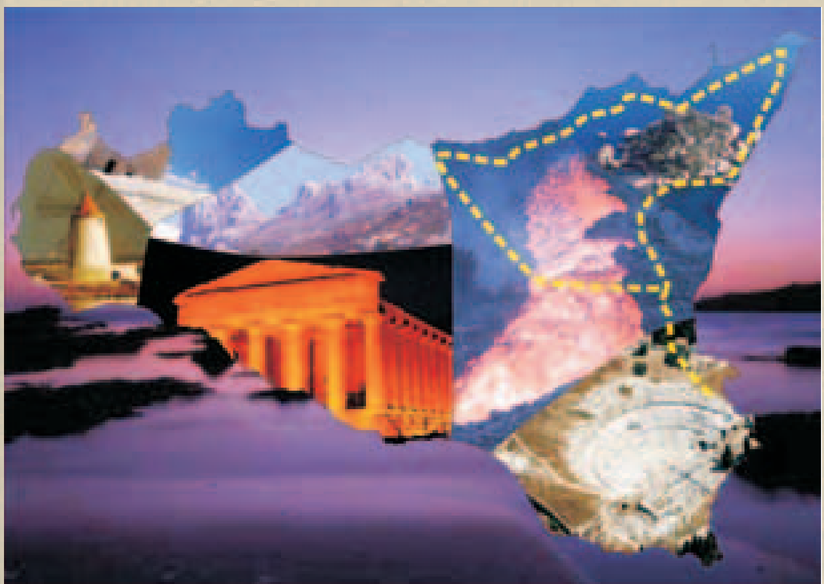
Field Trip Guide Book - P02

Florence - Italy
August 20-28, 2004

Volume n°3 - from D01 to P13

32nd INTERNATIONAL GEOLOGICAL CONGRESS

STRUCTURAL GEOLOGY, STRATIGRAPHY AND VOLCANICS ACROSS THE APENNINIC - MAGHREBIAN OROGEN IN SICILY



Leader: F. Lentini

Associate Leaders: P. Guarnieri, M. Coltelli

Post-Congress **P02**

The scientific content of this guide is under the total responsibility of the Authors

Published by:
APAT – Italian Agency for the Environmental Protection and Technical Services - Via Vitaliano Brancati, 48 - 00144 Roma - Italy

APAT
Italian Agency for Environment
Protection and Technical Services

Series Editors:
Luca Guerrieri, Irene Rischia and Leonello Serva (APAT, Roma)

English Desk-copy Editors:
Paul Mazza (Università di Firenze), Jessica Ann Thonn (Università di Firenze), Nathalie Marléne Adams (Università di Firenze), Miriam Friedman (Università di Firenze), Kate Eadie (Freelance indipendent professional)

Field Trip Committee:
Leonello Serva (APAT, Roma), Alessandro Michetti (Università dell'Insubria, Como), Giulio Pavia (Università di Torino), Raffaele Pignone (Servizio Geologico Regione Emilia-Romagna, Bologna) and Riccardo Polino (CNR, Torino)

Acknowledgments:
The 32nd IGC Organizing Committee is grateful to Roberto Pompili and Elisa Brustia (APAT, Roma) for their collaboration in editing.

Graphic project:
Full snc - Firenze

Layout and press:
Lito Terrazzi srl - Firenze

Volume n° 3 - from D01 to P13

32nd INTERNATIONAL
GEOLOGICAL CONGRESS

STRUCTURAL GEOLOGY, STRATIGRAPHY AND VOLCANICS ACROSS THE APENNINIC - MAGHREBIAN OROGEN IN SICILY

AUTHORS:
F. Lentini (Dipartimento di Scienze Geologiche - Università di Catania - Italy)
P. Guarnieri (Dipartimento di Scienze Geologiche - Università di Catania - Italy)
S. Branca (Istituto Nazionale di Geofisica e Vulcanologia - INGV, Catania - Italy)
ASSOCIATE LEADER:
M. Coltelli (Istituto Nazionale di Geofisica e Vulcanologia - INGV, Catania - Italy)

Florence - Italy
August 20-28, 2004

Post-Congress

P02

Front Cover:
Geological and touristic views of Sicily

Leader: F. Lentini
Associate Leaders: M. Coltelli, P. Guarnieri

Introduction

The field trip would like to head from south to north, from the Hyblean foreland to the Madonie-Nebrodi-Peloritani chain, ending with a tour across Etna including a visit to the summit craters and the *Valle del Bove*. In this way one goes across the Apenninic-Maghrebian orogen to gain an idea of the main stratigraphic and structural characteristics of the most representative sequences relative to the African margin, the Ionian palaeobasin, the carbonate platforms connected to an intermediate continental crust, the Tethyan basin s.s. to the European paleomargin. Such an up-to-date palaeogeographic overview is of general interest and valid for the whole central Mediterranean. The observations of the geometric relationships in the field will allow the participants to obtain a picture of the Neogene-Quaternary geodynamic evolution of the orogen, its connection with the Tyrrhenian opening, and the role of Etnean volcanism in this sector of the chain. The participants will receive several geological maps, mostly printed in recent years, and they will have the chance to visit and explore locations of worldwide historical and tourist interest.

Regional geologic setting

The central Mediterranean is an area where the geodynamic effects of the Neogene collisional

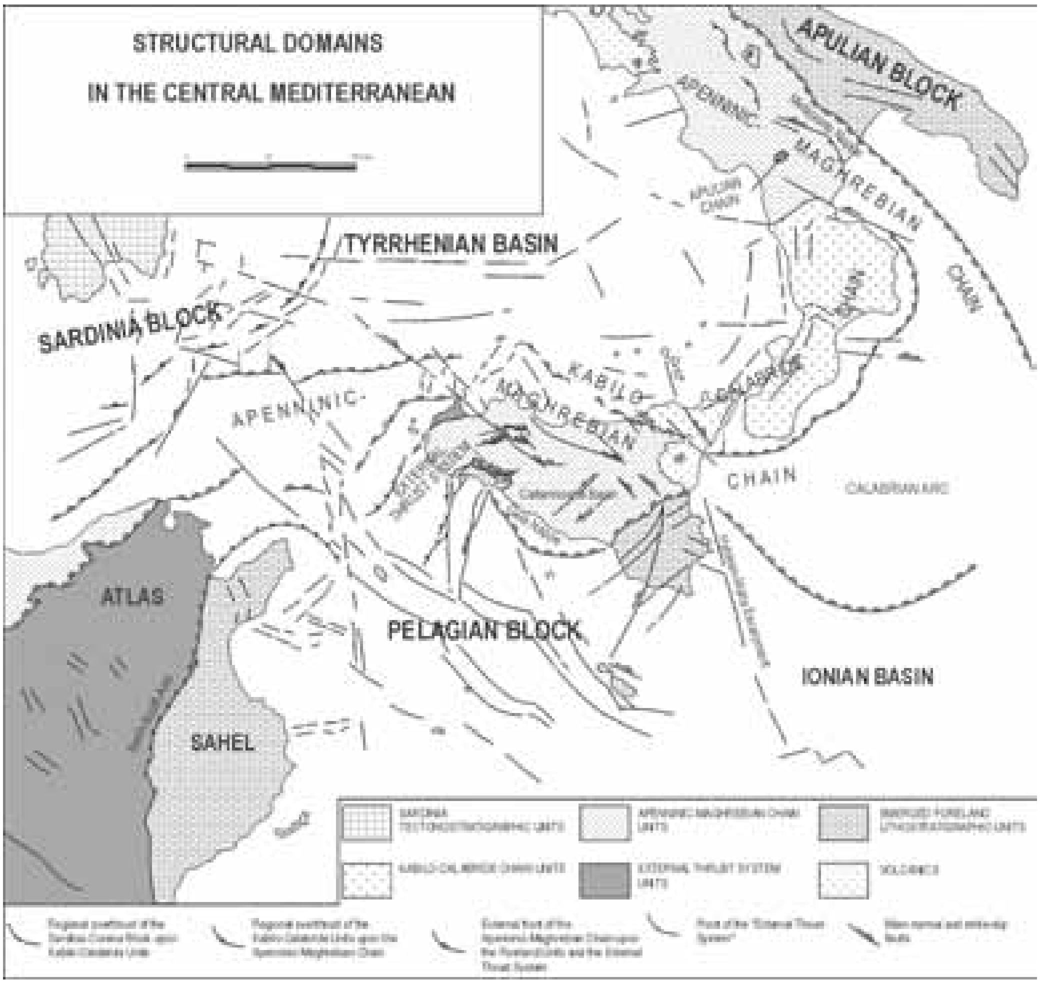


Figure 1 - Main Structural Domains in the Central Mediterranean area.

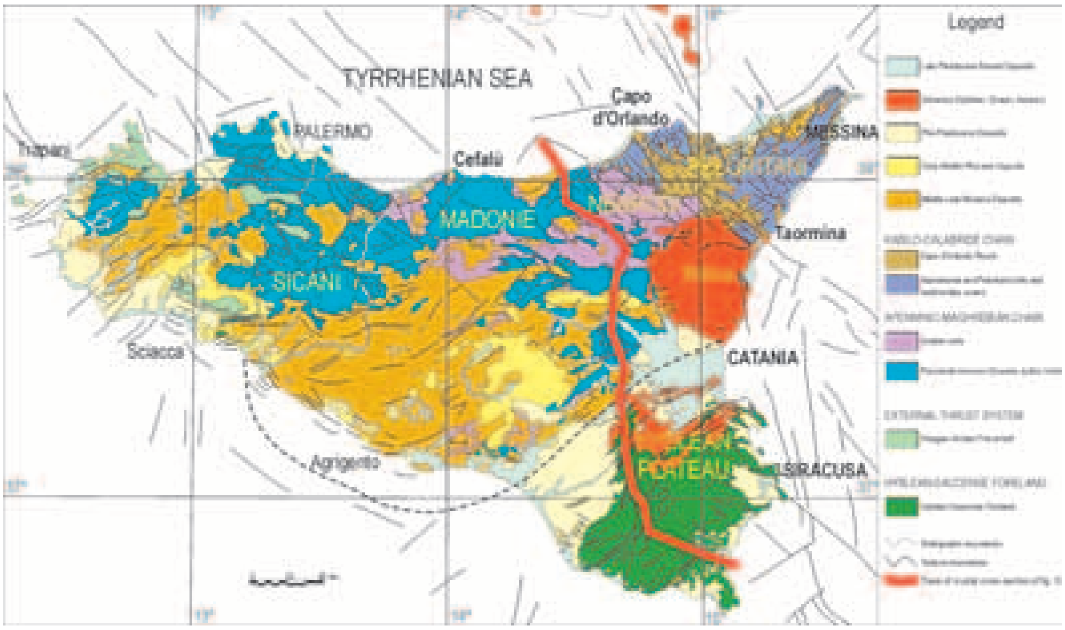


Figure 2 - Structural map of Sicily

and post-collisional history in the convergent Africa-Europe system can be well observed. In the Apenninic-Maghrebian thrust belt – foredeep system some structural domains can be distinguished: the Foreland Domain, the Orogenic Domains and the Hinterland Domains (Ben Avraham *et alii*, 1990; Lentini *et alii*, 1994; 1995; 2001; Finetti *et alii*, 1996;). The Foreland Domain is composed of two continental blocks: the Pelagian Block to the South and the Apulian Block to the North, respectively belonging to the Africa and the Adria plates, separated since the Permo-Trias by the oceanic crust of the Ionian Basin (Fig. 1).

The Orogenic Domains are composed, from the outer to the innermost areas, of three main orogenic belts: the External Thrust System (**ETS**), the Apenninic-Maghrebian Chain (**AMC**), and the Kabilo-Calabride Chain (**KCC**). The first one originated starting in the Tortonian by the detachment of the sedimentary covers of the flexured sector of the Pelagian and Apulian Blocks. The second one, the AMC, is composed of a roof thrust system tectonically overlying the ETS. The AMC is constituted by embricated sedimentary sequences derived from two palaeogeographic domains (the Alpine Tethys and the Palaeo-Ionian basin). They were floored by oceanic crusts, and separated by the inner carbonate platform (the Panormide Platform), originally located on a continental crust. The KCC has been interpreted as originating from the delamination of the European margin.

The Sardinia Block and the Tyrrhenian Basin represent the Hinterland Domains (Fig. 1). The Tyrrhenian Basin is composed of a central area, characterised by a new oceanic crust, in which the opening started in the middle Miocene, and encircled by a submerged chain related to a continental crust (the so-called Maghrebian Crust).

The **Foreland Domain** is represented by the undeformed sector of the Pelagian Block, which extends from the Tunisian Atlas to the Ionian Basin, and it is bounded to the west by a nearly N-S trending discontinuity known as the "N-S Axis", and to the east by the Hyblean-Malta escarpment, a discontinuity inherited from Mesozoic palaeogeography and reactivated in Plio-Pleistocene times. Thus the foreland includes the whole Sicily Channel and the Maltese Islands, and emerges in the southern part of eastern Sicily, known as the Hyblean Plateau (Figs. 1 and 2). This is made up of a thick Triassic-to-Quaternary carbonate sequence lying upon a 30-Km-thick continental crust. Northwestwards, the foreland is downfaulted, forming the Gela-Catania Foredeep, and overridden by the external front of the AMC.

In Sicily the architecture of the Orogenic Domains is characterised by a stack of ramp-anticlines built up by a carbonate thrust system (ETS), originating from the deformation of the innermost sector of the Pelagian

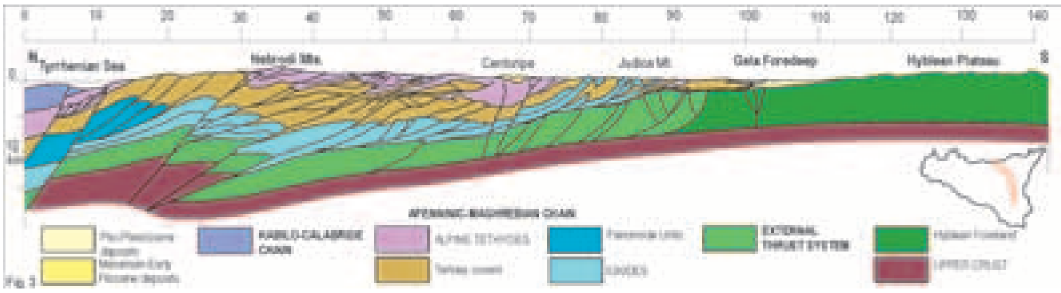


Figure 3 - Geologic cross-section of eastern Sicily.

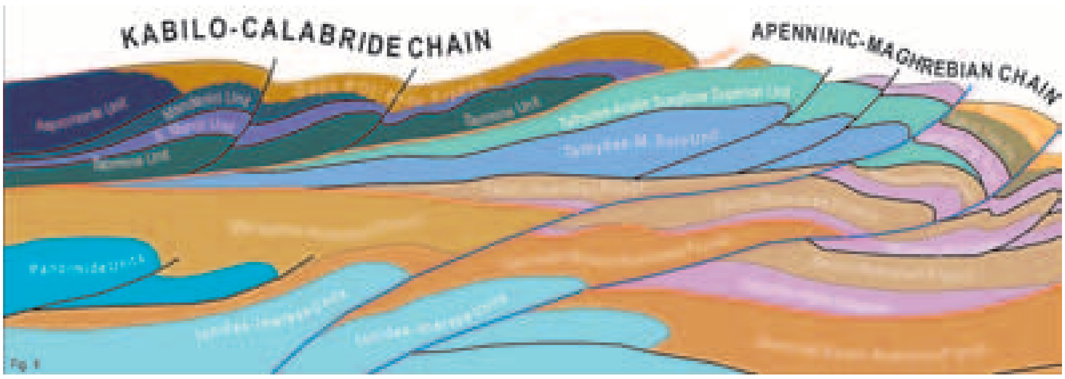


Figure 4 - Schematic profile illustrating the relationship between the Kabilo-Calabride and Apenninic-Maghrebian chains.

Block, and named "*Sistema siculo-pelagiano*". It underlies a pile of rootless nappes, the roof thrust system of the AMC, which in turn is overridden by the KKC (Fig. 3).

The **ETS** derives from the detachment, since the Tortonian onward, of the Meso-Cenozoic sedimentary covers of the continental margin of the Pelagian Block (African Plate). It is extensively exposed in the Tunisian Atlas. In western Sicily it outcrops along more or less E-W oriented ridges (Monte Kumeta, Rocca Busambra) and in the Trapani area (Erice, Capo S.Vito, Alcamo), while in eastern Sicily it is largely buried below the allochthonous AMC and cannot be observed during the field-trip.

The **Apenninic-Maghrebian Chain** is the most external of the allochthonous orogenic domains (Fig. 3) and is part of a fold-and-thrust belt that extends continuously as far as Morocco. It originated in the Late Oligocene, following the involvement of the deep basin and shallow sea paleodomains that originally laid between the European and African margins: the Alpine Tethys basin, the Panormide platform, and the Palaeo-Ionian basin (Lentini *et alii*, 2002). The deformation occurred in a context of thin-skinned tectonics and thus did not involve the crystalline basement.

The Meso-Cenozoic pelagic sequences originally deposited in the oceanic area of the Palaeo-Ionian basin, and successively involved in the orogenesis, are completely detached and tectonically rest onto the ETS. These covers are the so-called Imerese Units, Sicanian Units and M.Judica Unit and have been grouped, with the name of Ionides.

In fact the whole Jurassic-Cretaceous interval's (Mt.Judica area in Lentini, 1974) (STOP 1.1) facies, and its relatively-thin thickness, often represented only by volcanics, of , allow us to ascribe these sequences to permanent deep water conditions, as an oceanic area located between the "Maghrebian crust" and the Adria and Africa crusts.

