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Importance of Hercynian tectonics within the framework of the Southern Alps

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Abstract—The Hercynian remnants present within the Alpidic structural zones of the Southern Alps are reviewed. The pattern of Hercynian metamorphism is zonal from granulites in the western area to anchimetamorphic facies in the eastern one. In the folded zone at the eastern margin a severe Hercynian folding phase took place during the Westphalian. Thrust sheets comprising sequences of different facies ranging in age from Caradocian to early Westphalian are sutured by late Westphalian molasse deposits. The assumption that the Southern Alps and the external Dinarides remained outside the Hercynian folding front is contradicted by field evidence.

THE ALPINE FRAMEWORK

IN ORDER to recognise the tectonic structure of the Hercynian orogen in the Southern Alps it is necessary to decipher the structural framework produced by Alpine diastrophism. The Southern Alps are a post-collisional chain about 600 km long and 50–150 km wide (Fig. 1a). They are separated from the Alps (*sensu stricto*) by the Insubric Lineament. This is a major geosuture marked by a set of tectonic lines trending E–W and NE–SW and connecting the Piedmont area in the west to the Dolomites and Karintia in the east. South of the Insubric Lineament different structural zones occur from west to east.

Canavese Ivrea–Verbano zone

The westernmost border of the Southern Alps includes the poorly-known Canavese area and the Ivrea–Verbano structural zone consisting of upper mantle, lower crust and deep crystalline basement. Geophysical and seismic profiles confirm that the crust-mantle boundary is very close to the surface. Its elevation could be the result of either crustal duplication caused by subduction of the European continental margin beneath the African margin (Giese 1979) or dominantly transform motion between the two continental plates along their western N–S contact (Nicolas 1974).

The Lombardian zone

In this zone an imbricated tectonic style is dominant. The structure is produced by E–W trending thrusts in the Mesozoic cover. Thrust planes dip irregularly to the north producing an apparent vergence to the south in most tectonic elements. Within the northern sector of this zone (Orobic zone) the basement is also significantly involved in the deformation. The zone is wide in the east but gradually narrows towards the west, where deformation and shortening are severe (Lecco, Grigna Mountains). This complex was interpreted as an example of gravitational tectonics involving décollement of cover-nappes detached from their basement (De Sitter & De Sitter Koomans 1949), but this hypothesis has recently been re-examined (Gaetani 1979).

The Judicaria zone

The more marked and eastern border of the Adamello massif is dominated by NNE–SSW trending structural systems. Its southernmost termination merges with an E–W trending fold and thrust belt located along the southern border of the same crystalline massif. The southern Judicaria Line consists of three different segments within which structures can be explained only by proposing a vertical uplift of the western area. A décollement style produced by detachment of the Mesozoic cover along the Permo-Scythian plastic horizons has been recently suggested by Castellarin & Sartori (1980) confirming some previous interpretations (e.g. Dal Piaz 1942, Vecchia 1957). Moreover, the classical interpretation of the Judicaria Line (Trevisan 1939) as a deep-seated fault with prevailing strike–slip motion up to the surface and thus across the Mesozoic cover, is no longer tenable because of the substantial continuity of the Upper Permian to Middle and Upper Triassic stratigraphic units across the line. A compressional component through the Judicaria domain (Laubscher 1971, Semenza 1974), independent of the gravitational component, is however assumed in order to explain the strong tectonism and the presence of basement units involved in the thrusts at the northern termination of the Judicaria Line (M. Sabbion Line).

