The lower Permian Alpigia magmatic complex and its country rocks (Upper Maggia Valley, Central Alps): petrology, geochemistry and structural position

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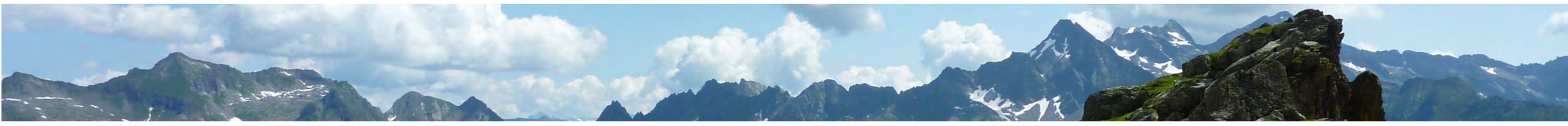

1. The Alpe d'Alpigia is located in the Upper Maggia valley (Ticino) west of the village of Fusio in the Lepontine dome of the Central Alps. It consists of a metamorphosed mafic to intermediate magmatic complex subdivided into a meso- to leucocratic "Alpigia Gneis" and a darker gabbroic facies on the 1:25'000 geological map of Keller et al. (1980) (Fig. 2). This complex is intruding a series of banded amphibolites, as well as ortho- and paragneisses. The structural position of the Alpe d'Alpigia (Fig. 1) is disputed for many years (review in Steck et al. 2013), as it is located at the convergence point of four structural units (Fig. 3): the Maggia, Sambuco, Simano and Antigorio nappes. No decisive field observation has been put forward so far to solve this dilemma.

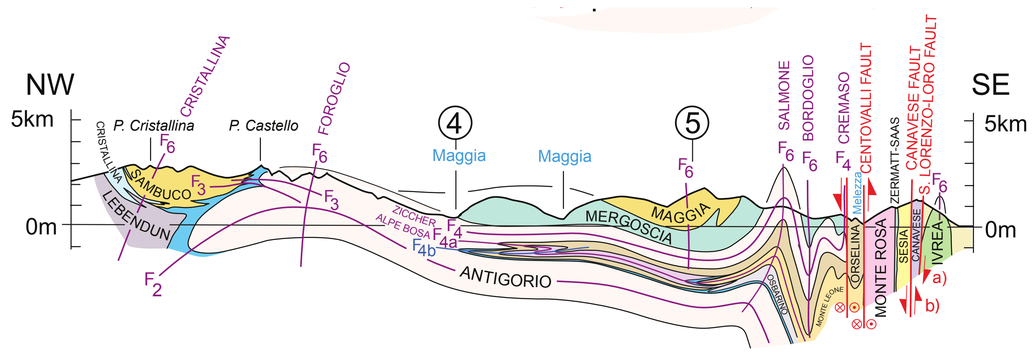

Figure 1: Structural cross-section of the Lepontine Dome (Steck et al. 2013)

2. The Alpigia complex is a calc-alkaline magmatic series displaying a differentiation trend from cumulitic hornblendites to gabbros, gabbro-diorites, quartz-diorites, tonalites and leucogranites (Fig. 6). Despite a relatively strong deformation, mingling features between mafic and intermediate to felsic facies are still visible, pointing to their (sub)contemporaneous emplacement (Fig. 4a-b).

