Understanding the closure of Alpine Tethys in the Western Carpathians using Receiver Functions

Tanishka Soni[a], Christian Schiffer[b], Stanisław Mazur[a]

[a]Institute of Geological Sciences, Polish Academy of Sciences, Senacka 1, 31-002 Krakow, Poland

[b]Department of Earth Sciences, Uppsala University, Villvägen 16, 75235 Uppsala, Sweden

Introduction

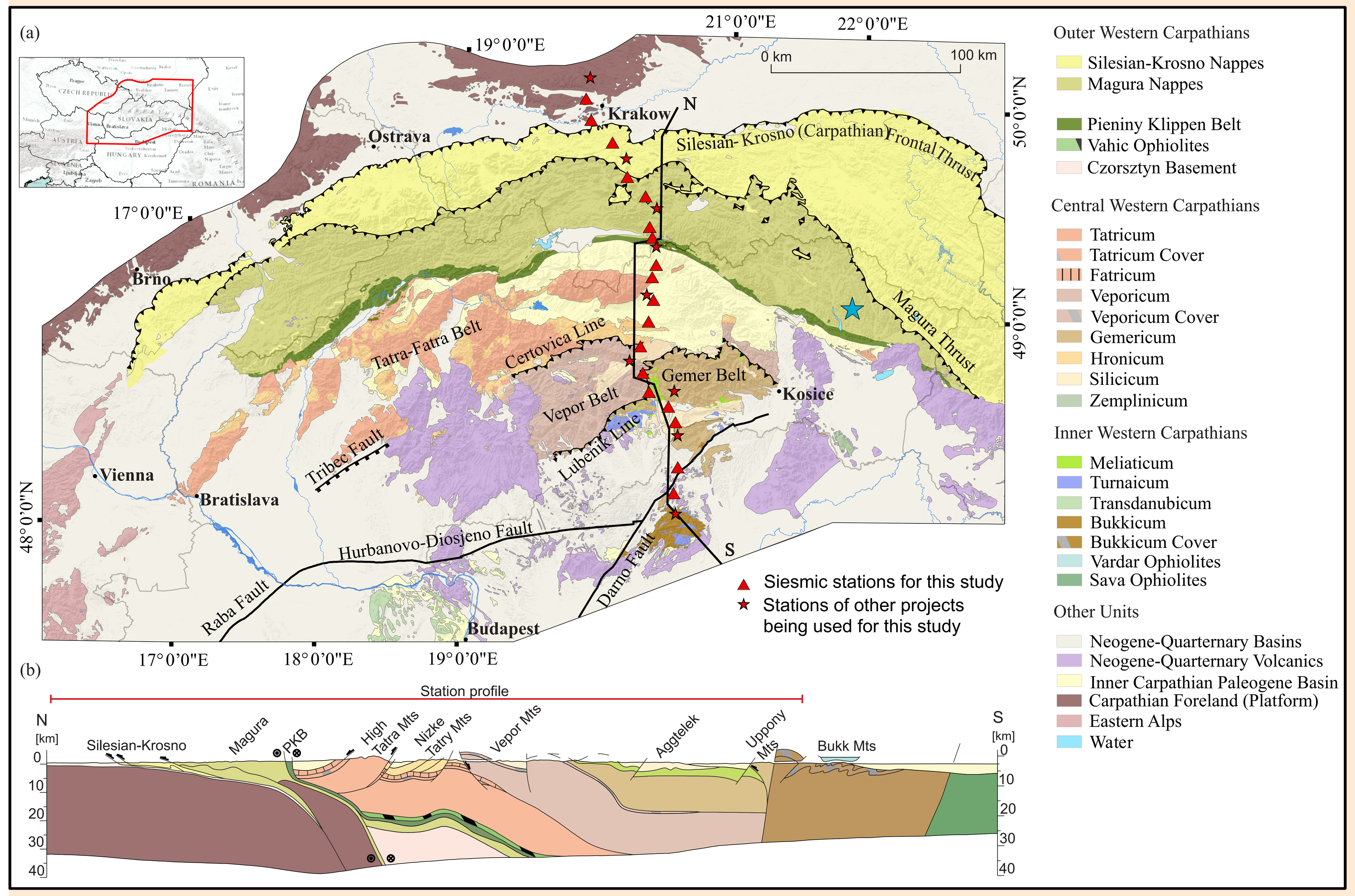

Figure 1: a) Geological map of the study area with locations of the seismic stations used in this experiment b) Cross section across the Western Carpathians (modified after Schmid et al., 2008)

