[65]Ivor Morgan, personal communication, 7 October 1975.

[66]A computer program for determining the time necessary to bring various parts of a sphere to various temperatures given a certain outside temperature was supplied by Ivor Morgan, engineer with the Birds Eye Division of General Foods Corporation, 250 North Street, White Plains, New York 10625.

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RAPID GROWTH OF DRIPSTONE OBSERVED

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Evolutionists generally assume that dripstone deposits, such as stalactites and stalagmites, form slowly, while creationists would maintain that rapid rates of formation must be possible. Here factors affecting the rate of formation of dripstone are discussed. Hypothetical environmental conditions immediately following the Genesis flood would be expected to produce rapid formation of dripstone. Actual observations of rapid formation are reported. Therefore, the creationist position is supported by theoretical as well as experimental data relating to the rate of formation of dripstone.

Introduction

Creationists assume that limestone caverns were formed several thousand years ago, during or immediately following the Genesis flood. The generally accepted phreatic (below the water table) theory of cave formation[1-5] is in agreement with the Genesis account of a world-wide flood and therefore supports this assumption. Caves may have formed rapidly during the flood (after the major sedimentary deposits had been laid down) or immediately following the flood. As the continents were raised, declining water tables would have drained the caves and produced conditions suitable for growth of dripstone. The present existence of large stalactites and stalagmites would therefore demand recent environmental conditions suitable for *rapid* formation of dripstone.

Evolutionists, on the other hand, generally assume that dripstone has always formed *extremely slowly* under the environmental conditions found in caves.[6] Consequently, large stalactites and stalagmites, and the caves containing them, are often considered to be hundreds of thousands to millions of years old.[7]

Data concerning the actual growth rates of stalactites and stalagmites under various environmental conditions should be of interest therefore, to creationists and evolutionists alike.

Since this type of research project was suggested[8] in 1970, several brief articles have appeared in the creationist literature which suggest that stalactite growth can and does occur rapidly.[5,9-11] It is the purpose of this communication to discuss the factors which may have affected the rate of stalactite and stalagmite growth since the Genesis flood, and to report actual observations of rapid dripstone deposition.

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Factors Affecting Stalactite and Stalagmite Growth

Water containing carbon dioxide is weakly acidic and reacts with calcium carbonate (calcite) in limestone to produce soluble calcium bicarbonate (reaction a) as it percolates into the ground. When the water reaches the ceiling of a cavern, evaporation and loss of carbon dioxide may reverse the reaction and cause precipitation of calcium carbonate in the form of a stalactite or stalagmite (reaction b).

$$CaCO_3 + H_2O + CO_2 \underset{b}{\overset{a}{\rightleftharpoons}} Ca^{++} + 2HCO_3^-$$

Several factors have been identified which affect the rate and manner of deposition of calcium carbonate as stalactites and stalagmites. These include: 1) the concentration of calcium bicarbonate in the solution 2) the drip rate and 3) the rate of evaporation (including loss of carbon dioxide) which is controlled by the air circulation, temperature, and humidity.[12]

Thus, a high calcium bicarbonate concentration (over 50 percent), slow drip rate (less than 1 drip per second), and rapid evaporation favor rapid vertical growth of a small diameter stalactite (Table I, A). Similar concentration and drip rate but with slow evaporation results in slow formation of a large diameter stalactite (Table I, B). High calcium bicarbonate concentration, rapid drip rate, and rapid evaporation favor rapid vertical growth of a small diameter stalagmite (Table I, C). Similar concentration and drip rate combined with slow evaporation, produces slow formation of a large diameter stalagmite (Table I, D). Finally, lower concentrations of calcium bicarbonate result in slower vertical growth rates for both stalactites and stalagmites, the effect being more pronounced for stalactites.[13]

Of these factors, the rate of deposition of calcium carbonate is usually determined by the *rate of evaporation* and the *concentration* of calcium bicarbonate. (Drip rate determines primarily whether a stalactite or stalagmite will be formed.) Since the rate of evaporation is controlled by three variables (air circulation,

Table 1. Effect of Environmental Conditions on Dripstone Formation.