The innermost basinal sedimentary sequences are those called Sicilide Units (Ogniben, 1960) originally deposited in the Alpine Tethys' realm, and for this reason named Tethydes. They are characterized by Upper Jurassic-Oligocene basinal carbonates, mudstones and varicoloured clays (Monte Soro Unit and "*Argille Scagliose superiori*" Unit) (STOPS 3.4; 3.5), evolving to Upper Oligocene-Lower Miocene terrigenous turbiditic successions, that are mainly detached from their substratum.

Lentini et al. (1996; 2000) emphasized that the architecture of the Sicilides is that of a tectonic wedge, progressively thinning out, until it disappears, below the Kabilo-Kalabride Chain (Fig. 4). Inside this wedge at least four tectonic units have been distinguished: two made up of Mesozoic sequences, the Mt. Soro Unit and the "Argille Scagliose superiori" Unit (ASSU), and two Paleogene up to Early Miocene successions, the Nicosia Subunit and the Troina Subunit. These latter two might represent the original Cenozoic cover of the Mt. Soro Unit and ASSU. The geometric relations probably are the result of a progressive accretionary process accompanied by a general detachment of the Tertiary terrigenous covers.

The Sicilide Units tectonically rest upon the Miocene terrigenous Panormide and Imerese units, which themselves have been detached and translated into a more external position, and at the present day they largely compose the frontal wedge of the AMC (Figs 3 and 4).

The Meso-Cenozoic basin and platform sequences (Ionides and Panormides) of the AMC pass upward into Oligo-Miocene flysch successions, mainly represented by the Numidian Flysch. From well data at least five units of the Numidian Flysch that have been tectonically multiplied can be recognized (Bianchi *et alii*, 1987; Carbone *et alii*, 1990).

In a semplified picture two main Numidian sequences can be distinguished: the external one, which represents the original cover of the Imerese and Panormide units, and the "far travelled Numidian Flysch" involved in the allochthonous Sicilides (the Nicosia Subunit).

In the Mt. Judica and the Sicanian Units the Oligocene-Early Miocene interval is represented by glauconitic marls and sandstones, coeval with the Numidian Flysch.

The structural setting of eastern Sicily is a product of phases of thrusting led by sole thrusts that lie within the Triassic horizons. Further detachment levels along the Oligocene strata of the Panormide and Imerese successions have led to the repetitions of the Numidian Flysch. The propagation of the thrusting was blocked when, from the Late Miocene onward, the front of the chain reached the thick successions of the Hyblean foreland, with the consequent activation of out-of-sequence thrusts in the internal zone, which provoked the overthrusting of the internal Maghrebide units onto the external units of the thrust system. Seismic lines show a deep substratum (the ETS) overridden by the chain units and connected to the collapsed Hyblean margin. In general the Middle-Miocene thrust fronts are truncated by transcurrent right-lateral faults oriented more or less NW-SE, which belong to the South Tyrrhenian System (Finetti *et alii*, 1996; Del Ben & Guarnieri, 2000; Giunta *et alii*, 2000). The Tyrrhenian margin is characterized, from the Late Pliocene-Early Pleistocene, by collapse tectonics accompanying the opening up of the Tyrrhenian basin.

The **Kabilo-Calabride Chain**, the structurally most elevated unit, and the innermost allochthonous orogenic domain, stems from the delamination of the European margin. It is made up of Hercynian basement nappes with the remainders of the Meso-Cenozoic sedimentary covers. Thick sequences of arkosic turbidites of Late Eocene and Oligo-Miocene age rest uncomformably upon the nappes, testifying to the early deformation of this domain (Fig.4).

The whole structural architecture of the Apenninic-Maghrebian Orogen can be connected to the distribution of the oceanic and continental crusts recognised by the CROP-Mare seismic lines. The progressive time-space migration of the thrust belt-foredeep system can be interpreted as a response of three subduction stages. In the first one the Alpine Tethys crust was consumed beneath the Adria Plate, as testified by the alpine wedges outcropping in Calabria and detected by seismic lines in the Tyrrhenian submerged areas (the Alpine stage); the second one (the Balearic stage) originated from the Late Oligocene-Early Miocene with the superposition of the Apenninic-Maghrebian wedge onto the Panormide Platforms, and the third stage (the Tyrrhenian Stage), is ascribed to Late Miocene up to Recent times, when the palaeo-Ionian crust subducted below the "Maghrebian continental crust" and the present-day collision with the African Plate was reached.

The interpretation of the CROP-MARE seismic lines in fact shows that both the Pelagian and Apulian continental blocks extend below, respectively, the island and the Southern Apennines to reach the Tyrrhenian offshore. A general thinning is evident and has been interpreted as an original transition to a thinned or oceanic crust. At present day these crustal sectors are in collision with a continental crust, found in the Tyrrhenian offshore, respectively, of the northern coast of Sicily and of the Southern Apennines and named "Maghrebian crust" by Lentini *et alii* (2002). In Sicily this latter has been identified in the Drepano Ridge located just some kms to the north of the Tyrrhenian offshore and has been interpreted as the original basement of the inner carbonate platforms (the Panormide Platforms). In the offshore of the Napoli-Cilento alignment a similar crust has been detected, and interpreted as the original basement of the Apenninic Carbonate Platform (equivalent to the Panormide Platform of Sicily).

Evidence of the original Ionian slab has been found in the seismic lines (CROP-M6A and M6B) across the offshore of the Tyrrhenian margins of Sicily and of Southern Apennines. The slabs appear disactivated and cut by the transcurrent margins of the Tyrrhenian Basin.

The superficial expression of this collisional setting is the South Tyrrhenian System, a NW-SE oriented fault pattern, with a dextral component of the motion.

The South Tyrrhenian System (STS) is an expression of the diachronous collision between the lithospheric buttress of the chain and the African margin. Collision did in fact initiate from the late Tortonian onward, first involving the western areas of Sicily and later extending to its eastern part.

The STS affects the South Tyrrhenian offshore and north-eastern Sicily. To the STS belongs also the Vulcano, Tindari, Giardini alignment, known as Vulcano Fault. It represents a boundary between the collisional belt to the west and the subduction area to the east, and it can be considered as the prolongation of the Malta Escarpment.

Present westward subduction occurs with a NW dipping Benioff plane, as indicated by the distribution of deep earthquakes, which outline the narrow belt of the active subduction.

The field-trip will end with a visit to the **Volcano Etna**. Mount Etna is the largest European basaltic stratovolcano and it is located along the eastern coast of Sicily in Southern Italy, reaching an altitude of about 3340 m. The volcanism in the Etnean region occurred during the Middle Pleistocene, about 600 ka, in a complex geodynamic setting developed on the frontal nappes of the Apenninic-Maghrebian Chain. In particular, the Mount Etna volcano rests on the Gela-Catania foredeep sediments, consisting of a Plio-Pleistocene regressive succession, along the south and southeastern margins, and on the Apenninic-Maghrebian units along the north and northwest ones (Di Stefano and Branca, 2002) (Fig. 2).

On the basis of new stratigraphic data Branca et al. (2003) subdivided the almost continuous eruptive activity in the Etnean region into four distinct evolutionary phases. The oldest phase (Basal Tholeiitic) corresponds to a long period of dispersed fissure-type volcanism, from about 580 up to 260 ka. This basal phase represents the northward extension of the Plio-Pleistocene Hyblean volcanism to the Etnean region. It was initially characterized by submarine eruptions of magmas with tholeiitic affinity occurring in the northern portion of the Pleistocene Gela-Catania foredeep basin. As a consequence of regional uplift, the eruptive activity gradually became subaerial, forming scattered tholeiitic lava flows, currently cropping out along the south periphery of the volcano. The second phase (Timpe) started about 220 ka when the eruptive activity concentrated mainly in the lower eastern flank of the Etna edifice, along the NNW-SSE oriented Timpe fault system. In this area the occurrence of fissure-type eruptions formed a small shield volcano, extending about 15 km, presentlycurrently cut by the Timpe fault scarps. During this second phase the passage from tholeiitic to alkaline volcanics occurred. The third phase (Valle del Bove centers) is marked by a main westward shifting of the feeding system to the Valle del Bove (VdB) area, forming a set of composite volcanics. The earliest volcanic edifices identified are Tarderia and Rocche, whose products crop out, respectively, in the north-eastern wall of the VdB and to the south of the valley. Afterward the volcanism concentrated mainly in the south-western side of the VdB with the formation of the Trifoglietto volcano. Local shifting of the feeder produced the building of the Giannicola, Salifizio and Cuvigghiuni volcanoes, which are superimposed on the Trifoglietto products. Finally, in the fourth phase (Stratovolcano) the definitive stabilization of the plumbing system led to the construction of the main stratovolcano, Ellittico, which forms the bulk of the present edifice. Four caldera-forming Plinian eruptions, occurring at about 15 ka, marked the end of Ellittico's activity (Coltelli et al., 2000). During the Holocene persistent basaltic volcanic activity formed the Mongibello volcano, whose products cover at least 85% of the Mount Etna area. They mainly consist of lava flows, which were emitted both from summit vents and parasitic cones spread over all the volcano's flanks. The spatial distribution of the eruptive vents evidenced the presence of at least four main weak zones of the volcanic edifice in which the propagation of the feeder dikes occurred along NE, W and S trends. The analysis of the historic eruptive activity of the Mongibello volcano has evidenced that even though it is characterized by almost continuous eruptions from the summit vents over the last four centuries, 46 flank eruptions occurred from an altitude lower than 2500 m (Branca and Del Carlo, 2003). The pyroclastic deposits that cover discontinuously the eastern flank of the volcano consist of tephra layers of scoriaceous lapilli and ash originated by one plinian, 24 subplinian and several strombolian events, occurring from about 13 ka to the Present (Del Carlo et al., 2003). The morphological setting of the Mongibello volcano was radically modified about 9 ka by a catastrophic eastern flank collapse, which produced the wide depression of the VdB (Calvari et al, 1998). The volcaniclastic deposits associated with this collapse event outcrop immediately eastward of the VdB area up to the coast. They are represented by a debris avalanche deposit (Calvari et al., 1998) and by a wide fan-shape detritic-alluvial body, locally named "Chiancone" (Romano, 1982; Calvari and Groppelli, 1996).

Field itinerary

28 August 2004. Arrival at the Fontanarossa airport of Catania in the evening by direct flight from Florence or via Rome (overnight stay in Catania)

Catania

A renowned port and Sicily's second largest city, after Palermo, with its 350,000 inhabitants, Catania was home to such great artists as the composer Vincenzo Bellini (1801-1835) and the writer Giovanni Verga (1840-1922). A great, very longed-for celebration takes place every year from 3 to 5 February in honor of Saint Agatha, when a huge crowd of believers parade through the city's historical centre, celebrating their beloved Patron Saint. The event draws thousands of visitors from all over Sicily and beyond. Catania is overshadowed by Mount Etna, the volcano that often has betrayed the trust of the local people, sending forth great flows of lava, on one occasion down into the town itself. Reminders of its presence is the dark color of most monuments and buildings in town. Some of them are of plaster, painted to look like lava. Black and white are the two dominating colours of the city, which combine to produce a magnificent effect. The 17th century was particularly catastrophic for Catania. First (in 1669), following Etna's eruption, a devastating lava river flowed into the city; a few decades later (in 1693), an earthquake razed it to the ground. A sumptuous reconstruction followed, starred in by the architect Giovanni Battista Vaccarini (1702-1768), who designed the most prestigious buildings. Baroque buildings covered nearly every ruined specimen of the past ages, which are hidden, with the exception of a few remnants – below the new buildings and the city's heart.

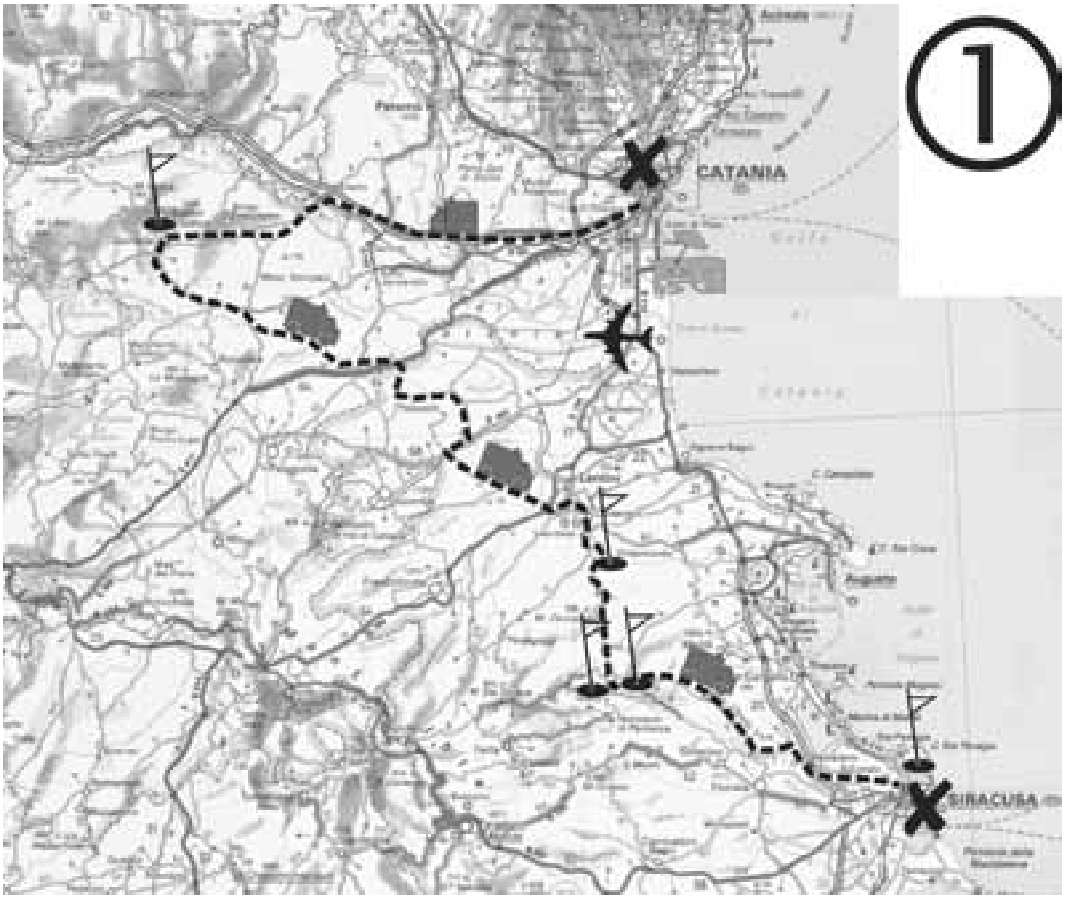
PIAZZA DEL DUOMO is the very heart of the city, designed by the celebrated architect Vaccarini, surrounded by magnificent Baroque buildings which impart it a great elegance. At its centre rises the Fontana dell'Elefante (the Fountain of the Elephant) which is the symbol of the town. On the South side is the fine 1800s Amenano Fountain, partly offset by the Chierici and Pardo palaces. The Cathedral façade, flanked by the Bishop's Palace and the Porta Uzeda, dominates the square. On the left, slightly set back, is the lovely Badia di S. Agata. On the North side stands the elegant Palazzo Senatorio or degli Elefanti, now the Town Hall. The Fontana dell'Elefante was conceived in 1735, and recalls Bellini's famous obelisk in Piazza Minerva, in Rome. The black lava elephant, perhaps of Byzantine epoch, has graced the square since the 1500s; it stands on a stone platform and bears on its back an ancient Egyptian obelisk covered with hieroglyphics that celebrate the cult of Isis.

DAY 1

(*29 August 2004*)

Subject: the Mesozoic-Cenozoic basinal sequences

Figure 5 - Structural scheme of south-eastern Sicily



of M. Judica (Ionides) in the frontal wedge of the Apenninic-Maghrebian Chain. Catania - Gela foredeep. Stratigraphy of the carbonate platform and volcanics of the Hyblean Foreland.
(Overnight stay in Siracusa).
Geological maps:
n°1 – "*Carta geologica della Sicilia centro-orientale"* 1:50.,000 scale.
n°2 – "*Carta geologica della Sicilia sud-orientale"* 1: 100,000 scale.

8^{00} *Starting from Catania*

From Catania to Mt. Judica. Out of Catania we cross the Catania Plain (Fig. 5), a vast alluvial plain located between the Etna Volcano (on the right side) and the Hyblean Foreland (on the left), that is characterized by a Quaternary regressive sequence, composed of clays, sands and conglomerates, infilling the Gela-Catania Foredeep. We are travelling westwards, to reach the Mt. Judica-Mt. Scalpello mountains .

Stop 1.1:

Mt. Judica–Lavina Valley.
Stratigraphy of the Mt. Judica sequence. Tectonic setting of the basinal sequences (Ionides).
Geological Map nr.1: "*Carta geologica della Sicilia centro-orientale"* 1:50,000 scale.