- The closure of Alpine Tethys ocean between North European platform and the Adria-derived derived Alps-Carpathian-Pannonian block is represented on the surface by the Pieniny Klippen Belt (PKB) in the Western Carpathians. (Plašienka et al., 1997; Schmid et al., 2008)
- The PKB is a ~600 km long and few kms wide unit that divides the Outer Western Carpathians (OWC) and Central Western Carpathians (CWC) (Figure 1). It is composed of mostly shallow marine limestone and flysch which form the typical "block-in-matrix" structure. Along with these, there is also the presence of so-called "exotic" clasts. (Plašienka et al., 1997; Schmid et al., 2008)
- Moreover, despite being interpreted as the surficial representation of a suture, the PKB does not exhibit characteristics associated with a suture. There is no evidence of presence of ophiolites or high pressure-low temperature rocks. (Plašienka et al., 1997, Plašienka, 2018)
- These observations have led researchers to hypothesize the presence of a Brianconnais-like island in the Alpine Tethys called the Czorsztyn ridge dividing the Alpine Tethys into two oceanic basins: Magura to the north and Vahic to the south. The crystalline basement of the Czorsztyn ridge is theorized to have been subducted beneath the CWC along with the Vahic oceanic crust. (Birkenmajer, 1986; Mišík, 1994; Schmid et al., 2008)
- The presence of the Czorsztyn ridge is a highly debated topic. We are testing this hypothesis by geophysical methodologies like the Receiver Function analysis (by performing a Passive Seismic Experiment) and Potential Field study.

Potential Field Study

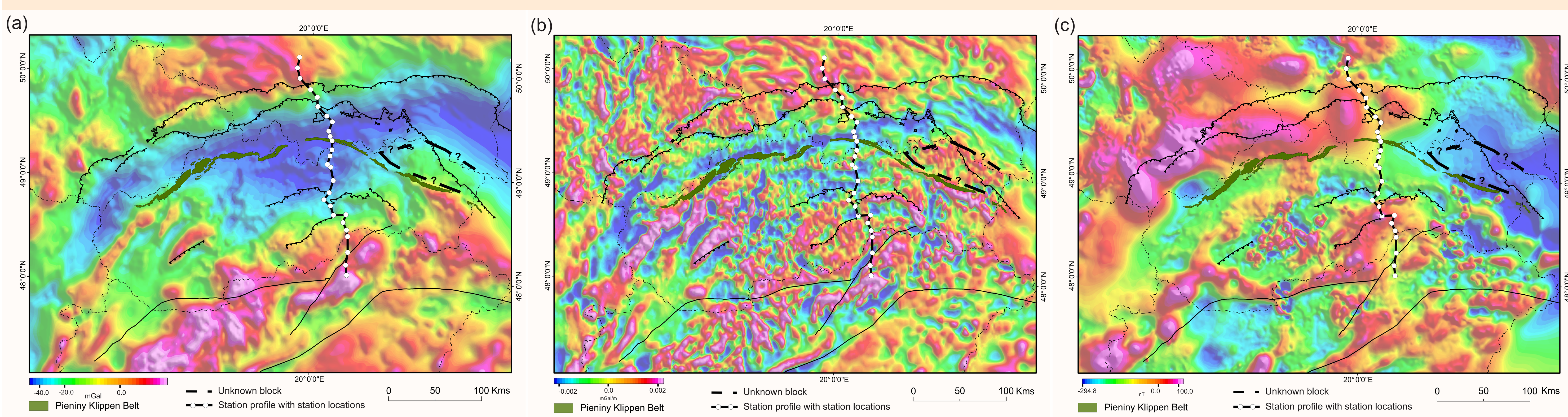

Figure 3: a) Bouger Anomaly Gravity Data

b) First Vertical Derivative of Bouger Gravity Data

c) Total Induced Magnetization reduced to pole.

- Gravity and Magnetic data were studied to shed light on the sub-surface features in the whole study area.
- The data was filtered and processed to create various derivatives and transformations which were mapped and studied.
- The Bouger anomaly map, the first vertical derivative of the Bouger anomaly and the total induced magnetization (reduced to pole) map reveal three elements in the study area (Figure 3).
- The three elements are
  - Northern European platform present to the north of PKB.
  - ALCAPA present to the south of PKB
  - An unidentified wedge to the north of eastern PKB having a positive gravity anomaly and a negative magnetic anomaly.
- A negative gravity anomaly follows the PKB until it encounters this unidentified wedge and appears to divert to the north of the wedge.