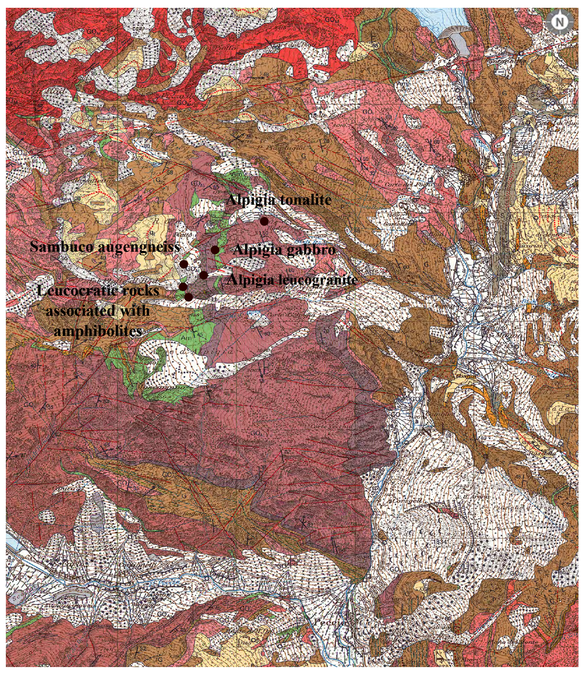

Figure 2: Geological map of the area and the dated samples locations, modified from Keller et al. 1980

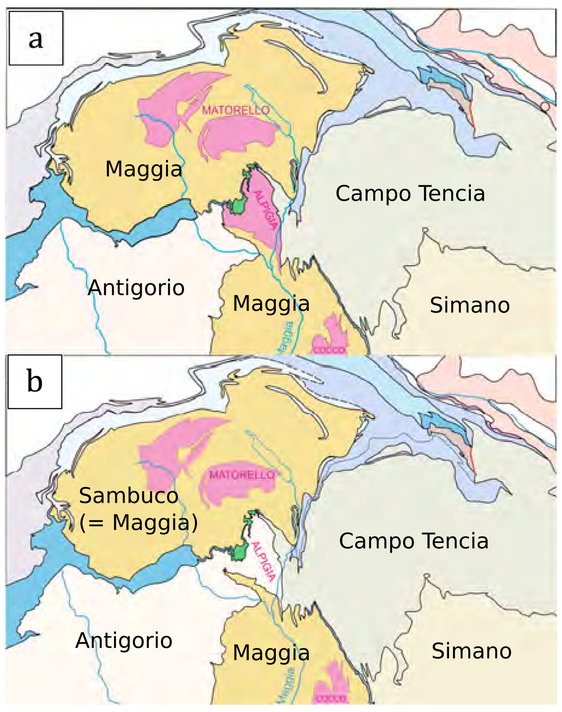

Figure 3: Models for the structural relations between the Sambuco, Maggia, Antigorio and Simano units a) Alpigia forms an integral part of the Maggia nappe b) the Maggia and Sambuco units represent two klippes of a single Maggia nappe and Alpigia is part of Antigorio (Steck et al. 2013)

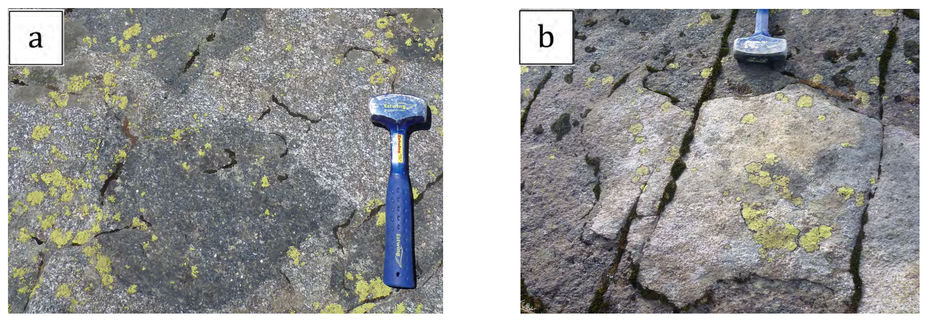

Figure 4: a) Mingling of the Alpigia gabbro and hornblendite b) Mingling of the Alpigia leucogranite and gabbro

3. Zircons have been extracted and dated in situ with the U-Pb LA-ICPMS technique on the basis of cathodoluminescence imaging.

A gabbro sample yielded a mean 206Pb/238U age of 292.8 ± 2.0 Ma (96.5% confidence level, based on 23 measurements) (Fig. 5b), whereas a tonalite yielded an age of 293.9 ± 1.2 Ma (35 measurements) (Fig. 5a) and a leucogranite an age of 288.7 ± 3.4 Ma (15 measurements) (Fig. 5c).

