

# Taphonomic Processes of Bone Distribution and Deposition in the Tufa Caves of Taung, South Africa

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The tufa caves at Taung create a somewhat unique depositional environment for the bones that are brought in by various taphonomic agents. The Taung hominin skull, type specimen of *Australopithecus africanus*, and associated fossil fauna must be interpreted within the particular context of such tufa caves. Taphonomic experiments with three animals were conducted to elucidate the nature of bone distribution and deposition in a cave that is similar in nature to those in which Pliocene fossils were deposited. It was found that dry portions of the cave tend to preserve a higher proportion of the skeletal remains, and that the distribution of bones is relatively restricted. Skeletal representation of this nature parallels that found in the densely fossiliferous Hrdlička Deposits at Taung. This contrasts with the wet portion of the cave in which water activity tends to spread bones over a wider area and results in lesser skeletal representation. It may be postulated that fossils of the Taung Dart Deposits, perhaps including the Taung hominin, could have been deposited as water-borne carcasses. This taphonomic process would account for the singularity of the *Australopithecus* fossil and the sparseness of fossils in the Dart Deposits. Another important conclusion is that, as both dry and wet depositional processes can occur simultaneously in a single cave, sediments are not necessarily reflective of changes in conditions outside of the cave. Therefore, paleoecological interpretations of the Taung fossil sites must take into account the taphonomic agents and immediate conditions of deposition.

**Keywords:** TAUNG, KARST TAPHONOMY, TUFA CAVES

## Introduction

The complex nature of the type site of *Australopithecus africanus* has been elucidated by excavations and analyses of Pliocene

deposits at the Buxton Limeworks, Taung from 1987 through 1993. It is now apparent that the Pliocene fossils attributed to Taung came from multiple deposits of distinct cave systems, only one of which has yielded

hominin remains (McKee, 1993a, 1993b; McKee & Tobias, 1994). Excavations of the Taung deposits did not yield further specimens of *Australopithecus africanus*, despite multiple specimens of other species, and thus the singularity of the Taung child is in need of explanation. The diverse nature of the fossil assemblages found in separate cave deposits exhibits the consequences of varied ancient taphonomic processes. Observations of appropriate modern analogues of these caves can be used to propose taphonomic models necessary for the interpretation of the fossil assemblages.

Hypotheses concerning the taphonomic circumstances of Pliocene and Pleistocene fossil deposition have been generated from the considerable research conducted on southern African cave taphonomy (Brain, 1981, 1993; Newman, 1993; Maguire *et al.*, 1980; de Ruiter & Berger, 2000), but most of the postulated models apply to the larger dolomitic caves of the Transvaal. The cave systems at Taung, however, formed in dynamic calcareous tufa accretions and are thus distinct from dolomitic caves in their smaller size, geomorphology and environmental setting (Marker, 1971; Brain, 1985; McKee, 1993a).

Episodic deposition of calcium carbonate layers formed the Taung tufas along the dolomitic Ghaap escarpment from Pliocene times to today. Springs from the water table in the dolomite carried a calcium bicarbonate solution of water; through evaporation and the photosynthetic action of moss and algae, layers of calcium carbonate precipitates accreted as successive hemispherical sheets of lime travertine (Young, 1925; Marker, 1971, 1973; Partridge, 1985; McKee, 1993a). As the lime carapaces built out from the escarpment, carapace caves would form as gaps on the surface (Figure 1).

Such caves would often fill with sediment and debris, including bones, only later to be sealed as the tufa continued to accumulate over the cave openings. In association with other local environmental factors (McKee *et al.*, 1995), the unique nature of each cave would have determined the types of animals that used the cave as well as the taphonomic forces of bone accumulation, distribution, deposition and preservation. The presence of actively forming caves in the Taung region allows for observations and experimentation on aspects of taphonomy that may help to resolve some of the outstanding questions about the ancient cave deposits.

Taung has always been enigmatic because much if not all of the hominin-bearing cave deposit was destroyed by quarry activity. Until recently, most of our knowledge about the site came from the research of Frank Peabody, who studied the Buxton Limeworks for a year spanning 1947-1948 (Peabody, 1954). Peabody postulated that the *Australopithecus* type locality was part of an extensive labyrinthine cave system connected to the fossiliferous deposits of a quarry remnant known as the Hrdlička Pinnacle. The Hrdlička deposits were characterized as having formed in two phases: an earlier “dry phase” in which most of the fossils accumulated and became encased in a sandy red breccia, followed by a “wet phase” in which bone deposition was less common but resulted in the fossilization of the Taung hominid in a silty pink breccia. These breccia phases have been interpreted as reflecting environmental conditions outside the caves (Butzer, 1974; Butzer *et al.*, 1978), and used to associate the Taung *Australopithecus* skull with particular deposits.

