Timing of rifting in the Central Western Carpathians post-Variscan orogeny and provenance of the Meliata Ocean

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Abstract

Slovakia is located within the Central Western Carpathians (CWC), one of many connected curved mountain belts prominent throughout the Mediterranean area and Europe. It is divided into tectonic domains considered “superunits,” termed the Gemeric, Veporic, and Tatric that correlate to the lower, middle, and upper Austoalpine nappes. For example, granite bodies exposed in the unit (termed apophyses) yield a wide range of zircon ages from 310±21 Ma to 87±4 Ma. This range of ages leads to problems in deciphering where the Gemeric unit was located in global plate reconstructions of eastern Europe and the western Carpathians specifically. This case study involves U-Pb dating of magmatic and detrital zircons from the Gemeric tectonic unit. This area records the Variscan orogeny that formed the CWC, rifting, and opening of the Meliata Ocean. This ocean was created due to the formation of a back-arc basin during closing/subduction of the Paleo-Tethys Ocean. We aim to constrain the timing of rifting and identify the provenance of Meliata Ocean radiolarian sediments collected from an obducted Meliata ophiolite suite (Dobsina, Slovakia). The relative age of the Variscan orogeny extends from the late Devonian to early Permian and was followed by rifting throughout the Mesozoic within the CWC. Eventually, the Meliata Ocean closed during the Cretaceous. Zircons from several S-type granites were collected throughout the Gemeric tectonic unit; they were dated using Laser Ablation Inductively Coupled Plasma Mass Spectrometry and imaged using cathodoluminescence. Rim crystallization ages from the granites are 295.8±3.4 Ma (2σ, 238U-206Pb) to 213.1±4.4 Ma. Ages from the detrital zircons are 346.4±4.5 Ma to 263.9±2.7 Ma, indicating that sediments overlying the Meliata Ocean ophiolite contain remnants of both the Variscan orogeny and Gemeric granites.

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(3) Earth Science Institute, Slovak Academy of Sciences, Bratislava, 84505, Slovakia

INTRODUCTION

Slovakia is located within the Central Western Carpathians (CWC), one of many connected curved mountain belts prominent throughout the Mediterranean and Europe. Its geology is divided into tectonic domains considered "superunits," termed the Gemeric, Veporic, and Tatric (e.g., Bezák et al., 2011). All domains are separated by major tectonic lineaments that were juxtaposed due to the closure of branches of ancient oceans. The Gemeric has a debated history that is obscured by vegetation (Kohút and Stein, 2005) (Fig. 1).

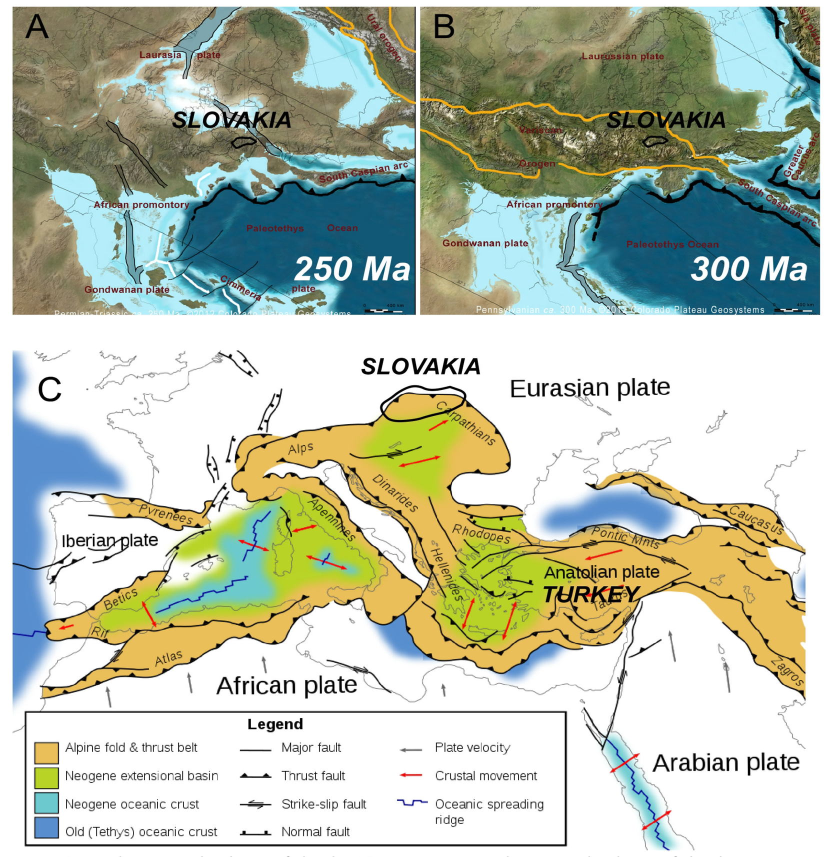

Figure 1(A): Paleogeographical map of Slovakia 250 Ma. **Figure B:** Paleogeographical map of Slovakia 300 Ma. **Figure C:** Geologic map of Eastern and Southeastern Europe showing major faults that have led to orogenic belts (Woudloper 2009).

Granite bodies exposed in the unit (termed apophyses) provide important clues into the tectonic history of this important unit in the western Carpathians. However, these rocks yield a wide range of ages from 310±21 Ma to 87±4 Ma (Kohút and Stein, 2004). This range of ages leads to problems in deciphering where the Gemeric unit was located in global plate reconstructions of eastern Europe and the western Carpathians specifically.

The goal of this study is to obtain zircon ($ZrSiO_4$) ages from igneous and sedimentary rocks exposed in the Gemeric unit to better understand the assembly of the CWC. We target granites, sedimentary rocks and exposed ocean floor.

GEOLOGIC BACKGROUND

- The Central Western Carpathians is composed of three tectonic units that create nappe stacking; the southernmost unit, the Gemeric unit, is thrusted over the Veporic unit which is thrusted over the Tatric unit (Fig. 2).
- The Gemeric unit, the southernmost tectonic unit constructing the country of Slovakia contains lower Paleozoic volcano-sedimentary sequences that have experienced amphibolite facies metamorphism during the Variscan orogeny.
- The Variscan orogeny is recorded by numerous granitoid plutons throughout the Gemeric unit; analysis of contact metamorphism indicates that these granites experienced 450-550°C and 1-1.5 kbar (Poller et al. 2002).
- The Gemeric unit contains the Meliata Unit, a fragment of obducted ocean floor that was once part of an accretionary-subduction wedge (Fig. 3).