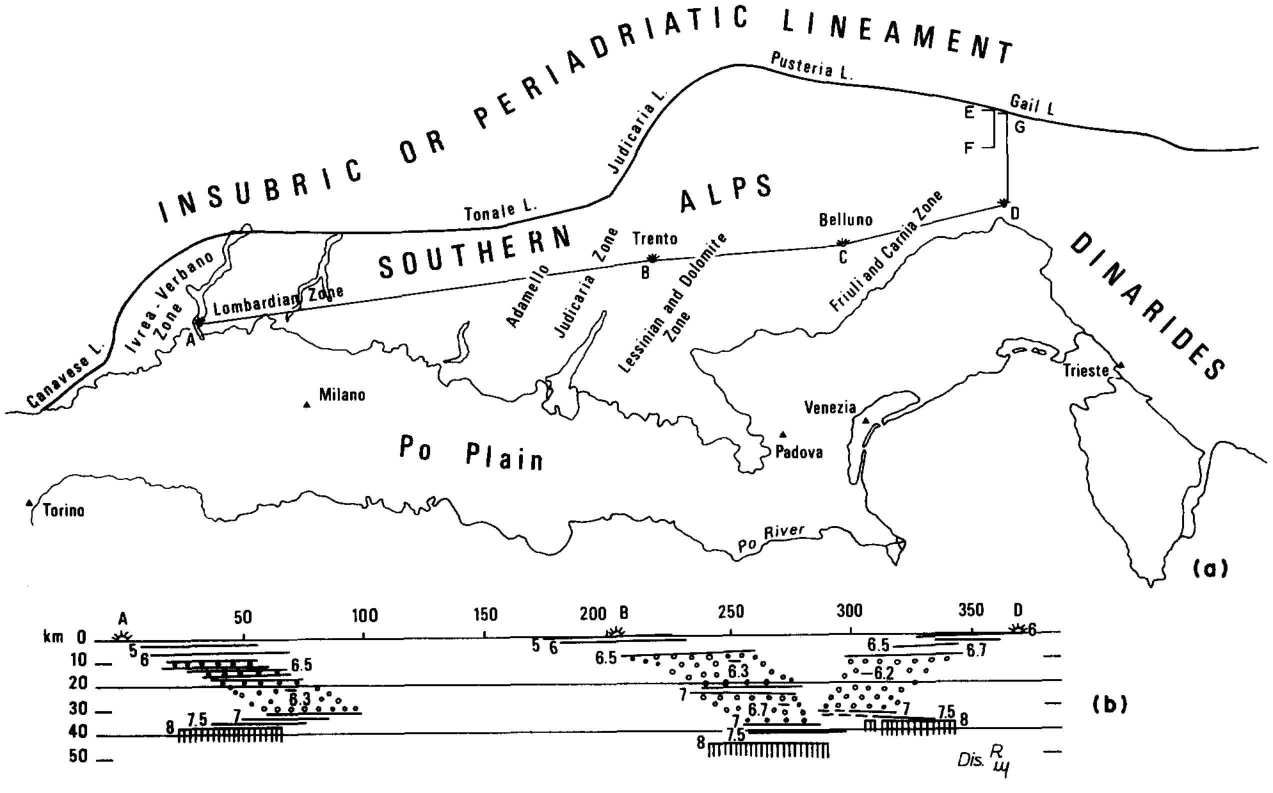

Fig. 1. (a) Location map of different structural zones described in the text with lines of the seismic refraction profiles A–D (the bars E–F and G–D locate the cross sections of Figs. 5 and 4 respectively). (b) Longitudinal cross-section in the form of isovelocity lines showing marked crustal differences. Low velocity layers (dotted) and upper mantle (striped) are outlined (after Colombi *et al.* 1978).

The Dolomites and Lessinian zone

This is the least deformed sector in the whole of the Southern Alpine chain. The most severe displacement occurs along the ENE–WSW trending Val Sugana element where strong deformation and possibly severe shortening occurs. Within the element, metamorphic and plutonic basement rocks override the Mesozoic and Tertiary cover sequence, with local complications related to large gravitational displacements. Additional deformational structures in the Dolomites are a group of small nappe sheets at the tops of the mountains (Gipfel Faltungen) (see Colacicchi 1960, Leonardi 1968), still poorly-known, and the extensional and compressional structures affecting the Upper Permian–Middle Triassic succession of the Dolomites (see Pisa *et al.* 1979). The latter structures, which were usually considered to be not older than Tertiary, are on the contrary of Middle Triassic age, though variously reactivated during later times. The Middle Triassic was a period of intense and widespread magmatic activity which affected the central and eastern Southern Alps, with a variety of volcanic and plutonic products. The volcanics display a common and unexpected calcalkaline and/or shoshonitic affinity, thus indicating possible subduction processes in the mantle (see Castellarin *et al.* 1979).

Nevertheless the general style of the area, encompassing the Dolomites and the Lessini Mountains and hills, is that of only modest deformation and shortening with prevailingly E–W trending elements. As a consequence, in this sector, the Southern Alps attain their maximum width from the Insubric Lineament to the Po plain.

Carnia and Friuli zone

These structural and stratigraphical units, which trend mostly E–W in the Dolomites and Lessini Mountains are distorted and were transported to the east, where the tectonic belt gradually turns into NE trending elements. The maximum deformation and shortening are observed in the central Friuli area where there is extreme imbrication of the E–W trending units. A great number of thrusts dipping to the north, consequently with an apparent vergence towards the south, have been recognized by Selli (1953, 1963) in the Carnian and Julian Alps, and Selli's conclusions have been confirmed in the so-called Bernadia anticline by AGIP wells (see Martinis 1966). In this sector, an attempt at palinspastic restoration indicates a reduction to one third of the former N–S palaeogeographic space, that is a shortening in the sedimentary cover which is much more severe than in the western sector (Dolomites and Lessini Mountains) (Vai 1979, Castellarin 1979). Moreover, the slightly shortened sector of the Dolomites appears as the most expanded, with a frontal side apparently more advanced to the south, whereas the tectonic border in the easternmost sector (the most severely compressed section in the Southern Alps) appears located much more to the north. As a consequence, the tectonic displacement affecting the zone derives from a general under-thrusting of the basement towards the north, producing an apparent overthrusting of the Mesozoic cover in the opposite direction (i.e. to the south) (Castellarin 1979) (Figs. 3 and 4).

Genetic interpretation

Earlier authors considered the Southern Alps as the nearly undeformed backland of the Alps. Since 1960 gravity tectonics has been envisaged as the principal deformation mechanism in the Southern Alps (e.g. Aubouin 1964, Van Bemmelen 1966, 1977, Engelen 1963, Agterberg 1961, De Boer 1963, De Jong 1967, Signorini 1951, Colacicchi 1960, Leonardi 1968, Martinis 1966). Other possible dynamic interpretations stemming from older conceptions (Argand 1924, Dal Piaz 1934, 1942), have been proposed mostly for the Carnian and Julian regions (see Selli 1953, 1963). More recently, Laubscher (1970, 1974) indicated how the Southern Alps could be directly involved in the shortening process, admitting a consumption of continental lithosphere coming from the south. The severe shortening in the cover of the Carnian sector is in good agreement with such an assumption. Furthermore, in a gravity tectonic interpretation other problems arise because the tectonic source areas are generally lacking and the upper crust and cover in the more shortened structures (the areas of tectonic thickening) are relatively thinned (Fig. 1b).

