Deep volatiles cycle during subduction of the continental crust and crust-mantle interaction

Volatiles (e.g., H_2O, CO_2, Cl, F, Br, I) are known to move between the Earth biosphere and the atmosphere making a cycle. This cycle has also a deep component that is instead controlled by plate tectonics. The deep cycle starts with the segregation of volatiles in oceanic and continental crust rocks within minerals, in pores between the grains and in microfossils and organic matter especially on the seafloor. In convergent margins, when two plates move towards each other, the denser plate continues to move under the lighter and towards the mantle in a processes called subduction. During subduction the crust transports the volatiles from the surface to mantle. The crust on its journey is a subject to processes such as dehydration and partial melting that release the volatiles and other incompatible elements (i.e., elements that are preferentially concentrated in a liquid phase rather than a solid) in fluids and melts. These fluids and melts can interact with the overlying mantle enriching it in the volatiles with a process called metasomatism. In the case of the subduction of the oceanic crust this processes can trigger the partial melting of the mantle and thus the partial re-emission of volatiles to the atmosphere via volcanic eruptions above the mantle; hence with the closure of the deep cycle. A good understanding of the deep volatile cycles is fundamental because they have important influence on several global scale processes such as Earth evolution and chemical differentiation, plate tectonics and most importantly the formation of ocean and atmosphere, climate changes and presence of life on Earth. The volatiles mobilization during subduction is a process extensively studied for the oceanic lithosphere (oceanic crust + uppermost part of the mantle underneath the crust) especially for carbon. Scientists have in fact estimated how much carbon is subducted and how much is re-mitted into the atmosphere and they have a good idea of the fluxes of other volatiles as well. However, the subduction of the continental crust has often been neglected for those type of estimates. Several studies over the last decade demonstrated that also this crust can actually mobilize significant amount of volatiles and other incompatible elements in melts and fluids but the quantification of the volatiles mobilized and the estimates of volatiles fluxes is still missing. In collisional settings, where after subduction of the continental crust the two continents converging collide, when the continental crust is subducted and the fluid and melts interact with the mantle there is no volcanic activity and thus the closure of the cycle in this case is prevented. Hence volatiles in fluids and melts are then ultimately stored in the mantle overlaying the subducted continental crust. The proposed project aims to better understand the contribution of the continental crust for the mobilization and storage of volatiles, carbon and halogens (Cl, F, Br and I) in particular. The objective is to understand the volatiles behavior in collisional setting during the subduction of the continental crust, quantify the amounts that are released in fluids and melts, determine their fluxes and track them through a stage of the Erath evolution between 420 Ma and 90 Ma (Phanerozoic). The volatiles are elements that generally are found preferentially into fluids/melts with respect to solid thus the target of the project will be primary melt and fluid inclusions trapped in minerals in rocks part of these geological settings. Primary melt/fluid inclusions are inclusions trapped in a mineral (host) while it was growing in the presence of a melt/fluid phase and give information about the nature of the melt-fluid present at the time of entrapment. The investigation will focus on rocks belonging to the overlying mantle that have recorded the interaction with the continental crust through the entrapment of the melt inclusions and now included in the continental crust and rocks from the continental crust itself. The samples selected were deeply subducted at ~ 100-120 km, high pressure, and formed at different times in the three major European mountain belts (i.e., orogens). The target of high pressure rocks is especially important for carbon because it is more soluble in fluids and melts at higher pressure. Geological filed work will be conducted in selected localities in the Western Gneiss Region (Scandinavian Caledonides, Norway), Bohemian Massif (Variscan orogeny, central Europe) and the Alpine orogeny (Eastern Alps) in order to collect suitable samples. Detailed observation with the optical microscope and geochemical analyses on minerals and inclusions will be performed to determine the volatiles distribution and concentration. Thermodynamic modelling and mass balance calculations will be carried out to determine the flux of elements in the different orogens and quantify the storage of volatiles within the single orogenic event and throughout most of the Phanerozoic. The results of this project will contribute to the global understanding of carbon and halogens behavior, their mobilization, their deep cycle and their storage in the mantle.