Review of the manuscript “Neogene kinematics of the Giudicarie Belt and eastern Southern Alpine orogenic front (Northern Italy)”
by V. F. Verwater, E. Le Breton, M. R. Handy, V. Picotti, A. Jozi Najafabadi, C. Haberland

General comments

The manuscript presents tectonic balancing of a network of seven cross sections parallel to the local shortening direction through the Giudicarie Belt, which is the boundary between eastern and central-western Southern Alps. In the area, several amounts of Neogene shortening have been proposed by different authors, but the use of forward modelling performed using 3-D MOVE software and different kinematic scenarios provides new robust insights to the problem.
The manuscript is generally consistent and well-written, while the conclusions aren’t fully justified by data. Within the work the section 3 is a bit weak. The main issues of the manuscript to be clarified are the Oligocene shortening direction, the decomposition of the shortening vector and the lack of the Thiene-Bassano fault (ITIS127 in DISS 3.2). In fact, several minor uncertainties are mainly related to the figures.

Specific comments and typographical corrections to the manuscript

Text

Line 204-217: the presumed contrasting styles to the east and west of the Schio-Vicenza fault may be just due to different levels of erosion of the hanging wall of the frontal thrusts (Bassano and Marana), which exposes rocks with different physical properties. In fact, the steepened and folded Lower Cretaceous strata of the thin-bedded Maiolica Fm in Fig. 3a are located on the forelimb of the M. Grappa ramp anticline where the steep mountain slope faces the foreland plain. By contrast, the cataclastic Dolomia Principale of Fig. 3b is located inside a valley, which deeply cuts the Marana thrust. Therefore, the Dolomia outcrop represents a deeper structural level, which is not exposed in the Bassano frontal slope. In fact, the Lessini block (southern part of Domain 2a) are a structural high interpreted as a foreland wedge separating the central-western from the eastern Southern Alps (see the Structural map of Italy, Bigi et al., 1990), also called the Adige embayment by Laubscher (1990).

Lines 226-227: “Striations in the field show thrust motion with a component of dextral strike-slip”. A close inspection of the stereoplot of Fig. 3e shows that most of the NE-trending mesofaults, i.e. the faults subparallel to the mean trend of the Valsugana fault, have a sinistral strike-slip component. The same is inferred from the structural map, where the red arrow of the Valsugana stop is oblique to the mean trend of the fault. Is the information on the strike-slip component relevant to the text development?

Lines 227-228: “Cross-cutting relationships show that the Valsugana Fault was later once more reactivated as a dextral strike-slip fault (Figure 3d)”. The photo 3d really shows one NNE-trending fault plane with dextral transtensional synkinematic calcite fibers, which is represented also in the stereoplot. However, the fault has a trend different from that of the Valsugana fault. In the photo the two cross-cutting lineations are not evident: please insert two arrows.

Line 691: I’m not convinced about the “if not all”. See comment to Fig. 11.

Line 715: Alfio instead of Alfi.

Figures

Figure 1. In the right half of the geological map, south of BA a blind frontal thrust is lacking (see comment to Figure 8).

Figure 3. This figure and the related caption require several improvements.

The exact location of the structures in the photos from a) to d) isn't declared. Please specify.

a) the significance of the horizontal dashed black lines (F1) is not explained in the caption. They seem axial planes of chevron parasitic folds. In the forelimb of the ramp anticline of the Bassano thrust they are very common in the thin-bedded Maiolica unit. These folds are produced by flexural slip rather than by kinking.

c) the strike-slip fault shown isn't the Schio-Vicenza fault, which is NW trending, but a conjugate fault ca N-S trending. In the text the fault is correctly labelled as Borcola Pass Fault zone. Stereolpots of e) confirm the trend of the faults. In fact, the Schio-Vicenza fault trace follow the axis of the Posina valley and passes through the Borcola pass, which is 250 m away from the inactive quarry of the figure (see also Fondriest et al. (2012). Fault Zone Structure and Seismic Slip Localization in Dolostones, an example from the Southern Alps, Italy. J. Struct. Geol., 45, 52-67, http://dx.doi.org/10.1016/j.jsg.2012.06.014 ).
Therefore, the structures shown in c) belong to the damage zone of the true Schio-Vicenza fault.

e) the graphical quality of the stereonets can be improved. The strain axes are not legible, please enlarge the labels. The stereonet Bassano seems a plot of NW-dipping faults with variable dip angle (reverse faults?) reactivated by strike-slip movements (the plunge of the lines contained on the fault planes is small). It seems that two deformation phases have occurred, a phase of contraction with reverse faults (lineations not recorded) followed by a strike-slip regime reactivating the same faults and originating some new sub-vertical faults. Please explain what you are showing.
Some lines fall outside the planes!
There are two Schio-Vicenza plots. The first presents a fault plane solution consistent with a transpressional stress regime, while the second (from the same Borcola pass stop?) shows an extensional character. Are the plots representative of two different stress fields? In the inactive quarry of fig. c there are Paleogene basaltic dikes injected along some faults. The wall of the dikes is generally overprinted by striations.

