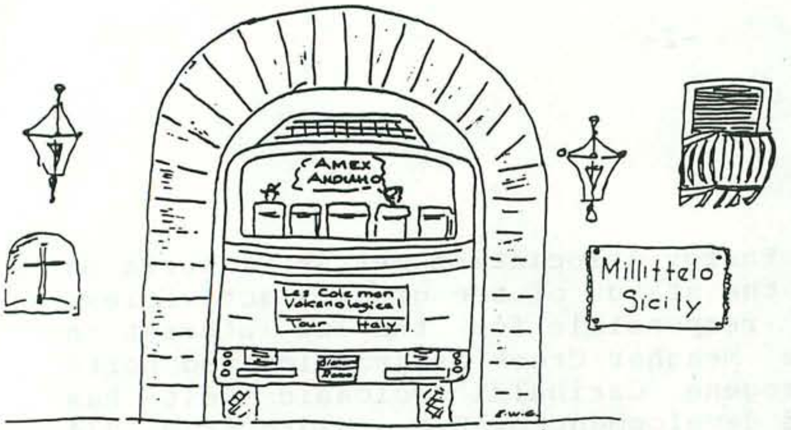

Precizion Driving Was Required on the Italy Tour

Retourno à Catania

*Keep on Driving Philipo!
Meester Coolaman says you have at least Uno cm. to spare*

ASH FALL

Newsletter of the Volcanology Divisior
Geological Association of Canada

ASH FALL # 22

November, 1989

REPORT OF PLANNED ACTIVITIES 1990

1. Publication of a booklet compiling abstracts of the Mount St. Helens Symposium (10th Anniv.) to be held in Vancouver, B.C. (G.A.C. - M.A.C, 1990). Catherine Hickson is organizing this Symposium which is sponsored by the Volcanology Division.

2. Testing a new formula for the selection of the Leopold Gelinas Award. The 1989 winner of the award was Francois Brissette, Universite of Montreal, M.Sc. 1988; runner up was Matthew I. Leybourne, M.Sc. 1988 Acadia University, Volcanism and geochemistry of parts of the Endeavour segment of the Juan de Fuca Ridge system and seamounts.

3. Toronto 1991. A symposium on "Komatiites and Associated Ore Deposits", is in the planning stage.

4. Wolfville 1992. "Advances in the Understanding of Appalachian Volcanic Rocks" is the current symposium title.

5. Preparation of the 1991 Volcanology Division Field Trip. A questionnaire is enclosed with this Ash Fall.

6. Tark Hamilton is again requesting help in compiling Volcanological Work in Canada for the Canadian Geophysical Bulletin. The response to his March 1989 was a DISMAL six replies!

CONFERENCES

Victoria, B.C.

1. Canadian Geothermal Energy Association met in Victoria on April 13, 1989 to discuss the status of the group's activities. A lack of incentives is responsible for the low interest in this energy resource. The Meagher Creek project located north of Vancouver in the Neogene Garibaldi Volcanic Belt has undergone exploration and development by B.C. Hydro from 1974 through 1979 and is now controlled by Canadian Geothermal. Hydro produced power in 1984 on a small scale and proposed to develop up to 400 mega watts (MW) from reservoirs on Nogood and Meagher creeks. New plans rely on possibilites for funding and potential for power sales to B.C. Hydro.

2. Members of the University of Victoria Dept. of Chemistry gathered to hear Prof. Zoller from the University of Washington discuss his studies of volcanic gases since 1970 at a variety of active sites. He described the sometimes dangerous sampling procedures and results using instrumental neutron activation analysis methods. He noted these results compare favourably with older published results. The new methods show how different the suites of trace elements from separate sites are, and the wide range of common to rare elements from each volcano. This year's work entails trips to Reunion as well as other hot spots to test for Ir, Os, etc.

3. A one day symposium on "NE Pacific - North America Plate Interactions", was held on April 21, 1989. Highlight of the talks was Tark Hamilton's extensively researched and documented "Tertiary Extensional Volcanism and Volcanotectonic Interactions Along the Queen Charlotte Portion of the Western Canadian Margin".

Montreal

The Montreal 1989 program included a good number of interesting talks on volcanology and related topics.

Officers and members of the Volcanology Division met on May 17, 1989 to discuss and plan activities for the coming year. It was decided by the members present that:

1. Both M.Sc., and Ph.D. theses would be eligible for the Leopold Gelinas Award.
2. The Gelinas Award will be increased to $250.00 for the best thesis for 1989/90 and subsequently will be awarded on an alternating M.Sc./Ph.D. basis.

3. Councilors nominated to replace outgoing Walter Gibbons and Mike Easton were Paul Wodjak for Western Canada, and Karen Stamatelopoulou-Seymour for Central Canada.
4. The Volcanology Division field trip is biennial - and it is understood that the field area chosen will be to a new area.

Les Coleman who was trip leader on the May 1989 Division Field Trip to Italy summarized the event which included southern Italy, Sicily and the Aeolian Islands. Participants included 18 geologists, 6 wives (1 geologist), and 1 family member. Trip leaders were arranged through Prof. Romano of the Volc. Inst. at Catania. The tour which included a variety of volcanologic features as well as many cultural sites was favoured by excellent weather, well arranged transportation and accommodation, and an interesting variety of food and wine. The main sites visited included Solfatara and Phlegrean Fields, Mount Vesuvius, Herculaneum and Pompeii, Mount Etna, the Ibleans Mountains, Lipari, Volcano, and Stromboli. Nature obliged with warm weather, fields of flowers, fumaroles, volcanism and strombolian eruptions.

CONTRIBUTIONS

A number of abstracts and papers have been received and will be included in this and forthcoming newsletters.

Contributions to Ash Fall are very welcome and should be sent to: E. W. (Ted) Grove, Editor Ash Fall
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Victoria, B.C. V8Y 3A5
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QUESTION - FIELD TRIP 1991

Please send in your answer/preference for the 1991 Volcanology Division Field Trip.

YES	NO	PLACE
		Kenya - Rift Valley
		Greek Islands
		Philippines
		Germany

Costs for the Kenya trip are unknown but expected to be high. For Greece we have an in-house expert. Time is important so please send your choice at the soonest.

of volcanic activity in what may have been an originally more extensive island arc terrane. Stage two records the fragmentation of the arc, with attendant hydrous partial melting of both refractory mantle sources and basal arc crust. Stage three records an early stage of back-arc magmatism with the eruption of alkalic and transitional alkalic/tholeiitic basalts, respectively formed by increasing amounts of partial melting of an oceanic island basalt-type source. Stage four records a more mature stage of back-arc volcanism with advanced partial melting of oceanic island basalt sources and possibly mixing with normal depleted mantle sources. The continued eruption of arc tholeiites at this stage indicates that the back-arc basin was not very wide, and even in the latter stages was still broadly in a "supra-subduction zone' environment.

The four volcanogenic sulphide deposits in the Wild Bight Group include both massive sulphides and stockwork deposits formed during Stage 2, probably as a result of increased fracturing, heat flow and hydrothermal circulation accompanying breakup of the arc.