The Southern Alps display a remarkable structural heterogeneity. In fact their extreme eastern and western sectors are similar in general tectonic style and their amount of shortening. By contrast, the wide central sector is weakly deformed and shows a nearly tabular attitude. Such differences agree with their different post-collisional sedimentary evolutions. Only the lateral sectors contained Upper Cretaceous–Palaeogene furrows with thick siliciclastic and turbiditic deposits as well as an external molasse basin. Furthermore, these longitudinal troughs migrated from north to south with the same time-space polarity in both lateral sectors (Fig. 2). These sediment evolutionary trends have been regarded as depending upon the presumed consumption of Southern Alpine lithosphere, whose source and motion were opposite to those of Mesozoic subduction. This would have produced shortening and deformation in the detached upper crust and southward migration of the basinal area (Fig. 3).

The distribution of tectonic deformation throughout the Southern Alps is also rather heterogeneous. Late Oligocene–early Miocene was the time of the main diastrophic event in the western section (marked by the turbiditic and molassic facies of the Gonfolite group). The late Miocene and Pliocene were the times of the strongest movements in the eastern Southern Alps, but nevertheless from the late Cretaceous to the early Late Miocene all Southern Alpine sectors experienced tectonic events at the same time, though with different intensities and effects. A further problem is the longitudinal structural heterogeneity of the Southern Alpine domain (Fig. 1). It is difficult to locate the lines of tectonic separation because N–S trending tectonic boundaries are not usually recognisable in the cover. The alleged discontinuities have to be located beneath the upper crust; unless a continuous increase in underthrusting towards the lateral sectors of the Southern Alps is admitted, without sharp N–S trending tectonic discontinuities.

Finally, the interpretation of the Southern Alpine crustal structure as due to the subduction of the European continental margin beneath the chain (Giese *et al.* in press) seems inadequate if we assume that the Southern

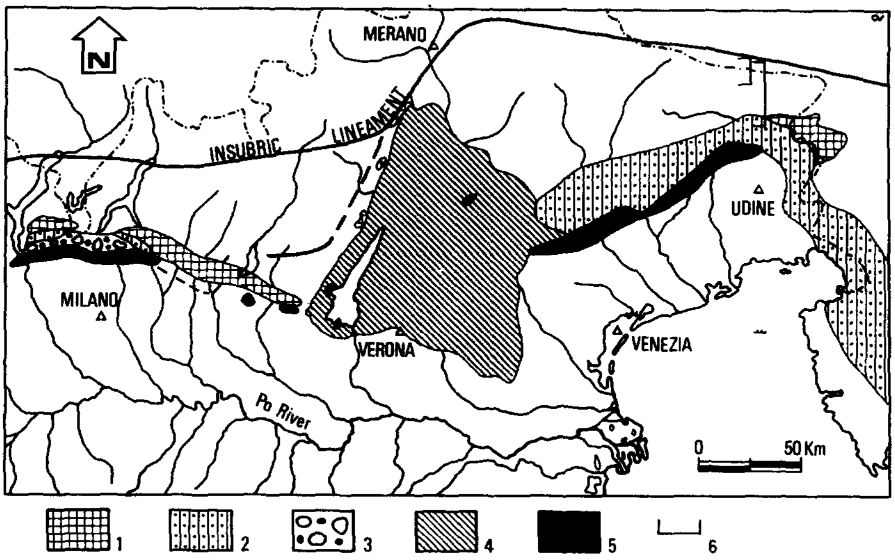

Fig. 2. Upper Cretaceous to Neogene facies distribution in the Southern Alps. 1, Upper Cretaceous Flysch; 2, Eocene Flysch; 3, Late Oligocene to Early Miocene turbidites (Gonfolite); 4, Upper Cretaceous to Lower-Miocene condensed carbonate sequence (structural high); 5, Miocene to lower Pliocene molasse; 6, Location of cross sections of Figs. 4 and 5 (long and short segments respectively).