Fig. 5. The trace of the Cross section 14 (see Cross section 14 in Fig. A1.1 of Supplementary material) seems truncated on its western part. Therefore, I am not able to understand if the fault in the mid of the cross section is the Schio-Vicenza fault or another normal fault placed outside Fig. 5 (the Paleogene graben boundary Castelvero fault?).

Fig. 7. In the cross-section 5 I can't see the Schio-Vicenza fault, which is undoubtedly crosscut by the profile trace in its northwestern tract (see Fig. 5). Clearly, the crossing of the strike-slip fault is irksome, because out-of-plane movements occur. Probably, the amount of movement is small compared to that of the fault system separating Domain 1 from Domain 2. However, I think you must discuss this problem and insert the subvertical Schio-Vicenza fault into the cross section.

Fig. 8. In the footwall of the Bassano fault a blind fault does exist. The surface expression of this thrust is the Montecchio Precalcino hill, interpreted to as the hinge of the hanging wall anticline isolated into the plain. It was recognized from a N-trending seismic section performed by Agip in the Eighties and consequently drilled by the 4 km deep Villaverla 1 well (see also Viganò et al., 2017. Past to present deformation of the central-eastern Southern Alps: from the foreland to the Giudicarie

belt. Annual Meeting of the Structural Geology Italian Group (GIGS) of the SGI. *Geological Field Trips and Maps*, vol. 10, 1.1, (2018). doi 10.3301/GFT.2018.01
In the DISS v. 3.2 the thrust is known as Thiene-Bassano fault (from the works of Galadini et al. 2005 and Burrato et al. 2008) and is therefore considered an individual seismogenic source (ITIS127) belonging to the composite source Thiene-Cornuda (ITCS007).
In the Profile 6 this blind thrust is neglected, although some seismic events are reported in the footwall of the Bassano fault. Therefore, I suspect that four basement thrust sheet, not three, best represent the profile 6. This would produce an additional, although limited (1-2 km?), shortening of the cross-section.

Fig. 11. It's unclear if the arrow labelled Late Oligocene shortening direction refers to Adria - Europe plate convergence or to the strain partitioning among the Giudicarie structures or simply to the field measurement. The cited works from Pomella et al. (2011, 2012) show a Late Oligocene/Earliest Miocene NNW-ward movement of the Southalpine indenter (large arrow) (Fig. 11 and 9, respectively). If the Late Oligocene shortening direction is NNW, then the 18-25 km of slip along the NGF requires a shortening of the domain 1 larger than 18 km. The same could be said for the mid Miocene shortening, since the hypotenuse of the triangle should be the shortening direction and not the strike-slip component along the NGF, which is the catheter. Applying different triangles with shortening corresponding to the hypotenuse (calculated by cross section balancing), the bend of the Periadriatic fault is at least half pre-existing to the Adria indentation. Therefore, while the calculation of the differential shortening in different domains seems correct, the conclusions of the manuscript that "Adriatic indentation into the Eastern Alps is responsible for most, if not all, of the 75 km sinistral offset along the NGF" would not be justified.
Please explain and insert some citation of papers from which the Late Oligocene shortening direction is taken.

Fig. 13. See previous comment to the late Oligocene shortening direction.
In figure 13 the sense of movement of SV and TC remains unchanged from a) to c). However, the indicated Late Oligocene shortening direction requires a dextral strike-slip kinematics of the SV and TC. In addition, the post Eocene CCW rotation of Adria relative to Europe casts doubts on the sketch of Fig. 13, where since the Late Oligocene the structures are shifted to the north, while their orientation remains fixed.

Comments to the Supplementary material:
Balanced cross sections along the Giudicarie Belt (Southern Alps, Northern Italy) in 3-D Move

p. 7:
Figure A1.9: The small red arrows indicating the kinematics of the faults with apparent downthrow of the hanging wall show a reverse kinematics. Is this the result of a partial inversion of the faults or of the stratigraphic dip subparallel to the faults?

Figure A1.10: The trace of the Cross section 14 in Fig. A1.1 seems truncated on its western part. As a consequence, I am not able to understand if the fault in the mid of the cross section is the Schio-Vicenza fault or another normal fault (the Paleogene graben-bordering Castelvero fault?).
The small red arrows indicating the kinematics of the faults show uplift of the hanging wall relative to the footwall, exactly the contrary of the stratigraphic offset.

Fig. A.12: see comment to Fig. 7 of the manuscript.

p. 9: A1.3 Description of Cross section 5 second line: Cross section 5 instead of 6.

I hope these comments are helpful, and I look forward to seeing the paper published in revised form

Dario Zampieri (Padova, Italy)