bedding in the vicinity of tear faults. Two stiff blocks with a curved, upward ramping surface were thrust under a plastic foil at different velocities, thereby producing relative lateral and vertical offset. Syn-tectonic sediments were simulated by dry quartz sand deposited in regular intervals on the plastic foil. The tilting of the plastic foil as it moves up the upward steepening ramps simulates progressive tilting during syn-tectonic sedimentation as in the forelimb of a progressively growing detachment or trishear fold.

Marker layers show that the tear fault is propagating in thrust direction and that offset accumulates in its rear part. The fault tip is buried by new sediment before it propagates upward and forward through the sediment and fault drag occurs. This causes bedding to curve around the fault tip. In field examples, changes of strike will we observed near the fault tip. At the end of deformation the model has been cut perpendicular to tear fault orientation and shows that the faults within syn-tectonic sediments always curve toward the slower side of the model before getting buried, independent of growth geometry within the folded blocks.

Angular unconformities resembling progressive unconformities, caused by changes of strike instead of changes of dip and connecting to tear faults are diagnostic for growth strata in transpressive fold belts. We term such unconformities fault-related progressive unconformities.