Rapid Canyon Formation: The Black Canyon of the Gunnison River, Colorado

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Abstract

How the Black Canyon of the Gunnison may have developed within a young-earth Flood model is discussed. Subaqueous currents during the Flood eroded the sediments on the Gunnison uplift. Later, retreating Floodwater continued to carve a canyon into the Precambrian basement. Vast regional volcanic activity introduced abrasive particulate matter into the flowing water aiding the erosional processes.

Introduction

Acceptance of a recent Creation and Flood model of earth history indicates that many natural events, such as canyon formation, would have occurred rapidly. This necessitates rapid erosion, a topic often discussed in the Quarterly.

Many monographs and articles have appeared in creationist literature in the last 25 years on the formation of various canyons. For instance, the Grand Canyon of the Colorado River, Pine Creek Gorge in Pennsylvania, Bangs Canyon in Colorado, gorge formation during the 1993 Midwest floods, Providence and Cloudland Canyons in Georgia, Santa Elena Canyon in Big Bend National Park (Texas), Kanab Canyon in Arizona and Utah and Little River Canyon in Alabama have been investigated by creationists. A bibliography containing selected creationist works on rapid erosion and canyon formation is contained in Appendix I.

This treatise on the Black Canyon of the Gunnison in Colorado is another introductory study reflecting the continuing field work of the Society on these topics, which are important aspects of Flood geology. A glossary of geologic terms used in this paper is provided after the acknowledgments.

Impressions of the Canyon

In 1904 a Reclamation Service engineer, I.W. McConnell, had this to say about the Black Canyon,

> . . . the Gunnison flows through a profound canyon, a chasm with almost vertical walls varying in depth from 1,000 feet to nearly 3,000 feet. The width is not great, being in some places only 1,700 feet, so that one standing on the rim has spread before him the great rent in the earth with its frightful crags and its wonderful spires, all so near that its grotesque details and its awful sublimity make a direct appeal to the eye (pp. 162–163).

Chronic (1980, p. 281) claimed that: "Within the 12-mile stretch set aside as a National Monument, the Black Canyon is narrower and deeper than any other canyon in the country..."

Hansen (1987a, p. 9) observed that:

> After the first emotional impact of the canyon, the same questions come to the minds of most reflective viewers, and in about the following order: How deep is the Black Canyon, how wide, how does it compare with other canyons, what are the rocks, how did it form, and how long did it take? Several western canyons exceed the Black Canyon in overall size. Some are longer, some are deeper, some are narrower, and a few have walls as steep. But no other North American canyon combines the depth, narrowness, sheerness, and somber countenance of the Black Canyon.

Obviously the canyon within the National Monument makes a vivid impression on those who view it. You marvel at the combined depth and narrowness of the feature such that often it is easy to forget the surrounding geography that makes the entire region so beautiful and awe inspiring.

Canyon Observations

Hansen (1981, p. 145) divided the Black Canyon physiographically and geologically into three distinct sections

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Received 10 March 1998; Revised 28 September 1998

(upper, middle, and lower), "...which merge gradually with one another but have marked differences." The upper section "...extends from Blue Mesa dam downstream to the mouth of Cimmeron Creek..." [Figure 1] (Hansen, 1987a, p. 12). The walls of the canyon are not as steep and the depth is not as great in this section compared to the middle portion. Remnants of volcanic rocks overlie the crystalline rocks of the inner gorge of the upper section (Figures 2a and 2b). The middle section, which includes the Black Canyon of the Gunnison National Monument, is where "...the inner gorge attains its greatest depth and grandest development..." (Hansen, 1981, p. 146). Between Pulpit Rock and Painted Wall (Figure 3), the depth of the canyon is 1.5 times its width. This middle section (Figures 4a and 4b) extends from Cimmeron Creek downstream to Chukar Canyon (Figure 1). The lower section goes from Chukar Canyon to the confluence of the North Fork with the Gunnison River (Figure 1). Very few people see the lower section, and it is not as imposing as the upper and middle portions. Outcrops of sedimentary

