Geologic sources of arsenic in groundwater: Crustal recycling of arsenic in convergent margins?

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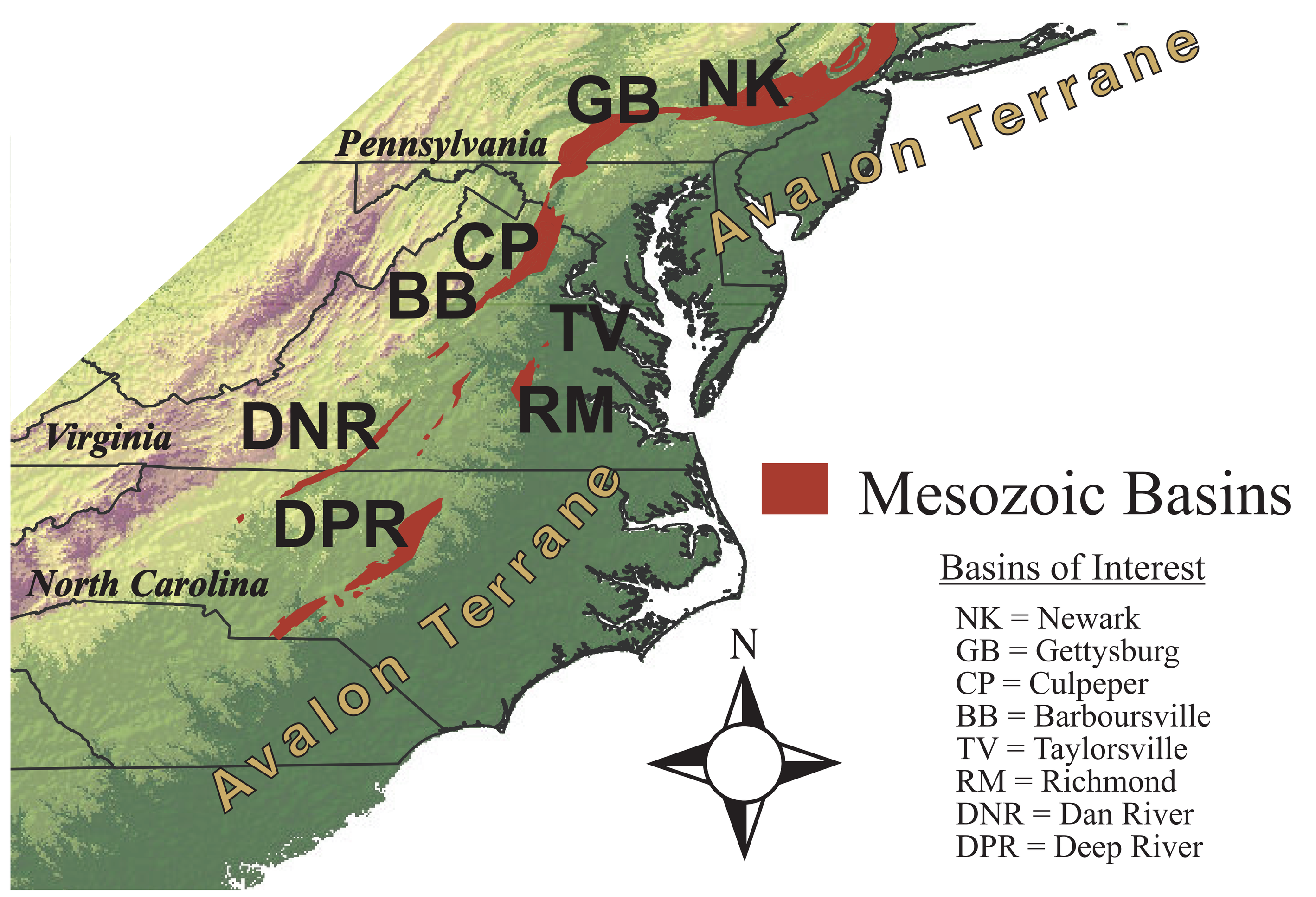
INTRODUCTION

