Formation of Hamilton Cave, West Virginia

Arthur Manning

Hamilton Cave is a popular wild cave not far from the Washington, DC and Richmond, Virginia area. It has several features which may be readily understood as having been formed in accordance with a biblical view of Earth history. The cave contains many smoothly contoured cave rock relief features, such as pockets in the walls and ceiling, indicating that they were shaped by hydraulic forces. Many of these features were measured in an attempt to understand the direction of the flow which formed them with the goal of relating this direction to how the cave itself was formed. Evidence is presented for several factors which together contributed to the formation of this cave and its features. These factors are in best agreement with the biblical Flood and Ice Age events, rather than with slow, uniformitarian dissolution.

Hamilton Cave is a wild cave located in Pendleton County, West Virginia, at 38°36'20"N, 79°22'15"W. It is about 5.6 km (3.5 miles) southwest of the town of Franklin. This cave receives numerous visitors each year due to its interesting features, accessibility (there is no need for technical equipment), and its proximity to millions of people who live close enough to visit it as a one day trip (including residents of Baltimore, Washington, DC, and Richmond). It and two other caves are found in the John Guilday Cave Preserve, which is owned by the National Speleological Society. All three caves are open to the public for recreational cave exploring. Of course, nothing is to be disturbed in these caves. They are to be left in their natural condition for the enjoyment of future cavers. Hamilton Cave should be of interest to biblical creationists since its geological features indicate massive flooding.

Hamilton Cave is in the Corriganville formation (formerly called the New Scotland formation), which is part of the Helderberg group (which is the lower of two subdivisions within the Lower Devonian rocks). This formation '... consists of 20 to 25 feet [6–7.5 m] of crystalline limestone with prominent chert nodules weathering white overlain by calcareous shale 10 to 30 feet [3–9 m] thick.'[1] In Pendleton County the Corriganville formation consists of only the lower chert-bearing limestone.[2] According to Davies, 'The cave is in the New Scotland Limestone which has a slight dip to the east. It is developed along major joints at N40°W and N50°E with subordinate joints at N60°W and N80°E modifying the passage.'[3]

Hamilton Cave (figure 1) is located about 55 m up a steep ridge on the southwest end of Cave Knob, above the South Branch of the Potomac River. It is different from the other two caves in the preserve in that it includes an extensive maze of passageways intersecting at right angles. The maze (or network) region occupies about 28,000 m^2 near the entrance of the cave. 'The most frequently cited example of a network cave located along the crest of an anticline is Hamilton Cave.'[4] Beyond the maze section is a passageway which is barely large enough for a person to squirm through with great difficulty. It is a narrow, straight, horizontal tube 6.4 m long, aptly named 'The Airblower' since there is usually a current of air passing through it. Beyond the Airblower are more passageways which lead to the very large 'Bowl Room'. The cave ends with a few relatively short dead end passages extending beyond the Bowl Room. The total length of all the cave's passages is about 7.7 km. The maze section near the entrance makes this a cave in which it is easy to become lost. I strongly recommend that visitors to Hamilton Cave always be lead by experienced cavers who are familiar with this cave. If markers are used, they must be removed on the way out. In addition, cave exploration should always be done in groups of at least three and each person should have at least two backup sources of light, in addition to their main light source. Hamilton Cave has a variety of features. It has passageways with high ceilings and others where it is necessary to crawl. There are many formations, crystals (figure 2) and fossils which can be seen in this cave. In addition, bats (figure 3), millipedes, cave crickets (figure 4), cave rats, etc. have been observed there.

Figure 1. Entrance to Hamilton Cave, about 0.6 m high.

Figure 2. Gypsum crystals in Hamilton Cave.

Figure 3. Bat hanging from ceiling in Hamilton Cave.

Figure 4. Cave cricket in Hamilton Cave. Notice the exceptionally long antennae.