The Mt. Judica Unit is characterized by a mostly pelagic Meso-Cenozoic succession (Fig. 6), starting with claystones, calcilutites, calcarenites and microbreccias with halobids, ammonoids and conodonts, known as the Mufara Formation or "Flysch Carnico", and ascribed by Lentini (1974) to the *aonoides* Zone (Carnian). The "Mufara Fm" commonly occurs at the base of the different tectonic units grouped as Ionides, as well as the Panormide Units. In the Mt. Judica Unit the "Mufara Fm" upgrades to 200-300-m-thick cherty limestones with halobids (Scillato Fm) ascribed to the Norian-Raethian age. Nodular facies are common. The Lias-

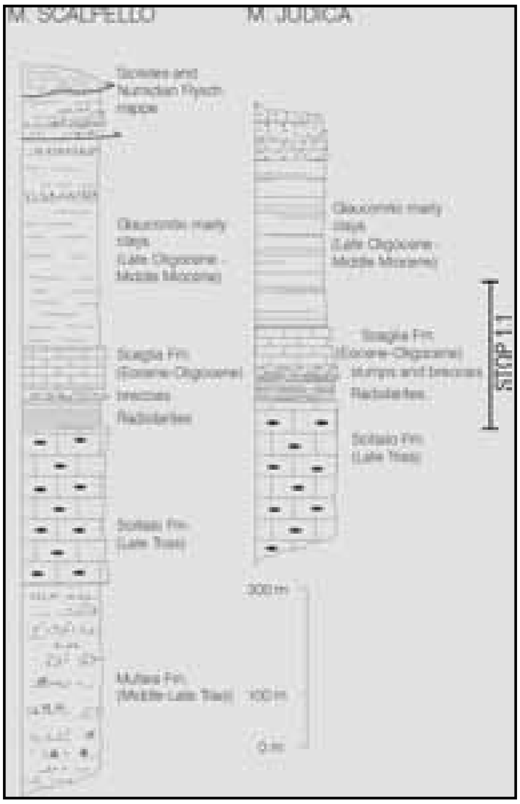


Figure 6 - Stratigraphic columns of the Mt. Judica-Mt. Scalpello units

Cretaceous interval is represented by 10 up to 100 m of radiolarites with volcanics, that were deposited in a deep water basin. This sequence was deposited below the ccd limit and represents a very long chronological interval (not less than 100 millionyears), in which the environmental conditions did not change at all, as in the oceanic environment. The upper part is characterized by slumps and breccias, indicating instability, probably due to movements along transform faults. These deposits are overlain by 10-100-m-thick red, greenish, or whtish marls and marly limestones ("Scaglia" facies) traced to the Middle Eocene –Early Oligocene, grading up to 300-400-m-thick marly clays with glauconitic sandstones of Late Oligocene – Serravallian age.

The Mt. Judica Unit tectonically is overridden by Sicilide and Numidian Flysch nappes, and altogether with them forms embricates (Fig. 7) overlying the deep seated External Thrust System and the topsection levels (Messinian to Pliocene) of the Gela Foredeep.

From Mt. Judica to Scordia. We cross the external wedge of the thrust belt to reach the outcropping margin of the foreland. The frontal wedge is made up of the Gela Nappe, a tectonic melange composed of allochthonous varicoloured clays and sandstones, Upper Miocene clays, Messinian evaporites, and Pliocene sediments. The Gela Nappe tectonically overlies the Pliocene topsection covers of the Gela-Catania Foredeep. The margin of the foreland is characterized by Miocene up to Quaternary carbonates and volcanics.

Geological Map nr. 2 – "*Carta geologica della Sicilia sud-orientale*" 1:100,000 scale.

13⁰⁰ *Lunch*

Stop 1.2:

Scordia-Loddiero Valley.

By G. Sturiale.

The Vallone Loddiero section represents an excellent place to observe the stratigraphic relationships between Plio-Pleistocene tholeiitic and alkalic lava products. It is also a complete section representing the

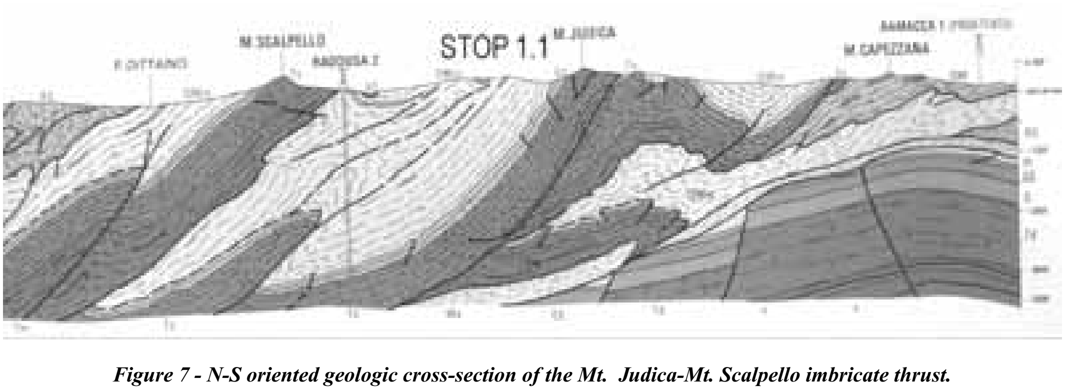


Figure 7 - N-S oriented geologic cross-section of the Mt. Judica-Mt. Scalpello imbricate thrust.

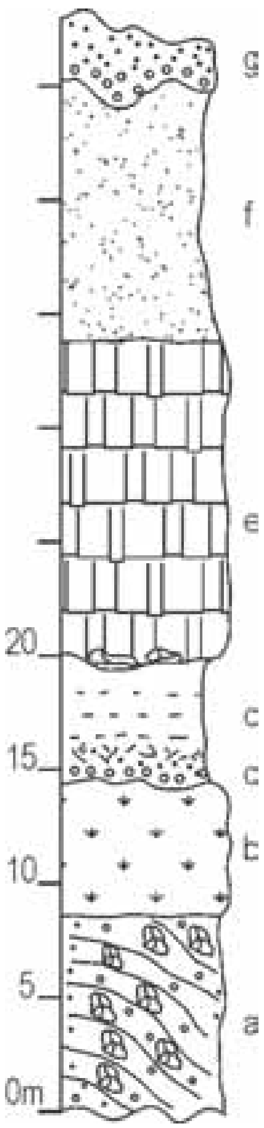


Figure 8 - Stratigraphic column of Vallone Loddiero.

Plio-Quaternary succession of the northern margin of the Hyblean Foreland.

The section is exposed in a quarry on the left bank of Vallone Loddiero, 3 kilometres southwest of the town of Scordia (Fig. 5). For the literature see Schmincke et al. (1997) and Pedley et al. (2001).

The base of the Loddiero section is composed of pillow lavas and pillow breccias (Fig. 8). The unit shows bedding, with strata dipping 25-30° toward the east. The strata consist of alternating intervals with distinct facies defined by varying contents of pillows (mostly isolated) and pillow fragments embedded within a hyaloclastite matrix. The apparent bedding of the breccias is most evident in the inclination of larger, elongate pillows, but also in the variations in the granulometry and lithology. All pillows and many pillow fragments have glassy crusts about 1 cm thick; the surrounding hyaloclastite matrix consists of small fragments of glass and pillows. The colour is orange-yellow due to a high degree of palagonitization. The thickness is 7.5 m.

Subaerial lavas, grey in colour, overlie the submarine unit with a horizontal contact. The transition from submarine to subaerial products appears to be due to the rapid filling of shallow marine basin. These lavas occur as a succession of individual flow units, with thickness varying from 1 to 2 m, and show pāhoehoe structures at the surface. The thickness of the subaereal unit is almost 7 m.

At the top of the subaerial flow lies an irregular erosional surface, filled with a fining-upward succession of bioclastic packstones and lava pebbles. Some of the pebbles are coated with coralline algae.

The basal conglomerate grades upwards to 3 m of cream coloured packestones (Fig. 8). At the top of the carbonate level two thin dark grey tephra layers occur. They probably represent the onset of the eruptive phase related with the alkalic products of the Poggio Vina formation. Foraminifera and nannofossils indicate an Early Pleistocene age (Emilian) (Pedley et al. 2001).

The Early Pleistocene carbonate are overlain by lava flows, black in colour, showing a typical columnar jointing (Fig. 8). The contact between the lavas and the carbonate bed is marked, locally, by the occurrence of pillow level intruded in the carbonate sediment. The thickness of the alkalic lava flows is up to 10 m in the quarry area, but exceeds 100 m in the western sector of the Loddiero valley.

The Loddiero section is closed by cream coloured plane-bedded wackestones and fine grained packstones (Early Pleistocene). These carbonates are part of a much more extensive regional development which encircles the Hyblean Plateau.

Along the road from the Loddiero quarry to Scordia, erosional channels cut the underlying micropackstones and wackestones. The channels vary from 1 to several metres in width and are filled by coarse grained packestones. This carbonate facies grades up to grey-blue clays, filling the structural depressions and flooring the Lentini Lake.

From Scordia to Sortino. On the way it is possible to observe the Pleistocene volcanics underlying the yellowish biocalcarenites. The lava flows are mainly subaerial and the old morphology influenced the sedimentary structures of the calcarenites, that upgrade to the blue clays, preserved in the structural depressions. Ahead we climb the carbonate plateau: the itinerary crosses the slope of the Miocene carbonates, controlled by NE-SW oriented faults, and continues upon the carbonate Plateau, cut by deep canyons.

Sortino

Completely rebuilt in the 18th Century on the top of a hill, the town is laid out on a rectilinear grid-like plan. The Chiesa Madre fronted by a forecourt cobbled with lozenges, has a fine façade of warm golden stone. The façade consists of a doorway flanked by spiral columns ornamented with vegetation decorations and garlands of fruit; a level articulated by statues; and, along the top, an open balustrade. The overall composition is strikingly effective, especially at sunset. The interior ceiling and apse is frescoed (1777-78) by Crestadoro. The church, belonging to the Montevergine monastery, enclosed within a secluded square, has a harmonious front and a bell-tower, fabricated with concave and convex lines (18C).

Pantalica

The deep canyons of this area, and, in particular, the Anapo Valley, are characterized by numerous tombs, *grouped in Pantalica. Identified as the ancient Hybla (founded, it is alleged, as Megara Hyblaea in 728 BC by a group of colonists from Megara, with the blessing of their last king, Hyblon), Pantalica has been inhabited since the Bronze Age. Towards the middle of the 13th Century BC, the Sicani moved inland from their original settlements in the coastal regions to a chosen site at Pantalica, for the coast at this time was subjected to attacks and regular waves of settlers, and therefore no longer secure. The narrow valley through which ran the Anapo river, together with the Cavagrande (which becomes Calcinara in its final section) were naturally defensible in that they comprised two deep gorges with one means of access. Today, little survives of the original town, which was probably destroyed by the Syracusans before the foundation of Akrai in 664 BC, save for an incredible number of tombs in the steep limestone cliffs (excavated at the cost of huge efforts, probably using bronze or stone axes, given that iron had not yet been discovered). New life was breathed into Pantalica by the Byzantines, who installed small communities in rock-hewn dwellings there. It is probable that the site continued to be occupied during the Arab and Norman periods, before being completely abandoned until the beginning of the 20th Century, when the archaeologist Paolo Orsi began excavating. More than 5,000 burial chambers honeycomb the walls of this quarry to make five necropoli through successive periods. The earliest in the north and northwest necropoli (13th- 11th Centuries BC) are elliptical in shape, while the most recent (850-730 BC) are rectangular. What is distinctive about these tombs is the way in which they are organised into compact family units, rather than into the more usual extended groups.*

Stop 1.3:

Sortino–Outer border of the Costa Giardini diatreme.

Subjects: Late Miocene hydromagmatic explosive volcanic activity, sedimentological characteristics of the pyroclastic products, and aereal distribution related to the vent.

Geological map nr. 2: *Carta geologica della Sicilia sud-orientale, 1:100,000 scale.*

The analysis of the sedimentological features of the volcanoclastics allowed us to distinguish three facies, whose distribution is related to their distance from the volcanic centre (Fig. 9). The distal facies is

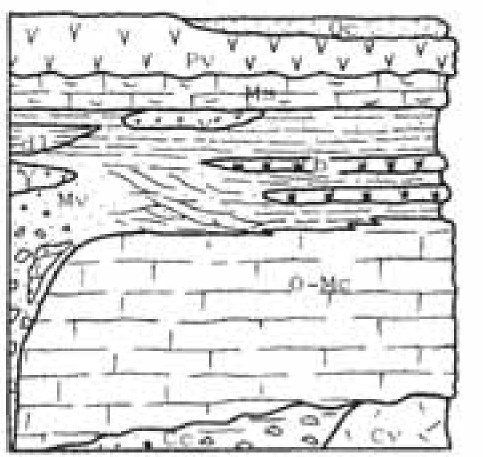


Figure 9 - Stratigraphic outline of the eastern Hyblean Plateau. (Qc)-Calcarenites, Quaternary; (Pv)-Volcanites, Pliocene; (Ms)-Lumachellae limestones, Late Tortonian-Early Messinian; (Mv)-Carlentini Fm.: volcanoclastics (v), biohermal limestones (b), lacustrine deposits (dl), Tortonian; (O-Mc)-Algae and Briozoa calcarenites, Oligocene-Middle Miocene; (Cc)-Calcarenites, Late Cretaceous-Eocene; (Cv) volcanites, Late Cretaceous.

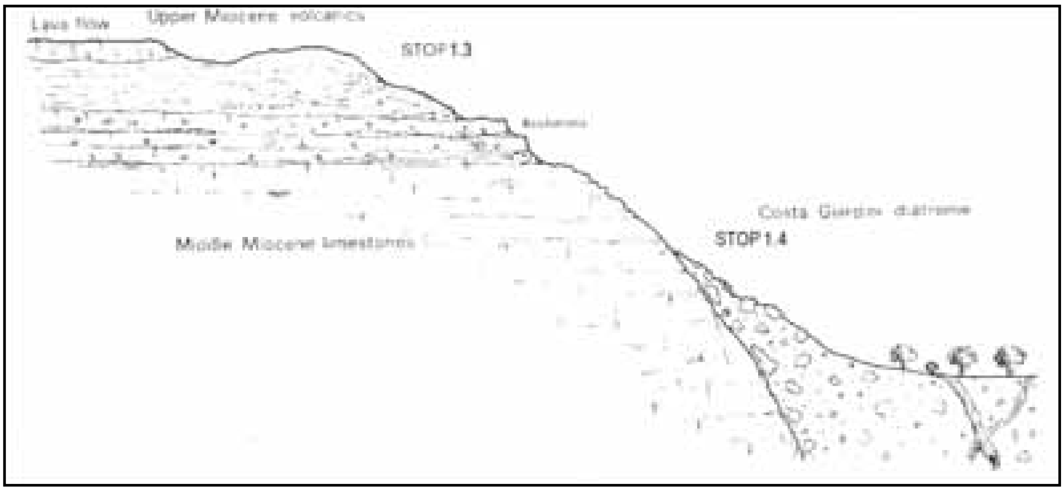


Figure 10 - Geologic profile across the diatreme of Costa Giardini.

represented by laminar, fine volcanoclastites mixed with carbonate sediments, not visible here; they are interbedded with bioherms of Tortonian age, which demonstrate the marine shallow water conditions (Fig. 9). Along the border of the diatreme the facies consists of cross bedded and laminated layers, locally showing impact sags and including fragments of the carbonate substratum and lherzolitic xenolithes. This facies is well exposed in this stop and is considered to be the product of hydromagmatic activity. A third facies, a very proximal product, is exposed along the inner walls and on the floor of the depression and is characterized by large carbonate xenolithes, in which fragments of bioherms and Cretaceous gasteropods have been identified (vent opening breccia).

Stop 1.4:

Diatreme of Costa Giardini.

This stop is devoted to the morphology of the diatreme (Fig. 10). The Costa Giardini area is characterized by a circular morphological depression (about 800 m wide in diameter), that can be interpreted as a diatreme, dissected in its southern edge by a series of NE-SW trending faults. The contours of the diatreme are made up of the Miocene limestones, deeply eroded, and the depression is filled by volcanoclastics with an intense cultivation of orange trees. The contacts between the limestones of the "ring" and the volcanoclastics show some preserved steeply inclined surfaces, that have been interpreted as the inner walls of the original hydromagmatic volcanic centre.

From Sortino to Siracusa. Going out of the diatreme, we cross small outcrops of diatomitic lacustrine deposits and lava flows of the same volcanic activity and successively we'll travel along the Anapo Valley to reach Siracusa. This valley goes out from a deep canyon and the river flows in a tectonic depression, the Floridia Graben, filled by Quaternary deposits.

Stop 1.5:

Syracuse.

The aim is to show the archaeological site in the geological setting.

The Greek theatre is excavated in the Middle-Late algal (rhodolithic) limestones of the eastern Hyblean Plateau, directly overlying the Late Cretaceous volcanics.

Overnight in Syracuse

Figure 11 - Panoramic view of Ortigia island.

Syracuse
Where settlers once from Corinth 's ithsmus built
Between two harbours their great battlements.
Ovid, Metamorphoses
Syracuse (built in 734 B.C.) has forever depended upon the sea, rallying herself around the island of Ortygia (Fig. 11)*, overlooking a wonderful bay on the east coast; its name is synonymous with an ancient Greek past, a series of valiant tyrants, the rivalry between Athens and Carthage; a past which has left a number of vestiges for the modern day visitor to see and enjoy. Alongside this dramatic historical background, there exists another less obvious past that can be explored among the streets of the island, where time seems to stand still somewhere between the medieval and Baroque eras. Just behind Ortygia stretches a flat area called Akradina – yet another name inherited from Antiquity.*
The district of Neapolis, literally meaning the 'new town', is one of the most evocative quarters claiming the theatre, the Ear of Dionysius and the Latomia del Paradiso within its boundaries. On the eastern side lies Tyche, so-called because there was a temple there dedicated to the goddess of fortune (from the Greek Tyche – fortune or luck). Dominating the remainder of the city is the part called Epipolae, guarded and defended by the Castle of Euryalus, strategically built in the most advantageous position.

