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Geochemistry and tectonic significance of the Stony Mountain gabbro, North Carolina: Implications for the Early Paleozoic evolution of Carolinia

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ABSTRACT

Carolinia comprises a collection of Neoproterozoic–Early Paleozoic magmatic arc and sedimentary terranes that were amalgamated and accreted to Laurentia in the early to middle Paleozoic. In central North Carolina, mafic rocks of the Stony Mountain gabbro intrude sub-aqueous volcanic and sedimentary rocks and submarine epiclastic sedimentary rocks of the Albemarle Group. The age of the Stony Mountain gabbro is constrained to the Early Cambrian–Middle Ordovician. Field relations indicate that the gabbro represents the final phase of magmatism following the eruption and deposition of the Neoproterozoic–earliest Cambrian Albemarle Group, yet the gabbro pre-dates regional metamorphism and tectonism related to the Late Ordovician accretion of Carolinia to Laurentia.

The Stony Mountain gabbro has a sub-alkaline basaltic composition, variable TiO_2, MgO and Ni/Cr values. The rocks have a geochemical signature typical of island-arcs; the degree of LREE enrichment, prominent negative Nb anomalies and Nb/Th ratios are all features of low-K to medium-K tholeiitic basalts in modern island-arc, subduction-related lavas.

Isotope data are dominated by juvenile compositions that are consistent with derivation from lithospheric and asthenospheric sources during decompression melting of the mantle. The Stony Mountain gabbro records subduction zone magmatism in a rifted island arc setting and can be modeled as the product of ~10–15% hydrous partial melting of variable mixtures of MORB- and OIB-like mantle sources overprinted by a minor subducted-slab derived hydrous fluid component. By analogy with modern settings the rocks of the Stony Mountain gabbro are comparable to MORB-like to OIB-type enriched rocks from the Lau Island and Sumisu Rift and are interpreted to have formed within an evolving Early Paleozoic island arc–back arc rift–basin system. The presence of an Early Cambrian arc–back arc rift system in Carolinia is broadly coeval with arc–back arc volcanism in other peri-Gondwanan blocks of the Appalachians and may be related to the Early Paleozoic opening of the Rheic Ocean.

1. Introduction

Carolinia comprises several late Neoproterozoic–Early Cambrian composite arc magmatic and sedimentary sequences that record a long and complex paleotectonic history (Fig. 1). Faunal, isotopic, paleomagnetic and detrital mineral data (Hibbard et al., 2002; Ingle et al., 2003 and references therein) indicate that Carolinia formed during the late Neoproterozoic along the margin of west Gondwana; however, several fundamental aspects of its Early Paleozoic tectonic evolution are poorly known. Although paleomagnetic data and regional, foliation-forming tectonothermal events constrain the accretion of Carolinia to eastern Laurentia during the Late Ordovician–Early Silurian (Hibbard, 2000), the timing and nature of separation of Carolinia from Gondwana related to opening of the Rheic Ocean (e.g. Nance et al., 2010), has hitherto remained elusive.

Neoproterozoic–Early Paleozoic felsic volcanic rocks of the Albemarle sequence are widespread throughout Carolinia in North Carolina and exhibit strong evidence for formation in a subduction zone setting with the possible incorporation of evolved continental material (e.g. Ingle et al., 2003). Mafic plutonic rocks of the Stony Mountain gabbro occur throughout the Albemarle sequence, but there is a paucity of geochemical and isotopic data for these intrusive rocks that can be used to constrain their petrogenetic history and paleotectonic setting of formation. As such the geochemical, isotopic, petrological and tectonic relationships between intrusive and extrusive phases of the Albemarle sequence remained unknown.

In an effort to address these unresolved questions, we initiated a lithogeochemical and isotopic study of the Stony Mountain gabbro and present new data that document the youngest known arc-related magmatism in Carolinia. The combined elemental and isotopic datasets presented herein aims to: (i) document the geochemical signatures of mafic plutonic rocks of the Stony Mountain gabbro;

