Outline of the Geology of Italy

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Alfonso Bosellini

Abstract

The Italian peninsula is an extremely active region from the geodynamic point of view as witnessed by the presence of active volcanoes (Vesuvius, Campi Flegrei, Stromboli, Vulcano, Etna) and by frequent earthquakes. Italian geology, however, is dominated by two different mountain chains, the Alps to the north and the Apennines to the south, along the peninsula. Geologically speaking, the Italian territory can be subdivided into seven specific sectors, i.e. The Alpine chain proper, the Po Plain, the Apennines, the Apulia foreland, the Calabrian-Peloritan arc, Sicily and Sardinia.

Keywords

Italian geology • Alps • Apennines • Mediterranean geodynamics

3.1 General Overview

Geologically speaking, Italy is in a quite active geodynamic evolution: volcanoes, earthquakes, land and coasts instability are a clear evidence. As a matter of fact, Italy, being situated in the middle of the Mediterranean, is subject to the same geological evolution which characterizes this entire region, controlled by the progressive approaching of two mega-plates, Eurasia to the north and Africa to the south (Bosellini 2005). The present geology of Italy, including the two major islands, Sicily and Sardinia, is remarkably varied and contains rock series from all eras and periods (Fig. 3.1). The Italian territory can be subdivided into seven specific sectors, which will be schematically described in the following pages.

3.2 The Alps

The Alpine chain, which extends from Provence and Ligurian coasts to Vienna and to the Hungarian Pannonian basin (Fig. 3.2), is the result of the convergence and collision of the European and African (Adria) continental margins, which took place between the Middle Cretaceous and the Late Eocene.

The Alps are a thrust belt with a double vergence. In other words, they are constituted by two different mountain chains which developed in opposite directions. In the north is the Alpine chain proper with European vergence, a pile of crustal nappes, overlapped northward since the mid-Cretaceous, whilst to the south a much younger tectonic system occurs, the so-called Southern Alps, similar to the Apennines, which since the Miocene has developed a southern vergence, i.e. toward the Po Plain. The boundary between these two large tectonic systems, with opposite vergence and different ages, is a series of faults, commonly and collectively identified as Insubric Line (Fig. 3.2), which from Turin and Canavese, through Valtellina and Tonale Pass, reaches Meran and more eastward Pusteria Valley, Gail Valley (Austria) and the Hungarian Pannonian basin.

A. Bosellini (✉)
Dipartimento di Fisica e Scienze della Terra, Università di Ferrara,
Via Saragat 1, 44122 Ferrara, Italy
e-mail: bos@unife.it