Comparison of geochemical data from the Wild Bight group with nearby, approximately coeval, volcanic sequences suggests that the environments can be recognized throughout central and eastern Notre Dame Bay and in south-central Newfoundland. Lead isotope studies of volcanogenic sulphide deposits throughout central Newfoundland suggest that deposits in the Wild Bight Group arc had similar lead sources to those in an earlier island arc of late Cambrian age that is represented throughout south central Newfoundland and Notre Dame Bay. This suggests a tectonostratigraphic relationship between them and it is possible that the earlier arc was the basement upon which the later arc was built. Lead isotopes in these sequences are relatively radiogenic and contrast sharply with those in most of the western Dunnage Zone deposits, where relatively non-radiogenic lead is prevalent. This contrast suggests that a major structural boundary may be present along the eastern side of the Buchans - Robert's Arm belt. Sequences on either side of this boundary may represent different tectonostratigraphic terranes, juxtaposed during the late Ordovician or early Silurian.

TERTIARY EXTENSIONAL VOLCANISM AND VOLCANOTECTONIC INTERACTIONS ALONG THE QUEEN CHARLOTTE PORTION OF THE WESTERN CANADIAN CONTINENTAL MARGIN

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Extensional volcanism (Masset Fm.) and plutonism characterize the longlived initial phase of Tertiary basin development in the Queen Charlotte portion of the Canadian-Pacific continent-ocean margin. In the Tertiary succession, as described by Hamilton (1985) and Cameron and Hamilton (1988), magmatism, which dominated from Late Eocene to Early Miocene, was regionally succeeded by subsidence and sedimentation (Skonun Formation). This succession, occurring across the width of the Insular Belt between 51° and 54° N.Lat., is presently described by only two formation names, although it is temporally and geographically as extensive as the entire Cascade system. Facies relationships between volcanics close to vent areas and sediment accumulation further away indicate that the Masset and Skonun formations are in part time correlative. To improve the understanding of the geology of this basin, further stratigraphic refinement and formal subdivision into members is required.

The profound Late Neogene uplift and structural deformation in the Queen Charlotte Islands complicates this task. With abundant faulting, the structural domain size for contiguous blocks of similar attitude, degree of uplift and facies is less than a few kilometers on a side (Wynne & Hamilton, 1988, 1989). The uplift, which was generally greatest in the south and west, can be readily seen from Sutherland Brown's mapping (1968). The sedimentary and volcanic basin fill has been differentially stripped, leaving a diachronous section comprised of isolated remnants of different facies, or exposing denuded blocks of Mesozoic basement rock which are cut by extensive and highly directional dyke swarms and occasional mesozonal and epizonal plutons. For both the volcanic and plutonic facies, the Eo-Oligocene components occur further south (Ramsay Island), while the Miocene section occurs further to the north (Naden Harbour; Dostal and Hamilton, 1988).

Characteristic of extensional volcanism, the Masset is highly variable in thickness and is thickest in basinal rather than constructional accumulations. Contrasting to the coeval and contemporaneous Cascades- Pemberton Arc to the south, the volcanic succession in the Queen Charlottes comprises accumulations in grabens, dominated by fluid aphyric to sparsely porphyritic flows rather than pyroclastic dominated constructional central volcanoes. Dominant magma types are within-plate calc alkaline volcanics and I-type calc alkaline plutonics early in the local succession and transitional morbs later on (Hamilton, 1988). Progressive rifting is evident in: the change from high pressure to low pressure assemblages, the transition from within-plate calc alkaline basalts and two pyroxene andesites to T-Morbs, increased melting % with time and late development of extensive dacite to rhyolite ignimbrites.

The longevity of magmatism, the tholeiitic parentage and the rifting of the thick crustal section on the North American side of this transtensile margin derive from tectonic interaction with the NE Pacific. The time period corresponding to the basal Tertiary unconformity corresponds to: the emplacement of Baja B.C.(Irving et al., 1985), Farallon-

Pacific spreading and reorganization north of the Mendocino Fracture Zone, and the opening of the Norwegian Sea. The extensional volcanism of the Masset Formation spans the transition from N.Am.-Farallon to N.Am.-Pacific plate interaction and the northwards transit of the Kula-Farallon and Farallon- Pacific Rises.

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ASPECTOS SISMOLOGICOS Y MORFOTECTONICOS EN EL EXTREMO OCCIDENTAL DE LA CORDILLERA VOLCANICA CENTRAL DE COSTA RICA

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ABSTRACT

An historical seismicity study in the near vicinity of Poas volcano (Central Volcanic Range), shows that five local, intermediate magnitude ($5 < M \leq 6.5$), shallow focus ($h < 20$ km) earthquakes had affected these area, whith Mercalli Modified intensities between VII and IX grades. The earthquakes that occurred on August 28, 1911, June 6, 1912 and September 1, 1955 had its focus approximately 5 km to the Southeast of the small town Bajos Toro. The remain two earthquakes that occurred on March 18, 1851 and on December 30, 1888 had epicenter near Fraijanes. The last earthquakes caused damaged specially at the city of Alajuela, Heredia and San Jose. The Bajos Toro's earthquakes affected specially the towns of Grecia, Naranjo, Zarcero and Bajos Toro. There is reference of landslides from the earthquakes. The Bajo Toro's earthquakes are possible related to a structural trend with a NNW-SSE orientation. There are different tectonic hypothesis in relation with the source of the Fraijanes earthquakes. A recurrence relation for the earthquakes from this seismic zone is 34.3 ± 10.3 years.

In the last 8 years four earthquake swarms have been detected in the vicinity of Platanar volcano (1980 and 1986) and of Poas volcano (1980 and 1982). A portable seismic network installed during 1985 in the vicinity of Bajos del Toro, showed that the microearthquake activity is one event each two days. These could be related to a 'seismic calm period. The seismic patterns obtained from this network shows relation with neotectonic controls of the region, that have NN-SE, NS and NNE-SSW trends.

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PETROLOGIA DE LAS ROCAS INTRUSIVAS NEOGENAS DE COSTA RICA

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ABSTRACT

The purpose of this paper is to present a synthesis of the petrology of the Neogene plutonic rocks of Costa Rica. Two series are distinguished: an alkaline one of Miocene/Pliocene age, restricted to a small area and a calc-alkaline series of Miocene and Pliocene age and with a wide areal extension.

The plutonic bodies are generally small and have been emplaced during various intrusive stages near to the surface. The mineralogical composition of the calc-alkaline rocks is very uniform. There are, however, great variations in their modal composition and texture, not only from one intrusive unit to another but also between the different intrusive bodies of the same unit.

Chemically there exists a difference between the calc-alkaline plutonic rocks of the Cordillera de Talamanca and those of the Cordillera de Tilarán, specially with regard to the alkali content and the iron enrichment, which might be due to crustal thickening during the Upper Miocene.

The origin of these calc-alkaline plutonic rocks is explained in terms of a two stage model. The first stage comprises the formation of tholeiitic and calc-alkaline melts which are underplated. The second stage yields intermediate to acid magmas by partial melting of the increased crust.

Mt. Etna (Sicily): Volcanic Hazard Assessment

G. FORGIONE[1], G. LUONGO[1,2] and R. ROMANO[2]

Abstract

In recent times in Italy many research programs on active volcanoes have been devoted to surveillance and volcanic hazard, because the density of inhabitants around the main active volcanoes produces a high risk. At Mt. Etna the principal volcanic hazards, on the basis of the historical activity, are lava flows. A preliminary hazard map for effusive activity is proposed. This is obtained starting from well-determined volcanological data (a geological map at a scale 1:50,000 is available) and utilizing geophysical results on the structure and dynamics of the area. The pattern of the main feeder structures, the probability of lava-flow invasion and of the opening of eruptive vents (fissures and/or cones) for the different zones of the volcano are shown.