Limestone cave formation

How were caves formed? A variety of views have been proposed through the years. First of all, there are several different kinds of caves. Hamilton Cave is an example of the most common kind; caves found in limestone rock. Many observations indicate that limestone rock can be, has been, and in some cases is still being dissolved today by carbonic acid, which can be formed from CO_2 (from the atmosphere and soil) dissolved in water. This process is considered to be of primary importance in limestone cave formation. Today, speleologists recognize different kinds of limestone caves, which are thought to have been formed in different ways. Hamilton Cave is what is referred to as a network cave because of its maze. This paper will only deal with how Hamilton Cave and its features may have been formed. Other caves likely may have been formed under different circumstances.

The earliest stage of cave formation (speleogenesis) is referred to as inception. According to Lowe, 'most models of early speleogenesis (inception) in carbonate rocks are based on water movement through physically formed voids.'[5] However, he proposes a model of chemical inception in which variations (in unconsolidated sediment or in consolidated rock) favour the initiation of dissolution rather than it being initiated by fractures caused by uplift of consolidated rock. He then postulates a subsequent increase in the dimensions of void systems which permit laminar flow and refers to this phase as gestation. Regardless of whether caves start off in this manner or from fractures which allow a laminar flow of acidic water, the putative subsequent phase involves the slow dissolution of adjacent conduit surfaces which increases their separation.

The enlargement of conduits by dissolution is believed to proceed in two major scenarios. The first is caused by meteoric water (water which flows from above). The second is caused by water rising from below (hypogenic speleogenesis). For deeper caves, water flowing from above would soon become saturated and the dissolution process would cease. Only in recent years have speleologists recognized the importance of the hypogenic process in deep cave formation.

Although dissolution is often considered as the only means of passage enlargement, Arthur N. Palmer adds another significant factor to this process. Palmer has studied caves extensively and his view (based on much field research and experimental data) of their possible origins may be the most noteworthy that is currently available in the English language. In 1975 he published *The Origin of Maze Caves*,[4] which David J. Lowe in 2004 described as 'a seminal work that received and has retained widespread acceptance.'[6] In this article Palmer states that:

> 'Application or release of stress is not only capable of producing fractures in a rock formation, but also of enlarging the fractures to considerable width in local areas. Major sources of stress include tectonic processes, erosional or glacial unloading, gravity sliding, and ice wedging. Many maze-like

> fissure caves have been formed essentially by these mechanical processes alone. Although these effects are generally obscured in a soluble rock by solution and precipitation, the mechanical enlargement of fractures prior to, or during, solutional cave development may be significant in initiating or maintaining the competitive growth rates among alternate flow paths that are necessary to form a maze.'[7]

So, in addition to dissolution, mechanical factors may well be significant in the formation of solution caves. Within a biblical framework, the tectonic events associated with the continental uplift after the Flood would have been significant in the formation of Hamilton Cave.

Rate of cave formation

Hamilton cave and its features are apparently not in the process of being formed today (with the exception of some stalactites which have water dripping from them in a very damp room which is well removed from the main passageways). Therefore, all speculations about its formation cannot be based upon extrapolations of processes presently operating within the cave. Models are therefore constructed based on the present features that we observe there as well as observations of active caves and laboratory experiments.

In 1991 Palmer wrote 'Origin and Morphology of Limestone Caves'.[8] In it he states that 'Solutional caves form where there is enough subsurface water flow to remove dissolved bedrock and keep undersaturated water in contact with the soluble walls. This is possible only where a pre-existing network of integrated openings connects the recharge and discharge areas.'[9] However, a recent article states that using computers, 'Differing lithologies of bedrock in aquifers can also be simulated. They can cause isolated cave systems without entrances or exits or caves with entrances but no exits.'[10] Palmer adds, 'Dissolution rate depends on the chemical undersaturation of the water, but only weakly on flow velocity or turbulence.'[11] He cites a measured rate of limestone retreat in cave streams as being on the order of 0.04–0.08 cm/yr.[12] Based on his analysis, the average rate of wall retreat in typical groundwater averages about 0.01–0.1 cm/yr.[12] He claims that 'under favorable conditions a cave requires a minimum of ~10,000 years for its initial phase. Several thousand years more are required for it to reach traversable size.'[13] He adds that 'Rates in typical groundwater are probably slower by an order of magnitude.'[13]

It is obvious that these amounts of time are incompatible with a biblical interpretation of Earth history, especially when we consider that the rock in which we find Hamilton Cave (which obviously predates the cave itself) contains numerous fossils which are in strata which biblical creationists would consider to have been formed during the Noachian Flood. As with all dating mechanisms, there are underlying assumptions. They are usually stated as being (1) the initial conditions, (2) an assumed constant rate of change and (3) no outside interference in the process which is being used to calculate a period of time.