Long term exposure to arsenic in drinking water has caused health problems across the globe. Exposure of humans to arsenic through drinking water may cause health impairment ranging from stomach pain and circulatory problems to skin, lung, bladder, and kidney cancer (WHO, 2001; EPA, 2010). Arsenic can enter groundwater from anthropogenic sources, but in many areas of the world, arsenic in groundwater is derived from naturally occurring geologic sources (Welch et al., 2000; Smedley and Kinniburgh, 2002). Weathering and desorption of arsenic from geologic formations into groundwater can cause water quality degradation, which is well recognized now in the United States, Argentina, Chile, New Zealand, Taiwan, India, Bangladesh, and other countries (Smedley and Kinniburgh, 2002). While the geochemical behavior of arsenic in groundwater systems is well studied, the interplay of tectonic, geologic, geomorphic, and geochemical processes that result in elevated arsenic in drinking water are not well understood.

RESEARCH LOCATION



Mesozoic Basins (shown in Red) of the eastern United States provide ideal locations to research the arsenic cycle. Samples of rocks, soils, and water will be taken in and around these basins to assess the parameters that allow arsenic to exist in groundwater.

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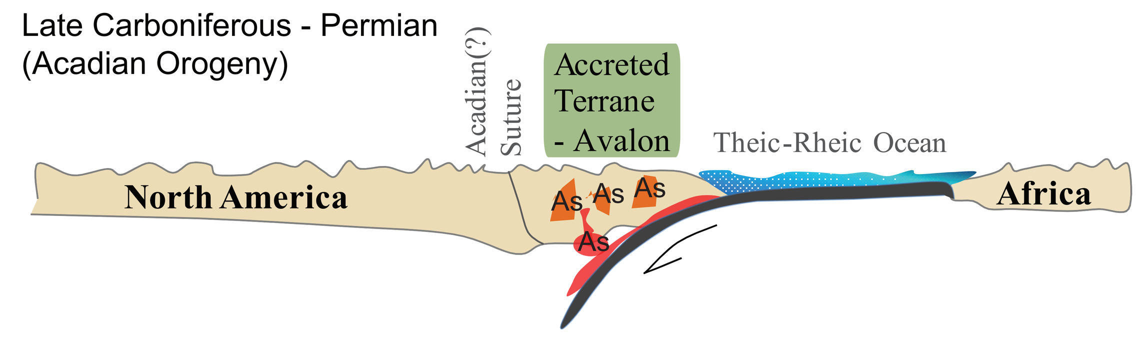
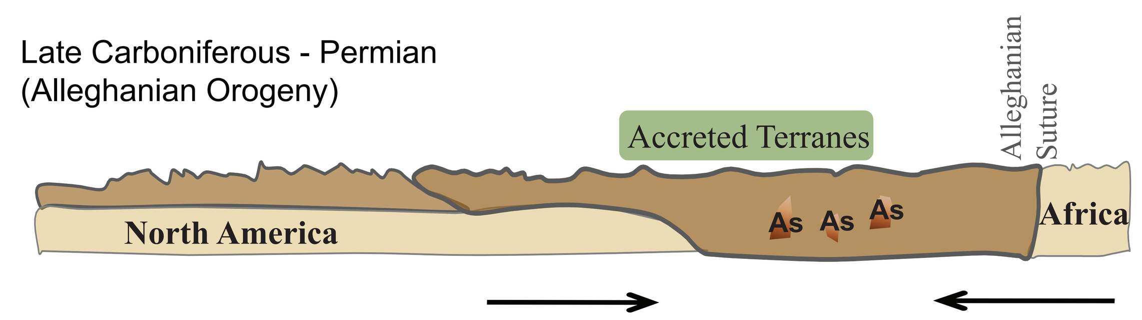
THE ARSENIC CYCLE: CONVERGENT MARGINS TO DRINKING WATER



