Atti Accademia Nazionale dei Lincei

Classe Scienze Fisiche Matematiche Naturali

Rendiconti

Maurizio Gaetani, Flavio Jadoul

The structure of the Bergamasc Alps

Atti della Accademia Nazionale dei Lincei. Classe di Scienze Fisiche, Matematiche e Naturali. Rendiconti, Serie 8, Vol. **66** (1979), n.5, p. 411–416.

Accademia Nazionale dei Lincei

<http://www.bdim.eu/item?id=RLINA_1979_8_66_5_411_0>

Atti della Accademia Nazionale dei Lincei. Classe di Scienze Fisiche, Matematiche e Naturali. Rendiconti, Accademia Nazionale dei Lincei, 1979.

SEZIONE II

(Fisica, chimica, geologia, paleontologia e mineralogia)

Geologia. — *The structure of the Bergamasc Alps* (*). Nota di MAURIZIO GAETANI e FLAVIO JADOUL, presentata (**) dal Socio A. DESIO.

RIASSUNTO. — Le Alpi Bergamasche sono costituite da un insieme di grandi embrici accavallati l'uno sull'altro, con raccorciamenti crostali superiori al 100%. Le dislocazioni sono avvenute nell'Eocene superiore–Oligocene inferiore, in corrispondenza della orogenesi Meso–Alpina, ma le strutture più meridionali hanno subito una nuova compressione nel Miocene superiore.

FOREWORD

The Bergamasc Alps are a part of the Southern Alps. They are bounded to the north by the Tonale Fault, while to the south their termination is concealed under recent clastic deposits of the Po Plain. Their north-south extent is about 50 to 60 km, of which the northernmost 10 to 15 km are free from the post-Carboniferous sedimentary cover.

STRUCTURAL PATTERN

Displacement structures are of remarkable size, showing compressed asymmetric folds cut by faults and developed into wide reverse faulting, with gliding of large detached slices and thrust blocks. As illustrated by De Sitter and De Sitter Koomans (1949, [1]), the region is characterized by a N-S succession of structural steps ranging from the pre-Permian basement to the Tertiary sediments, in which the following zones may be distinguished. (Fig. 1).

Orobic Basement. – Comprised between the Tonale and the Orobic Faults. Rocks consist of phyllites, micaschists (composed either of muscovite alone or two kinds of mica, and containing garnet), biotite paragneisses and gneisses of various composition. The northern portion of the crystalline basement outcrops as an extensive monocline. Further to the south the area is characterized by a complex shearing and thrusting, with important reverse faults entrapping wedges of sedimentary cover (Porcile Fault), and thrusting of the basement over sedimentary formations (Orobic Fault). (Porro, 1903 [2]; Casati and Gnaccolini, 1967 [3]; Liborio and Mottana, 1971 [4]).

(*) Istituti di Geologia e di Paleontologia dell'Università di Milano. Piazzale Gorini 15 – 20133 Milano.

Lavoro eseguito nell'ambito dei programmi del Centro di Studi per la Stratigrafia e la Petrografia delle Alpi Centrali del CNR.

(**) Nella seduta del 12 maggio 1979.