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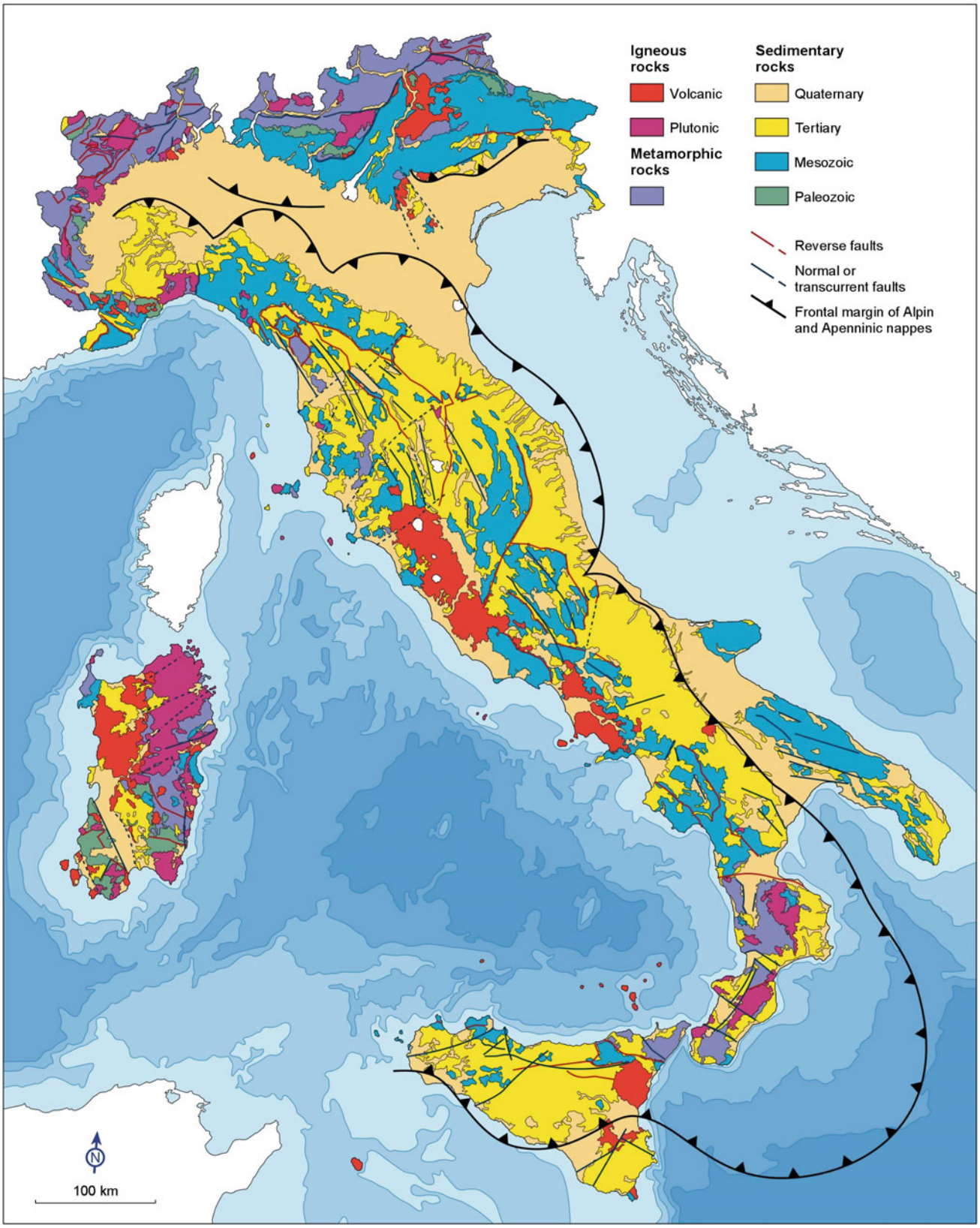

Fig. 3.1 Simplified geological map of Italy (modified after APAT 2005)

