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Plate motions in the Alpine region and their correlation to the opening of the Atlantic ocean

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With 5 Figures

Abstract

The plate motions in the Alpine region are related to the stepwise breakthrough of the Atlantic ocean to the north. The present outline briefly describes and illustrates the suggested plate motions in the Alpine region (FRISCH, 1977, 1979) in connexion with the evolution of the Central and North Atlantic (BIJU-DUVAL et al., 1977; SCLATER et al., 1977; SMITH and BRIDEN, 1977) during five stages.

Fig. 1 (Triassic): All continental masses in the Alpine region and on both sides of the later North Atlantic are part of one coherent continent, Pangaea, which is partly covered by shelf seas.

Fig. 2 (Jurassic): The Central Atlantic and the South Penninic oceans are opening at about the same time (Lower Jurassic) and are considered to belong to the same spreading axis, offset by a major left-lateral transform fault between Iberia (part of Laurasia) and Africa (part of Gondwana).

Fig. 3 ("middle" Cretaceous): The second stage in the evolution of the Atlantic ocean is the separation of Iberia by protrusion of the Atlantic ocean to the north and into the Bay of Biscay. At about the same time (since the early Cretaceous, with incipient rifting in the Upper Jurassic), the Briançonian (Middle Penninic) continental mass separates from the Laurasian plate while forming the North Penninic trough in its wake. Although both minor plates, Iberia and Briançonia, are not coherent which becomes evident by the reconstruction of their motions (mainly lateral motions relative to Laurasia in the Pyrenees and the Western Alps: no creation of oceanic lithosphere), it is strongly suggesting that the events in the Alps are triggered by those in the North Atlantic and the appendant Bay of Biscay. The southward or southeastward drift of the Briançonian plate is compensated by a southward dipping subduction zone along which the oceanic lithosphere of the South Penninic basin is consumed beneath the northern part of the Adriatic plate (Austroalpine-South Alpine realm). A paired metamorphic belt, the temperature-emphasized limb of which is not pronouncedly developed, bears witness of this process. At about mid-Cretaceous time the Adriatic plate is believed to separate from Africa carrying out a counterclockwise rotation. The

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~200 m.y. (late Triassic)

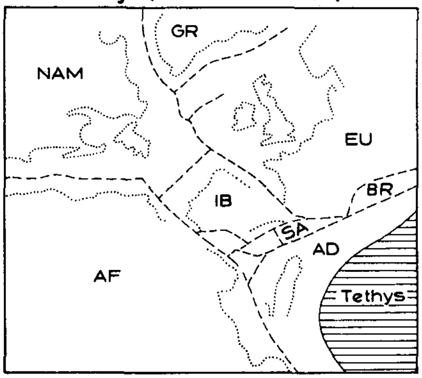


Fig. 1

~140 m.y. (late Jurassic)

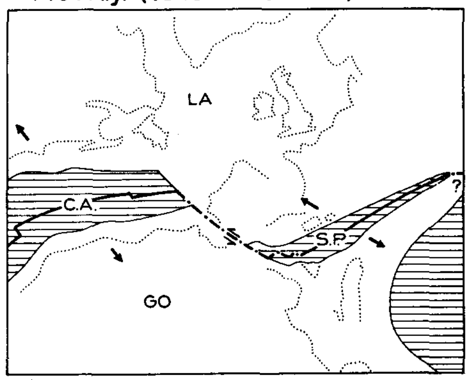


Fig. 2

~110 m.y. (late Lower Cretaceous)

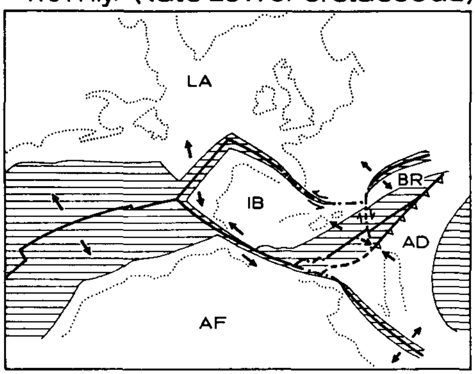


Fig. 3

~80 m.y. (Upper Cretaceous)