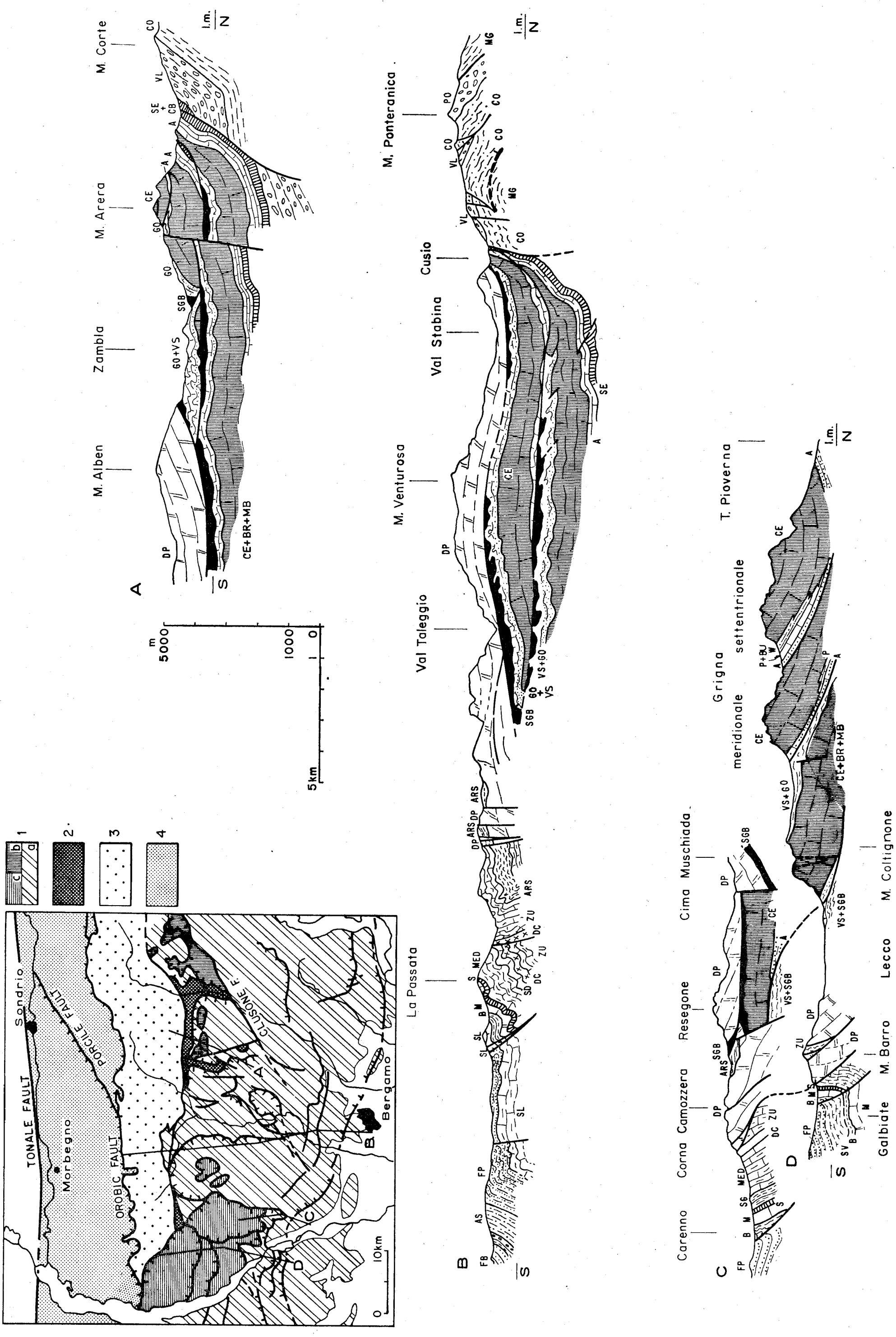
TONALE FAULT
Sondrio
Morbegno
PORCILE FAULT
OROBIC FAULT
CLUSONE F.
Bergamo
10km
M. Alben
Zambla
M. Arera
M. Corte
M. Venturosa
Val Taleggio
Val Stabina
Cusio
M. Ponteranica
La Passata
Carenno
Corna Camozzera
Resegone
Cima Muschiada
Lecco
M. Barro
Galbiate
M. Coltignone
Grigna meridionale
Grigna settentrionale
T. Pioverna
5km

Fig. 1.

Orobic Anticline. – A broad culmination of the basement, covered by a veneer of Permian volcano-sedimentary deposits and of Lower Triassic terrigenous series. The cover appears to have been detached from the basement and presents minor intracutaneous shear structures.

Thrust slices of Valtorta Valcanale. – A pile of variously interrelated, dislodged and upright tilted slices mostly belonging to Middle Triassic rocks. Faulting amounts to a total throw of 0.5 to 3 km, and the tectonized area embraces up to 2 km width. Exposed structures show a 70° to 80° S dipping; as to deeper direction, a northward dip can only speculatively be assumed. In our views, this zone bears a greater significance than pointed out by previous Authors.

"Autochtonous" of Val Vedra-Ardesio. – This zone shows supposedly rooted strips of Middle and Upper Triassic rocks stretching N-S, exposed in a window through Mt. Menna and Mt. Arera—Mt. Secco allochtonous units. From latest mining data (Rodeghiero and Vailati, 1978 [5]) and our field mapping, we are led to assume a lateral continuity of the Vedra—Ardesio unit beneath the allochtonous cover. These autochtonous units are thought to be connected in some way with the succession of thrust slices in the Valtorta-Valcanale zone to the north.

Parautochtonous–Allochtonous of the Prealpi. – Sedimentary succession 5 to 8 km thick ranging from Anisian to Eocene, the largest of the structural zones here considered, extending over an area with an average width of 20 km. The sedimentary cover is totally disconnected from the Val Vedra "autochtonous" or from the Valtorta–Valcanale thrust slices, along shear planes formed by slabs and slices generally of Carnian plastic units (Gorno and S. Giovanni Bianco Formations). The section shows stratigraphic repetitions, considerable decollements, and shearing both in competent Triassic carbonate formations and in plastic Carnian units. The shear plane at the base of Dolomia

Fig. 1. – *Tectonic map and profiles through the Bergamasc Alps.* Tectonic map. 1. *a*) allochtonous and parauchtonous of the Prealpi; *b*) overthrust slices of Arera, Presolana, Timogno; *c*) overthrust slices of Grigne, Resegone, Val Taleggio. 2. Thrust slices Valtorta–Valcanale and "autochtonous" Val Vedra—Ardesio. 3. Orobic Anticline. 4. Southalpine metamorphics.