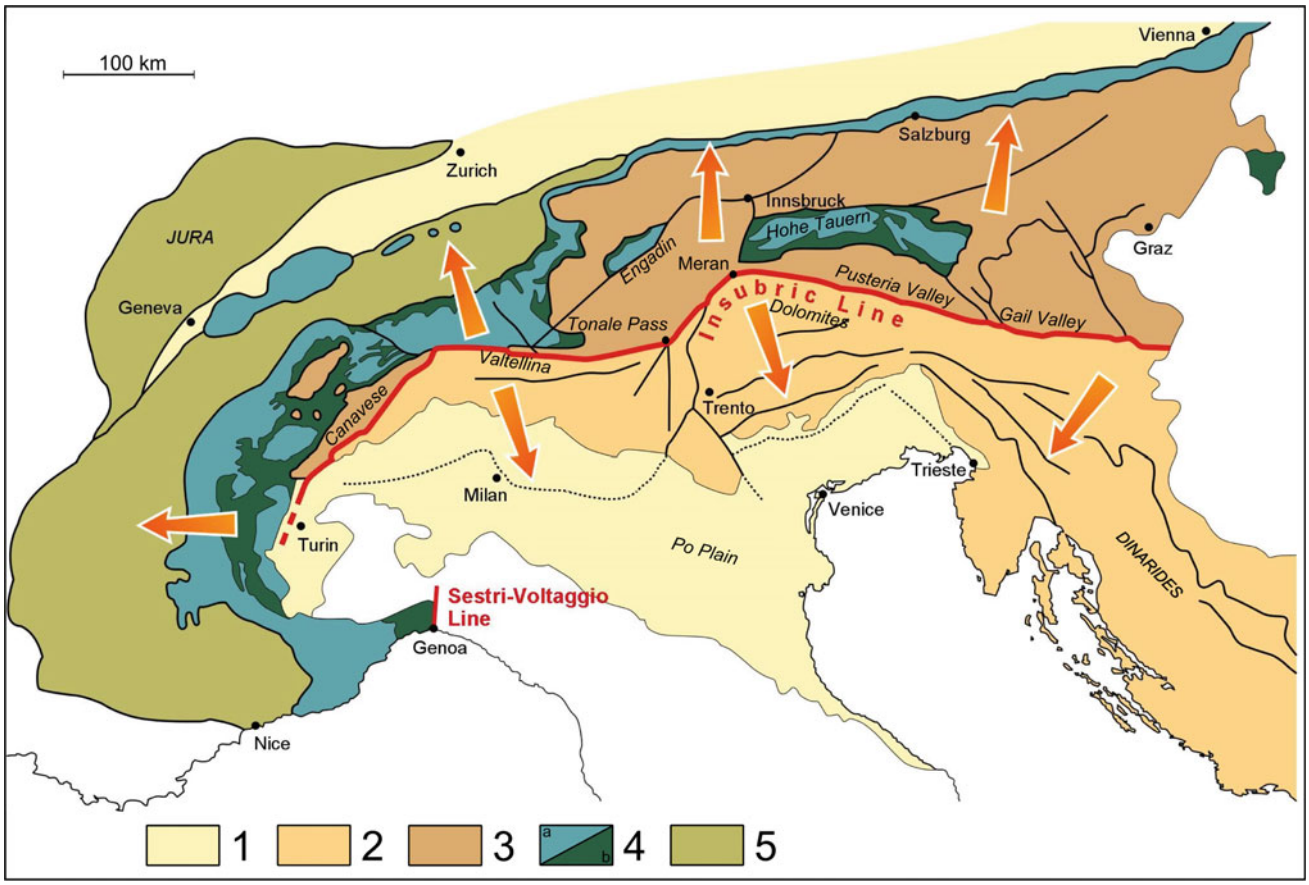

Fig. 3.2 Geological–structural map of the Alpine chain. *Arrows* indicate the opposite vergence of two sectors of the edifice: the Alps proper to the north, the Southern Alps to the south, separated by the Insubric Line (*red line*). Legend: (*1*) Plains bordering the alpine chain; (*2*) Rocks of the African south-vergent continental margin (Southern Alps and Dinarides); (*3*) Rocks of the African north-vergent continental margin (Austroalpines); (*4*) Rocks of the Penninic Ocean (Pennides): (*a*) sediments; (*b*) oceanic crust (ophiolites); (*5*) Rocks of the European continental margin (Helvetides)

The Alps proper, i.e. the north-verging sector, are constituted by three groups of nappes, the Helvetides, the Pennides and the Austroalpines (Argand 1924). These three groups of nappes consist of rocks belonging to the European continental margin, the former Penninic Ocean, and the African (Adria) continental margin, respectively. The Austroalpine nappes are the highest (structurally) in the Alps edifice, whereas the Helvetides lie along the frontal sector. The Pennides, which bear metamorphic ophiolites, crop out mainly in the Western Alps and within two large tectonic windows, the Hohe (High) Tauern to the east and the Engadin in the Swiss sector.

To the south, the Southern Alps consist mainly of Mesozoic sedimentary rocks deposited on the ancient Adria continental margin (Winterer and Bosellini 1981). Here spectacular carbonate sceneries include the Garda Lake area and the well-known Dolomite region.

3.3 The Po Plain

The Po Plain is an alluvial, relatively flat region, the result of an earlier marine and more recent fluvial sedimentation, mainly by the Po River and its tributaries. From the geological point of view, the Po Plain can be considered the foreland trough both of the Northern Apennines and the Southern Alps (Fig. 3.3). Large part of the Po Plain has a substratum of "buried mountains" (Fig. 3.4) which are the front of both the Apennine system and of the Southern Alps (Ghielmi et al. 2010; Fantoni and Franciosi 2010). This Apennine front is still active, and thus responsible for the earthquakes occurring so frequently in the Emilia region.

During the Pleistocene glacial periods, the future Po Plain was involved in repeated transgressions and regressions. In particular, during the Last Glacial Maximum (LGM), the shoreline was between Ancona and Pescara.