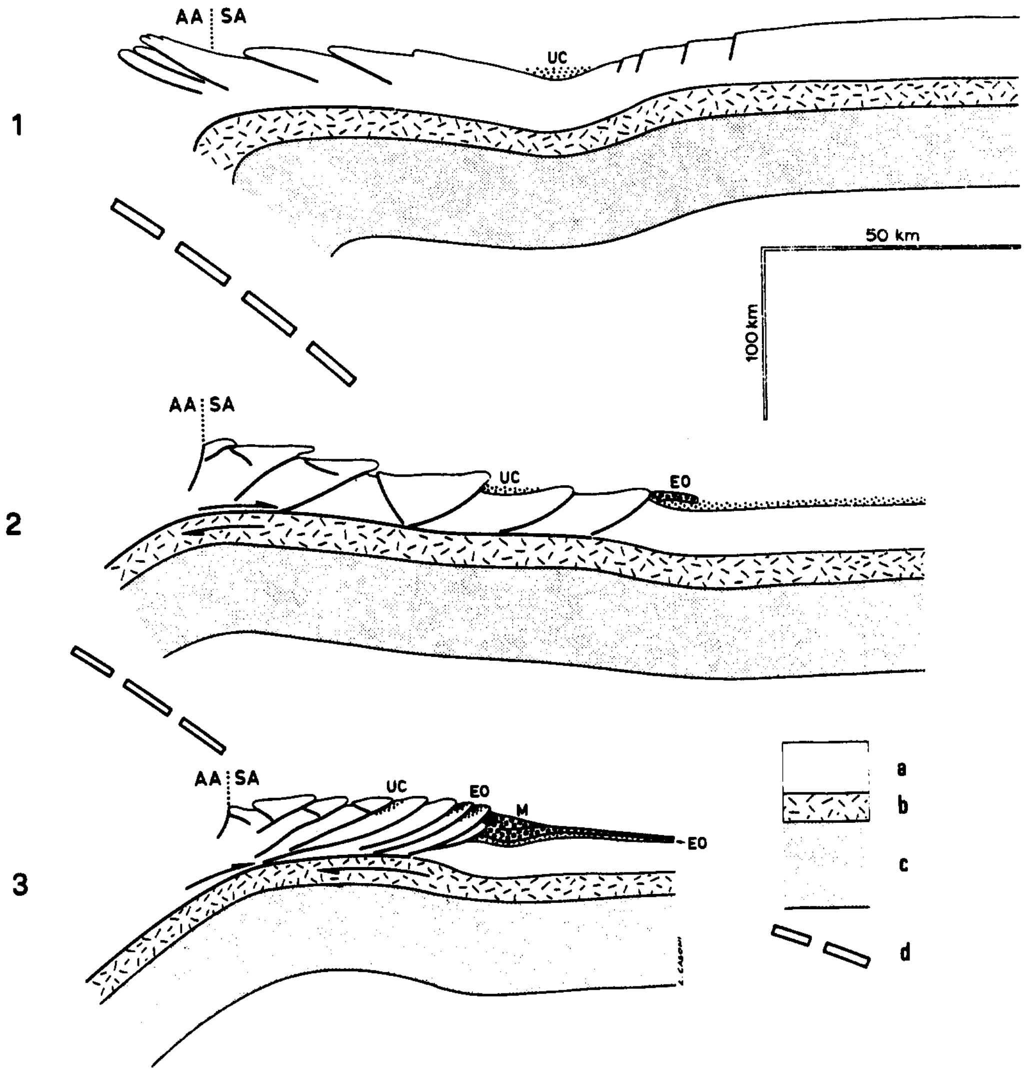

Fig. 3. Hypothetical interpretation of the geodynamic and sedimentary evolution of the eastern Southern Alps. Key: AA, Australpine units; SA, Southern Alps; 1, End of Cretaceous; 2; End of Oligocene; 3, Pliocene; UC, Upper Cretaceous flysch; EO, Eocene flysch and Upper Eocene–Oligocene molasse; M, Miocene molasse. (a) Cover and upper crust. (b) Lower crust. (c) Lithospheric mantle. (d) Mesozoic subduction.

Alps originated by displacement and sinking of lithosphere from the south. Further, the seismic refraction data are consistent with the latter explanation (see Castellarin *et al.* 1980).

THE HERCYNIAN REMNANTS

All the alpidic structural zones of the Southern Alps referred to earlier contain Hercynian or pre-Alpine remnants either as individual nappes or as basement masses attached to the overlying Mesozoic–Tertiary cover, which is not everywhere metamorphic throughout the Southern Alps. The pattern of Hercynian metamorphism shows a rough zonation because there is a trend from granulitic facies in the western area to anchimetamorphic conditions in the eastern or southeastern one (Boriani *et al.* 1976, Vai 1980).

A major problem, however, relates to the age of the metamorphism. Earlier authors claimed a Precambrian age for the Southern Alpine crystalline basement. Radiometric ages obtained during the last ten years cluster around two main groups: (i) one at 500–400 Ma contains dates neither consistent with (Vai 1975) nor related to events supported by independent geological evidence (Vai 1975, Boriani *et al.* 1976, Frank 1978, Bögel *et al.* 1979); (ii) one at 350–250 Ma covers the complete Hercynian cycle. The general picture of Hercynian tectonogenesis and metamorphism is therefore clearly outlined whereas the alleged occurrence of the older metamorphic events is more hypothetical. The Hercynian orogenic belt of the Southern Alps can be subdivided into a metamorphic zone to the west-northwest and a folded zone to the east-south east.

The metamorphic zone

In the Ivrea–Verbano Zone the data show an early metamorphic event around 580–520 Ma and a dominant second metamorphism around 300–285 Ma. (Hunziker 1979). The metamorphic grade decreases from the northwest (granulite facies of lower continental crust with basic to acidic granulites, kinzigitic gneisses, marbles and ultramafic mantle slices at the northwestern margin of the zone) to the southeastern (amphibolite facies); the Hercynian metamorphism is connected with a major tilting responsible for the elevation to the surface of the lower continental crust of the western Southern Alpine basement (Boriani *et al.* 1976).

