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Double saloon door tectonics in the Japan Sea, Fossa Magna, and the Japanese Island Arc

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ABSTRACT

A number of criteria considered diagnostic of double saloon door rifting and seafloor spreading are matched by data from the Japanese Arc. These include:

i) a pair of terranes, SW and NE Honshu, which rotated in opposite directions from 22–21 Ma to 14–11 Ma;
ii) rotated terranes which comprise a retro-arc fold/thrust belt attached to an accretionary wedge intruded by a magmatic arc;
iii) contemporaneous backarc extension from 24 to 21 Ma which is brought to a halt by progressive collision of the Izu-Bonin and Japan Arcs from 15 to 5 Ma;
iv) isolation of blocks of thicker continental crust by areas of thin continental or oceanic crust, during backarc rifting;
v) such isolation may be due to simultaneous rifting or to progressively seaward rifts, associated with ridge jumps towards the subduction zone;
vi) opposite rotations are accommodated by subduction rollback demonstrated by seaward migration of the volcanic front from 30–26 Ma to 16–15 Ma;
vii) concurrent development of a major arc-orthogonal rift, the Fossa Magna, from 23–18 Ma to 14 Ma, which was thereafter inverted from 15 Ma to the Recent;
viii) a northeast propagating rift in the northern Japan Basin demonstrated by the relationship of linear magnetic anomalies to the mapped continent ocean boundary.

Driving mechanisms for double saloon door tectonics are discussed in relation to various reconstructions of the northwest Pacific. Opposite rotational torques, leading to opposite terrane rotations, may be caused by rollback of a curved trench hingeline, or by the divergent slab sinking forces of the Pacific and Philippine Sea Plates.

1. Introduction

The Japan Sea is a classic marginal basin in the northwestern Pacific (Fig. 1). Seaward of the Japanese magmatic arc/accretionary wedge, both the Philippine Sea and Pacific Plates are being subducted, the former towards the northwest, the latter in a west northwesterly direction (Fig. 2). These two plates meet at a trench–trench–trench triple junction offshore central Honshu (Fig. 1).

Hypotheses for the origin of the Japan Sea marginal basin include rollback of the subducting Pacific Plate (Seno and Maruyama, 1984), landward retreat of the overlying Amurian Plate, part of the Eurasian Plate, (Kimura and Tamaki, 1986; Tamaki, 1988; Wei and Seno, 1998), pull-apart extension (Lallemand and Jolivet, 1985: Tamaki et al., 1990; Jolivet et al., 1991, 1994), and double-door opening (Otofuji et al., 1985a,b). Reversal of mantle convection (Gurnis, 1988; Lowman and Jarvis, 1996) has been proposed for the separation of Japan from Asia (Otofuji et al., 2006), whereas Japanese Arc rotations have been related to the collisions at the subduction zone of the Kyushu–Palau Ridge, and the Kuril Arc (Wallace et al., 2009a,b). Many of these proposals envisage increased influence of the asthenosphere rather than the lithosphere as seafloor spreading proceeds, impacting magmatic products (Nohda et al., 1988; Tatsumi et al., 1989; Shimazu et al., 1990; Okamura et al., 2005; Shuto et al., 2006).

Double saloon door tectonics occurred in the Western Mediterranean, Alboran, Tyrrhenian, Pannonian, Aegean, and Caribbean Basins (Martin, 2006, 2007a). This scenario has been invoked to explain Early Jurassic breakup of Gondwana (Martin, 2007a,b), and the Japan Arc (Martin, 2007b; Wallace et al., 2009a).