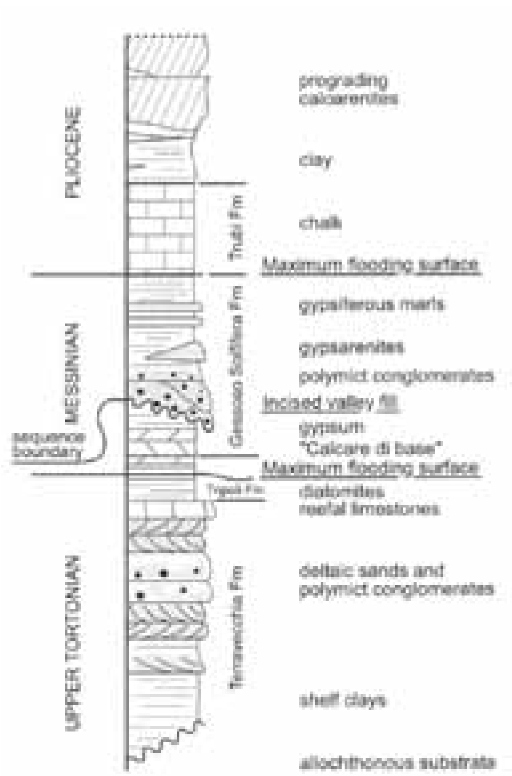


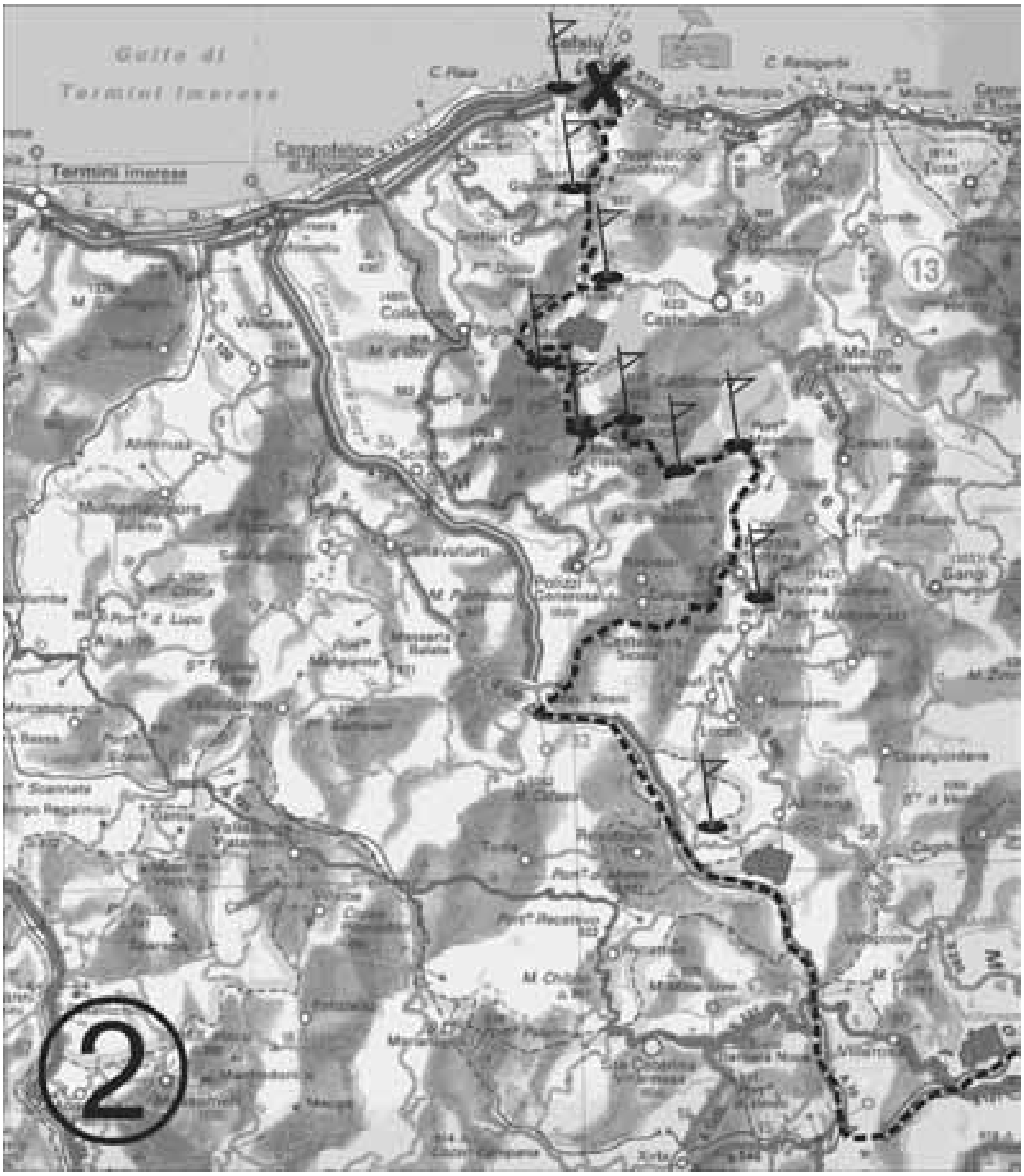
Figure 12 - Stratigraphic log representing the Late Miocene-Early Pliocene deposits of central Sicily.

DAY 2

(30 August 2004)
Subject: Marginal sequences of the Imerese basin (internal Ionides), Panormide carbonate platforms, Numidian Flysch, internal basinal Sicilide sequences (Alpine Tethydes), Neogene silicoclastic and evaporitic deposits.
(Overnight stay in Cefalù).
Geological map nr. 3 – "*Carta geologica delle Madonie"* 1:50,000 scale.

7[30] *Starting from Syracuse*

From Syracuse to Tremonzelli. This second day excursion is a very long trip, requiring a little bit of physical effort. We cross through a vast area of Central-Eastern Sicily, reaching the Cefalù village on the northern coastline in front of the Tyrrhenian Sea. Leaving Siracusa it's possible to still observe the northeastern sector of the Hyblean Foreland and to cross again the edge originated by the downfaulting toward the foredeep.
Along the highway from the Catania Plain toward Palermo the landscape of Central Sicily is characterized by gentle morphology. The hills belong to the thrust belt of the Apenninic-Maghrebian Chain. In proximity of Catenanuova Mt. Scalpello (on the left side) there is an outcrop of Triassic cherty limestones of the Mt. Judica sequence, interpreted as a S-verging thrust (Geological map nr. 1 and Fig. 7). Varicoloured Clays and Numidian Flysch (Nicosia Unit) of the Sicilide Complex tectonically rest upon the Middle Miocene top levels of this sequence (Figs.3;4). Clays, sands and evaporites, Late Miocene in age, rest uncomformably. The highway passes between two cities, Enna and Calascibetta, located at 1000 m above the sea level and builr upon Middle Pliocene clays and calcarenites, which represent a regressive succession. The trip continues through the Late Miocene clays and the evaporitic sequence evolving to Early Pliocene marls (Fig. 12), the nappes of Alpine Tethydes (Numidian Flysch sandstones and Varicoloured Clays), going out toward Tremonzelli (Figs. 3; 4).



Overall, the architecture of the Sicilides is that of a tectonic wedge, progressively thinning, until it disappears, below the Kabilo-Calabride Chain. Inside this wedge at least four tectonic units have been distinguished: two made up by Mesozoic sequences, the Mt. Soro Unit and "Argille Scagliose superiori" Unit (ASSU), and two Paleogene up to Early Miocene successions, the Nicosia Subunit and the Troina Subunit The former is probablythe original cover of the MT. Soro Flysch; the latter represents the Cenozoic cover of the ASSU. The geometric relations probably are the result of a progressive accretionary process, accompanied by a general detachment of the Tertiary terrigenous covers, ending with out-of sequence thrusting of the Mesozoic sequences (Fig. 4).

The Sicilides tectonically overlie the Late Oligocene – Early Miocene Numidian Flysch, which represents the original cover of the Imerese sequence (the External Numidian Flysch), but they involve some

Numidian sequences belonging to the innermost palaeogeographic domains (the Nicosia Unit). This latter, the so-called far-travelled Numidian Flysch, crops out along the way in a chaotic melange with the Varicoloured Clays.

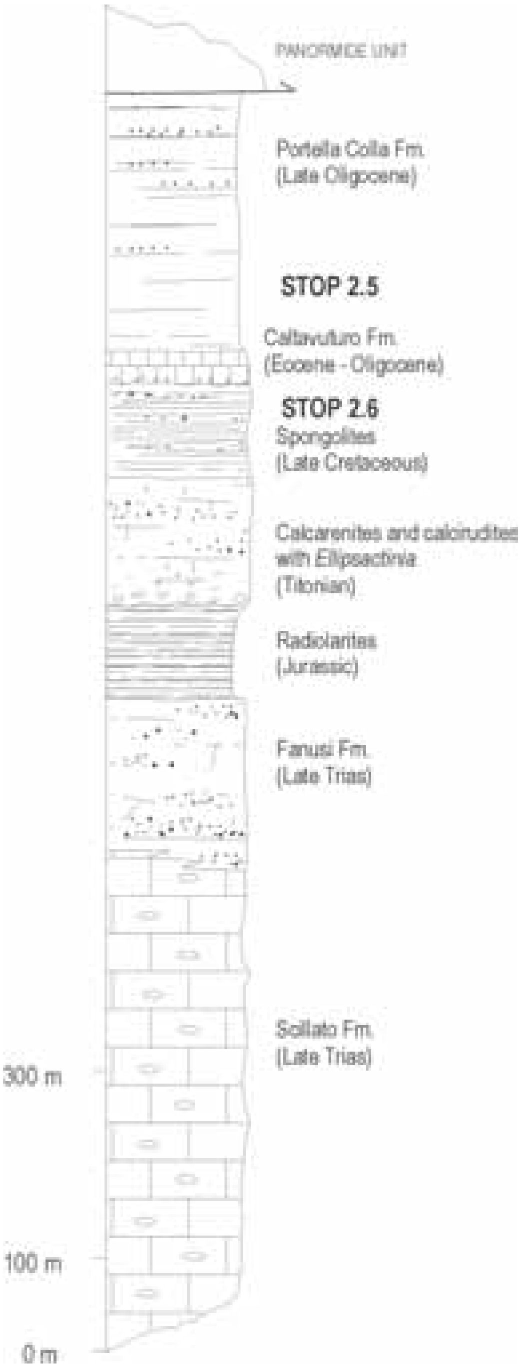


Figure 13 - Stratigraphic log of the Imerese Units (Ionides).

Stop 2.1:

Bivio Tremonzelli.

The purpose is to show a general view from south of the Madonie Mountains, located in northern Sicily, representing mesocenozoic tectonic units, which overrode the buried External Thrust System.

Geological map nr. 3: "*Carta geologica delle Madonie"* 1:50,000 scale.

In this general view of the southern slope of the Madonie Mountains we can observe on the left the Imerese Unit forming the anticline of Mt. dei Cervi, characterized by a basinal Mesozoic-Tertiary sequence, belonging to the Ionides, tectonically underlying the carbonate platform of the Panormide Unit, visible on the right side.

The Ionides are here represented by the Imerese Unit, originally sedimented in an area contiguous to the Panormide Platform. The stratigraphic column (Fig. 13) shows, from the bottom to the top, cherty limestones and dolorudites, Late Triassic in age (Scillato and Fanusi Fms), followed by Jurassic to Cretaceous radiolarites with carbonate breccia intercalations (which differentiates them from the Mt. Judica sequence), Eocene pelagic sediments (the Caltavuturo Fm) and the Upper Oligocene Portella Colla Fm, basal horizon of the Numidian Flysch.

The Panormide Platform (Fig. 14), related to the homonymous tectonic unit, forms the Eastern Madonie Mountains and crops out along the N-S Pizzo Dipilo – Pizzo Carbonara ridge, and the emplacement onto the Imerese Unit is thought to have developed during the Early-Middle Miocene. The basal level, a detachment level, consists of grey euxinic marls and calcarenites, known as the Mufara Formation. Carbonate platform deposits (tidal flat to back reef lagoon, to reef complex) developed from the Late Triassic up to Malm (Stop 2.4). Upper Cretaceous lagoon to open-shelf deposits (including rudist patch reefs) colonized the remnants of the platform (Cefalù). With the subsequent drowning, Upper Cretaceous–Eocene pelagic calcilutites sedimented, sometimes infilling palaeokarst fissures of the platform. Incipient orogenetic processes brought the platform to be uncomformably overlain by silicoclastics, referred to as the Gratteri Formation and to Numidian Flysch.

Two different sequences, ascribed to subunits, have been distinguished (see Fig. 14), the Mt. Quacella and the Pizzo Carbonara Subunits.

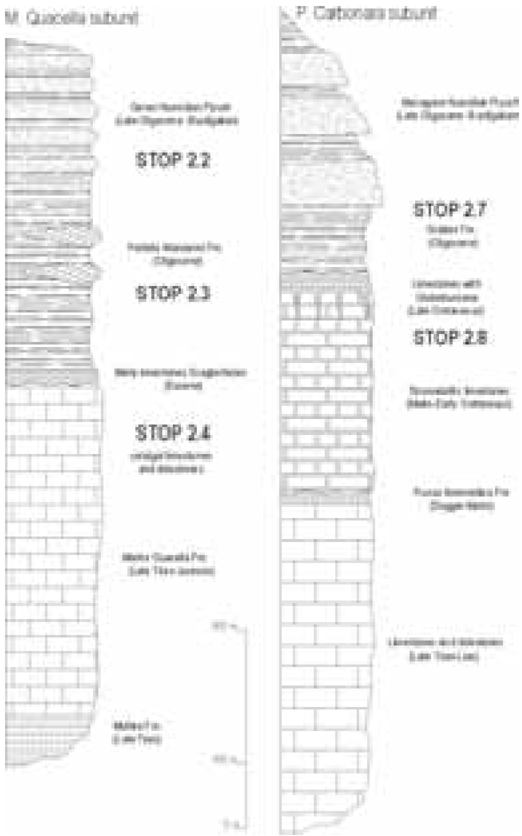


Figure 14 - Stratigraphic log of the Panormide Units.

From Bivio Tremonzelli to Petralia Village. On the way, varicoloured clays (Sicilides), grey-bluish clays, sands and conglomerates, small bioherms and evaporites, Late Miocene in age, crop out. At the end we pass through the Mandarini Valley on the eastern flank of the Panormide Platform.

Stop 2.2:
Mandarini Valley.
Numidian Flysch and relationships with the underlying Mesozoic carbonate platform. Late Miocene-Pliocene tectonics.
The stop allows us to observe the quartzarenites of the Numidian Flysch and the structural setting of the Panormide Unit outcropping on the other side of the valley (Fig. 14). The Numidian sequence belongs to the Oligocene-Early Miocene original cover of the carbonate platform. The provenance of the quartz is thought to be from craton areas.
Geological map nr. 3: *Carta geologica delle Madonie*; 1:50,000 scale.

From Mandarini Valley to Portella di Mandarini-Pizzo di Corco area. The road cuts the Mandarini Clays. The Upper Oligocene sandy shales contain some amygdaloid or lens-shaped intercalations of carbonate breccias, that were interpreted by Ogniben (1960) as a wildflysch related to the Panormide nappe emplacement. The elements of this breccia, cm to dm in size, mostly cobble to boulder, consist of reefoidal or shallow-water carbonates and they derive from the progressive dismantling of the Panormide platform; they originated due to the combined effects of the synsedimentary tectonics and the eustatic lowering.

Stop 2.3:
Pizzo di Corco area.
Megabreccia and structural setting of the Panormide Platform. The stop is devoted to observing the breccias intercalated in the Mandarini Clays and to explaining the topsection of the Panormide Unit.

12^{50} *Lunch (Rifugio Pomieri)*

From Rif. Pomieri to P. Battaglia. The road crosses the Panormide unit: Numidian Flysch, Triassic dolomites, and a tectonic window, in which the top levels of the underlying Imerese Unit crop out.

Stop 2.4:
Piano della Battaglia.
The Upper Jurassic coralgal limestones of the Panormide Platform. Along the road fossiliferous limestones crop out. They contain colonial corals, *Ellipsactinia*, Echinoids, Ammonoids, Sponges and are referred to facies of the margin of the platform.

From Piano della Battaglia to P. Colla. We go down the Pizzo Carbonara platform, observing the succession from the top to the bottom. The road crosses first the Jurassic limestones, the Triassic dolomitic breccias, and then the marls and marly limestones of the Mufara Fm (Middle-Late Trias). Beneath the Panormide Nappe we can observe the "Argille di Portella Colla" Member, the top-level of the Imerese Unit.

Stop 2.5:
Portella Colla.
General view of the Panormide Nappe. This stop represents a classic locality, where it is very clear the superposition of the Panormide sequence, the Mufara Fm, cataclastic dolomites, reefoidal

limestones, onto the Imerese top-levels, which consist of Oligocene brownish shales with quartzose silts, coeval with Mandarini Clays, grading downwards to red clays with *Nummulites* and *Discocyclina*-bearing calcarenites (Caltavuturo Fm).