In the Lombardian Alps (Strona–Ceneri Lakes and Orobic Zone) the amphibolite facies is dominated by paragneisses, orthogneisses, micaschists and migmatites. The greenschist facies prevails in the area between Lake Como and the Adamello Massif (Dal Piaz *et al.* 1975). Important Hercynian folding and shortening is represented by major thrust planes between rock units of different metamorphic grade (Boriani 1976, Boriani & Mottana 1978).

East of the Adamello Massif (Judicaria and Dolomite Zones) the amphibolite facies is restricted to the Val Rendena area in the Judicaria Zone, whereas the greenschist facies underlies all the remaining areas, with metamorphic grade decreasing towards the east-southeast (Boriani *et al.* 1976). Remnants of higher-grade metamorphic rocks within the basement can be regarded as tectonic slices along important Hercynian thrust planes.

This short review of recent data on the Hercynian metamorphism of the Southern Alps emphasizes a radical change in the interpretation of this unit, that is from older views which discarded Hercynian effects in favour of Precambrian metamorphism, to present ideas which recognise Hercynian tectonism and metamorphism in a setting similar to that of Hercynian *Meso-Europa* (Vai 1980). This Hercynian metamorphism may be superimposed on older metamorphic events and be overprinted by Alpine deformation.

The folded zone

The crystalline basement in the western and central parts of the Southern Alps passes laterally into the folded Palaeozoic rocks of the Carnia Zone (part of the Friuli-Carnia Zone) (Fig. 1), made of several epi- or anchimetamorphic to non-metamorphic thrust slices containing Ordovician to Carboniferous sedimentary sequences.

The contact between the crystalline basement and the Carnic Palaeozoic rocks, which is cut by the Insubric Lineament, has been interpreted as being related to either stratigraphic superposition (Sassi *et al.* 1974, Zanferrari in Dal Piaz *et al.* 1975) or lateral transition (Vai 1975, 1976). If the first interpretation is true the Carnic Palaeozoic rocks represent the post-Lower Caradocian cover of a pre-Hercynian metamorphic basement, and if the second interpretation is true the Carnic Palaeozoic rocks are a non-metamorphic equivalent to the crystalline basement, that becomes increasingly metamorphic towards the west, and possibly includes tectonic sheets or slabs as remnants of pre-Hercynian orogenies. The gradual transition between non-metamorphic, anchimetamorphic and epimetamorphic units, the constant decrease of metamorphic grade towards the southeast, and some stratigraphic evidence seem to favour the second interpretation. The first explanation would require that the Hercynian metamorphic zonation should repeat, almost exactly, the pre-Hercynian zonation, a coincidence which appears to be highly unlikely.

The folded zone is the main object of this paper because it is considered to lie outside the Hercynian folding front (Brunn 1967, Argyriadis 1970, Mariotti 1973, Chorowicz 1977, Aubouin 1980). The same assumption has been extended to the external Dinarides, the southeastern continuation of the Southern Alps.

Such a view could be accepted for the Dinarides in the 1960's because of a lack of detailed mapping and stratigraphic knowledge. It is however unacceptable for the eastern Southern Alps, at least since the publication of the classic work on the Hercynian nappes in the Carnic Alps by Gaertner (1931) and the regional syntheses of Selli (1963) and Kahler & Prey (1963).

The so-called Palaeocarnic Range, affected by strong Alpine tectonics, crops out across all the folded zone as a band 10–20 km wide (Fig. 5), limited to the north by the Insubric Lineament and buried to the south beneath a pile of Mesozoic thrust sheets (Frascari *et al.* 1979, 1980, Castellarin *et al.* 1980). The contact between the Palaeozoic Range and its late to post-Hercynian cover is found only within some individual small-scale Alpine units. Detailed field analysis (Fenninger *et al.* 1976, Vai 1976, Vai *et al.* 1980) has shown that this contact is always stratigraphic and represents a classical major angular unconformity (Fig. 6). The view that the whole Permo-Carboniferous molasse of the Carnic Alps represents a large Alpine nappe overlying the Palaeocarnic Range (Argyriadis 1970) is therefore inadequate. The reduced and corrected version of the same hypothesis, as presented by Mariotti (1973), is also not supported by field evidence. Mariotti (1973) divided the Permo-Carboniferous molasse into two units: (i) the Straniger Alm-type unit, unconformably overlying older Palaeozoic rocks and (ii) the Auernig-type unit, interpreted as a large nappe. New field evidence shows that the Straniger Alm unit forms the stratigraphic base of the Auernig unit, or interfingers with the lower member of the Auernig unit (Vai *et al.* 1980). The Permo-Carboniferous molasse of the Carnic Alps (the Southern Karawanken and the external Dinarides) thus does not represent a nappe and its basal contact is primarily stratigraphic. This is still evident despite a tectonic overprint involving both the Hercynian folded basement and the Permo-Carboniferous to Tertiary cover.

