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SHORT NOTES

Inherited structures in the hangingwall of the Valsugana Overthrust (Southern Alps, Northern Italy)

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Abstract—In the hangingwall of the Valsugana Line (north side), the most important Neogene overthrust of the Venetian Alps, two major palaeostructural pre-thrusting elements are recognizable, the Atesina Platform to the west and the Carnico-Bellunese Basin to the east. These palaeostructures, which are oblique to the overthrust, are demonstrated by variations in thickness of the sedimentary cover. The present structural framework of the hangingwall of the Valsugana Line, with the crystalline basement more uplifted toward the west, is genetically related to these pre-thrusting Permo-Mesozoic structural elements. The apparent variation in throw along the Valsugana Line is mainly a result of these palaeostructural geometries, and was not, for example, produced by a lateral hangingwall ramp.

INTRODUCTION

PALINSPASTIC restorations of thrust belts need to take into account possible complexities of the pre-deformational geometry, such as horst and graben structures (highs or lows). This can be difficult, so that researchers are often forced to assume a very simplified pre-deformational medium (i.e. a tabular and isotropic one), or they are restricted to restoring those parts of thrust belts where an isotropic layer-cake medium existed prior to deformation.

The aim of this note is to describe an example from the Italian Southern Alps, where both the position and the present geometry of a major thrust structure are strictly controlled by the regional palaeostructural setting.

REGIONAL GEOLOGICAL SETTING

The example we have chosen is the Valsugana Line, one of the most important structures within the Southern Alps (Fig. 1). This region is currently considered to be the southern branch of a Neogene 'megaflower' structure (Laubscher in press) formed by dextral transpressive movement along the Insubric Line. In this view, the Valsugana Line is the main south-directed thrust within this megaflower structure. The youngest sediments involved in the Valsugana thrust are of Tortonian (Late Miocene) age (Venzo 1940).

The Valsugana Line can be traced eastward from just south of Trento, striking N50–60°E to eastern Cadore, where it branches onto the Fella–Sava Line, an E–W dextral Neogene transpressive fault (Doglioni in preparation). In the Valsugana area proper (Figs. 1 and 2, Section A), the Valsugana Line thrusts the Palaeozoic basement (phyllites, paragneiss, granite) over the youngest (Miocene) terrains of the sedimentary cover. To the east, from Agordo to Cadore, at about the same elevation, the oldest outcropping overthrust rocks of the hangingwall belong mostly to the lower sedimentary section (Upper Permian, Middle–Lower Triassic, Figs. 1 and 2, Section B). Along the cross-sections of the Valsugana Line, both in the hangingwall and in the footwall, typical geometries of thin-skinned tectonics are observable (Doglioni 1985), as described elsewhere (Dahlstrom 1969, Elliott & Johnson 1980, Boyer & Elliott 1982). Along the Valsugana Line, flats are particularly localized in the Permian evaporites, at the base and top of the thick Dolomia Principale formation (Upper Triassic), and within and at the top of the Cretaceous marly pelagic limestone (Doglioni 1985). A major flat is apparently also present in the basement (Fig. 2, Section A). The Valsugana Line is bounded to the south by a large box-fold structure with a broadly constant structural height. Assuming a mean inclination of the thrust plane of about 30–40°, a conservative estimate of shortening is 8–10 km. This does not take into account the possible doubling of the sedimentary cover within the footwall of the Valsugana Line itself, or along a major flat of the Valsugana Line in the upper crust below the Dolomites, factors which could increase considerably the true magnitude of the displacement (Fig. 2).

PALAEOSTRUCTURAL SETTING

Several palaeostructural features characterize the area of the Venetian Alps cross-cut by the Valsugana Line. Among the most important are (a) Mesozoic structural highs and lows, (b) a volcano-tectonic complex of Permian age (the so-called 'Bolzano porphyric plateau') bounded by a hinge fault and (c) several Triassic structures, including normal faults, overthrusts, transcurrent faults, flower structures, diapirs and fault-bounded troughs, (Castellarin *et al.* 1980, Castellarin & Vai 1982, Bosellini 1984, Doglioni 1984 a & b). It is well known that the Venetian Alps, which are cut into two