These three dates are almost overlapping within uncertainties and point to a magmatic event at ca. 292 Ma.

An augengneiss from the host rock of the Alpigia magmatic complex has also been dated. Gem-quality zircons yielded a mean 206Pb/238U age of 451.8 ± 2.8 Ma based on a coherent set of 19 measurements (Fig. 5d).

This ca. 450 Ma magmatic age is typical of the so-called "older orthogneisses" found in most Alpine basement units.

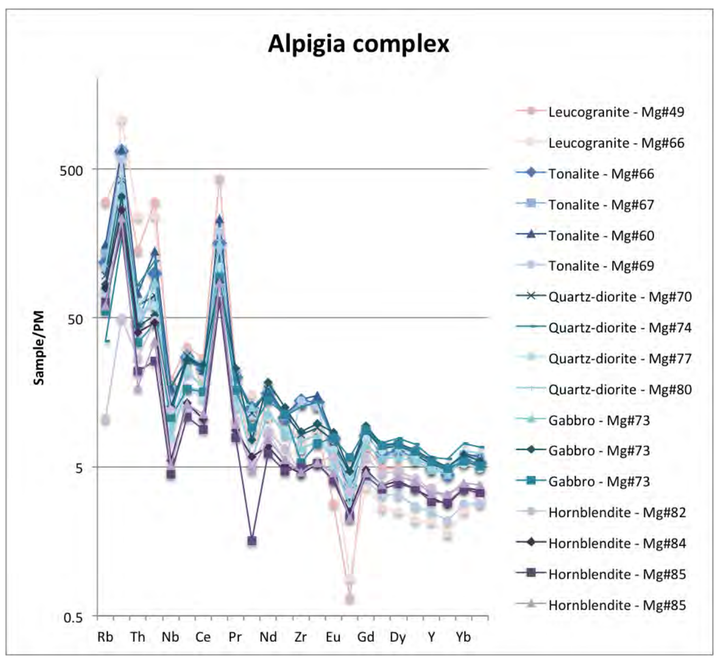

Figure 6: Trace elements primitive mantle normalized diagram for the different facies of the Alpigia intrusion(primitive mantle values of McDonough and Sun (1995)

