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Tectonic Framework of the East Scotia Sea

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ABSTRACT

This chapter reviews the tectonic evolution of the East Scotia Sea, testing and extending previously published conclusions in light of the additional and expanded data sets now available. The East Scotia Sea floor was generated behind the east-migrating South Sandwich Trench, at a spreading center now lying along 30°W. On its western flank, lineated magnetic anomalies are identified out to at least anomaly 5 (10–11 Ma) and probably out to anomaly 5B (ca. 15 Ma). Spreading was essentially symmetric at about 27 mm/year from 15 Ma to about 5–7 Ma, then slowly accelerated. From 4 Ma to 1.7 Ma, spreading was at 50 mm/year and slightly asymmetric. Since 1.7 Ma, spreading has been up to 15% asymmetric, favoring accretion to the arc flank, within an overall rate of 65 mm/year. Asymmetry is confined within segments bounded by fracture zones that in some cases were created only at 1.7 Ma. A relation between asymmetric spreading, segmentation, and ridge migration seems likely. The median valley is between 6 and 20 km wide and exceptionally is up to 1200 m deep, but usually is smaller and the ridge flanks smooth, as is typical of faster spreading. The ridge crest depth is 500 m or more deeper than the global MOR average. Before 3–4 Ma the ridge was rougher and probably the ridge crest shallower.

In the south, the extensional zone is narrower, and the present spreading probably started only about 3 Ma, after an eastward ridge jump associated with ridge crest–trench collision in the South Sandwich forearc. The ridge jump caused fragments of the previous South Sandwich arc and forearc to be transferred to the Scotia and Antarctic plates, as part of the inevitable adjustment of plate boundaries following ridge crest collision. The detailed history of collision along the South Scotia Ridge is poorly known, but previous collisions involved similar transfers of arc and forearc fragments and may have influenced previous episodes of backarc extension.

On the eastern flank, volcanoes of the South Sandwich island arc lie on ocean floor aged from about 10 Ma to as young as 3 Ma, formed during the present spreading episode. Both island-arc and backarc extensional volcanic geochemistry seems to reflect varying

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degrees of contamination of the mantle, by fluids from the subducting South American lithosphere, and of partial melting. The rocks appear similar to but simpler than those from other intraoceanic backarc environments, showing only minor prior source depletion. However, the arc chemistry is geographically heterogeneous and does not reflect systematic north-south variation in the age and sediment cover of the subducted slab, as might have been expected.

The distribution of older magnetic anomalies on the western flank suggests that congruent ocean floor of the eastern flank should occupy most of the present forearc. If so, there has been significant tectonic erosion of the northeast corner of the forearc, where also serpentinized ultrabasic rocks have been dredged. This corner lies directly above the locus of tearing of the subducting slab at its northern end. In the southern forearc off Montagu Island, dredge hauls have identified an abnormally elevated block as a fragment of a 31 Ma calc-alkaline arc volcano, presumably associated with the early stages of Scotia Sea evolution.

There is no correlation between the level of development of the accretionary prism in the lower forearc and the sediment cover of the subducting slab. Variations along strike in the elevation of the forearc mid-slope high have controlled the transport of arc volcaniclastic sediment to the trench, and hence influenced accretionary prism development to some extent, but the main control appears to have been tectonic.

1. INTRODUCTION

The East Scotia Sea backarc basin is in many respects an end member of the wide range of backarc extensional environments, and its overall setting and behavior are sufficiently unusual to merit close examination. However it is less well known than many backarc basins because of its geographic isolation and the rumored unpleasantness of its climate. A principal aim of this chapter is to expose its inherent interest to a wider audience so as to encourage further work.

Knowledge of the East Scotia Sea and its surroundings has accumulated only slowly. Historically, the two most significant data sets have been bathymetric and magnetic. These were last reviewed and interpreted in detail by Barker and Hill (1981). Those findings were incorporated with minor revision into a tectonic map of the entire Scotia Sea region and review of tectonic evolution (Tectonic Map, 1985; Barker *et al.*, 1991). Meanwhile, these data sets have grown by collection on passage and by specific survey of a young ridge crest collision at the southern end of the backarc basin (Hamilton, 1989). Of other, lesser data sets, earthquake distribution (Isacks and Molnar, 1971; Forsyth, 1975; Brett, 1977; Pelayo and Wiens, 1989) and dredge hauls (Saunders and Tarney, 1979; Hamilton, 1989) have been described and discussed at intervals. Seismic reflection profiles remain sparse. More recently, a small geologic long-range inclined asdic (GLORIA) survey was accomplished in 1989 in the area considered by Hamilton (1989), and release in 1992 of Geosat GM altimetry of the region south of 30°S has provided a major new free-air gravity data set.

Since this region was last reviewed, significant additional data have accumulated, only published in part, and it is not sufficient here merely to review published work. In Section 2 therefore I set in context the main conclusions drawn from published work. In Sections 3 and 4 I evaluate the new and enlarged data sets now available, then use them to reassess and extend those conclusions.