Geological history of the Troiseck-Floning Nappe (Austroalpine unit, Styria/Austria)

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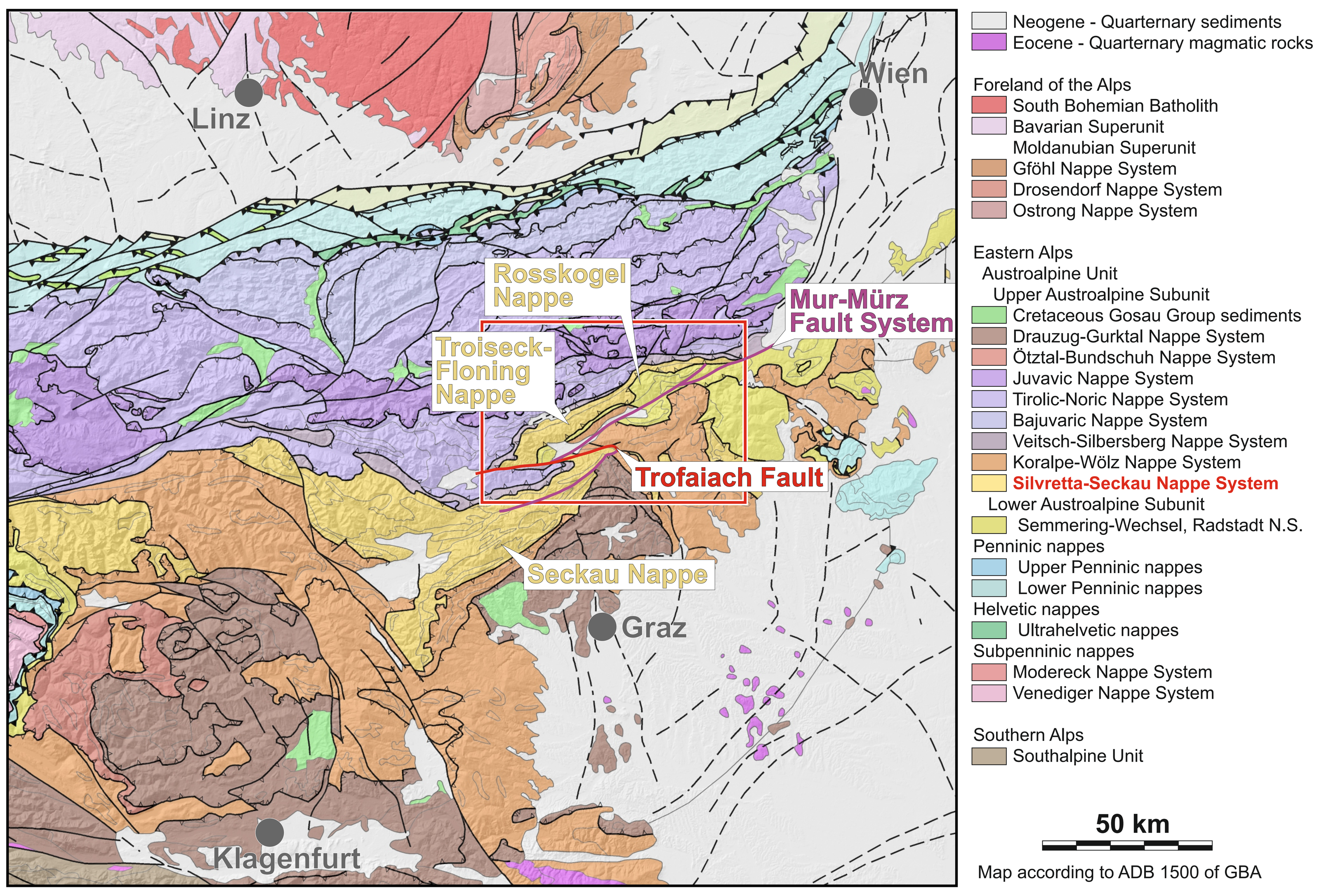
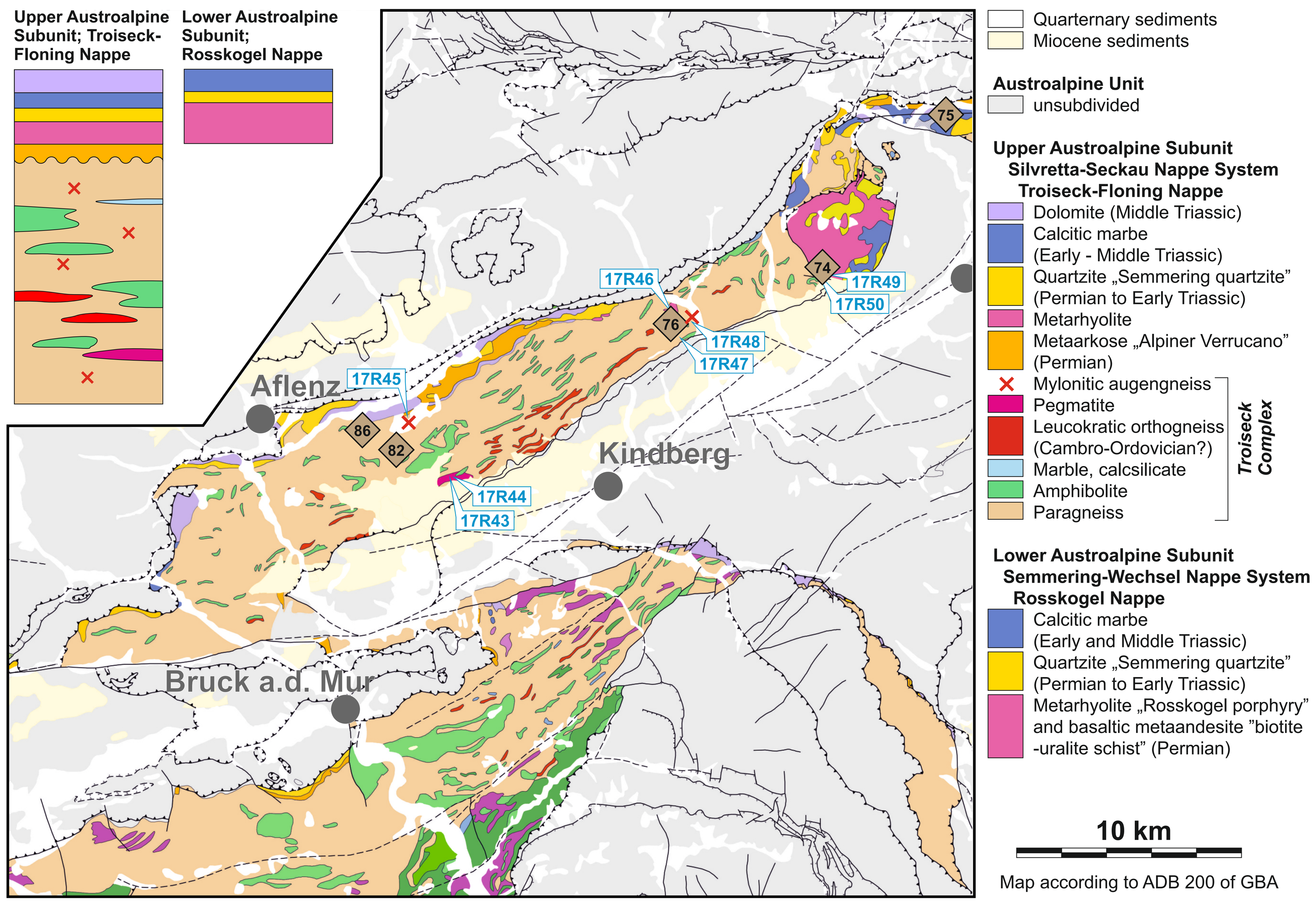