1 Introduction

Mount Etna is Europe's largest volcano and sits in a complex and incompletely understood tectonic setting: the Calabrian Arc, which is thought to be an arc-trench system which developed from the subduction of the Ionian plate in a NW-SE direction beneath the southern Tyrrhenian Sea. However, the subducted plate might be considered as a passive element of the dynamics of the area, rather than as an active one because the European plate (Tyrrhenian basin) overthrusts the African plate (Ionian Sea). The stress-strain field for southern Italy, inferred from geological and geophysical data, is consistent with that of a bending plate fixed at one end (Fig. 1: Gaudiosi et al. 1984). This stress field is produced by the continuing collision between Africa and Europe which started when the Tyrrhenian Sea began to open 10 million years ago (Boccaletti and Manetti 1978; Calcagnile et al. 1981; Scandone 1979). The acting stress field is dominantly compressive on the inner side of the arc (Aeolian volcanism), and extensive on the outer side of the arc (basaltic volcanism of Mt. Etna) (Fig. 2). The bending of the plate produces the clockwise rotation of Sicily, and the opening of a chasm between the eastern coast of Sicily and

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IAVCEI Proceedings in Volcanology 1
J.H. Latter (Ed.), Volcanic Hazards

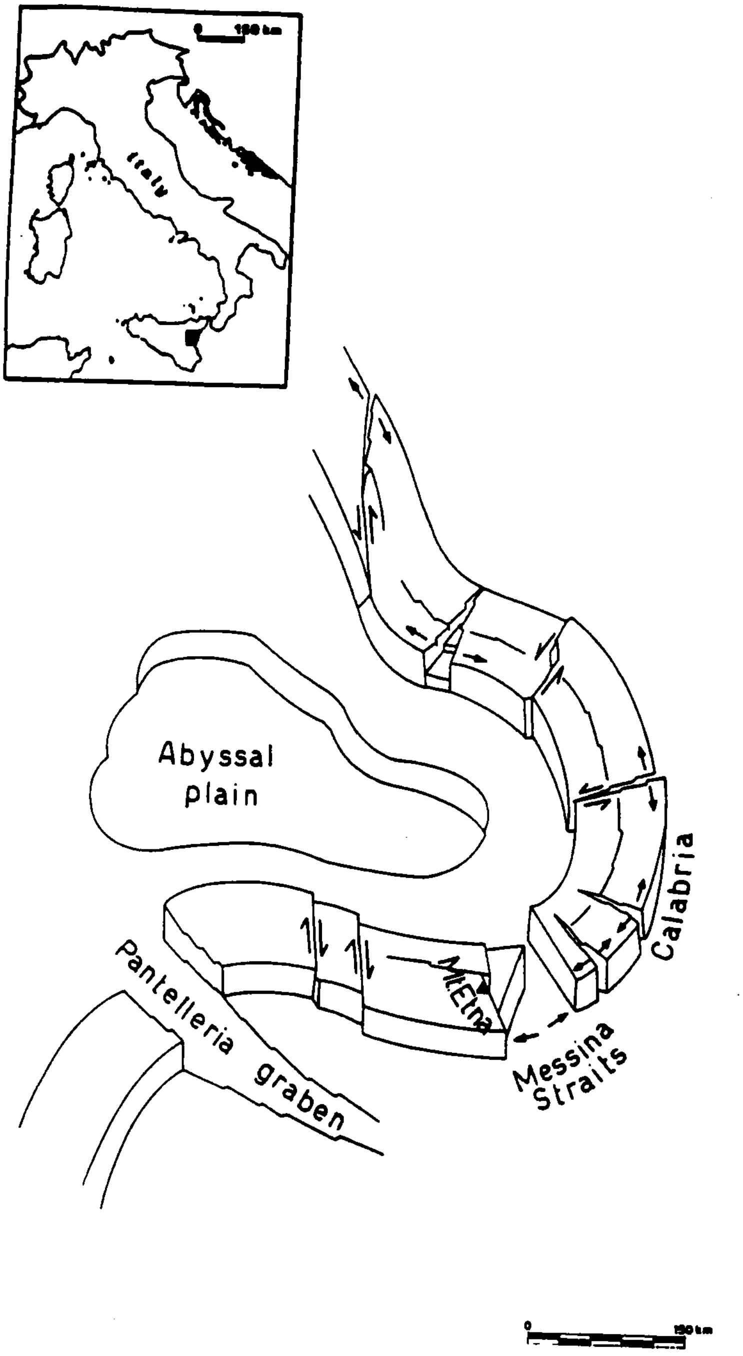

Fig. 1. The bending model for southern Italy. (After Gaudiosi et al. 1984)

the southern Calabria peninsula. These extensional processes are thought to cause volcanism at Etna and also give rise to the general migration of the main feeding conduits of the Etnean volcanic area from SE to NW (Ancient Alkalic Eruptive Centres, Trifoglietto Unit, Mongibello Unit; Romano 1982). Because of the uprising of a large volume of magma in the Etnean area, the direction of the principal stresses in the upper part of the crust has changed: the maximum principal stress direction has become vertical, and the strain reaches a maximum value along belts 120° apart. Eruptive vents (fissures and/or cones) are prevalently located along these belts (Fig. 3).

The initial products of Mt. Etna, about 500,000 years old, are subalkaline lavas of both submarine and subaerial character.

