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SOME SEISMOTECTONIC ASPECTS OF THE ALPAGO-CANSIGLIO AREA (N.E. ITALY)

Abstract. The historical and present-day seismicity of the eastern sector of the Veneto region is analyzed and some hypotheses on the seismogenesis are presented. The activity at the intersection of the easternmost Alpine overthrusts with transcurrent lines, is demonstrated and the neotectonic activity is documented. The maximum seismicity appears connected to the recent deformational front.

FOREWORD

The geological and geophysical characteristics of northeastern Italy were recently studied in order to formulate a seismotectonic model of the region (Slejko et al., 1987) even if in the absence of definite hypotheses about its geodynamical evolution. In particular, some aspects of the seismicity remain poorly correlated with the tectonic setting (e.g. in the Garda zone and in the Veneto plain). For this reason, further detailed studies were done to analyze particular aspects of the seismogenetic processes (e.g. the interference of Alpine and Dinaric structures: Rebez et al., 1988, and the seismotectonic evidence around lake Garda: Slejko e Rebez, 1988).

In this context, the central-eastern Veneto, an important sector connecting the piled structures in Friuli to the "more articulated" structures in the Garda area, remains poorly analyzed due mainly to the lack of good seismological data.

The aim of the present work is to fill in this gap, evaluating all the available seismological information (historical and present-day seismicity, and principal earthquakes, from which detailed aspects of the energy release can be derived) in relation to the tectonic evidence, to produce some reasonable hypotheses on the seismogenesis of the Alpago-Cansiglio area. The analysis of the seismicity was developed taking into account the spatial distribution of the hypocentres, the focal mechanisms of the major earthquakes and the variations in time of the b-parameter.

TECTONIC OUTLINE

The studied area (Fig. 1) belongs to the external sector of the Southern Alps (Castellarin, 1984); this was the last zone to be involved in the collisions of the Alpine chain. It represents a passage zone between two different structural systems: the Valsugana system in Veneto, and the Tagliamento in Friuli (Slejko et al., 1987).

The tectonic style is characterized by south-verging overthrusts and folds with variable

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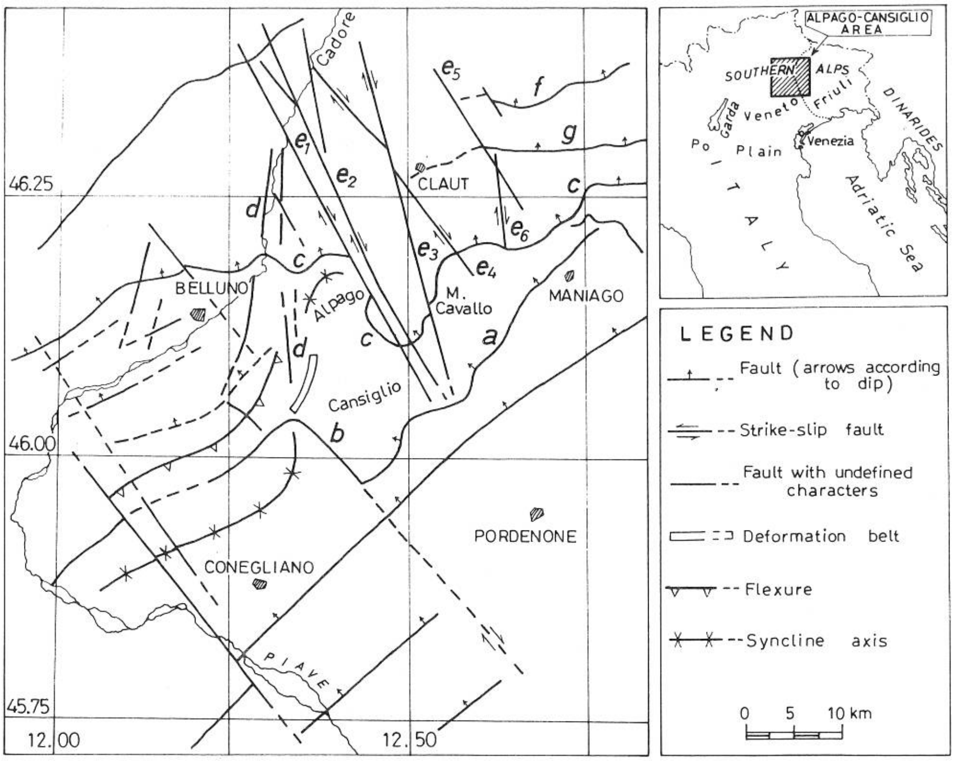

Fig. 1 — Neotectonic sketch of the study region (from Zanferrari et al., 1982); small letters refer to the structures cited in the text.

direction from NE-SW to E-W. They are cut by transcurrent faults of NW-SE trend. The paleogeographic evolution in platforms and troughs, linked to a Jurassic rifting phase, caused various reologic phenomena in the area when it was later affected by compressional events. This is particularly strong in the Cansiglio-Cavallo area (Friuli Platform: Pellegrini e Zanferrari, 1980) where the presence of a long-lived biohermal structure (from Lower Jurassic to Upper Cretaceous) has formed a rigid carbonate unit. The morphologically hard relief separates differently directed structures (SW-NE westwards, E-W eastwards) and limits sections with variable crustal shortening (Castellarin, 1979); a clockwise rotation has been attributed to it (Zanferrari, 1973).

