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CHAPTER 1

The geology of Italy: a brief overview

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1.1 TRIASSIC TO NEOGENE GEOLOGICAL EVOLUTION OF ITALY

The present-day geological framework of the Italian peninsula, as well as that of the Peri-Mediterranean regions, is mainly the result of a complex paleogeographical and geodynamical evolution due to the opening and successive closure of the Tethyan ocean.

The Mediterranean area is an assemblage of a number of lithospheric blocks, the present organisation of which is due to active collision between the African and the European blocks. The convergence between these two major plates had as a major effect the formation of important orogenic belts all around the Mediterranean area (Fig. 1). While Africa and Europe converge, the smaller intervening blocks of the Mediterranean region (e.g., the Adria plate) are subjected to rigid trailing translations and/or rotations. This explains the variety of kinematic processes presently occurring, including lithospheric subduction, back-arc spreading, strike-slip faulting and lateral expulsion of lithospheric blocks (e.g., Anatolia, Carpathians).

The above scenario is well supported by both the earthquake distribution and the present regional stress field (Fig. 1). It is worth noting the good correspondence between earthquake distribution and the main tectonic lineaments. In particular, it can be observed that the most of seismic activity concentrates all along the circum-Mediterranean orogenic belt.

Continental collision of the Adriatic plate over the European plate (A-type subduction) occurred since Eocene times, when the subduction of oceanic crust under the European continent was completed. The Mesoalpine (Eocene-early Oligocene) tectonic phase was initiated. The middle and external (lower) Penninic domain were progressively incorporated into the Alpine chain, beneath the rising and progressively exhumed Eoalpine belt. A double-vergent orogenic belt formed both sides of the Insubric line.

To the south, the south-vergent southern Alpine thrust system was initiated, with its associated deep-water flexural basins and related flysch deposits. In the eastern part (Friuli and east Veneto foothills and plains, north-eastern Italy) the South-Alpine foredeep interfered with the foredeep formed in front of the Dinaric orogen, an orogen due to the underplating of the Adriatic plate under the eastern European plate since at least Paleocene times. Continental collision was realised by progressive upward expulsion of most of the ophiolitic units previously imbricated with the basement nappes of the metamorphic wedge,

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and was accompanied by thermal relaxation that progressively restored normal to high-T gradients, causing regional metamorphism. Coeval with the active collision, extensional structures developed in a direction perpendicular to the compressive structures. Locally, these structures recorded basic volcanic activity (e.g. the Trento Platform). Also magmatic plutonic activity took place along or nearby the Insubric Line. A series of acid-basic batholiths were emplaced cutting across previous (Eoalpine) thrust planes (e.g., Adamello). Others, e.g., the Bregaglia batholith, were sheared during their emplacement by the dextral shear that characterised the movement of this composite tectonic feature at least since the Oligocene.

Cretaceous-Eocene flysch deposits accumulated along the Paleo-Apenninic foredeeps during the Alpine phase and the early Apenninic evolution. The North-Calabrian units (shales, sandstones, and conglomerates), and the Sicilidi Units are deposits recording the early deformational compressive history of the Southern Apennines (Liguride phase).

1.2 THE NEOGENE TO PRESENT GEODYNAMIC EVOLUTION OF THE CENTRAL-NORTHERN THYRRENIAN AREA

This Apenninic orogene was related to a W-dipping subduction connected to the back-arc opening of the Provencal Basin (west of the Corso- Sardinian block) during Oligocene-Early Miocene times.

The Neogene paleogeographic and paleotectonic evolution of the Italian peninsula is principally influenced by the evolution of the Apenninic orogen. Alpine continental collision being already consolidated, the Neogene evolution of the Alps (Neoalpine phase) was mainly characterised by the emplacement of decollement nappes thrusted over the molasse foredeeps along both the European and Po plain sides. This was accompanied by basement underplating progressively involving the European foreland.

Contemporaneously the internal axial zone underwent further uplift as recorded by Upper Oligocene to Recent clastic deposits which accumulated in the Padan Basin where no appreciable shifting of sedimentation occurred. By Burdigalian times, after inactivation of the south-vergent backthrusts of the Po plain, tectonic transport stopped in the western Alps (sealed by the Burdigalian beds of the Apenninic foredeep), but was still effective in the southern Alps through the Neogene and until present times (Fig. 2).

