AN OVERVIEW OF THE GEOMORPHOLOGY OF ARIZONA (VAN ANDEL CREATION RESEARCH CENTER REPORT NUMBER 1)

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Abstract

The recently established Creation Research Society Van Andel Creation Research Center (CRS/VACRC) located in Chino Valley, Arizona provides an excellent working laboratory for Young-Earth Creationist studies. An important component for many studies to be conducted from this facility is a general knowledge of the geomorphology of the state and region. Arizona can be divided into three general provinces: 1) the Colorado Plateau Province, 2) Transition Zone or Central Mountain Province, and 3) the Basin and Range Province. The CRS/VACRC lies within the Transition Zone/Central Mountain Province, With a general knowledge of the geomorphology of the state we can then better understand how the Arizona terrain and topography are affected from a climatic, floral, and faunal perspective. We can also initiate studies into how these geomorphological provinces were originally formed and developed within the constraints of the Young-Earth Flood Model.

Introduction

Over the years the Research Committee of the Society realized the need of establishing a center totally devoted to creationist research and field studies. Walter Lammerts, the founder, and George Howe, former Quarterly editor and one of the past presidents, strongly advocated that such a center be located on or near the Colorado Plateau because of the scientific possibilities of the region. In the early 1980's, Walter Lammerts, George Howe and Emmett Williams, then the chairman of the Research Committee, made two trips to Arizona to seek a site for a proposed laboratory. The lack of water and remoteness of many of the sites plus a brutal winter climate militated against selecting a location on the Colorado Plateau. The place chosen (Chino Valley) to build the facility had an abundance of water, milder climate and was not as remote. Two and a half acres were purchased on a paved major north/south US highway. Some of these details and other interesting circumstances of the search for property can be found in Lammerts, 1983; Howe, 1983. The Board of Directors unanimously approved the purchase of the land in 1983.

Later George Howe and John Meyer conducted a unique reconnaissance of the region around Chino Valley and issued a comprehensive report of the investigation (Howe, 1984). However, the Society did not have funds to build on the land. John Meyer evidenced keen interest in a laboratory/study center and brought detailed plans to several Board meetings. He submitted a grant proposal to the Jay and Betty Van Andel Foundation which was accepted and because of the generous gifts of the Van Andels, construction could begin! (See Meyer, 1991; 1992.) Two and a half additional acres were purchased to give a total of five acres, and construction was completed under the guidance of Dr. Meyer. Thus a center is available to facilitate research and field studies within the framework of the Creation Young-Earth model from its strategic location in north-central Arizona (Figure 1). Recently, the Van Andels have donated funds for the construction of a greenhouse which will provide for greater research possibilities at the center.

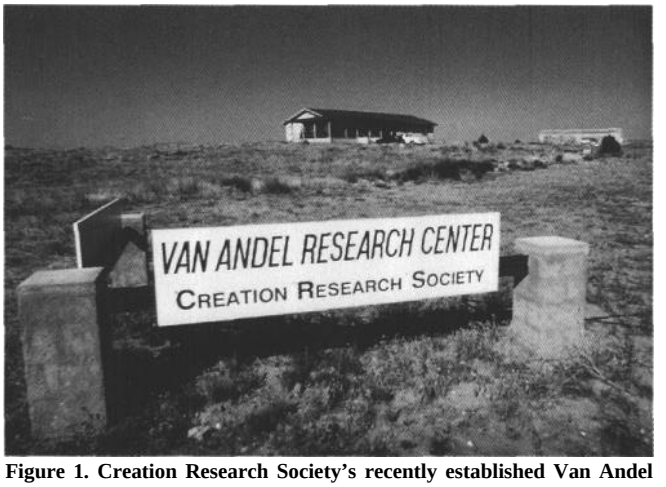

Figure 1. Creation Research Society's recently established Van Andel Creation Research Center located in Chino Valley, Arizona. This facility provides working space for many creationist researchers to conduct a variety of experiments (both laboratory and field).