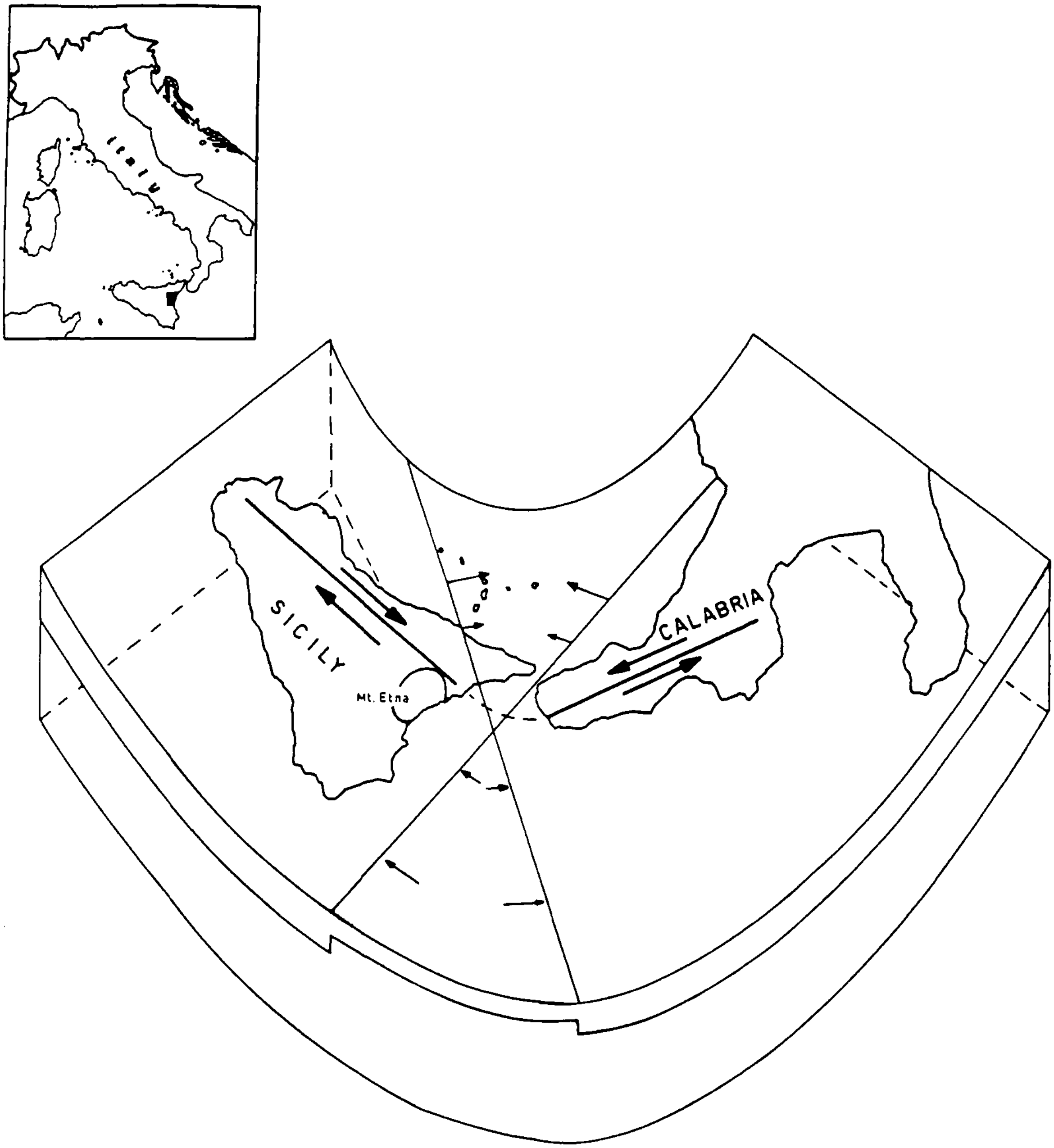

Fig. 2. The bending of the plate produces compressive stresses on the inner side of the arc, tensile stresses on the outer side of the arc and the clockwise rotation of Sicily. (After Gaudiosi et al. 1984)

Between about 200,000 and 100,000 years ago, alkali-basaltic volcanics were erupted, with the formation of small isolated centres (Ancient Alkalic Eruptive Centres). After that time, there were two periods when more extensive differentiation of the magma occurred and the explosivity increased notably. This activity produced two large stratovolcanoes (the Trifoglietto Unit and Ancient Mongibello), formed of numerous secondary eruptive centres. This stage lasted until 8,000 years ago, when prevalently effusive activity started (Recent Mongibello) with a lesser degree of evolution in the alkali-basalt products (Fig. 4: Romano et al. 1979; Romano 1982).

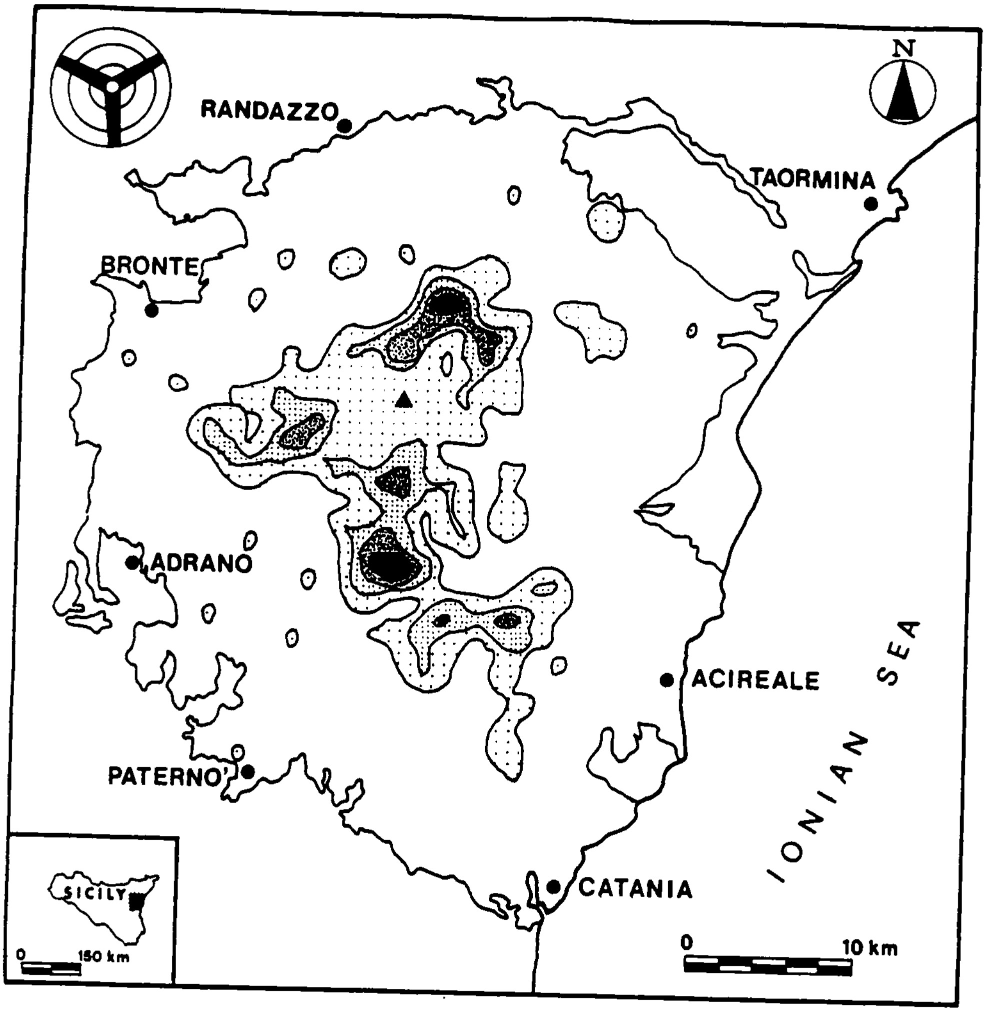

Fig. 3. Density distribution of eruptive vents on Mt. Etna. The dark areas of greatest density contain more than two centres km^{-2}. The other areas (dotted less and less closely) indicate a lower density (after Rittmann 1973). The circle represents the principal stress direction with belts 120° apart. The Central Crater is indicated by a black triangle

2 Discussion

During its evolution, Etnean volcanism has varied in its degree of hazard in accordance with changes in its prevalent eruptive activity. While the initial eruptive events were mainly effusive, with low volcanic hazard, the later eruptive activities of the Trifoglietto Unit and Ancient Mongibello were explosive with high volcanic hazard (Fig. 4). During the activity of Ancient Mongibello there were also eruptive episodes with the formation of lahars and pyroclastic flows (Romano 1982).