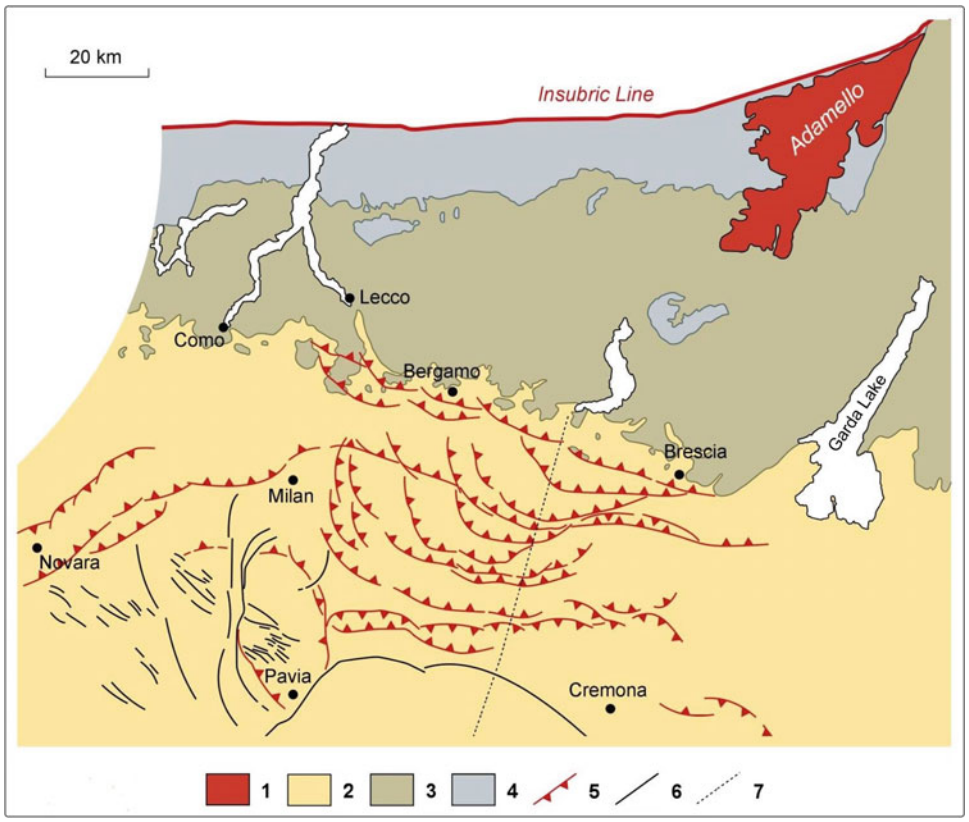

Fig. 3.3 Structural elements characterizing the central Po Plain in the Lombardy area. Legend: (*1*) Plutonic rocks; (*2*) Alluvial deposits of the Po Plain; (*3*) Sedimentary cover of the Southern Alps; (*4*) Crystalline basement; (*5*) Overthrusts; (*6*) Faults; (*7*) Section depicted in Fig. 3.4

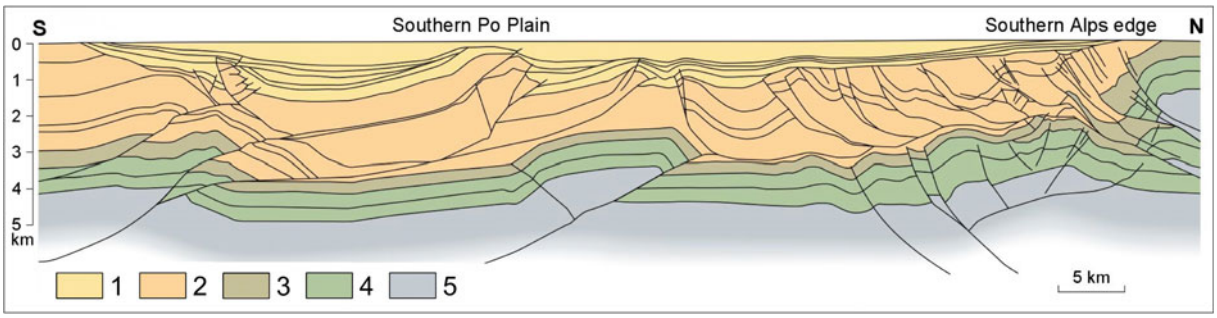

Fig. 3.4 Cross section of the Po Plain showing its deep complex structure (Lombardy area). Legend: (*1*) Plio-Quaternary; (*2*) Miocene; (*3*) Paleogene; (*4*) Jurassic–Cretaceous; (*5*) Triassic (modified from Bosellini 2005)