In this article we orient the readers of the *Creation Research Society Quarterly* to the location of the Society's Van Andel Creation Research Center (CRS/VACRC) within Arizona's geomorphologic/geologic provinces. Field studies and activities conducted from the CRS/VACRC will likely occur within one of these provinces. Hence, this information should prove valuable. This work is only intended as a general overview of the geomorphology of Arizona. It is not expected to satisfy the details of specific areas or preclude additional reporting on other aspects of the geomorphology of Arizona. It is our hope that additional studies will be con-

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ducted to further investigate the geomorphology of the state. Through this paper we will seek to examine and describe Arizona's geomorphology based within the constraints of the Biblical record (e.g., Froede, 1995; Reed, Froede, and Bennett, 1996; Walker; 1994).

Geomorphology

Geomorphology is a broad based science. According to Bates and Jackson (1987, p. 272) geomorphology is defined as:

> The science that treats the general configuration of the Earth's surface; specifically the study of the classification, description, nature, origin, and development of present land forms and their relationships to underlying structures, and of the history of geologic changes as recorded by these surface features.

Thus, geomorphology is more than just the simple study of surface landforms. It is also an attempt to explain the forces which occurred throughout Earth history in shaping the land surface. The geomorphic features observed by creationist or uniformitarian scientists remain the same. Additionally, our description of the various landforms will not vary from those previously proposed by Uniformitarians. However, we do not accept either the proposed vast ages suggested as necessary to create these many features, or some of the suggested conditions in which they were formed (e.g., subaerial versus subaqueous, paleoenvironmental succession, sedimentary environments, facies development).

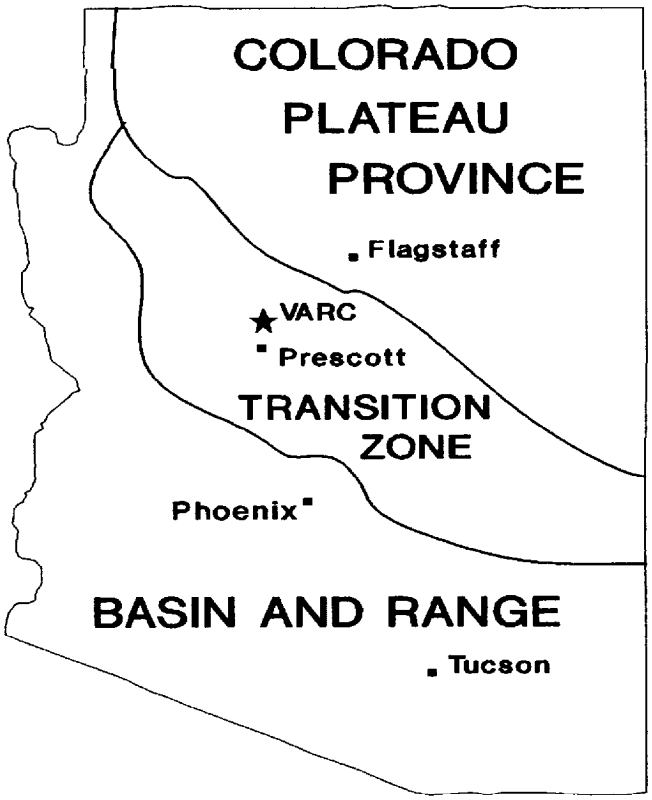

Figure 2. The three major geomorphologic regions identified in Arizona are based on a variation in elevation, surface features, and geological mechanisms in their formation. Modified from Nations and Stump, 1981, p. 79.

For geomorphologists the similarities among landscape features usually suggest a common geologic history. Divisions can be made within any given region based on the differences in flora, fauna, climate, and geology (Hunt, 1967). Geologic divisions within a region can be based on such features as rock type, structure, and erosion (Shimer, 1972, pp. 3-4; Thombury, 1965, pp. 1-12).

Arizona Geomorphology

Arizona can be divided into three general regions or provinces: 1) the Colorado Plateau Province, 2) Transition Zone or Central Mountain Province, and 3) the Basin and Range Province (Figure 2). Parts of these three geomorphological regions extend across other areas of the Western United States. For the many subprovinces also recognized across Arizona, see Krantz, 1989, p. 464; Menges and Pearthree, 1989, p. 651; Peirce, 1986; and Smiley, Nations, Péwé and Schafer, 1984. According to Peirce (1986, p. 80) the unraveling of Arizona's geologic history cannot be performed unless interprovincial considerations are also addressed. We agree and believe that additional studies should be conducted to orient all of these geomorphic provinces within the framework of our model.