Fig. 1 (left side): Tectonic map of the eastern part of the Eastern Alps with a subdivision based on Schmidt et al. (2004). The area of the Troiseck-Floning Nappe shown in Fig. 2 is indicated by the red rectangle.

Fig. 2 (right side): Lithological map of nappes belonging to the Silvretta-Seckau Nappe System in the eastern part of the Eastern Alps. Additionally, the Rosskogel nappe of the Lower Austroalpine Unit is shown. In the upper left corner, schematic rock-columns of the Troiseck-Floning and Rosskogel nappes are shown. Further locations of investigated samples and Rb-Sr biotite ages (brown diamonds) are indicated. They include data from Handler (1994) and Schmidt (1998).



INTRODUCTION

This contribution reports new geochronological data from the Troiseck-Floning Nappe (Handler et al., 1994), forming the northeasternmost extension of the Silvretta-Seckau Nappe System (Fig. 1). The data include zircon crystallization ages determined by Laser Ablation ICP-MS (LA-ICP-MS) as well as Rb-Sr biotite ages reflecting cooling below c. 300°C. Based on the determined pre-Alpine evolution, the Troiseck Complex can be correlated with specific basement complexes in the Alpine orogenic belt of central Europe.

REGIONAL GEOLOGY

The Troiseck-Floning Nappe consists of a basement formed by the Troiseck Complex and a Permo-Triassic cover sequence (Fig. 2).

Paragneiss is the dominant lithology, but there are several intercalations of micaschist, amphibolite and different types of orthogneiss including pegmatite gneiss. The basement rocks experienced a Variscan (Late Devonian) tectono-thermal overprint at amphibolite facies conditions (Handler et al., 1999.

The cover sequence includes Permian siliziclastic sediments and metavolcanic rocks, Early Triassic quartzite (Semmering quartzite) and rauhwacke as well as Middle Triassic calcitic marble and dolomite. The Troiseck-Floning Nappe formed during the Eoalpine (Cretaceous) tectono-thermal event. Related deformation at lower greenschist facies conditions (Schmidt, 1999; Schuster et al., 2001) is penetrative in the cover sequence, whereas in the basement the Variscan structures are mostly well preserved.

LA-ICP-MS ZIRCON AGES

Detrital zircon grains of a paragneiss (Fig. 3) yielded ages in the range of 530-590 Ma. The intercalated amphibolite bodies derived from basalt with a calc-alkaline to island arc tholeiitic signature.