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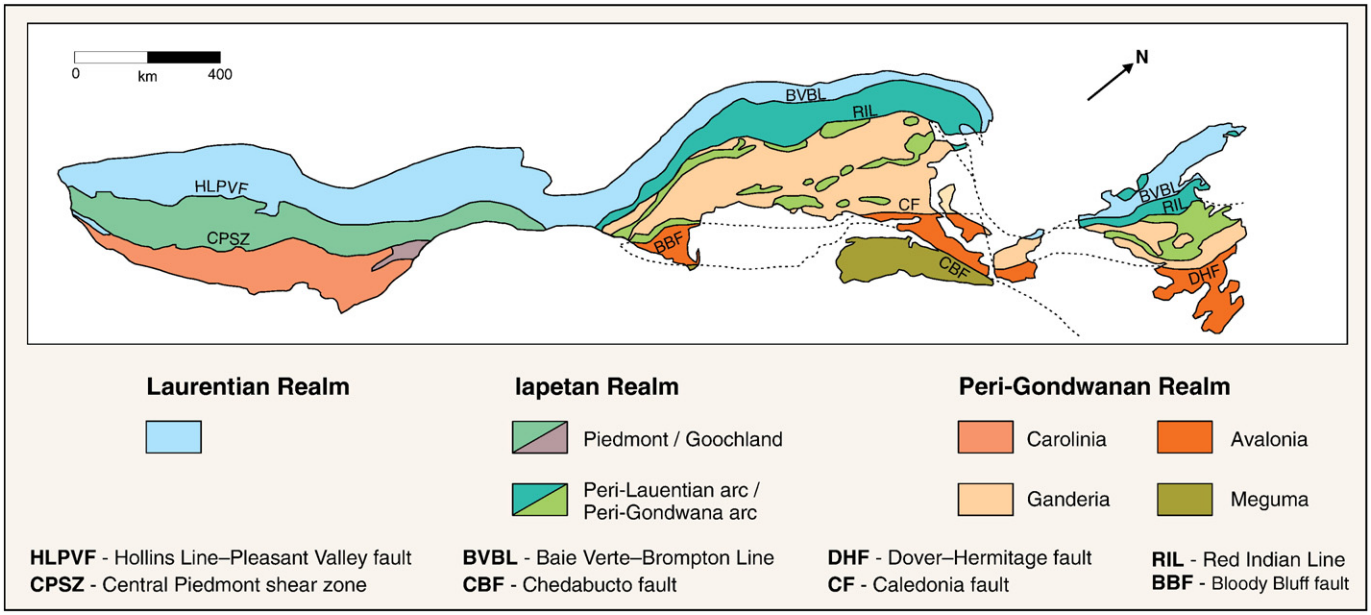

Fig. 1. Simplified geological map of the Appalachian orogen with the distribution of the tectonostratigraphic zones and major tectonic elements discussed in text (modified after Hibbard et al., 2007).

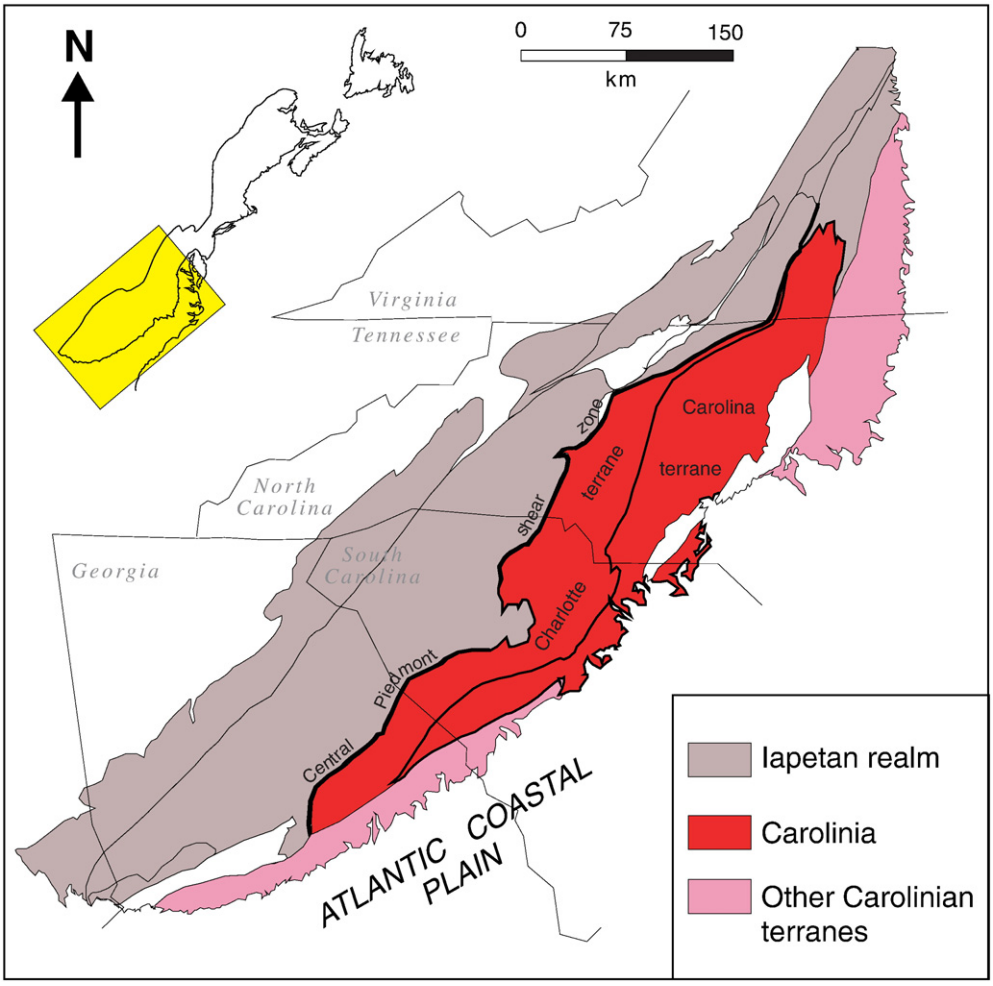

Fig. 2. Major tectonic elements of the southern Appalachians and Carolinia (modified after Hibbard et al., 2007).