The Colorado Plateau Province

The Colorado Plateau Province extends across the upper third of Arizona where it comprises several individually named plateaus together with various valleys, buttes, and mesas (Wilson, 1962, p. 96). According to Nations and Stump (1981. p. 80), this province is described as:

> ...predominantly horizontal stratified sedimentary rocks that have been eroded into numerous canyons, plateaus and scarps along which are exposed many colorful rocks ranging in age from Precambrian to Cenozoic. Many of the famous landscape features such as the Grand Canyon, Black Mesa, Painted Desert and Petrified Forest, and the Mogollon Rim have been carved into these rocks by erosion. Others such as the San Francisco Mountains and the White Mountains have been piled on top of the Plateau by Cenozoic activity.

A study of the lower-most strata in the Colorado Plateau Province reveals complex structural relationships between Archeozoic basement and overlying Proterozoic rocks. The flat-lying Paleozoic rocks which overlie the Proterozoic reveal that little to no tectonic activity occurred both during and following the deposition of the original sediments. Figure 3 shows a typical landscape of the Colorado Plateau Province with canyons and generally flat-lying strata. Prob-

Figure 3. The Colorado Plateau Province looking north across the Little Colorado River. Note the flat-lying nature of the surface of this province. Much of the strata found in the subsurface also exhibit this same flat layering.

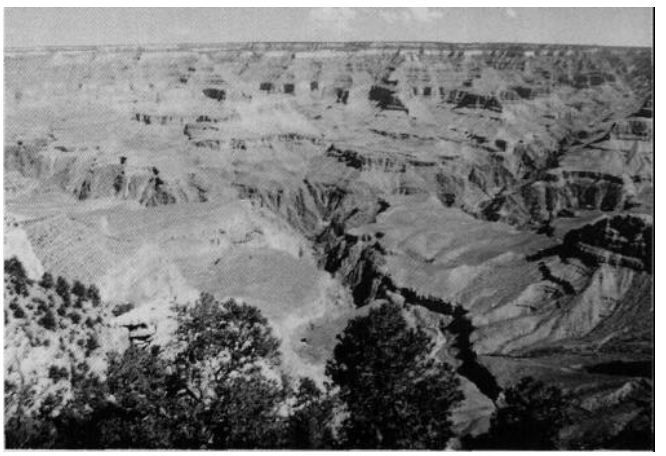

Figure 4. The Grand Canyon from the south rim. This is probably the best known feature found in the Colorado Plateau Province. Note the flat-lying nature of the strata exposed along the sidewalls of this photograph.

ably the most famous feature within this province is the Grand Canyon where the horizontal nature of the Paleozoic strata are clearly exposed (Figure 4).

The Transition Zone

The Transition Zone/Central Mountain Province is an area which lies between the Colorado Plateau and the Basin and Range Provinces. Strata found within this province contain characteristics of both the adjacent provinces. Nations and Stump (1981, p. 90) have identified this relatively narrow band of landscape which forms this province as:

> ...rugged mountains of igneous, metamorphic and deformed sedimentary and volcanic rocks of Precambrian age, with erosional remnants of Paleozoic age. The elevations are generally lower and the crustal rocks have been more severely faulted than in the Plateau Province. Well known landscape features in the Central Mountain Province include the Black Hills near Jerome and Prescott, the Mazatzal and Sierra Ancha Mountains around Roosevelt Lake. and the Salt River Canyon between Show Low and Globe. The important copper mining districts extending from Jerome to Morenci, and the uranium occurrences in the Precambrian Dripping Spring Quartzite, are located in this area.

According to Wilson (1962, p. 96), three great valleys (i.e., the Chino, Verde, and Tonto) have formed as a result of the relative downfaulting and erosion associated with this province. The CRS/VACRC is located in Chino Valley (Figure 2 and Figure 5). These same tectonic and weathering processes have affected the strata found within the Transition Zone in many other locations and has served to separate them from the Colorado Plateau Province, which it structurally resembles, in that its strata are essentially flat-lying except for local flexing (Wilson, 1962, p. 98) [Figures 6 and 7]. Hence, this province is viewed as having experienced greater tectonic instability than the adjacent Colorado Plateau Province in Earth's past.