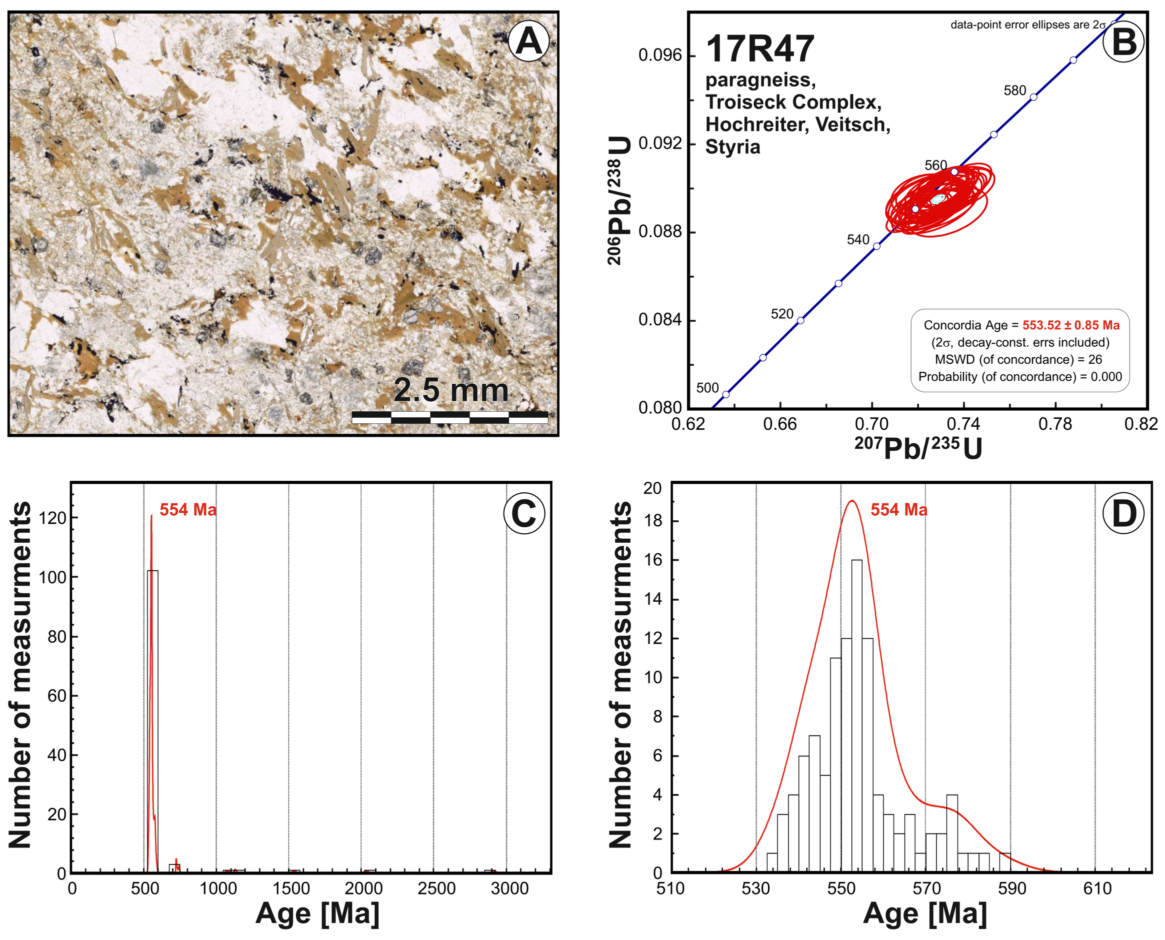


Fig. 3: Paragneiss of the Troiseck Complex collected along the road to farm Hochreiter (sample 17R47). A) Thin section showing a fine-grained upper greenschist to amphibolite facies assemblage of plagioclase + biotite + quartz + garnet + opaque ore minerals. B) Concordia plot and C) + D) kernel density plots and histograms of detrital zircon ages indicating a source with an Ediacarian to early Cambrian imprint.

