PROVENANCE OF SEDIMENTS IN THE WADESBORO TRIASSIC SUB-BASIN: USING MAGNETIC MINERAL SEPARATION TO INVESTIGATE CHANGES IN SEDIMENT PROVENANCE DURING BASIN EVOLUTION

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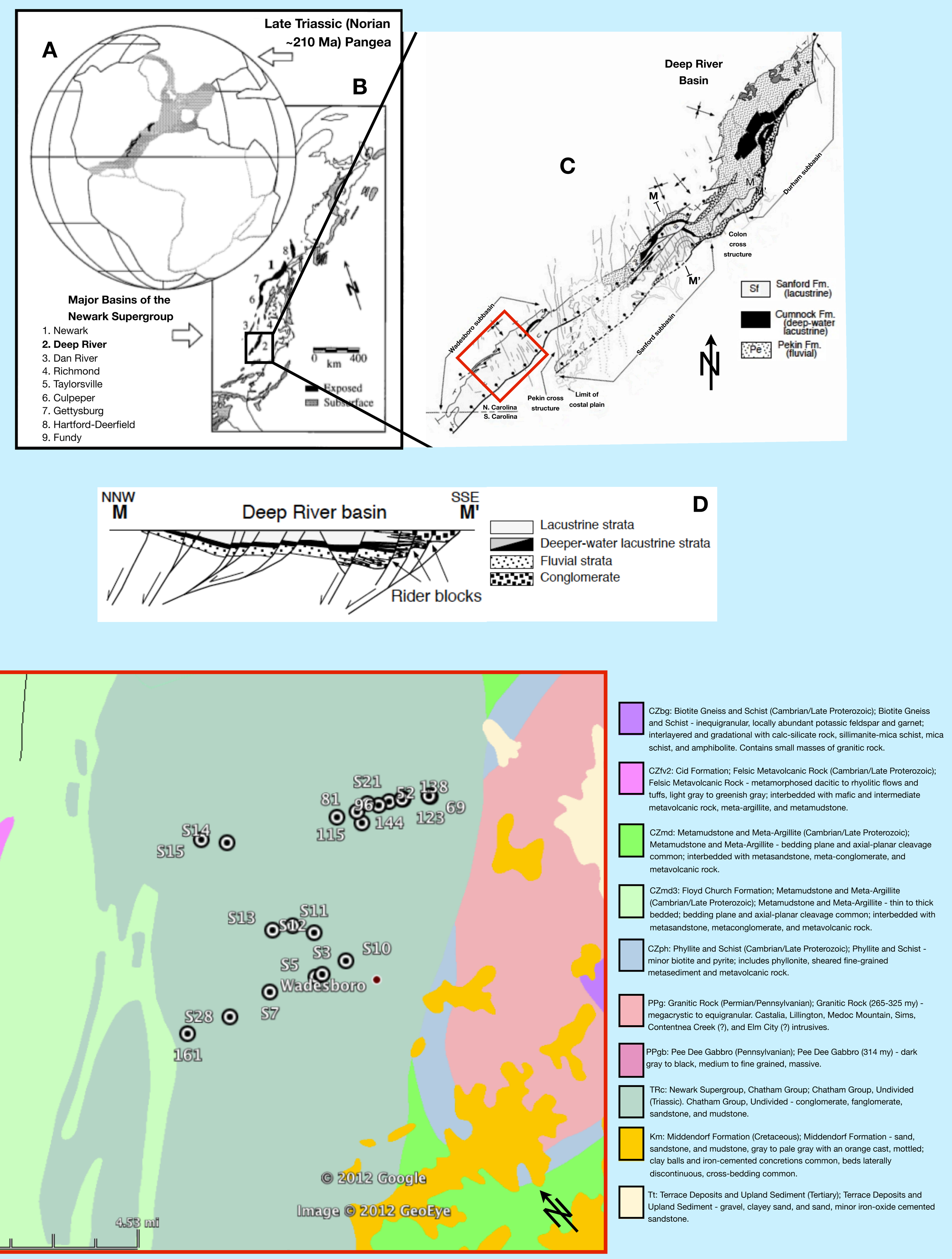
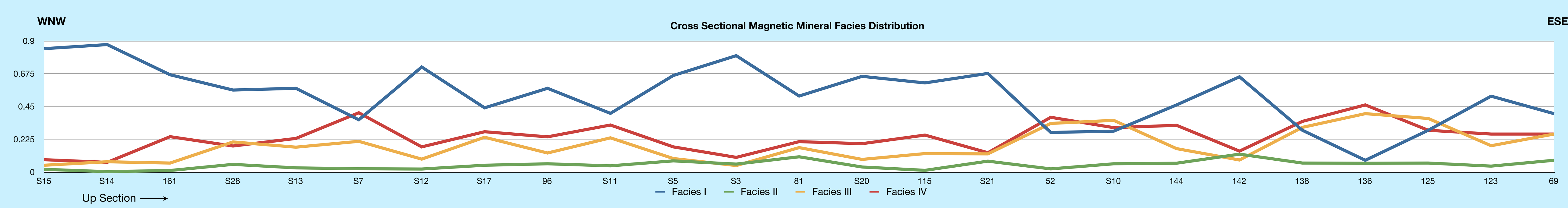
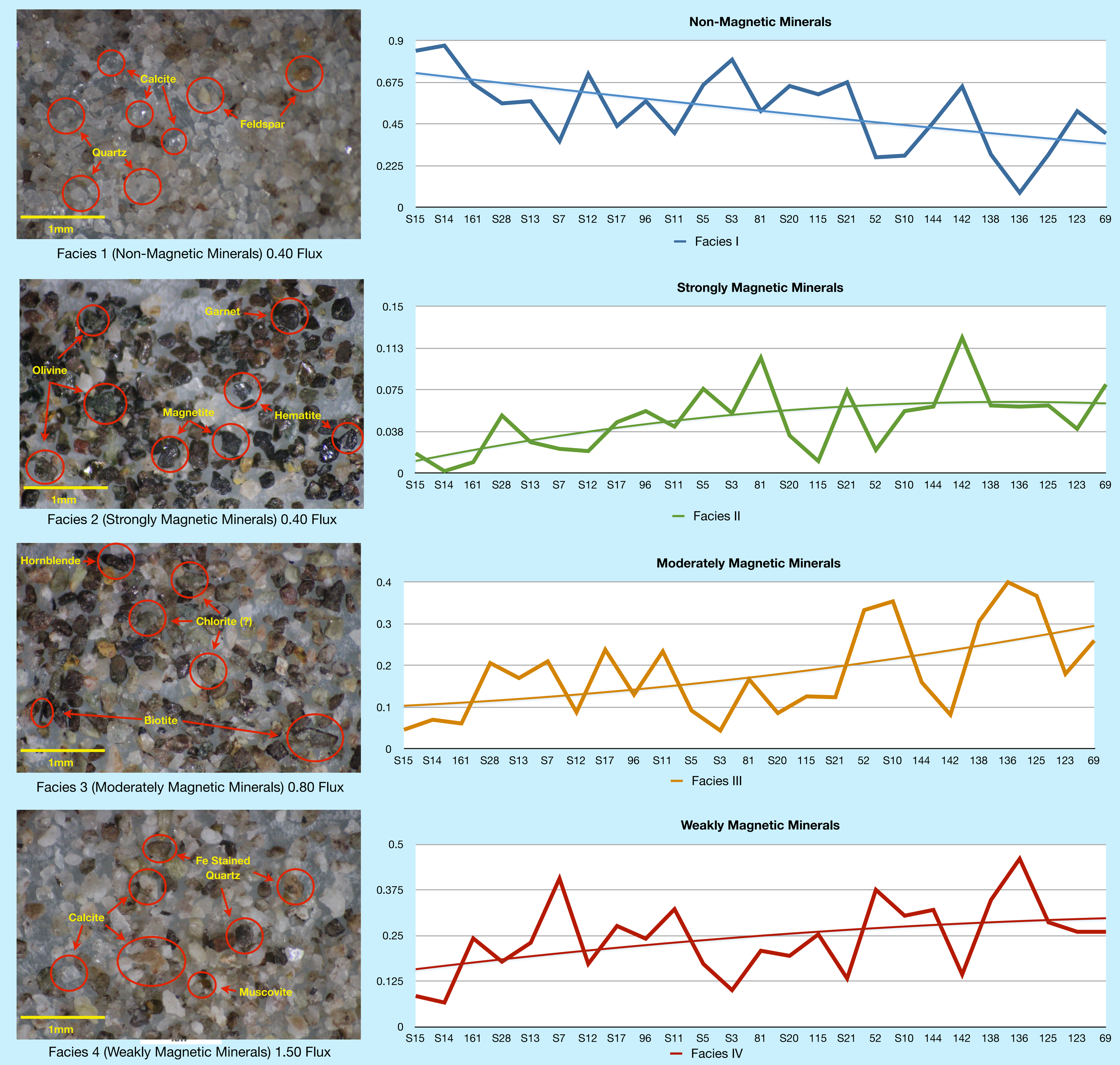
Abstract