Figure 5. A photograph of the Chino Valley looking northwestward. This valley is one of three major valleys found in the Transition Zone/Central Mountain Province.

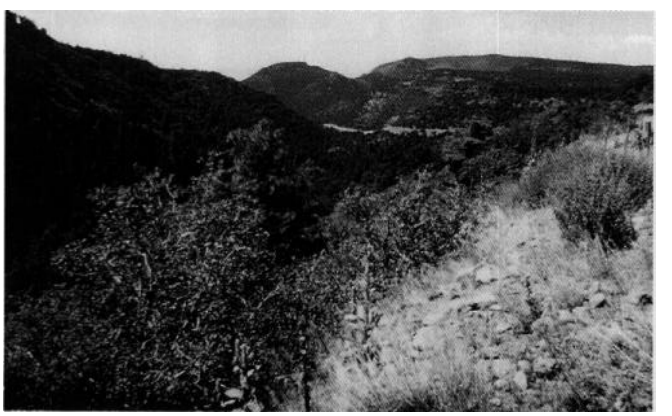

Figure 6. A photograph showing some of the peaks of the Mingus Mountains which lie to the west of Jerome, within the Transition Zone/Central Mountain Province.

Figure 7. A photograph taken from Transition Zone Mingus Mountains looking northward across the Verde Valley toward the Colorado Plateau.

The Basin and Range Province

The Basin and Range Province extends across most of the Southwestern United States. In Arizona this province stretches across the lower third of the state. According to Nations and Stump (1981, p. 80) the Basin and Range Province in Arizona is characterized by:

> ...elongated mountain ranges trending northwest-southeast, separated by broad alluvial valleys. The mountains consist of tilted, and sometimes structurally deformed, blocks of Precambrian, Paleozoic, Mesozoic and Cenozoic rocks that are bounded by faults and have been severely eroded. The valleys are intermontane depressions that have subsided thousands of feet, and are filled with Cenozoic volcanics, alluvium, and lacustrine sediments.

The southernmost portion of the Basin and Range in Arizona exists within the Sonoran Desert. Because of the influence of aridity associated with the Sonoran Desert the topography becomes progressively sharper and more rugged as one moves southwestward and westward (Wilson, 1962, p. 90).

The Basin and Range Province has experienced the greatest amount of tectonic instability. Extensional tectonics within this province has served to stretch and rotate the Earth's crust forming a whole series of fault-block mountains (Eaton, 1982). The fault-block pattern for most of the Basin and Range mountains generally trend in a northwest to southeast direction (Figure 8a and 8b). Uniformitarians suggest that orogenic activity which occurred during the Miocene (Tertiary) resulted in the formation of the Basin and Range Province (Nations and Stump. 1991, p. 9). In some places the Basin and Range fault-block mountains are superimposed over metamorphic core complex mountains. The metamorphic core complex mountains generally lie in a southwest to northeast direction which is opposite to the general direction of the other mountains found within the

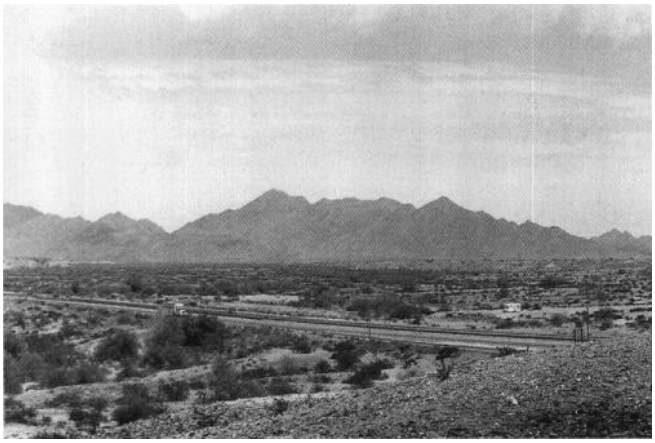

Figure 8a. A photograph showing the general topography of the Basin and Range Province. This is an example of fault-block mountains. This is Dome Rock Mountain, looking southeastward from mile marker 8 along Interstate 10, near Ehrenberg, AZ. Photograph by George F. Howe.

