

# The *Homo naledi* “Burials” are Highly Improbable



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Submission: November 02, 2017; Published: November 28, 2017

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## Abstract

In 2015 the discoverers of *Homo naledi* in the Dinaledi Chamber of the Rising Star Cave of South Africa proposed ‘Deliberate Disposal’ (i.e. burial) as the best explanation for this uniquely rich monospecific trauma-free fossil deposit. Due to the small brain size and other primitive features of this new species, the proposed ‘cultural’ explanation was met with considerable skepticism, practical difficulties were soon pointed out and other possibilities proposed, but due to lack of dating and other details the issue remained unresolved. Concrete dating of the fossils and additional information published recently by the same team has led them to reaffirm the ‘cultural’ hypotheses in three separate papers, but the evidence is still unconvincing. In fact, several of the conditions the authors claim to be evidence for burial are shown to argue against this option. Alternative ‘natural’ mechanisms are proposed, evaluated and estimated to be significantly less improbable than the burial hypothesis.

**Keywords:** *Homo naledi*; Dinaledi chamber; Burial; Traps; Cave; Paleoanthropology

## Introduction

In 2015 I attended a talk by Becca Peixotto on the Rising Star Cave Expedition and the discovery of *Homo naledi* [1], in the Dinaledi Chamber of the cave. The story is fascinating, but seen from my experience in wildlife trapping the chamber-as-a-trap idea seemed feasible, whereas their proposed ‘deliberate disposal’ idea seemed farfetched. Further analysis supported this view, but the arguments for and against the idea remained inconclusive.

Dirks et al. [2] of the same team, propose that these cave deposits may indicate deliberate transport and deposition of dead group members in a deep recess of the cave system and might thus represent early evidence of burial. The facts prompting this suggestion include: skeletons are remarkably complete and some are articulated, it is a huge mono specific sample, over 1550 bones of 15+ individuals, it is not a mass event, rather they came in one at a time over time, there are no signs of predation or trauma and the age distribution is mostly young, few adults and some old, similar to burial sites.

This, they point out, contrasts with most or all other known early cave deposits which are poly specific, hominin remains are fragmentary and amongst the rarest in the assemblages, the bones are scattered and incomplete, not articulated, usually missing all the smaller ones such as wrist bones, and signs of either injury or predation-scavenging are frequent.

Dirks et al. [3] Considered several explanations for the Dinaledi Chamber deposits and refuted all but two, but no viable

‘natural’ mechanism has been proposed, as opposed to their ‘cultural’ one. Briefly I list the hypothesis they considered:

- a. H1. No evidence of Occupation in the Dinaledi Chamber.
- b. H2. No evidence of Water transport (flood or significant current). There is evidence of slumping.
- c. H3. No evidence of Predator accumulation in the Dinaledi Chamber, but many in Dragon’s Back chamber. Also no damage indicative of intra-species fighting or cannibalism.
- d. H4a. Mass fatality (catastrophic) no evidence of flood, massive roof collapse or other catastrophes. Deposits show amazingly little signs of perturbation.
- e. H4b. Death trap (attritional). Never an open pit. A death trap scenario considered unlikely.
- f. H5. Evidence of Deliberate disposal of dead conspecifics by *Homo naledi*. (“No other explanation”, L. Berger in an interview).

According to the authors very poor fit or contradiction with facts make H1-3 inviable, H4a very improbable, H4b and H5 as more likely, but they clearly favored H5, deliberate disposal (burial).

The more recently described *H. naledi* material from the disjunct Lesedi Chamber of the same cave system likewise presents no evidence of cut marks, tooth marks, scoring, puncture marks, gnawing or bone cylinders, “or perimortem trauma such

as may be expected in a natural death-trap scenario” Hawks et al. [4]. The existence of a second chamber with virtually identically atypical deposits has strengthened the team’s conviction for the ‘cultural’ hypothesis: “We consider it untenable to hypothesize that both the Dinaledi Chamber and the Lesedi Chamber were accidental death trap situations. We have previously written . . . that the accidental death trap hypothesis was one that the physical evidence from the Dinaledi Chamber might not reject. Still, the evidence that hominin individuals of all ages were deposited in the chamber over some period of time, as well as the sediment composition within the chamber itself, led us to view that hypothesis as less likely” Berger et al. [5]. I disagree.