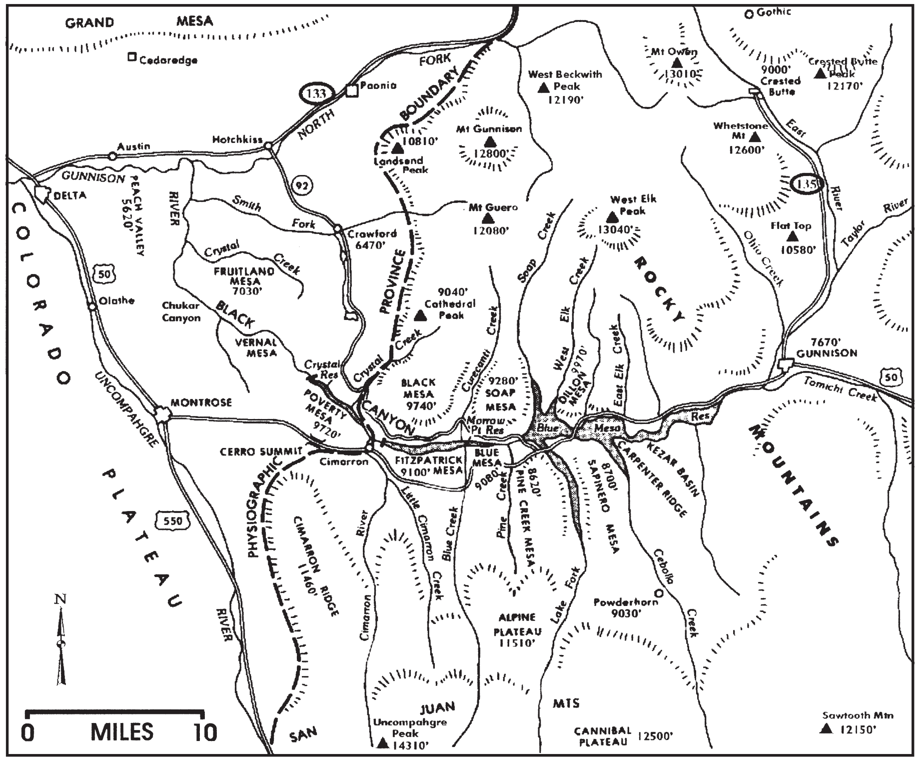

Figure 1. The Black Canyon of the Gunnison region of western Colorado. The canyon commences at the Blue Mesa Reservoir Dam and the mouth of the canyon is at the confluence of the North Fork with the Gunnison River. The approximate maximum altitudes of some of the geographic features are given in feet. Most major cities, towns and highways are included. The canyon lies in two difference physiographic provinces (see dashed line), the Colorado Plateau to the west and the Southern Rocky Mountains to the east (after Hansen, 1981, p. 145; USGS, 1977).

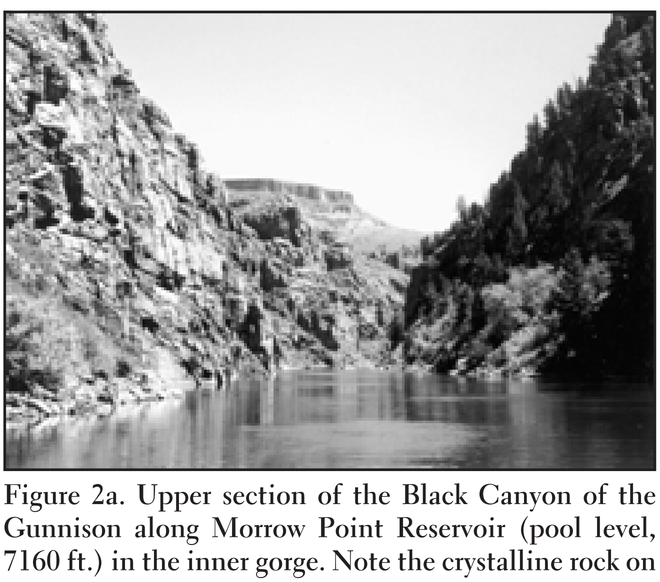

Figure 2a. Upper section of the Black Canyon of the Gunnison along Morrow Point Reservoir (pool level, 7160 ft.) in the inner gorge. Note the crystalline rock on the canyon wall to the left. Douglas fir trees can be seen on the opposite wall (right). The outer wall of the canyon at Soap Mesa in the distance is capped by Blue Mesa Tuff. See Figure 2b for a closer view of this formation.