Neotectonic indications show that the deformational front has migrated in time and space according to the direction of the stress field (Ahorner, 1975); this shift to the SSE drives the present front into the buried faults of the eastern Po plain. Considering the Upper Pleistocene-Holocene interval as the most meaningful for seismogenetic analysis, the northern alignments show low or undefined neotectonic activity while the southern ones show large movements.

In detail, the following structures can be recognized from south to north (Fig. 1):

- the Sarone-Aviano line (or Caneva-Maniago line; marked by a in Fig. 1), a subvertical fault that allows the uplift of the Cansiglio-Cavallo area above the plain level;

- the Caorle-Montaner line (Zanferrari, 1973; marked by b), a large fault with right-lateral movement that limits westwards the carbonate massif;

- the Periadriatic overthrust (or Barcis-Starasella line; marked by c), a regional tectonic structure (middle angle overthrust) whose western termination is uncertain (Martinis, 1966;

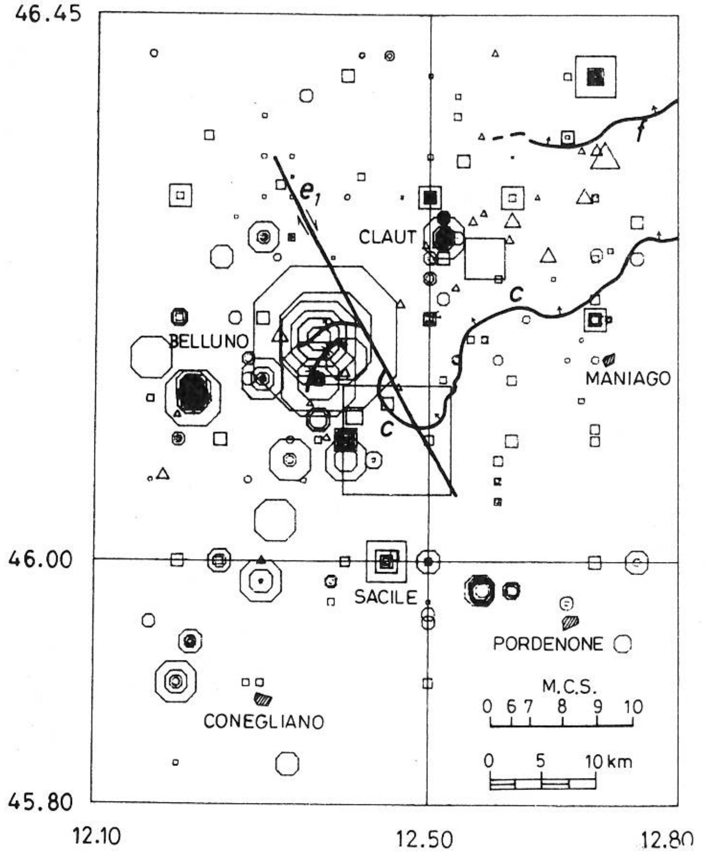

Fig. 2 — Epicentre map of the earthquakes in the area and simplified neotectonic lines. The size of the symbols is proportional to intensity; the shape indicates different periods: octagons = from 1000 to 1930, squares = from 1931 to 1976, triangles = from 1977 to 1984.

Zanferrari, 1974);

- the Longarone graben and the Santa Croce system (Bozzo e Semenza, 1973; marked by d), disjunctive N-S orientated structures;

- Mount Cornetto and neighbouring faults (marked by e1-e6), a system of vertical planes of Dinaric direction that testify to the right-lateral movement in neotectonic times.

Two additional important overthrusts appear eastwards: the Alto Tagliamento line (marked by f) and the Tramonti line (marked by g), and are characterized by north-dipping, low-angle planes. Further structures in the area are neotectonically less meaningful.

HISTORICAL SEISMICITY

The region experienced notable seismicity in the past (see Table 1 and Fig. 2) but the main information generally refers only to the principal towns (Belluno and Sacile). Since the end of the 18th century, the information has become exhaustive. Thus the main seismic crises (in 1750, 1859, 1873, 1892 and 1936) are sufficiently well documented.

A clear alignment of foci NE-SW orientated can be seen in the map of the epicentres of the earthquakes of the period 1000-1984 (OGS; 1987) shown in Fig. 2: this swathe

Table 1 — List of the earthquakes with intensity greater than, or equal to, degree VI MCS in the study area during the period 1000-1984 (obtained from OGS, 1987).