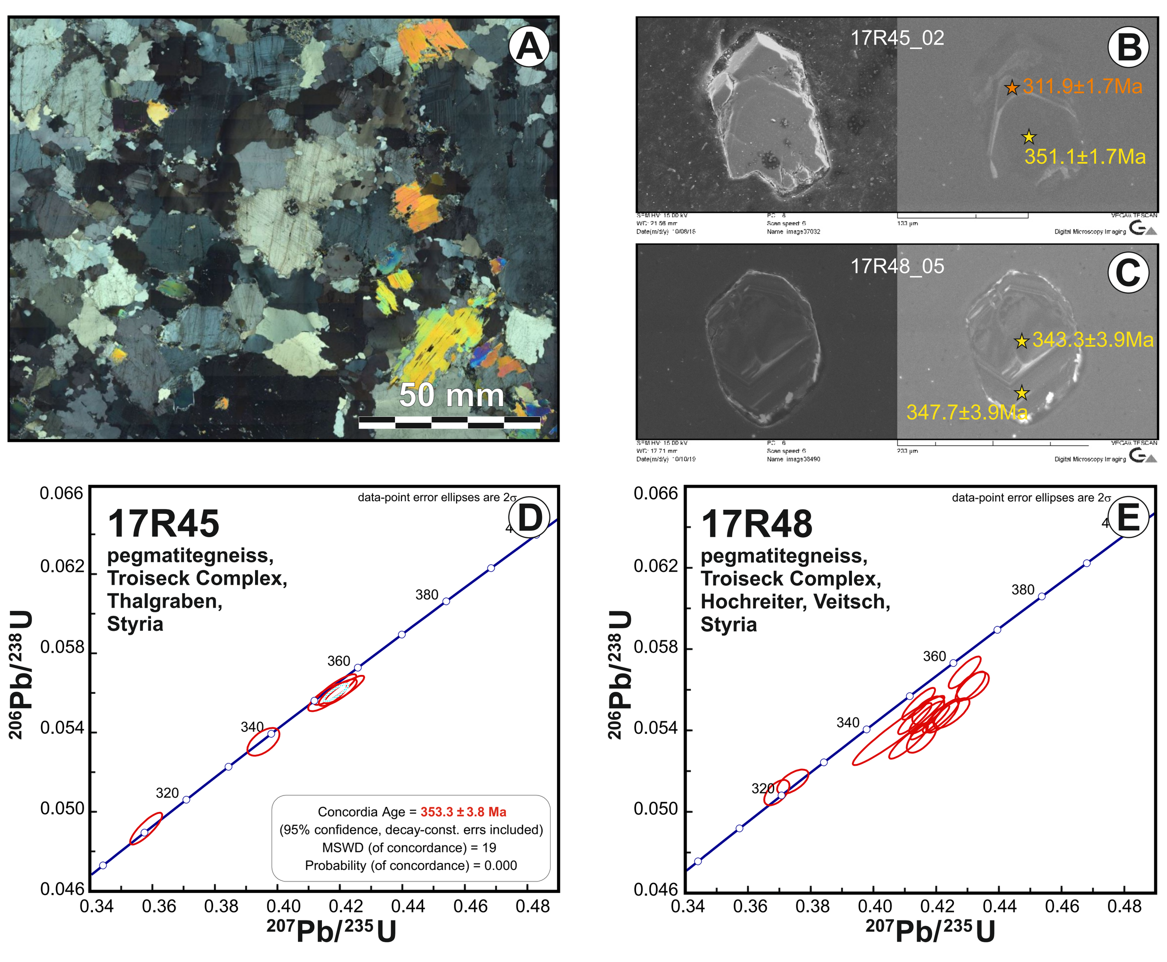


Fig. 4: Pegmatitegneiss of the Troiseck Complex collected at Thalgraben (sample 17R45) and along the the road to farm Hochreiter (sample 17R48). A) Thin section (crossed polarizers) showing a weekly deformed magmatic assemblage of K-feldspar + plagioclase + quartz + muscovite. B) + C) Selected zircon grains yielding Carboniferous ages. D) + E) Concordia plots indicating Carboniferous crystallisation ages.

Leucocratic orthogneiss with K-feldspar porphyroclasts up to 1 cm in size and a calc-alkaline granitic composition plots in the field of volcanic arc granite in the diagrams of Pearce et al. (1984). According to the youngest zircon grains, it crystallized during the Variscan event in the Late Devonian. Inherited zircon cores yield mostly Cambrian to Middle Ordovician ages (sample PYG17-37; Zöberer Höhe; not shown).

Two pegmatite gneisses with a simple mineralogical composition and a calc-alkaline composition are Carboniferous in age (Fig. 4). Their zircon grains are characterized by high U contents (147-2400 ppm) and high U/Th ratios (60-820).

Mylonitic orthogneiss with a pronounced stretching lineation appears as layers with an irregular shape in the southern, tectonically lower part of the nappe. It is leucocratic, very fine grained and contains scattered feldspar porphyroclasts with a round shape and a diameter of about 1 mm (Fig. 5). Its chemical composition is granitic/rhyolitic with an alkali-calcic signature. In the diagrams by Pearce et al. (1984), it plots in the field of syn-collision granite. Zircon ages indicate a Permian age of about 270 Ma. Inherited grains yield Pennsylvanian ages reflecting a late Variscan event in the source rocks, whereas some Ediacarian to Ordovician grains are absorbed from the surrounding paragneiss.