	Concentration	Drip	Evaporation	Results in:
A.	High	Slow	Rapid	Rapid vertical growth of small diameter stalactite
B.	High	Slow	Slow	Slow formation of a large diameter stalactite
C.	High	Rapid	Rapid	Rapid vertical growth of a small diameter stalagmite
D.	High	Rapid	Slow	Slow formation of a large diameter stalagmite

temperature, and humidity), it is difficult to determine what effect, if any, the changing environmental conditions following the Genesis flood would have had on the rate of evaporation in caves and thus, on the rate of deposition. However, the rate of deposition could have *decreased* significantly due to the reduction in calcium bicarbonate concentration produced by one or more of the following factors.

The concentration of calcium bicarbonate present in solution at equilibrium is determined primarily by the concentration of dissolved carbon dioxide.[14,15] The concentration of carbon dioxide in *surface* water is controlled by the water temperature and partial pressure of carbon dioxide in the atmosphere. Although these factors may have changed somewhat since the flood, it is unlikely that they would be major factors producing changes in the carbon dioxide content of *vadose* (between the land surface and the water table) water.

The amount of carbon dioxide produced by *bacterial decay of organic material* may be much more significant. Since surface water absorbs additional carbon dioxide as well as humic acid produced by bacteria in the soil, as it trickles into the ground,[16,17] the concentration of bicarbonate in *vadose* water would be strongly dependent on the concentration of decaying organic material in the upper sedimentary strata. That these strata were once rich in organic material which has since decomposed is apparent from the wealth of fossils remaining. Thus, the concentration of calcium bicarbonate arriving at the ceiling of a cave would be expected to decrease with time due to decreasing concentrations of organic material remaining in the sedimentary strata above the cave.[18]

Limestone above a cave would also be expected to decrease in *solubility* with time due to the spontaneous diagenesis (aging) process. The decrease in solubility of precipitates due to aging is a well-known phenomenon to analytical chemists. Furthermore, *diagenesis is known to occur in limestone* as a result of pressure and presence of water.[19] It has been cited to account for the more rapid vertical growth of stalactites on young concrete (less than one year old) relative to stalactites on older concrete (three to 11 years old) under similar conditions of evaporation.[20] Thus, the concentration of calcium bicarbonate arriving at the ceiling of a cave would also be expected to decrease with time due to the decreasing solubility of limestone above the cave.

Limestone is generally crisscrossed with fractures produced by geological stresses.[21] Diagenesis may also produce enlargement of the fractures due to the shrinkage of the limestone.[22] These fractures would be further enlarged due to solution of calcium carbonate from the walls of the openings.[23-25] Enlarged fractures would allow vadose water to penetrate the limestone more rapidly, again reducing the calcium bicarbonate concentration at the ceiling of a cave because of the reduced contact time between the solvent and solute.

Consequently, vadose water percolating through newly consolidated limestone strata soon after the flood would have possessed a higher concentration of calcium bicarbonate upon reaching the ceiling of a cave than is usually observed today. Since the rate of growth of dripstone formations in the cave is directly proportional to the concentration of calcium bicarbonate in the solution, more rapid growth rates would have occurred in the years immediately following the flood than are generally found today.

Observations of Rapid Stalactite Growth

In April, 1976, numerous stalactites were observed under concrete bridge Number CLA42-0012 (Figure 1) on U.S. 42 approximately five miles east of Cedarville, Ohio. According to construction records,[26] the bridge was built in 1941. Thus, the stalactites measuring up to 150 mm in length and 13 mm in diameter (Figure 2) with approximately a 3 mm diameter capillary, have grown in *35 years or less.* The *minimum* average growth rate is therefore 4.3 mm per year.

Since the road surfaces of bridges in this part of Ohio are sealed to reduce penetration and thus erosion by rain water, and since stalactite growth under bridges can only occur during wet weather, this minimum average growth rate is indeed surprising. (See Table 2 for information about the weather.) It is an order of magnitude greater than that reported for stalactites on the spillway ceilings of a dam.[27] Furthermore, the minimum volume of deposition, approximately 0.53 cm^3 per year, is the same order of magnitude as the 0.83

Table 2. Weather conditions at Cincinnati and Columbus, Ohio, which are thus typical of those prevailing where the investigations reported here were carried out. These data are from Conway, H. McKinley, Jr. ed., 1963. The weather handbook. Conway Publications, Inc., Atlanta, Georgia, and World Weather Records, 1951-1960, Vol. 1, North America, U.S. Department of Commerce, Washington, D. C., 1965.

