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Structural asymmetry and distributed strain of low-T shear planes inducing evidence for orogen-scale kinematic partitioning during denudation of high-P rocks (Pelagonian Zone, Greece)

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Numerous strain assessments put forward to the role of structural asymmetry where non-coaxial strain is applied, contributing to the exhumation and denudation of mid-crustal rocks during and after continental collision. This work summarizes strain data in Western Macedonia and in Western Attica of Greece in order to document the structural asymmetry and distributed strain of low-T ($<250\ ^0$C) shear planes in the Upper plate of two metamorphic core-complexes. Little attention has been paid, in Internal Hellenides, to the mechanical response and brittle decomposition of the Upper plate's configuration during denudation of high-P rocks. A qualitative study of the finite and instantaneous strain fields and of the produced fault-rocks is reported. Both examples occur in Pelagonian Zone of Internal Hellenides, where Oligocene-Miocene asymmetric stretching exhumed proportions of Cenozoic ductile crust (Jolivet et al. 2003). In Western Macedonia, an Oligo-Miocene core complex includes: (I) a Lower plate consisting of Olympos Unit with Triassic-Eocene carbonates and flysch, (II) an Intermediate zone of Eocene high-P tectonites, (III) an Upper plate composed by Mesozoic ductile crust with of pre-Alpine age, Almopia Unit with Permo-Triassic volcano-sedimentary serie-Triassic-Jurassic marbles-Late Jurassic meta-sediments, Ultramafic-Mafic Unit of Mesozoic age and Cretaceous Unit with limestones-flysch. In Attica, a Miocene Cordillera-type core complex was arranged, including two structural plates separated by a long-lived km-scale detachment fault. Upper Plate contains non-metamorphic rocks of Pelagonian Zone and Lower Plate

composes a-type domes in eastern Attica as part of the high-P Cycladic belt. Eocene high-P and Oligo-Miocene greenschist metamorphic parageneses together with syntectonic granodioritic intrusions during Miocene compose the Lower plate (Altherr and Seidel 2002). In Western Attica, three tectonic units are distinguished in the Upper plate: (I) Sub-Pelagonian unit with Permo-Triassic volcano-sedimentary series and Triassic-Jurassic carbonates, (II) Ultramafic-Mafic Unit of Mesozoic age, (III) Cretaceous Unit with platform limestones and flysch. Qualitative strain evaluation in the Upper Plate of both core-complexes shows that multiple shear planes of intense cataclastic flow occur (Diamantopoulos 2005, Diamantopoulos 2006), interpreted as brittle detachment faults. Such shear planes separate: A) distinct pre-Alpine lithologies from each other, B) Alpine from pre-Alpine rocks, C) Permo-Triassic series from Triassic-Jurassic carbonates, D) Triassic-Jurassic rocks from Ultramafic-Mafic rocks, E) Cretaceous rocks from Permo-Early Mesozoic rocks and F) distinct Cretaceous lithologies from each other. Discrete and distributed strain identified in both examples explains the inferred external and internal asymmetry of the lithological successions, inducing km-scale horizontal stretching and vertical thinning. Geometrical analysis of strain history indicators found in damage zones, fault cores and along footwalls was used for the determination of the asymmetry. Strain evaluation of more than 350 kinematic indicators concluded that progressive non-coaxial strain is localized in the broad space of the shear planes and prevails within footwall-rocks, with SSW-ward asymmetry for Western Macedonia and NNW-ward asymmetry for Western Attica. Extensional and shortening structures are typical products of the nappe-emplacements, imparting mechanical heterogeneity. Slip systems, asymmetric folds and inequant clasts of variable shape appear agreeable structural asymmetry. The total of the S-, Z- and M-asymmetries of the folds within footwalls reveal a prominent structural transport, concordant with the asymmetry of the shear planes. Qualitative strain assessment of the footwalls showed that two distinctive domains I and II are formed, according to the frequency of the slip systems, of the recorders of incremental strain and of the asymmetric folds. This strain subdivision appears a variable geometry in space, where the mode of deformation probably controls its two-dimensional development. The finite strain of both Pelagonian examples may be associated with gravitational instabilities during Oligo-Miocene, coeval with the SW-ward migration of the entire orogenic front of the Hellenides (Burchfiel 1980). The relation of the gravity potential with the spatial potential along the Pelagonian orogen as well as the rate of the plate convergence and of energy dissipation during Late Cenozoic possibly control the produced kinematic partitioning, compensating the brittle perturbations of the upper crust. In both examples the structural perturbation of the rigid upper crust ultimately intimates the denudation of high-P rocks, corroborating the mechanical coupling among exhumed ductile tectonites and brittely decomposed crust.

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