There have been many informal objections and suggestions for alternative explanations, perhaps too many to cite here. The first thing to acknowledge is that many aspects of the find are unprecedented and verging on the impossible. So ‘just how improbable’ are the options? Even so, there are several possible natural explanations that can account for most if not all the observed features of the deposits. Had the Lesedi deposit been found alone it would have been dismissed as a freak random event. The key rests in the Dinaledi Chamber deposits, so I will focus on them.

### Comments on the six original hypothesis considered by Dirks et al. [2]

Cognitive issues are not considered. I assume an overall premise that natural explanations are more parsimonious than those requiring intentional, deliberate intervention of any kind.

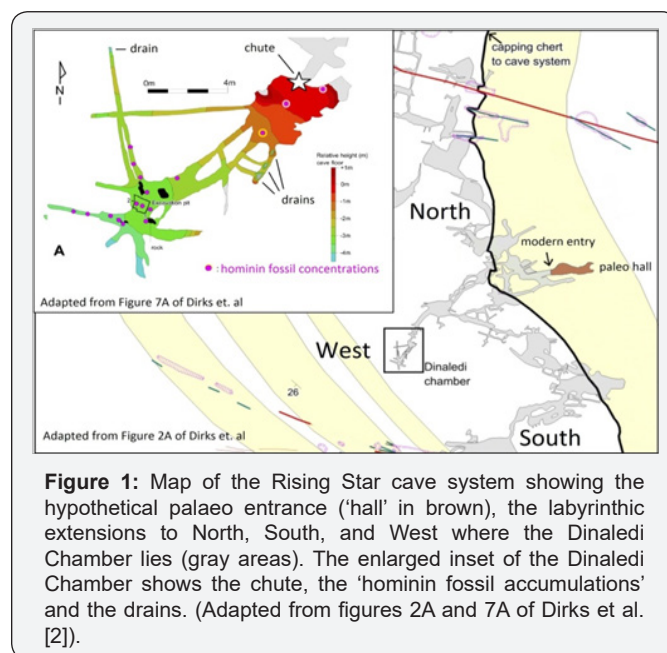
Hypothesis 1, Occupation: H5 has practical flaws not least of which is that it subsumes H1 which the authors rule out for lack evidence. However, this lack of evidence refers only to the Dinaledi Chamber. It is not clear if such evidence exists for the rest of the Rising Star cave system. If other parts of the cave system were occupied regularly or at least used sporadically the picture and the probabilities of random accidents, etc. change substantially.

H2. Water transport: ‘no evidence’ again refers only to the Dinaledi Chamber, and to high-energy flows. They do not seem to consider the possibility of passive transport of floating rotting carcasses that may have drowned inside the water-filled chambers. This possibility is considered below.

H3. Predator accumulation: ‘no evidence’ in the Dinaledi Chamber seems consistent with the evidence. The ~1550 bones represents a large sample, enough to yield at least some evidence. That none was found definitely needs an explanation, more so because the adjacent chamber apparently has plenty of such predatory deposits.

H4a. Mass fatality (catastrophic): The absence of signs of flood, roof collapse, etc. again refers only to the Dinaledi Chamber. Events of this nature in the upper cave could indirectly affect the lower chambers. Still, a mass event seems unlikely and for the most part unnecessary (see Appendix 1c).

H4b. Death trap (attritional). This is a key issue. The term “death trap” is very unspecific, but other comments and references in their papers indicate that they allude exclusively to pit-fall traps which are often bone-traumatic. Two other options must be considered: pit-slide traps and ‘maze’ traps, both of which are not bone-traumatic. The slanting narrow chute into the Dinaledi Chamber makes it a potential slide-trap. The sheer complexity of the floor plans of both the Dinaledi and the Lesedi Chambers, and of the cave system as a whole, make them potential maze-traps. Even speleologists get lost in unfamiliar caves.



**Figure 1:** Map of the Rising Star cave system showing the hypothetical palaeo entrance (‘hall’ in brown), the labyrinth extensions to North, South, and West where the Dinaledi Chamber lies (gray areas). The enlarged inset of the Dinaledi Chamber shows the chute, the ‘hominin fossil accumulations’ and the drains. (Adapted from figures 2A and 7A of Dirks et al. [2]).

