The Mont Collon mafic complex (Austroalpine Dent Blanche nappe), Permian evolution of the Western European mantle

MONJOIE Philippe; June 28, 2004

Supervisor: Dr. François Bussy et Prof. Hans-Ruedi Pfeifer, Institut de Minéralogie et Géochimie; Prof. Henriette Lapierre, Université de Grenoble

The early Permian Mont Collon mafic complex (Dent Blanche nappe, Austroalpine nappe system) is one of the best preserved examples of the Permian mafic magmatism in the Western Alps. It is composed of discontinuous exposures and a well-preserved magmatic layering (the Dents de Bertol cliff) crops out in the center part of the complex. It mainly consists of cumulative mafic rocks, which represent 95 vol-% of the mafic complex (ol- and cpx-bearing gabbros and rare anorthositic layers, troctolites, wehrlites and plagioclase-wehrlites) and locally pegmatitic gabbros. All these facies are crosscut by widespread acidic (aplites, quartz-rich pegmatites, microgranodiorites) and late mafic Fe-Ti melanocratic dikes.
Olivine-augite thermometric calculations yield a range of 1070-1120 ± 6°C, while amphibole-plagioclase thermometer yields a temperature of 740 ± 40°C at 0.5 GPa. Pyroxene geobarometry points to a pressure of 0.3-0.6 GPa, indicating a middle crustal level of emplacement. Moreover, temperature calculations on the Mont Collon coronitic amphiboles indicate temperatures of 700 ± 40°C, close to those calculated for magmatic amphiboles. These temperatures confirm that coronitic reactions occurred at subsolidus conditions.
ID-TIMS U/Pb zircon ages of 284.2 ± 0.6 and 282.9 ± 0.6 Ma obtained on a pegmatitic gabbro and a quartz-pegmatitic dike, respectively, were interpreted as the crystallization ages of these rocks. 40Ar/39Ar dating on amphiboles from Fe-Ti melanocratic dikes yields a plateau age of 260.2 ± 0.7 Ma, which is probably very close to the crystallization age. Consequently, this 40Ar/39Ar age indicates a second magmatic event.
Whole-rock major- and trace-element compositions show little variation across the whole intrusion and Mg-number stays within a narrow range (75-80). Trace-element concentrations record the cumulative nature of the rocks (e.g. positive Eu anomaly) and reveal systematic Nb, Ta, Zr, Hf and Ti negative anomalies for all basic facies. The lack of correlation between major and trace elements is characteristic of an in situ crystallization process involving variable amounts of interstitial liquid (L) trapped between the cumulus mineral phases. LA-ICPMS measurements show that trace-element distributions in minerals are homogeneous, pointing to subsolidus re-equilibration between crystals and interstitial melts. A quantitative modeling based on Langmuir's in situ crystallization equation successfully reproduced the Rare Earth Element (REE) concentrations in cumulitic minerals. The calculated amounts of interstitial liquid L vary between 0 and 35% for degrees of differentiation F of 0 to 45%, relative to the least evolved facies of the intrusion. Furthermore, L values are well correlated with the modal proportions of interstitial amphibole and whole-rock incompatible trace-element concentrations (e.g. Zr, Nb) of the tested samples. The calculated parental melt of the Mont Collon cumulates is characterized by a relative enrichment in Light REE and Th, a depletion in Heavy REE, typical of a transitional affinity (T-MORB), and strong negative Nb-Ta anomaly.
Cumulative rocks display Nd-Sr isotopic compositions close to the BSE (-0.6 < Ndi < +3.2, 0.7045 < 87Sr/86Sri < 0.7056). Initial Pb ratios point to an origin from the

melting of an enriched subcontinental lithospheric mantle source, previously contaminated at the source by oceanic sediments. The contrasted alkaline Fe-Ti melanocratic dikes are representative of liquids. They display enriched fractionated REE patterns, a positive Nb-Ta anomaly and Ndi of +7, 87Sr/86Sri of 0.703 and initial Pb ratios, all reminiscent of Ocean Island Basalt-type rocks, pointing to a moderately depleted asthenospheric source. Thus, partial melting of an enriched lithospheric mantle is triggered by post-orogenic thinning and up-welling of hot asthenospheric mantle. The Fe-Ti melanocratic dikes originated, after the complete delamination of the lithospheric mantle, from the melting of the asthenospheric mantle.