	Cincinnati	Columbus
Average number of days of rain (0.01 inch) per year	132	135
Average number of days of snow (1 inch) per year	8	8
Mean annual precipitation (mm)	1004	857
Average wind velocity (mph)	7sw	8ssw
Mean annual temperature (°C)	12.9	12.1
Average relative humidity (%)	57	58
Percent possible sunshine	57	55

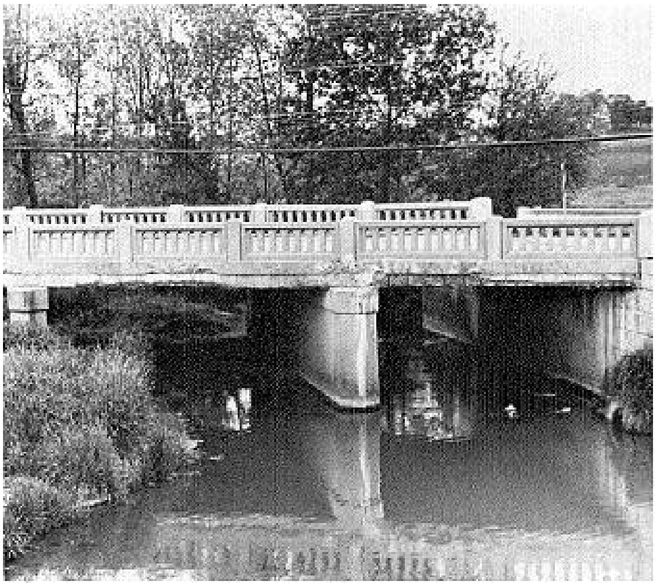

Figure 1. Bridge CLA42-0012 on U.S. 42 near Cedarville, Ohio.

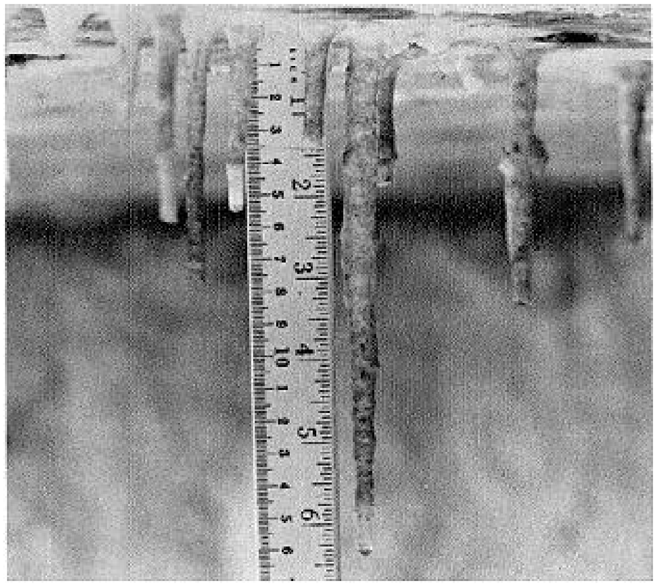

Figure 3. October 2, 1976. This stalactite grew 10 mm in length in only 19 weeks.

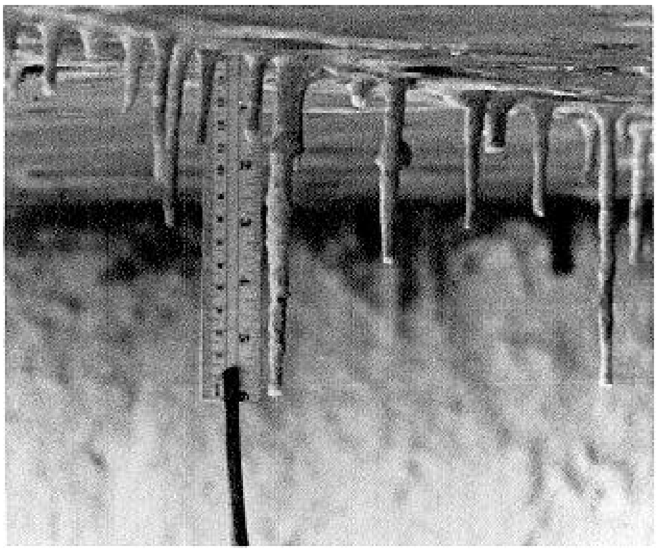

Figure 2. May 22, 1976. The largest stalactite was 150 mm in length.