H5. Deliberate disposal. I see little positive evidence for burial. The absence of alternative explanations cannot be considered ‘evidence’ in favor of this one. The most frequently cited objection is the difficulty of access to the Dinaledi Chamber. The cave system is a labyrinth with other options for disposal (Figure 1). It now takes cavers over half an hour to get into chute area and chamber. Carrying a corpse of an adult con-specific would be extremely challenging. Dirks et al. also use this problem to explain the lack of predator accumulation (H3). Evidently they consider even a leopard would find it difficult.

Also, if there is absolutely no evidence of trauma of any sort, what did these individuals die of? Starvation, disease, snake bite, drowning, old age? To be bone-trauma free they must have died of non traumatic causes inside the cave. Sick animals do tend to seek cover and rest. Since corpses attract dangerous scavengers ‘disposal’ deep in the cave might be adaptive. But for the same reason bringing wounded kin or dragging smelly corpses in from the outside would be asking for trouble. Living in or regular use of the caves seems to require an effective predator defence system and other aids. This has led people to suggest the need for fires, torches and so on (e.g. Shreeve, 2015) [6], all deemed very unlikely for such a primitive hominin and unnecessarily neo-anthropomorphic [sapiens - morphic?] [7].

[7] Since the whole field is 'anthropo. 'sensu lato, the classic 'anthropo-morphic' is inadequate.

### New information published in 2017

Two papers are most relevant. The contiguous Lesedi Chamber fossils described by Hawks et al. [8] and the dating of the fossils by Dirks et al. [3]. A third unrelated element, a documentary released by BBC Earth, also deserves a special mention (see below).

Material from at least three individuals was recovered from the Lesedi Chamber, which is in the central sector of the Rising Star system, at a depth of 30 m below the surface above. There is no straight-line route between the Dinaledi and Lesedi Chambers, the shortest traversable route being almost 145m. There are currently four access routes from the surface. The most accessible of these follows an 86m downward-sloping path with several narrow passages and short climbs, but only one squeeze and no significant crawls. The other three routes are each substantially more challenging. The general preservation of the Lesedi Chamber hominin material resembles that from the Dinaledi Chamber. Hawks et al. [8], The Lesedi Chamber H. naledi sample adds very little to the morphological variability of the Dinaledi Chamber sample.

On the basis of direct dating of three of the 15 individuals recovered and stratigraphic constraints Dirks et al. [2] conclude that the Dinaledi Chamber hominin material was deposited between 236ka and 335ka, though there is some indication that part of the material could be even younger. The hominin sample is morphologically uniform [2,8], suggesting that the chambers samples a single biological population belonging to a single species.

### Alternative scenarios

"We welcome alternative scenarios that explain the data, but they must explain all the data" [3]. For a data set as complex and multidimensional as this, that is a pretty tall order. Anyway, here we go.

The first item that needs revision is the no occupation assumption, and the associated idea that deep exploration of the cave required fires or torches and so on. An impertinent troop of cave dwelling Chacma Baboon (*Papio ursinus*) has proved us all wrong. As mentioned, BBC Earth has recently released the documentary "Monkey Planet" the first Episode of which includes one story on Chacma Baboons in South Africa's Cape area that use a deep cave as a sleeping refuge. This case could hardly be more relevant to this discussion. The troop lives and forages on a very windy exposed coastal area almost devoid of trees, but the greatest threat comes from leopard predation at night. The troop has discovered a cave system accessed by a small hole in the ground and an eight meter vertical drop. According to the commentator, Dr. George Mc Gavin, the cave has probably become accessible to them recently, via a rope left dangling

from the outer lip to the pit's floor by a bat research team time ago. The baboons rappel into the pit at dusk and feel their way about, up to 100 m into the cave system in pitch darkness, where they sleep. They seem to have a mental map of the cave. Signs of habitual use are everywhere, including at least one baboon skull and many bones scattered on the floor (the cave surely also acts as a pitfall trap).