Stop 2.6:
Mandria del Conte.
Imerese stratigraphy.
At this stop the Cretaceous interval of the Imerese sequence is shown, characterized by redeposited carbonates intercalated within the pelagic or hemipelagic sediments (Fig. 13). The succession is characterized by 50-70-m –thick redeposited calcirudites and calcarenites (Calcari ad *Ellipsactinia*), followed by alternating thinly stratified argillites, green to red radiolarian marls, and bioclastic wackestones to grainstones. Bioclasts consist of algae, corals, hydrozoans, orbitolinidae and other benthonics. In many cases the bioclastic limestones appear to be silicified. This sequence has been deposited on a slope along the scarps of an adjacent carbonate platform. Thus the observed facies should belong to a basinal environment, but proximal to the Panormide Platform.

From Mandria del Conte toward Isnello. The road goes down in the valley beween Mt. dei Cervi (Imerese) and Pizzo Carbonara (Panormide), through Piano Zucchi and ends in Isnello.

Stop 2.7:
Isnello.
Subjects: Tertiary cover of the Panormide Platform, structural setting of the platform.
At the village the Gratteri Fm is well exposed. This formation represents the original Oligocene cover of the Panormide Platform, coeval with the Portella Colla member seen before. But it took part in the displacement of its carbonate substratum, and is composed of an alternation of clays, marls, calcarenites and quartzarenites. These latter indicate an original vertical evolution compared to the Numidian Flysch at the Oligocene-Miocene boundary. The village is located in a tectonic depression inside the Panormide Platform, between Pizzo Carbonara and Pizzo Dipilo.

Stop 2.7:
Mt. Puraccia (Pizzo Dipilo).
Jurassic tidal plain facies of the Panormide Platform.
Along the road we can observe the Upper Jurassic interval of the Panormide Platform. Here alternations of stromatolitic, algal and gastropod grey limestones crop out and show beautiful examples of oncolites. This cyclothemic tidal-subtidal facies grades laterally and upwards into lagoonal facies and is heteropic with marginal sequences like those observed in the stop 2.4.

Figure 15 - The cathedral of Cefalù

From Isnello to Cefalù. Toward Cefalù, the road goes down to reach the Tyrrhenian coastline. Clays and quartzarenites of the Numidian Flysch, tectonically underlying some klippen of Sicilide Units (Tufiti di Tusa Fm. and Reitano Flysch), discontinuously crop out along the way. Cefalù is a beautiful village built at the base of the Rocca. The "Rocca di Cefalù" is a Cretaceous rudist-bearing limestone, bounded by a pattern of faults. Field work has demonstrated that it is not an isolated block, but it's connected in subsurface to the calcareous mountains seen before. This interpretation is supported by hydrogeological data: at the base of the "Rocca" some springs (many hundreds of liters per second) gush out (Fig. 15).

Overnight in Cefalù

Cefalu'
Enjoying a splendid position and clearly visible from the road running north from Palermo, Cefalù was originally a fishing village, now a small town, perched between the sea and a craggy limestone promontory ("La Rocca"), landmarked by a cathedral and a maze of narrow streets. Of Greek origin, its current name derives directly from the Greek "Kephaloidion", meaning head or chief. It saw its heyday under Roger II who, in 1131, decided to initiate work on the cathedral.
The Romanesque cathedral is built of a gold-coloured stone that, set back behind a series of palm trees,

seems to merge with the limestone hillside called La Rocca rising behind. The edifice was built between 1131 and 1240 at King Roger II's behest, following a vow he made when on the point of being shipwrecked when returning from Naples. It is more evidently Norman than its counterpart in Palermo, notably in the Moorish style of the façade framed by two towers and in the upper apse flanked by smaller ones. The façade, completed in 1204, is divided into two storeys by a portico which was rebuilt in the 15th century by the Lombard architect Ambrogio da Como. The upper section is finely ornamented with blind arcading. The twin towers, built on a square plan, rise through levels with single and double openings that culminate in crenellations. Below the portico is the central Porta dei Re, the ancient main entrance to the building. The church has a Roman-cross floorplan divided into three naves by columns bearing fine capitals carved in the Sicilian-Norman style. The chancel is adorned with wonderful mosaics, in a spectacular array of colours on a gold background. The eye is immediately attracted to the huge majestic image of the Christ Pantocrator.

DAY 3

(31 August 2004)
Subject: flysch successions of the Nebrodi-Peloritani belt, relationships between the Kabilo-Calabride chain and the Maghrebian chain, metamorphic units of the basement and Meso-Cenozoic covers.

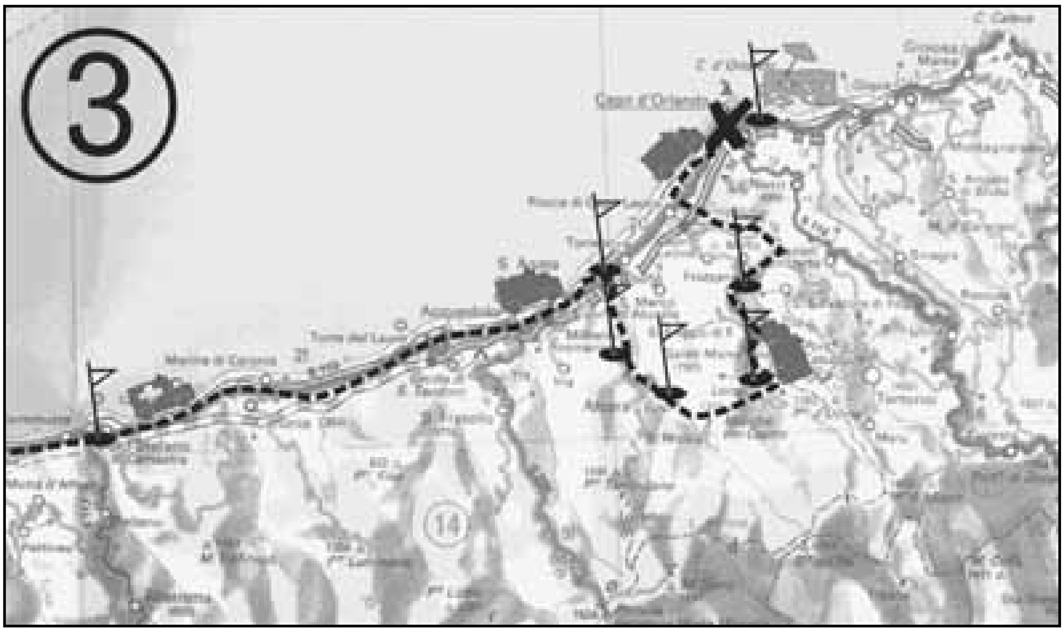
(Overnight stay in Capo d'Orlando)
Geological maps:
nr. 4 – *Carta geologica della Provincia di Messina*, 1: 50,000 scale;
nr. 5 – *Carta geologica del settore occidentale dei Mt. Peloritani*, 1:25,000 scale.

8^{00} *Starting from Capo d'Orlando*

From Cefalù to Bivio Pettineo. Starting from Cefalù and leaving the "*Rocca di Cefalù*", we travel along the shoreline, where outcrops of Numidian Flysch (original cover of the Panormide Platform) can be observed.
On the Tyrrhenian coastline the Numidian Flysch is tectonically overlain by Sicilide Nappes, Varicoloured Clays, Tusa Tuffites and Reitano Flysch, originally deposited in the Alpine Tethys realm.

Stop 3.1:
Road 113, junction with the road to the village of Pettineo.
Sedimentological and petrological characteristics of the Reitano Flysch. The Reitano Flysch represents the Early-Middle Miocene cover of the Sicilide nappes, deposited before the tectonic emplacement onto the Numidian Flysch.

From B. Pettineo to S. Stefano di Camastra. The trip continues until reaching the village of S.Stefano di



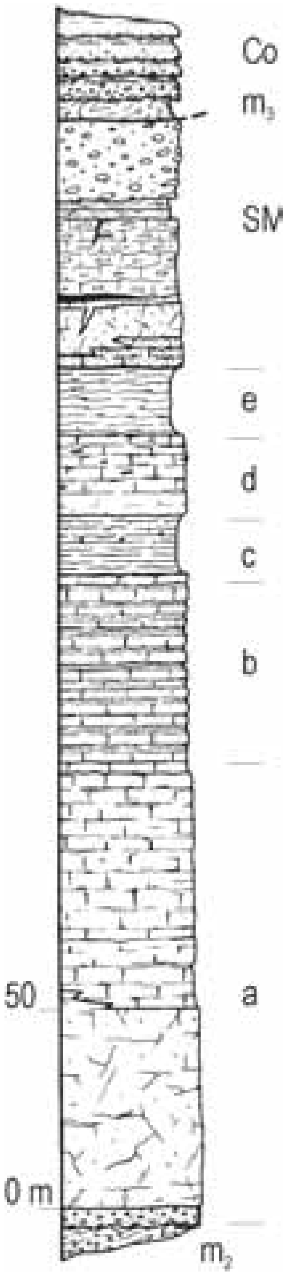


Figure 16 - Stratigraphic column of the Longi-Taormina sedimentary sequence and of the overridden St. Marco condensed succession (Rocche Rosse section; Stops 3.3 and 3.6): m_2 – Hercynian basement; a) Lower Lias "Verrucano" and platform carbonates (dolomites, black limestones); b) Lower-Middle Lias "Medolo" facies; c) Upper Lias marly "Ammonitico Rosso"; d) Malm to Lower Cretaceous calcareous "Ammonitico Rosso" and Majolica-Biancone facies; e) Cretaceous-Eocene "Scaglia"; SM) condensed sequence of St. Marco Unit (red crinoidal limestones, Ammonites-bearing limestones, Nummulitic breccias); m_3 – epimetamorphites of the S.Marco Unit; CO – Capo d'Orlando Flysch.

Camastra.

Stop 3.2:
S.Stefano di Camastra.

Santo Stefano di Camastra

Santo Stefano di Camastra is well-known for its hand-painted ceramics, as attested to by the myriad of small shops lined along its streets, offering pots, vases, plates and ceramic trinkets to suit every need and taste. Among its main buildings, a special mention goes to Palazzo Sergio, once the Duke's Palace, now holding the Museo della Ceramica. The place of honor in the museum is given to Lorenzini's Andare (departing), on the right of the entrance, depicting a group of warriors gradually sinking into the ground. Several rooms in the building have conserved their original tiled floors, frescoed ceilings and 1700s furnishings. Out of town (beyond the Istituto per la Ceramica), is the Cimitero Vecchio, a cemetery that was used for two years only, between 1878 and 1880, containing a number of graves ornamented with maiolica.

From S. Stefano di Camastra to Militello Rosmarino.
Along the way it is possible to see Numidian outcrops, and then we'll leave the Apenninic-Maghrebian units to enter the Kabilo-Calabride domain. This is made up by Hercynian basement nappes with remains of the original Mesozoic-Tertiary sedimentary covers, whichpredominantly crop out along the way. The crystalline nappes display the highest grade metamorphic rocks, going progressively toward the top of the structural sequence; that means that the highest tectonic nappe (the Aspromonte Unit) shows middle-high grade metamorphites.
The lowermost nappes can be grouped in an epimetamorphic complex. They are characterized by more or less condensed Meso-Cenozoic sedimentary covers. Three tectonic units have been distinguished from the bottom to the top: the Capo S.Andrea Unit; the Longi-Taormina Unit (less condensed) and the St. Marco Unit (Fig. 16). The former is exposed only in the Ionian side, near Taormina (Stop 4.6)
(**Geological map nr. 4** – *Carta geologica della Provincia di Messina,* 1:50,000 scale).

$12^{\underline{00}}$ *Lunch*

Stop 3.3:
Vallone Rosmarino.

The aim of this stop is to show the sedimentary covers of the Longi-Taormina Unit in an overview along the Rosmarino Valley, and to illustrate the very complicated tectonics.
(Fig.16 and Stratigraphic column of Longi-Taormina unit in geological map nr.5).
In the valley, and especially on the other side, the outcrops are represented by Early Liassic red conglomerates and sandstones (Verrucano facies), and carbonate platform limestones, followed upwards

Figure 17 - Panoramic overview of the tectonic contact between the Kabilo-Calabride units and the Sicilide units.

by Ammonites-bearing marly limestones (Medolo facies) and Rosso Ammonitico, Middle-Late Lias in age. This sequence ends with red marls (Scaglia Facies), upgrading to an Eocene-Oligocene flysch and is overridden by the St. Marco Unit. This latter is characterized by an epimetamorphic basement with a condensed sedimentary cover, mainly represented by fractured blocks of Jurassic red limestones ("*Rosso di S.Marco*").

From Militello to Alcara Li Fusi we travel along the tectonic contact between the Mt. Soro Flysch and the Kabilo-Calabride units. The Mt. Soro Flysch is a Cretaceous terrigenous deposit, belonging to the Apenninic-Maghrebian Chain, in particular, to the Sicilide Complex. The geometric relations probably are the result of a progressive accretionary process accompanied by a general detachment of the Tertiary terrigenous covers.

Stop 3.4:

Alcara Li Fusi.

This stop is aimed at observing the aspect of the Mt. Soro Flysch. It is composed of clays and quartzarenites, alternating with marly limestones.

It is clear that this flysch tectonically underlies the thick carbonate sequences of the Calabride (Fig. 17), but a further tectonic unit, the Argille Scagliose Superiori (ASS), is sandwiched between them. The Tertiary intervals of the Sicilide Complex, including the Reitano Flysch seen in Stop compose the wedge cropping out in the southern slope of the Nebrodi Mountains and are not visible here.

Stop 3.5:

Contrada Gazzana.

The panorama shows from the bottom to the top the nappe-pile: the Mt. Soro Flysch, the ASS, and upwards the Calabride nappes. Some klippen (Pizzo Mueli) demonstrate the tectonic relationships.

Stop 3.6:

Contrada Cillo-Rocche Rosse di Galati.

From this point of observation it's possible to appreciate the tectonic style of the Longi and St. Marco tectonic units (Fig. 16, or see the stratigraphic column in geol. map nr. 5).

Stop 3.7:

St. Basilio (Galati).

In this stop we can observe the aspect of the low-grade metamorphic rocks of the St. Marco Unit (m_3). Further information about the general view can be provided.

From Galati to Capo d'Orlando.
The field trip goes on and proceeds through the village of Galati, and then down along the valley until reaching Capo d'Orlando.
(overnight in Capo d'Orlando)

Capo D'orlando
A charming little seaside resort, Capo d'Orlando sits on a promontory of the same name surrounded by the sea. Its history is intertwined with the legend of its foundation at the time of the Trojan War by Agathyrsus, the son of Aeolus. The legend also relates how the ancient settlement of Agathyrnis came to be renamed Capo d'Orlando by Charlemagne, who, when passing through these lands on a pilgrimage to the Holy Land, decided to call it after his heroic paladin.

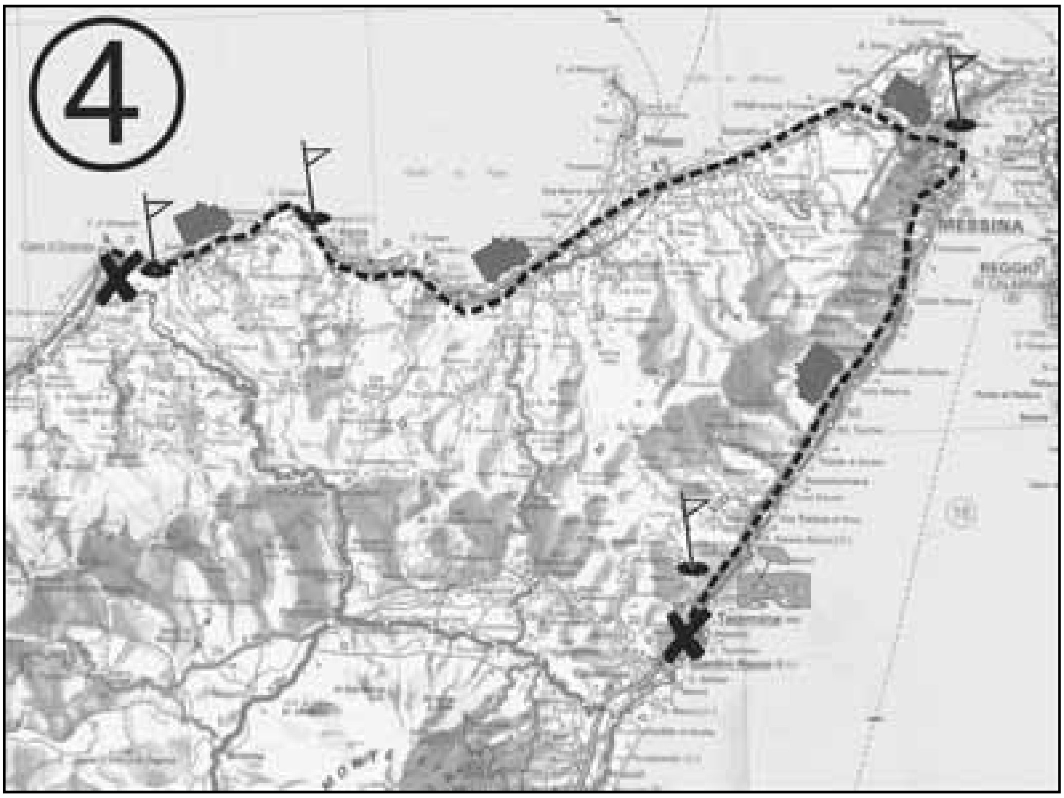
DAY 4

(1 September 2004)
Subject: Hercynian crystalline units and Oligo-Miocene covers of the Kabilo-Calabride Chain. South Tyrrhenian fault system. Times and modes of the opening of the Tyrrhenian basin. Messina Strait.
(overnight stay in Taormina)
Geological map nr. 6 – Carta geologica del Golfo di Patti; 1:25,000 scale.
Geological map nr. 7 – Carta geologica di Messina e del settore nord-orientale dei Monti Peloritani; 1: 25,000 scale.
Geological map nr. 8 – carta geologica dei Monti di Taormina; 1:25,000 scale.