Opposing viewpoints have arisen concerning whether or not the *Australopithecus* fossil should be directly associated with the Hrdlička deposits. It is true that one sample

of breccia from part of the remnant cave fill is quite similar in its particle size distribution to the matrix from which the Taung hominin was extracted, leading to the suggestion that the skull had come from those deposits (Partridge *et al.*, 1991; Tobias *et al.*, 1993). On the other hand, analyses of the geomorphology of tufa caves (McKee, 1993a) combined with clues from the historical record and excavations (McKee & Tobias, 1994) strongly suggest that the *Australopithecus* cave was separate from the Hrdlička deposits, probably predating them, and may be most closely associated with the more recently discovered "Dart deposits" (6 m lower and 60m to the west of the back wall and floor of the Hrdlička cave). In either case, the Taung hominin skull was associated with sparsely fossiliferous breccia, in stark contrast to the sandy red breccia of the Hrdlička deposits which are densely packed with mammalian skeletal remains and particularly with nearly complete skeletal representation of early baboons (*Parapapio antiquus* and *Papio izodi*). This suggests that distinct taphonomic process may have resulted in the different characteristics of the deposits, and a single taphonomic model would be inappropriate for the assemblage as a whole.

Research on appropriate modern taphonomic analogues may help to answer some of the questions that arise from the debates about Taung. Experiments conducted in a carapace cave of the Blue Pool tufa at Taung provide clues to nature of bone distribution and deposition that elucidate the conditions leading to dense and sparse accumulations as well as to putative "wet phase" and "dry phase." The implications of these initial experiments are reported here toward generating testable hypotheses concerning the nature of the ancient Taung caves. Although the sample size is small, they elucidate some

key considerations for the interpretation of the Taung fossil assemblages.

### Experimental context and procedures

Carcasses of three animals were used for taphonomic experiments in a cave of the Blue Pool tufa known as "Razor Cave" (Figure 1). This cave is one of the larger carapace caves (McKee, 1993a), extending to a maximum horizontal depth of approximately 8 m perpendicular to a mouth that reaches 16 m across the dissected shale valley. The extensive cave mouth has four enlarged openings, through which medium-size mammals can pass, on the eastern overhang of the carapace. Two of the entrances are above the normal water level of the Thabasikwa River, whereas the others bring in a backflow of river water up to a maximum depth of approximately 1 m.

During 1991, the carcasses of a juvenile baboon and a dog were taken into the most southerly entrance of the cave and left in a perennially dry chamber. (Neither animal was sacrificed for this purpose, but were moved to the cave when their deaths were brought to the attention of the author.) The dry chamber extends over 8 m diagonally up a gentle 2° slope before dropping abruptly down to the larger wet chamber. Currently the dry floor comprises mostly water-worn pebbles along with minimal organic matter that has been carried or blown in through the entrance. The conditions of the animals' remains were checked periodically over subsequent years through 1994.

In most of the remainder of Razor Cave, river water usually flows over the cave floor. The water depth varies from year to year, but is normally about 0.6 m deep; the maximum height of the cave is 3.5 m.