Having assessed this critical point we can attempt to restore the sedimentary and structural setting at selected Mesozoic or Late Palaeozoic intervals provided that the Alpine kinematics have been correctly understood from an adequate number of cross sections (Vai 1979, Frascari *et al.* 1979, 1980, Castellarin *et al.* 1980). Figure 5 shows a palinspastic reconstruction of the Palaeozoic Range at the

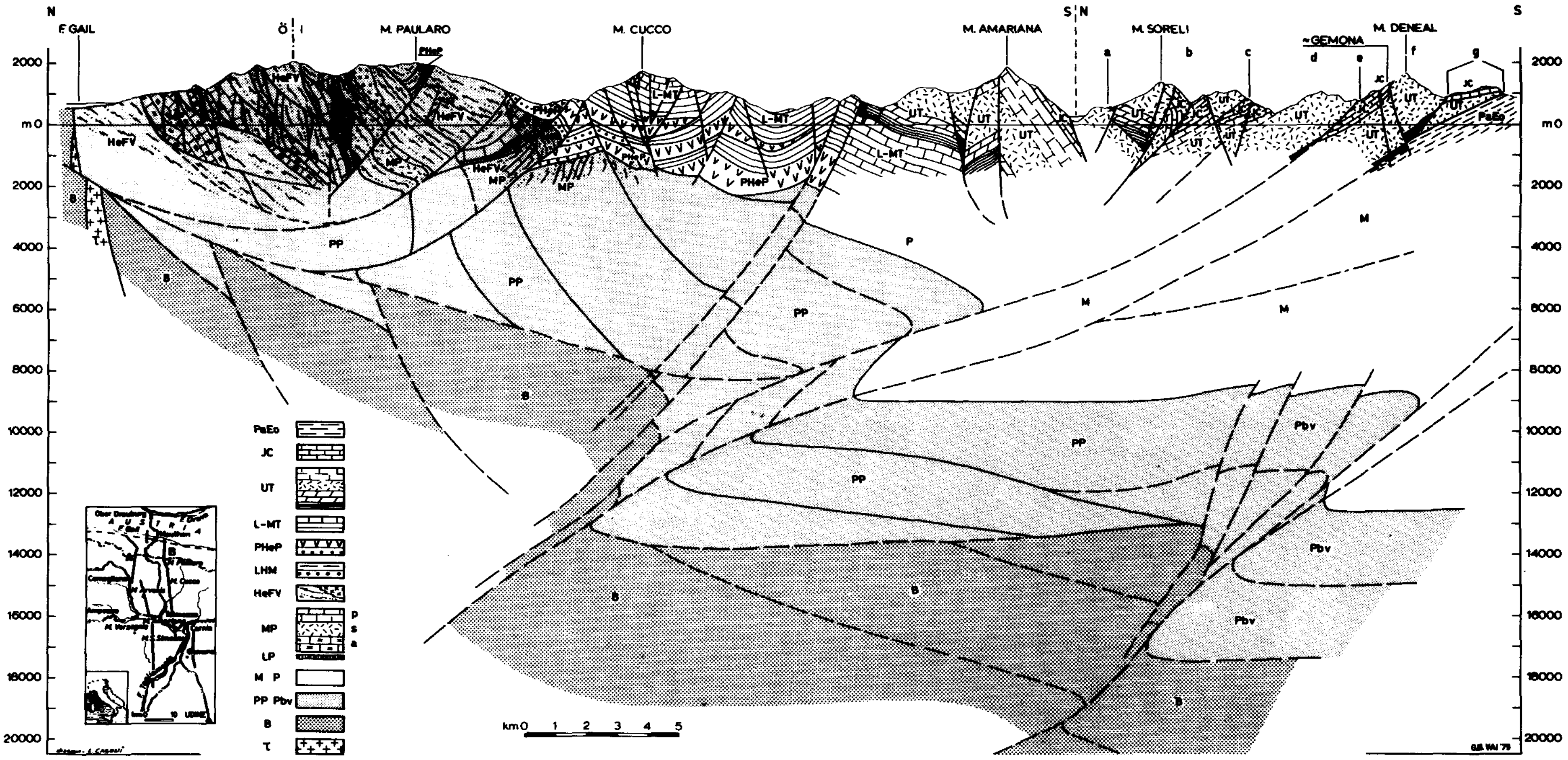

Fig. 4. Profile across the Carnia and Friuli Zones and a tentative deep-structural interpretation. PaEo, Palaeocene and Eocene; JC, Jurassic and Cretaceous; UT, Upper Triassic; L-MT, Lower and Middle Triassic; PHeP. post-Hercynian Palaeozoic; LHM, late Hercynian molasse; HeFV, Hercynian flysch and volcanics; MP, Middle Palaeozoic (p, pelagic radiolarite; s, shallow water; a, anchimetamorphic); LP, Lower Palaeozoic; M. Mesozoic; P, Palaeozoic with Alpine tectogenesis; PP, Palaeozoic with Alpine as well as Hercynian tectogenesis (Pbv, basic volcanics); B, pre-Hercynian (?) crystalline basement; τ, Alpine tonalite.