Figure 2b. View of Blue Mesa Tuff on Soap Mesa, which overlies a deposit of cobbles and volcanic debris on the outer rim of the upper section of the Black Canyon. (See Olson, Hedlund and Hansen, 1968.)

Figure 3. A portion of the Black Canyon of the Gunnison River National Monument showing the various overlooks and viewpoints in the Monument where some of the specific locations mentioned in this article can be seen (from National Park Service, 1995).

Mesozoic rocks can be seen on the walls of the canyon in the lower region (Figure 5). Common to all three sections, except at the mouth of the canyon, is the inner gorge of crystalline rock (Hansen, 1981, pp. 145-146). See Table I for the stratigraphy of the Black Canyon region.

"The dominant structural feature of the region is the Gunnison uplift..." [Figure 6] (Hansen, 1981, p. 149)—an upraised composite tilted fault block. The entire canyon region apparently was once covered with tertiary volcanics (Figure 7). Volcanic activity occurred in the West Elk Mountains located to the north as well as the San Juan Mountains to the south. The Black Canyon has

Table I. Rock Formations of the Black Canyon Region*

Formation	Approximate Thickness (feet)
Alluvium, talus	~100
Hinsdale Formation	<150
Carpenter Ridge Tuff	<225
Fish Canyon Tuff	<300
Sapinero Mesa Tuff	<220
Dillion Mesa Tuff	<80
Blue Mesa Tuff	<250
West Elk Breccia	~1100
Mancos Shale	~2200
Dakota Sandstone	<100
Burro Canyon Formation	<120
Morrison Formation	
Brushy Basin Member	<360
Salt Wash Member	~150
Wanakah Formation	<225
Junction Creek Sandstone Member	<90
Pony Express Limestone Member	<7
Entrada Sandstone	<100
Diabase	<300
Pegmatite	<100's
Curecanti Quartz Monzonite	—
Vernal Mesa Quartz Monzonite	—
Pitts Meadow Granodiorite	—
Metamorphic rocks	>1000's

*After Hansen, 1981, p. 147; 1987a, p. 23; not all of the formations are found in every place in the region.

been incised into a synclinal feature (Hansen, 1981, p. 152). The walls of the canyon have a V-shaped profile which is indicative of water being the agent of formation as opposed to a fault feature. Even in the imposing middle section, the V-shaped walls are evident (Figure 8).

Uniformitarian Speculations on the Development of the Black Canyon

Wallace Hansen has done the majority of the modern geologic work on the erosion of the Black Canyon. Thus I will summarize his geologic model for the formation of the canyon using the uniformitarian time scale. Hansen (1987b, p. 321) stated that:

> ... this world-class gorge is an excellent example of superimposed drainage in a youthful river valley deepened by rejuvenation,... Although the drainage pattern was set by superposition... the canyon itself is a product of continued downcutting through the crystalline basement, in response to a gradual rise of the Gunnison uplift...

Figure 4a. Pulpit Rock overlook in the Black Canyon of the Gunnison National Monument (middle section of canyon), view looking upstream. Depth of inner gorge is 1770 ft. Note talus on the slopes. See Figure 3 to locate this overlook.

Figure 4b. Painted Wall in the Black Canyon of the Gunnison National Monument (middle section of canyon). The wall consists of metasedimentary gneiss interlaced with pegmatite dikes. Depth of gorge is 2240 ft. making the Painted Wall the highest cliff in Colorado. See Figure 3 to locate the viewpoint.

