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the Azores, involving all islands except Santa Maria. São Miguel, São Jorge, Terceira, Pico and Faial all have active volcanoes, and fumaroles are present on Graciosa. The first recorded eruption was in 1539 on São Miguel; other notable eruptions occurred on Pico in 1562 and 1718; São Miguel in 1563, 1630, 1652 and 1713; on São Jorge in 1580 and 1808; on Terceira in 1761; and on Faial in 1672 and 1957–1958.

The 1957–1958 Faial eruption was an explosive basaltic (basanitoid) eruption. It began with offshore submarine activity, during which a new islet (Capelinhos) was formed. After this had disappeared, a new island emerged that became connected to the coast, and with the continuation of the eruption, the area of Faial was extended by several square kilometers. Intense tremors occurred before, during, and after the major paroxysms, with a long period of plinian and strombolian types of eruption (Walker and Croasdale, 1971). Capelinhos was not a new outburst of Paricutin type, but rather a revival of earlier ones (Machado, 1962).

During a submarine eruption of mostly ash and scoria near São Miguel in 1811, the commander of an English frigate, the *Sabrina* reported spectacular activity that gave rise to an island, which he called Sabrina. The island disappeared some months later, reduced by wave erosion to a depth of 27 m (Wharton, 1897; Weston, 1964).

Tectonic setting

The Azores overlie oceanic crust with magnetic ages ranging from 0 to 50 Ma. The islands lie on a submarine plateau of thickened oceanic crust called the Azores Plateau (Ridley, Watkins and MacFarlane, 1974), which is bordered on the S by the Pico–East Azores Fracture Zone and on the N by the North Azores Fracture Zone–Teceira Ridge. Recent seismic activity along the Terceira Ridge indicates that it represents the Eurasian–African plate boundary (Grimison and Chen, 1986). Earthquake focal mechanisms along this ridge suggest both normal and dextral displacements along NW-trending faults paralleling the Teicera Ridge. The Eurasian–African Euler pole is not far from the Azores, and the resultant very slow linear plate relative motion makes the nature of the boundary difficult to determine precisely. Similarly, the nature of the Azores triple junction is difficult to determine – whether it represents a ridge–ridge–ridge (Grimison and Chen, 1986) or a ridge–fault–fault type (Friere *et al.*, 1994).

The Azores and the Azores Plateau are thought to represent the result of plume-generated volcanic activity (Schilling, 1975), recalling the suggestion made on morphological grounds by Cloos (1939). Trace element data indicate the influence of a mantle plume from an enriched mantle source extends over 1000 km along the Mid-Atlantic Ridge N and S of the Azores Plateau (Schilling, 1975; Feighner and Richards, 1995). Carbon and water enrichment in Azores volcanic rocks suggest crustal contamination in the mantle source region of the magma (Kingsley and Schilling, 1995).

Historical earthquakes have been fairly common in the Azores. These earthquakes have shallow foci, and they have not been particularly violent, although the 1757 event on the S coast of São Jorge had an estimated Richter magnitude of 7.4, and the 1522 paroxysm claimed 5000 lives. Earthquakes have historically been most common on São Miguel. Four events of m_b between 5.0 and 6.5 occurred between 1963 and 1979. The 1979 event, the epicenter of which was on Terceira, caused considerable local damage.

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This manuscript represents a revision and update of an earlier manuscript by G. Soares de Carvalho and R.C. Mitchell-Thomé.

PORTUGAL: MACAO

Macao (= Macau) is a tiny Portuguese province (= Território) established in 1556. It is situated near the mouth of the Pearl or Canton River (Chuchiang), and not far from the delta of the West River (Hsi Chiang), on the SE coast of Asia. With an area of about 16 km^2, Macao is made up of a small peninsula, Macao proper, on which the city is built, and the offshore islands of Taipa and Colowan (Coloane), to the S. Its climate is monsoonal, characterized by wet summers from April to September and dry winters, with average temperatures of 28°C and 15°C, respectively.