The present-day hazard of Mt. Etna (Recent Mongibello), on the basis of the historical activity, is due essentially to lava-flow invasions from flank eruptions (Frazzetta and Romano 1978; Guest and Murray 1979; Chester et al. 1985). The eruptions on Mt. Etna have been classified (Rittmann 1973) according to the site where they occurred and the way in which the activity evolved, as <u>terminal</u>, <u>subterminal</u>, <u>flank</u> and <u>eccentric</u>. The

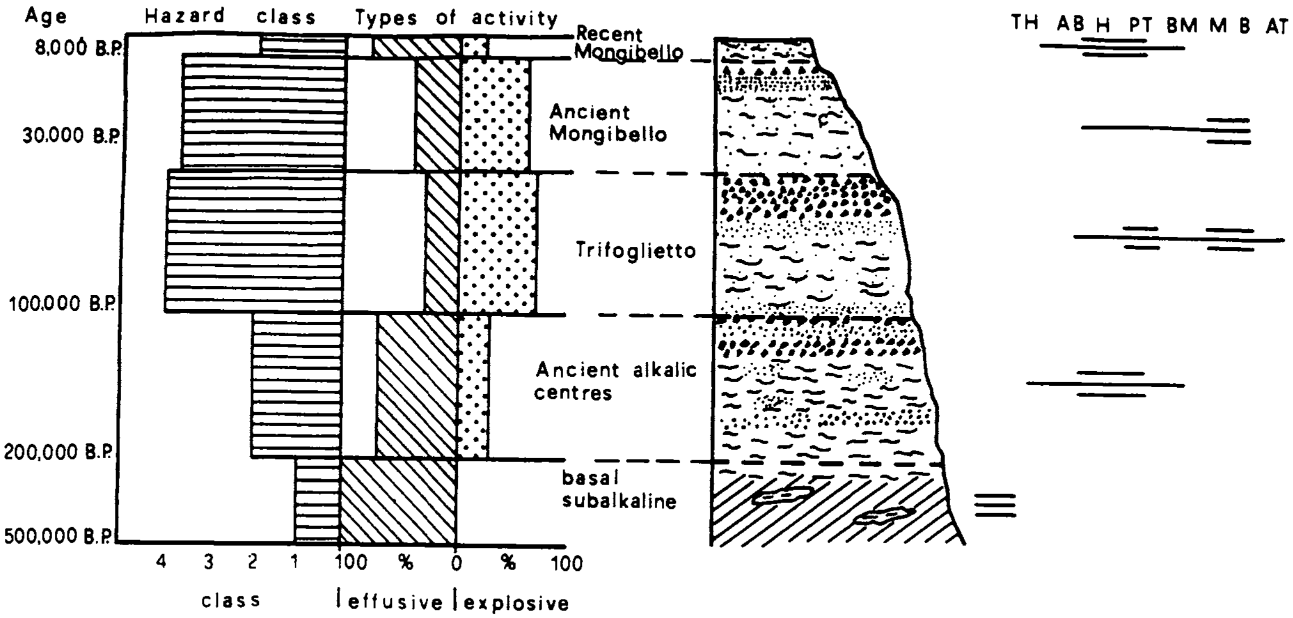

Fig. 4. Right: An idealized stratigraphic cross-section of the volcanic units found in the Etnean area. At top right the various types of volcanics are indicated: TH tholeiitic basalts; AB alkali-basalts; H hawaiites; PT phonolitic tephrites; BM basic mugearites; M mugearites; B benmoreites; AT alkali-trachytes. The triple lines indicate a greater frequency of those types of volcanics in that particular period. Left: The variations of volcanic hazard in the various periods of the evolution of the Etnean area volcanism. In the stratigraphic sketch section the volcanic products are stylized with: wavy lines (lava flows); small triangle and dots of various size (pyroclastics); diagonal lines (clays). Class of explosivity: 1 0%; 2 0% to 30%; 3 30 to 60%; 4 >60%

study of recent eruptions, in comparison with volcanological data of the previous activity, has shown that the Etnean eruptions can be broadly divided into two overall categories: quiet eruptions, characterized by slow and continous lava effusion, with effusion rates <10 m^3 s^{-1}, which usually last for several months, or even years; and paroxysmal eruptions, characterized by an intense explosive-effusive activity for a short period of time, usually days to a few weeks, with effusion rates from 10 to 100 m^3 s^{-1} (Romano and Sturiale 1982).

Table 1 shows the most recent historical eruptions, from 1978 to 1985. Data for the greatest historical eruption (1669) are given for comparison.

Figure 5 shows the frequency of all eruptions which occurred from 812 A.D. to 1985, as a function of their energy. The energy output has been defined by utilizing the relation:

$$E = M\ (\Delta T \cdot C + H),$$

where M is the mass, ΔT the temperature difference between lava and environment (1000 °C), C is the specific heat (0.25 cal/°C),

Table 1. The recent eruptions from 1978 to 1985(2)

Eruption (year)	Duration (days)	Flank	Altitude vents (m a.s.l.)	Maximum length of flows (km)	Altitude reached by flows (m a.s.l.)	Area covered by flows (km^2)	Volume lava emitted (10^6 m^3)	Rate, (m^3 s^{-1})	Energy (10^{17} J)
1978(1)	37 29/IV-5/VI	Eastern	3000 2875-2575	4	1625	1.8	27.5	8.5	0.88
1978(2)	6 24/VII-30/VII	Eastern	2725 2700-2520 2300	3.5	1650	0.75	4	7.7	0.13
1978(3)	12 18/XI-30/XI	Eastern	2600 1675	5	1100	2.75	11	10.6	0.36
1979	6 3/VIII-9/VIII	Eastern; north-eastern	3000 1850 1700-2150	8	870	2.5	7.5	14.5	0.22
1981	6 17/III-23/III	North-western	2550 1400-1300 1150	7.5	600	6	30	58	0.97

Table 1. (cont.)

Eruption (year)	Duration (days)	Flank	Altitude vents (m a.s.l.)	Maximum length of flows (km)	Altitude reached by flows (m a.s.l.)	Area covered by flows (km^2)	Volume lava emitted (10^6 m^3)	Rate, (m^3 s^{-1})	Energy (10^{17} J)
1983	131 28/III-6/VIII	Southern	2300	7.5	1080	6	100	8.8	3.2
1984	172 28/IV-16/X	Eastern	3000	3	2000	1.5	10	0.7	0.32
1985(1)	3,123 8/III-10/III 12/III-3/VII	Southern	3000 2500	3	1830	2.2	30	2.8	0.97
1985(2)	1,4 25/XII 28/XII-31/XII	Eastern	2600	3.5	1675	0.7	0.7	1.6	0.022
The greatest historical eruption									
1669	122 2/III-11/VIII	Southern	850- 800	15	0	37.5	937.5	14	30