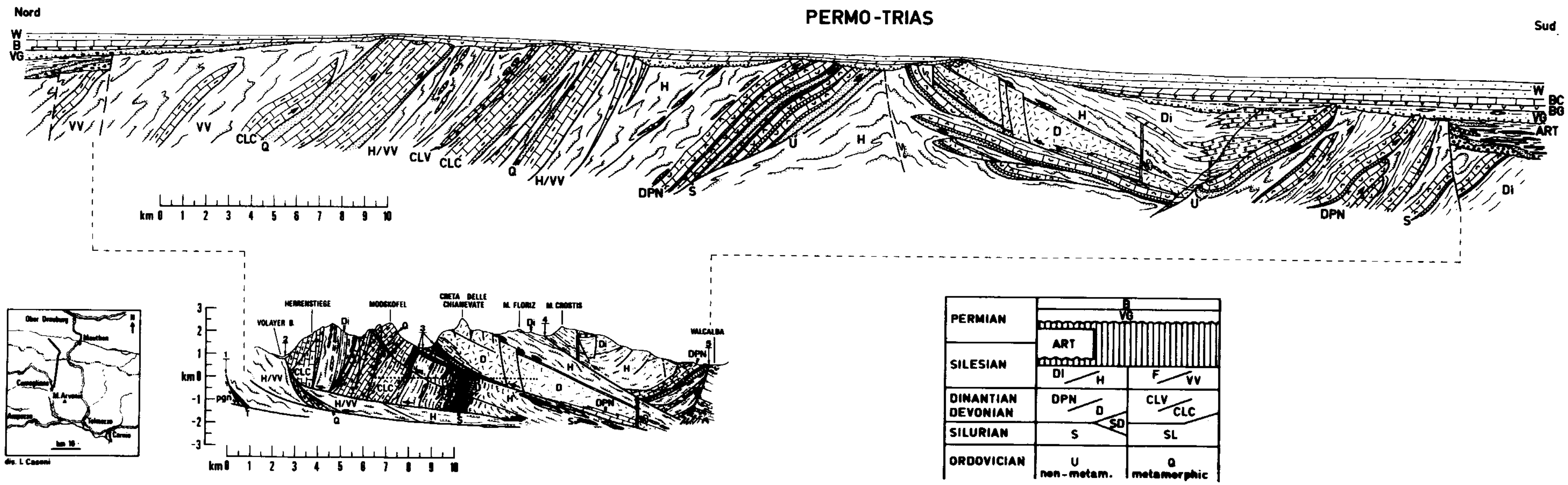

Fig. 5. Palinspastic profile across the Palaeocarnic Range at the Permo-Triassic boundary. W. Werfen Fm. (Scythian); BC-p, Bellerophon Fm. (Permian); BG, Bellerophon Fm, evaporite (U. Permian); VG, Gardena Sandstone (M. Permian); ART, Auernig, Rattendorf and Trogkofel Groups (U. Carboniferous-L. Permian). Non-metamorphic formations: Di, Dimon Fm. (L. Westphalian); H, Hochwipfel Fm. (Namurian-L. Westphalian); DPN, neritic pelagic limestone (Gedinnian-Visean); D, shallow-water limestone (Gedinnian-Frasnian); SD, radiolarites (Silurian–Devonian); S, limestone, marls, shales and cherts (Silurian); U, Uqua Fm. (Caradoc–Ashgill). Anchi- to metamorphic formations: F, Fleons Fm. (L.-M. Carboniferous); VV, Val Visdende Fm. (L.-M. Carboniferous); CLV, varicoloured 'banded' limestones (Devonian); CLC; grey banded limestones (M.-U. Devonian); SL, dark-banded limestones and cherty slates (Silurian); Q, quartzites, schists and sandstones (Ordovician). Numbers in the shorter profile refer to the named Alpine thrust planes (see Frascari *et al.* 1979).

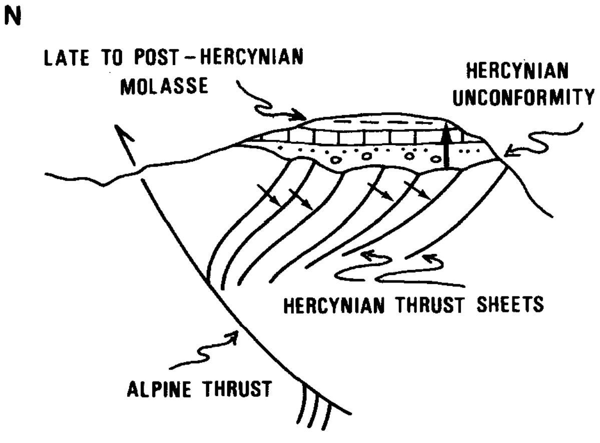

Fig. 6. Sketch of the Hercynian angular unconformity preserved within individual Alpine thrust units. Arrows show stratigraphic polarity.

Permo-Triassic boundary, (Vai 1979), after smoothing out the effects of Alpine tectonics.

The Hercynian tectonic history can be subdivided into two main phases.