This natural experiment looks as if designed to shed light on the alternatives discussed here. It's very existence demonstrates that monkeys, and presumably hominids, will take advantage of any situation that becomes available, will penetrate deep into the dark zone of a cave system without the need for torches or any other 'cultural' accessories, and will die in the cave in the absence of predation. A similar situation could easily have develop in the Rising Star system. If a troop periodically slept in Dragon's Back Chamber the probability of individuals occasionally stumbling into the Dinaledi Chamber's chute increases exponentially. Over the thousands of years involved fifteen such 'accidents', or even fifty, could easily occur. If this were correct no other explanation would be needed, but this might not satisfy everybody so let's consider other alternatives.

### The time span of the deposits

The intentionality argument hinges on the implied improbability of over 15 independent rare events occurring in one spot. However, this is inversely proportional to time span. Thus the 99ka range (335-236ka) also argues against the burial hypothesis. Even with a restricted span of 20-50ka and an optimistic ~100 individuals, that's still 200-500 years interval per burial. In my opinion this is simply too low to speak of a cultural trait. How could such a cultural trait be passed on with intermittent appearances every 30 generations, or even a fraction of that? A modest population with a death rate of 1 or 2 per year would produce thousands of corpses in the time involved. Since most deaths occur in the core area, the random probability of one or two dying in any given spot becomes quite high. In fact, the problem for any 'natural' explanation may well be how to explain the paucity of remains in the rest of the cave system! Presumably the upper sectors of the caves were exposed to the more usual effects of carnivore + scavenger deterioration. For the disposal hypothesis, on the other hand, a burial rate of ca. 1 in 1000 group members, one burial in 20 to 30 generations at best, again seems much too low to speak of a 'cultural' phenomenon.

### The predator-induced slide trap hypothesis

Predators drag carcass into caves and leave the remains, but a predator is not likely to drag a carcass up Dragon's Back and down a narrow shaft, granted. But all this only considers predation after the prey has been killed. Predators would very likely chase potential prey deep into a cave if the prey escapes into the cave or they wandered in and surprised prey already in the cave. Leopard, hyena, and even lions are likely candidates [9].

So could the peculiar layout of the Rising Star Cave act as a species-specific predator-induced trap for hominins? The obvious candidate for the Dinaledi Chamber is to consider it a slide trap (typified by the antlion's cone pits). In a nutshell: moving deep into the cave to escape predators, hominins clambered up the Dragon's Back, crammed at the top and occasionally into the chute, where some slipped down and ended up trapped in the Dinaledi Chamber. See Appendix Ia.

### The flood-induced Trap Scenario

Given the possibility that hominins could use the middle cave as a 'water hole' or dormitory, Dragon's Back Chamber can become a passive trap if the water level in the cave increased by a mini flood or rose overnight, as might be expected in a seasonally wet-dry environment. Every year at the end of the dry season they would have to go deep into Dragon's Back to find water. Because Superman's Crawl is at 'floor' level and very low, even a modest flood from the first rains would seal the outlet forcing them up Dragon's Back or any other ledge in the chamber. Once trapped in this chamber the probability of one or several hominins finding their way to the top of Dragon's Back and into the chute is reasonably high, especially if the raised water level persisted a few days. See Appendix Ib.

### Do these mechanisms explain the facts?

All forms of pit-slide traps are notoriously non-specific. So how or why might this one have acted as a species-specific trap? Several questions need to be addressed. Q.1: Could they get there unharmed? Q.2: Could the chamber be a death trap for climbing apes? Q.3: Why so many? Q.4: Why only hominins? Q. 5: How to explain the age distribution, and Q. 6: Why then and not later?

Q 1. As described predator avoidance or flood could get healthy and only healthy individuals unharmed into the Dinaledi chamber. The 12 odd meter chute into the lower chamber is too narrow and slanted to produce a free-fall, so green fractures are not expected. The inaccessibility of the top of the chute would impede access to any would-be predator or scavenger (hyenas can't climb, lions are too big). It would also make access very difficult for any crippled or injured ape, thus further reducing the likelihood of finding trauma in the deepest chamber. Any individual caught and killed in the upper or middle chambers would be consumed on the spot or dragged out and would thus leave no remains in the Dinaledi chamber. Since trap victims are live healthy trauma-free individuals, the mechanism can explain the data. Subsequent victims groping around the chamber before they succumbed would also add to the scattering and dry breakage of previous skeletons. These later victims are more likely to preserve articulated and in situ.