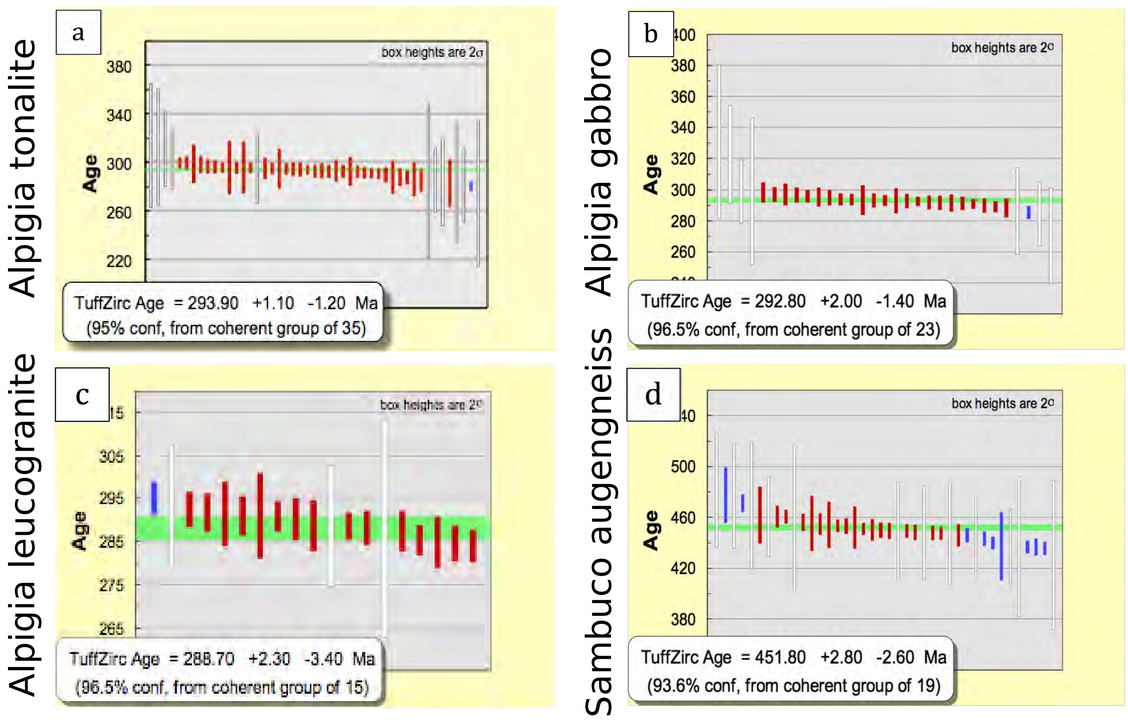

Figure 5: TuffZirc diagrams with all the measurements of a) the Alpigia tonalite, b) the Alpigia gabbro, c) the Alpigia leucogranite and d) the Sambuco augengneiss with their analytical uncertainties. The mean age is calculated from the red measurements

4. The mafic layers of the banded amphibolites intruded by the Alpigia magmatic complex display basaltic compositions with tholeiitic geochemical characteristics (Fig. 7a). The associated felsic layers consist of a quartz + plagioclase ± amphibole ± carbonates mineral assemblage. They are chemically very heterogeneous, ranging from 50 to 76 wt-% SiO2, and display unusual concave-shaped REE chondrite-normalized patterns (Fig. 7b) .

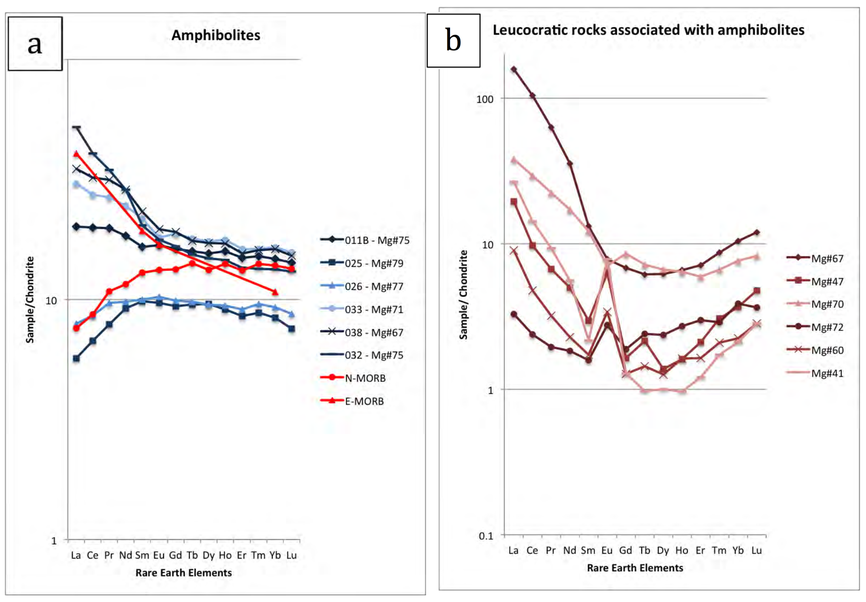

Figure 7: Chondrite-normalized REE diagrams (chondrite values of Nakamura (1974) and Boynton (1984)) a) amphibolites with N-MORB and E-MORB b) associated leucocratic rocks

5. Cathodoluminescence imaging revealed complex internal structures (Fig. 8a-b).

As a matter of fact, measured dates spread over a large range from ca. 480 down to 160 Ma. Both samples yielded a consistent subset of data allowing calculation of mean 206Pb/238U ages. The first sample yielded an age of 476.3 ± 5.2 Ma (Fig. 9a) and the second sample an age of 464.5 ± 4.1 Ma (Fig. 9b). Although no field evidence has been found to establish the contemporaneity of the felsic and tholeiitic mafic layers (Fig. 8c), the latter are most probably no younger than Ordovician