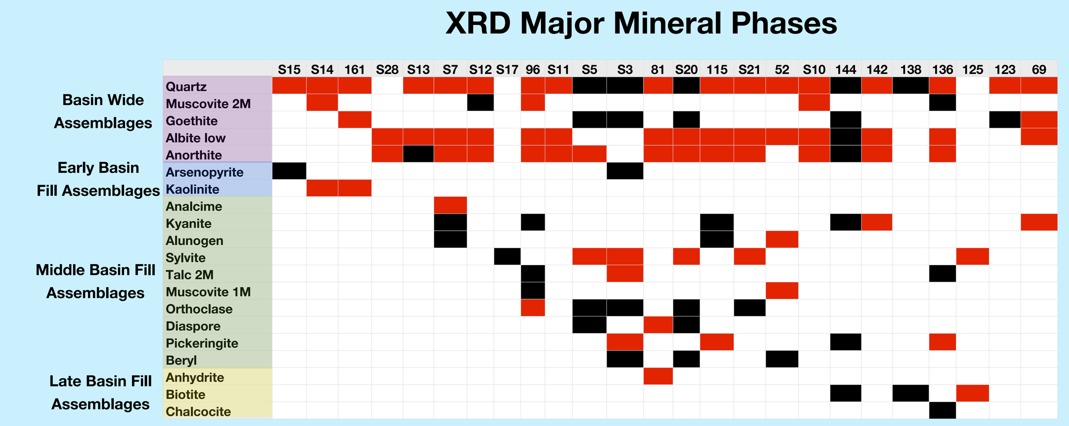
The Wadesboro sub-basin, which together with the Sanford and Durham sub-basins comprise the Deep River Basin, is a clastic sedimentary half-graben basin that formed during late Triassic rifting of Pangea. During early stages of basin growth, sediment was likely derived only from the adjacent basin margins and deposited in alluvial fans. As the Wadesboro sub-basin continued to grow both in volume and axial extent it may have linked with the Sanford sub-basin to the northeast (Schlische 1993). This linkage may have caused the Wadesboro sub-basin to transition from a closed to open basin with an axial fluvial system transporting sediments along the length of the combined basins (Gore 1988). The combined sediment load likely was derived from a wider range of source rocks than supplied the alluvial fans during the early stages of filling the Wadesboro sub-basin when it was a closed basin. Magnetic mineral analysis using a Frantz magnetic barrier separator has been used to test the linkage hypothesis. This method classifies mineral assemblages on the basis of their magnetic properties. In this study we examined separates of clastic sediments that range from 125 μm to 250 μm in diameter (Rosenblum 1958). Fine-grained sandstones were sampled from across the basin to provide a representative cross section of the stratigraphy exposed at the surface. Several magnetic mineral assemblage facies were identified and the fluctuations in the abundance of those facies are interpreted as changes in sediment provenance during basin filling, consistent with a transition from closed to open basin conditions as the Wadesboro sub-basin linked with the Sanford sub-basin.