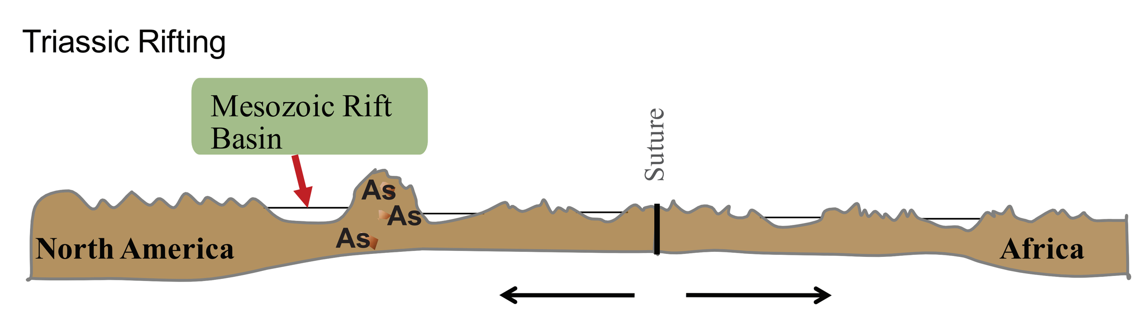
1. Hydrothermal Processes

At convergent margins, oceanic crust is subducted beneath the continent. Along the subducting slab, a hydrothermal melt is formed where arsenic can be found.



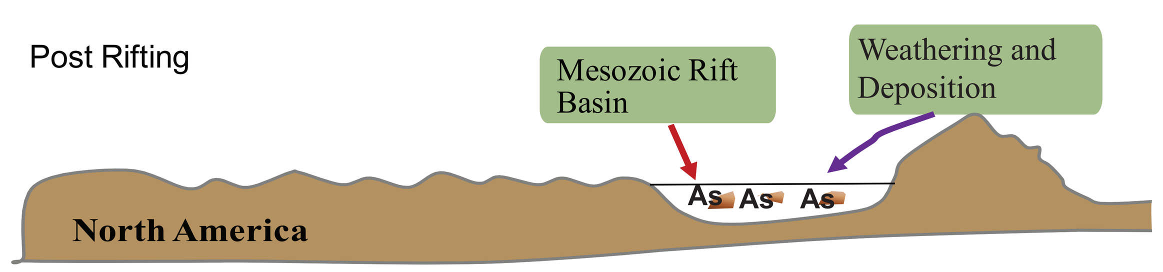
2. Mineral Crystalization and terrane accretion

As the convergence continues, island arcs and portions of Africa are attached to North America. These are called accreted terranes. Meanwhile, the arsenic in the melt from process 1 crystallizes heterogenously in the terrane.