DATE y m d	TIME h m s	COORDINATES lat N	 long E	DEP km	MAG	INT MCS	EPICENTRE
13920128	0030	46°08.4'	12°13.2'			6	BELLUNO
14010629	09	46°08.6'	12°12.9'			6	BELLUNO
14040201	21	46°08.6'	12°12.9'			6-7	BELLUNO
15950714	20	46°08.4'	12°13.2'			6-7	BELLUNO
16900504		46°08.2'	12°13.0'			6	BELLUNO
17501128	22	45°58.5'	12°33.9'			6	SACILE
17501216	2330	45°58.6'	12°33.8'			6	SACILE
17501217	16	46°00.0'	12°45.0'			6	CORDENONS
17501217	2230	45°58.4'	12°33.9'			6	SACILE
17501217	2230	45°58.5'	12°33.8'			6	SACILE
17501217	2230	45°58.6'	12°34.0'			6	SACILE
17501217	2230	45°58.6'	12°33.9'			6	SACILE
17501217	2230	45°58.7'	12°33.7'			6	SACILE
17501218	05	45°58.6'	12°33.7'			6-7	SACILE
17940605	24	46°00.0'	12°30.0'			6	VENETO-FRIULI
18280114	2245	46°00.0'	12°30.0'			6	VENETO-FRIULI
18590120	0755	45°54.0'	12°12.0'			7	BAGOLINO
18590407	23	45°56.0'	12°13.0'			6	VITTORIO VENETO
18590408	23	45°54.0'	12°12.0'			6	COLLALTO
18730629	0355	46°11.0'	12°22.5'			10	ALPAGO
18730630		46°09.0'	12°22.0'			8	BELLUNO
18730702		46°10.0'	12°24.0'			7	PIEVE D'ALPAGO
18730703	0847	46°11.0'	12°22.0'			6	BELLUNO
18730705		46°11.0'	12°22.0'			6	BELLUNO
18730705	0847	46°05.0'	12°24.0'			7	CANSIGLIO
18730706	04	46°08.0'	12°13.0'			7-8	BELLUNO
18730706	0915	46°08.0'	12°13.0'			6	BELLUNO
18730706	0955	46°02.0'	12°19.0'			7	COL VISENTIN
18730707		46°05.0'	12°20.0'			7	CANSIGLIO
18730711	0143	46°11.0'	12°22.0'			7	BELLUNO
18730722	1205	46°11.0'	12°22.0'			7	BELLUNO
18730727	1210	46°11.0'	12°22.0'			7-8	BELLUNO
18730731		46°09.0'	12°18.0'			6	BELLUNO
18730801	0245	46°07.0'	12°22.0'			6	PUOS
18730801	0345	46°07.0'	12°22.0'			6	PUOS
18730801	0455	46°07.0'	12°22.0'			6	PUOS
18730801	0655	46°07.0'	12°22.0'			6	PUOS
18730801	0818	46°07.0'	12°22.0'			6	PUOS
18730808	0715	46°11.0'	12°22.0'			8	BELLUNO
18730821	0905	46°11.0'	12°22.0'			7	BELLUNO
18731012	1055	45°59.0'	12°18.0'			7	VITTORIO VENETO
18731106	0830	46°08.0'	12°13.0'			6-7	BELLUNO
18731120	1855	46°09.0'	12°22.0'			7	PUOS
18731220	0930	46°05.0'	12°24.0'			6	CANSIGLIO
18731225		46°11.0'	12°22.5'			8-9	BELLUNO
18731225	0525	46°09.0'	12°18.0'			7	BELLUNO
18751024	20	46°00.0'	12°15.0'			6	BELLUNO
18780306	0914	46°00.0'	12°15.0'			6	BELLUNO
18831022	0240	45°59.0'	12°18.0'			6	VITTORIO VENETO
18900326	2008	46°16.0'	12°18.0'			6-7	LONGARONE
18920623	2320	46°16.0'	12°31.0'			7	CLAUT
18931027	1631	46°15.0'	12°15.0'			6	LONGARONE
18950227	1538	46°16.0'	12°31.0'			6	CLAUT
18950227	2316	46°16.0'	12°31.0'			6	CLAUT
19041009	0641	46°18.0'	12°30.0'			6	CLAUT
19120805	1033	46°06.0'	12°24.0'			6	CANSIGLIO
19340608	031309	46°18.0'	12°30.0'	20	4.5	6	CLAUT
19361018	031012	46°06.0'	12°27.7'	17	5.6	9	CANSIGLIO
19361018	0725	46°00.0'	12°27.0'			6	CANSIGLIO
19361018	214940	46°00.0'	12°27.0'			6	CANSIGLIO
19361019	070554	46°00.0'	12°27.0'		4.5	7	CANSIGLIO
19370218	0530	46°08.0'	12°13.0'			6	BELLUNO
19390710	162753	46°18.0'	12°12.0'			6	BELLUNO
19550723	035431	46°12.0'	12°42.0'		4.2	6	MANIAGO
19550723	044832	46°06.0'	12°24.0'			6	MANIAGO
19590613	215645	46°15.0'	12°34.0'			7	CLAUT
19590614	2200	46°18.0'	12°36.0'			6	M. CASERINE

collects, over an area of only 35% of the total territory, 85% of the earthquakes of the whole region. It is part of the seismic swathe connected to the present Prealpine deformational belt which connects Friuli to lake Garda (Slejko et al., 1987). Two evident concentrations of earthquakes can be noted: the first in the Alpago area (NE of Belluno) and the second around Claut.

In the Alpago area, the strongest events of the whole region occurred: the 1873 earthquake with epicentral intensity Io of degree X in the Mercalli-Cancani-Sieberg (MCS) scale and the 1936 earthquake with Io equal to IX MCS. Additional low intensity seismicity is not very frequent. Most of the epicentres located around Belluno, due to the scarcity of detailed information, are probably to be referred to earthquakes in Alpago. This area is located close to the Alpago syncline, slightly eastwards of the zone where the Periadriatic overthrust (marked by c in Fig. 2) is cut by the Mount Cornetto fault (righ-lateral transcurrent fault marked by e1).