As far as the initial conditions are concerned, the Deluge and the subsequent continental uplift of the Flood-formed strata all in about a year's period of time would have provided vastly different conditions than what may have been expected from an extremely slow uplift of sedimentary rock. These differences would likely include the degree of consolidation of the strata, amount of water available for passage formation, temperature, mixing of chemicals, pressure and pH. Powerful evidence for a Flood origin of the strata can be seen in the extensive, jumbled marine fossils found in the cave walls. So the cave's initial conditions were evidently not those assumed by Palmer's model.

As far as the second assumption is concerned, rates of change during the post-Flood Ice Age would likely have been far different from today's rates due to the vastly different conditions then present. The amount of water available for recharge during the whole time from inception to the present may have varied considerably, as well as its temperature and pH. As we shall see, the cave exhibits dramatic evidence that more than just dissolution was involved in its formation. We shall examine evidence that the cave was altered by flooding during the Ice Age. This would have resulted in rates of change which were far from constant.

Concerning the third assumption, other factors were very likely involved in the formation of Hamilton Cave besides just CO_2 dissolution. I have already mentioned Palmer's statement regarding mechanical passage enlargement above. However, in his calculated time of at least 10,000 yr (or 100,000 yr!), he apparently did not take into account this additional process.

Another factor mentioned by Palmer which can modify the rate of cave enlargement is water entering into the passages due to flooding. 'Flood waters temporarily raise the water table in caves far above its normal level, modifying pre-existing passages, creating new ones, and blurring the distinction between vadose [above water table] and phreatic [below water table] development.'[14] He adds that 'abrasion by stream-born sediment can drive the rate [of enlargement] higher than calculated by the equations.'[13] Again, Palmer states that 'Although flood-water processes operate only during a small part of the year, they involve such intense dissolution and abrasion that, under favorable conditions, traversable passages can form in less than 10,000 years.'[15] It is therefore not inconceivable that powerful and frequent flooding of Hamilton Cave in the past (especially due to a damper climate during the Ice Age) could have contributed to enlarging it to its present size within a biblical timescale.

Is there evidence for such flood modification in Hamilton Cave? Many Ice Age vertebrate fossils have been found buried in the floor of Hamilton Cave, especially in the 'Cheetah Room', located about 150 m into the cave. Even though the entrance to the cave today is located 55 m above the shallow South Branch of the Potomac River, it seems most plausible that this fossil assemblage is the result of river flooding. This is because the bones of these animals were most likely washed back into the cave, rather than having accumulated there due to either the animals venturing in

that far or having been brought there by predators (this is discussed in more detail in a subsequent paper dealing with the fossils of Hamilton Cave[16]). Therefore, either the river was deeper during the Ice Age or the river bed was higher, or there were one or more high floods during that time (or more than one of these possibilities were true). So river flooding during this time would have contributed to the formation of the cave, resulting in a more rapid rate of formation than would have occurred otherwise.

There is additional evidence for flooding in Hamilton Cave. Palmer tells us that solution pockets can form rapidly due to flooding.[15] There are many such features in Hamilton Cave, as shall be described below. He also adds that 'Where fractures are prominent and flooding is severe, network mazes can form.'[15] Hamilton Cave, as has already been stated, has an extensive network maze. These features could therefore be interpreted as possibly being the result of severe flooding, which would greatly increase the rate of passage formation. However, I believe that the flooding that was the primary cause of these features and the formation of Hamilton Cave was not Ice Age local flooding. Rather, it was flooding due to the rapid expulsion of hypogenic water during the tectonic upheaval associated with Noah's Flood.