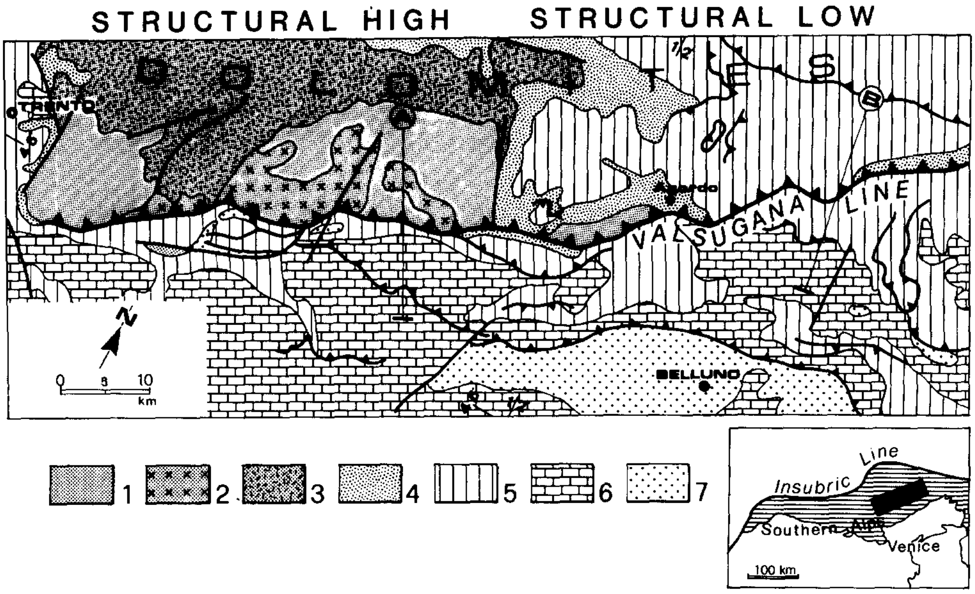

Fig. 1. Schematic geological map of the region cross-cut by the Valsugana Line (Neogene overthrust of the Southern Alps, Northern Italy). On the left side of the figure, in the hangingwall of the Valsugana Line (north side), the basement crops out (Hercynian metamorphic and granitic rocks, Permian ignimbrites), while on the right side of the figure younger formations of the sedimentary cover crop out. This is due to pre-existing palaeostructural geometries (cf. Fig. 3): a palaeostructural high to left (Atesina Platform) and a palaeostructural low to right (Carnico Bellunese Basin). A and B are the traces of the cross-section of Fig. 2. Basement: 1, Crystalline basement; 2, Late Hercynian granitic intrusions; 3, Permian ignimbrites; sedimentary cover: 4, Upper Permian and Lower Triassic; 5, Middle and Upper Triassic; 6, Jurassic and Cretaceous; 7, Tertiary.

blocks by the Valsugana Line, underwent strong differential subsidence throughout the entire Mesozoic (Bosellini 1965). This behaviour produced a pronounced structural low in the east, the Carnico Bellunese Basin, in which 4–5 km of Permian–Mesozoic sediments accumulated; while on the western structural high, the Atesina Platform, the same section is only 2 km thick (Fig. 3). The stratigraphic section of the Atesina Platform is measurable mainly in the northern Dolomites, just north of the geological map of Fig. 1. The hinge line separating the two structural elements runs approximately N–S and now intersects the Valsugana Line at an angle of about 60°.

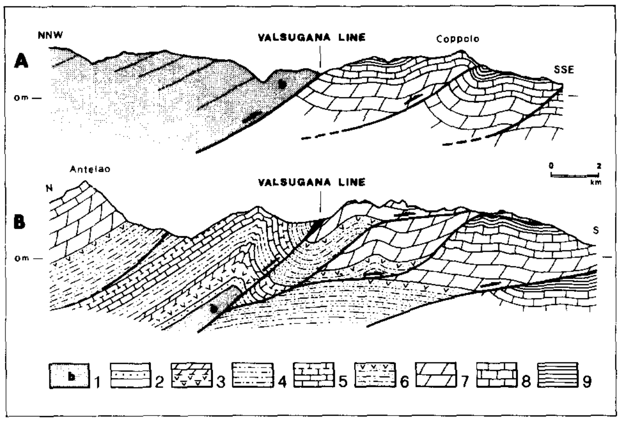

Fig. 2. Cross-sections of the Valsugana Line (see Fig. 1 for location). Note how in section A the basement (b) is more uplifted in the hangingwall of the Valsugana Line than in section B. In section B we can also see a duplex in the footwall of the Valsugana Line. 1, Undifferentiated basement; 2, Val Gardena Sandstone; 3, Bellerophon Formation; 4, Werfen Formation; 5, Anisian and Ladinian formations; 6, Carnian formations; 7, Dolomia Principale; 8, Jurassic limestones; 9, Cretaceous marls and limestones.