The Claut area shows a high epicentre density but with low intensity quakes, and it is limited by the Alto Tagliamento overthrust (marked by f) and the Periadriatic overthrust (marked by c) in a zone of NW-SE orientated transcurrent faults (see Fig. 1).

The 1873 Alpago earthquake

The most destructive event in the region occurred on June 29, 1873 (at 3h55m G.M.T.) and destroyed most of the villages in the Alpago valley, causing great damage in Belluno. The duration of the seismic sequence greatly exceeded one year. Accurate time reconstructions and ground effect descriptions are available in detailed reports (e.g. Pirona e Taramelli, 1873).

The analysis of the macroseismic field (Gentile et al., 1985) suggests that the observed maximum intensities (X MCS) were local ground amplifications. Strong ground effects associated to a small mesoseismic area could have been caused by a shallow hypocentre, probably with focal depth not greater than 5 km. The macroseismic epicentre is close to the crossing of the Mount Cornetto vertical fault with the Periadriatic overthrust, and the shape of the macroseismic field tentatively suggests a combined-slip mechanism.

The 1936 Cansiglio earthquake

Another very important event occurred on October 18, 1936 (at 3h10m G.M.T.). Great damage and destruction were reported at the same sites striken in 1873; but even in the southern plain strong effects were recorded (Agamennone, 1937; Andreotti, 1937). The maximum observed intensity reached degree IX MCS and the mesoseismic area greatly exceeded that of 1873 (Barbano et al., 1986).

The hypocentral locations and the source mechanisms of the main shock and of some strong aftershocks have been calculated using the data of the seismographic stations operating at that time in Italy and in neighbouring countries. The arrival times of P and S waves and the first arrival polarities were collected from studies developed ad hoc in the past (Caloi, 1938) and from the European seismological bulletins. The Hypo 71 (Lee and Lahr, 1975) computer program for hypocentre location was used with a two layer crustal model above an half space with thicknesses and velocities in agreement with the data obtained by deep seismic sounding profiles (Italian Explosion Seismology Group and Institute of Geophysics ETH Zurich, 1981).

In Table 2 the results of the relocations, and the parameters of the focal mechanisms are presented. The anomalous arrival times at the Padova seismographic station probably caused the large error in the hypocentral determination of the second event; moreover, the number of recording stations, dependent on the magnitude of the shock, strongly conditions the results. The focal mechanism has been constructed only for the main event and for the largest aftershock. The solution is of the strike-slip type for both the events, with right-lateral movement along a WNW-ESE orientated subvertical plane or left-lateral

Table 2 — Focal parameters of the main events of the 1936 sequence.

DATE y m d	TIME h m s	COORDINATES lat N	long E	DEP km	MAG	GAP	RMS s	ERH km	ERZ km	PLANE A strike/dip	PLANE B strike/dip	T-AXIS strike/dip	P-AXIS strike/dip	B-AXIS strike/dip
19361018	031005.4	46°04.4'	12°28.2'	14.4	5.6	65°	1.1	2.5	3.0	193°/60°	291°/80°	60°/14°	157°/28°	310°/58°
19361018	214954.1	46°17.0'	12°45.3'	11.0	4.3	146°	3.4	19.0	25.9					
19361019	070557.7	46°03.4'	12°28.7'	21.4	4.5	78°	1.8	4.1	4.6	28°/70°	291°/80°	247°/24°	339°/06°	87°/66°

movement along a NNE-SSW orientated subvertical plane.

In Fig. 3 a simplified neotectonic scheme is superimposed on a map with the epicentres of the seismic crisis (till April 1937) and the two available focal mechanisms are reported. The mechanisms are in good agreement with those already known (Ritsema, 1974; Slejko et al., 1987). Most of the epicentres (marked by squares in Fig. 3) are obtained from macroseismic observations and they have little meaning from the seismogenetic point of view as the macroseismic data refer principally to the main towns in the region (Belluno and Sacile). The epicentres of two of the three instrumentally relocated events (marked by octagons in Fig. 3) are very close to each other; the third has a large standard error in the solution. The slight discrepancy (about 4 km) between the macroseismic (marked by a star in Fig. 3; Giachetti et al., 1987) and the instrumental epicentre of the main shock is probably due to the village distribution and to geo-morphological amplification factors.

In the hypocentral zone, three regional structures are expected to cross one another:

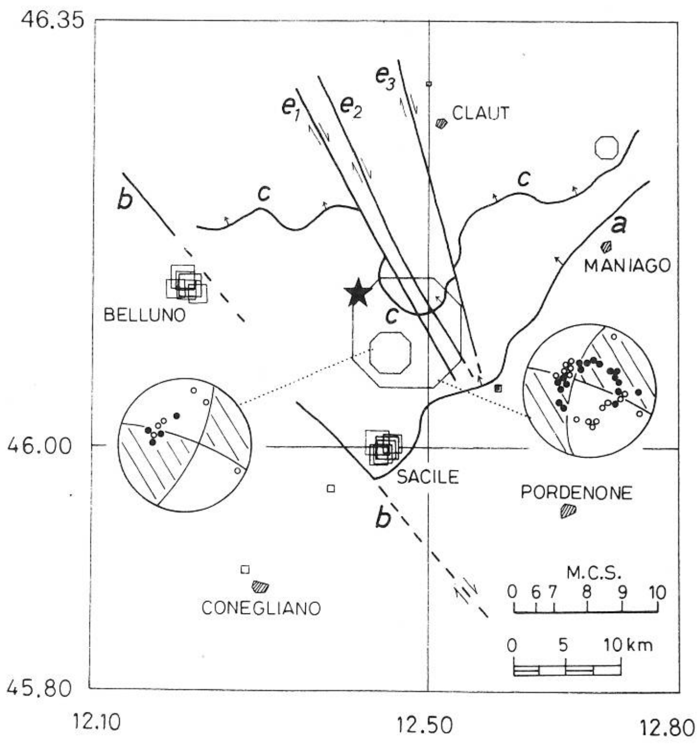

Fig. 3 — Epicentral map of the shocks of the 1936 sequence, simplified neotectonic map and focal mechanisms of the two main shocks (Wulff projection on the lower hemisphere: empty circles indicate dilatation and solid circles compression). Squares indicate macroseismic epicentres, octagons the epicentres obtained by instrumental relocation and the star shows the macroseismic epicentre of the main shock (Giachetti et al., 1987).

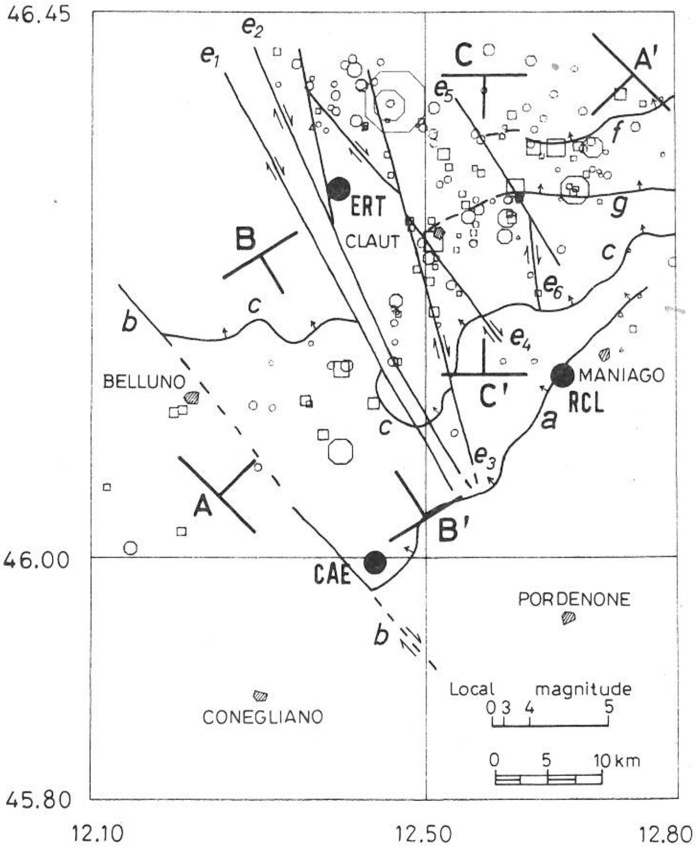

Fig. 4 — Epicentre map of the earthquakes of the period 1977-1986 with main neotectonic lines superimposed and location of the vertical cross-sections constructed. The locations of the OGS stations are marked by circles. Different symbols indicate classes of depth: octagons = earthquakes with depth less than 10 km, squares = depth between 10 and 20 km, triangles = depth greater than 20 km.

the Mount Cornetto fault (marked by e1 in Fig. 3), the Montaner-Caorle line (marked by b) and the Caneva-Maniago line (marked by a). The right-lateral character of the first two cited lines agrees with the solution of the focal mechanisms, even if a weak rotation in the strike direction has to be invoked.

PRESENT-DAY SEISMICITY

The local seismometric network of the Osservatorio Geofisico Sperimentale of Trieste (OGS) has been operating since 1977 in the Friuli region (OGS, 1977-1981, 1982-1986). During recent years new stations have been added for monitoring the whole of northeastern Italy, from lake Garda to the border with Yugoslavia. The earthquakes detected by the local net during the period 1977-1986 are defined in this work as present-day seismicity. Only three seismographic stations (Caneva-CAE, Erto-ERT, Montereale-RCL; see Fig. 4) have been recording in the region since the first installation of the net; for this reason low magnitude seismicity is hardly detected and the accuracy in hypocentral determination is sometimes poor. Presently, four additional stations are recording in the Veneto.

Epicentral distribution

In Fig. 4, the epicentres of the earthquakes of the period 1977-1986 are shown;

different symbols indicate different classes of hypocentral depth. The average statistical errors are about 1 km in the epicentre location and 3 km in the depth assessment.

The maximum earthquake during this period was the 4.4 magnitude event of Cadore (Renner e Slejko, 1986) but most of the located quakes had magnitude between 2.5 and 3.0. The seismicity shows a main NE-SW orientation, in accordance with the distribution of the historical seismicity (Fig. 2), and with a notable concentration of epicentres in the northeastern sector; there, some clusters of foci can be seen; for example around Claut from where a secondary alignment towards the NW starts. The seismicity of the Alpago area, seen in the map of the historical earthquakes (Fig. 2), is here less evident.