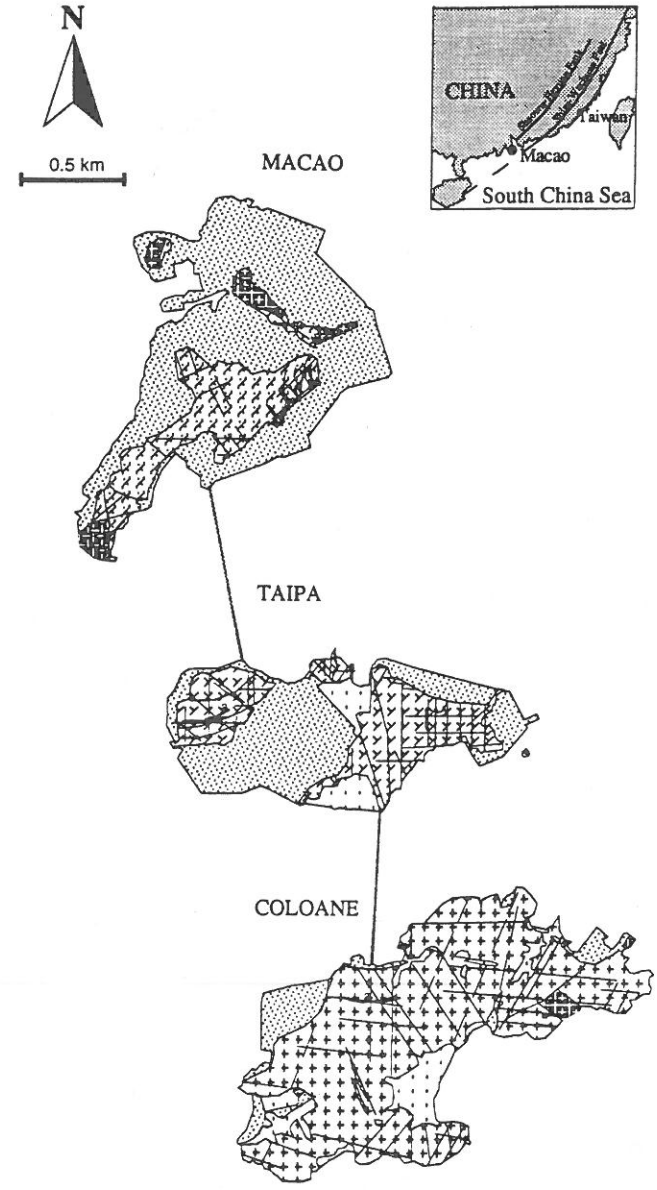

Fig. 496 Geologic map of Macao (simplified from Ribeiro *et al.*, 1992).

The area consists of a number of small, low-lying hills separated by valley flats. Although the peninsula of Macao has summits reaching just above 50 m, the land rises much more on the islands, where the highest point (Alto de Coloane) reaches 174 m (Costa and Sousa, 1964). Where the infilling of the valleys or silting along the coast has taken place, steep slopes change abruptly to flats composed of sediments. All the lowlands from Macao and Taipa, some of Colowan and their prolongation into the offshore, are now filled by artificial deposits which modified the original landscape. In Colowan, where the natural landscape is relatively preserved, there are three erosion levels respectively at heights of 170 m, 130 m and 110 m corresponding, probably, to an original erosion surface displaced by NW–SE fracturing (Ribeiro *et al.*, 1992). Notwithstanding the intense weathering due to the relatively wet and hot climate, boulders of unweathered rock occur in some places. The best outcrops are in the coastal regions.

From the geological point of view, Macao is situated nearby the great Sihui–Wuchuan Fault Zone considered as the 'Caledonian Front' and just in the alignment of the great Shenzhen–Wuchua (Shaown–Heyuan) active fault zone (Anonymous, 1980; Hunan and Quianhong, 1990). Earthquakes occur occasionally, as on 12 August, 1905 when the magnitude reached 5.5.

The area is predominantly of medium to fine-grained, biotite-rich, granitic rocks. Several metric to centimetric dikes of acid (micro-granites, aplites and a few pegmatites) and intermediate to basic rocks intrude the granites. Isotopic K–Ar data (Ribeiro *et al.*, 1992) indicate that the Macao and Taipa granites are Jurassic (164 Ma), while the equivalent rocks from Colowan are younger (Cretaceous; 94 Ma). Petrology and geochemistry indicate the existence of more than one sequence of igneous rocks and that the regional granites did not result from processes of minimum melting of crustal rocks (Ribeiro *et al.*, 1992).

Relicts of metasedimentary rocks occur as metric outcrops on Colowan (Alto de Coloane and Ká-Hó; Ribeiro *et al.*, 1992). These rocks are considered as Paleozoic (probably Devonian) by lithologic correlation with similar rocks from China (Huang, 1948). The low metamorphic grade of these rocks suggests that the granites rose up through fault planes.

Overlying the older rocks on the lowland parts of Taipa and Colowan, sandy and silty fluviomarine deposits and few arkosic and conglomeratic alluvial and eluvial formations can be found. Correlation with similar deposits in surrounding regions suggests a Holocene–Pleistocene age for these sediments (Marques, 1988). The superficial deposits, best preserved on Colowan island, are being destroyed to provide material for land reclamation of shallow nearshore areas.

All of Macao province was subject to strong fracturing at the time of the Yenshanian Orogeny. This tectonic event conditioned the morphology. The strong fracturation is well visible on coastal outcrops. The main fracture systems are oriented ENE–WSW and NW–SE. Among the secondary systems the most important directions are oriented NE–SW and N–S to NNE–SSW. The later reactivation of this Yenshanian structures cannot be excluded. The interpretation of stress fields suggests that σ_1 changed from NW–SE to NNE–SSW and finally to NNE–SSE (Ribeiro *et al.*, 1992).

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PORTUGAL: MADEIRA

A Portuguese possession situated at 32°30′ N and 17° W. Madeira (capital, Funchal) is the largest island (728 km^2) in a small archi-