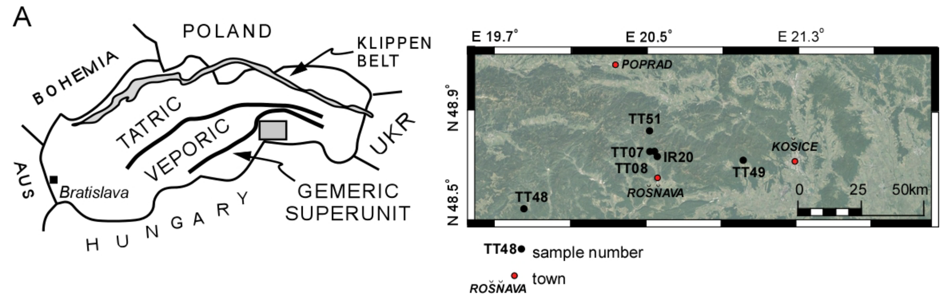

Figure 2(A): General map showing the three superunits that form Slovakia and the field site. **Figure B:** Google Earth map of field sites showing the sample number and locations

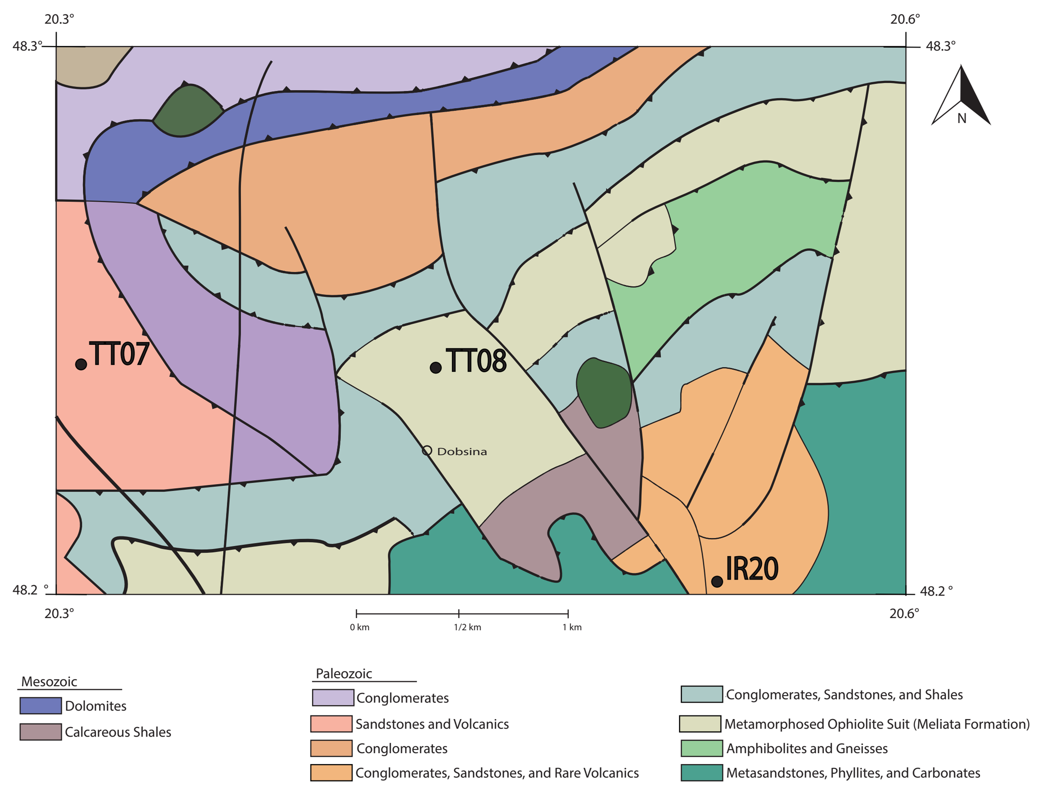

Figure 3: Geologic map of Dobsina Locality.

FIELD OBSERVATIONS

The Gemeric granites, peraluminous and low calcium fractioned S-type granites, are rare in itself due to its high concentration of tin; while the accessory minerals include zircon, apatite, monazite, tourmaline, and garnet.The Dobsina locality is located in Dobsina, Slovakia, a small mining town that used the locality for its asbestos. This locality represents the Meliata Formation, an obducted ophiolite suite that thrusted onto the Gemeric unit in the Cretaceous. A highly altered blueschist incorporates the base of the locality, while serpentinite overlies it. The serpentinite is the harzburgite phase of the serpentine group, which proves that this formation was formed as a back-arc basin. On top of the harzburgite package are metamorphosed radiolarians that record sedimentation within the Meliata Ocean throughout the Mesozoic (Putiš et al. 2013) (Fig. 4).

Figure 4(A): Cores of Gemeric granite from a mine near a field site within the Gemeric Superunit. **Figure B:** (Left to Right) PhD student Thomas Etzel, Undergraduate students Gabriel Villasenor and Theresa Perez in the field searching for Gemeric granite outcrops. **Figure C:** Dobsina Locality. **Figure D:** Radiolarian package found with southeastern dipping faults along with under-graduate students, Gabriel Villasenor and Thomas Quintero.