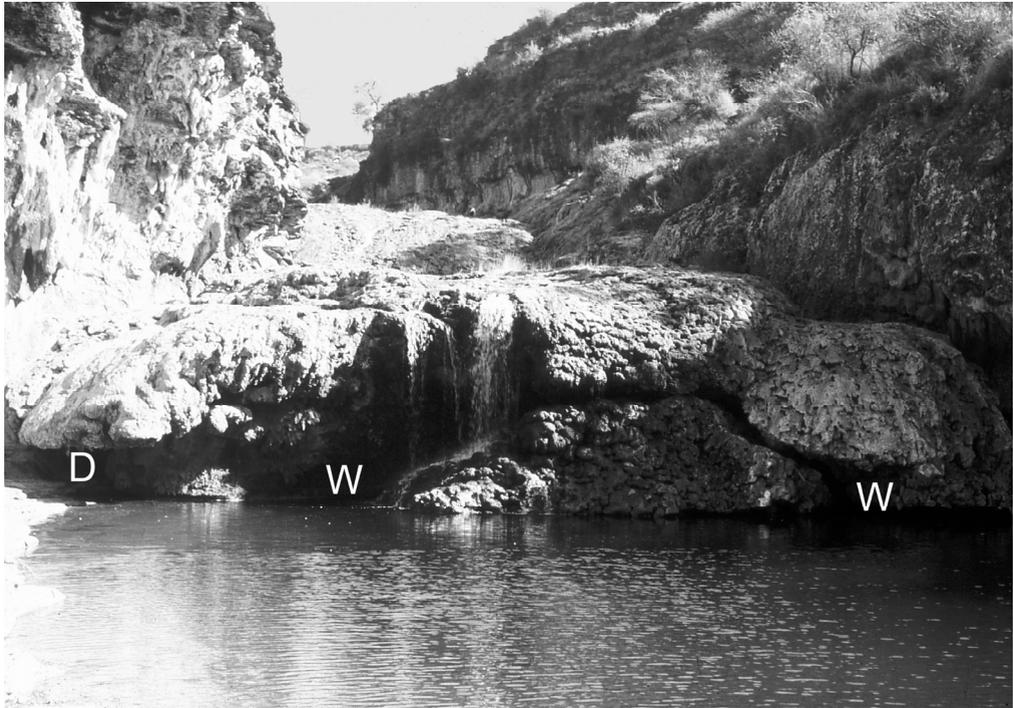


Figure 1. Opening to Razor Cave at the base of a tufa accretion in the Thabasikwa River valley. The southern opening (D) leads to the dry chamber, with the remaining openings (W) leading either directly or indirectly to the wet portion of the cave. An additional dry opening is not visible on the right. The cave system is approximately 16 m across the valley.

Fortuitously, an adult goat drowned in the river in July 1991; the backflow of the river washed the complete floating goat carcass into the back of the cave where it was discovered by a student who was participating in the nearby excavation. The distribution of remains visible in the cave was observed when possible during the dry winter periods in years of drought.

Described here are the visible surface remains of the animals as of the last observation in November, 1994. No material has been excavated so that the process of deposition may continue unimpeded.

### **Descriptions of the animals and their remains**

#### *Juvenile Baboon Remains*

Near Razor Cave, a juvenile baboon was caught in a leg trap set by the local villagers and left to die. The trap had caused little direct damage to the animal, so it appeared that the baboon had died of starvation. After being retrieved by the author, the entire carcass was left on dry, rocky ground in a sheltered spot approximately 2.5 m back from the entrance, in March of 1991.

One month later, the entire baboon had been totally eviscerated, primarily by insects as evidenced by the numerous larval remains. Nothing but dry bones and fur remained of the baboon. Most of the bones were close to their original position, with the smaller bones and unfused epiphyses detached and lying on the ground. The mandible had become detached from the skull and moved by the insects, resulting in a change of relative positions with the mandible approximately 3 cm behind the occiput of the skull.

The baboon bones had become more dispersed by 1992, in part due to the apparent

use of the cave for a shamanistic ceremony (as evidenced by candle wax and other paraphernalia). The skull and mandible had been removed, presumably due to human interference, but the rest of the bones seemed to have been ignored. Traffic from baboons, humans and perhaps other animals entering the cave dispersed the bones over an area of approximately 1 m<sup>2</sup> by June 1993. The bones remaining at that time are listed in Table 1. The bones were largely intact, with no readily apparent damage. By late November 1994 their status remained virtually unchanged.