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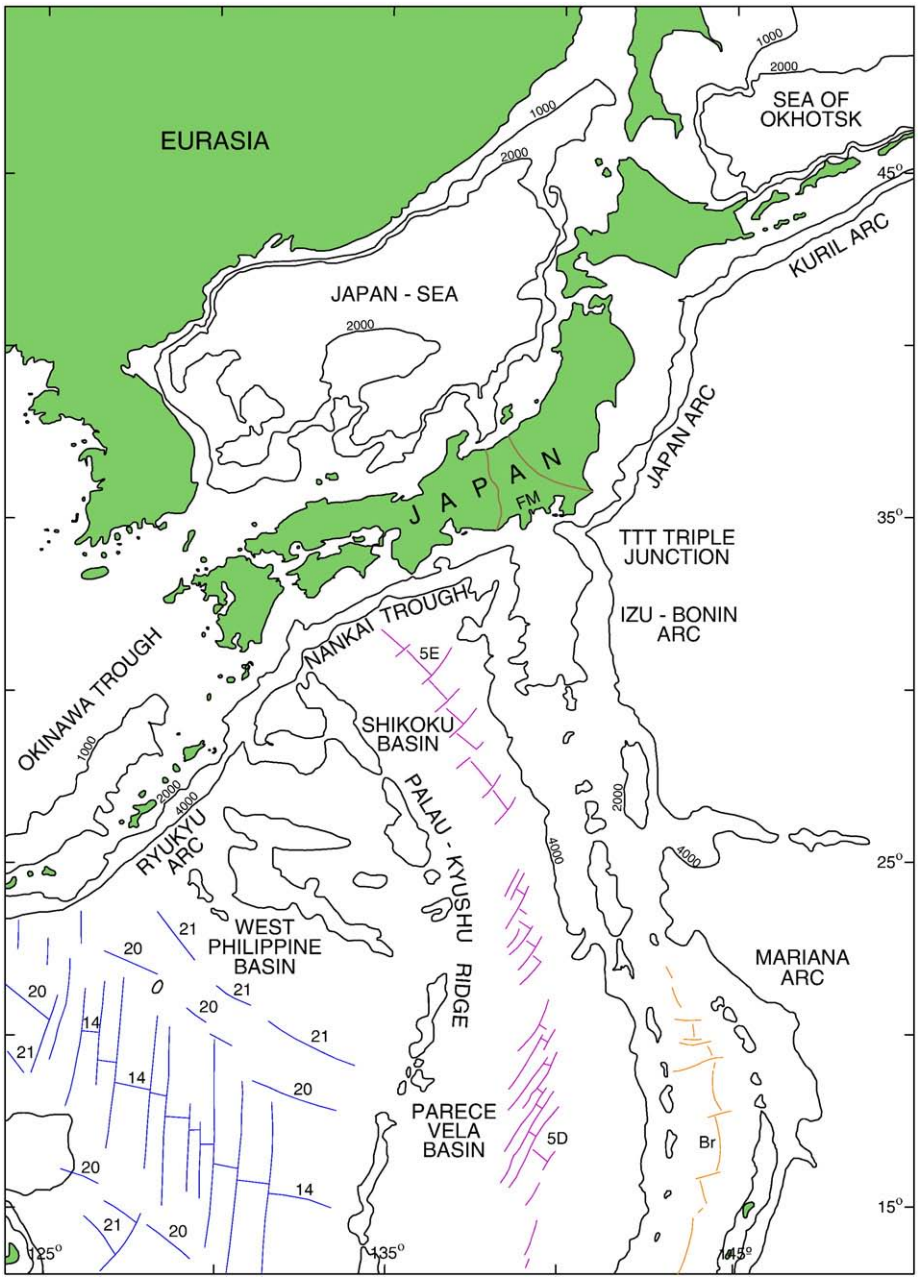

Fig. 1. Japanese Island Arc and the Japan Sea in relation to the main tectonic elements of the Northwest Pacific. FM = Fossa Magna delineated by pink lines on mainland Japan. Bathymetry of Okinawa Trough, Japan Basin and Sea of Okhotsk shown by 1000, 2000 and 4000 m isobaths. Seaward of the arcs, the Pacific is shown only by 2000 and 4000 isobaths. Seafloor spreading anomalies 14 to 21 and fracture zone in the West Philippine Basin (shown in dark blue) after Hilde and Lee (1984) and Deschamps and Lallemand (2002); anomalies 5D and 5E in the Shikoku and Parece Vela Basins (shown in magenta) after Mrozowski and Hayes (1979), Okino et al. (1998, 1999); Brunhes (Br) magnetic anomaly in the Mariana Trough (shown in orange) after Martinez et al. (2000) and Yamazaki et al. (2003). The Nankai Trough, Izu-Bonin Arc and Japan Arc meet at a trench–trench–trench triple junction. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Here, I propose that the Japan marginal basin opened via double saloon door rifting and seafloor spreading. Several features predicted by the double saloon door model match the attributes of the Japan Sea and surrounds. These include opposite terrane rotations, the orientation of magnetic anomalies, and the distribution of rifted basins, including the arc-perpendicular Fossa Magna (Fig. 1). The purpose of this contribution is five-fold.

First, the double saloon door rifting and seafloor-spreading model is briefly outlined.

Secondly, properties of the Japan Sea are compared to characteristics diagnostic of double saloon door tectonics.

Thirdly, reconstructions of the northwestern Pacific are reviewed for the period when double saloon door tectonics occurred.

Fourthly, geodynamic driving mechanisms are discussed in the context of these plate tectonic models, with emphasis on the geodynamics of opposite rotations.

Finally, some additional issues are discussed.

2. Double saloon door rifting and seafloor spreading

The double saloon door model was first developed for the opening of the Western Mediterranean backarc basin which formed in the Chattian to Langhian. Two arc-parallel rifts propagate in opposite directions from an initial central location during backarc seafloor spreading and subduction rollback (Martin, 2006). The resultant geometry causes pairs of terranes to simultaneously rotate clockwise