METHODS

- Collected Gemeric granite samples throughout the Gemeric superunit
- Created thin sections out of each sample
- Extracted zircons through mineral separation using crushing instruments and heavy density liquids
- Imaged zircons using Cathodoluminescence (CL) and Secondary Electron Microscopy (SEM)
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RESULTS

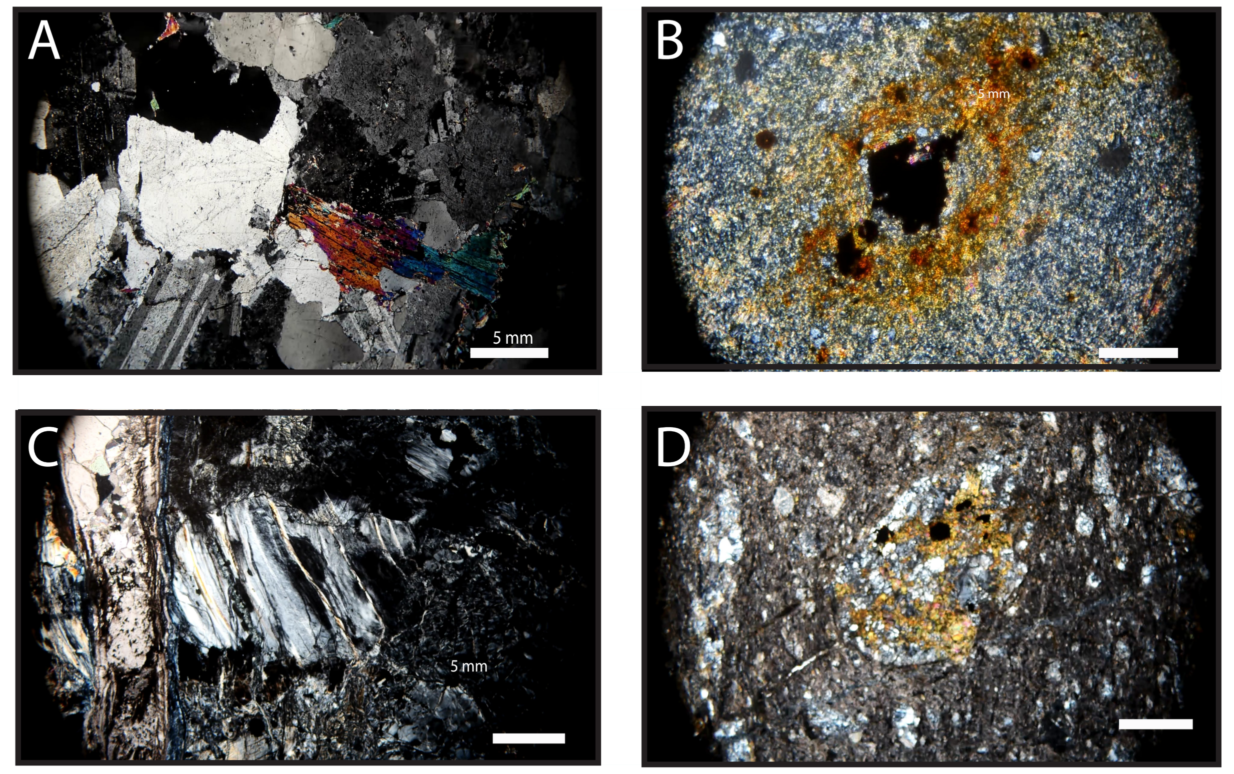
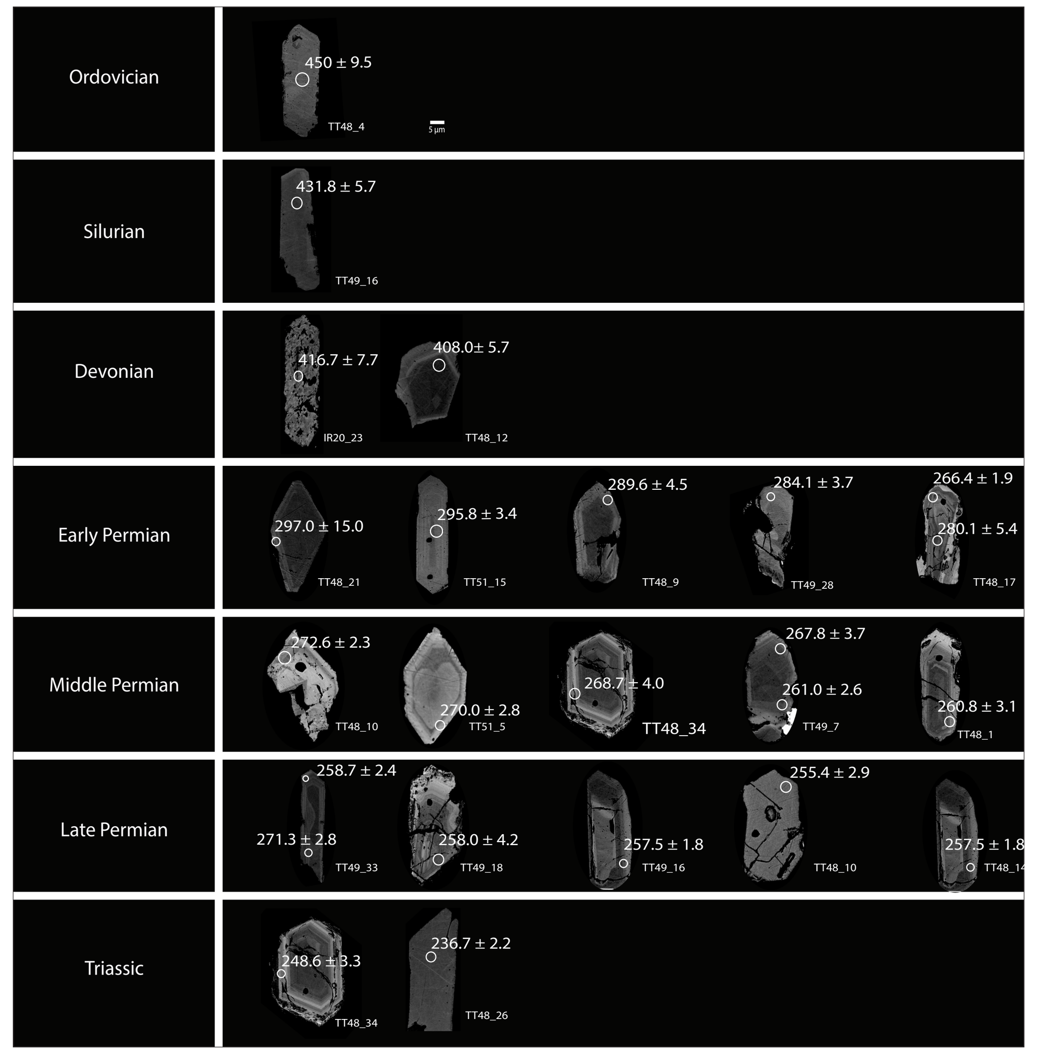


Figure 5(A): Thin section photograph of Gemeric Granite sample TT07. **Figure B:** Thin section photograph of blueschist package sample TT08I. **Figure C:** Thin section photograph of serpentinite sample TT08F. **Figure D:** Thin section photograph of radiolarian package TT08B.