Profiles. Legend. MG = micaschists and gneisses, CO = Collio Fm., PO = Ponteranica Cg., VL = Verrucano Lombardo, SE = Servino Fm., A = Angolo Lmst., P = Prezzo Lmst., CB = Bovegno Carniola, BU = Buchenstein Fm., W = Wengen Fm., VS = Val Sabbia Sdt., GO = Gorno Fm., SGB = San Giovanni Bianco Fm., DP = Dolomia Principale Fm., ARS = Riva di Solto Shale, MED = Medolo Group, SG = Sogno Fm., S = Selcifero Group, M = Maiolica Fm., B = Bruntino Marl, FP = Pontida Flysch, SL = Sass de la Luna Fm., AS = Sarnico Sdt., FB = Bergamo Flysch.

Principale seems to have played a role of basic importance. In the absence of surface geologic evidence of the subsurface continuation towards south of the allochtony, we will consider the foothill frontal portion as parautochtonous. In the 5 to 10 km wide exposed frontal margin of the Prealpi, the structures are lowered through a series of southward overturned folds and thrust faults, accompanied by short displacement along steep dipping planes. All these structures are more tightly compressed together in the areas where the front of Jurassic rocks, stepping over Cretaceous flyschs, approaches the Orobic anticline, along the Mt. Barro–Bellagio alignment.

Overthrust slices. – The roof of the structural edifice of the Bergamasc Alps consists of totally allochtonous slices, namely the Grigne, Coltignone, Resegone, Muschiada, Val Taleggio slices, and glided top slices of the Arera-Secco-Timogno-Presolana ridge. All these slices are composed of either Mid Triassic to Carnian carbonates units or Dolomia Principale, and lie directly to the south of the Val Torta–Valcanale thrust-sheets zone.

Areal distribution of the Structural Units

Gliding and thrusting are more densely located in the northern portion of the Bergamasc Alps. In the middle area, 10 to 20 km wide, structures are less pronounced. Tectonic effects become important again in the southernmost portion, on the hills facing the plain, with a succession of structural steps, by reverse faulting.

Timing of tectonic Events

From surface geologic data the following succession of events can be inferred.

1) Folding, main faults and thrust slices as in Valtorta—Valcanale, wide reverse faulting. Strike is about E-W, tending to rotate WSW-ENE in the eastern portion. These features as a whole provide evidence of the first main orogenic phase. In the stretch from Chiasso to Como, the Gonfolite Fm. of Early to Middle Oligocene age (Rögl *et al.*, 1975 [6]) unconformably overlies and truncates parauchtoctonous structures of the Southern Alpine margin. On the basis of this evidence displacement phenomena such as faulting, thrusting, and shearing are assumed to have taken place before the deposition of Gonfolite, that is during the Meso-Alpine orogenesis (Trümpy, 1973 [7]).

2) A part of the Grigne-Resegone overthrust was formed later than the Valtorta Fault. This is demonstrated in the edge of Grigna Settentrionale—an allochtonous slice in our views—at Rocca di Baiedo, Valsassina, where the thrust is seen to truncate an offshoot of the Valtorta Fault. The structural history of Grigna Settentrionale, however, seems to be more complex than presented in the interpretations by the De Sitters (1949 [1]) or by De Jong

(1967 [8]). Detachment of sedimentary cover from the basement is undoubtely evident in many places (Casati, 1968 [9]), as well as minor faulting (Francani, 1971 [10]), but their importance alone is not such as to account (Gianotti, 1968 [11]) for the great amount of thrusting and gliding observed on the southern front of the Grigna Settentrionale thrust. Consequently we are inclined to suspect the occurrence of younger orogenic stresses causing the rocks to move again along the Orobic Fault, so that the northern edge of the thrust slice became concealed in the subsurface. More research on this problem is necessary.

3) The Gonfolite, of which the youngest exposed strata belong to the Langhian (Rögl *et al.*, 1975 [6]), is gently tilted and faulted in the area of Como, while the Oligocene Gonfolite outcrop at Briosco, Brianza, is tilted upright to vertical. From subsurface data a new deposition of coarse sediments is indicated along the southern margin of the Bergamasc Alps during Serravallian and Tortonian (Rizzini and Dondi, 1978 [12]). All these facts may provide evidence of a reactivation in orogenesis. This surprisingly coincides with the Neo-Alpine orogenesis (14—to 16 MY).

