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KINEMATIC LINKAGE BETWEEN INTERNAL ZONE EXTENSION AND THRUSTING IN EXTERNAL PARTS – A WORKING HYPOTHESIS FOR THE EVOLUTION OF THE CENTRAL EASTERN ALPS

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In the eastern central parts of the Eastern Alps three major deformation events can be distinguished within the Koralm Complex and the adjacent units (Plankogel Complex, Gleinalm Complex, Seckau Crystalline Complex, Paleozoic of Graz). A first deformation event D_1 is characterised by the formation of a penetrative foliation and a stretching lineation oriented in an E-W- direction. Remnants of deformational microstructures indicate a top-to-the W sense of shear during this deformation event. Most of the D_1- related fabrics were overprinted by subsequent metamorphism. This metamorphic event did affect the assumptive tectonic boundary between the Koralm Complex and the Gleinalm Complex below. Particularly, D_2 is related to the Plattengneis shear zone, which formed in the uppermost structural sections of the Koralm Complex, characterised by a N-S oriented stretching lineation. The eclogites in the foot-wall have been affected by this deformation event, too. This deformation event is associated with pure shear in the central parts of the Koralm Complex, probably with top-to-the S displacement in the southern parts, and top-to-the N displacement in the northern parts. Deformation within the Plattengneis and the eclogites below occurred along the decompressional path, indicated by decreasing minimum pressures within the eclogites, and by northward and southward decreasing pressures and temperatures. The Plattengneis shear zone continuously passes over into a low-angle normal fault in the northeastern part of the Koralm, forming the contact between the Koralm Complex and the Paleozoic of Graz. Thus, the Plattengneis shear zone primarily formed as an extensional structure and triggered the exhumation of the eclogites. D_3- related structures are restricted to distinct low-angle normal shear zones along the northern and southern margins of the Koralm Complex, with top-to-the N/NE and top-to-S/SE dispacement, respectively. These are related to the juxtaposition of exhumed high-pressure rocks of the Koralm Complex, and medium- to low- grade metamorphic units above.

According to this evolution, the Cretaceous collisional process (Eo-Alpine cycle), which formed the present Austroalpine Nappe Complex, may be subdivided into two distinct phases:
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the (ES)E- ward subduction and closure of the Hallstatt-Meliata basin resulted in the assembly of the Upper Austroalpine Nappe Complex, including the Juvavic, Tirolic and Bajuvaric Nappes of the Northern Calcareous Alps, and parts of their Paleozoic basement. After closing of the Hallstatt-Meliata oceanic basin during the Late Jurassic, the Cretaceous orogeny in the Eastern Alps encompasses the collision between (south)easternmost parts of the Austroalpine continental crust (including the Koralm Complex) and a continental fragment to the (south-)east. The Paleozoic of Graz, and probably the Gurktal Nappe, may represent the remnants of this fragment in the Eastern Alps.
Southward underplating of the southern Apulian continental margin resulted in the imbrication of the Middle Austroalpine basement complexes and Lower Austroalpine basement-cover nappes. These units were additionally affected by pronounced metamorphim, increasing from greenschist facies conditions in the northern parts to amphibolite and eclogite

facies conditions in the southernmost parts. The related high-pressure rocks are exposed along the Southern limit of Alpine Metamorphism, juxtaposing Austroalpine units with a strong metamorphic imprint to the north against very-low grade Austroalpine units in the south. Therefore, the SAM is assumed to represent an intracontinental suture. In the eastern part of the Eastern Alps, this jump of Alpine metamorphic imprint is marked by the base of the Gurktal Nappe and the Paleozoic of Graz. Both units are therefore supposed to represent the upper plate during this phase of Alpine collision. Continuous underplating during the Late Cretaceous was accompanied by extension in the internal parts of the orogen, resulting in the formation of an extensional detachment in the lower crust (Plattengneis shear zone), the exhumation of high-pressure metamorphic rocks below, and the extrusion of the units above. Extension in the upper plate resulted in the formation of the Gosau sedimentary basins. Towards north, the Plattengneis shear zone continuously climbed towards shallower crustal levels and passed into a foreland-directed thrust. This thrust is supposed to have affected the Upper Austroalpine Nappe Complex as well by the formation of distinct out-of-sequence thrusts. Along these out-of-sequence thrust, parts of the Tirolic unit were emplaced onto the Juvavic unit. In the actual Alpine nomenclature, these dismembered parts of the Tirolic unit represent the Upper Juvavic Nappe.

The present structure of the Koralm-Saualm and adjacent areas is the result of Late cretaceous extension tectonics. In particular the Plattengneis shear zone, previously interpreted as a major thrust, is now re-interpreted as a major extensional shear zone that developed subsequent to nappe stacking.

The effect of Late Cretaceous to Early Paleogene tectonics on Alpine orogeny and metamorphism is still under debate. Recognition of this structural and metamorphic event is hampered by the fact that the spatial distribution of Cretaceous / Paleogene structural elements coincide frequently with later, Miocene extrusion-related structures. However, from geochronological and tectono-metamorphic arguments there is strong evidence that extrusion tectonics played a major role in Alpine architecture during the latest Cretaceous and Paleogene. In particular, (1) major tectonic lines, interpreted as Early Creataceous thrusts are overprinted and sealed by upper greenschist- to amphibolite-facies metamorphism and tectonics, e.g., the contact between the Gleinalm and Koralm Complexes. (2) Large rock volumes within eastern sectors of the Eastern Alps cooled down below 300°C already in Cretaceous times. (3) A large number of age data previously interpreted to date Early Alpine nappe stacking cluster around 80 Ma and may easily be re-interpreted in terms of strike-slip and/or extension tectonics. In particular, sets of highly ductile strike slip and normal faults are traced along the southern margin of Austroalpine units, although frequently obliterated by younger tectonic events in the vicinity of the Periadriatic Fault. The juxtaposition of the Plankogel Complex against the Koralm Complex is explained by Late Cretaceous normal faulting. Thus, palinspastic reconstructions of the Eastern Alps have to include Late Cretaceous to Paleogene dispersal of Austroalpine units, which had been largely exhumed during Paleogene times.

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