A: Gemeric Granite Zircons



B: Radiolarian Zircons

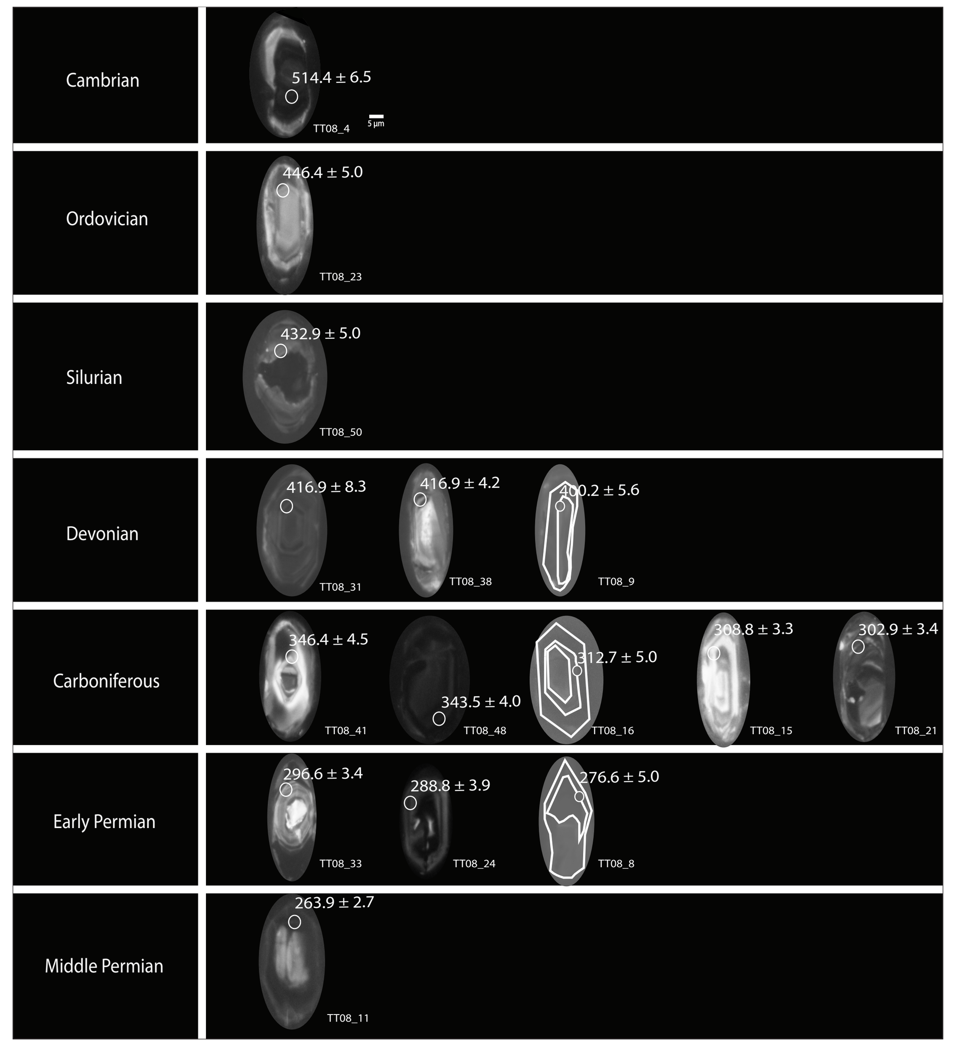
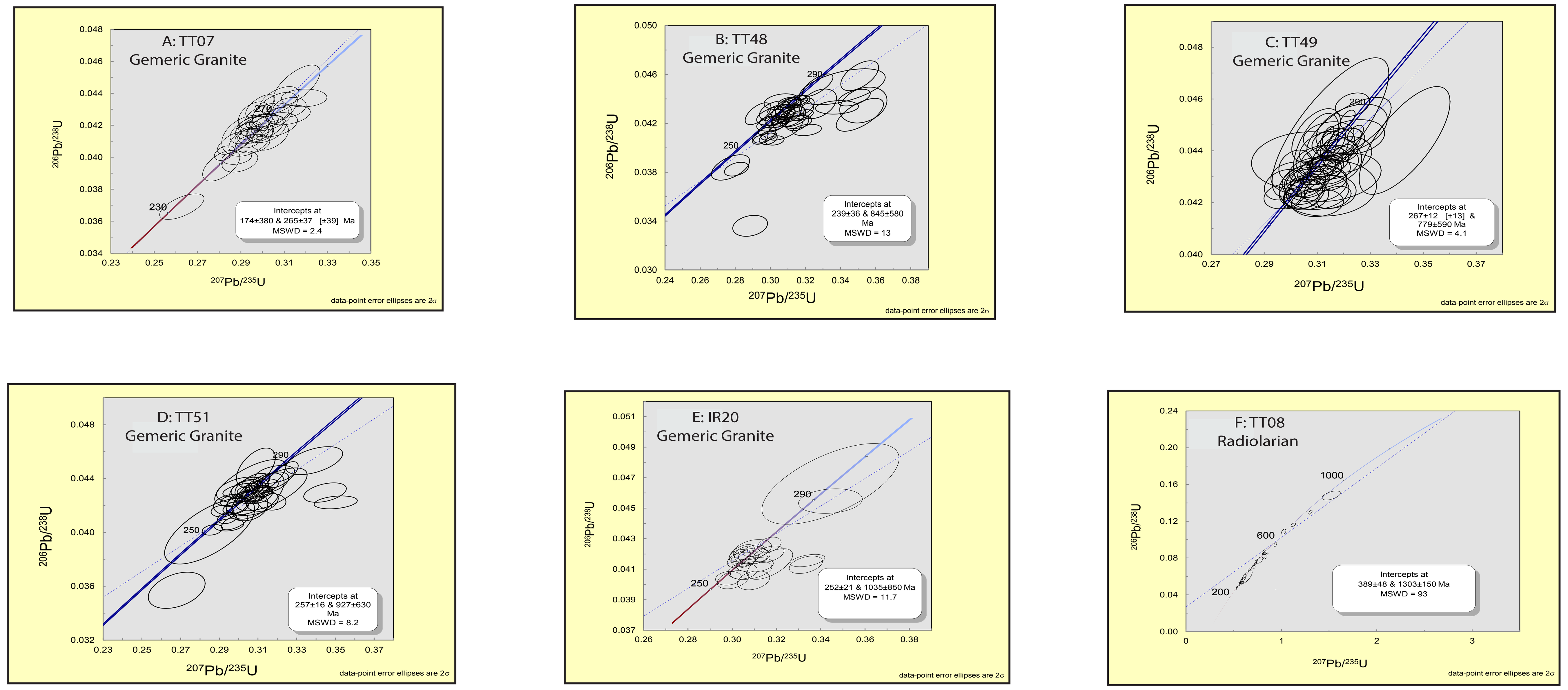