The Neogenic evolution of the Apenninic orogen was characterised by a rapid eastward shift of both foredeep and chain areas, and by the contemporaneous collapse of the inner side of the chain. Coeval with, and related to the migration of the foredeeps, was the contemporaneous migration of the W-dipping subduction zone to the east of the Corso-Sardinian block, which started its counter-clockwise rotation around the Oligocene-Lower Miocene boundary. Subduction of the Adriatic plate was accompanied by Late Oligocene-Middle Miocene calc-alkaline volcanism in western Sardinia. Foreland migration and subsidence are expression of the same mechanism, that is of the eastward roll-back of the subduction hinge which was driven by the deep load associated with the subducting plate in combination with the load of material overlying the plate. The Apenninic system migrated north-eastward in the northern Apennines, in the central-southern Apennines. Through time migration of the Apenninic foredeeps is well recorded, specially in the Central Apennines, by eastward younging of the clastic wedges filling the foredeep.

During Early Miocene time, the paleo-Apennines formed a thrust belt, now dismembered under the Tyrrhenian Basin, in front of the counter-clockwise rotating Corso-Sardinian block. Nappe formation was accompanied by formation of high-T/low-P metamorphic mineral assemblages (e.g., in the basement units of the Calabrian-Peloritan Arc). Foredeep deposits associated with this early