3.4 The Apennines

Geologically speaking, the Apennine chain extends from Genoa to the Sibari plain in Calabria. It can be subdivided into two principal sectors, the Northern Apennines and the Central-Southern Apennines (Fig. 3.5). These two sectors are bounded by regional transcurrent faults. To the north the Apennines are separated from the Alps by the so-called Sestri–Voltaggio Line, whereas the boundary between the Northern and Southern Apennines is marked by a series of faults collectively called Ancona–Anzio Line.

The Apennines are the result of the collision of the western continental margin of Adria (the African Promontory) with the Sardinia–Corsica block, which happened mainly during Miocene–Pliocene time (Castellarin and Cantelli 2010). The structural edifice of the Apennines consists of a series of east-verging nappes. The Ligurides, structurally the highest, include ophiolites and oceanic

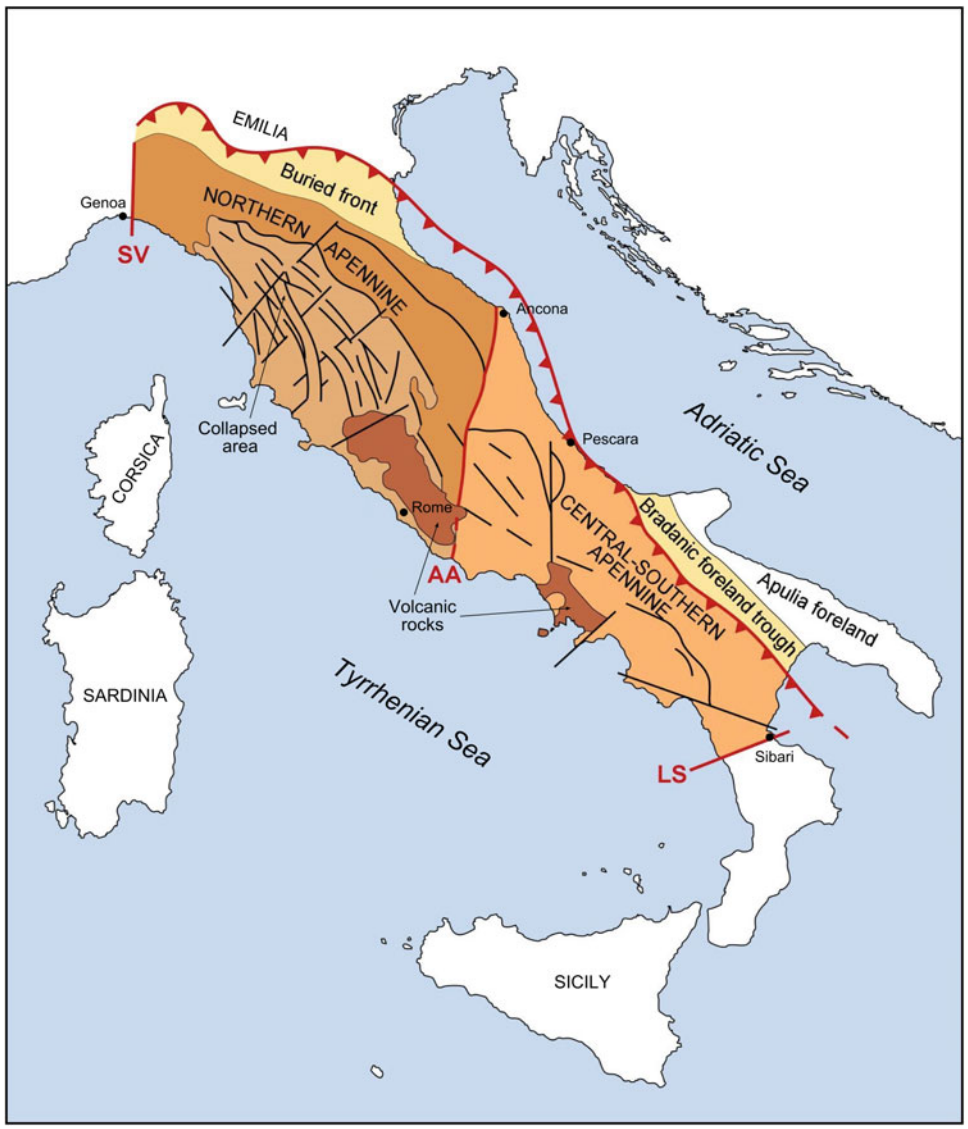

Fig. 3.5 General outline of the Apennine chain. The *red line* is the active front of the chain. Legend: (*SV*) Sestri–Voltaggio Line; (*AA*) Ancona–Anzio Line; (*LS*) Sangineto Line

sedimentary rocks like radiolarites. The Ligurides originated from an ocean that has disappeared since, the so-called Ligure-Piemontese Ocean.

The Northern Apennines are characterized by the abundance of flysch formations ranging in age from Cretaceous to Miocene. There is also a large tectonic window (the Apuanian Alps), where the famous Carrara marbles are exposed. Many grabens (tectonic valleys) occur in the western (internal) part of the chain (mainly in Tuscany); they are the result of the collapse of the western part of the chain caused by the opening of the Tyrrhenian Sea.