Hypogenic cave formation

Not only can network caves be formed by flooding, but Palmer relates that they can also be formed by hypogenic activity: 'Regardless of their size or flow, if many fissures receive thermal water of similar character, they will all enlarge at the same rate, forming a network maze.'[17] It is his belief that 'most thermal cave origin probably requires the presence of hypogenic acids or mixing with meteoric water from nearby sources.'[17] 'In humid climates, there must be many caves initiated by deep-seated processes that have not yet been suspected of having such an origin. Prime candidates are certain network caves in the Appalachians that show no evidence for flood water or diffuse recharge.'[18] His explanation as to why these caves have not been suspected as having a hypogenic origin is that in humid climates 'invading surface water tends to overwhelm the deep-seated process, or to modify the caves so that their pre-existing hypogenic features are masked.'[18] As discussed in the preceding section, Hamilton Cave is a network cave in the Appalachians so it would be a candidate for hypogenic formation according to the view of the uniformitarian cave expert, Palmer. And even though this cave shows evidence for flood water activity, there is also additional evidence for it having a hypogenic origin. Palmer relates that hypogenic caves may have ceilings which contain rounded, dome-like alcoves.[17] There are several of these in Hamilton Cave, providing such evidence.

Palmer claims that 'Doubling either the thermal gradient or $[CO_2]_i$ (initial aqueous CO_2 concentration) allows a potential increase in growth rate of approximately ten times.'[17] So a hypogenic factor in the formation of Hamilton Cave plus subsequent flooding could have together significantly increased its rate of formation over that surmised by only considering a meteoric source of water. This could result in it not being unreasonable for the cave to have been formed within a biblical time frame.

Cave rock relief formation

While it is universally believed that limestone caves are primarily the result of chemical dissolution rather than mechanical erosion, some features in the walls of some caves can be attributed to the erosive as well as the corrosive action of moving water. Such features are called 'cave rock relief' and include ceiling and wall pockets. Mihevc *et al.* discuss this in a part of their 'Morphology of caves' article under the heading, 'Erosional sculpture within passages (rock relief)'.[19] They attribute such features to eddies in flow.[20] There are many smoothly rounded pockets found in the ceiling, walls and floor of Hamilton Cave, giving evidence of voluminous amounts of swirling water formerly moving through the passages wherein they are found (figure 5). There are also other examples of smoothly curved cave rock relief, such as pendants. Some students of karstology may attribute such erosional features to a water-filled passage in which the water moves very slowly and forms these features over long periods of time. However, there has already been presented evidence for considerable flooding in Hamilton Cave and it seems reasonable to attribute the erosional features to such flooding, resulting in their formation in a relatively short period of time.

Did the same water that sculpted these cave rock relief features also form the cave itself or were they sculpted after the cave was formed? In order for them to have been sculpted out of consolidated rock after the cave was formed, there would have needed to be a large volume of water available to move under great pressure. Could this water have come from the depths of the cave? According to the cave's map, the US Geological Survey map of the land above the cave and personal observations of the terminal region of the cave and the environs above the cave (and also personal conversation with one of the members of the first team to

Figure 5. This smoothly-curved, cup-shaped wall pocket (number 5) in Hamilton Cave measures 46 cm wide and 57 cm deep.

Table 1. Orientation of ceiling and wall pockets in Hamilton Cave. Angles of more than 90° are oriented toward the entrance and angles of less than 90° are oriented toward the terminus.