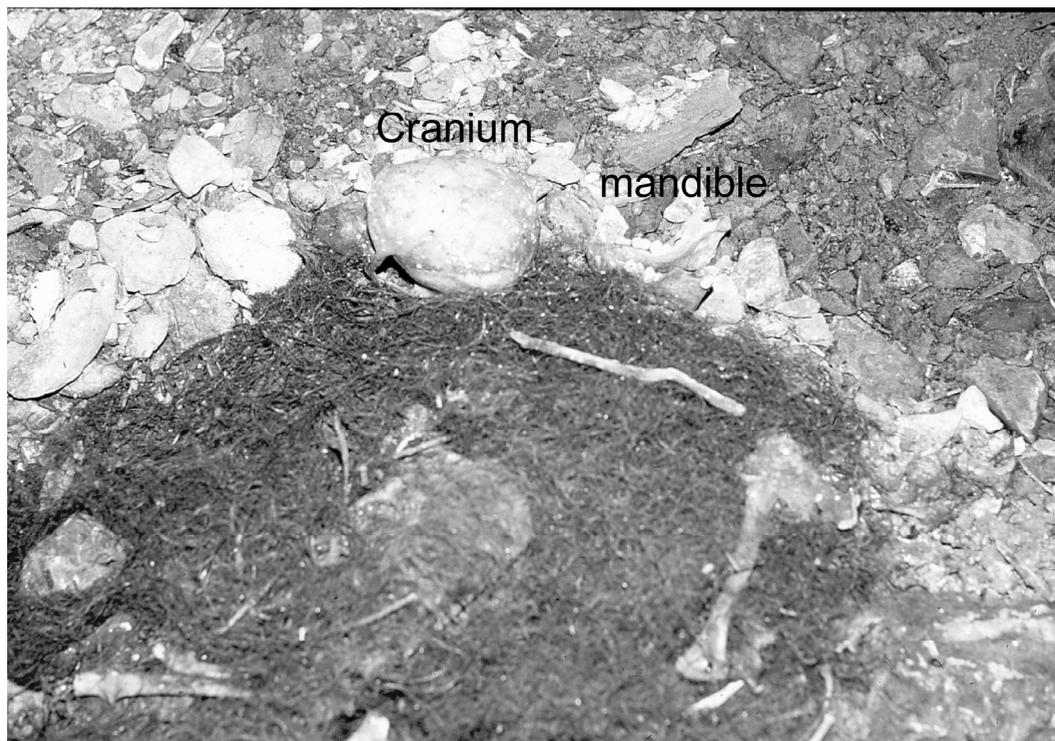


Figure 2. Remains of the juvenile baboon, one month after it was placed in Razor Cave. Note the cranium and mandible, having been separated by the maggots that defleshed the carcass. Most of the postcranial bones are covered with hair, but an ulna and humerus are visible.

*Table 1. Frequency of experimental animal bones remaining in Razor Cave. The total number of bones expected is based on a typical adult, with fused bones (e.g. individual bones of the cranium or sacrum) counted once. An asterisk (\*) indicates bones probably removed by human interference.*

	Goat 1992	Goat 1994	Dog 1993,1994	Baboon 1993,1994
Skull	1	1	1*	1*
Mandible	2 (halves)	2 (halves)	-	1*
Vertebrae	11	-	13	6
Ribs	19	3	7	4
Scapula	1	1	1	1
Humeri	-	-	1	1
Radii	-	-	2	1
Ulnae	-	-	2	2
Carpals & Tarsals	-	-	-	1
Metapodials & Phalanges	1	-	-	-
Sacrum	1	-	-	-
Pelvis	1 (whole)	1 (whole)	1 (half)	-
Femora	2	-	2	2
Tibiae	-	-	1	2
Total/Expected	39/136	8/136	31/153	22/210
Percentage	28.7%	5.9%	20.3%	10.5%

Bony elements such as unfused epiphyses and few of the smaller bones were not visible by the end of the study period. They may have disintegrated, but it is also possible that they slipped down between the rocks on which the skeleton lay. Careful inspection of the area revealed only one carpal or metacarpal bone deep amongst the rocks, suggesting that most of the rest may not have been preserved. Nevertheless, excepting the lost epiphyses, approximately 10.5% of the skeleton remained (see note in Table 1 legend).

Remains of the baboon skeleton in 1994 were still mostly exposed on the surface, but a small amount of sandy sediment and cave debris was beginning to cover the bones.

#### *Dog Remains*

In October 1991, a complete adult beagle carcass was left at the end of the dry passage, about 2.5 m deeper into the cave, upslope from the baboon's position. Just beyond this point the passage opens into the main chamber and the floor drops down sharply to below normal water level.

Natural processes took considerably longer to eviscerate the beagle than the baboon. It is not clear why the dog's viscera lasted nearly a year as compared to the one month for the baboon: the size of the animal, the position in the cave, and the temperature and humidity ranges are all potentially relevant variables. Nevertheless, the time of

evisceration may not be important for palaeontological purposes, for the pattern of bone preservation and distribution of the dog were similar to that of the baboon.

Gradual dissipation and destruction of bone left about 20.3% of the dog skeleton remaining as of June 1993. Again the skull had apparently been removed by human agents, but the rest of the bones remained in the same state and position in November 1994, as listed in Table 1. Most of the bones remained in a concentrated area along a level surface 1.2 m long and 0.9 m wide. The remaining observable bones lay on the slope leading down to the water. It is quite possible that additional remains were unseen, buried under the thick sediment at the base of the slope; on that slope, however, was the partially buried sacrum of an animal that did not come from any of the three experimental carcasses.