According to Hansen (1981, p. 151), the uniformitarian geologic history of the region is as follows. Before 1.7 billion years ago, sandstones, graywackes, shales and possibly volcanic rocks were deposited in the area. These rocks were subjected to folding and metamorphism yielding the Precambrian rocks found in the region today. Later, plutons and dikes were intruded into this basement during a period of tectonism along with some possible faulting at the same time (Hansen, 1964; Hansen and Peterman, 1968). At a later date, diabase dikes were injected into fracture zones of the Precambrian rock during a time of tectonic activity. Hansen then postulated a sequence of orogeny followed by a period of erosion. During the Jurassic and Cretaceous, sedimentation commenced again. The Gunnison uplift developed during the Laramide orogeny as:

> Block uplift proceeded along preexisting fault lines . . . Early Tertiary erosion subsequently reduced the uplift to a low rolling plane, partly stripping away the Mesozoic cover and exposing the Precambrian basement. The entire area was buried beneath a thick accumulation of Middle Tertiary ... pyroclastic rocks and gravel. Finally the Gunnison River—in a superimposed course—entrenched itself down through the volcanic cover, through the remaining Mesozoic rocks, and into the crystalline core of the uplift, where it cut the present canyon (Hansen and Peterman, 1968, p. C80).

Hansen (1987a, pp. 18-19) suggested that the walls of the Black Canyon are so steep because down-cutting proceeded rapidly as the hard crystalline walls prevented much lateral erosion from occurring. He noted that (1987a, p. 19), "...the actual cutting of the canyon started perhaps a scant 2 million years ago," which is a mere drop in the uniformitarian bucket of time. Chronic (1980, pp. 280-284) essentially agrees with Hansen's view of canyon cutting.

Prior Creationist Studies on the Black Canyon

Walter Brown (1995, pp. 94-95) discussed the formation of dikes in the walls of the Black Canyon in the context of his hydroplate model. He commented on the tectonic forces and magmatic activity that would have been necessary to fracture the walls and inject intrusive material into the matrix rock. Brown emphasized the rapidity of the process as all of his postulations are developed in a young-earth framework.

Edmond Holroyd, III conjectured in a research proposal (1991, pp. 5-8) that strain, which developed on the crystalline rock core of the Gunnison uplift by tectonic forces, was relieved by cracking within the rock. The Gunnison River was captured by this rent in the rocks, thus the Black Canyon formed by such a mechanism. Holroyd also considered the existence of post-glacial lakes in the region that could have eventually drained through this crack causing erosional downcutting in the canyon walls.

Canyon Formation: Flood, Young-Earth Model

The geomorphology of the western United States has been strongly affected by canyon formation. A creationist explanation of the geologic history of this region must address these important features. This work has started (See Appendix I and, particularly, Austin, 1994.) and the Black Canyon presents another opportunity to demonstrate the superiority of the Flood model over uniformitarian speculations. I encourage creationists to offer other models of canyon formation besides mine for comparison to published uniformitarian interpretation (the excellent work of Hansen [1964; 1981; 1987a, b; Hansen and Peterman, 1968; Olson, Hedlund and Hansen, 1968]). Although this

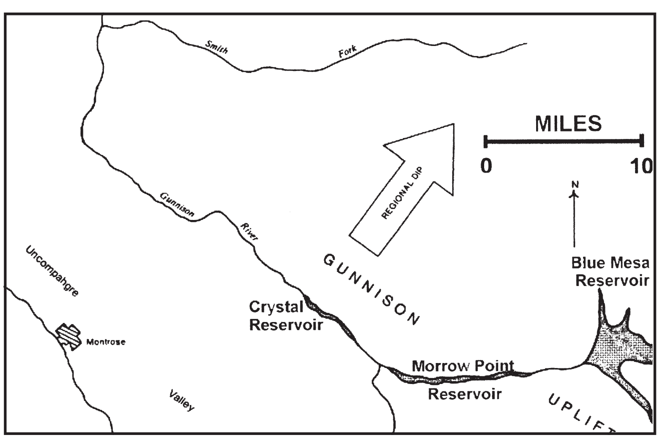

Figure 6. Location of the Gunnison uplift (after Hansen, 1981, p. 150; 1987b, p. 321).

Figure 5. The mouth of the Black Canyon of the Gunnison looking upstream from the confluence of the North Fork with the Gunnison River. The North Fork is to the immediate left of the photograph. The walls of the canyon are Entrada Sandstone topped by Dakota Sandstone. River level is approximately 5100 ft.