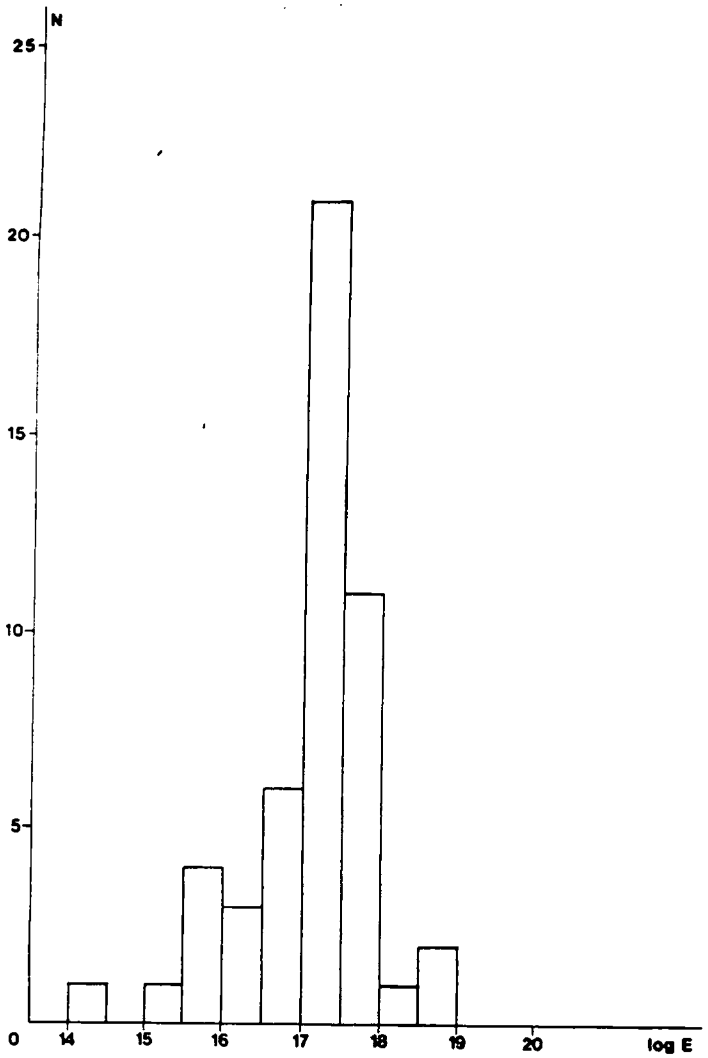

Fig. 5. Frequency of volcanic events as a function of their energy. N Number of volcanic events; log E logarithm of energy in Joules

H the latent heat (50 cal/°C). M has been calculated with a density of 2.6 g cm^{-3}; volumes of lava are those reported by Romano and Sturiale (1982). Then, the distribution of the number of eruptions has been calculated according to their energy. The greatest number of events (21) is found in the energy range 0.8 x 10^{17}-2.8 x 10^{17} J.

From the analysis of the spatial distribution of the eruptions considered, it is seen that the greatest number of them, within the log energy range 17-17.5, are located along all the magmatic feeder structures without there being one preferential structure. The same is seen in the case of the eruptions with the highest and lowest energy. Moreover, there is no apparent relationship between the type of eruption (paroxysmal or quiet), on the one hand, and the energy output on the magmatic feeder structures, on the other hand. The two types of eruption may be related to the particular chemical and physical magmatic conditions, or to the stress acting in the area at the time of the eruption.

The cumulative amount of thermal energy released (Fig. 6) shows three trends with different rates separated by a period with low volcanic activity. The first one has very low volcanic ac-

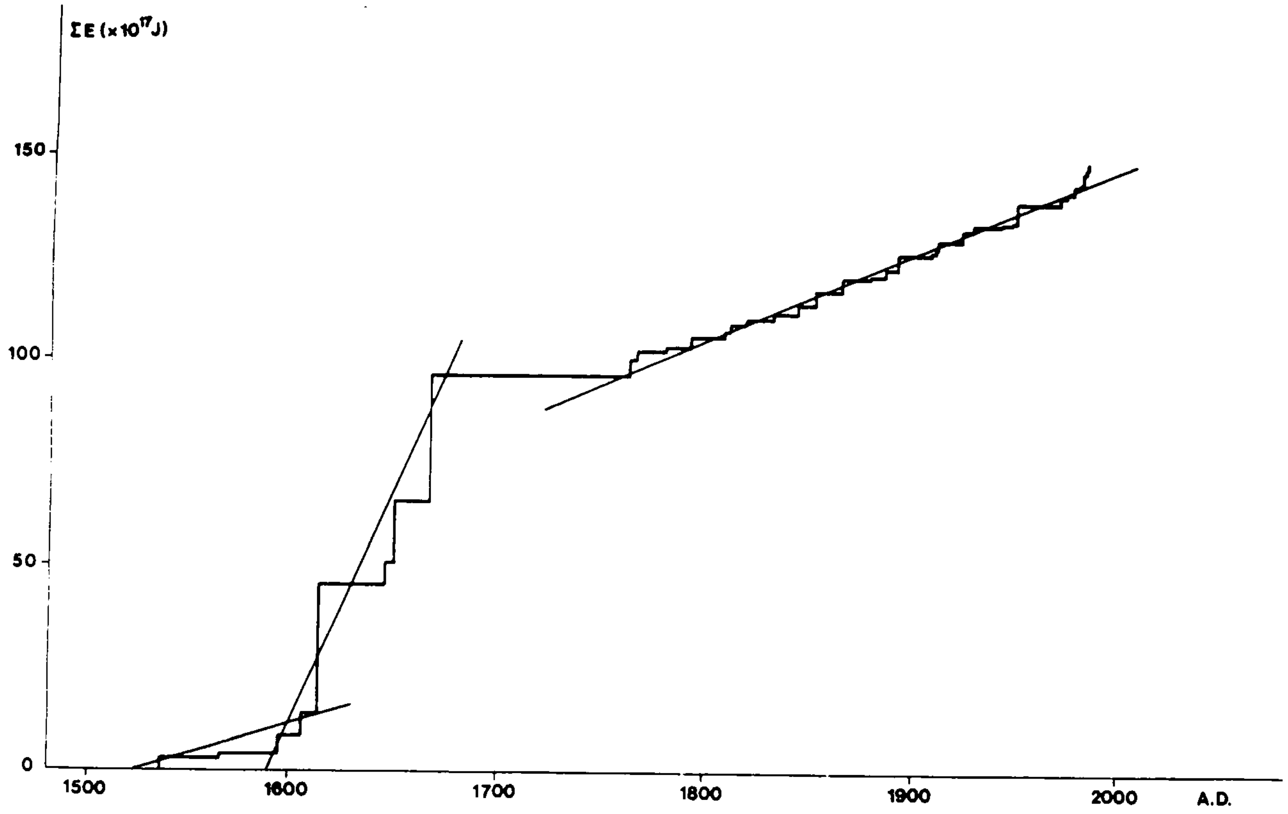

Fig. 6. Cumulative amount of thermal energy released at Mt. Etna volcano from 812 A.D. to 1985

tivity and the last moderate activity, while in the second trend the largest eruptions occur. In general, the same trends of eruptive energy released were obtained by Wadge et al. (1975), but the level of energy they report is different to ours because they utilize different estimates for the lava volume emitted.

The difference between the first and second trends in Fig. 6 is considered as related to the dynamics of eastern Sicily. During the 17th century, a large amount of magma evidently migrated to the surface (see the 1669 eruption) and there was a pause in this phase, probably due to the change in the dynamics of the region as the large earthquake of 1693 (M = 7.1), which violently shook eastern Sicily, can show (Progetto Finalizzato Geodinamica-CNR 1985). After that time, the dynamics of the area quietened, as the low seismicity shows. Only during the 20th century did the regional seismicity increase again (Fig. 7; Barbano et al. 1981).