Pocket #	dist. from entrance (m)	location (left, right, ceiling)	width (cm)	depth (cm)	vertical dimension (cm)	angle (degrees)	orientation (towards entrance or terminus)
1	160.0	R	195	170	125	90	--
2	160.0	L	107	103	88	90	--
3	172.0	R	38	62	78	90	--
4	176.0	R	46	46	100	48	T
5	176.6	R	46	57	51	90	--
6	176.6	L	36	46	153	90	--
7	185.0	R	64	62	113	90	--
8	186.0	R	160	160	130	90	--
9	186.0	R	215	300	192	90	--
10	186.0	L	59	90	72	132	E
11	188.5	C	23	23	18	90	--
12	189.9	C	15	21	18	180	E
13	190.5	C	20	44	46	105	E
14	194.2	side	33	13	21	90	--
15	194.3	side	36	13	31	90	--
16	196.1	R	46	46	33	90	--
17	196.1	L	92	54	92	90	--
18	202.7	side	41	36	31	120	E
19	203.1	side	54	26	21	90	--
20	203.8	R	18	51	31	180	E
21	205.3	C	125	82	65	90	--
22	211.3	C	130	130	38	90	--
23	208.5	R	52	31	25	< 90	T
24	208.5	L	59	31	38	> 90	E
25	215.1	C	130	125	246	90	--
26	217.9	R	82	69	90	50	T
27	235.2	R	25	13	105	135	E
28	236.8	R	51	23	82	50	T
29	237.7	side	41	15	36	140	E
30	240.0	C	62	70	74	0	T
31	241.2	C	64	46	36	107	E
32	241.8	C	36	28	31	0	T
33	241.8	C	62	59	33	0	T
34	242.9	side	18	62	28	110	E
35	244.8	side	39	15	62	50	T
36	245.1	side	46	18	52	50	T
37	245.7	side	49	51	39	180	E
38	246.2	side	21	18	31	90	--
39	247.6	side	46	26	49	155	E
40	249.4	side	21	39	59	0	T
41	252.5	side	31	18	36	105	E
42	257.1	side	74	51	130	130	E
43	257.7	side	62	31	82	130	E
44	257.7	opposite side from 43	31	54	82	120	E
45	259.5	side	21	23	31	50	T
46	261.8	side	62	83	105	0	T
47	273.1	side	87	62	54	47	T
48	273.1	C	~ 70	68	46	90	--
49	273.8	C	92	185	~ 46	90	--
50	277.4	side	51	31	72	90	--
51	277.5	side	76	64	82	--	--
52	277.5	side	51	87	21	68	T
53	298.9	side	33	31	--	< 90	T
54	303.8	side	66	117	165	0	T

reach the terminus of the cave), it appears that there is no exit from the cave's depths. Since this cave apparently has only one entrance and dead ends in the middle of Cave Knob, with no connection to any underground river, there would not be sufficient pressure to drive any water from within the cave outward with enough power to do the sculpting.

Could large amounts of pressurized water have flowed into the cave to sculpt these features? Water would not flow under great pressure into the cave from the outside (through the entrance) because there would have apparently been no exit for such a flow. In addition, if all the water that carved these features came from either the outside or the inside, then all of these features would have been oriented in the same direction (towards the entrance or towards the terminus). However, as shall be seen, some of these features are oriented toward the entrance while others are oriented toward the terminus. Thus, it seems most reasonable to conclude that the ceiling and wall pockets were not formed after the cave was formed. Therefore they must have formed contemporaneously with the passages of the cave.

However, it must be added that some caves have water flowing out of them (springs) at times and at other times have water flowing into them as a result of local flooding. But if such a scenario were responsible for the rock relief, then it would seem that an inordinate amount of water would have had to have been involved entering and exiting the cave for an inordinate amount of time in order to completely fill the passages so that ceiling pockets could be formed. This seems unlikely considering the cave's present location. Even if in the past the entrance of the cave were located nearer the Potomac River, that could possibly explain pockets oriented towards flow from without. However, such a scenario would not seem to be sufficient to establish an outward flow needed to form some of the rock relief features.

Orientation of cave rock relief formations in Hamilton Cave

In order to understand how the cave was formed, an investigation was made in order to determine how these water-sculpted features were formed. To this end, measurements were made of the orientation of the openings of the ceiling and wall pockets along the major passageway from the cave's entrance to the Rosslyn Escalator, a downward trending crevice found shortly anterior to the Air Blower (table 1).