Extensional phase. This phase is represented by synsedimentary block faulting, which was active from the Devonian–Dinantian boundary to the Visean, gradually becoming stronger until the end of the Namurian. Some of the faults can still be mapped, having been preserved from the later Alpine overprint. Usually, however, they are indirectly reflected by fault scarps, slope breccias, Neptunian dykes, hiatuses, oliostromes and large olistoliths originating from a shallow-water to pelagic-carbonate platform and deposited in the collapsing flysch basin during the Namurian (Vai 1976). The extensional climax was accompanied by important volcanic to subvolcanic activity starting with keratophiric tuffs and passing rapidly to thick sequences of diabases, pillow-lavas and breccias of alkali–olivine basalt affinity (Marinelli 1975), alternating with volcanogenic turbidites (Spalletta *et al.* 1980). The geodynamic implications of this volcanism have largely been overlooked. The volcanism could be related to large-scale Early Carboniferous strike–slip movements disrupting the Early Palaeozoic Eurafrican plate to allow the development of the later Alleghany–Mauritanid suture (Vai 1976, 1980). The Southern Alpine branch of the Hercynian geosyncline developed upon an ensialic crust possibly close to the western end of one of the narrow sea-ways passing from the east to the Eurafrican plate (Vai 1980). It is assumed that at the end of this phase a Lower Palaeozoic platform sequence from the Carnic Alps (and the southern Karawanken) was detached from its basement at the basin margin and glided into the deeper part of the volcanoclastic basin. This is consistent with the lack of remains of the basement underlying the Ordovician stratigraphic base of each thrust sheet as well as with the parachaotic attitude of large and small Lower Palaeozoic carbonate units floating within the body of the Silesian volcanoclastic flysch.

Compressional (orogenic) phase. Cessation of the large-scale dextral transcurrent motion of different Southern European microplates linked to the motion of the African plate resulted in progressively expanding compressional conditions responsible for underthrusting of the continental crust (Vai 1980). In the folded zone of the eastern Southern Alps this compressional phase started in Westphalian A to B times. It produced important shortening in the sedimentary-volcanic layer at the surface, that is the tightly imbricated south-verging Schuppenbau (Selli 1963, Cantelli *et al.* 1965, 1968, Schönenberg 1970, Vai 1976) as shown in Fig. 5. Almost all the (pre-Caradocian) basement layer, part of which was already depleted of its Palaeozoic cover, disappeared after underthrusting beneath the surficial Schuppenbau. This strong Hercynian folding event in the eastern Southern Alps (Carnic phase, Vai 1975) was accomplished during the Middle Westphalian, as proved by the occurrence of late Hercynian (Westphalian D) molasse deposits suturing the Schuppenbau.

It is tempting to estimate the degree of Hercynian shortening from this orogenic phase. In doing so we can follow a combined facies analysis and geometric approach. On the basis of a pure geometric approach, Vai (1979) estimated a factor of five for the Hercynian shortening in the Palaeozoic Range. Taking into account a minimum shortening factor of three for Alpine tectonics (as independently documented by Castellarin 1979 and Vai 1979), and the present maximum width of the exposed Palaeocarnic Range, which is about 20 km, then the minimum original width of the Carnic Palaeozoic basin would have been about 300 km.

A similar value can be calculated by analysing Devonian facies (Spalletta *et al.* 1980, Vai 1980). The three main Devonian facies of the Carnic Alps are as follows: (1) the reef-complex facies reaching a thickness in excess of 1000 m; (2) the transitional (slope) facies with a thickness of about 100 m and (3) the pelagic (basinal) carbonate to pelitic-radiolaritic facies with a thickness of about 10 m. The maximum width of the largest exposed shallow-water carbonate thrust-sheets of Devonian age is about 4 km. However, because of severe tectonic squeezing and loss (reflected by the dramatic lateral break in a series of shallow carbonate subfacies) we can assume a mean width of 5 to 15 km for the Devonian carbonate build-ups in the Carnic Alps. The compositions of thrust sheets in terms of facies are as follows (weighted mean of surface and subsurface data): carbonate build-ups 10%, carbonate pelagites 70%, and carbonaceous radiolaritic shales 20%. Assuming that the carbonate build-ups were split into two different belts by an intervening pelagic basin (as suggested by important facies differences), the extent normal to the basin axis might be estimated to have been about 30 km for the two shallow carbonate belts, to have been about 210 km for the pelagic carbonates, and to have been about 60 km for the radiolaritic shales.

A minimum shortening factor of five for the Hercynian orogeny is consistently obtained from both approaches. Therefore it seems fully justified to include the eastern part of the Southern Alps (as well as the external Dinarides, Flügel 1975) largely within the Hercynian orogen. Their Hercynian structures are not less intense than those of similar areas within Variscan *Meso-Europa* (Vai 1980). Probably the Hercynian folding front has to be sought very far from the southeastern limit of the Southern Alpine–Dinaric system.

CONCLUDING REMARKS

Examining the relationships between Hercynian and Alpine elements within the chain some points can be stressed. The Hercynian structures display pervasive metamorphism, a character completely absent from areas of Alpine deformation. The Judicarian sector of the Insubric Lineament was severely deformed during the Hercynian movements, with blastomylonite and recrystallised mylonite much more developed than during Alpine geosuturing (Dal Piaz 1942, Morten *et al.* 1977, and new unpublished data). The anchimetamorphic to non-metamorphic Carnian sector displays a tectonic style characterised by imbrication with an apparent principal vergence towards the south. These tectonic features are similar to those of superimposed or adjacent Alpine structures. As to the problem of the main axial trend of the Hercynian belt versus the Alpine trend in the Southern Alps much more research is needed in the different sectors in order to define more completely and properly the whole of the southern Alpine structural system.

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