Since the sifting out of trauma occurs before entering the chamber, the subsequent taphonomy would have very limited impact on this alternative. The possibility of old healed injuries can't be ruled out, but infirmity and injury are selected against by Dragon's Back instead of positively by the disposal

hypothesis. No perimortem bone-trauma is expected, nor any post mortem green fractures from hauling accidents, so the overall net 'improbability handicap' will be much lower for predator avoidance than for the disposal option, easily two orders of magnitude (see below).

Ending up in the western chambers is obviously certain if disposal is deliberate, though other options to north and south are also possible. If a troop is attacked by a pack of predators and scatters in all directions it is equally likely that at least some will end up in the western chambers.

Q.2: Is the chamber a trap for healthy apes? Yes. Consider the plight of a lone hominin that dozed off in the chute or chamber. It wakes up in a soundless pitch black unfamiliar location, thirsty and hungry. It is just as likely to go down rather than up. Apes have descended from their sleeping tree-nests since time immemorial. If it wandered even a little in this sensory deprived chamber, just finding the outlet would be very difficult and escape virtually impossible. In all likelihood it would die long before it found the way out.

Q.3: How so many? These events need only happen once per millennium to produce the 15 to ~100 individuals estimated to lie in the chamber in only 100ka, even without an occasional mother-infant or pair of any sort. This is well within the estimated range of the deposits.

Q 4: Why only hominins? So far *Homo naledi* is the only species of large vertebrate found in the chamber. Selectivity can be expected from the size and location of the opening, the depth, species availability and so on, but even then a trap would catch all species that fit those restricted criteria and wander in.

In wetter times with woodland or forest, surface cover and water would be abundant and there would be little reason for arboreal species to enter the cave. Drier seasonal conditions postulated to induce cave use would retain a bipedal hominin but eliminate most other forest dwellers. Other animals must be considered: aardvarks, pangolins, hogs, jackals, even small antelope or hare [9]. Any of these and others could be chased deep into the cave by predators. Most are solitary and none seem able to clamber up a steep rock face like Dragon's Back.

Harder to weed out are the good climbers like hyrax, baboons and, of course, other hominins. Any of these could use the cave or be chased by predators, climb Dragon's Back and get trapped. Hyrax are too small to lure large predators. Maybe baboon troops are more inclined to fight back than to venture into a deep cave? Open question. Still, if any other larger mammal remains are ever found in the Dinaledi Chamber, the predator-induced trap hypothesis would predict these to be the most likely candidates. Update: baboons do enter caves and one baboon tooth was recovered from the Dinaledi chamber [10].

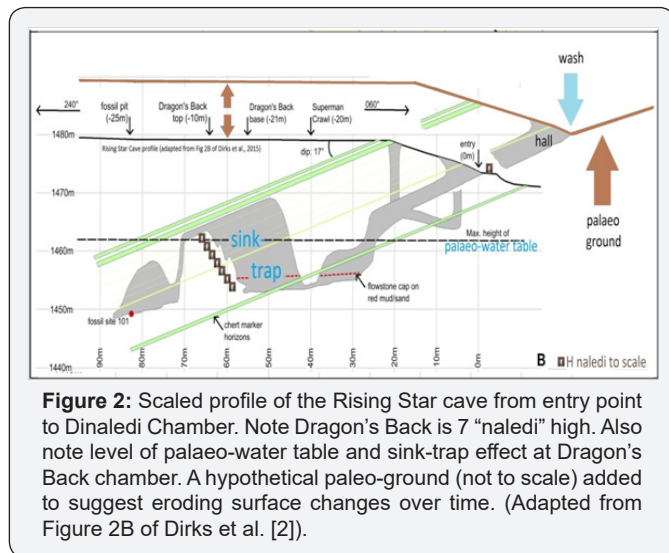
Q.5: Why mostly young? The answer may lie in a bias in cave use and in the struggle at the top of Dragon's Back. Nursing

females, the young and the old may linger in the cave while the rest of the group goes off foraging. Struggling for a foothold at the top of Dragon's Back dominant individuals would push subordinates away, thus making them more prone to huddle up in the chute area and slip to the lower chamber. Since subordinates tend to be either small, young, old or female, either mechanism would make those age/size groups more likely candidates.