8^{00} *Starting from Capo d'Orlando*

Stop 4.1:

Capo d'Orlando.
Before leaving the village, we'll visit the outcrops along the Cap: the high grade metamorphic rocks and the overlying Capo d'Orlando Flysch.
The metamorphites belong to the Aspromonte Nappe and consist of upper to lower Variscan amphibolites - facies, banded paragneiss and mica-schist with interlayered minor amphibolites, metahorneblendites, metaultramafites, marble and Ca-silicate fels. This



metamorphic basement is intruded by Variscan plutonites.
The Flysch is characterized by arkoses and sandy clays; a conglomerate basal horizon may be present. The sandstones are frequent and form thick banks. The sedimentological characteristics and the petrological composition indicate that this deposit is a turbidite, fed by the crystalline basement. The age is Late Oligocene-Early Miocene, and this deposit is linked to the Balearic Stage of the orogen.
(Geological map nr. 5)

From C. d'Orlando to C. Calavà. We leave Capo d'Orlando to reach and visit the Capo Calavà area. The coastline is a beautiful "falesia" cut in high metamorphic rocks of the Aspromonte tectonic unit.

Stop 4.2:
Scoglio Nero–Capo Calavà.
Here it's possible to observe the overthrust of the Aspromonte nappe, resting on the Mandanici Unit. In the Aspromonte Unit, gneiss and micaschists exhibit anatectic phenomena, from leucocratic pockets up to flebitic-stromatitic diatessite process. The palaeosome is represented by biotite-muscovite-sillimanite paraderivates; the neosome consists of mobilized quartz and feldspars as ptygmatic veins and concordant bands. The Mandanici Unit consists of a Variscan low greenschist-facies to low amphibolite-facies basement. The basement is made up of a pelitic-arenaceous sequences with subordinate volcanic and carbonate levels. The widespread cataclastic to mylonitic effects in the unit suggest the occurrence of a significant Alpine tectogenesis.
From C. Calavà to Tindari. Leaving the Capo Calavà area, we enter the Patti Gulf, which coincides with a complicate structural depression, bounded by NW-SE oriented fault pattern (the South Tyrrhenian System), which is the response to the regional shifting of the orogenic system toward the Calabrian Arc. The area suffered repeated earthquakes, which demonstrate that the structures are still active.
(**Geological map nr. 6:** *Carta geologica del Golfo di Patti*, 1:25,000 scale).
We cross the structural depression of Patti, controlled by faults of the South Tyrrhenian System and filled by Miocene-Pleistocene deposits. Along the way the Capo d'Orlando Flysch and the crystalline basement crop out.

Stop 4.3:
Tindari.
Tindari is a promontory characterized by high grade metamorphic rocks, made up by Variscan migmatitic augen-gneiss bodies and paragneiss interbedded by Late Variscan aplitic-pegmatitic dikes and by medium-grade two micas marbles with associated micaschists.
(Geological map nr. 6)

Tindari
Classical civilization has left here its testimony at what was called Tyndaris, in the Theater and the Basilica. Archaeological excavations have revealed the regular outlines of the old Greco-Roman city. On the ruins of the Acropolis there is now a sanctuary, a pilgrimage center for the entire island, where a miraculous Black Madonna is venerated. Below the cape of Tindari extend the lagoons of Marinello.
According to legend, these pools came into existence to save a little girl who otherwise would have fallen to her death from the top of the headland because of her faithless mother (unable to believe in a Black Virgin); she was saved when the sea miraculously withdrew to leave a soft landing pad of sand that cushioned her fall. In 1982, one of the rock pools assumed the profile of a veiled woman identified by the local people as the Madonna of the Sanctuary. Occupying a fine position high on its own headland, the Greek colony of Tyndaris was founded by the tyrant of Syracuse, Dionysius the Elder, in 396 BC, to accommodate refugees from Sparta at the end of the Peloponnesian War (404 BC). Its name may be related to the Dioscuri (Castor and Pollux), and to their father, Tyndareus of Sparta, husband of Leda and father of Helen who, according to Homer's Iliad, indirectly provoked the War of Troy. The link between the town and the heavenly twins is taken up on coins and mosaics.
Thanks to its strategic location, the town could easily control and defend the stretch of sea between the Aeolian Islands and Messina, until it fell to the Carthaginians, when its defensive walls, sadly, were unable to protect it from the enemy's ravaging.
Under the Romans, the city entered a period of renewed prosperity, marked by construction of new buildings -- schools, baths, a theatre, markets -- and the restoration or modification of older ones. The theatre, built by Greeks, was modified so as to accommodate the demands of its new audience. Thereafter, it progressively declined, notably following a landslide that destroyed part of the city, as well as

Figure 18 - Picture showing the foreset geometries of the Ghiaie e Sabbie di Messina Fm.

after the Arab conquest in the 9th century AD.
The path going up to the top of Capo Tindari passes alongside sections of the defensive walls built during the reign of Dionysius, later reinforced and replaced by a double barrier of square stone blocks. They protected the vulnerable parts of the town, which was laid out on a regular grid system with three wide decumani (main thoroughfares) interconnected by perpendicular cardini (cross streets). The natural inclination of the site facilitated an efficient drainage system along the secondary streets.
The Insula Romana area comprises the large block south of the Decumano Superiore (the main axis), complete with baths, taverns and houses, including a large patrician house preserving fragments of mosaic.
The Basilica consists of arcaded ruins that give some suggestion of the scale and elegance of the original basilica. It is built of large square blocks of sandstone, and must have comprised five great arches. The central, and widest, archway provided access to a barrel-vaulted passage spanning the main road.
The theatre was built by the Greeks in the late 4th century, in such a way as to take full advantage of the natural lie of the land, with the cavea (auditorium) facing the sea and the Aeolian Islands. It was adapted in Imperial times for staging gladiator fights.

From Tindari to Messina.
The field-trip goes on to reach Messina. Along the way it's possible to observe Tertiary and Quaternary deposits, marine terraces and, on the left, Capo Milazzo, a sunny peninsula, verdant with age-old olive trees, characterized by high-grade metamorphic rocks, with a picturesque fishermen's village, embarcation point for the Eolian Islands. These are seven islands, which form a volcanic arc connected with the Ionian slab; among these Vulcano and Stromboli are active.

Stop 4.3:
Messina.
The town is built on the eastern flank of the Peloritani ridge in front of the Ionian Sea. The area of the Messina Strait is characterized by a crystalline basement, underlying Late Miocene to Quaternary deposits. These are exposed along the Tyrrhenian slopes as well as the Ionian side of the Peloritani

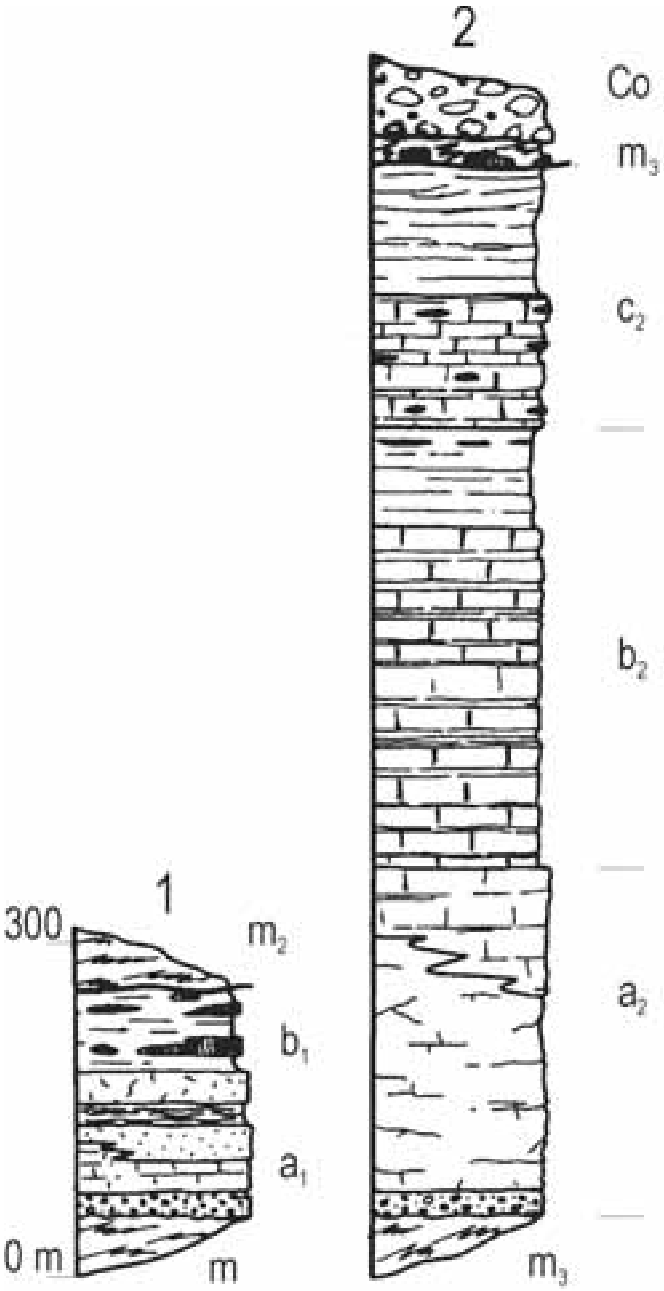


Figure 19 - Stratigraphic columns of the Mesozoic-Cenozoic sedimentary covers exposed in the Taormina area. (1) Capo S. Andrea Unit: m_1 – Hercynian basement; a_1 – Lower Lias to Cretaceous condensed sequence ("Verrucano", nodular limestones); b_1 – Upper Cretaceous – Eocene "Scaglia" facies; m_2 – crystalline basement of the Longi-Taormina Unit
(2) Longi-Taormina Unit: m_2 – Hercynian basement; a_2 – Lower Lias "Verrucano", platform limestones and dolomites; b_2 – Ammonite-bearing marls and marly limestones (Medolo facies), "Rosso Ammonitico" and radiolarites (Middle Lias-Malm); c_2 – Lower Cretaceous to Eocene calcilutites and marls (Biancone and Scaglia facies); m_3 - Hercynian metamorphites of the St. Marco Units; Co – Capo d'Orlando Flysch.

ridge, controlled by a NNE-SSW oriented fault system (**Geological map nr. 7**: *Carta geologica di Messina e del settore nord-orientale dei Mt. Peloritani*, 1:25,000 scale). The sedimentary sequence is made by Late Tortonian silicoclastics, some Messinian evaporites, Early Pliocene Trubi, Pliocene-Pleistocene sands and calcarenites and sands and gravels, known as *Ghiaie e sabbie di Messina* (Fig. 18), deposited about 200 Ka ago.

The stratigraphical studies carried out on the deposits outcropping on both sides leads us to conclude that the paleogeography of the Strait starts from the Middle Pleistocene calcarenites (0,98-0,58 ka) (Guarnieri et al., 2004).

The main tectonic lines controlled the aereal distribution of the *Ghiaie e Sabbie di Messina* Fm., mainly along a NNE-SSW direction; subsequently, the Ganzirri-Scilla Fault System (ENE-WSW trends) became active; this currently controls the portion of the Strait falling between Ganzirri and Scilla. The off-shore geophysical data confirm those collected onland, and clearly show the presence of active fault systems.

The outlined structures correspond to the main lineaments connected with a deep structural setting related to a re-orientation of the direction of retreat of the subduction hinge from SE to SSE (Guarnieri & Carbone, 2003; Guarnieri, 2003). This new setting is responsible for the formation of the ENE-WSW extensional faults connected with compressional mechanisms in depth.

Messina

In the past, Messina was a major stop in the Mediterranean trade routes and represented a crossroads of cultural and artistical exchanges, able to provide a dynamic and stimulating environment for important artists, among which the most important certainly is Antonello da Messina. In more recent times, several natural catastrophes have hit the city, notably two earthquakes, in 1783 and 1908, the latter razing 9/10 of it to the ground, causing as many as 60,000 deaths. The city was rebuilt first as a shanty town, with modern Messina dating back to 1928. It is a gracious and lively city with long and ample streets built to antiseismic requirements. But, in contrast, the modern suburbs encroach upon the rivers, and the development of the town, forgetful of the past disasters represents a typical example of needing to apply geological investigations in urban areas.

14^{00} *Lunch*

From Messina to Taormina. The field trip goes on along the Ionian coast, from the highest crystalline nappes toward the lowest, from the Aspromonte Unit, to the Mandanici Unit and reaching the Epimetamorphic Complex. Some sedimentary sequences are exposed (Capo Sant'Alessio).

Stop 4.6:

Capo Taormina and Isola Bella.

From Capo Taormina a general view shows the Capo S.Andrea Unit, a condensed Lias up to Cretaceous carbonate sequence, that tectonically underlies the low-grade metamorphic rocks (m_2), which represent the Hercynian crystalline basement of the Taormina sequence (Fig. 19).

Walking from Capo Taormina toward Giardini along the sea, we can observe the Mesozoic sequence of the Taormina Unit, unconformably lying over low metamorphic rocks, related to the Hercynian orogenesis. From the bottom to the top the basal level is made up of red conglomerates and sands in "Verrucano Facies", grading up to a Lower Liassic carbonate platform, partially dolomitized, followed by Ammonites-bearing marls and marly limestones ("Medolo" facies), indicating a general drowning during Early-Middle Lias. The Upper Lias up to Malm interval is represented by few meters of "Rosso Ammonitico" and diaspers, which indicate the maximum depth of the sedimentation. The Cretaceous-Eocene top level of the sequence is constituted by whitish-grey cherty calcilutites ("Biancone"), and red marls in "Scaglia" facies (Fig. or see stratigraphic column in geological map n°4).

Overnight in Taormina

Taormina

Perched on a rocky spur at about 200m height, Taormina, the pearl of the Ionian Sea, was the capital of Byzantine Sicily until the Arab conquests. Because of the mildness of its climate, the natural scenery with the superb view of Etna, and with its historical heritage, Taormina is a privileged international tourist attraction. It has been a popular destination for travelers since the 18th century, although only in the last decades has it developed into a well-known tourist resort. Many foreigners, notably British and German, have decided to build villas in the town, and many illustrious figures have sojourned there, including Emperor William II and King Edward VII, and such famous families as the Rothschilds and the Krupps.


MONTE ETNA
CATANIA
Bronte
Randazzo
Maletto
Adrano
Paternò
Acireale
Giarre
Riposto
Mascali
Giardini
Aci Castello
Misterbianco
Belpasso
Nicolosi
Pedara
Zafferana
Linguaglossa
Castiglione
Piedimonte
Fiumefreddo di Sicilia
Lido di Plaia
Golfo di Catania
5

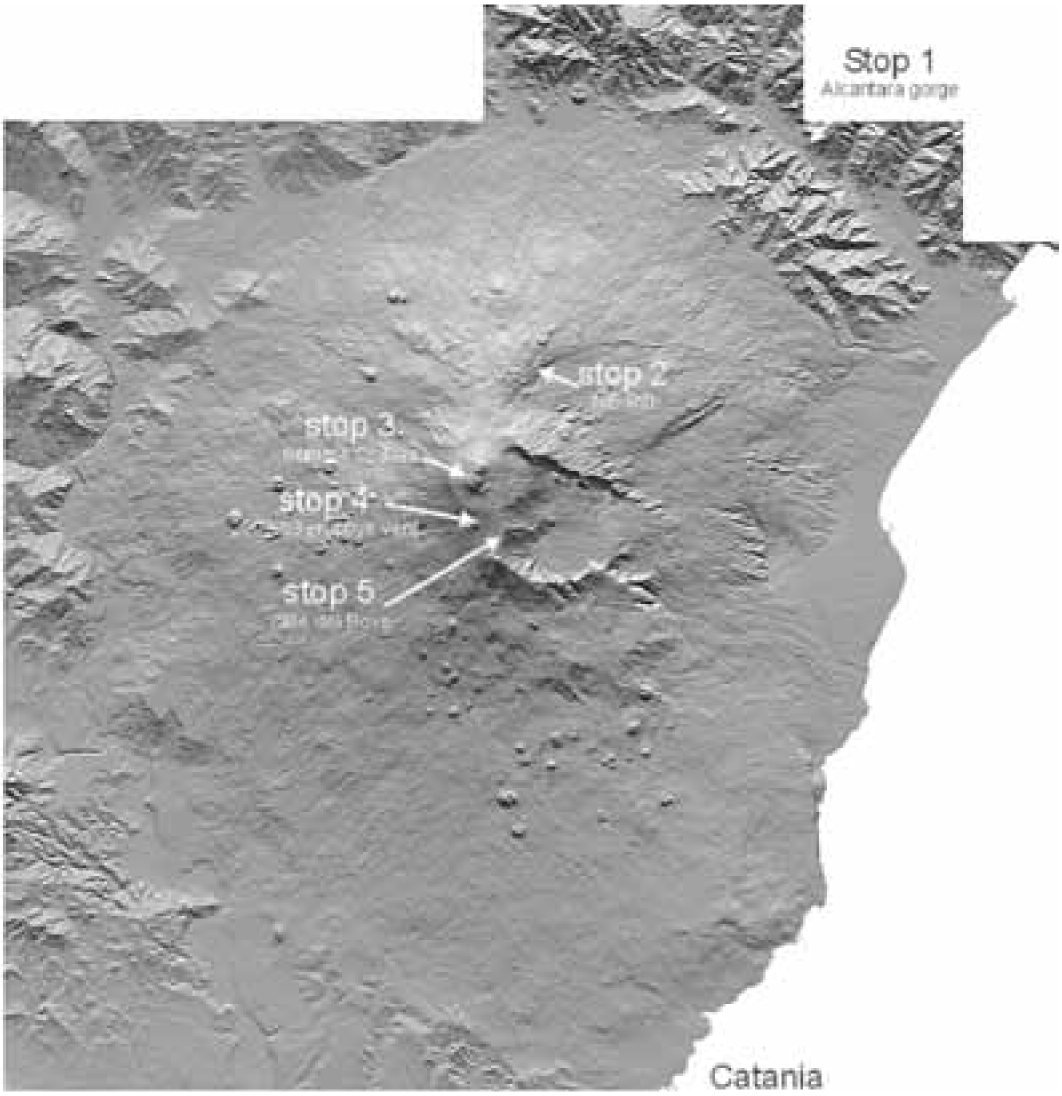


Figure 20 - DEM of Mt. Etna (modified after Favalli et al., 1999) on which the stops are indicated.