#### *Goat Remains*

The context of the goat in terms of the initial taphonomic agent and condition of deposition differs considerably from that of the dog and baboon. The dog and baboon were brought into a dry cave floor by a pseudo-predator (myself) in order to mimic the activity of a carnivore such as a leopard, which leaves most of the carcasses skeleton untouched (de Ruiter & Berger, 2000). A young adult goat provided a more serendipitous experiment, however, as it drowned in the river sometime during July 1991. The taphonomic agent was thus water, the gentle backflow of which carried the goat's bloated carcass into the deepest reaches of the cave.

Having remained afloat in the back of the cave for at least two weeks, the goat eventually sank and the flesh had begun to

disintegrate by our next visit two months later. During the dry winter seasons of drought years (1992 and 1994), when the Thabasikwa River receded from the cave, the distribution of remaining bones visible in the cave were observed.

Eviscerated skeletal remains of the goat, observed in June 1992, showed a 28.7% preservation of bones within the cave but a much more extensive distribution than characterized the baboon and dog. Activity in the water, which includes that of fish (barbel), spread the bones over an area extending to a maximum distance of 6.5 m across the underground channel. The cave floor had little sediment except along the margins of the tufa walls where bones and debris were partially buried. Egg shells from pigeons roosting in the cave also littered the floor, similar to the guinea fowl egg shells of the Dart deposits (McKee & Tobias, 1994; McKee, 2001).

The water level in the cave rose with subsequent rains, and the entirety of the cave floor remained under water until 1994. By November the entirety of the study area was dry enough to observe the condition of the remaining goat bones. Only 5.9% of the bones remained visible in the cave, representing 20.5% of the 1992 remains (Table 1). Presumably the other bones had washed away. Some smaller pieces may have been completely buried in the sediment along the tufa walls, but the sediment was no more than 3-5 cm thick, so certainly most if not all of the bones within it were visible on the surface with little evidence of weathering.

Although most of the bones observed in 1994 were in a position similar to that of 1992, there were two notable exceptions. The pelvic girdle, which had been resting on its right side, was now standing upright on the pubic bones near the back wall, where

its position was secured by fine sediment. The skull had moved over 2.5 m closer to the other remains, and unlike the other bones which were in good condition, had become somewhat potted with holes of unknown origins. There were no longer remains of eggshells visible, but there were now baboon faeces on the cave floor, rich in crab shell remains (see McKee, 1992).

## **Discussion**

Under two distinct modes of bone accumulation, distribution and preservation, the skeletal remains of the Razor Cave experiments reveal principles that appear to parallel the situations evident in the late Pliocene deposits of Taung. The dry portion of the cave in which the baboon and dog were left is characterized by a relatively complete preservation of skeletal parts and limited spatial distribution of bones. The fossils in the so-called "dry phase" red breccia of the Hrdlička Pinnacle deposits have a similar degree of skeletal representation and concentration of bone (McKee & Tobias, 1994). In contrast to the dry gallery of Razor Cave is the portion that is normally submerged under water, where the goat sank. This wet chamber is characterized by a relatively low preservation of skeletal parts and a more expansive spatial distribution of bones. Likewise, the "wet phase" pink breccia that is associated with the Taung hominin skull as well as the Dart Deposits, have poor skeletal representation and a low concentration of fossil bone (McKee & Tobias, 1994).

Natural processes of the Pliocene and Pleistocene, evidenced from other cave deposits, may account for aspects of the Taung deposits in association with the artificial taphonomic processes described

here. One may hypothesize that the Hrdlička deposits, particularly H-B and H-E (McKee, 1993a, 1993b), represent feeding lairs of a carnivorous animal that brought its prey into the depths of a dry low-roofed cave, not unlike the dry portion of Razor Cave. The lack of distinctive tooth-marks, save occasional punctures in the baboon skulls, as well as the common loss of proximal humeri, is consistent with the activity of leopard or leopard-like animal, as is the accumulation of a considerable amount of bone (Brain, 1981, 1985; de Ruiter & Berger, 2000; McKee, 2001). The high proportion of aeolian sands comprising the breccia (Peabody, 1954; Butzer, 1974; Butzer *et al.*, 1978), is consistent with such a model, hence the notion of a "dry phase".