Figure 6(A): Cathodoluminescence images of Gemeric granite zircons that were extracted from each sample; a total of 200 zircons were analyzed. In addition, each zircon presented contains the spot where the laser ablated the grain along with its specific age and uncertainty. **Figure B:** Cathodoluminescence images of the radiolarian package zircons that were extracted from each sample; a total of 50 zircons were analyzed. In addition, each zircon presented contains the spot where the laser ablated the grain along with its specific age and uncertainty.



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CONCLUSION

In conclusion, the zircon rim crystallization ages from the granites are 295.8±3.4 Ma (2σ, 238U-206Pb) to 213.1±4.4 Ma. Crystallization ages of the Gemeric granites indicate that rifting of the Meliata Ocean happened soon after. In addition, ages from the detrital zircons are 346.4±4.5 Ma to 263.9±2.7 Ma, indicating that sediments overlying the Meliata Ocean ophiolite contain remnants of both the Variscan orogeny and Gemeric granites.

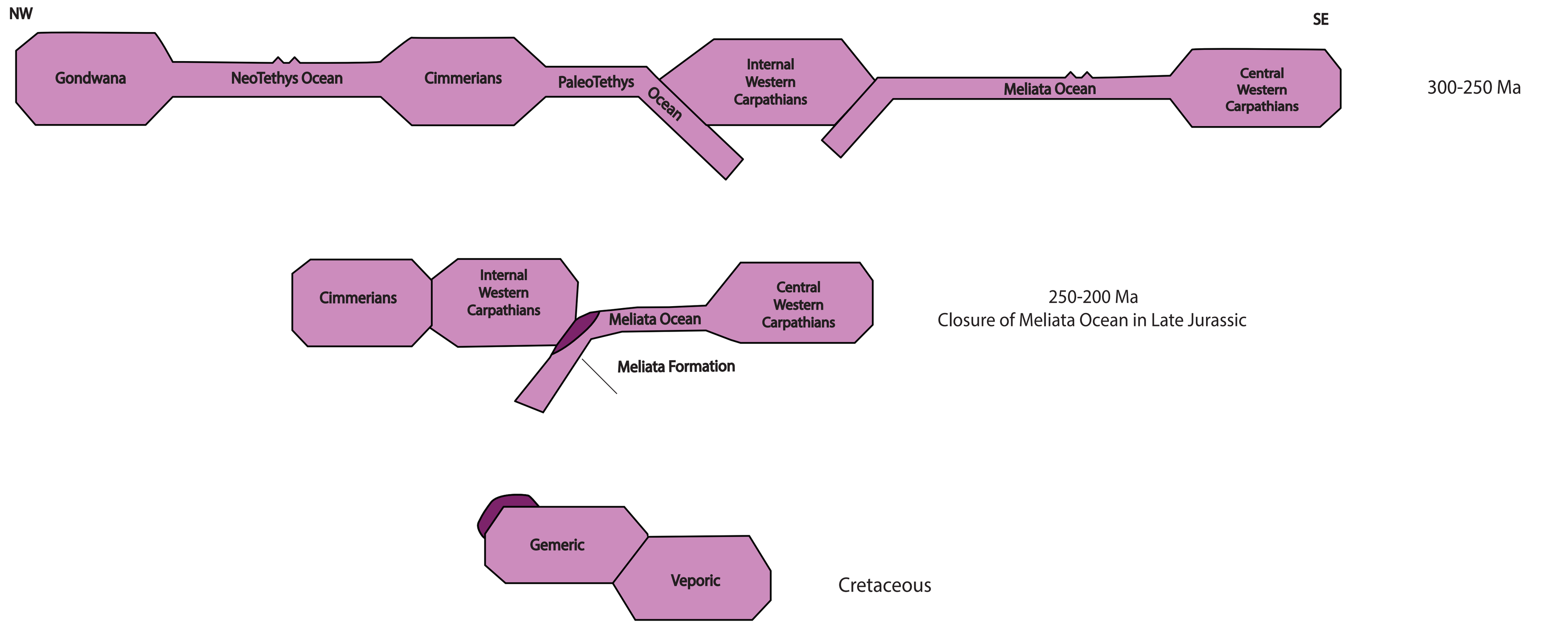

Figure 8: Tectonic model and cross section of Eastern Europe during the opening and closing of the Meliata Ocean as a back-arc basin during the Paleozoic through the Mesozoic.