On the main street, ending with Porta Messina to the north and Porta Catania to the south, stand the medieval Cathedral and the 15th-century Palazzo Corvaja.

But its most famous monument is the Greek Theater, which was built by the Ancient Greeks, then transformed and enlarged by the Romans. It continues to be used at the present time. What survives today dates from the 2nd century AD. It was built in such a way as to exploit the natural lie of the land. Some of the cavea's steps are cut directly from the base rock. The Greek theatre conformed with the correct application of the Classical orders; it included a semi-circular orchestra section reserved for musicians, the chorus, and dancers. The Romans removed the lower tier of steps when converting the orchestra into an arena – circular, therefore –, a shape better suited to hosting circus games; they also added a corridor to provide access for gladiators and wild animals.

The red of the bricks, the white of the marble columns which still adorn the stage, the intense blue of the sky above are the predominant colors in this idyllic landscape. From the top of the cavea (auditorium), visitors and spectators can absorb the full impact of the glorious panoramic view, spreading out before the

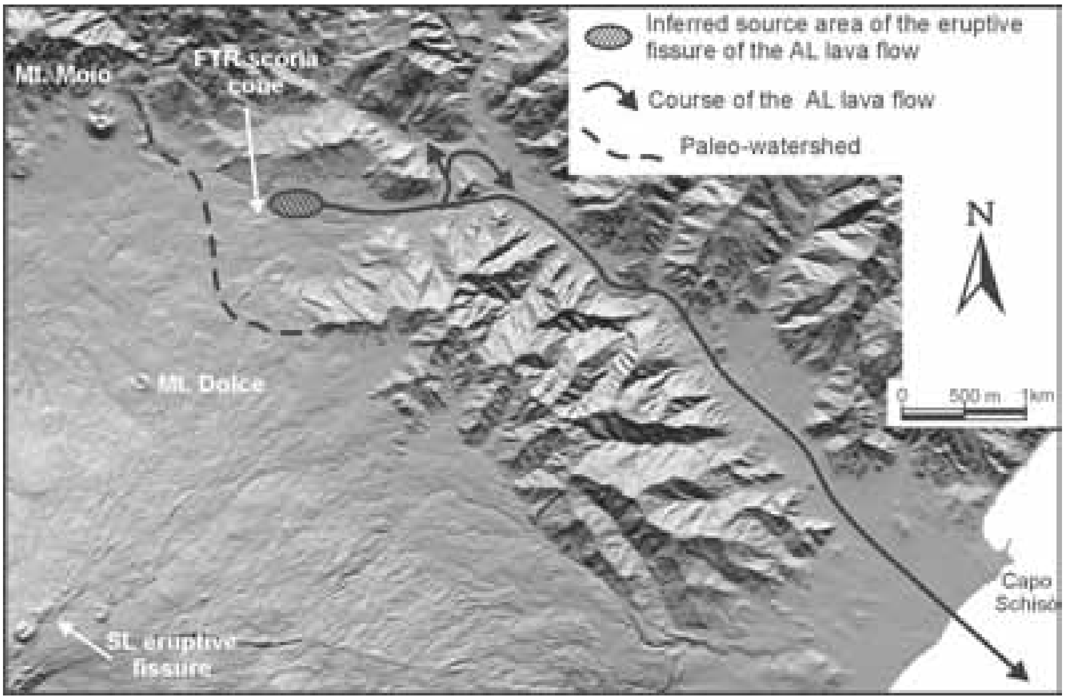


Figure 21 - DEM of the NE flank of Etna and of the Alcantara Valley (modified after Favalli et al., 1999 and Branca, 2003), in which are evidenced the location of the eruptive fissures of the lava flows that have modified the morphologic setting of the valley.

majestic presence of Mount Etna.

DAY 5

(2 September 2004)

Subject: Quaternary Etnean volcanism and its role in the geodynamic framework of eastern Sicily. TAORMINA / ALCANTARA GORGE / MT. ETNA (summit craters and Valle del Bove) / CATANIA.

The excursion focuses on showing some of the main features of the volcano (Alcantara gorge, NE-Rift, summit craters and Valle del Bove depression) and the eruptive vents of the 2002-03 eruption. The trip develops on five stops, starting from the Alcantara gorge (first stop), passing along the Alcantara Valley, and then crossing the Etna volcano from the NE flank to the southern one (Fig. 20)

Following the visit to the Alcantara gorge we'll reach the area of Piano Provenzana at about 1800 m a.s.l. on the NE flank of the volcano. From this area we'll go on by 4×4 van toward the NE-Rift (second stop) and the volcano summit craters (third stop). Here, we'll stop at about 3050 m in altitude, where we'll begin the climb to the Voragine and Bocca Nuova crater rims at 3250 and 3260 m a.s.l. The path is one km long, developing on lava and sand.. It is not very difficult, but for the altitude and the eventually-irritating breathing in of volcanic gas, the climb is not advisable for those who have problems in breathing. All participants need a cotton handkerchief, water and, of course, mountain boots. The entire stop will

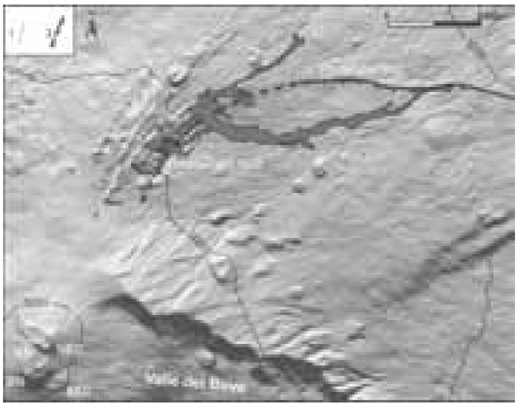


Figure 22 - Sketch map showing the area covered by the lava flows from Etna's 2002 NE-Rift eruption. 1) eruptive fissure; 2) fault.

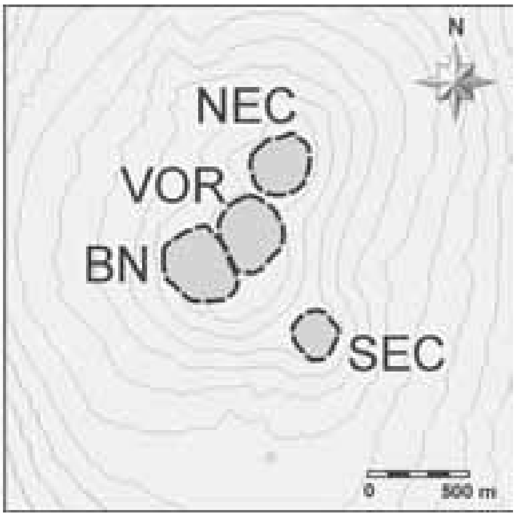


Figure 23 - Sketch map showing the summit area of the Etna volcano. VR = Voragine; BN = Bocca Nuova; NEC = Northeast Crater; SEC =Southeast Crater.

last about one hour. Afterwards, we'll continue by van towards the upper southern flank of the volcano where we'll reach the 2002-03 eruptive fissure, at about 2800 m of altitude (fourth stop). The trip finishes with an overview of the Valle del Bove depression from the Belvedere area, at about 2760 m of altitude (fifth stop). Some little changes to the scheduled program might occur, due to the variable weather conditions at the Etna summit area (above 2500 m of altitude).

13^{00} *Starting from Taormina*

Stop 5.1:

Alcantara gorges.

The present-day morphological setting of the Alcantara Valley is the result of two main evolutionary phases initiated during the activity of the Ellittico volcano about 45 ka ago (Branca, 2003). Only one lava flow invasion of the valley floor occurred in the first phase. This phenomenon was followed by a long period of erosional processes leading to the entrenchment of the drainage pattern and the erosion of the Ellittico

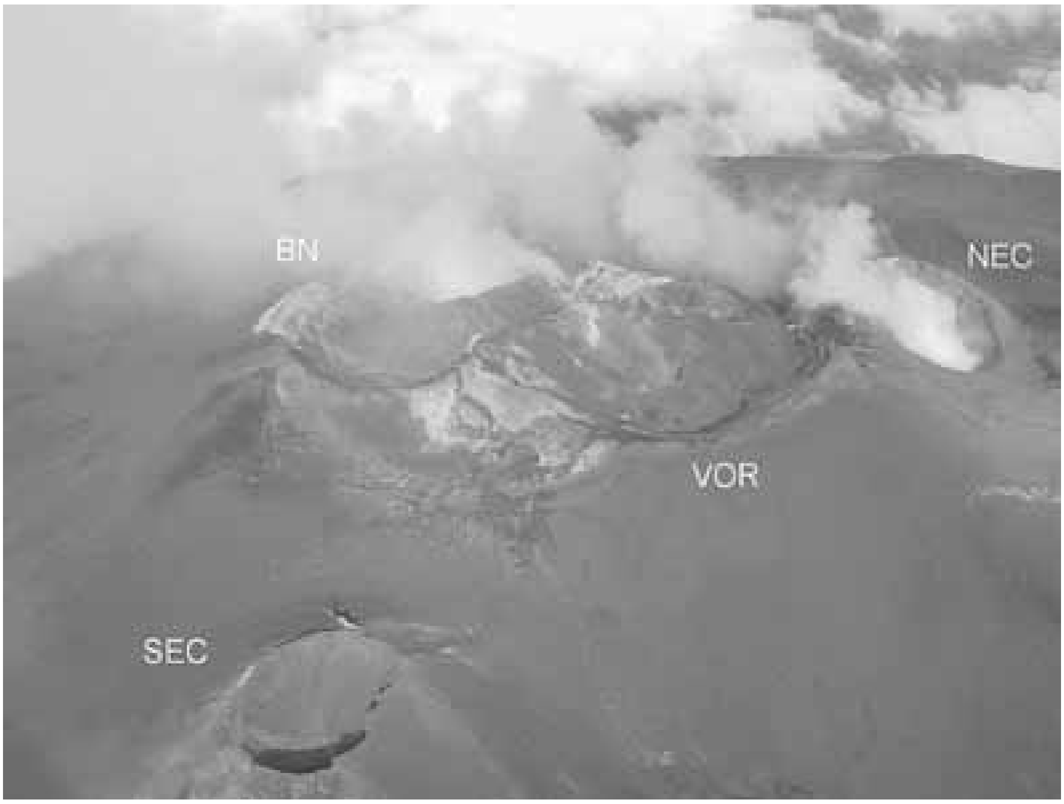


Figure 24 - Oblique aereal view of the summit craters from the east in August 2001 (photo by INGV-Catania).

Figure 25 - Aerial view from north of the summit craters and the eruptive column produced by the 2750 m vent along the S fissure on 2nd November (Photo by S. Branca).

lava flow. About 20-25 ka ago, an important change in the frequency of the lava flow invasions into the valley occurred associated with the final stage of the Ellittico volcano activity marking the beginning of the second phase. During this phase, volcanic processes predomited over other morphogenetic processes in the Alcantara Valley. Lava flows coming from the NE flank of the Ellittico volcano caused a radical modification of the morphological setting of this area, even though only one lava flow emitted by an eruptive fissure located within the valley partially filled the riverbed. During the eruptive activity of the last 15 ka the complete filling of the Alcantara Valley floor occurred. In particular, between 15 and 7 ka, a lava flow originating from the Mt. Moio scoria cone filled the valley floor for a distance of about 9 km. Following a short period of erosion, an eruptive fissure located within the valley generated a 20-21 km-long lava flow that was channelled along the full extent of the Alcantara Valley, forming the Capo Schisò along the Ionian coast, and stretching for about 3 km offshore (Fig. 21). The erosion and the entrenchment of the water course formed the attractive Alcantara gorges, where the internal structure of the lava flow is well exposed and an impressive columnar jointing generated during the lava cooling can be observed.

A flight of stairs takes you to the river bed and it is possible to enter the gorges, as well as take a swim were the water is deepest (up to 1 m).

Stop 5.2:

NE-Rift.

The NE-Rift is one of the main intrusion zones of the Etna volcano (McGuire and Pullen, 1989). It consists of a network of sub-parallel eruptive fissures, striking from 42°E to 47°E, and with dispersion axes ranging from 15°E to 62°E. These fissures cluster in a restricted area about 2 km wide and extend from 2500 m down to 1700 m a.s.l.. They consist of spatter ramparts and scoria cones related to the eruptive activity of the last 15 ka (Branca et al., 2003). In the upper part of the volcano this fissure system strikes

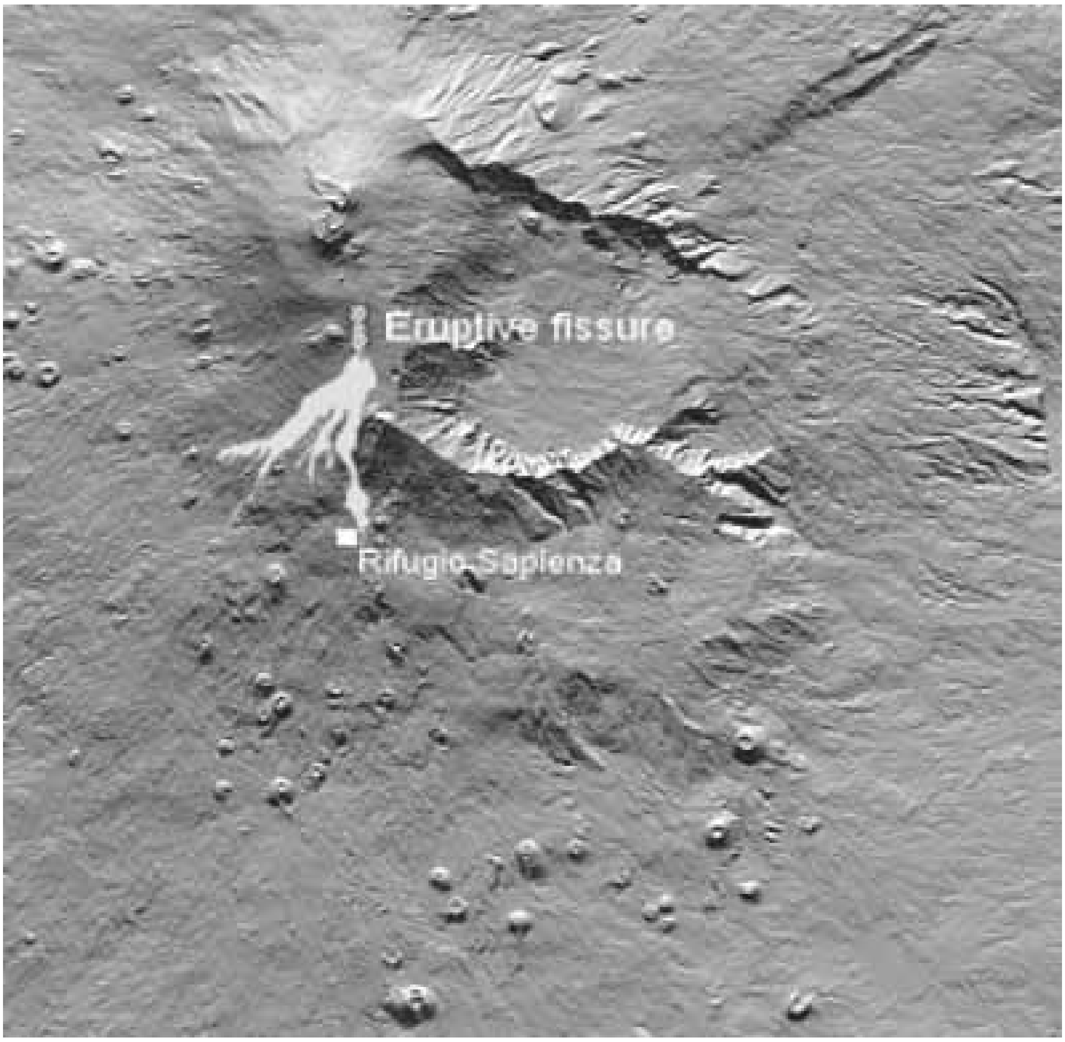


Figure 26 - Sketch map showing the area covered by the lava flows generated by the 2002-03 eruptive vent in the southern flank of Etna.

N and is almost completely covered by the historic lava flows originated from Etna's North-East Crater (NEC).

The NE-Rift is affected by a strong extensional tectonic evidenced by the presence of both dry fissures and pit craters along the eruptive fissures. The NE-Rift is delimited eastward, in the Piano Provenzana area, by a 200 m-high fault scarp, one of the discrete segments of a near continuous left-lateral shear zone that dissects the north-eastern flank of Etna (Azzaro et al., 1998; Groppelli and Tibaldi, 1999).