The Southern Apennines are instead characterized by the presence of large carbonate platforms of Jurassic–Cretaceous age, which constitute the highest mountain of the Abruzzi region (Gran Sasso, Maiella). This southern sector of the chain has a tectonic boundary, the so-called Sangineto Line, with the adjacent Calabrian-Peloritan arc (Fig. 3.5).

3.5 The Apulia Foreland

The Apulia region consists of two geologically distinct zones, the foreland trough and the foreland bulge (Fig. 3.6). Mainly constituted of Cretaceous carbonate rocks, the region is totally outside of the Apennine mountain system and only mildly deformed by recent tectonics. Except the Gargano promontory, where the transition from the Jurassic–Cretaceous shallow-water platform to the Adriatic deep-water basin is exposed, the entire region is a sub-horizontal carbonate plateau.

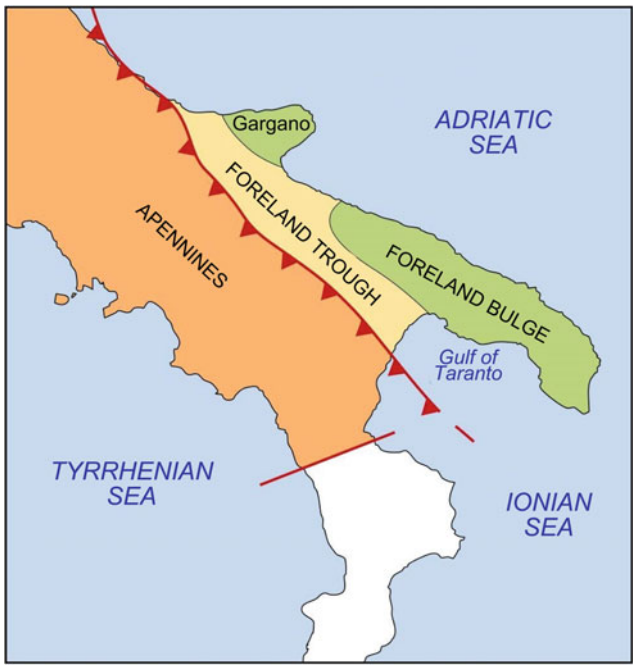

Fig. 3.6 Geological sketch of the Apulia region, showing the foreland trough (*yellow*) and the foreland bulge (*green*)

Fig. 3.7 The Calabrian-Peloritan arc (*brown colour*) and its regional geological framework

During the last fifteen years, several dinosaur footprints have been discovered in the Cretaceous shallow-water carbonates of Apulia (Bosellini 2002). These findings document the Mesozoic connection of Apulia with the African Continent.

The Apulia carbonates are deeply affected by karst as documented by the numerous dolines and caves (for example the famous Castellana caves).