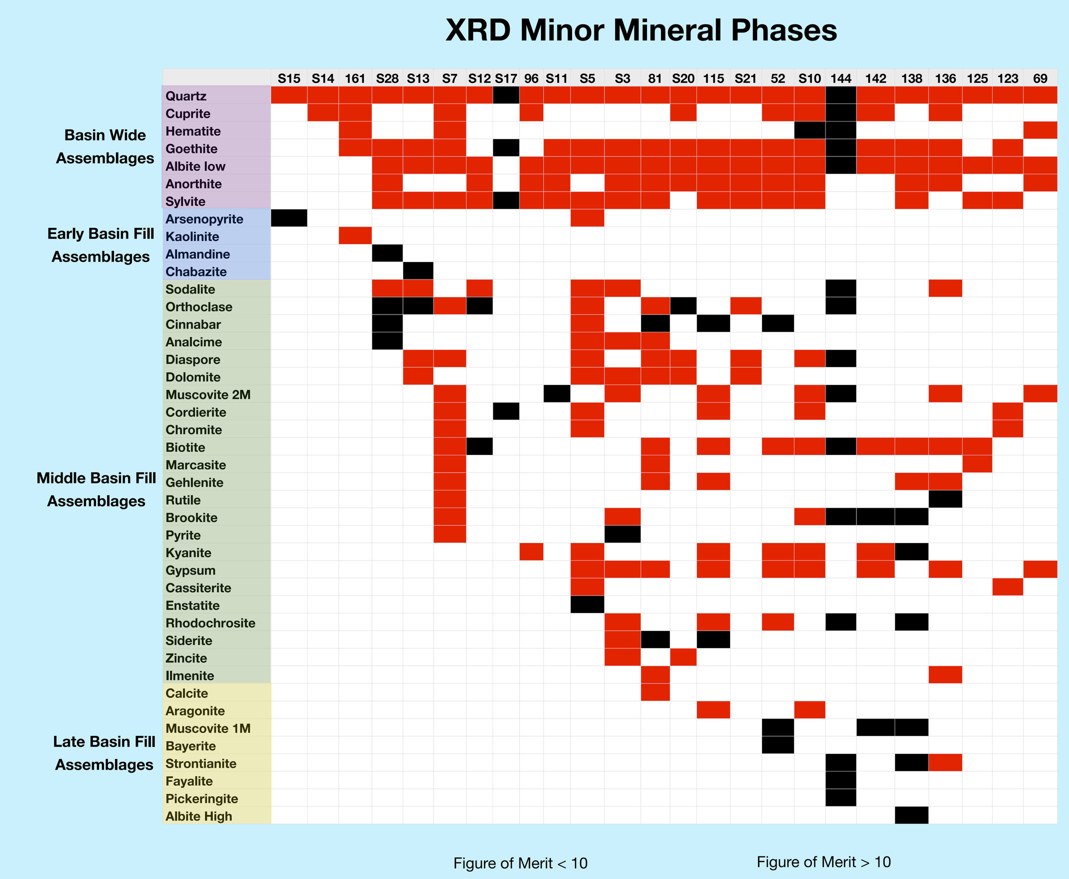


Location of the Wadesboro subbasin, Deep Rive basin, in the eastern Piedmont of North Carolina. **A**) Reconstruction of Pangea for the middle Norian showing the zone of early Mesozoic rifting (shaded) and the preserved basins of the Newark Supergroup (black). **B**) Early to Middle Mesozoic rift basins of eastern North America (From Olsen et al., 1996). **C**) Geologic map of the Deep River basin with cross section of the Sanford subbasin labled M-M' and geologic map of the central Wadesboro subbasin (see **E**) highlighted in red (Modified from Schlische, 1993). **D**) Cross section of Sanford subbasin (From Schliche, 1993). **E**) Geologic map of central Wadesboro subbasin and surrounding with locations of fine grained sandstones (Image Google Earth 2012).