According to table 1, measurements of over 50 wall and ceiling pockets reveal variable flow pathways. Such patterns are less consistent with a constant supply of acidic water from superjacent rocks and surficial infiltration. Instead, these patterns are more consistent with the Silvestru model.[21] In particular, figure 6 shows two adjacent ceiling pockets (numbers 48 and 49) connected by a window. Figure 7 shows another window between pocket 49 and the continuation of the passageway as a large corridor which drops down to a lower level. These two large ceiling pockets can be easily interpreted as having been formed as water moved upward and outward from the large corridor below, exerting pressure on the ceiling; rather than from an inward and downward flow from the direction of the entrance, which would have exerted more pressure on the floor. This indicates that the large corridor would have originally been a reservoir of hypogenic water.

Figure 6. Jared Smoker's head within a ceiling pocket, looking down into the cave through a window connecting to another ceiling pocket and out of that pocket through a second window to the cave below.

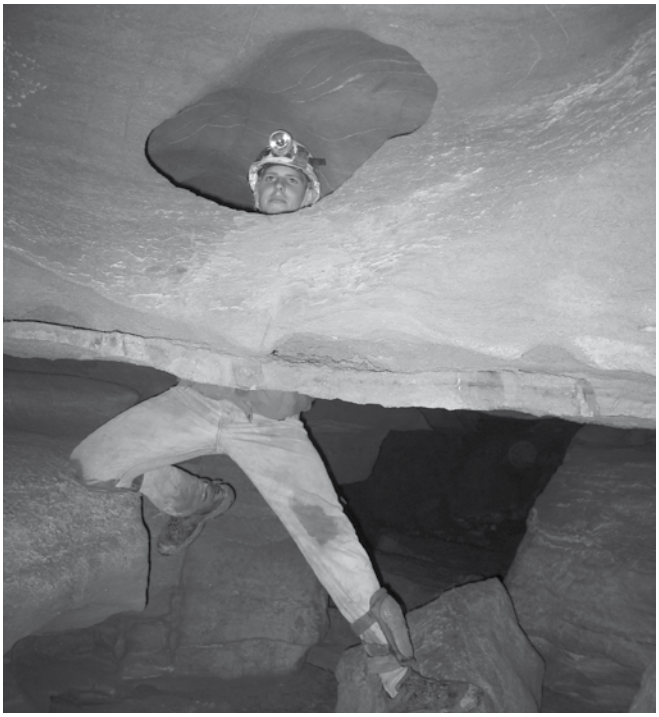

Figure 7. Jared Smoker's head in the lower ceiling pocket seen in figure 6. This pocket measures about 2 m wide and about 1 m from window to window.

Crystal formation

The many gypsum crystals (figure 2) located in the passageway before the 'Airblower' also could have been formed as a result of hypogenic activity. Gypsum crystals ($CaSO_4 \cdot 2H_2O$) are generally believed to form subaerially as sulfate rich water infiltrates to the cave walls. Such sulfate-rich water would provide evidence that sulfuric acid karsting had indeed previously taken place. 'If the concentration of dissolved sulfate is great enough, it can replace the limestone wall rock with gypsum.'[22] So Hamilton Cave's crystals also give evidence for hypogenic activity in the origin of the cave, not just carbonic acid dissolution from meteoric water.

Model of Hamilton Cave formation

In order to explain the formation of this cave in keeping with the requirement for large amounts of pressurized water, Emil Silvestru's model of cave formation will be applied to Hamilton Cave.[21] Silvestru's model consists of four consecutive stages briefly described as follows:

1. Porous, unconsolidated, karstic rocks (formed during Noah's Flood) were intensely circulated by hydrothermal solutions ascending from below, also as a result of the catastrophic events associated with the Flood. These hot, acidic solutions would have produced chambers holding reservoirs of water.
2. The uplift of rocks toward the surface of the Flood waters (producing a change from ascending solutions to descending solutions), accompanied by orogenic movements and diagenesis (hardening of soft rocks), resulted in the formation of cave passages.
3. As the reservoirs' solutions drained downward, they drew other fluids still in the rocks downward, also, which intensified conduit formation.
4. Karsting continued from the movement of water above the cave passages down into them, resulting in breakdown and collapse.

