Minibasins upside down – Salt tectonics in the Karwendel mountains, Northern Calcareous Alps of western Austria

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The western Northern Calcareous Alps (NCA) are outside of the classical salt occurrences of the Eastern Alps. However, the salt mine of Hall in Tirol and numerous exposures of Haselgebirge, the solution residue of originally salt-bearing shales, give evidence of the presence of salt. This part of the NCA has a sedimentary succession starting with Permian (Haselgebirge) to Lower Triassic evaporites, overlain by carbonate platforms reaching a total thickness of more than 2 km. Two structural domains can be distinguished. A southern domain is characterized by a fold train of symmetric, WSW-trending folds with a wavelength of 6–8 km. In a northern domain, a km-scale recumbent fold is observed. The inverted limb has a length of at least 7 km. Within this inverted limb we observe minibasins that have their base in the summit region of the mountains. Due to high topography (up to 2 km), the entire minibasin fill is exposed in mountain walls. The basins are filled by lagoonal platform carbonates, sunken into Permo-Triassic evaporites. In the southern domain, the abovementioned fold train is characterized by parallel bedding (except forereef clinoforms). New field work in the area revealed major normal faults within the platform, with up to 1 km offset displaying Triassic growth strata in their hanging wall. The abundance of recumbent slump folds, locally sheath folds, and seismites (clastic dykes and sills, ball-and-pillow structures and breccia layers) in the platform carbonates is conspicuous. The thickness of the Ladinian to Carnian part of the platform (Wetterstein limestone) varies between 1.5 and almost 4 km. All this may relate to the presence of salt and salt-bearing shales at the base of the sedimentary succession, causing tilting of blocks and associated seismic activity. Thrust geometries in the northern domain only make sense when more than a km of salt is imagined that disappeared subsequently. Currently, the thrusts are bent around minibasins, however, during activity these must have been straight. Nappe transport and emplacement onto Lower Cretaceous deposits was probably only possible after salt evacuation and weld formation. During inversion of the passive margin in the Cretaceous, the NCA rocks were detached along the evaporite decollement and stacked onto Cretaceous synorogenic sediments. Initial lower Cretaceous transport of the thrust sheets did not create folds. Erosion during late Cretaceous shortening created the evaporite-cored detachment folds of the fold train and the recumbent fold.