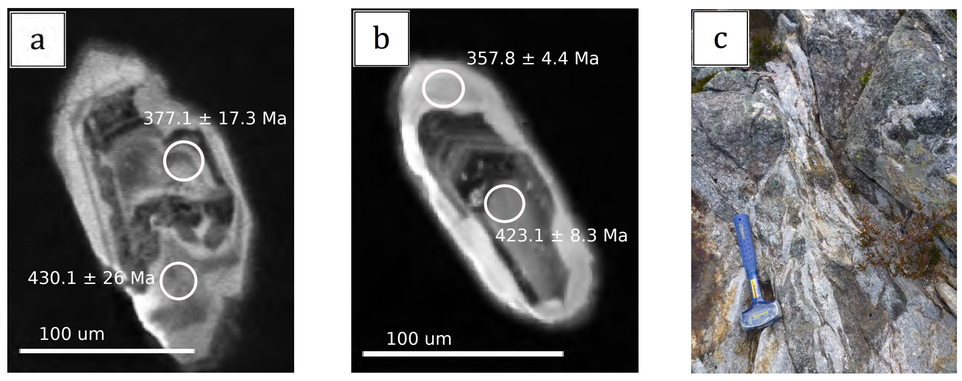

Figure 8: a) and b) Representative cathodoluminescence images of the zircons present in the leucocratic rocks associated with amphibolites with location and 206Pb/238U age c) macroscopic view of the intimate association of amphibolites and their associated leucocratic rocks

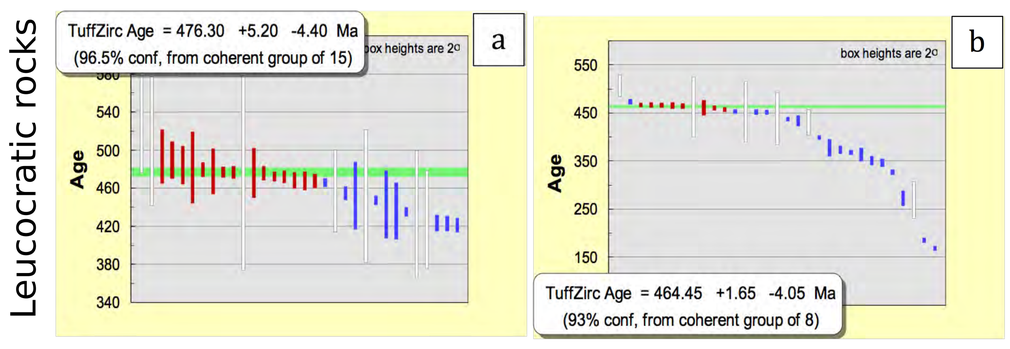

Figure 9: TuffZirc diagrams with all the measurements of two leucocratic rocks associated with amphibolites with their analytical uncertainties

6. In conclusion, the ca. 292 Ma age of the Alpigia calc-alkaline magmatism is very similar to that of the neighbouring Antigorio pluton, where Bergomi et al. (2007) dated a tonalite at 296 ± 2 Ma, granodiorites at 294 ± 5 and 290 ± 3Ma, and a granite at 289 ± 4 Ma. Conversely, Bussien et al. (2011) obtained mean 206Pb/238U ages of 300 ± 5 Ma and 302 ± 8 Ma for the Matorello granodiorite in the Sambuco unit and 308 ± 7 Ma for the Cocco granodiorite in the Maggia unit. Thus, if the spatial distribution of late Variscan magmatic ages is used as a paleogeographic criteria, the Alpigia magmatic complex and its host rock should be linked to the Antigorio nappe rather than to the Sambuco-Maggia units, in line with the tectonic interpretations of Keller et al. (1980) and Steck et al. (2013)