A correlation between seismicity and tectonic structures was not easy due to the presence of low-angle faults, whose activity could only be investigated with a three-dimensional analysis. The epicentres can be generally related to a probable deep interference between overthrusts and transverse lines; the most notable fit between epicentres and tectonic structures can be seen in the Claut area at the intersection of two transcurrent vertical lines with the Friulian overthrusts. Here, a seismic sequence occurred in the summer of 1986. The three main events had different mechanisms: two of the strike-slip type and the third of the dip-slip type related to a reverse fault (Renner e Slejko, 1986). Further quakes in the westernmost Piave valley had a strike-slip mechanism (Slejko et al., 1987).

The hypothesis about the activity of the southernmost overthrusts (Caneva-Maniago and/or Periadriatic lines) is supported by the distribution in classes of depth of the earthquakes NE of Claut (see Fig. 4), and their genesis on N-NW dipping planes can be tentatively suggested.

Depth distribution

To analyze the deep distribution of the seismicity, vertical cross-sections have been constructed using the present-day earthquakes (circles in Fig. 5). The sections are narrow enough to allow correlations with the main tectonic elements, to which they are tentatively considered normal. The main historical earthquakes (the events of 1873 and 1936) are marked in the transects by squares. Surface tectonic data (reference letters in Fig. 4) are derived from the literature (Castellarin, 1981; Zanferrari et al., 1982; Slejko et al., 1987). Where a reasonable prosecution in depth is recognized from the hypocentral distribution, a numbered line indicates the tentative geometry of the structure.

In Fig. 5, three transects (for their location see Fig. 4) are presented as examples.

In section AA' (Fig. 5a), four subvertical distributions of shocks in agreement with the geological data (lines from 1 to 4) can be seen. In particular, Line 2 presents a good tridimensional fit with a NW-SE vertical fault (e4 in Fig. 4). The westernmost events could be related to a 50° NE dipping plane (Line 5), consistent with a possible deep prosecution of the Montaner-Caorle line (b in Fig. 4). In the northern sector, the seismicity seems to be confined beneath two curves: the eastern one (Line 8) could be linked to the Alto Tagliamento overthrust, the other (Line 7) could represent the deep continuation of the Tramonti overthrust. Line 6 could be one of the NE-SW orientated lines (Periadriatic or Caneva-Maniago overthrusts, with different hypotheses as to their inclination) whose projection onto a plane parallel to its direction gives a nearly horizontal trace. It is important to emphasise that the inclination on the plot of these last structures is only apparent because of the projection angle: the real inclination agrees with the superficial geological data. Finally, the shallow seismicity (less than 5 km deep) is present only in the northeastern sector, while the carbonate sequence of the southwesternmost Friuli Platform seems to confine the seismicity to deeper layers.

Section BB' (Fig. 5b) crosses the Alpago valley up to the Cansiglio-Cavallo area. It is normal to the NE-SW orientated reverse faults, and the few events that appear do not define any clear trend. The seismicity may be limited downwards by a "spoon-fault"

