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South China Sea rifted margin: A cross between magma-poor and magma-rich margins?

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Four deep boreholes targeted by IODP expeditions 367/368 at the northern South China Sea (SCS) rifted margin sampled pre-rift crust, the entire syn- to post-rift basin evolution, pre-spreading basaltic magmatism, and early seafloor-spreading type crust. The seismic data across the SCS margin show extensive crustal thinning by deep detachment faulting typical for magma-poor rifted margins. The cores, however, consistent with seismic data suggesting the presence of a ductile lower crust below most of the margin, show no evidence of mantle exhumation. Cores demonstrate a relatively short and major rifting event (∼10 myrs) translating directly into accretion of igneous oceanic crust. While the latter is typical for magma-rich rifted margins caused by excess temperature of the asthenospheric mantle during breakup, the SCS margin lacks other characteristics, such as transient formation of anomalously thick oceanic crust with seaward-dipping reflectors and reduced to absent rift subsidence. We therefore interpret the SCS margin as a separate class of rifted margins, and not a simple combination of the processes leading to respectively magma-poor and magma-rich margins.

These SCS findings raise the fundamental question: In a rifting scenario assuming both normal temperature asthenospheric mantle and passive upwelling, what extension regime (time and space) can lead to coincident plate rupture and accretion of igneous oceanic crust by seafloor spreading? Core data combined with seismic observations even indicate that limited amounts of Mid Ocean Ridge Basalts (MORB) were generated and laid down on thin continental crust before the fully oceanic crust formed. Previous numerical modeling of Atlantic rifted margins suggests that depth-depending extension of the lithosphere in a setting with an effective mechanical decoupling between the crust and the mantle lithosphere may propel magmatism to develop at, or soon after plate rupture, and to be associated with reduced subsidence during rifting. While a ductile lower crust below SCS margin decoupling crust and mantle extension is consistent with both seismic and coring data, the subsidence of the SCS margin shows that bathyal depths developed prior to plate rupture.

Rifting and breakup leading to the SCS formation, however, took place in a setting of a hotter and younger lithosphere (late Mesozoic) than those of the well-studied north and south Atlantic rifted margins (Archean to Paleozoic lithosphere). We surmise that rapid rifting within a young, thin and thermally not fully equilibrated lithosphere might have allowed small degree of melting within the mantle lithosphere to take place. Small degree of melt lowered lithospheric mantle viscosity and allowed it, due to the decoupling provided by a ductile lower crust, to mechanically extend at higher rates and independently from the crustal part of the lithosphere. Rapid, passive upwelling and decompression melting of the underlying asthenosphere below the proto-spreading center generated MORB type magmatism even before final plate rupture, and subsequently underpinned robust magmatism and accretion of oceanic crust at, or shortly after final plate rupture.