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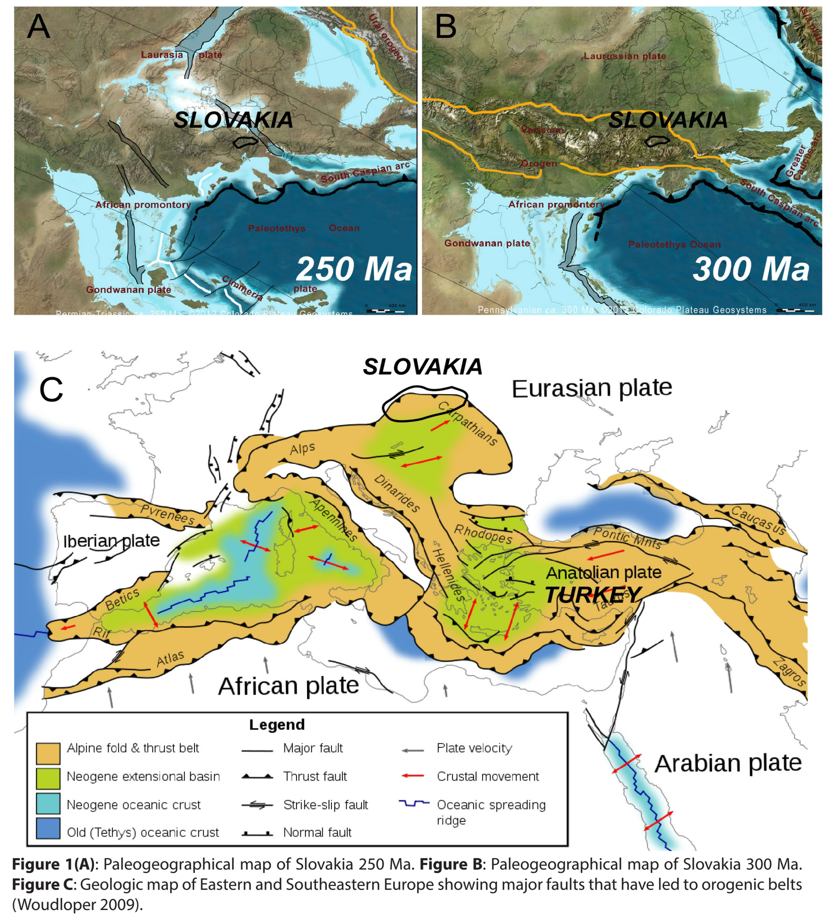

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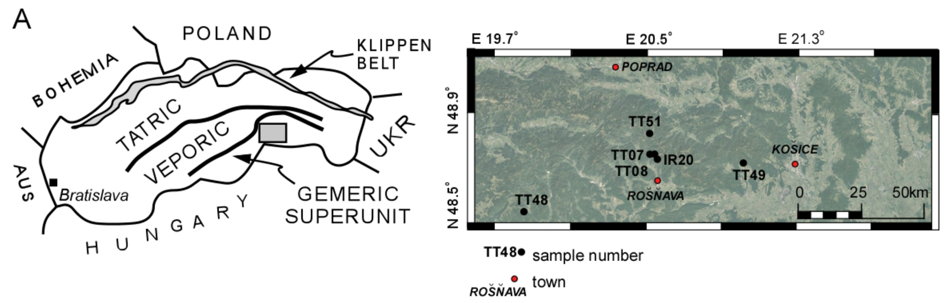

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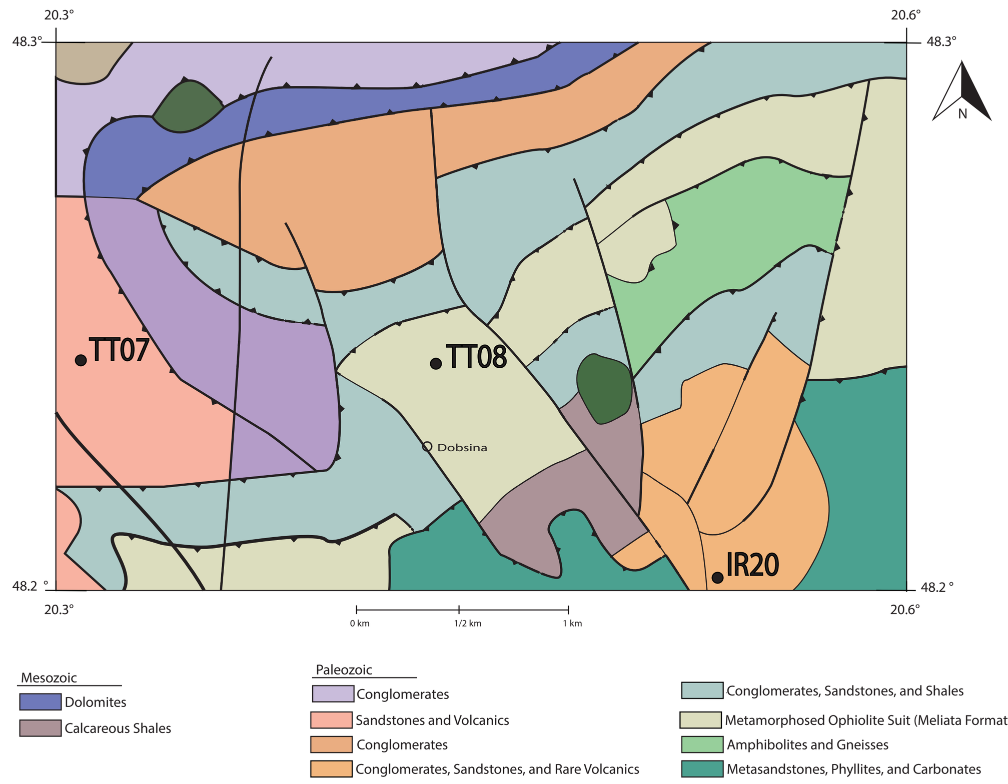