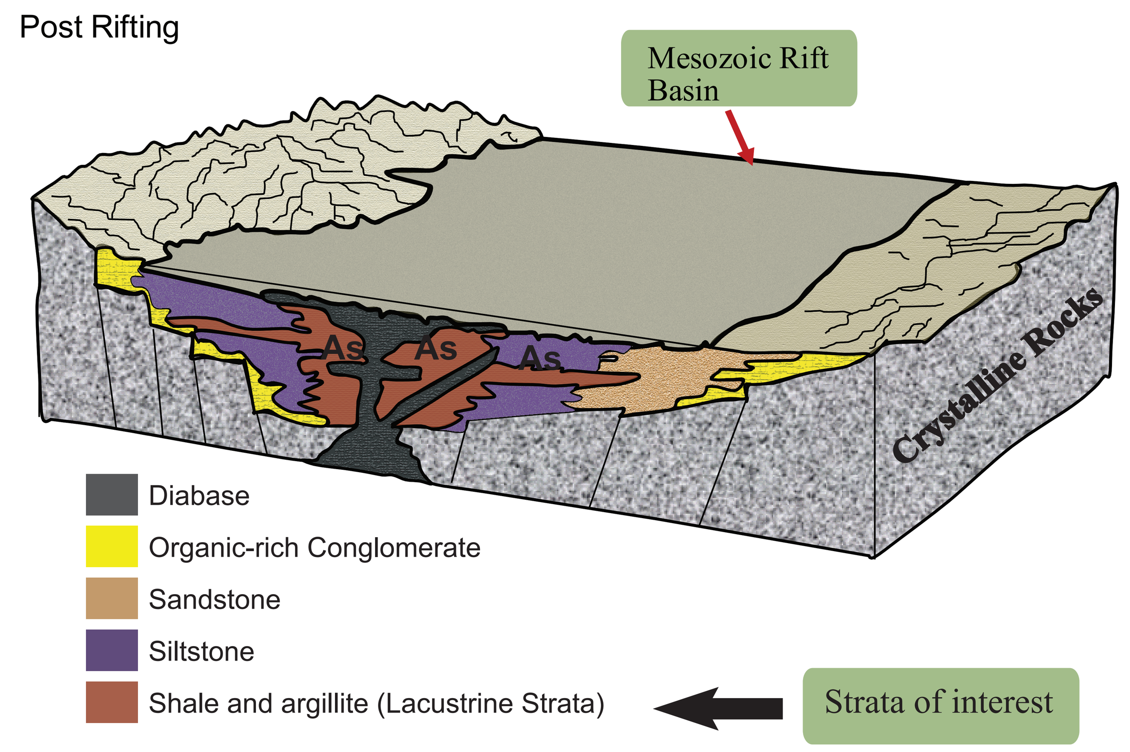
3. Creation of accumulation space

During the Triassic, the Atlantic Ocean began to open at a divergent boundary. This created basins in North America and Africa. These basins allow an area for weathered and eroded sediment to accumulate.



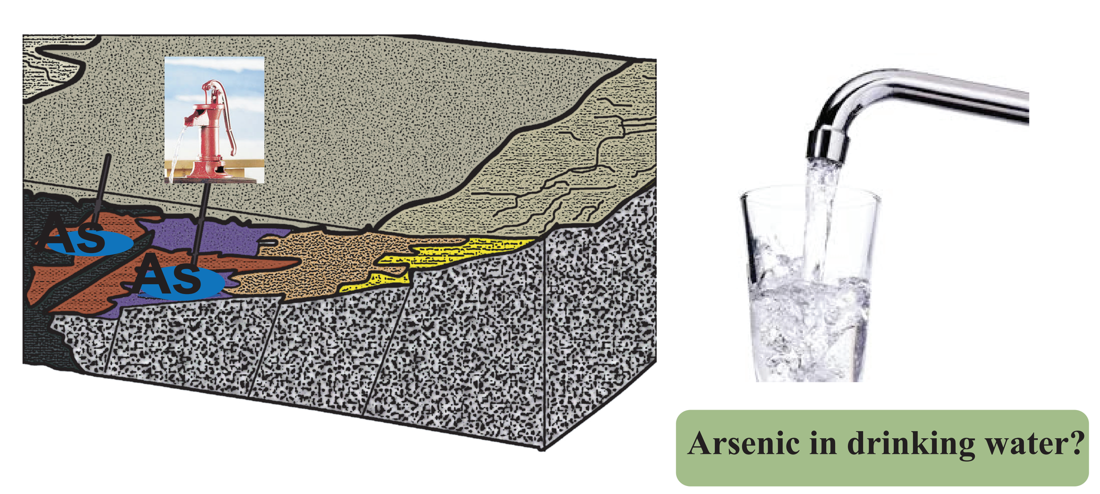
4. Weathering and Deposition

Rocks weathered at topographic highs are deposited into lakes and alluvial fans in the Mesozoic Rift Basin



5. Sediment Burial

After sediments are deposited, they are buried and compacted. Igneous intrusions such as diabase are found throughout the lacustrine and alluvial sediments. Lacustrine strata such as shale and argillite will be studied in detail.



6. Arsenic dissolution and mobility in water

Fractured bedrock provides space for groundwater storage. Depending upon goechemical conditions, arsenic can undergo dissolution from bedrock and enter the groundwater.

Modified from Hatcher 1987, Hatcher 1989, and Trapp and Horn 1997

PURPOSE

Investigating the relationship between tectonic processes and geochemistry will transform the understanding of natural occurrences of arsenic globally in rocks and water and enable the creation of a predictive model.