PALAEOSTRUCTURAL CONTROL ON THE ALPINE TECTONICS

As stated above, in the Valsugana area proper, a large and thick portion of the crystalline basement is present in the hangingwall of the thrust, while to the east (Cadore) only the Mesozoic cover is apparently involved (Fig. 1). This fact could be ascribed to a differential throw, and consequently a different displacement of the thrust, as would be produced by a lateral hangingwall ramp. An alternative explanation that we present in this paper is that the present framework is linked to pre-existing block-faulting oblique to the later Valsugana Line. We suggest this because the cover thickness on the basement varies inversely with the elevation of the top of the basement. Where the basement surface is lower we find the greatest thickness of sedimentary cover; where it is higher the cover is thinnest. In fact we can observe the following relationship: where the youngest Mesozoic rocks crop out in the hangingwall of the Valsugana Line the sequence is thickest (Figs. 1 and 3). The biggest differential subsidence must have been in the Permo-Triassic.

The height of the basement-cover contact in the hangingwall of the Valsugana Line could be interpreted as a result of a lateral hangingwall ramp, or as an effect of a pre-thrusting horst and graben, but the variation in cover thickness supports the second hypothesis. Moreover it is possible to observe that the thrust surface of the Valsugana Line has a more or less linear trace, without major corrugations (lateral or oblique ramps, Butler 1982), so that it is possible to trace the position of the Valsugana Line at 5–600 m of altitude (intersection of the Valsugana thrust plane with the 5–600 m contour)

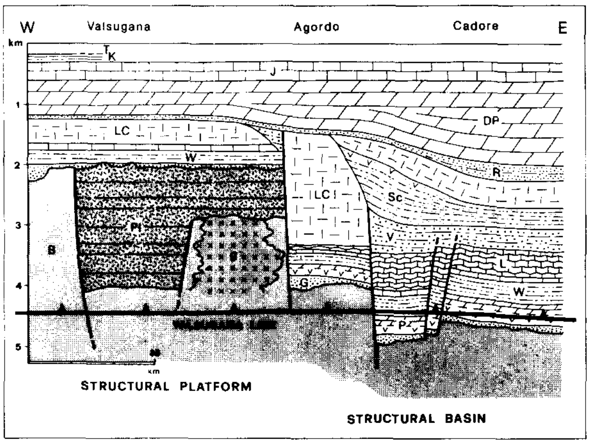

Fig. 3. Palaeostructural cross-section in the hangingwall of the Valsugana Line (normal to direction of transport). Note the structural high to left (Atesina Platform) and the structural low to right (Carnico Bellunese Basin) of the basement that are pre-thrusting geometries. The sedimentary cover is thicker to the right (4–5 km), while to the left it is only 2 km. The Valsugana Line, as it crops out at the present day, at about 500 m elevation, cross-cuts these N–S trending palaeostructures. To the left the Valsugana Line cuts more deeply into the basement, while to the right it enters the sedimentary cover. This is clearly visible on the geological map (cf. Fig. 1.). The stratigraphic throw is therefore the same in both areas, and the crustal shortening could be about the same along the entire Valsugana Line. Minor palaeostructures are present along the hinge between the major high and low. Grey, metamorphic basement (B), associated granites (g) and Permian ignimbrites (Pi); sedimentary cover, G, Val Gardena Sandstones; P, Bellerophon Formation; W, Werfen Formation; L, Livinallongo Formation; LC, Ladinian and Carnian carbonate platforms; V, volcanics and volcanoclastic sandstones; Sc, S. Cassiano Formation; R, Raibl Beds; DP, Dolomia Principale; J, Jurassic; K, Cretaceous; T, Tertiary.