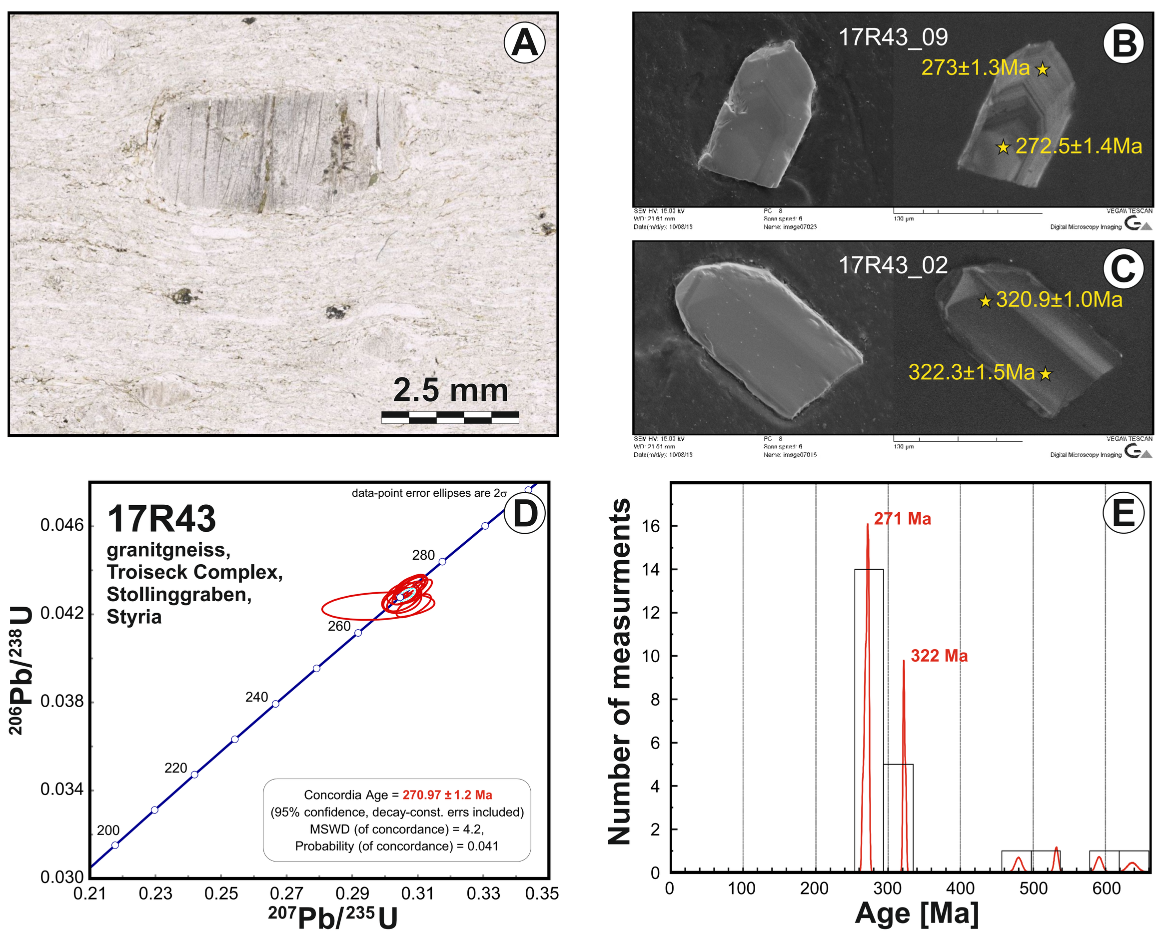


Fig. 5: Mylonitic orthogneiss of the Troiseck-Floning Nappe from locality Stein–Kehre near to farm Hochegger (samples 17R43, 17R44): A) Thin section showing a fine-grained mylonitic matrix and a feldspar porphyroclast. B) Permian zircon grain indicating crystallization age. C) Inherited Variscan zircon grain. (D) Concordia plot indicating a crystallization age of c. 271 Ma. (E) Related kernel density plot and histogram.

Rocks similar as the mylonitic orthogneiss appear on top of the Troiseck-Floning Nappe (Fig. 6A and 6B) and in the neighboring Rosskogel Nappe of the Lower Austroalpine Unit (Fig. 6C). Gaal (1966) classified them as Permian rhyolitic metavolcanics and they share a similar chemical composition and a crystallization age of about 270 Ma. Ediacarian to Ordovician grains dominate their detrital zircon spectra, but there is also an age group of about 2 Ga.

Intermediate metavolcanics associated with the rhyolitic rocks (Fig. 6D) (referred in the literature as "biotite-uralite schists") occur. They developed from calc-alkaline basaltic andesite and their zircon age is the same as for the rhyolitic rocks. Further, they contain few grains with Pennsylvanian ages.