3.6 The Calabrian-Peloritan Arc

This peculiar geological province extends from the Sibari Plain to the Messina Strait and beyond to the northeast corner of Sicily, where the Peloritan mountains are present (Fig. 3.7). The Calabrian-Peloritan block is an "exotic terrain" and a segment of the Alpine chain. Before the opening of the Tyrrhenian basin it was posted close to Sardinia. The arc includes metamorphic basement and granites of Paleozoic age and, moreover, it consists of a pile of east-verging nappes. In conclusion, the Calabrian-Peloritan arc must be considered a fragment of European crust, a terrain totally different from the remainder of Italy, which pertains to the African plate. Naturally, underneath the "exotic Alpine chain" the Apennine chain is present. It crops out in several tectonic windows.

At the margin of the mountains, near the sea, relatively undeformed Miocene–Pliocene terrains suture the front of the various nappes.

3.7 Sicily

The island of Sicily (except the Peloritani mountains) is the easternmost tract of the Maghrebian chain of north Africa (Fig. 3.8) and belongs to the northern continental margin of this continent. It consists of several south-verging nappes and a foreland area in the southeast corner (Iblei Mts.) (Abate et al. 1978). The Panormide carbonate platform of northwestern Sicily is considered to act, during the Jurassic–Cretaceous interval, as a temporary continental bridge between Africa and Adria (Zarcone et al. 2010). Moreover, the highest volcano of Europe, Mount Etna, is present along the eastern coast.

3.8 Sardinia

Geologically speaking, the island of Sardinia is not part of Italy. It is a fragment of the European continent, together with the island Corsica (France). It separated from Catalunia (Spain) about 30 Ma ago and reached the present position about 18 Ma ago. Large part of the eastern side of the island consists of granites and Paleozoic rocks formed during the Hercynian orogenesis. The most complete Paleozoic sedimentary succession of Italy is present in the island, where several Hercynian tectonic nappes have been discovered (Carmignani et al. 1992). The eastern side of the island is characterized by the presence of widespread volcanics, mainly of Tertiary age.

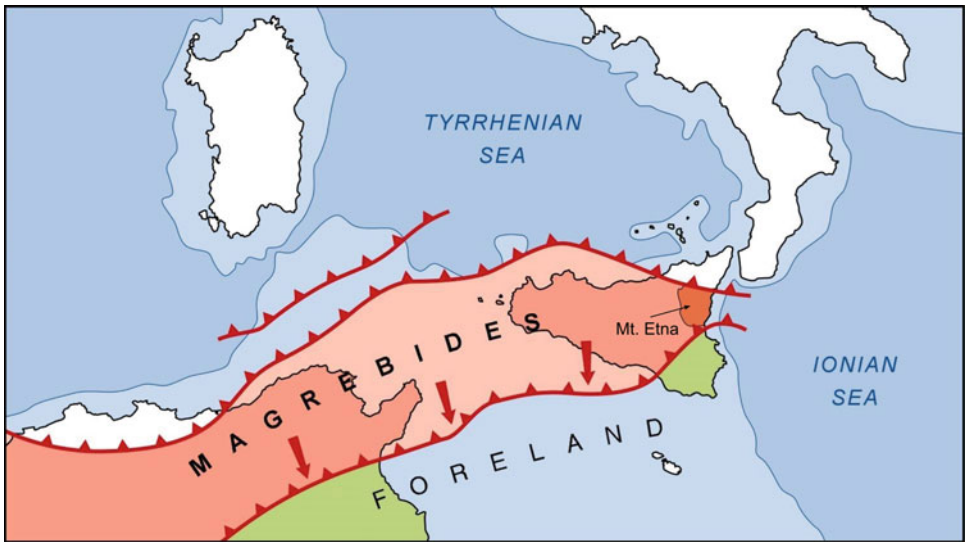

Fig. 3.8 The Maghrebian chain and its eastern Sicilian tract

3.9 Conclusions

Concluding this brief geological description of Italy, it should be emphasized that the Italian peninsula is an extremely active region from the geodynamic point of view, as witnessed by the presence of active volcanoes (Vesuvius, Campi Flegrei, Stromboli, Vulcano, Etna) and by frequent earthquakes.

Due to its geological complexity, the Italian territory shows extremely varied and spectacular landscapes which are of great interest from the geomorphological viewpoint. On the other hand, its intense geodynamic activity locally favours highly hazardous contemporary geological and geomorphological processes.

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