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Kinematics and extent of the Liguro-Piemont Ocean

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Assessing the extent of a former ocean, of which only remnants are found in mountain belts, is challenging but crucial to understand subduction and exhumation processes. Here we present new constraints on the opening and width of the Liguro-Piemont (LP) Ocean (or Alpine Tethys) in Mesozoic time using plate kinematic reconstructions of the Western Mediterranean-Alpine area.

Our kinematic model is based on a compilation of geological-geophysical data and published reconstructions of the opening of the Atlantic for the motion of Europe, Africa and Iberia, and of the Cenozoic deformation along fold-and-thrust belts (Alps, Apennines, Dinarides, Provence) and extensional basins (Liguro-Provencal Basin and Sicily Channel Rift Zone) for the motion of the Adriatic plate (Adria) and Sardinia-Corsica. For Jurassic and Cretaceous times, our main assumption is to avoid significant convergence or divergence between Adria and Africa and between Iberia and Sardinia-Corsica, as there is no geological evidence for such deformation. This implies in return strike-slip motion between southern France and Iberia-Sardinia-Corsica and within the Adriatic plate.

Our model shows that the LP basin opened in three phases: (1) first a slow extensional phase of c. 4 mm/yr (full rate) in Lower-Middle Jurassic between 200-165 Ma, followed by (2) a faster (up to 1.5 cm/yr) oblique extension in Middle-Upper Jurassic between 165-154 Ma, which coincides with emplacement ages of gabbros and pillow-lavas, and (3) a final main extensional phase in Upper Jurassic between 154 and 145 Ma, with rates up to 2.3 cm/yr. At 145 Ma, Iberia starts to move relative to Europe and thus extension in the LP domain decreases rapidly till it ceases completely at about 130 Ma. We interpret the first phase as rifting of the proximal part of the continental margins (200-165 Ma) followed by hyper-extension and formation of the ocean-continent transition zone (165-154 Ma), and break-up and ultra-slow oceanic spreading during the final third phase (mainly 154-145 Ma). Along a NW-SE transect between Corsica and northern Adria, we estimate the width of the LP Ocean to a maximum of ~ 240 km (oceanic domain) and the extent of the whole rifted margins to ~ 500 km, subdivided into ~380 km for the proximal and necking zones, and ~120 km for the hyper-extended and ocean-continent transition zones. Our results are supported by high-resolution thermo-mechanical modelling of the rifting phase that, using our kinematic constraints, reproduces very well the geometry of the Adriatic margin, as obtained by

published geological reconstructions of the Southern Alps.

We test other kinematic scenarios for the motion of Sardinia-Corsica and for the opening of the Ionian Basin which would increase the obliquity of rifting and reduce even more the width of the extended domain. Therefore, our calculated extent of the LP Ocean constitutes a maximum estimate providing crucial constraints for geodynamic modelling and a better understanding of subduction processes during the Alpine Orogeny.