Figure 7. Dillon Mesa as seen from the south across Blue Mesa Reservoir. The palisade consists of West Elk Breccia capped by Blue Mesa Tuff. Volcanic activity blanketed the region from the north and south. The volcanism in the West Elk Mountains formed the West Elk Breccia which covered the sedimentary rock on Dillon Mesa to a depth of about 600 ft. The breccia is mainly composed of a mixture of igneous rock clasts in a volcanic ashy matrix Later volcanic eruptions in the San Juan Mountains ejected hot ash which formed the welded tuff over the West Elk Breccia. This is evidence of extensive volcanism in the region. (See Olson, Hedlund and Hansen, 1968.) Note the pinnacles and spires that have formed on the face of the breccia due to weathering.

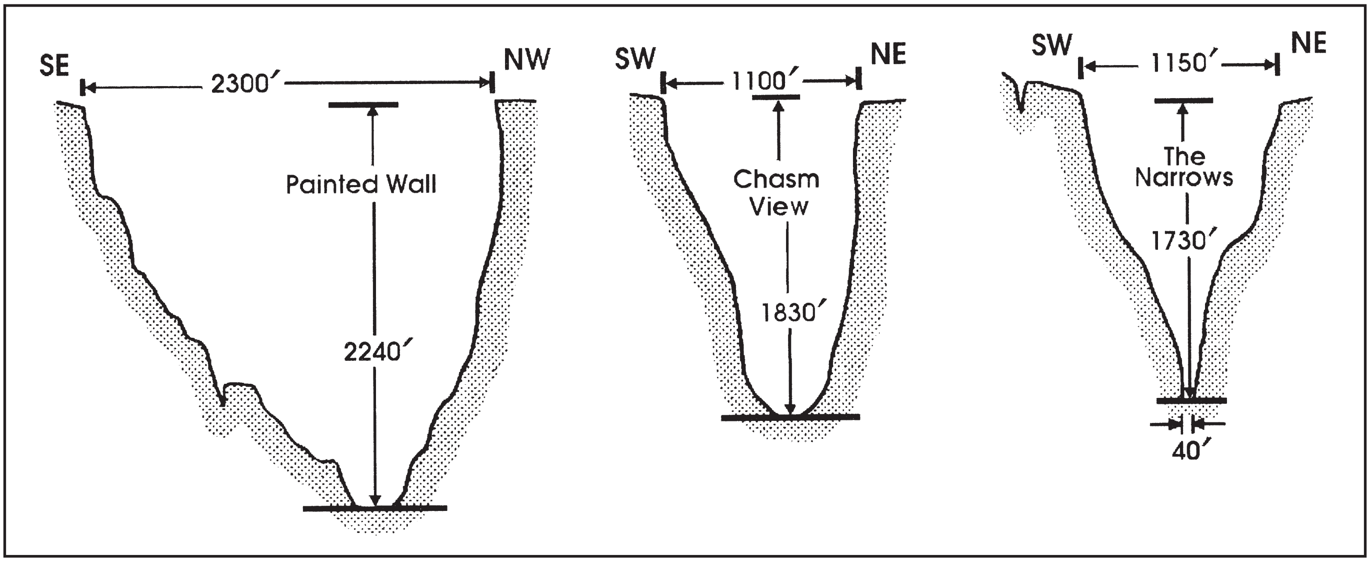

Figure 8. Drawings of particular cross-sections of the middle portion of the Black Canyon of the Gunnison within the National Monument. Note the V-shaped nature of the walls indicating erosion by the action of flowing water. Locations of these viewpoints can be seen in Figure 3 (after Hansen, 1987a, p. 11; Parker, 1993).

paper provides a brief interpretive sketch, much work remains to be done. Future work could profitably focus on some aspects of the following issues.

Hansen (1981, 1987a, b) explains the location of the present canyon as a function of drainage redirection around accumulating volcanics during uplift of the Black Canyon region. Is this a sufficient explanation? Are the unique morphologic features of the canyon (steepness of the walls, narrow width, channel gradient, etc.) better explained by uniformitarian or catastrophic processes? What is the relative timing of canyon formation to the surrounding geologic events? Hansen (1981) interprets canyon cutting as the last event in a long history of the area. To what extent is he constrained by physical evidence as opposed to his uniformitarian paradigm? Why are Paleozoic and Mesozoic strata generally missing from the uplift? What is the relationship of the canyon to the abundant, late-forming volcanics in the area? Are these volcanics subaerial, subaqueous, or a mixture of both? Finally, what are the regional implications of any interpretation of the Black Canyon for other similar features? Although this paper is not an exhaustive evaluation of the canyon or the region, the preliminary interpretation that follows attempts to outline possible answers for some of these questions.

