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Insights into the mode of the South Georgia rift extension in eastern Georgia, USA

C.W. Clendenin Jr. *

South Carolina Department of Natural Resources—Earth Science Group, 5 Geology Road, Columbia, SC 29212, USA

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ABSTRACT

The South Georgia rift (SGR) lies oblique to the east coast margin of North America and across the Alleghenian suture between Laurentia and Africa in southern Georgia. Regionally, the SGR can be divided into a southwest compartment and a northeast compartment across the Jacksonville structure that is located in the vicinity of that suture. Analytical and numerical models are used to characterize the mode of rifting in the northeast compartment. Borehole, COCORP seismic, and regional geophysical information from the compartment, that were used previously to infer the geometry of the basin, are reassessed with the use of those models to analyze the lithospheric conditions influencing Triassic extension. This approach led to the interpretation of core complex mode extension and to the proposal of a model of progressive rifting. The model shows how the Riddleville and Main SGR basins are associated and how changes in structural style of those two basins resulted from changing lithospheric conditions during extension. The core complex model also indicated that extension was influenced by distributed deformation of a younger, warmer, and less stable lithosphere adjacent to the Permian suture; whereas extension in other east coast rifts that lie subparallel to structural fabric was probably localized by preexisting zones of weakness.

1. Introduction

Continental extension is characterized by differences in structural styles, width, and magmatic processes. These differences are the result of lithospheric conditions prior to and during extension (ten Brink et al., 2000). Buck (1991) emphasized that geothermal state and crustal thickness are the dominant lithospheric conditions influencing continental extension and described three modes of rifting: narrow, wide, and core complex. Modeling also shows that old, thick, and cold crusts tend to yield narrow rifts; whereas extension of younger, thinner, and warmer lithospheres give wider rifts, in which core complexes may develop (Corti et al., 2003). Keranen et al. (2009), however, demonstrated that preexisting zones of weakness influence rift mode under different conditions, if the prevailing stress field and preexisting weaknesses are properly oriented. In nature, the resulting structural style, therefore, should be considered a function of heat flow, crustal age, crustal thickness, and orientation of preexisting weakness (Buck, 1991; Corti et al., 2003; Keranen et al., 2009). Van Wijk and Blackman (2005) also point out that structural style varies along the rift axis during extension.

Appreciation of the described relations is important when one tries to characterize the tectonic development of the South Georgia rift (SGR). The SGR is the southernmost Triassic basin along the east coast of North America and is buried under Atlantic Coastal Plain sediments (Fig. 1). Being buried has hampered the understanding of the SGR; and what little is known has come from borehole, regional geophysical information, and a few seismic images. Interest was reignited in 2010 when the U.S. Department of Energy funded a characterization study of the basin. However, borehole samples that could have provided a better understanding were lost with the closure of the Georgia State Geological Survey. Loss of those samples forced this part of the characterization study to rely on regional relations, published data, and a priori evidence.

In this paper, subcrop maps, seismic images, and regional geophysical patterns of the SGR in eastern Georgia are reexamined, and the information is compared to analytical and numerical models to decipher structural style. This information is used to interpret mode of rifting, and then a progression rifting is proposed for the tectonic development of the SGR in eastern Georgia. The regional implications of that model are discussed to help characterize what may have influenced the mode of rifting.

2. Triassic precursor basins

Regional relations show that two series of Triassic rift basins formed in western Pangea prior to the opening of the central Atlantic Ocean and that these rift series are time equivalent (Traverse, 1987). Basins found along the east coast of North America commonly are exposed on the surface, are subparallel to structural fabric, and are referred to here as the Newark series (Fig. 1). The Newark series basins are characterized by elongate half-grabens, bounded by listric-like faults lying subparallel to the coast (Withjack et al., 1998). Although the SGR is oblique to the coast, published cross sections also tend to depict a half-graben structural style (McBride et al., 1987; Withjack et al., 1998).

* Tel.: +1 803 896 7702.
E-mail address: clendeninb@dnr.sc.gov.