on an E–W stratigraphic section (Fig. 3). The stratigraphic throw of the Valsugana Line appears to be the same (about 4 km) along the entire structure (Fig. 3). The two major palaeostructures (Atesina Platform and Carnico Bellunese Basin) can be clearly recognized in the hangingwall of the Valsugana Line (Fig. 1). The thrust cuts deeply into the basement to the west, while to the east minor Triassic structures like the Primiero fault, the Agordo high and the Cadore trough are present, so that the position of the thrust within the formations changes. As the palaeostructures intersect the Valsugana Line at an angle of about 60°, the line must have offset the Atesina Platform towards the SSE, partially thrusting the platform onto the adjacent basin. The Valsugana thrust, together with a branch-thrust to the south (Belluno Line), could also have considerably disrupted the original spatial relationships of the shallow-water carbonates (Trento Platform) and of the deeper water carbonates (Belluno Trough, Winterer & Bosellini 1981).

CONCLUSIONS

The Valsugana Line is an important Neogene thrust in the Venetian Southern Alps. Its present geometry is the result of an inherited palaeostructural setting carrying a palaeo-high (Atesina Platform) and its adjacent palaeo-low (Carnico Bellunese Basin) toward the SSE. The comparison of the geological map and of the thickness of the sedimentary cover in the hangingwall of the Valsugana Line (Figs. 1 and 3) supports this statement. To the west the Valsugana Line overthrusts a thick slab of crystalline basement, which was a high prior to Neogene displacements (Figs. 1 and 3), while at the same elevation to the east the line is entirely within the sedimentary cover. Taking into account the differential thickness of the sedimentary cover in the hangingwall of the Valsugana Line (about 2 km on the high, 4–5 km in the basin), it is clear that its stratigraphic throw is approximately constant on both the western and eastern sectors. A conservative estimate of the shortening along the entire structure is in the order of 10 km. Finally the Valsugana Line has probably offset dextrally the originally N–S facies boundary of the Jurassic palaeogeographic domains.

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REFERENCES

Bosellini, A. 1965. Lineamenti strutturali delle Alpi Meridionali durante il Permo-Trias. *Mem. Museo St. Nat. Ven. Trid., Trento* **15**, 1–72.

Bosellini, A. 1984. Progradation geometries of carbonate platforms: examples from the Triassic of the Dolomites, northern Italy. *Sedimentology* **31**, 1–24.

Boyer, S. E. & Elliott, D. 1982. Thrusts systems. *Bull. Am. Ass. Petrol. Geol.* **66**, 1196–1230.

Butler, R. W. H. 1982. The terminology of structures in thrust belts. *J. Struct. Geol.* **4**, 239–245.

Castellarin, A. (Ed.) 1981. *Carta tettonica delle Alpi Meridionali alla scala* 1:200.000. C.N.R., Progetto Finalizzato Geodinamica, No. 441.

Castellarin, A., Lucchini, F., Rossi, P. L., Simboli, G., Bosellini, A. & Sommavilla, E. 1980. Middle Triassic magmatism in the Southern Alps—II. A geodynamic model. *Riv. It. Paleont. strat., Milano* **85**, 1111–1124.

Dahlstrom, C. D. A. 1969. Balanced cross-sections. *Can. J. Earth Sci.* **6**, 743–757.

Doglioni, C. 1984a. Triassic diapiric structures in the central Dolomites (northern Italy). *Eclog. geol. Helv.* **77**, 261–285.

Doglioni, C. 1984b. Tettonica triassica transpressiva nelle Dolomiti. *Giorn. Geol.* series 3, **46**, 47–60.

Doglioni, C. 1985. The overthrusts in the Dolomites: ramp-flat systems. *Eclog. geol. Helv.* **78**, 335–350.

Elliott, D. & Johnson, M. R. W. 1980. The structural evolution of the northern part of the Moine thrust zone. *Trans R. Soc. Edinb. Earth Sci.* **71**, 69–96.

Laubscher, H. P. in press. The late Alpine (Periadriatic) intrusions and the Insubric Line. *Mem. Soc. Geol. It.*

Venzo, S. 1940. Studio geotettonico del Trentino meridionale-orientale tra Borgo Valsugana e M. Coppolo. *Mem. Ist. Geol. Univ. Padova*, **14**, 1–86.

Winterer, E. L. & Bosellini, A. 1981. Subsidence and sedimentation on Jurassic Passive continental margin, Southern Alps, Italy. *Bull. Am. Ass. Petrol. Geol.* **65**, 394–421.