Figure 4. Flowstone up to 1 cm thick.

cm^3 per year reported for continuous deposition of calcium carbonate using simulated rain water in a laboratory situation.[28] Finally, it is considerably larger than the average rate of deposition of dripstone of 0.164 cm^3 per year (1 in^3 per hundred years) sometimes mentioned in the geological literature.[29]

The actual growth rates of the stalactites under this bridge may vary considerably during the year, depending upon the temperature, humidity, wind velocity, and rain fall. Between May 22 and October 2, 1976 (19 weeks), the stalactite mentioned above increased in length by *10 mm* (Figure 3)! Such rapid growth was completely unexpected! Yet, other stalactites under the same bridge appear to have grown even more rapidly though quantitative data are not yet available. Therefore, it must be emphasized that the minimum average growth rate of 4.3 mm per year is indeed a *minimum. Actual* rates of growth may easily be as much as an order of magnitude greater than this minimum under ordinary environmental conditions.

On September 23, 1976, several white circular calcium carbonate deposits 4 to 5 cm in diameter were also observed on the bare ground under the bridge. They had not been noticed in the spring, and therefore, must have formed during the summer months. They were located directly under growing stalactites where water dripped from the bridge to the ground, and thus appeared to be premature stalagmite deposits. Therefore, stalagmites might be expected to form very rapidly at these locations. Absence of stalagmites several centimeters in length is undoubtedly due to annual erosion and redeposition of soil under the bridge when the creek rises during the wet spring weather.

Finally, deposition of flowstone (a deposit formed by flowing rather than dripping water) has been reported to be even slower than deposition of dripstone.[30] Yet flowstone deposits up to approximately 1 cm thick on the concrete supporting walls of this bridge (Figure 4) attest to the reality of relatively rapid flowstone deposition as well.

Such rapid rates of deposition of calcium carbonate are not limited to this particular bridge or location. Since April, 1976, stalactites have been observed under two other concrete bridges in this same area as well as under a bridge in Grand Rapids, Michigan. They have also been mentioned in the creationist literature by others.[31] Thus, minimum average growth rates measured in millimeters per year for stalactites under concrete bridges appear to be relatively common.

However, environmental conditions under *bridges* are considerably different from those in *caves*. Thus, it could readily be argued that these growth rates do not apply to stalactites in caves. Conditions in *mines*, however, might be expected more closely to resemble those found in caves. But a study of stalactite and stalagmite growth conducted at the Experimental Mine of the United States Bureau of Mines near Bruceton, Pennsylvania, revealed even larger growth rates. Growth rates of stalactites on the concrete roof of the mine range from 12 mm per year to 173 mm per year.[32] These are from 3 to 40 times the minimum average growth rate observed under the concrete bridge! Obviously the environmental conditions in this mine are even *more*, rather than less, conducive to rapid stalactite growth than those under the bridge.

Finally, an effort was made to obtain evidence of rapid deposition of calcium carbonate under authentic *cavern* conditions. A survey of the Olentangy Indian Caverns,[33] just off U.S. 23, north of Columbus, Ohio, revealed that the electrical wiring is encrusted with 1 to 2 mm of flowstone in several locations, and in one instance at least, is actually cemented to the wall of the cave by the deposits. Much of the original wiring, installed in 1935, has been replaced in more recent years. Since maintenance records concerning the wiring have not been kept, the exact age of the encrusted wiring is uncertain, but it cannot be more than 41 years old. Obviously, deposition of calcium carbonate can occur at measurable rates even under the environmental conditions found in caves today.

Furthermore, the large stalagmite known as Crystal Spring Dome in Carlsbad Caverns has been reported to be growing as fast as 2.5 in^3 (41.0 cm^3) per year ". . . in spite of the present dry New Mexico desert above!"[34] At this rate, a 10,000 in^3 stalagmite which would require *1 million years* for formation at an average deposition rate of 1 in^3 per hundred years could actually be formed in only *4000 years*! When the possibility of even *greater* growth rates in the recent history of the Earth are considered, it becomes apparent that even the *largest* known dripstone formations could have formed in only a *few thousand years*. Therefore, it is clearly unnecessary to postulate that large stalactites and stalagmites have required hundreds of thousands of years for their formation.

Conclusions

Dripstone growth rates in caves are directly proportional to the concentration of calcium bicarbonate in vadose water. The concentration of calcium bicarbonate is dependent on the concentration of dissolved carbon dioxide, the solubility of the limestone through which the solution passes, and the contact time between the solution and the limestone. Thus, increased amounts of carbon dioxide in the soil, existence of the limestone strata in a more soluble state, and longer contact time between the solution and the limestone immediately following the Genesis flood would have provided ideal conditions for rapid dripstone growth in caves.

