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SHRIMP II U/Pb geochronological constraints of pre-Alpine magmatism in the Lower Penninic Units of the Ossola Valley (Western Alps, Italy)

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The Lower Penninic Units of the Ossola Valley (Western Alps, Italy) are mainly composed of orthogneisses, which suffered the Alpine metamorphism under amphibolite facies conditions. The Verampio gneiss is considered the deepest Unit and underlays the Antigorio, Pioda di Crana and Monte Leone gneisses. Each unit is separated from the others by thin metasedimentary sequences Carboniferous(?) to Permo-Mesozoic in age. Most of the Penninic orthogneisses are well known as dimension stones (beola and serizzo), but their geochemistry is poorly investigated and geochronology completely lacks for most of them. The investigate orthogneisses are medium to fine-grained and granitic to granodioritic (rarely tonalitic) in composition. Their mineralogical assemblage mainly consists of Qtz+Kfs+Pl+Bt+/-WM+/-Ap+/-Zr. Grt and Hbl are locally found in the Pioda di Crana orthogneisses, while in the Antigorio rock-types Aln is the prevailing accessory mineral and WM is a minor phase. These assemblages were re-equilibrated under amphibolite facies conditions during the Mesoalpine event; no relicts of high pressure phase were recognized. Major, minor and trace elements were performed on 90 samples from the different Units. On the basis of their chemical features and mineralogical compositions some samples were selected for U/Pb SHRIMP II zircon investigations in order to define the possible emplacement age of the protoliths. The silica contents of the Lower Penninic orthogneisses range from 60 to 78 wt%. The samples are generally metalluminous to weakly peraluminous with A/CNK ratios between 0.9-1.2. They show a typical AFM calc-alkaline trend and plot in medium to high-K calc-alkaline field. They also present a similar enrichment in LILE with respect to HFEE. REE patterns of the Antigorio and the Pioda di Crana

orthogneisses are smooth and moderately enriched in LREE. (La/Yb)N ratio ranges from 9 to 30 with a slight Eu anomaly (Eu/Eu*=0.6-1). In contrast the Monte Leone orthogneisses show a flatter REE patterns, because of their HREE-enrichment with (La/Yb)N between 5 and 9 and a more pronounced Eu anomaly (Eu/Eu*=0.2-0.9). CL images of the zircons from one Verampio orthogneiss highlight a concentric, oscillatory zoning, interpreted as primary magmatic growth. The U-Th geochemistry also supports this interpretation: high Th (60-415 ppm) and U (440-2500 ppm) contents and Th/U ratios ranging from 0.1 to 0.6. Results of SHRIMP II U/Pb analyses (14 data points) on zircons give a concordant age of 289+/-3 Ma, interpreted as the time of the crystallization of the magma. Four samples, which represent the main varieties of the Antigorio Unit, were selected depending on their different silica and Zr content. All the analyzed zircons show typical magmatic textures characterized by a well-defined concentric and oscillatory zoning. They show high Th (150-400 ppm) and U (235-1500 ppm) contents and high Th/U ratios (0.15-0.9). On the concordia plot, all 8 data points on zircon from VM4 (metatonalite) give a concordant age of 296+/-2 Ma, whereas all 12 analyses on zircon from the NS1 (metagranodiorite) sample provide a concordant age of 294+/-5 Ma. 12 data points on AN8 (metagranodiorite) zircon form a concordant population with an age of 290+/-3 Ma. All 12 analyses on BR (metagranite) zircons define a concordant age of 289+/-4 Ma. These ages could represent the emplacement age of the Antigorio orthogneiss protoliths. Zircons from one Pioda di Crana sample are characterized by a concentric, oscillatory zoning, with Th ranging from 125 to 655 ppm and U from 325 to 1875 ppm. The Th/U ratios range between 0.16 and 0.50. On the concordia plot, all 14 analyses on zircons give a concordant age of 301+/-4 Ma, interpreted as the age of the Pioda di Crana protolith. Two samples of the Monte Leone unit were studied. All 10 SHRIMP II analyses performed on the zircons from the ML1 sample provide a concordant age of 302+/-6, interpreted as the emplacement age of the protolith. This is also supported by CL images (concentric and oscillatory zoning) and U-Th geochemistry (Th=170-390, U=340-860 ppm ppm and Th/U>0.4). On the contrary, some zircons from the ML8 sample are characterized by the presence of inherited cores surrounded by magmatic overgrowths, showing a concentric and oscillatory zoning. The age of the inherited cores rages from 563 to 962 Ma. All 13 data points on the magmatic rims give a concordant age of 456+/-4 Ma. According to zircon textures and U-Th geochemistry (Th=24-214, U=137-590, Th/U=0.1-0.4), this age could be interpreted as the emplacement age of a magmatic protolith older than the other investigated orthogneisses. As a whole, the Lower Penninic orthogneisses show mineralogical assemblage, chemical composition and zircon features, which suggest a common magmatic source and pre-Alpine evolution. Geochronological data confirm a Late Carboniferous to Early Permian magmatic emplacement age for most of their protoliths. Moreover, the span age is concordant with the late-Variscan event widespread in all pre-Alpine basements of the Alps. The unexpected Ordovician age, recorded in the Monte Leone Unit, could be referred to the country-rocks of the Late Variscan protoliths. It could be a first contribution to a better understanding of the pre-Variscan/Variscan crust in the investigated area.