Perhaps, in the final stages of Noah's Flood, the same forces that caused continental uplift also forced acidic, hydrothermal solutions to ascend into and dissolve out chambers in rapidly lithifying limestone (later to become the 'Slab Room', the large corridor just anterior to the Rosslyn Escalator, and other rooms, including the large 'Bowl Room' located near the terminus of Hamilton Cave). Joints (later to become cave passages) would also have formed at this time. Some of these joints would connect chambers and one would lead to the surface (later to become the entrance to Hamilton Cave). Joints connecting these chambers would have allowed this superheated, pressurized, acidic water to violently gush through them, dramatically enlarging them into cave passages by erosion and dissolution, and sculpting smoothly contoured pockets as they did so in a short amount of time. The maze section of the cave is located at the top of an anticline,[23] and the orogenic process which formed that anticline may well have been responsible for a labyrinthine pattern of joints at its top that later were enlarged to become the maze. As the hydrothermal water gushed out of the chambers, this would draw forth additional water from the saturated rocks above them, adding considerably to the total volume of water being discharged from those chambers.

From the terminus of Hamilton Cave it is about 186 m to the surface at the top of Cave Knob. If all 186 m of water-saturated rocks were to discharge their water into the Bowl Room, the pressure may have been considerable, resulting in a flow which would have further enlarged the passages in a short period of time. As the initial powerful flow subsided, there would have been a continuation of waters moving down from the overlying rocks into the cave passages and out the entrance at a slower (but still considerable) rate. This would have resulted in the significant amount of breakdown which can be seen in the 'Bowl Room', the 'Slab Room' and the large corridor anterior to the 'Rosslyn Escalator'. After this would have been the time when rapid speleothem (stalactites, stalagmites, etc.) growth occurred.

So the apparent flow directions indicated by the pockets etc. would have been caused by water flowing from the rooms toward the entrance and also toward the terminus. And the explanation for pockets oriented in both directions between the 'Slab Room' and the large corridor is that water flowed in both directions in that region. As water flowing from the large corridor approached the 'Slab Room' it would slowly lose pressure as it dispersed into side joints, enlarging them. It would also lose pressure because of the force of water coming from the 'Slab Room' until finally the water from the 'Slab Room' pushed back into the same passages which were just enlarged by water from the large corridor. In addition, as water from the large corridor gushed down towards the depths of the cave it would leave that corridor partly emptied, so that water that had just been ejected outwards and upwards would have returned back to that corridor. So this backwash could also have contributed to the formation of pockets oriented in both directions between the slab room and the large corridor. Perhaps the main direction of water movement in such a chaotic scenario alternated several times, resulting in the alternating pattern of pocket orientation. The pockets would have been formed whenever rushing water encountered an area in which it was temporarily impeded by, for instance, a narrower joint. The water would tend to swirl around and form pockets until the impediment was overcome by the water's pressure.

To summarize, the cave rock relief found in Hamilton Cave can best be interpreted as giving evidence for a hypogenic origin of the cave, rather than a meteoric source. In addition, these features would not likely have been formed by backflooding from the Potomac River.

Conclusion

In Palmer's 'The Origin of Maze Caves', he gives his interpretation of the origin of Hamilton Cave as follows:

'Tension along the crest of the anticline has

> probably been a factor in determining the strong joint control of the networks. … Thickness of the overlying bedrock is apparently the key factor in selective enlargement of the joints, for, of all the passages, the networks are located closest to the overlying land surface, where joint enlargement by erosional unloading has been most pronounced. Groundwater recharge to the mazes during their development was probably contributed both by diffuse recharge through the overlying surface and by backflooding from the river early in the history of the water gap.'[4]

Although Palmer did not mention a time factor in the above reference, it may be assumed from his other writings that he would have believed that much more time was involved in the formation of Hamilton Cave than would be allowed from a literal biblical perspective. To Palmer's model I would add that the evidence can be readily interpreted that Flood-associated, catastrophic, acidic, hypogenic activity was significant in the cave's formation. I agree with him that a mechanical factor was also significant. However, I would ascribe this joint enlargement to the catastrophic effects of rapid continental uplift occurring during the aftermath of the Flood. I agree with Palmer about backflooding from the river; but do not think that this was significant in the cave's formation. From my personal observations, I have noticed no alluvial sediments which would have formed if such were the case. However, I believe that backflooding was most likely the cause of Ice Age, vertebrate fossils being buried in the cave's floor in the Cheetah Room.