And Q.6: Why then and not later? The cave entrance surely changed over time, and may have been too narrow or blocked by cave-ins. The surface ecology may have shifted either too dense forest or to treeless arid not supportive of early hominids. On later swings of climate *Homo naledi* might have been replaced by larger hominins that no longer got trapped in the same manner.

**A question of improbabilities**

The predator-induced or water-induced trap options can be tested against deliberate disposal. The observed complete absence of trauma in such a large sample also actually argues against the Disposal hypothesis. Two individuals are inferred from one tooth each, so the rest of the remains (~1548) can be assigned to the other 13 individuals, giving an average of about 119 each, very close to 50% of the hominin bone/teeth count. By paleontological standards that is fantastic, yet of the ~600 bones evaluated by the study no signs of trauma were found (only dry fractures). The argument that bones with signs of trauma all washed down the drain (literally, the Dinaledi chamber has four drains) and that only the 'good' bones remained is not good probability-wise for the Disposal hypothesis: around 1% chance if on average half the individuals had one (and only one) damaged piece each ( $p^n=0.5^{6.5} \sim 1\%$ ). [The complete expression is  $(p+q)^n$ , but only the first term ( $1! p^n q^0=p^n$ ) of the expanded formula is 100% trauma free].



**Figure 2:** Scaled profile of the Rising Star cave from entry point to Dinaledi Chamber. Note Dragon's Back is 7 "naledi" high. Also note level of palaeo-water table and sink-trap effect at Dragon's Back chamber. A hypothetical paleo-ground (not to scale) added to suggest eroding surface changes over time. (Adapted from Figure 2B of Dirks et al. [2]).

The physical difficulty of hauling corpses in is so obvious it is one of the most cited objections. Again, lack of trauma in such a large sample strongly argues against the notion that the individuals died prior to reaching the chamber. It is inconceivable that over countless cases nobody ever dropped a body as they

were struggling in the dark with a heavy load up Dragon's Back, about 11 meters or 7 erect "naledi" high (Figure 2). To illustrate, if the probability of hauling one body in without a scratch is say 85%, then the probability of succeeding with over a dozen is less than 12%. That assumes of course that none of the bodies had suffered perimortem bone-trauma, highly unlikely in the harsh african environment [11]. If 75% of deaths are bone-trauma free the likelihood of hauling 13 intact skeletons into the chamber in a row drops below 1%. If p is lower than 50%, the end odds shrink to less than 1/10,000.

The key point is that the likelihood of getting a large number of trauma-free corpses is exponential ( $p^n$ ), so increasing the number of corpses means exponentially decreasing the probability.

This is also true for rare events such as accidents, say 'one per year'. In that case ten accidents in one year are very unlikely. But the probability of 'at least ten' random accidents occurring over increasing number of units of time is additive so, given enough time, they become a virtual certainty. Or, if you prefer, the probability of getting zero accidents ( $q^n$ ) becomes vanishingly small.

The lack of bone-trauma has been stressed as being so low that the most reasonable explanation is that these individuals died inside the Dinaledi Chamber in a way that was non-traumatic to bones. So the problem is more a question of how and why they got there alive and uninjured. A natural explanation demands a very species-specific trap as described above or some other passive mechanism.

**Discussion**

The Disposal Hypothesis is appealing in many ways. Associating early hominin evolution with caves, self conscious development and burials all seems fitting. But deliberate disposal also implies all sorts of practical skills and cognitive abilities, shared intentionality and much focused determination! The practical and statistical improbabilities also detract from the viability of the hypothesis. Adding the problems derived from the time span of the deposits, in my opinion it all makes this alternative highly improbable.

Conversely, no cognitive assumptions are necessary for random 'maze' accidents including predator or water induced trap scenarios, so these ideas seem to be much less problematic. Thus these 'natural' mechanisms can explain most of the data and are not affected by the improbabilities surrounding the lack of trauma in the fossil remains. This alone makes it at least a couple orders of magnitude less improbable than the disposal hypothesis and the overall difference may well be much much larger. Also, as shown above, the probability of random accidents is additive over time so, given enough time, they become a virtual certainty. Since the time spans are huge, cumulative accidents are a viable answer to the Dinaledi mystery in particular.