FUNDAMENTAL QUESTIONS

1. Which lithologies in the southern Appalachian Mountains contain high concentrations of arsenic?

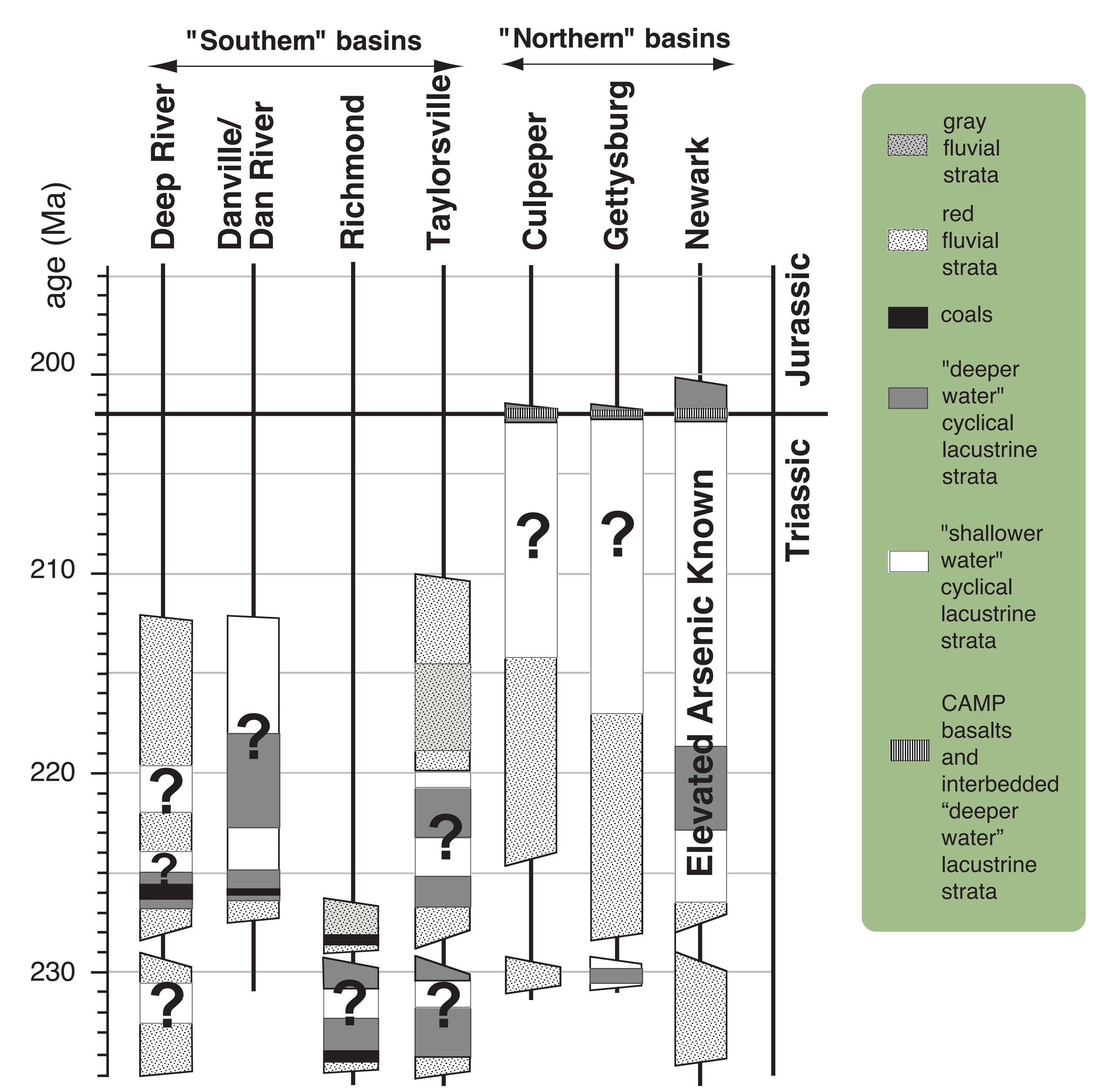
2. Why do those lithologies contain higher arsenic than others? Is there a common process or them that links all the high arsenic lithologies?

3. Which tectonic event or events appears to cause these high arsenic lithologies?

4. What variables could be used in a predictive geologic model to show the occurrence of arsenic in the lithologies, soils, and waters?

5. Are the modern hydrologic and geochemical controls of desorption of arsenic from rocks and soils consistent with those observed at other sites?

LITHOLOGIES OF INTEREST



Stratigraphic columns depict the lithologies in seven Mesozoic rift basins. Lacustrine deposits are shown as solid white and gray. Question marks (?) show strata of interest for sampling. Lacustrine deposits in the Newark basin of Pennsylvania have known areas of elevated arsenic. Modified from Schlische et al., 2002.