At about 2500 m the eruptive fissure of the 2002 eruption (Andronico et al., 2003), which extends for about 3.5 km up to 1900 m a.s.l, is located. (Fig. 22) The upper portion of the eruptive fissure (2500-2030 m) is formed by spatter ramparts and by a series of pit craters in which the volcanic succession of the rift is exposed. The lower segment of the fissure (2030-1900 m) is formed by a series of coalescent scoria cones. During this eruption about 10 millions of cubic meters of lava were emitted, forming a 6.2 km long lava flow field that destroyed the ski station and tourist facilities in the Piano Provenzana area and parts of the pine forest.

Stop 5.3:

Summit Craters.

Above 2900 m a.s.l. rises the summit cone of Etna

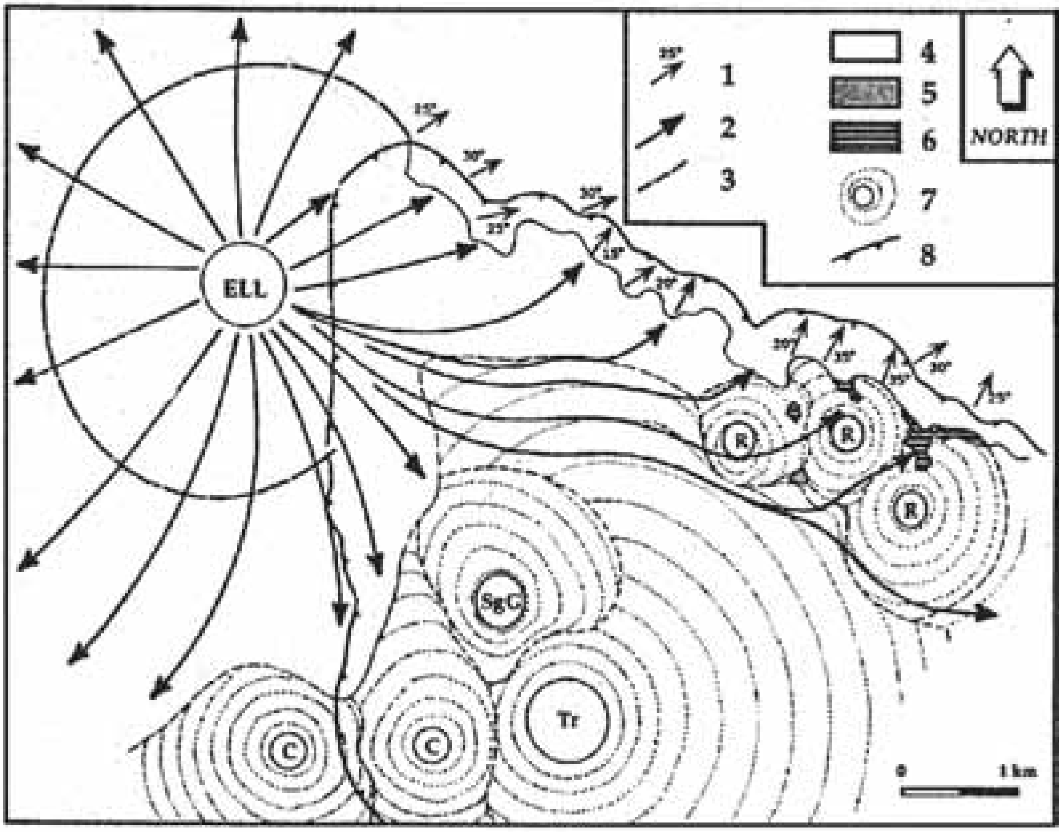


Figure 27 - Morphological reconstruction both of the Ellittico volcano and of the volcanoes located in the area of the southwestern wall of the Valle del Bove (Coltelli et al., 1994).

(Figs. 23 and 24). It rests on a flat area formed by the filling up of two almost concentric calderas. The smaller and younger one is the "Cratere del Piano", created by the 122 BC plinian eruption (Coltelli et al., 1998), while the larger and older one is the "Cratere Ellittico", made during the final activity of the Ellittico volcano, about 15.000 yrs BP (Coltelli et al., 2000).

The summit cone, as visible today, was rebuilt after the last largest Etna eruption, in 1669, which partially destroyed the previous one. During XVIII and XIX century an almost continuous strombolian activity produced a perfect conical structure that in this century was deeply modified by the growth of two parasitic cones. The "North-East Crater" (NEC) has beem built since 1911 on the homonymous flank of the summit cone; the younger cone the "South-East Crater" (SEC) was born as a depression in 1971, and took the actual shape during the 1989-90 subterminal activity. In 1999 lava flows, produced by three eruptive fissures opened at the base of the SEC, formed a wide lava flow field directedsoutheastward in VdB. 65 fire fountain episodes occured at SEC in 2000, producing lapilli and ash fall along the eastern flank of Etna. The large crater (Central Crater) located in the upper part of the summit cone, about one km in diameter, was completely filled by lava during 1956; after that and till 1960, a strong explosive activity, alternated with collapses, reopened the vent now named "Voragine (Chasm)" (VOR). It is a spectacular, funnel-shape crater where we can observe, if the steam allows us, two degassing vents.

On the southern side of the old surface topping the summit cone, another important vent opened as a pit in 1968, with a diameter of about 4 m; it was enlarged by numerous collapsing episodes in the following two decades. Today, it is a 300-by-250 m wide and 100-m-deep pit crater named "Bocca Nuova (New Vent)". Starting in the 70s this crater became the most active of the volcano; it has generally some vents on the bottom with strombolian activity that sometime become very strong, throwing large bombs out of the rim. After the large 1991-93 eruption, the crater is dormant, and only minor collapses and degassing occur from a vent located below the septum that divides it by the VOR. In 1999 an eruption occurred at BN, forming a lava flow field produced by a series of overflows from the western rim of the crater. During this eruption the BN was characterised by an intense Strombolian activity.

Stop 5.4:

2002-03 eruptive vent.

On 27 October 2002 a N-S 1 km-long eruptive fissure opened on the high southern flank of the volcano (2850-2600 m a.s.l.), close to the Torre del Filosofo shelter (Andronico et al., 2003). An intense and continuous fire fountain activity occurred at this fissure from 27 October to the end of December (Fig. 25). This explosive activity formed an eruptive column 1-4 km high. During this period ash fall occurred in all directions, and mainly in the eastern flank of Etna. 2.5 kg/m2 of ash fell in Catania in two days (28-29 October). Ash fell in eastern Sicily and reached the Calabria and Campania regions, the western coast of Greece and the coast of Libya. Proximal deposit formed two coalescent scoria cones along the N-S eruptive fissure, at 2750 and 2800 m of elevation, which covered the Torre del Filosofo shelter. The persistent ash fall caused extensive loss to the economy of eastern Sicily because of the prolonged closure of the Catania and Reggio Calabria airports, and damage to the crops.

Discontinuous effusive activity formed a lava flow field south and southwestward 4.2 km long (Fig. 26) Lava flow cut the S.P. 92 road and destroyed a facility and a restaurant in the Rifugio Sapienza area, at about 1900 m a.s.l. where a phreatic burst injured 59 people on 16 December.

Stop 5.5:

Valle del Bove.

Taking a short deviation from the road climbing toward the volcano's summit, we arrive at the western rim of the Valle del Bove. From this scenic point, if weather conditions are good, we can enjoy a beautiful overview of the whole Valle del Bove, the southern bottom of which is covered by the huge 1991-93 lava flow field. The Valle del Bove is a 7 km long and 4 km wide depression, striking ESE from the summit. the northern and western wall are fairly straight, while the southern wall is W-shaped. The origin of the Valle del Bove is related to a catastrophic eastern flank collapse which occurred about 9 ka ago (Calvari et al, 2003). The volcaniclastic deposits associated with this collapse phenomenon outcrop immediately eastward of the VdB area and up to the coast, forming a wide fan-shape detritic-alluvial body, locally named "Chiancone". On the southwestern wall, the volcanic successions belonging to the Trifoglietto, Giannicola, Salifizio and Cuvigghiuni eruptive centres are visible (120-60 ka). On the contrary, along the northern wall of the valley a complex volcanic succession related to the eruptive activity of the Ellittico volcano (60-15 ka) crops out (see Regional geologic setting) (Fig. 27). The Valle del Bove depression is the favorite area where most of the historical lava flow has streamed and piled up. The main eruptive fissure of 1991-93 eruption occurred below the stop site, between 2400 and 2200 m a.s.l. It is the lowest end of a longer fracture system originating from the eastern flank of the summit cone.

END OF EXCURSION. Departure from Catania during the evening, or overnight stay in Catania with departure on 3 September 2004 for individual destinations.

Acknowledgements

The authors are indebted to S. Carbone, and A. Di Stefano for their fruitful comments and suggestions.

References cited

Andronico, D., Branca S., Calvari S., Burton M.R., Caltabiano, T. Corsaro, R.A. Del Carlo, P. Garfì, G. Lodato, L. Miraglia, L. Muré, F. Neri, M. Pecora, E. Pompilio, M. Salerno, G. Spampinato, L. (2003). A multi-disciplinary study of the 2002-03 Etna eruption: insights for a complex plumbing system. Submitted to *Bull. Volcanol*.

Azzaro, R., Branca, S., Giammanco, S., Gurrieri, S., Rasà, R., Valenza, M. (1998). New evidence for the form and extend of the Pernicana Fault System (Mt. Etna) from structural and soil-gas surveying. *J.Vulcanol. Geotherm. Res*., 84, 143-152.

Ben-Avraham, Z. Boccaletti, M. Cello, G. Grasso, M. Lentini, F. Torelli, L. Tortorici, L. (1990). Principali domini strutturali originatisi dalla collisione nogenico-quaternaria nel Mediterraneo centrale. *Mem. Soc. Geol. It*. 45, 453-462.

Bianchi, F. Carbone, S. Grasso, M. Invernizzi, G. Lentini, F. Longaretti, G. Merlini, S. and Mostardini, F. (1987). Sicilia orientale: profilo geologico Nebrodi-Iblei. *Mem. Soc. Geol. It*., 38: 429-458.

Branca, S. (2003). Geological and geomorphologic evolution of the Etna volcano NE flank and relationships between lava flow invasions and erosional processes in the Alcantara Valley (Italy). *Geomorphology*, 53, 247-261.

Branca, S. and Del Carlo, P. (2003). Eruptions of Mt Etna during the past 3,200 Years: a revised compilation integrating the historical and stratigraphic records. In: *Etna Volcano Laboratory,* Geophys. Monogr. Ser., edited by Calvari S., Bonaccorso A., Coltelli M., Del Negro C., Falsaperla S., AGU, in press.

Branca, S., Coltelli M. and Groppelli, G. (2003). Geological evolution of Etna volcano. In: *Etna Volcano Laboratory*, Geophys. Monogr. Ser., edited by Calvari S., Bonaccorso A., Coltelli M., Del Negro C., Falsaperla S., AGU, in press

Calvari, S. and Groppelli, G. (1996). Relevance of the Chiancone volcanoclastic deposit in the recent history of Etna Volcano (Italy). *J. Volcanol. Getherm. Res.,* 71, 239-258.

Calvari, S., Tanner, L.H., and Groppelli, G. (1998). Debris-avalanche deposits of the Milo Lahar sequence and the opening of the Valle del Bove on Etna volcano (Italy). *J. Volcanol. Geotherm. Res.,* 87, 193-209.

Calvari, S., Tanner, L.H., Groppelli, G., and Norini, G. (2003). A comprehensive model for the opening of the Valle del Bove depression and hazard evaluation for the eastern flank of Etna volcano. In: *Etna Volcano Laboratory*, Geophys. Monogr. Ser., edited by Calvari S., Bonaccorso A., Coltelli M., Del Negro C., Falsaperla S., AGU, in press.

Carbone, S. Grasso, M. and Lentini, F. (1984). Carta geologica della Sicilia sud-orientale. Scala 1:100.000, S.EL.CA., Firenze.

Coltelli, M., Garduno, V.H., Neri, M., Pasquarè, G., Pompilio, M. (1994). Geology of the northern wall of the Valle del Bove, Mt Etna (Sicily). *Acta Vulcanol*., 5, 55-68.

Coltelli, M., Del Carlo, P., and Vezzoli, L. (1998). The discovery of a Plinian basaltic eruption of Roman age at Etna volcano, Italy. *Geology*, 26, 1095-1098.

Coltelli, M., Del Carlo, P., and Vezzoli, L. (2000). Stratigraphic constrains for explosive activity in the last 100 ka at Etna volcano. Italy. *Inter. J. Earth Sciences*, 89, 665-677.

Del Ben, A. and Guarnieri, P. (2000) Neogene Transpression in the Cefalù Basin (Southern Tyrrhenian): comparison between land and marine data. *Mem. Soc. Geol. It.,* 55: 27-33.

Del Carlo, P., Vezzoli, L. and Coltelli, M. (2003). Last 100 ka tephrostratigraphic record of Mount Etna. In: *Etna Volcano Laboratory*, Geophys. Monogr. Ser., edited by Calvari S., Bonaccorso A., Coltelli M., Del Negro C., Falsaperla S., AGU, in press.

Di Stefano, A., and Branca, S. (2002). Long-term uplift rate of the Etna volcano basement (Southern Italy) from biochronological data of the Pleistocene sediments. *Terra Nova*, 14, 61-68.

Favalli, M., Innocenti, F., Pareschi, M.T., Pasquarè, G., Mazzarini, F., Branca, S., Cavarra, L., Tibaldi, A. (1999). The DEM of Mt. Etna: geomorphological and structural implications. *Geodin. Acta*, 12, 5, 279-290.

Finetti, I. Lentini, F. Carbone, S. Catalano, S. and Del Ben, A. (1996) Il sistema Appennino Meridionale-Arco Calabro -Sicilia nel Mediterraneo Centrale: studio geologico-geofisico. *Mem. Soc. Geol. It*., 115: 529-559.

Giunta, G. Nigro, F. Renda, P. and Giorgianni, A. (2000) The Sicilian-Maghrebides Tyrrhenian Margin: a neotectonic evolutionary model. *Boll. Soc. Geol. It.*, vol. 119, 553-565.

Guarnieri, P. and Carbone, S. (2003) Assetto geologico e lineamenti morfostrutturali dei bacini Plio-quaternari del Tirreno meridionale. *Boll. Soc. Geol. It., 112.*

Guarnieri, P. (2003) Plio-Quaternary segmentation of the South Tyrrhenian Forearc basin. Submitted to *Canadian Journal of Earth Science.*

Guarnieri, P. Lentini, F. Carbone, S. Del Ben, A. Di Stefano, A. (2004) Structural features of the Messina Strait (with Geological map 1:25000 scale). *Atlante Geologico d'Italia*.

Groppelli, G., Tibaldi, A. (1999). Control of rock reology on deformation style and slip-rate along the active Pernicana Fault, Mt. Etna, Italy. *Tectonophysics*, 305, 521-537.

Lentini, F. Carbone, S. Catalano, S. Grasso, M. (1996). Elementi per la ricostruzione del quadro strutturale della Sicilia orientale. *Mem. Soc. Geol. It.,* 51, 179-195.

Lentini, F. (1974) Caratteri stratigrafici e strutturali del gruppo del M. Judica (Sicilia centro-orientale). *Riv. Min. Sic*., Anno XXV, nn. 145-147, 1-22, Palermo.

Lentini, F., Carbone, S., Catalano, S. 1994. Main structural domains of the central Mediterranean region and their Neogene tectonic evolution. *Boll.*

Geof. Teor. e Appl. 36, 103-125.
Lentini, F., Carbone, S., Catalano, S., Grasso, M. 1995. Principali lineamenti strutturali della Sicilia nord-orientale. *Studi Geol. Camerti,* vol. speciale 2, 319-329.
Lentini, F. (2000) - Carta Geologica della Provincia di Messina, scala 1:50.000 e Nota Illustrativa, a cura di Lentini F., Carbone S. e Catalano S., Ed. SELCA - Firenze.
Lentini, F. Carbone, S. Di Stefano, A. and Guarnieri, P. (2002) Stratigraphical and structural constraints in the Lucanian Apennines (Southern Italy): Tools for reconstructing the geological evolution. *Journal of Geodynamics*, 34 (1): 143-160.
McGuire, W.J., Pullen, A.D. (1989). Location and orientation of eruptive fissures and feeder-dikes at Mount Etna: influence of gravitational and regional tectonic stress regimes. *J. Volcanol. Geotherm. Res.,* 38, 352-344.
Ogniben, L. 1960. Nota illustrativa dello schema geologico della Sicilia nord-orientale. *Riv. Min. Sic*. 11, 183-212.
Pedley, H.M. Grasso, M. Maniscalco, R. Behncke, B. Di Stefano, A. Giuffrida, S. Sturiale, G. (2001) The sedimentology and palaeoenvironment of Quaternary temperate carbonates and their distribution around the northern Hyblean Mountains (SE Sicily). *Boll. Soc. Geol. It*. 121: 233-255
Romano, R. (1982). Succession of the volcanic activity in the etnean area. *Mem Soc. Geol. It*., 23, 27-48.
Schmincke, H.U. Behncke, B. Grasso, M. Raffi, S. (1997) Evolution of the northwestern Iblean Mountains, Sicily: uplift, Pliocene/Pleistocene sea-level changes, paleoenvironment, and volcanism. *Geol. Rundsch.* 86: 637-669.

Back Cover:
field trip itinerary

FIELD TRIP MAP

Edited by APAT