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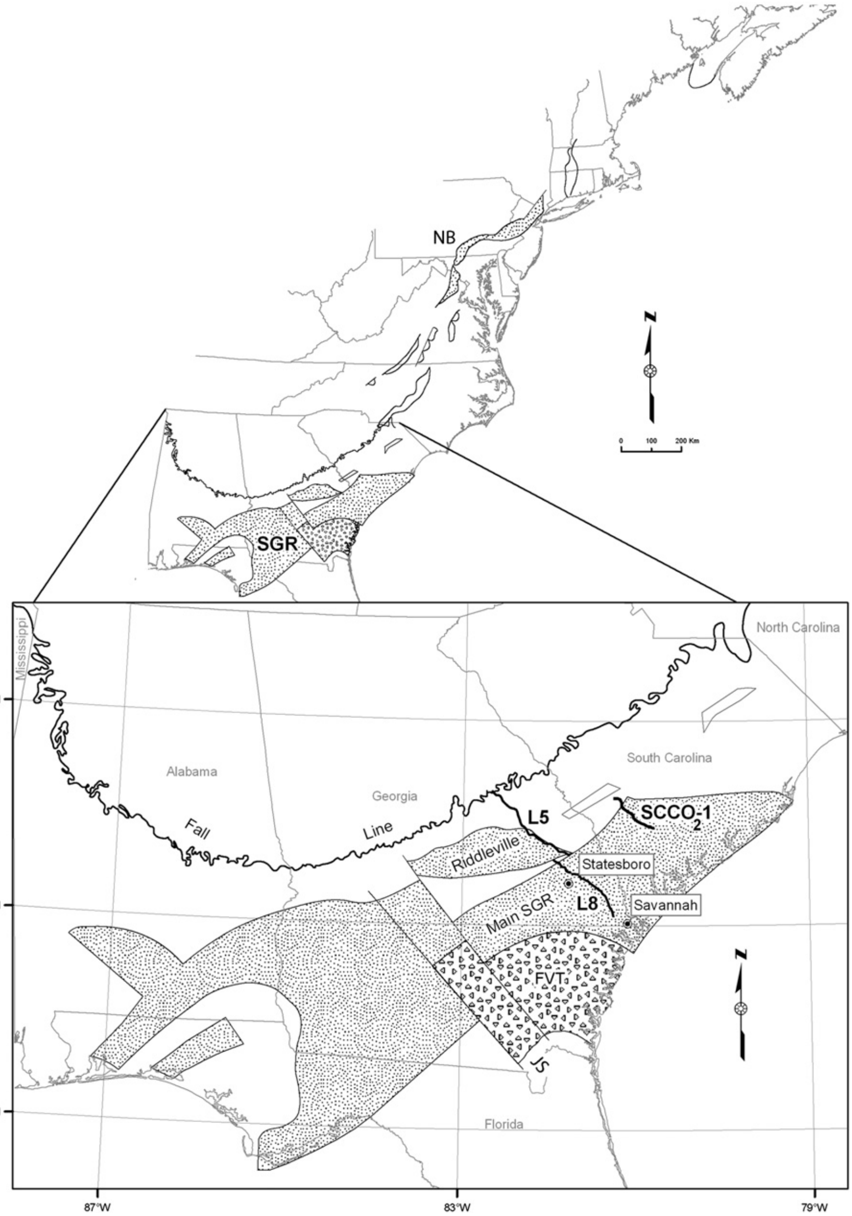

Fig. 1. Reference map showing seismic lines L5, L8, and SCCO21; Fall Line, and other features. Newark series basins are shown to north-northeast on reference map. NB: Newark basin; FVT: Felsic Volcanic Terrane; JS: Jacksonville structure (modified after Chowns, 2009).

Less attention has been given to the second series of Triassic basins that is buried in the Gulf Coast area and referred to here as the Eagle Mills series (Fig. 2). This series of precursor basins begins offshore of Florida immediately southwest of the SGR and extends in the subsurface northwest across Alabama–Mississippi, west across southern Arkansas–northern Louisiana, and then southwest into eastern Texas (Moy and Traverse, 1986; Pindell and Kennan, 2009; Tew et al., 1991). Pindell and Kennan (2009) also have correlated another set of basins off the northeast coast of Yucatan with this series. Structural style is not known, but regional distribution and limited seismic information suggest a horst-and-graben pattern (McBride, 1991; Pindell and Kennan, 2009; Sartain and See, 1997).

3. SGR in eastern Georgia

3.1. Borehole information

Chowns and Williams (1983) produced a subcrop map of the SGR over parts of Florida, Alabama, Georgia, and South Carolina (Fig. 1). The map shows that the SGR is divided into northeast and southwest compartments by the Jacksonville transfer fault system in southern Georgia (Tauvers and Muehlberger, 1987). The existence of the Jacksonville transfer system is considered controversial, but the polarity of extension shifts from down-to-the-northwest in the southwest compartment (McBride, 1991) to down-to-the-southeast in the northeast compartment (Cook et al., 1981) across the mapped faulting. A change in polarity implies transfer faulting or an accommodation zone. An investigation of the structure is beyond the scope of this study; and for the time being, it simply is referred here as the Jacksonville structure.

In southern Georgia, the southwest compartment is characterized by horsts and grabens (McBride, 1991; Sartain and See, 1997; Fig. 1). In eastern Georgia, the northeast compartment consists of two basins separated by a horst block. The northern basin, identified from aeromagnetic information, is known as the Riddleville basin (Daniels et al., 1983). A borehole near its northwest margin penetrated 2522 m of Triassic sediments (Chowns, 2009). Depth-to-basement rocks estimated from magnetic data suggest a down-to-the-southeast asymmetric geometry (Daniels et al., 1983). The southern basin simply is referred