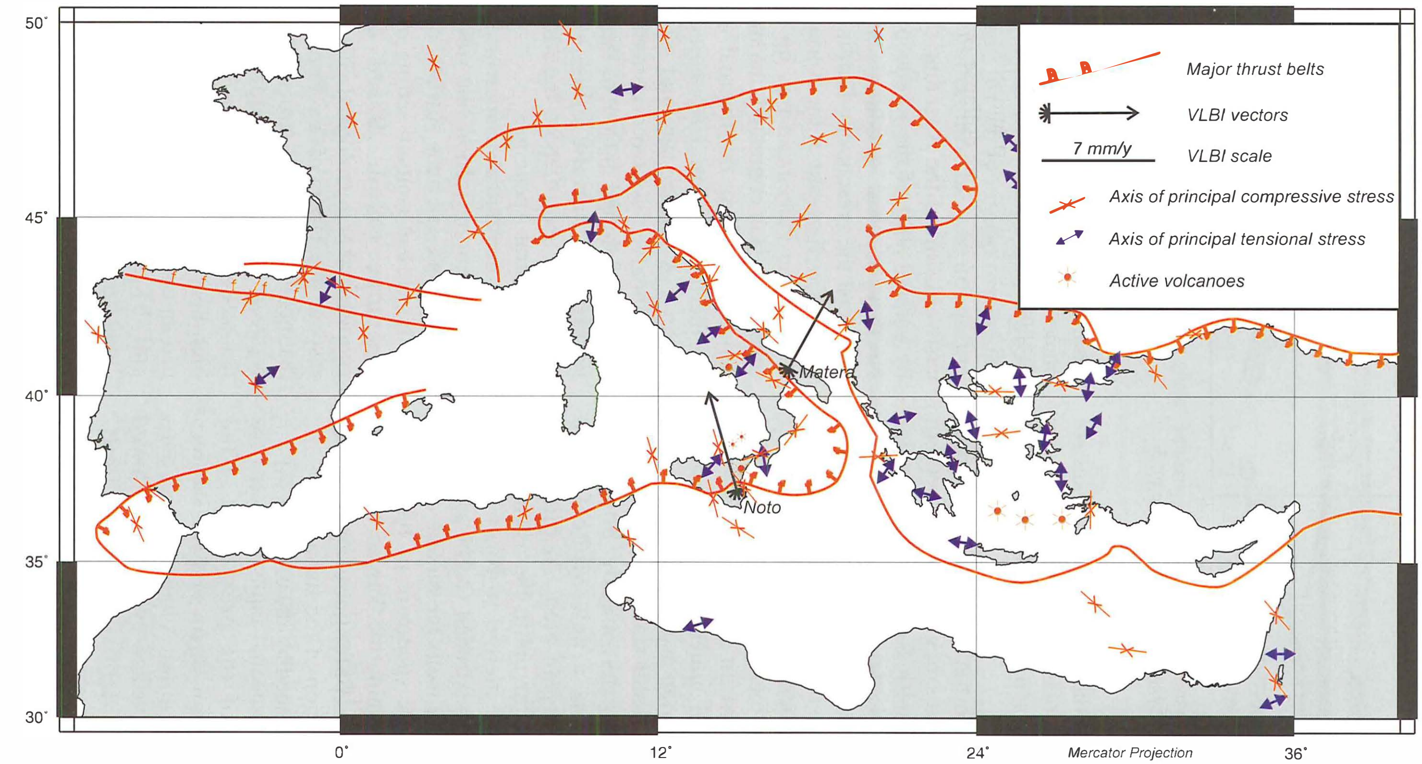

Fig. 1 – Earthquake distribution and present regional stress field in the Mediterranean area.

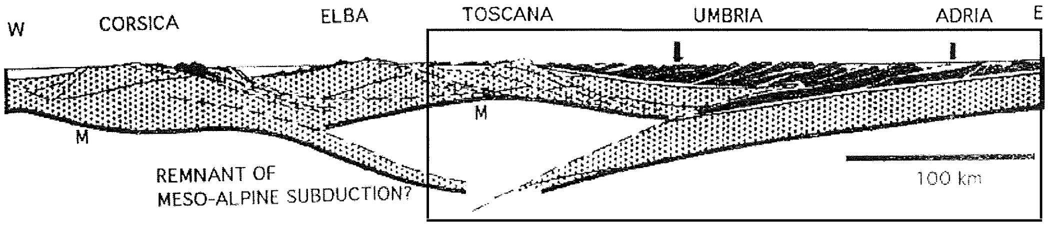

Fig. 2 – Schematics showing the main geological structures along a W-E transect from Corsica to the Adriatic Sea. Square inset represents the geological section shown in figure 3.

Apenninic phase in the Northern Apennines are the Macigno (Oligocene), Cervarola (Lower Miocene), and Marnoso Areanacea (from Middle Miocene).

From the Late Tortonian to Messinian p.p., extensional tectonics began in the Northern Tyrrhenian area, with formation of fluvio-lacustrine and paralic environments, and in the western part of the Southern Tyrrhenian Sea. Oceanic crust possibly emplaced in limited portions of the southern Tyrrhenian Basin.

From Middle Pliocene times, the western Tuscany underwent an almost generalized, and strong regional uplift, still active today. This was caused by an astenospheric intrusion that thinned the crustal stack and completely restructured the crust-mantle boundary. As a result of this a new Moho formed underneath the Tuscan area. At this stage, and in response to the uplift, the astenosphere and the litosphere melted to form basaltic magmas that either extruded (e.g. Capraia) or intruded in anatectic melts the mixing of which generated the wide spectrum of basic-acid associations constituting the Tuscan Magmatic Province (e.g. Elba, Montecristo, Giglio, and S. Vincenzo).

From Late Messinian to Piacenzian p.p., a new system of extensional faults dissected the eastern portion of the previously rifted Northern Tyrrhenian Basin and the western margin of the Apenninic chain. Terrigenous deposits and re-deposited evaporites followed by marine clays deposited in the fault-controlled basins in the northern sector (e.g., Southern Tuscany), whereas widespread rifting occurred in the Southern Tyrrhenian Basin, leading to the opening of the central bathyal plane (Magnaghi-Vavilov basin). Thick clastic wedges (e.g. South Thyrrenian sea) formed to the eastern margin of the rift basin. Tyrrhenian extension was accompanied by a further eastward shift of the Apennine thrust front and by parallel shift of the foredeep basins. In the Northern-Central Apennines, the shortening produced the present-day Emilia and Romagna folds, as well as part of the Adriatic folds.

