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Geologic and seismic deformation during unroofing of the Dora Maira Massif; Western Alps, Italy: tectonic versus climatic control

M.S. Zechmeister (1), **E.C. Ferré** (2), B. Carrapa, (3), R. Caby (4), M.A. Cosca (5) and J.W. Geissman (6)

(1) The University of Oklahoma, School of Geology & Geophysics, Norman, OK 73019, USA, (2) Department of Geology, Southern Illinois University, Carbondale, IL 62901, USA, (3) Institut für Geowissenschaften, Karl-Liebknecht-Strasse 24, Haus 27, D-14476 Golm, Germany, (4) Laboratoire de Tectonophysique, Place E. Bataillon, Université de Montpellier 2, 34095 Montpellier 2 Cedex 05, France, (5) Institut de Minéraologie et Géochimie, Université de Lausanne, Bâtiment Humense, CH-1015 Lausanne, Switzerland, (6) Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, USA (eferre@geo.siu.edu / Fax: +1 (618) 453 7393 / Phone: +1 (618) 453 7368)

Orogenic deformation occurs both at geologic strain rates (ca 10^{-14} to 10^{-15}/s) and at seismic strain rates (ca 10^{0} to 10^{-2}/s). Yet the interplay between these two vastly different rates of deformation is poorly understood. In convergent orogens, most seismic activity is recorded in the upper crust, although deep earthquakes also take place. Fault-related pseudotachylytes are typically found in orogenic belts and require seismic deformation rates to form by frictional melting. These "*fossils*" of ancient earthquakes might provide valuable insights into seismic deformation processes.

The Western Alps are a young and still active orogenic belt and expose several pseudotachylyte occurrences in many rock types. One of these localities, the Dora Maira massif (DM), is a type example of an ultra-high pressure (UHP) metamorphic province where *non –impact related* coesite was first described. The tectonic exhumation of this massif took place extremely rapidly (tens of mm/yr) between 38 and 30 Ma, after the peak of metamorphism (up to 4.2 GPa), like in most UHP massifs, and is characterized by a pervasive mylonitic fabric.

New field, microstructural and geochemical data on the pseudotachylyte veins and

their mylonitic gneiss host are presented. Pseudotachylyte veins formed at about 20.1 $\pm$ 0.5 Ma (Cosca et al., 2005) and at shallow depths ($<$ 3 km), after the early stages of unroofing and rapid cooling. The pseudotachylyte generation veins are remarkably planar and conformable with a low-angle mylonitic foliation that developed during exhumation under greenschist facies conditions. This control on the vein geometry exerted by the host rock preseismic fabric is also observed in other localities and provides opportunities to assess the interplay between geologic and seismic deformation. Pseudotachylyte injection veins and networks are less common than generation veins.

The presence of seismic deformation features during an otherwise fast but yet ductile exhumation needs to be explained. Preseismic, coseismic and postseismic deformation microstructures suggest that seismic slip happened when the geologic strain rate was particularly low (surprisingly). A stick-slip model along the mylonitic foliation plane in which slip was preferentially along phengite-chlorite rich layers could explain this. Frictional sliding instability is promoted by a slow slip rate (*"shuttering brake"* model). However this model requires an external perturbation to the system. An external cause that might account for abrupt changes in deformation rate could be a rapid increase in erosion. Unique 20 Ma-old phengites in 20 Ma sediments (i.e. essentially zero lag time) are found in the sedimentary record of the adjacent Alpine foreland basin (Tertiary Piedmont Basin) sourced from the Western Alps. Such short lag time implies extremely high cooling and exhumation/erosion rates. Such rates are not compatible with a tectonic scenario given that the main tectonic exhumation phase of the massif occurred in the late Eocene-Oligocene. We propose that a rapid climate change around 20 Ma may have triggered fast erosion of the Dora Maira UHP rocks, as also supported by an increase of the sediment flux to the foreland.