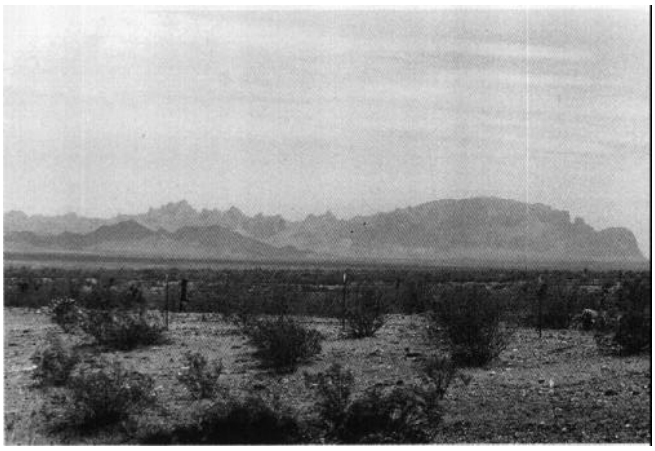

Figure 8b. A photograph showing the general topography of the Basin and Range Province. This is an example of fault-block mountains. This is Castle Dome, part of the Kofa Mountains, looking southeastward from mile marker 13 along Interstate 10, Quartzite, AZ. Photograph by George F. Howe.

Basin and Range Province (Armstrong, 1982: Chronic, 1983, p. 75: Crittendon, Coney, and Davis, 1980: Dickinson, 1991; Reynolds, 1980: Rehrig, 1986; Reynolds, Richard, Haxel, Tosdal, and Laubach, 1988, pp. 483-490; Spencer, 1992; Spencer and Reynolds, 1989a, p. 553; 1989b) [Figures 9a and 9b]. These mountains contain metamorphic rocks (i.e., mylonite) within fault zones which suggest their formation under directional tension. It has been proposed that the metamorphic core complex mountains were formed in the Mid-Tertiary, about 20 million years before the orogeny which created the Basin and Range Province (Chronic, 1983, p. xii-viii; Howard, John, and Miller, 1987; Livaccari, Geissman, and Reynolds, 1995; Nelson and Beratan, 1995). Reynolds et al., (1988, p. 483) suggested that western Arizona and adjacent parts of southeastern California have had:

Figure 9a. A photograph showing the general topography of the Basin and Range Province. This is an example of metamorphic core complex mountains. Harcuvar Mountains looking northwestward from mile marker 79 along Arizona Highway 60, near Aguila, AZ. Photograph by George F. Howe.

> ...a more complicated history of Mesozoic and early Tertiary metamorphism and deformation than the rest of Arizona. In addition to middle Tertiary mylonitization and detachment faulting, at least five major metamorphic episodes, ranging in age from Triassic to early Tertiary, have affected the region. Most metamorphic episodes were associated with regional deformation, including large scale thrusting, and some were accompanied by synkinematic plutonism.

Figure 9b. A photograph showing the general topography of the Basin and Range Province. This is an example of metamorphic core complex mountains. Whipple Mountains looking northwestward from Highway 95, eastern California. Photograph by George F. Howe.

This plutonism is the result of deep-seated volcanics which have been injected into the overlying fractured and faulted crust. Erosion later served to exposed these rocks (e.g., granite and diabase) at the surface. In some places within this province these volcanic magmas penetrated to the surface and erupted resulting in the formation of volcanic deposits.

Young Earth Flood Model

Much creationist field work has been accomplished in Arizona and on the Colorado Plateau. The palynology of certain strata in the Grand Canyon (Burdick, 1966, 1972; Chadwick, DeBord and Fisk, 1973; Howe, 1986; Lammerts and Howe, 1987; Howe, Williams, Matzko and Lammerts, 1988) has been investigated extensively. The stratigraphy of the Colorado Plateau in relation to the rapid deposition of the various layers was noted by Clark (1966). A study of Grand Canyon strata with an emphasis on continuous deposition without any interval of erosion was accomplished (Waisgerber, Howe and Williams, 1987). Austin (1994) discussed the sedimentary strata in the Grand Canyon extensively from a creationist perspective. A possible pre-Flood/Flood boundary was identified within Grand Canyon strata (Austin and Wise, 1994). A fossil location within Redwall Limestone was discussed as evidence for a catastrophic burial event by Austin and Wise (1995).