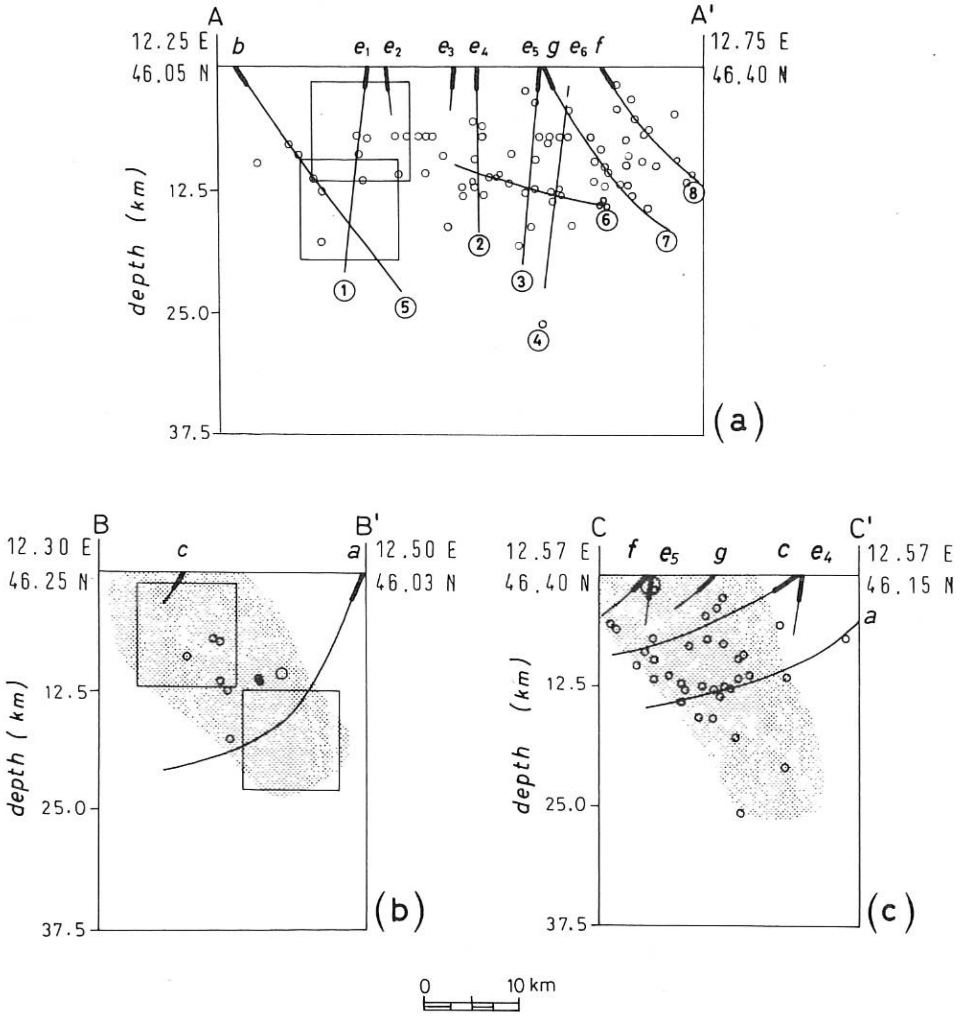

Fig. 5 — Vertical cross sections with 1977-1986 hypocentres (circles); squares indicate the 1873 and 1936 main event foci. Small letters indicate the main structures cited in the text and numbers their supposed deep prosecution. The dotted area emphasizes the deepening of the seismic activity towards the present deformational front.
a) AA' profile, NE-SW orientated, 10 km wide;
b) BB' profile, NW-SE orientated, 8 km wide;
c) CC' profile, N-S orientated, 8 km wide.

hypothesized as the deep continuation of the Caneva-Maniago line. A deepening of the seismic activity (dotted strip) moving towards the external (more recent and more rigid from the geological point of view) deformational front can be postulated.

Section CC' (Fig. 5c) is N-S orientated and placed in the eastern sector of the studied area. The presence of piled overthrusts probably causes an large bias on hypocentral distribution; therefore, it is impossible to evaluate the seismic activity of the individual overthrusts. These planes could be tentatively considered as upward and downward barriers to the main seismicity. Here, the presence of a kind of seismically defined backthrust plane is very clear. As in section BB' (Fig. 5b), the hypocentres become deeper as they approach the plain.

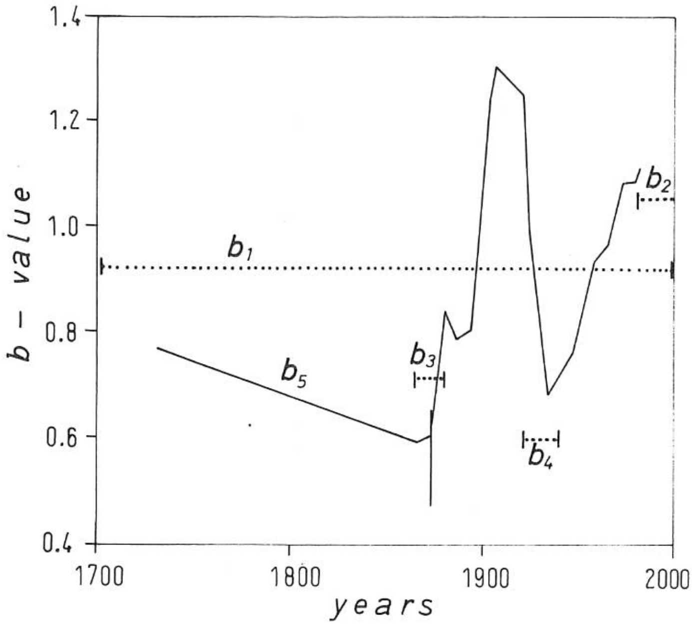

Fig. 6 — b-value variation in time for the period 1600-1984 (b5). Horizontal segments indicate the mean b-value in the quoted periods: b1 = 1600-1984; b2 = 1977-1986; b3 = 1873 sequence; b4 = 1936 sequence.

b-VALUE VARIATIONS IN TIME

The b-parameter in the classical frequency-magnitude relationship (Richter, 1958):

$$log\ N = a - bM,$$

where N is the number of earthquakes with magnitude greater than or equal to M (cumulative distribution), gives the ratio between high and low magnitude events, and it could therefore be considered as a stress indicator (Scholtz, 1968; Wyss, 1973; Pasquale, 1985). Our aim was to compute average b-values for selected periods of time and the time series for the whole interval considered, to verify whether a reasonable hypothesis on the stress accumulation can be supported by the b-values variations.

All the events in the region since 1600 were taken into account, least squares fitting the data referred to magnitude subintervals of 0.2. Magnitude, when not available in the catalogue (OGS, 1987), was calculated from intensity (I) using that relation found to be the most adequate (M = 0.44·I + 1.67 for Central Alps and Po valley; Tinti et al., 1986).

The following four average b-values were computed:

- b1 (historical) = 0.93 + /—0.02: referred to the period 1600-1984, with magnitude range 2.5-6.0;

- b2 (instrumental) = 1.05 = /—0.01: from the data collected by the OGS network in the period 1977-1986, with magnitude range 1.9-4.4;

- b3 (1873 earthquake) = 0.71 + /—0.01: for the period June 29, 1873-December 31, 1874, with magnitude range 3.0-6.0;

- b4 (1936 earthquake) = 0.60 + /—0.02: for the period October 18, 1936-March 31, 1937, with magnitude range 3.0-5.6.

