Preliminary results from FT dating of the Adula nappe: late tilting or not?

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The Alpine evolution of the Adula nappe proposes at least three regional phases leading to multiple metamorphic overprints: A series of eclogitic rocks found at the E side of the crystalline nappe body (HEINRICH 1986) reveals a strong P-T gradient (MEYRE et al. 1998) during the time of Eocene HP metamorphism (BECKER 1993). This gradient reveals that during subduction the nappe must have been in a strongly inclined position. The Oligocene intrusion of the Bergell granodiorite causes contact metamorphism at the SE end of the nappe, leading locally to the formation of granulite facies rocks. Finally, the middle Tertiary Lepontine metamorphism causes regional greenschist to amphibolite facies metamorphism (ENGI et al. 1996), showing a trend of increasing temperatures along the N-S extension of the nappe.

Exhumation of the nappe is primary the result of obduction after HP metamorphism, isostatic rebound around the Bergell intrusion body, vertical displacement along the Insubric line S of the Adula nappe (HURFORD 1986), and finally the doming and denudation of the Lepontine area. So far, the temporal frame of exhumation is only vaguely determined, in particular because of an ongoing debate about the age of early Alpine HP metamorphism and the age of the Lepontine overprint.

The here presented study aims to reveal the amount and precise timing of late tilting or thermal relaxation of the Adula nappe by fission track (FT) dating. For this purpose, the crystalline body was sampled along its maximum N-S and E-W extension. At present, only apatite data are available and are discussed in the light of the addressed tilting and cooling processes. Apatite FT data (ages and track length distributions) do not show any significant patterns of late tilting after cooling below a temperature of 120 °C. A further step into the past will be given by zircon FT data, and eventually white mica Ar/Ar data.

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The Deuterium Anomaly in Stratospheric Molecular Hydrogen

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Molecular hydrogen (H_2) is the second most abundant reduced gas in the atmosphere (after methane) and has a globally averaged mixing ratio of ~ 530 ppbv. Its recognized sources include: photochemical oxidation of CH_4 and non-methane hydrocarbons (NMHC); biomass burning, fossil fuel burning, nitrogen fixation, and ocean degassing. The stable isotopic composition of H_2 can help quantify the relative importance of these various sources and balancing sinks. The average δD_{SMOW} of H_2 in the surface atmosphere is ca. +100 ‰ — strongly D enriched compared to that measured for atmospheric CH_4 (δD_{SMOW} ~ -90 ‰), expected for NMHC's, and known for combustion sources of H_2 (δD_{SMOW} of ca. -200 to -300 ‰) [*Gerst and Quay*, 2001; *Rahn et al.*, 2002]. The D/H ratios of H_2 from ocean degassing and nitrogen fixation are poorly known but are likely to have δD_{SMOW} values of ca. -700 ‰, in near thermodynamic equilibrium with local H_2O. Thus, all major sources of atmospheric H_2 are hundreds of permil poorer in D than H_2 itself. Either the loss processes (photo-oxidation and/or soil uptake) must discriminate against reaction with HD and/or isotopic fractionation associated with photo-oxidation of CH_4 must favor production of HD over HH. Our current understanding of the global H_2 budget depends strongly on the exact contribution of each of these effects to observed D enrichment.

We analyzed concentration and D/H of H_2 in a suite of stratospheric air samples in order to investigate the photochemical processes influencing the deuterium content of H_2. We find that although the concentration of H_2 is nearly constant in the lower stratosphere, its δD_{SMOW} varies up to +440 ‰ after ~6 years of stratospheric residence time. To our knowledge, H_2 in the lower stratosphere is the most D-rich, natural material on earth. In order to account for this extreme D enrichment of H_2, we have determined that the reaction chain from CH_4 to H_2 involves an isotopic fractionation of $\alpha_T = k_{CH3D \rightarrow HD}/k_{CH4 \rightarrow H2} = 1.31$; this is in addition to the enrichment due to the known slower oxidation of HD [*Ehhalt et al.*, 1989]. Return flux of this exceptionally D-enriched H_2 from the stratosphere must be accounted for to correctly balance the isotopic budget of tropospheric H_2. The process we document also influences the overall distribution of deuterium in the upper atmosphere.

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