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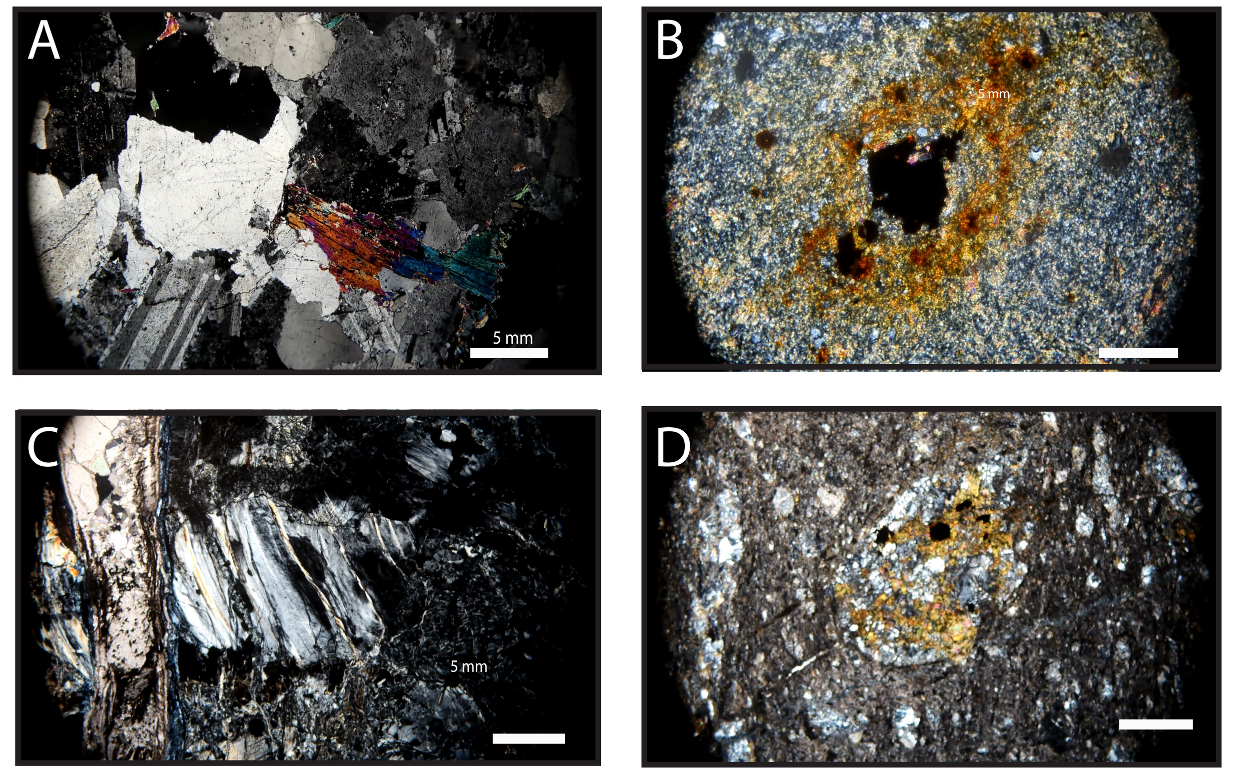

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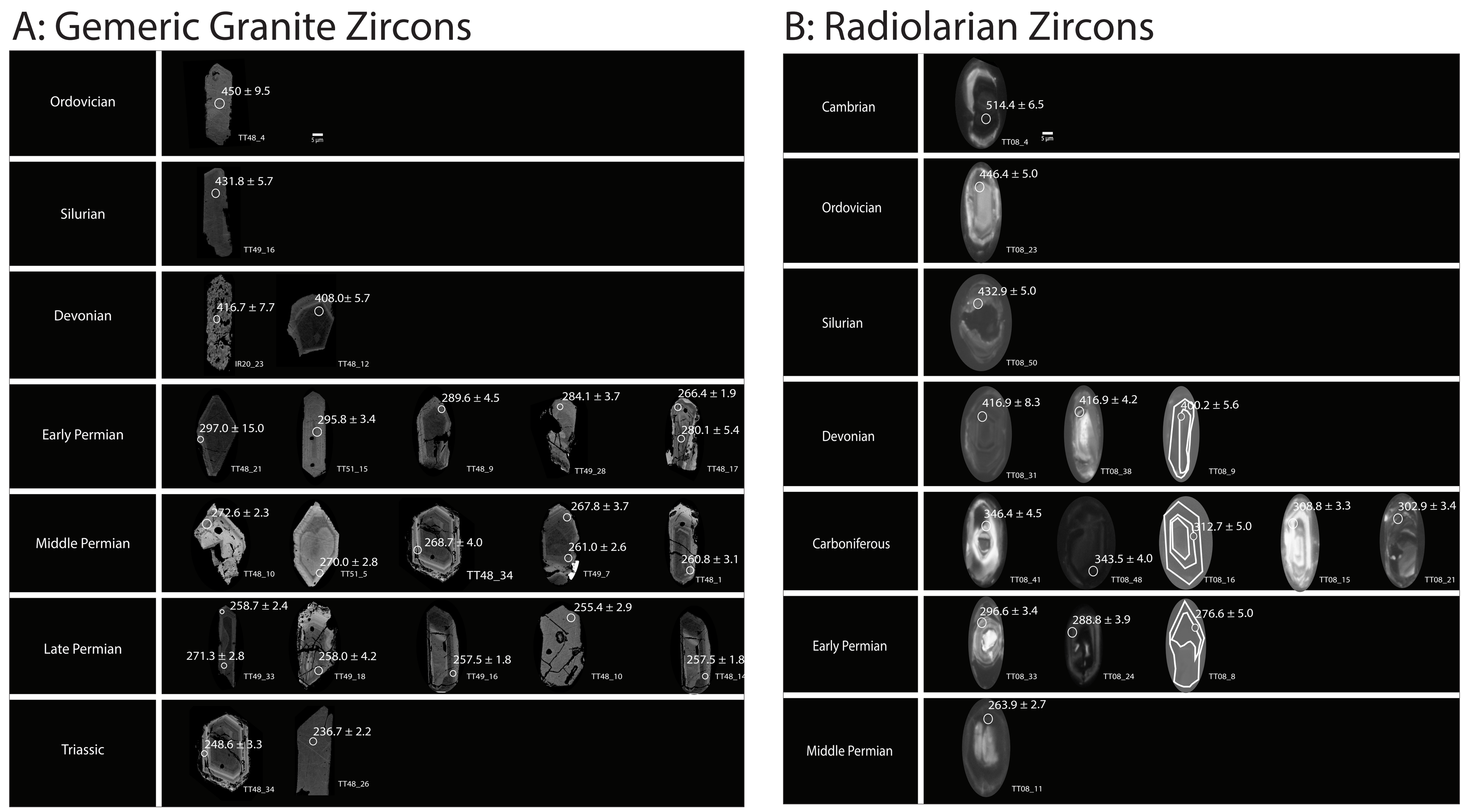