Considerable effort has been exerted by creationists in developing models for the formation of the Grand Canyon as well as showing the extent of the immense post-Flood erosion evident on the Colorado Plateau (Austin, 1994; Brown, 1989; Burdick, 1974; Cunningham, 1977; Holroyd, 1990a, b; Oard, 1993; Williams, 1996; Williams, Meyer and Wolfrom, 1991; 1992a, b). Several biogeography studies which relate to geomorphology of the region have been done by creationists (Howe, 1981; Meyer, 1985 [The creationist model developed in this investigation depends directly on the recent formation of the Grand Canyon]; Meyer and Howe, 1988; Williams, Howe and White, 1991). An ichnological study was conducted by Rosnau, Auldaney, Howe and Waisgerber (1989a, b). DeYoung (1994) discussed the meteor crater in Arizona within a young earth model. A geomorphological study of Kanab Plateau and the Grand Staircase on the Colorado Plateau has been finished and a report is being prepared. Also a proposal for a geological investigation of the San Francisco Mountain region has been approved.

The stratigraphy of the Colorado Plateau spans more uniformitarian time than anywhere else on Earth. This strati-

graphic column is also important to our understanding of Earth history within the context of our own model (i.e., Flood energy and its effect on sedimentation—see Reed, Froede, and Bennett, 1996). It is easy to understand why so many creationist investigators have focused their attention on it.

Presently it is unknown when much of the strata which composes the Transition Zone/Central Mountain Province was formed. We anticipate that the Flood served to redistribute Antediluvian sediments along with adding new materials derived from other sources across both the Colorado Plateau and Transition Zones. There are many areas within the Transition zone which contain the same strata as sections of the Grand Canyon (e.g., Supai, Redwall, and Tapeats formations). During the Flood, tectonic activity within the Transition Zone served to break the basement rocks into large fault-bounded blocks. These blocks then rose or sank due to various orogenic forces transforming the Transition Zone into a mountainous region which no longer resembles the adjacent Colorado Plateau or Basin and Range Provinces.

Many investigations have been conducted within the Transition Zone/Central Mountain Province because of the economically important minerals contained in certain areas (Anderson and Blacet, 1972; Anderson and Creasey, 1958, 1967; Anthony, Williams, Bideaux, and Grant, 1995; Krieger, 1965; Lehner, 1958). These investigations have concluded that this region has undergone a complex geologic history. Various volcanic strata found within this province suggest that they originally formed in a subaqueous environment. This is evidenced by the occurrence of pillow and amygdaloidal basalt structures in certain areas of this Province (Anderson and Creasey, 1958, 1967). These subaqueous deposits suggest to us a possible link to the Flood. Further investigation is required to develop this interpretation.

In topographically higher areas within this province we observed evidences of subaerial ash fall, lava flow, and base surge deposits all of which suggest subaerial Ice Age or even Present Age Timeframe deposits. These sedimentary and volcanic deposits and their associated erosional features, suggest a complicated history for the Transition Zone/Central Mountain Province which has yet to be investigated with any detail, within the framework of our model.

The Basin and Range Province of the southern and far western sections of the state also contains minerals of economic significance and much work has been conducted in locating these valuable deposits (Anthony, Williams, Bideaux, and Grant, 1995). The Basin and Range is interpreted by Hunt (1975, pp. 144-145) to have started with the injection and uplift associated with the granitic intrusion of the Sierra Nevada which created conditions of instability and resulted in the formation of this province. Austin (1994) and Austin and Wise (1994) have addressed a portion of this province from northwestern Arizona through southern Nevada, extending into California.

Conclusions

The Creation Research Society's Van Andel Creation Research Center now provides the creationist researcher with an outstanding facility from which to conduct field investigations. A general understanding of these three major geomorphic provinces could prove important for future research conducted from this facility.

Geologically, the sediments and strata found within these three provinces range in age from Creation Week (Day 3) to Present Age Timeframe (following Froede, 1995). With additional investigation we hope to reconstruct the geological history for each of these provinces within the framework of the Young Earth Flood Model. We believe that such a model fits with the Creator's activity recorded in Genesis.

Much work remains to be performed in characterizing the geology of Arizona within the Young-Earth Flood Model. However, with the advent of the CRS/ VACRC we now have a base of operations from which creationist research can be conducted.

AcknowIedgments

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