The time-space distribution of the Etnean eruptions allows zones with different levels of hazard to be classified. The volcanic hazard can be considered variable in one and the same area depending very much on the local morphology and on the distance from potential eruptive vents. On the basis of the location and frequency of past eruptions, a map has been drawn of the probability of eruptive fissures and/or cones opening up and of lava-flow invasion; such a map shows the zones with in-

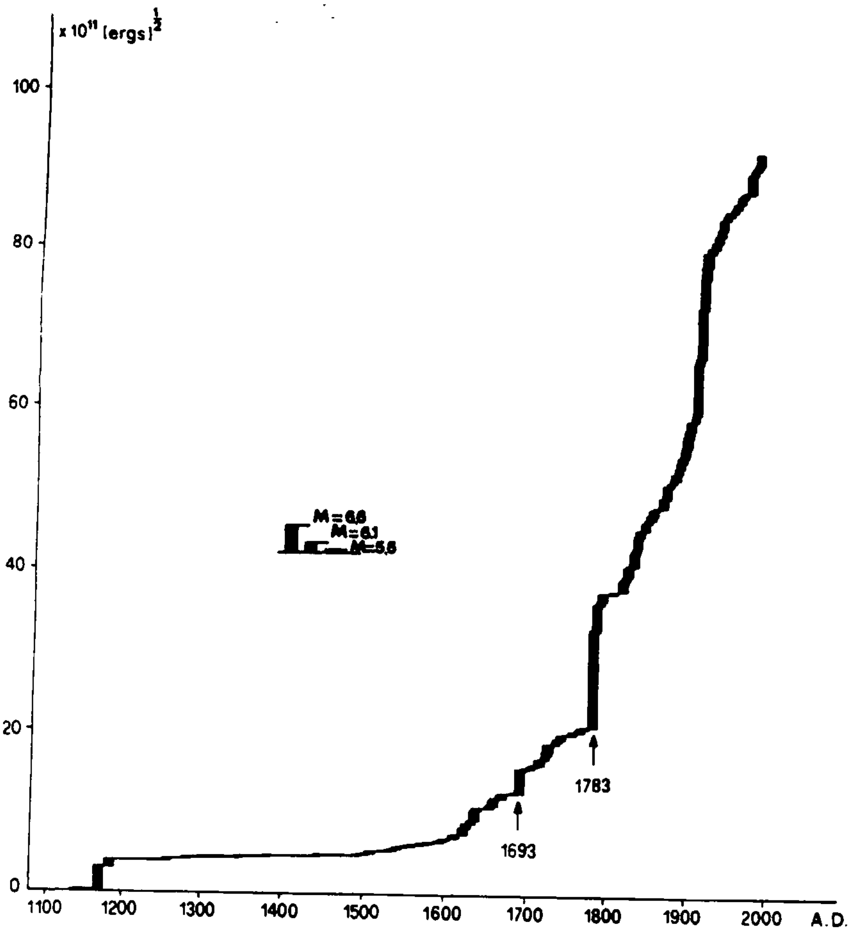

Fig. 7. Benioff diagram. Earthquakes localized in Sicily and Calabria from 1000 A.D. to 1978. (After Barbano et al. 1983)

creasing degrees of volcanic hazard (Fig. 8). In Fig. 8 four zones of greater or lesser probability of the opening up of eruptive vents are drawn:

Zone 1: no opening of eruptive vents has occurred in recent time;
Zone 2: at least one eruptive vent has opened up per km;
Zone 3: 2.5 eruptive vents have opened up per km;
Zone 4: 3 or more eruptive vents have opened up per km.

In the same figure (Fig. 8) three areas of increasing probability of lava invasion are drawn:

Area A: little probability;
Area B: medium probability;
Area C: great probability.

These three areas are delimited by a lower boundary, representing the maximum extension of the lava cover from the very first activity of the volcano; an intermediate boundary, related to flank and eccentric eruptions; and an upper boundary, referring essentially to terminal and sub-terminal eruptions.

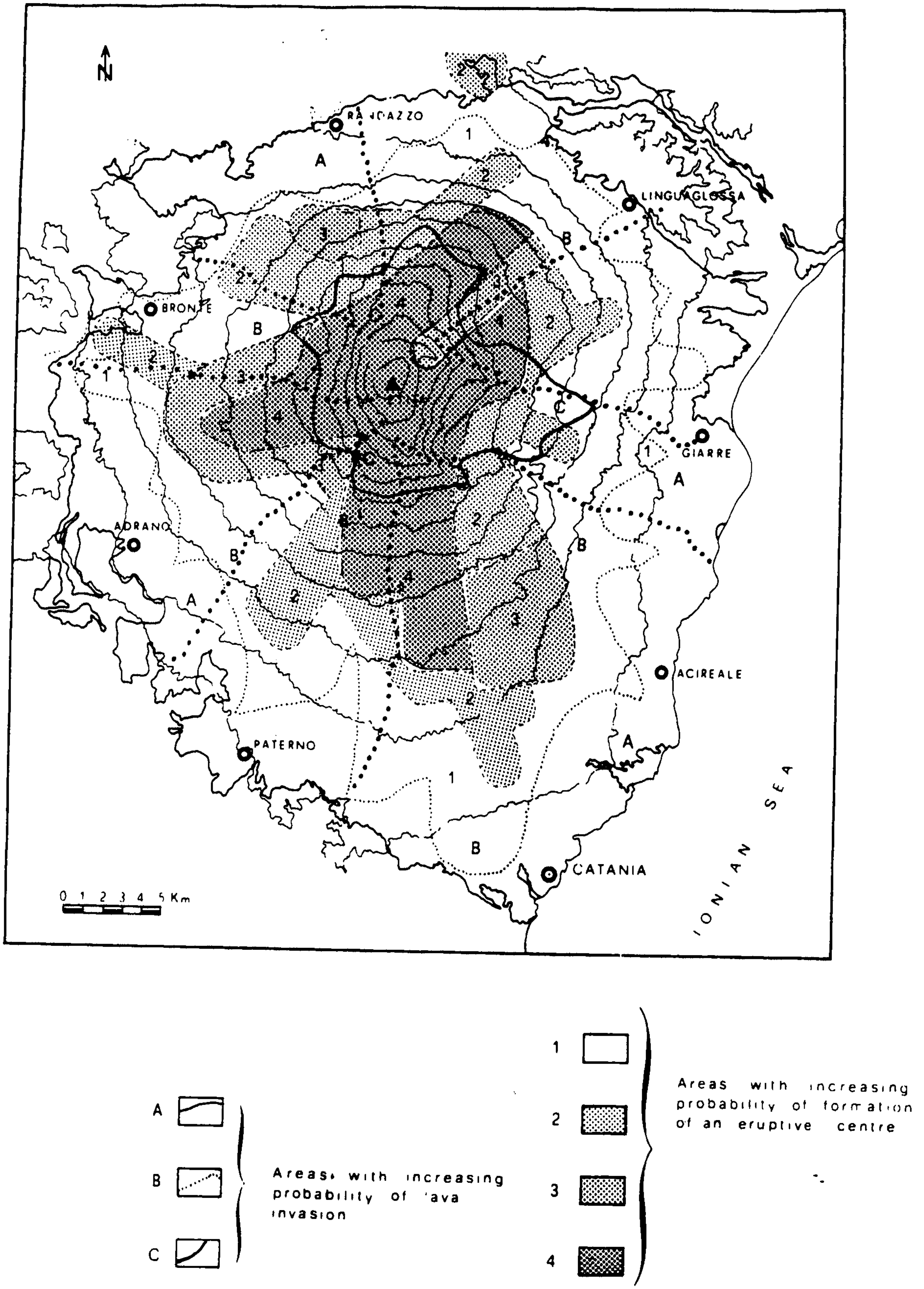

Fig. 8. Map of potential volcanic hazard. Dotted lines delimit radial sectors with different volcanic hazard; the boundaries are traced on a morphological basis

The second and third of these boundaries have been obtained from consideration of the ease with which lava can flow in a given area (potential flow paths) due to the surface morphology present, and of the frequency in historic times of the same area being covered by lavas.