I propose that the sedimentary strata, which were eventually metamorphosed into the hard, crystalline rock core of the Gunnison uplift, were deposited during the early stages of the Flood. Metamorphism resulted from heat generated by regional igneous activity, and pressure from regional tectonism and the overburden of rapidly depositing masses of sediment. Plutonic and dike intrusion followed.

Ongoing tectonism resulted in the uplift of the region (Figure 6) with accompanying folding and faulting. Uplift resulted in the erosion of sedimentary overburden on the newly metamorphosed and intruded core during the Flood. In the late stages of the Flood, subaqueous volcanism was initiated in the San Juan and West Elk areas. As uplift continued, volcanic activity became subaerial, and lahars, lava flows, and ash deposits continued to accumulate. These volcanics quickly covered the Gunnison region, and buried the thin remaining sediments on the uplift. During later Flood stages, falling base level and continued uplift resulted in further erosive drainage of waters across the uplift (Figure 9). Flood drainage (generally moving east to west) carried abrasive particles,

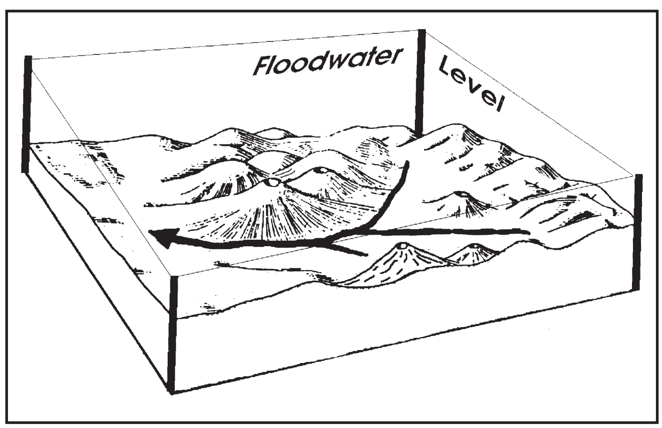

Figure 9. Proposed representation of regional Flood currents (noted by arrow) flowing across the Gunnison uplift which eventually formed the Black Canyon of the Gunnison. For an interesting discussion of the Flood currents, see Baumgardner and Barnette, 1994.

gravel, and boulders, which enhanced erosion, even into the crystalline core in places. As uplift continued and the base level fell, the core began to be more strongly eroded. The erosive power of the receding Floodwater was directed into the area of the current Black Canyon by ongoing volcanism. The drainage could also have been directed and enhanced along preferential pathways defined by structural zones of weakness. Mature canyon development could have been augmented by episodic flooding events triggered by the restriction and release of drainage by continued uplift and breaching of temporary volcanic deposits even into the wet, post-Flood ice age (Oard, 1990). Rapid uplift is evident from the steep, narrow channel carved into the crystalline core, and by the steep gradient of the present river channel.

Summary

One important aspect of Flood geology is how canyons formed during and after the Flood within the context of a young earth. Several canyons have been studied by creationists in an effort to provide models of canyon formation employing catastrophic processes. This introductory investigation concerns the Black Canyon of the Gunnison River, a unique feature considering the steep walls and narrow width of the middle section within the National Monument.

W. R. Hansen has provided an outstanding model of canyon formation from the uniformitarian perspective. His model was reviewed and a new approach to canyon development from a catastrophic viewpoint was outlined. To understand fully how the canyon may have formed, all sections (upper, middle, lower) were investigated as well as the regional geology and geomorphology. A brief summary of this new tentative model is given below.

First, Flood currents established the original drainage pattern across the Gunnison uplift. Retreating Flood water followed this same path (generally east to west) being hemmed in by the high peaks of the mountains to the north and south. In this region, the wet post-Flood ice age (Oard, 1990) created conditions where sediment-choked water flowed from the volcanic highlands along the now firmly established drainage pattern. This sediment-laden water continued downcutting along the channel in the uplift, but with less effective lateral erosion. I propose that the Black Canyon of the Gunnison formed in this manner in a very short period of time (from the late stages of the Flood through a period of Flood water retreat to the end of the ice age). When cutting of the canyon commenced, the path of flow through the uplift could have followed along fault lines in the core, however, water, loaded with abrasives, did the work of canyon cutting.