Rapid calcium carbonate deposition has actually been observed under concrete bridges as well as in a cave in the Midwest. Furthermore, rapid growth rates for stalactites on the concrete ceiling of a mine and for stalagmites under actual cavern conditions are known. Therefore, it is concluded that dripstone formations do not always grow slowly. Under appropriate conditions, they may form very rapidly, even in caves. Consequently, it is not necessary to accept the evolutionary postulate that caves have existed for long periods of time in order to allow for the slow growth of stalactites and stalagmites. Instead, the creationist theory involving recent cave origin and rapid dripstone growth is a viable alternative which is in agreement with experimental data concerning dripstone growth rates.

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[33]The Olentangy Indian caverns have been formed in the Delaware Blue Limestone which is overlain by the Columbus White Limestone. Cavern tours include the first three levels below the surface (55, 75, and 105 ft.), although the cave is thought to extend as deep as 500 feet. Cave temperature is a constant 54 °F (12.2 °C) and complete air exchange occurs every 25-30 minutes. Only a few small stalactites are observable. Rapid deposition of calcium carbonate in this cavern was brought to our attention by Mr. Randy Helmick, Assistant Plant Chemist, Quality Assurance Department, Foundry Division, Ashland Chemical Company, Cleveland, Ohio.

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THE ROTATION-CURVE OF THE VIRGO CLUSTER OF GALAXIES

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The rotation-curve for the Virgo cluster of galaxies and the so-called Southern extension is presented. The two appear distinct in their radial velocity distributions and, in addition, there appears to be another grouping associated with NGC 4261. The masses of the two clusters are $(1.3 \pm 0.2) \times 10^{15}$ *and* $(1.6 \pm 0.2) \times 10^{14}$ *solar masses respectively. The central densities are* $(3.5 \pm 1.0) \times 10^{-25}$ *and* $(2.6 \pm 0.5) \times 10^{-26}$ *gm cm*$^{-3}$ *respectively. Boundary conditions yield an estimate for the intercluster medium of the supercluster of* $(2.2 \pm 0.8) \times 10^{-29}$ *gm cm*$^{-3}$. *The period of revolution of the two clusters about each other is about* 3.4×10^{11} *years; more than ten Hubble ages. This latter factor and the discovery of a previously unsuspected shell wherein the number of direct and retrograde moving galaxies are equal provide further damaging evidence against the prevailing modern cosmogony.*

Introduction

The study of rotation-curves is fundamental to galactic dynamics. This report presents a study of evidence that clusters of galaxies are rotating and that they are stable on "time scales" some ten times greater than the presently held age of the cosmos.

Everyone is familiar with the idea of putting men and satellites into orbit about the earth, moon or other planets. Such behavior is held possible because the gravitational force can be balanced by the centrifugal force. The former tends to draw bodies together while the latter acts in such a way as to draw them apart. In the same way the planets revolve about the sun. It is also observed that stars may go around each other, as is the case for double stars.

The stars, in turn, are organized into larger bodies called galaxies which also appear to be held together gravitationally in the same way as is true for the solar system. Galaxies, in turn, can also be double or multiple and can also be grouped into ensembles called galaxy clusters. Evidence is presented here to show that these clusters are also held together by gravitation, and that they, too, rotate as a whole in just the same manner as the solar system.

Now the gravitational attraction of bodies depends upon their masses and hence it is possible, for example, to deduce something about the mass of the sun from the motion of the planets. Similarly, something can be found out about the masses of double stars; likewise for galaxies and, by extension of the idea, the clusters of galaxies.

Of course, the motion of galaxies cannot be observed directly as that of the planets can. It can, however, be deduced from the Doppler effect, the phenomenon which lowers the pitch of a passing automobile horn. Instead of sound, of course, in the case of stars and galaxies one is dealing with a shift in the color of the object's light as it moves toward or away from the observer.

Simply stated, a rotation-curve is a plot of the rotational velocity against the central distance. To arrive at a rotation-curve for the solar system, for example, one would plot the orbital speed against the distance from the sun. This approach is not very practical nor necessary for the solar system where there are only a few objects which can easily be dealt with separately; but in the case of a galaxy with some 10^{11} objects it is quite practical.

The same is true for galaxy clusters, although they contain only a few hundred member galaxies. Part of the reason is that at present an observer can only estimate the motions of a few stars and no galaxies perpendicular to the line of sight (i.e. in what direction

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