Figure 5. Sidewall along Providence Canyon, Georgia (USA). Uniformitarians assert that these sands were deposited in a mixed-energy barrier island setting cut by tidal inlets.[8] Some of the canyon sidewalls display a few sub-vertical *Ophiomorpha* traces but many more do not. This sidewall exhibits no evidence of any bioturbation where it would be expected within the hypothesized uniformitarian setting. The cross-bedding displayed in the sands indicates this was a high-energy depositional environment. While some trace makers were present in this energetic setting, they had little opportunity to bioturbate the sediments due to rapid deposition and the reworking of the sediments during the later stages of the Flood. Scale in 15-cm divisions.

A large population of filter-feeding or mobile sediment-feeding animals could easily bioturbate marine sediments within the short time frames of the global Flood of Genesis. The lack of any bioturbation should direct us to other important considerations why sediment stirring did not occur.

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Colorado Plateau sandstones derived from the Appalachians?

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Provenance studies have become rather popular lately.[1] In these studies, the types of grains or rocks within a formation are analyzed, and the original outcrop location "upcurrent" is determined. This in turn can provide the minimum transport distance, and the path of the particle is reinforced by paleocurrent indicators in the sedimentary rock. These indicators are typically abundant in sandstones and conglomerates.

Long distance spread of resistant rocks from mountains

Creationists have employed provenance studies in tracing the long distance transport of rocks to determine the paleo flow regime and transport distance. For instance, powerful currents in the northern Rockies region of the United States eroded and transported quartzite rocks both east and west: up to 1,300 km to the east and about 640 km to the west.[2–6] During transport, the power of the current can be estimated by the rounding of these extremely resistant rocks and by percussion marks that have indented many of them. A similar phenomenon has been observed in northern Arizona, where quartzite and other igneous rocks were spread a modest distance east and northeast from their source across the area of the Mogollon Rim.[7] And it is not restricted to the western United States; resistant rocks have spread up to 1,000 km east, south and west from sources in the Appalachian Mountains and a fair distance north of the Alaska Range in southern Alaska.[8,9]

The ubiquitous distribution of such gravel beds, the distance of transport from the nearest source upcurrent, the location of the source across present day mountain ranges or continental

Figure 1. Pine Creek Canyon, which intersects Zion Canyon in the distance, in Zion National Park, south central Utah, USA. Most of the vertical walls are the massive Navajo Sandstone (view west from Canyon Overlook).

divides, the number and size of clasts transported, and the deposition of gravel beds on plateaus or mountain tops strongly suggests that the water responsible for these deposits was the enormous water runoff from Noah's Flood, rather than the uniformitarian explanation of rivers. Based on modern observations, rivers do transport rocks, but do not deposit them over wide areas. Seldom do they have the current velocity to carry larger rocks long distances.

Very long-distance transport based on dating of zircons

Although empirical provenance studies are beneficial to diluvial interpretation, uniformitarian assumptions and methods call others into question. Provenance research has become quite sophisticated; some studies attempt to find the outcrop of origin by dating heavy minerals, such as zircons, and then tracing those minerals back to basement rocks of the same date. They usually obtain a variety of dates for zircons, which they assume was caused by the sediments flowing over a multitude of different "aged" environments:

> "The ages of detrital zircons in these arenites provide information for locating the source areas, for understanding the amount of mixing from multiple sources, and for determining sedimentary dispersal patterns."[10]

An interesting conclusion of such studies is the suggestion that the grains of the Navajo Sandstone on the Colorado Plateau originated from the Appalachian Mountains.[11] The Navajo Sandstone is one of the largest supposedly wind-deposited formations in the geological record and is estimated to have once covered up 400,000 km^2, the size of the state of California.[12] It reaches a thickness of 670 m in Zion National Park (figure 1) and thins eastward. Moving such a volume of sand all the way across North America would require large, powerful currents.

Similar studies based on zircon dates and isotopes have also suggested extended transport distances. For example, some of the grains in rocks found in South Australia supposedly originated in eastern North America.[13] Of course this assumes the reality of the "Rodinia" supercontinent. Similarly, grains in Tasmania are though to have originated in Nevada,[14] and zircons in rocks on Victoria Island (western Canadian Arctic) were supposedly transported over 3,000 km from the eastern United States.[15] Eastern North America appears to be a favorite origin for any number of well-traveled clasts. Even some rocks in southeast Siberia are claimed to have also originated from the Appalachians, although their relative positions on "Rodinia" are not well constrained.[16]

Sediments from much of Southwest US originated in the Appalachians

Provenance studies of sandstones other than the Navajo Sandstone on the Colorado Plateau have also concluded that some of the sand originated in the Appalachians.[17,18] Even some sandstones north of the Colorado Plateau, in southwest Wyoming and southeast Idaho, are thought to be of Appalachian origin. Paleocurrent data shows that these sands were transported from the north and northwest,[19] but finding a source for so much sand north of the plateau has proven challenging. Some geologists think the source was as far away as Canada.

The theory that the source was the Appalachians is largely based on the 950–1,250 million-year age for about half of the zircons, which suggests that they were eroded from the Grenville Province of the basement, just west of the Appalachians. If true, that would mean that these sands were transported between 1,000 and 2,000 km to a location just north of the Colorado Plateau.

Much of the Late Precambrian to Cambrian sediments in the western United States and northwest Mexico are also believed to have originated in or near the Appalachians.[20] If true, those mountains would have been higher than the Himalayas to have supplied such a volume of sediment.

What do these provenance studies mean?

The zircon-dating provenance studies indicate very long distance transport. Although uniformitarian

scientists invoke rivers to carry these grains, few rivers in the world are 2,000 km long. Even if they were, could those rivers have really moved such vast quantities of sediment that distance? Although modern rivers carry heavy sediment loads, they do not move sand grains over such distances in such quantities. This seems to be another example of the breakdown of uniformitarianism.

Figure 2. Multiple bounding surfaces, represented by the horizontal lines, that truncate cross-beds in the Navajo Sandstone, Zion National Park, Utah.

Nor can creationists blithely accept the zircon dates as a firm basis for deducing the original outcrops. A map of basement rock dates across North America shows trends that are interpreted as discrete tectonic terranes, but we are left with the problem that has plagued radiometric dating for decades. Since "bad" dates are usually not reported, we have no way of assessing the reality of even relative trends shown by these dates. And of course since basement rocks are classified stratigraphically by their radiometric dates,[21] an empirical basis for assessing these trends remains uncertain.

Even if the studies showing these vast transport distances are right, they would seem to provide additional evidence for the Flood, which could easily account for large-scale, high-velocity currents. Flood currents are a better explanation than rivers, especially for areally widespread deposits of large clasts that have been carried long distances.

In addition, these Flood currents support the other evidence that suggests that the "eolian" sands of the southwestern United States were actually deposited by aqueous means. For example, the sandstones have flat upper and lower contacts, sometimes grade horizontally or vertically into marine sedimentary rocks, and contain ubiquitous bounding or truncation surfaces (a type of planation surface) that shears off cross-beds (figure 2). Uniformitarians also face other problems, such as the need to maintain consistent paleocurrent directions (south onto the Colorado Plateau) for 100 million years. That seems to be a long lifespan for an average wind system!

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