This proposal needs further refinement as more field work is conducted in this beautiful region of southwest Colorado.

Appendix I: Creationist Bibliography for Rapid Erosion and Canyon Formation

Several articles have appeared in the *Creation Research Society Quarterly* (*CRSQ*) on rapid erosion and canyon formation. The most recent in the series is:

Williams, E. L., R. L. Goette and J. R. Meyer. 1997. Kanab Canyon, Utah and Arizona: Origin speculations. *CRSQ* 34:162–172.

References to past Society field work on these subjects can be found in the above article, and interested readers and investigators can follow the series to find other references on the topics in earlier reports. The works of Steven Austin, Walter Brown, and Edmond Holroyd, III, among others, are referenced in the series.

Several references not contained in these reports are noted in this Appendix in an attempt to be complete as of the writing of this manuscript:

Akridge, A. J. 1998. A Flood-based origin of Little River Canyon near Fort Payne, Alabama. *Proceedings of the Fourth International Conference on Creationism*. Creation Science Fellowship. Pittsburgh, PA. Preprint.

Froede, Jr., C. R. 1995. Dauphin Island, Alabama: Evidence for rapid erosion. *CRSQ* 32:143–148.

Froede, Jr., C. R. 1997. Cloudland Canyon State Park, Georgia: 300 million years of erosion? *CRSQ* 34:38-43.

Shaver, M. 1998. Flood geology sheds light on Unaweep Canyon mystery. *CRSQ* 34:219–224.

Williams, E. L. 1991. Catastrophism and rapid erosion III. *CRSQ* 28:109–110.

Williams, E. L. 1997. Canyon formation by solution and collapse of limestone, Trans-Pecos Texas. *CRSQ* 34:183–184.

Williams, E. L., T. L. Bruce and J. R. Carson. 1996. Tropical Storm Alberto 1994, some catastrophic geological consequences in Georgia. *CRSQ* 33:175–178.

Glossary

Clast—An individual fragment of a detrital sediment or sedimentary rock, produced by physical disintegration of a larger rock mass.

Diabase—An intrusive igneous rock consisting essentially of labradorite and pyroxene, and characterized by ophitic texture.

Dike—A tabular body of igneous rock that cuts across the structure of adjacent rocks.

Fault block—A crustal unit bounded by faults either completely or in part.

Gneiss—A foliated rock with coarse crystals formed by regional metamorphism, in which bands of granular minerals alternate with bands of minerals with flaky or elongate prismatic habit.

Graywacke—A term generally applied to a dark gray firmly indurated course-grained sandstone.

Intrusion—The process of emplacement of magma into a pre-existing rock reflecting magmatic activity.

Lahar—A landslide or mudflow of pyroclastic material.

Magmatic—Derived from magma.

Metasediment—A sedimentary rock that shows evidence of having been subjected to metamorphism.

Orogeny—The process of mountain formation.

Pegmatite—A coarse grained igneous rock usually found as irregular dikes, lenses, or veins.

Pluton—An igneous intrusion.

Pyroclastic—Pertaining to clastic rock formed by volcanic explosion or expulsion from a volcanic vent.

Superimposed stream—A stream that was established on a new surface which maintained its course despite changes in lithology and structure encountered as it eroded downward into underlying rocks.

Syncline—a configuration of folded stratified rocks in which the rocks dip downward from opposite directions to come together in a trough.

Tectonism—A general term for all movement of the crust produced by deformational processes.

Tuff—Consolidated pyroclastic fragments.

Welded tuff—A pyroclastic rock that has been indurated by the welding together of its glass shards under the action of heat retained by individual particles along with the pressure produced by overlying material.

Acknowledgments

Appreciation is expressed to Carl R. Froede, Jr. for his work on the graphics for this article. Also Carl and Jack Cowart offered helpful comments on the first draft of the manuscript. The opinions expressed in this paper are solely mine. I thank the many donors to the Creation Research Society Research Fund, interest from which financed a portion of these studies.

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