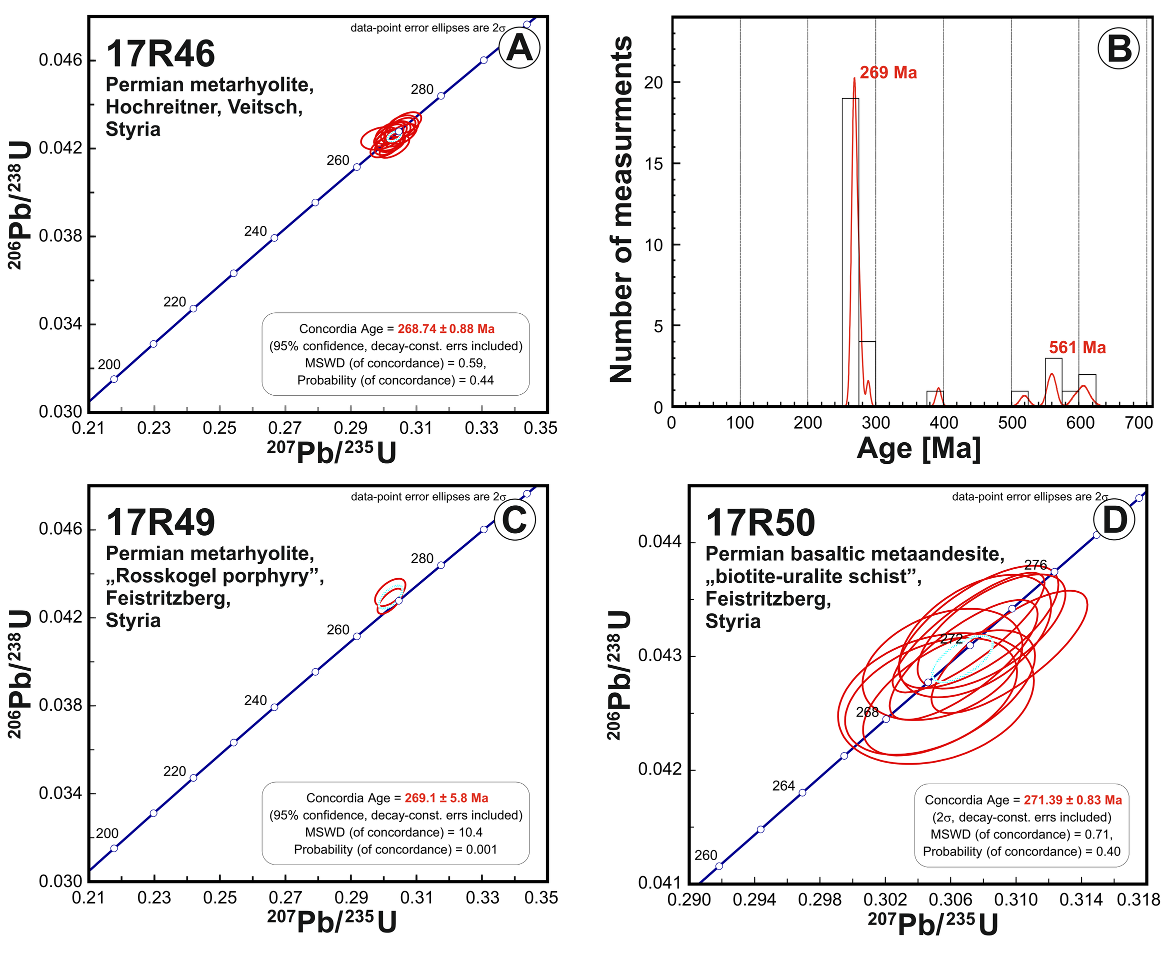


Fig. 6: Permian volcanic rocks from the Troiseck-Floning and Rosskogel nappes: A) Concordia plot of metarhyolite (sample 17R46) overlying the Troiseck Complex close to farm Hochreiter. B) Related kernel density plot and histogram. (C) Concordia plot of metarhyolite (sample 17R49) from the Rosskogel Nappe (Lower Austroalpine Unit) at Freistritzberg. (D) Concordia plot of basaltic metaandesite from a nearby locality.

Rb-Sr BIOTITE AGES

Rb-Sr biotite ages (Fig. 7) indicate a cooling trend in the Troiseck-Floning Nappe. A single age from the western part is 88 Ma, about 80 Ma were measured in the central part and new data from the eastern part are 75 Ma (Handler et al., 1994; Schuster et al., 2001). A similar trend is documented by Oligocene and Miocene apatite fission track data (van Gelder et al., 2020).