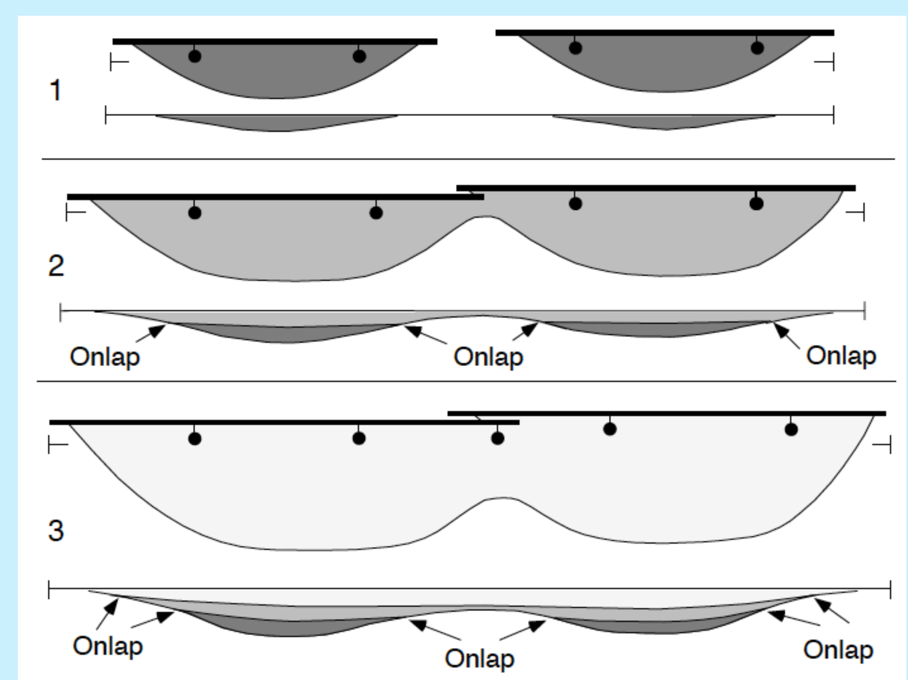




Methods

25 fine grained sandstones were selected from across the basin (perpendicular to strike) to investigate changes in magnetic mineral assemblages up section. The indurated fine sandstone sedimentary rocks were disaggregated with a rock crusher, mortar and pestle, and sieved to isolate discrete grains ranging in size from 125-250 μm. This fine sand fraction was separated using a Frantz Magnetic Barrier Separator oriented with a side slope of 20° and a forward tilt of 25° to identify 4 ferromagnetic mineral facies identified by Rosenblum (1958). Facies 1 (>1.50 amp flux): Non-magnetic minerals including quartz, feldspar, and calcite; Facies 2 (0.40 amp flux): strongly magnetic minerals including magnetite, garnet, ilmenite, hematite, and olivine; Facies 3 (0.80 amp flux): moderately magnetic minerals including biotite, hornblende, augite, and chlorite; and Facies 4 (1.50 amp flux): weakly magnetic minerals including muscovite, orthopyroxene, and tourmaline (Rosenblum 1958). Petrographic analysis of the separated mineral facies generally agreed with the ferromagnetic mineral facies identified by Rosenblum (1958). Whole rock samples of the 25 fine grained sandstone were powdered for X-ray Diffraction analysis using a Rigaku MiniFlex XRD instrument and processed using Materials Data Inc. Jade 6.5 software to identify Major and Minor Mineral Phases. The ferromagnetic mineral facies for each sample were plotted by wt.% along with Major and Minor Phases from XRD analysis and were arranged WNW-ESE to examine changes in these facies up section.

Model for the Linkage of Isolated Basins



Model for the growth of a basin complex containing two border fault segments proposed by Schlische (1993) showing map view and cross section of three stages of basin development. 1) Early isolated basins 2) merge as the fault tips propagate along strike and 3) synrift sediments are deposited across basin.

Discussion

Frantz Magnetic Barrier Separation analysis identifies a general decrease of non-magnetic minerals facies and an increase of ferromagnetic mineral facies contained in fine grained sandstones of the Wadesboro sub-basin moving up section. X-ray diffraction analysis also identifies distinct mineral facies present basin wide and within early, middle, and late basin fill. Two hypotheses are proposed to interpret these results: 1) a change in paleoclimate and diagenetic processes, and 2) evolving source area by linkage with the Sanford sub-basin.

Paleoclimate and Diagenetic Effects

The oldest sandstones in the Wadesboro sub-basin generally have fewer magnetic minerals and/or inclusions of ferromagnetics than younger strata exposed in the sub-basin. The effects of diagenesis have been studied for several decades and a general finding is the dissolution of ferruginous minerals over time as hydrologic and biochemical transformations and translocations, i.e. Fe minerals to pyrite (Berner, 1984). Stable clays, e.g. kaolinite, form during early and late stages of diagenesis primarily by the leeching of feldspars and white micas in sandstone sequences. XRD analysis of fine grained sandstones in the lowest sections of the Wadesboro subbasin identified major and minor phases of kaolinite, pyrite, aresnopyrite, hematite, and siderite and are interpreted as secondary minerals that formed by diageneitic processes in wetter, anoxic conditions during burial. These mineral phases are absent moving up section and, along with the presence of easily weathered feldspars and evaporites (e.g. gypsum and sylvite) up section, reflect a decrease in diagenetic effects that may be a result of an arid or sub-arid event.

Linkage with Sanford subbasin

During basin growth, once isolated basins may join together as their fault displacement increases, faults lengthen along strike, and connect. Similar processes have been interpreted from basins in the East African Rift (Burgess et al. 1988). Furthermore, paleoflow directions consistent with longitudinal streams suggest linkage between the northern members (Durham and Sanford subbasins) of the Deep River Basin (Gore, 1989). Deposition in this environment requires older synrift sediments deposited separately in the three subbasins of the Deep River Basin, while younger synrift sediments are be deposited throughout the basin. If the Wadesboro and Sanford subbasins linked during synrift deposition it is likely a change in the mineralogy of the younger units will be present. A likely source area for the Wadesboro subbasin is the Lilesville pluton, a mega-crystic granitoid intrusion with a thin phyllitic contact aureole, that lies unconformably on the western border fault system. The border fault system of the Sanford subbasin is dominated by biotite gneiss and other amphibolite facies metamorphics. The absence of the amphibolite facies mineral kyanite in the oldest units of the Wadesboro and its presence in younger, synrift sedimentary rocks may be evidence of this linkage.

Conclusions

It is likely that both diagenesis and an evolving source area have contributed to the changing mineralogical landscape of the Wadesboro subbasin through time. Future quantitative provenance analysis would be greatly benefited from trace element and geochemical analysis described in Weltje and Eynatten (2004).

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