The seismic surveillance of Mt. Etna shows that the level of activity before and during paroxysmal eruptions is higher than that accompanying quiet eruptions (Cosentino et al. 1984; Cosentino and Lombardo 1984; Glot et al. 1984; Guerra et al. 1976; Patané et al. 1984). Notwithstanding the moderate energy of the earthquakes which precede and accompany the eruptive activity, the seismic hazard may be high due to the shallowness of the hypocentres. In recent times (Christmas 1985) a 4.5-magnitude earthquake localized in the eastern flank of the volcano produced the collapse of a small hotel and the death of one person. On the basis of the historical and present-day seismicity and the local and regional tectonics, a preliminary seismogenetic map is drawn (Fig. 9), which shows that the zones with high seismic hazard are located in the eastern part of the volcano. The complex picture is due to the contribution of a tensile stress which is produced by the opening of the Messinian chasm and by a local tensile stress due to the uprising of large magmatic masses. The first stress field acts prevalently along the Ionian coast while the second acts in three belts in the SE, SW and NE parts of the volcano. However, this seismogenetic map is only an oversimplification of the real strain field, because other tectonic trends are not well understood as, for example, the E-W faults observed in the NE sector of the volcano. The complexity of the active superficial tectonics is due also to the variable geometry of the sedimentary basement and to the changes of the thickness of the volcanics in the different parts of the volcanic area.

3 Conclusions

The bending model gives a sufficiently real picture of the tectonics of the Mt. Etna volcano. The bending of the plate produces a tensile stress field that creates the conditions for the formation of this volcanic area. This process gives rise, in general, to the overall migration of the main feeding conduits in the volcanic area from SE to NW. A local stress field is added to the regional one. Magmatic pressure has superimposed a local volcanic stress field on Etna. Three extensional rift zones, 120° apart, have been created and magma is preferentially erupted along these zones. High seismic hazard areas occur along the coastal line and the rupture zones induced by the local stress field.

A detailed analysis of the eruptive history of the volcano in the last centuries evidences the high probability of new fissures and eruptive cones opening up, and thus of there being lava invasion, in the southeastern flank. There is a corresponding relative safety on the southwestern flank. Unfortunately, recent population censuses show the southeastern and eastern flanks, with their apparently high seismic hazard, to be the

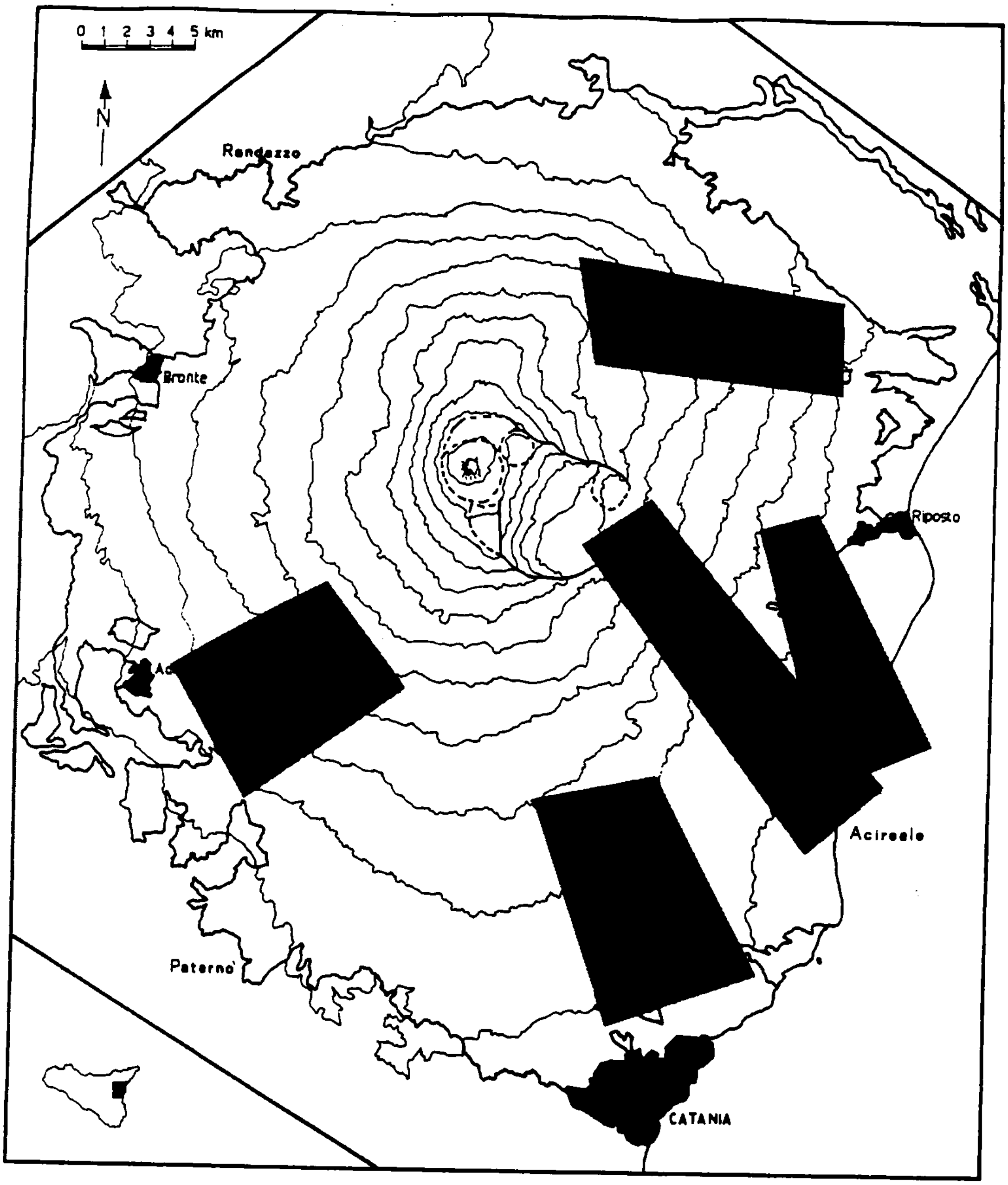

Fig. 9. A tentative seismogenetic map showing the structures with high hazard. These are prevalently located in the eastern part of the volcano, where a regional stress is acting. The sheaves indicate the zones of major concentration of faults and fractures together with the epicentres of major earthquakes

most densely populated and to contain the most industrial plants and public structures of social interest.

The other sectors with a lesser volcanic hazard, the northeastern (Linguaglossa) and northwestern flanks (Bronte and Randazzo) are less densely populated (ca. 50,000 inhabitants), although they contain agricultural crops of a certain prestige (pistachio nuts and vines).

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