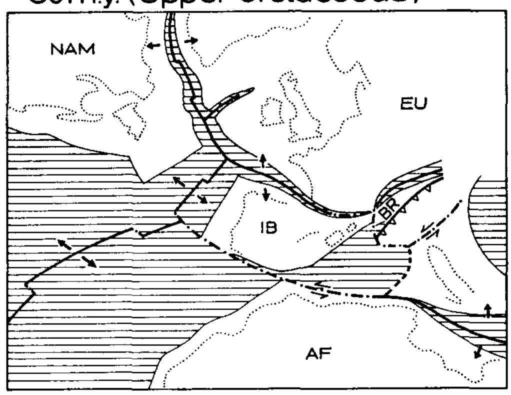
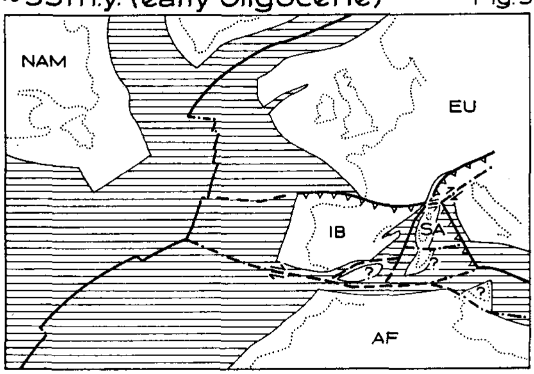


Fig. 4

~35 m.y. (early Oligocene)

Fig. 5



accreting, conservative, consuming, indefinite — plate margins

continental crust

oceanic crust

counterclockwise rotation of the minor plates is an effect of the persistent left-lateral motion between Europe and Africa.

Fig. 4 (Upper Cretaceous): The couterclockwise rotation of the Adriatic plate leads to oblique collision with the Briançonian continental mass to the north. The Adriatic plate disintegrates and, as a consequence, its northern part rotates in the opposite direction (see MAURITSCH and FRISCH, this vol.). The collision is responsible for intense deformation and nappe formation in internal parts of the Alps and is also reflected by the radiometric 80 m.y. cooling ages of the paired metamorphic belt. In the northern part of the orogen, the distending motions continue in the North Penninic basin. Mainly lateral motion in the Western Alps and the Pyrenees opens into the spreading axis of the Bay of Biscay. This period is correlated with the next stage in the evolution of the Atlantic ocean: North America separates from Eurasia after a triple junction northwest of Iberia has been formed. The resulting distension between Eurasia and Africa is responsible for a tranquil period in the Alps between the Cretaceous and the Tertiary orogenies, i.e. in the late Upper Cretaceous and early Tertiary.

Fig. 5 (Lower Tertiary): After cessation of the spreading activities in the Bay of Biscay and the Labrador Sea, the Atlantic ocean finally finds its way through between Greenland and Eurasia in the early Tertiary. This results in convergent motion in the Mediterranean region and leads to the Tertiary orogeny in the Alps and the Pyrenees. The North Penninic basin is being subducted, and the continental mass to the south collides with the European margin (Helvetic zone) in the Eocene. Continuing compression is responsible for the formation of the Molasse trough, and of nappes in the Helvetic realm up the end of the Tertiary. The convergent motion in the Mediterranean which is active until Recent, is caused by differential spreading along the mid-Atlantic ridge north and south of the Azores triple junction.

This paper is an outline of a more detailed presentation being published in the Alfred Wegener Volume in the "Geologische Rundschau" (1980).

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Fig. 1—5: Paleogeographic sketches of the western Mediterranean and the North Atlantic from late Triassic to Lower Tertiary. Positions of North America, Greenland, Europe, Iberia and Africa after BIJU-DUVAL et al. (1977), SCLATER et al. (1977), and SMITH and BRIDEN (1977). Minor plates in the Alpine region after FRISCH (1977, 1979). Plate motions are approximate (semiquantitative), and so are the arrows indicating relative motion between two plates. Dashed lines in Fig. 1 are lines of later disintegration of plates.
Plates: GO, Gondwana. LA, Laurasia. AF, Africa. EU, Eurasia. NAM, North America. GR, Greenland. IB, Iberia. BR, Briançonia. AD, Adriatica. SA, Sardegna-Corsica. Small plates between IB, AF and AD include the Betics, Calabria, and Sicily and are not well defined. Oceans (Fig. 2): C.A., Central Atlantic; S.P., South Penninic ocean.

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