In conclusion, I believe that there are several factors which left evidence of having been involved in the formation of Hamilton Cave in a timeframe agreeable with a biblical perspective. These factors would be responsible for increasing the rate of passage enlargement over that due solely to meteoric dissolution, the conventional mechanism for cave formation. These factors include tectonic uplift, the cooling of hot water, mixing of waters of different chemistry ('Solutional aggressiveness can be renewed or enhanced by mixing waters of contrasting chemistry'[14]), acidic water ('Conversion of H_2S to H_2SO_4 provides a sudden burst of dissolution'[22]), and flooding (during the Ice Age and especially during hypogenic activity when subterranean reservoirs were drained). It is my view that Hamilton Cave's features provide compelling evidence that all of these factors were involved in the cave's formation and that the combined effect would have been responsible for forming this cave in the time available since the Flood.

Acknowledgments

I wish to thank Jayson Auxt, Phillip Auxt, Tim Auxt, Tricia Auxt, Cameron Eaby, Jordan Keefer, Daniel Smoker, and Jared Smoker for their invaluable assistance in measuring and photographing various features of Hamilton Cave. In addition, special thanks are due to Emil Silvestru and an anonymous reviewer for their suggestions concerning this article.

References

1. Davies, W.E., Caverns of West Virginia, *West Virginia Geological Survey* **XIX** (A):10, 1958.
2. McCue, J.B. *et al.*, Limestones of West Virginia, *West Virginia Geological Survey*, **XII**: p. 24, 1939.
3. Davies, ref. 1, p. 213.
4. Palmer, A.N., The origin of maze caves, *The NSS Bulletin* **37**(3):72, 1975.
5. Lowe, D.J., Inception of caves; in: *Encyclopedia of Caves and Karst Science*, Gunn, John (Ed.), Fitzroy Dearborn, London, England, p.437, 2004.
6. Lowe, D.J., Speleogenesis Theories: Post-1890, ref. 5, p. 673.
7. Palmer, ref. 4, p. 71.
8. Palmer, A.N., Origin and morphology of limestone caves, *Geological Society of America Bulletin* **103**:1–21, 1991.
9. Palmer, ref. 8, p. 1.
10. Dreybrodt, W. and Gabrovsek, F., Speleogenesis: Computer models, ref. 5, p. 678.
11. Palmer, ref. 8, p. 6.
12. Palmer, ref. 8, p. 8.
13. Palmer, ref. 8, p. 10.
14. Palmer, ref. 8, p. 4.
15. Palmer, ref. 8, p. 14.
16. Manning, A., Fossils of Hamilton Cave, West Virginia, *Journal of Creation* **21**(2):116–120, 2007.
17. Palmer, ref. 8, p. 18.
18. Palmer, ref. 8, p. 19.
19. Mihevc, A. *et al.*, Morphology of caves, ref. 5, pp. 521–524.
20. Mihevc, ref. 19, p. 523.
21. Silvestru, E., A hydrothermal model of rapid post-Flood karsting, *Proceedings of the Fifth International Conference on Creationism*, Creation Science Fellowship Inc., Pittsburgh, PA, pp. 233–241. 2003.
22. Palmer, ref. 8, p. 17.
23. Dasher, G., The caves and karst of Pendleton County, *West Virginia Speleological Society Bulletin* **15**:160, Aug. 2001.

Arthur Manning has a Master's degree in biology from the Institute for Creation Research Graduate School and teaches high school science in Utah. He gives creation presentations in a wide variety of settings and has conducted many creation field trips to several places, including the Smithsonian and Hamilton Cave, West Virginia.