I did not consider the complete design of the Lesedi Chamber. It is said to be less challenging with four access tunnels, so presumably also easier to escape from, which would explain the lower body count. Many of the other aspects are quite similar so several of the proposed mechanisms would also work here. Again, adding three more trauma-free individuals goes against the burial hypothesis.

Granted this is a complex explanation, but I believe overall it is less complex and far less improbable than the deliberate disposal hypothesis. The combination of predator and/or flood 'herding', placement (the chute at the inaccessible top of Dragon's Back), size (the narrow chute) and the design of the lower chamber all combined to make a uniquely species-specific trap. So unique that it will have a monumental impact on our understanding of hominin evolution.

## Appendix I: The Dinaledi Chamber-as-a-trap

### The predator-induced Trap Scenario

Several predators will follow prey into a cave and even into a narrow passages such as the Superman's Crawl. The possibility of an attack by pack hunters is relevant because a pack is more likely to persist on the hunt even if other members have secured a prey item in another area, whereas a leopard might not bother. Once in the middle chamber hominins have the possibility of climbing up Dragon's Back. Early hominids lived most of their nights in total darkness and would be used to groping around in a tree, rock face or cave. Threatened by predator(s) on the hunt they'd hardly have a choice.

Even if the predators could not get to the middle chamber an alarm call or a screaming victim in the inner passages would send other members scampering up the walls, pushing back into every nook and cranny at the top of Dragon's Back. This is precisely the situation described by Steven Tucker and Rick Hunter that lead them into the chute that leads to the lower chamber, and to their discovery of the Dinaledi Chamber and the fossils. They might then slip down, particularly a scared infant or youngster, plus the mother attempting reaching it, till it drops into the lower chamber. Once in the Dinaledi Chamber it would be doomed, particularly if it was filled with water.

### The flood-induced Trap Scenario

The lack of evidence of flooding or significant current in the Dinaledi Chamber is expected because flooding of the upper cave would not show in the deepest chamber for two reasons. Dragon's Back chamber acts as a sink-trap for coarse sediments and rubble. If the water table is high enough to allow direct overflow from Dragon's Back to the lower chamber via the chute of the Dinaledi Chamber any inflow would be diffused throughout the chamber and could take months to drain out, so silt would be deposited evenly all over the chamber floor. Given the possibility that hominins could use the middle cave as a 'water hole' or dormitory, Dragon's Back Chamber can become a passive trap if the water level in the cave increased by a mini

flood or rose overnight, as might be expected in a seasonally wet-dry environment. (*Homo naledi* retains features of a good tree climber so must have lived in a partially forested area). Every year at the end of the dry season they would have to go deep into Dragon's Back to find water. Because Superman's Crawl is at 'floor' level and so low, even a modest flood from the first rains would seal the outlet forcing them up Dragon's Back or any other ledge in the chamber. Once trapped in this middle chamber the probability of one or several hominins finding their way to the top of Dragon's Back and into the chute is reasonably high. If the raised water level persisted even a few days any hominin caught inside would perish. Again, Dragon's Back would turn the middle chamber into a drain-sink and would act as a barrier to any non climbing animal.

### Other options: floods and roof collapses

Flooding during the periods of high water table might be sufficient to fill Dragon's Back Chamber and overflow down the chute to Dinaledi Chamber. This could explain the presence of microfaunal bones. Since bloated corpses float, weak flooding (low-energy flows) may be enough carry drowned small mammals and fine sediments over the lip, but less likely to move remains of larger mammals and debris. Note that repeated major (high-energy) floods would almost certainly produce a polyspecific deposit and thus is unlikely to explain the selective attritional accumulation of *Homo naledi*. A significant roof collapse in the upper cave need not be evident today, especially if it occurred in the now eroded 'hall' area depicted in Figures 1 & 2. The issue is relevant because such a collapse could seal the cave entrance or inner passages for a period of time and thus mark the beginning and/or the end of the H, naledi cycle. An extended period of high water table would also work.

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DOI: [10.19080/GJAA.2017.02.555586](https://doi.org/10.19080/GJAA.2017.02.555586)

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