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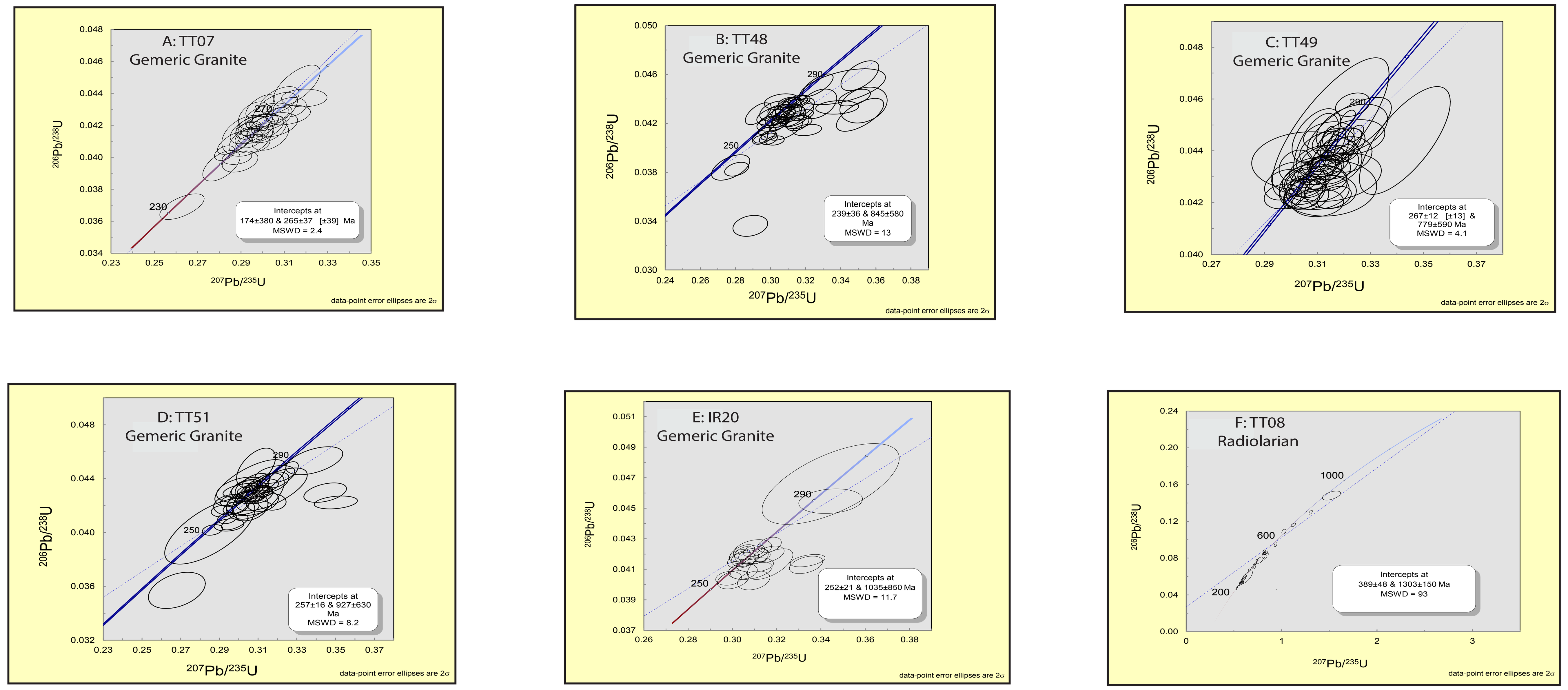

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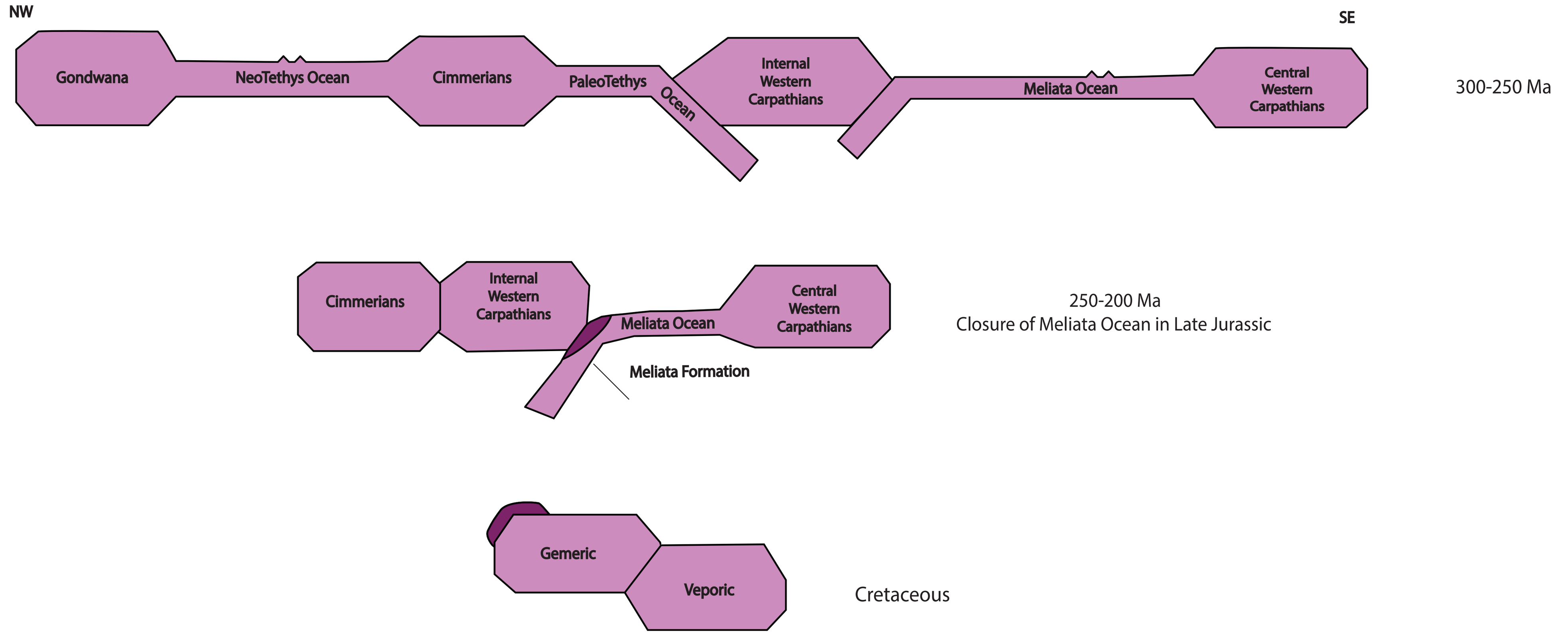

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