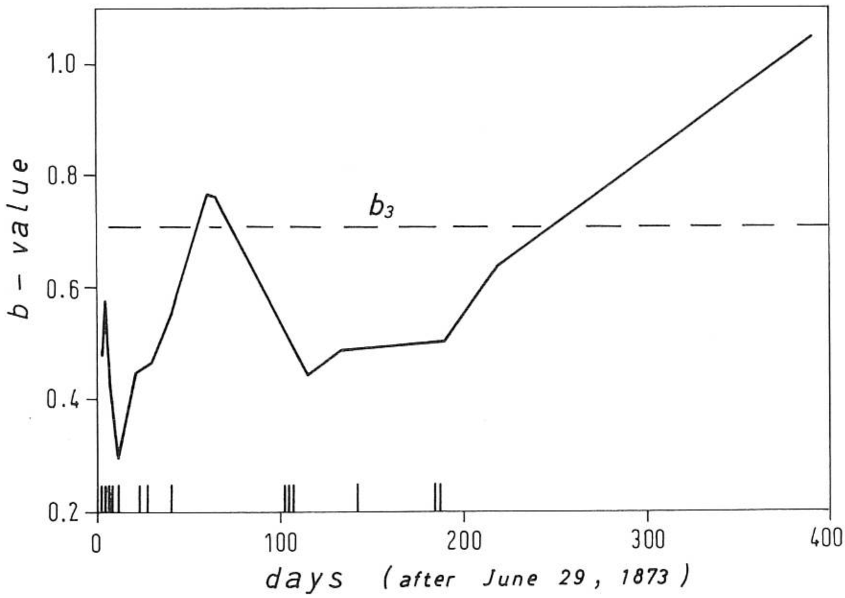

Fig. 7 — b-value variation in time for the 1873 sequence. The horizontal line (b3) indicates the mean b-value for the whole crisis. Small vertical lines on the x-axis represent the strongest shocks.

These values represent seismic activity reference levels. The first and the second are related to the global seismicity, derived from two catalogues of different observation period and accuracy. The third and the fourth are the mean b-values of the seismic sequences.

In addition the b-value variations during the period 1600-1984 (b5) were computed using a 50 sample sliding window with 25 sample overlap. The result obtained is referred to the window centre time. The average values b1, b2, b3, b4 and the curve of the value b5 are shown in Fig. 6.

b-value variation in time b5 agrees with the results obtained for recent Italian aftershock sequences (Pasquale, 1985): after each strong energy release the b-value increases and then decreases to a minimum for the next major event. The absolute minimum does not correspond to the year 1936 but to 1873 due to sampling and smoothing effects: in fact, only 30 events over 50 of the prefixed window are referred to the 1936 crisis. This does not happen in 1873 because this last data set is greater (143 shocks). If we accept the hypothesis that the b-value is related to the stress status, we must attribute more meaning to the average values b1, b2, b3 and b4 than to the time variation b5. In such a view, the lowest b4 value remains associated with a greater strain release than that of the 1873 sequence (expressed by b3). This statement is consistent with the observation that even if the magnitude of the 1873 event is unknown, it could be smaller than that of 1936 (i.e. 5.6) because the latter earthquake had a greater depth (14 km against 2-5 km of the first) associated with a similar area of IX MCS. The b2 value, associated with the present-day seismicity, is larger than that of the whole investigated period (b1), this fact may testify to a "relaxed" situation as persistent consequence of the 1936 earthquake.

In addition, the evaluation of b-value variation in time was also done for the 1873 sequence using a smaller sample window (20 shocks). In Fig. 7, the obtained curve is plotted: small vertical lines on the x-axis indicate occurrences of shocks with intensity greater than or equal to degree VII MCS. It can be seen that minima correspond well to the strongest aftershocks, and a sharp increase of slope underlines the end of the crisis.

CONCLUSIONS

The study area represents the passage zone between Friuli (tectonically extremely deformed and with seismicity related to overthrusts) and the Berico-Lessini Platform (a rigid block in the westernmost Veneto plain with low seismicity). The hypothesis of differential deformational rates in the area is not supported by tectonic or structural evidence, since continuity in the structural lineaments and constancy of the crustal shortening are observed. The changes in seismic style could rather be explained in terms of different geologic behaviour. The historical and present-day seismicity are concentrated in a thin, NE-SW orientated belt corresponding to the recent deformational front.

The historical epicentres (Fig. 2) are more scattered than those of the present-day seismicity. This dispersion is probably due to the low epicentral accuracy. The greatest earthquakes occurred in the western sector (Alpago, Cansiglio), and their focal mechanisms indicate strike-slip displacements on right-lateral Dinaric structures. A shallow focus within the sedimentary cover for the 1873 earthquake and a deeper one for the 1936 shock within the basement, where Alpine and Dinaric lines cross each other, can be hypothized from macroseismic and instrumental data (Figs. 3 and 5). This statement is supported by the characteristics of the b-parameter as stress-indicator (Fig. 6).

The present-day seismicity is concentrated in a narrow belt where good hypocentral determinations fit the positions of some mapped geological structures (Fig. 4). Concentrations of shocks occur near subvertical faults with neotectonic evidence of right-lateral movements and in correspondance to the eastern overthrusts that seem also to limit the seismically active volume (Fig. 5). In the Alpago-Cansiglio-Cavallo area, the presence of the carbonate deposits of the Friuli Platform probably confines the seismicity to deeper layers, causing less frequent and more energetic quakes. To the east the situation is complicated by the piling of low-angle reverse faults and by interference with the seismogenesis of the Friuli region. It is important to underline that, for the whole area, there is a deepening of the seismicity moving towards the external front of the chain; this may testify to the spatial involvement in the deformational front of new volumes.

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