From the Piacenzian p.p. up to Quaternary times extension continued, intramontane basins forming all along the internal margins of the Northern and Central Apennines (e.g., Tiber Valley). A further foreland migration of the chain/foredeep system occurred. The foredeep depocentre shifted in front of the buried Emilia, Ferrara and Adriatic folds in the Northern Apennines, and offshore the Marche coastline in the Central Apennines.

In this geological framework the CROP 03 deep seismic reflection line (running from the Thyrrenian coast o the Adriatic one) sheds light on the present tectonic setting of the Northern Apennine region. Based on the main geophysical and geological characters and with respect the Tiber Valley Barchi et al. (1998) distinguish two main structural domains: a) A western «Tyrrhenian» domain, whose main features consist of positive Bouguer anomalies, high heat flow values , thin crust (22-25 km), and an extensional regime lasting since 15 Ma; and b) an eastern «Adriatic» domain, characterized by relatively thick crust (35 km), negative gravity anomalies, low heat flow and a compressional stress field that is still acting today (Fig. 3).

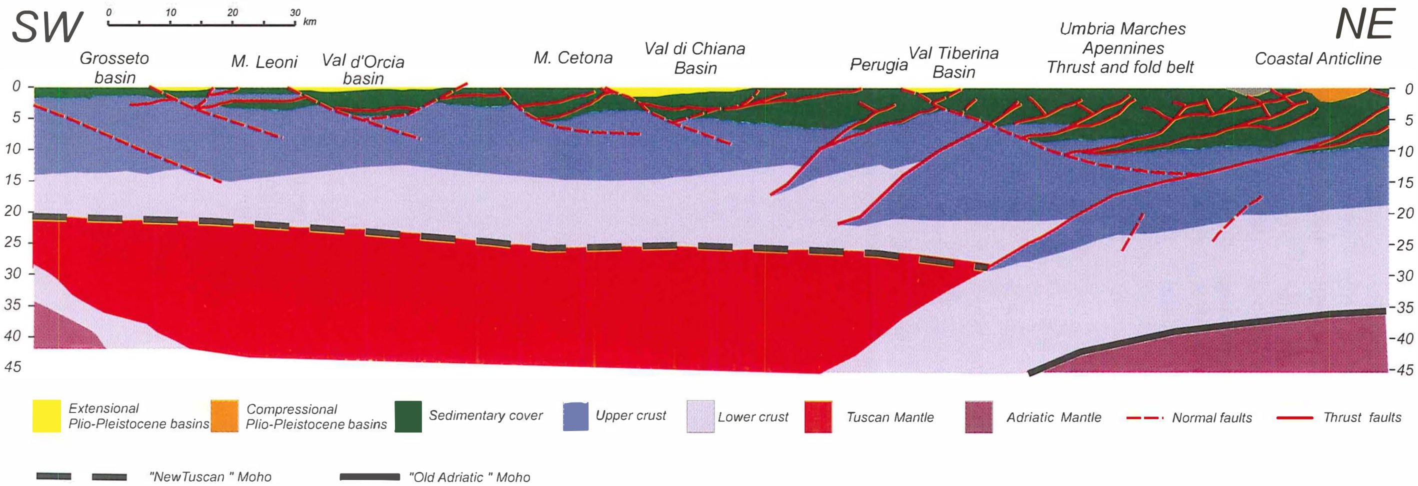

Fig. 3 – Detailed view of the main geological structures along the W-E transect evidenced in figure 2 by the square inset.

According to Barchi et al. (1998) the present-day, thinned crust is the result of a crustal thinning started in Middle Miocene in the Corsica basin (Bartole et al., 1991), and continued during the Upper Miocene-Middle Pliocene in Tuscany, allowing post-orogenic basins to form. Extension, and the accompanying uplift reached internal Umbria in the Upper Pliocene. This process is still ongoing in the axial zone of the Umbria-Marche Apennines.

Extension migrated from west to east in the same way compression did, so that while western sectors of Apennines were subjected to extension, thrusts were acting in Adriatic area. In this scheme the shallow Moho detected by the CROP 03 line on the Tuscan and western Umbria regions could be interpreted as a «new» moho resulting from a thinning processes of a previously thicker crust.