Goat remains from the wet portion of Razor Cave suggest that a different set of conditions may have characterized the deposition of the Taung hominin and of the Dart deposits. I postulate that the carcasses of the animals whose remains litter the deposits may have been water-borne, much in the same way as the goat. The Taung child itself may have been left at the water's edge by a predator or simply drowned in a pool outside the cave (the latter of which is not uncommon in shallow pools at Taung today). It has been hypothesized that a bird of prey may have contributed to the assemblage (Berger & Clark, 1995; Berger, 2006), but as other large bovid bones with tooth marks were found in the Dart deposits, a bird of prey would likely not have been the sole contributor (McKee, 2001). Irrespective of the death agent, the backwash of the water would have carried its complete body or body parts into the cave where it subsequently sank and became deposited with a few other such animals, with only certain portions surviving. This process, not the alleged bird of prey (as per Gilbert *et al.*, 2009), would explain the

singularity of the hominin and the sparseness of the fossils in the Dart deposits.

Connotations of the high silt content in the breccia from which the Taung hominin was extracted (Peabody, 1954; Butzer, 1974; Butzer *et al.*, 1978; Partridge *et al.*, 1991; Tobias *et al.*, 1993) may support the above hypothesis, for the silt deposit may represent a quiet portion in the back of a cave. One can apply a model in which water-borne sediments wash back into the cave, with the coarser sediments precipitating out first and successively finer sediments carried to more stable environments near the back of the cave. This may also explain the remarkable preservation of the Taung skull, with the mandible still in occlusion, if the head, like the goat pelvis, found itself in a relatively undisturbed position near a cave wall.

Hypotheses concerning the ancient processes at Taung should be subject to a number of reservations, despite the general concordance of observations on recent phenomena and Pliocene fossil deposits. First, there is very little sediment in Razor Cave in which to bury the bones, with neither much sand in the dry portion nor much silt in the wet portion. As the allegedly comparable fossiliferous deposits provide evidence of bones laid upon varying proportions of sand and silt, the conditions have not been precisely duplicated. Sedimentation rates may have been higher during the deposition of the respective deposits, and this may have altered the conditions of bone preservation and distribution to an unknown degree. Other known tufa caves along the Ghaap escarpment have considerably greater amounts of sediment in them today, and may provide a source for further corroborating experiments; this would be necessary as the sample reported here is quite small. Nevertheless, given the variety of conditions that exist simultaneously

within a single cave, and among other caves in and around Taung, one must be careful of claims of general dry and wet "phases" based upon the sediments alone. Although phases may occur within parts of a cave, they do not necessarily reflect significant ecological changes outside the cave.

It should also be noted that whereas the Dart Deposits have been postulated to be associated with the hominin deposits (McKee, 1993a, 1993b; McKee & Tobias, 1994), initial breccia samples have exhibited low silt contents in contrast to the high proportion of silt characterizing the Taung hominid matrix (Tobias *et al.*, 1993). On the other hand, the matrix of deposit D-D is horizontally stratified in fine layers, and is highly suggestive of water deposition (McKee & Tobias, 1994), albeit with a high sand component. It has yielded only one fossil mandible of an extinct baboon (*Parapapio cf. broomi*). Further west in the Dart Deposits is D-C, representing an area deeper in the ancient cave, continuous with D-D (McKee & Tobias, 1994), which contains considerably more fossils but which is not nearly as densely fossiliferous as the Hrdlička Deposits. If the model of sand and silt precipitation suggested above is true, then further tests of the breccia may reveal silt contents more similar to that associated with the Taung hominid.

## Conclusion

Local conditions within tufa caves play an important role in the distribution and preservation of skeletal remains. Contemporary observations in Razor Cave lead to the hypothesis that Taung *Australopithecus* child, whether drowned or left by a predator, washed back into cave in unique but replicable and explicable circumstances. This scenario is

based upon observations of contemporary taphonomic processes and correlates with aspects of the fossil record, in which water-borne deposition results in a more sparse distribution of bone as compared to the distribution apparent in drier portions.

Despite years of excavation and research, the precise conditions of deposition for the Taung hominin, like the cause of death, will never be known. Too much of the ancient cave system has been lost, and records of its exact locality are vague. However, the initial taphonomic experiments reported here reveal principles that are most relevant to the particular situation in the tufa caves at Taung, and which may be applied to the continuing study of Taung fossil deposits. The most important conclusion is that past conditions of deposition would have been highly dependent not only on time and the external environment, but on the immediate taphonomic agents as well as the particular part of the cave in which deposition occurred.

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