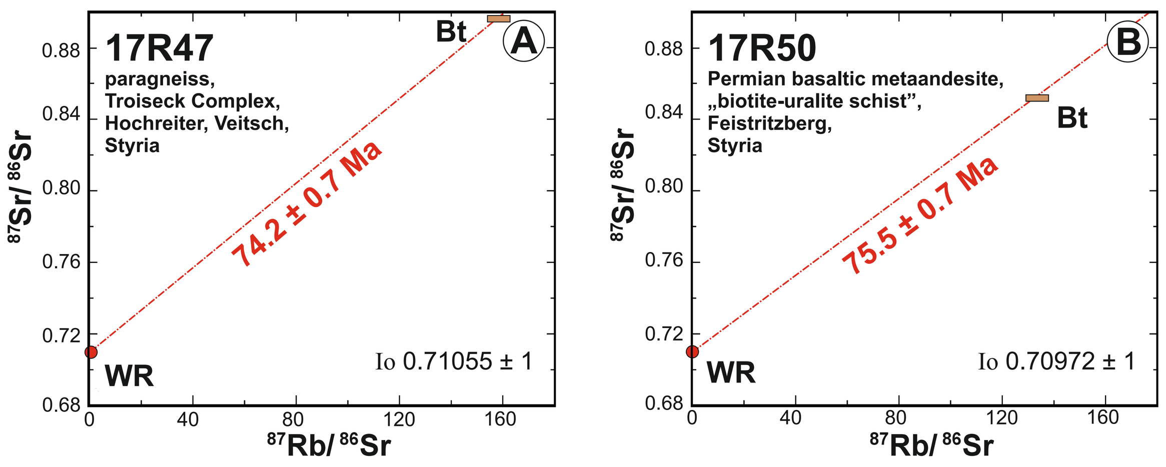


Fig. 7: Rb-Sr biotite ages from the Troiseck-Floning Nappe.

GEODYNAMIC EVOLUTION

Based on the available data, the geodynamic evolution of the Troiseck-Floning Nappe can be summarized as follows:

„Ceranian" event

The Troiseck Complex developed from siliziclastic metasediments and basaltic volcanic rocks deposited in middle Cambrian to Ordovician (530-480 Ma) times. The siliziclastic material derived from a hinterland with an Ediacarian to early Cambrian imprint.

In late Cambrian to Early Ordovician time (510 - 480 Ma), intrusion of mainly S-type granitoids of the Hochreichart Plutonic Suite occured (Mandl et al., 2017). A contemporaneous metamorphic overprint can be expected.

Variscan event

During the Late Devonian, the Troiseck Complex was affected by an early phase of the Variscan collisional event causing deformation at amphibolite facies conditions and intrusion of calc-alkaline granites. Geochemical signatures suggest a volcanic arc setting. In the Carboniferous pegmatite dikes intruded, maybe during decompression and exhumation.

At least in Permian time the Troiseck Complex was at the surface, because clastic sediments and volcanic rocks were deposited on top. Permian volcanic and subvolcanic rocks include rhyolite and basaltic andesite. Even if the rhyolite is characterized by a syn-collisional signature, a generally extensional environment can be assumed based on regional considerations (Schuster & Stüwe, 2008).

In Triassic times carbonate platform sediments were deposited on top of the Troiseck Complex.

Alpine event

During the Eoalpine collision, the Troiseck Complex was part of the tectonic lower plate and subducted to shallow crustal levels, as indicated by a lower greenschist facies metamorphic overprint. The Troiseck-Floning Nappe was formed and exhumed since about 85 Ma. Final exhumation occured since the onset of the Miocene lateral extrusion of the Eastern Alps. Rb-Sr as well as apatite fission track data indicate a tilting with more pronounced exhumation and erosion in the eastern part.

CORRELATIONS WITH OTHER BASEMENT UNITS

The western continuation of the Troiseck-Floning Nappe is represented by the Seckau Nappe showing an analog geodynamic history (Mandl et al., 2017).

A similar type of pre-Alpine basement is present in the Tatric and Veporic units of the Central Western Carpathians (Putiš et al., 2009; Kohút et al., 2022). However, the Alpine tectonic evolution of the latter is different.

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