4) All the above-mentioned structures are cut by a system of mainly faults, trending in a roughly N-S direction. The age of these faults is thought to range from Pliocene to Quaternary, glacial deposits being also involved (Orombelli, 1977 [13]).

SUGGESTED TECTONIC MODEL

The great amount of displacement and the large size of thrust sheets strongly suggest the occurrence of important crustal shortening—over 100 %—in the northern and central portion of the Bergamasc Alps. The gravity tectonic, which is surely present, cannot alone account for the total amount of dislocation displayed under sedimentary cover. Our model, therefore, tends to go further than current interpretations (De Sitter and De Sitter Koomans, 1949 [1]; De Jong, 1967 [8]; Casati and Gnaccolini, 1967 [3]; Francani, 1971 [10]; Rodeghiero and Vailati 1978 [5]). Deformation resulting in up-and over-thrusting, shearing, and gliding of thrust sheets within the sedimentary cover occurred during Late Eocene and Oligocene in the northern and central portion of the Bergamasc Alps, in connection with still more conspicuous movements affecting the Alpine chain to the north (Dal Piaz *et al.*, 1975 [14]). In the framework of this Meso-Alpine orogenesis a sequence of minor tectonic events of local importance can sometimes be recognized. Tectonic displacements appear to smooth towards the south.

From Middle to Late Miocene the existing structures were again subjected to folding and/or thrusting, especially in the southernmost zone where Oligocene Gonfolite strata appear to have been tilted and turned upright. A complete reconstruction of this Neo-Alpine orogenesis in the Bergamasc Alps, however, cannot be attempted with the sole support of surface geological data.

REFERENCES

[1] L.U. DE SITTER and C.M. DE SITTER ROOMANS (1949) – *Geology of the Bergamasc Alps, Lombardia, Italy*. « Leidse geol. Med. », v. 14, pp. 1–257.

[2] C. PORRO (1903) – *Alpi Bergamasche. Carta geologica rilevata dal 1895 al 1901. Scala 1 : 100.000. Note illustrative della carta geologica e delle sezioni*, 30 pp.

[3] P. CASATI and M. GNACCOLINI (1967) – *Geologia delle Alpi Orobie Occidentali*. « Riv. It. Pal. Strat. », v. 73, pp. 25–164.

[4] G. LIBORIO and A. MOTTANA (1971) – *Formazioni metamorfiche sudalpine*. In Note Illustrative della Carta Geologica d'Italia, F. 7 e 18, Pizzo Bernina e Sondrio, 130 pp.

[5] F. RODEGHIERO and G. VAILATI (1978) – *Nuove osservazioni sull'assetto geologico strutturale del settore centrale del distretto piombo–zincifero di Gorno (Alpi Bergamasche)*. « L'Industria Mineraria », v. 27, pp. 298–302.

[6] F. RÖGL, M. B. CITA, C. MUELLER e P. HOCHULI (1975) – *Biochronology of the conglomerate bearing Molasse sediments near Como (Italy)*. « Riv. It. Pal., Strat. », v. 81, pp. v. 81, pp. 57–88.

[7] R. TRÜMPY (1973) – *The timing of orogenic events in the central Alps*. In DE JONG K.A. and R. SCHOLTEN (Ed.) – « Gravity and Tectonics », pp. 229–251, J. Wiley.

[8] K.A. DE JONG (1967) – *Tettonica gravitativa e raccorciamento crostale nelle Alpi Meridionali*. « Boll. Soc. Geol. It. », v. 86, pp. 749–776.

[9] P. CASATI (1968) – *Rapporti tra il basamento cristallino e le formazioni del Permiano presso Introbio in Valsassina (Lombardia)*. « R. Ist. Lomb. », A, (1967), pp. 866–872.

[10] V. FRANCANI (1971) – *Osservazioni sulla geomorfologia e l'idrogeologia del gruppo delle Grigne*. « Geologia Tecnica », v. 18, pp. 71–101.

[11] R. GIANOTTI (1968) – *Considerazioni sul margine settentrionale del gruppo delle Grigne (Lombardia Centrale)*. « Atti Ist. Geol. Pavia », v. 18, pp. 82–101.

[12] A. RIZZINI and L. DONDI (1978) – *Erosional surfaces of Messinian age in the subsurface of the Lombardian Plain (Italy)*. « Marine Geol. », v. 27, pp. 303–325.

[13] G. OROMBELLI (1977) – *Indizi di deformazioni tettoniche Quaternarie al margine meridionale delle Prealpi Comasche*. Gruppo di Studio Quatern. Padano, 3, pp. 25–37.

[14] G.V. DAL PIAZ, V. J. RAUMER, F. P. SASSI and A. ZANFERRARI (1975) – *Geological outline of the Italian Alps*. In C. SQUYRES H. — « Geology of Italy », pp. 299–375, Tripoli.