Passive Seismic Experiment

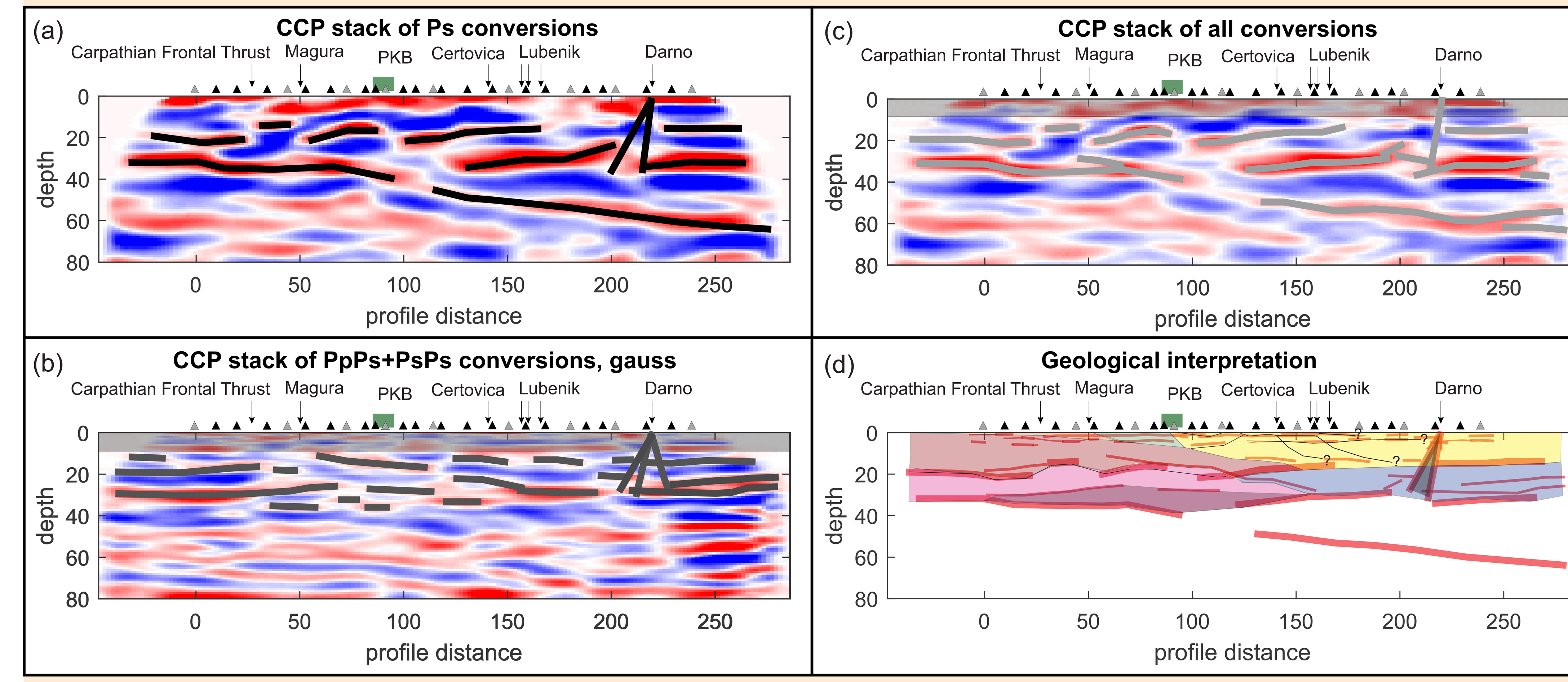

Figure 2: CCP images with observed boundaries (a) CCP image of Ps conversions, (b) CCP image of stack of multiples conversions, (c) CCP image of stack of all conversion and (d) geological interpretation of observed boundaries in all the CCP images shown

- The Passive Seismic Experiment was designed to provide data for crustal imaging across the Western Carpathians. Eighteen seismic stations were deployed along a ~N-S profile to supplement data from other temporary and permanent stations in the region.
- Receiver Function analysis of the data was done in order to produce Common Conversion Point (CCP) images (Figure 2) of the profile using conversions of the primary and the multiples.
- The CCP image of Ps conversions is used to identify major features like Moho while the CCP images of stacks of multiples and of all conversions is used to identify other minor features, especially at shallower depths. All of these images are carefully studied together to produce a cohesive interpretation.
- Moho is identified at ~30 kms depth with two steps; one under the PKB and one under the Darno fault. The exception is between profile distances 70-125 kms where Moho appears to be deeper, upto ~40 kms.
- Another prominent feature is a low dipping boundary in the upper mantle beneath the ALCAPA crust.
- It is observed that the fabric of the crust on either side of the surficial location of the Darno fault is different.
- The upper and lower crust for both Europe and ALCAPA have been identified based on intracrustal discontinuities seen in the CCP images.
- Based on these observations, a geological interpretation is made as shown in Figure 2(d).

Results

- The Czorsztyn ridge basement, along with the Vahic oceanic crust, cannot be identified as a distinct body beneath the CWC, as it has been hypothesized.
- The European crust wedged against the ALCAPA crust extends further south than previously understood.
- A dipping feature is observed in the upper mantle which appears to be connected to the Moho at the point of expected contact of northern Europe and ALCAPA.
- The Darno fault seems to be a major lineament in the region considering the difference in crustal fabric on either side of it.
- The Potential Field study has helped identify a previously unknown block towards the east of the study area. This block shows a positive gravity anomaly and a negative magnetic anomaly.

Scan here for OSPP

Acknowledgments

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