Lori Cori Cave Accident Analysis

text by Andrea Futrell & Bill Storage, photos by Laura Maish

On Saturday September 27, 2003 a crew consisting of Mike Ficco, Andrea Futrell, Mike Futrell, Dick Graham, Sue Setzler, Ron Simmons, and Steve Wells entered Lori Cori Canyon Cave in Wise County, Virginia. A routine survey trip had been planned.

Everything proceeded normally as the group climbed down the entrance, and then crawled, climbed, and chimneyed down to the 90-foot pit. The rope is 11 mm PMI. When Dick began his descent of the 90-foot pit, Sue was at the top of the pit. For about the first 10 feet at the top when Sue could see him, he was slow and said, "Man! This rope is really slow. I'm really having to feed it a lot." Sue looked over and could see him pulling up the rope to feed it, but Sue didn't take any particular note of his rappel device and assumed he was using a rack.

Dick was using a simple bobbin. Dick wrote a Safety and Techniques article about bobbins in the March 1982 *NSS News*. In the article he mentions trading his used rack for a used bobbin with Philippe Crochet during the 1981 pre-Congress camp before the International Congress of Speleology in Kentucky. The simple bobbin Dick used for the Lori Cori Canyon Cave trip had PC engraved on the bobbin. It is possible that it is the same bobbin he acquired from Philippe in 1981.

Dick wrestled with his bobbin as he went down out of sight. He was probably just out of sight because his voice was clear and Sue could see the rock lit up by his light. The drop is free at that point. Dick said, "Hold on a minute, I have to make an adjustment." He paused for a couple of minutes and then finished his rappel without further comment.

A few hundred feet farther, beyond some tight drops and difficult passage, is a 213-foot drop. The rig points are bolts; the rope is 11mm PMI. At the top of the 213 one would be cow-tailed to the traverse line while standing or kneeling on a very slick sloping shelf approximately four feet wide. A heavy pad is on the lip. From that point the rope hangs free to the bottom. For the upper few dozen feet the rope hangs inches away from the wall, gradually increasing to several feet. By midway down the drop the wall is 8 to 10 feet away. Here a flowstone shelf rolls out and comes within 2 inches of the free-hanging rope. Below the flowstone are some nice draperies and the wall gradually recedes again to about 10 feet away at the bottom.

Narrowness of the passage leading to the 213 requires a group to spread out along this area while waiting to descend. Andrea was in the lead. Andrea talked to Dick briefly at the top of the pit, stating that her micro-rack was very slow on the stiff, muddy rope. Dick commented about his descending gear saying, "This thing seems to be working pretty well so far."

Andrea descended the pit and called, "off rope." Mike Ficco was next in line to descend after Dick. Dick began his rappel in a normal fashion and Ficco watched the reflected light from his lamp begin to fade as he descended. Mike estimates that Dick had rappelled 20-30 feet, after which he heard Dick say, "No, No!". This was immediately followed by a very loud Boom, BOOM, which was heard by all, presumably a result of Dick first hitting the flowstone shelf followed by the floor of the shaft. Instantly, Andrea began yelling for Dick as she raced down and over from the waiting alcove about 100 feet distant.

Andrea found Dick about 25 feet away from the bottom of the rope and completely detached. With great difficulty she communicated that Dick was dead and that someone else should come down, carefully observing the rope and ledge. Ficco was ready and descended next. He confirmed Andrea's observations. Dick's bobbin (simple) was open and his gear appeared normal. Dick's safety ascender was attached to his seat by a carabiner, but was not otherwise clipped in to his seat. Andrea and Ficco did not observe any evidence of rockfall.

Root cause

We examined Dick's rappelling device (bobbin), and found no evidence of defective manufacture. Material hardness (strength) and tolerances are similar to that of other specimens of this design. Clearances of parts that move relative to one another are all out of the normal range. The bobbin appears to have been damaged extensively during the fall. The bobbin, as received after the accident, was bent in such a manner that the two main arms of the bobbin (the bent-plate members that move relative to one another) had about two millimeters of interference rather than the normal close fit. In the normal state the two arms slide smoothly so that they lightly touch or nearly touch when the bobbin is closed. The gate mechanism was also sprung, with the small tab on the gate bent in such a manner that the gate could be moved inward or outward to any position. Since no one witnessed the start of descent, and the bobbin was found open and detached from the rope, we cannot rule out the possibility that a bobbin "C rig" was used. In our simulations we did not find a major difference in consequences of incomplete gate closure with the C rig as compared to the standard arrangement.

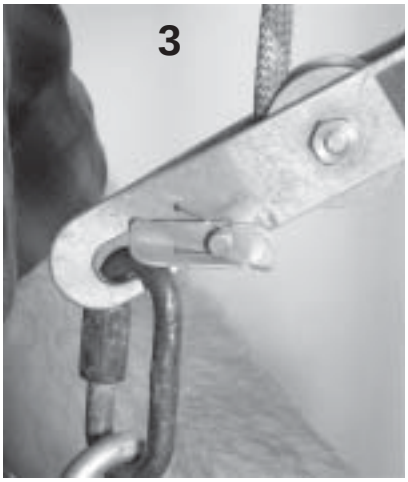
This individual device, built around 1980, is of a general design that has been in common usage since the 1960s, manufactured by the Petzl Company in France. It is not possible to determine if the spools in the bobbin are parts of original manufacture, or have been replaced by one of the owners. Dick Graham was not the original owner of the device, as noted above. The bobbin bears identifying engravings from both owners.

Because their were no direct observers, and because the equipment sustained damage during the fall, the root cause of this accident cannot be determined with certainty. It possibly involved incomplete closure of the bobbin, but marks on the equipment strongly suggest a misconfigured harness/bobbin attachment played a significant role. Of course, misconfiguration of the rigging could indeed increase the likelihood of incomplete bobbin closure, as we experienced in attempting to reenact/simulate the accident. The amount of excess rope at the bottom of the pit excludes the possibility that Dick had been using a control carabiner below the bobbin. It is very unlikely that use of a control carabiner would have affected the outcome in this case.

The bobbin was bent during the fall, so we can only speculate as to the degree to which its condition before the accident contributed to the incomplete closure. Interference between the two arms of the bobbin would certainly contribute to incomplete closure as seen in photo 1. However, we found that we could also improperly rig a new bobbin (of several different designs, including the one involved in this accident) in an identical state. Mud and grit on the bobbin would


1


2


3


4


5


6


7


8


9


10


11


12


13


14


15


16

contribute to such interference. We found a considerable amount of dried mud on all surfaces of the bobbin, but it is uncertain whether any of this mud was present before the accident. The mud is present in photos of the gear at the accident site.

We found that we could descend long distances with an incompletely closed bobbin, as shown in photos 1 and 2, before our movement resulted in the quick link falling into the normal position, thereby forcing the bobbin fully closed. However, in certain conditions we found that, instead of falling into the normal position, the bobbin was forced open by counterclockwise rotation of the quick link (as viewed from the top) as shown in photo 3.

This rotation can also pry the bobbin open, producing a gap of several millimeters between the main arms of the bobbin (photo 4).

Minor jiggling of the rig then results in random movement of the right (non-loaded) arm of the bobbin. The right arm's pivot point is near its center of gravity, so it has no tendency to rotate merely because of agitation. In simulations, at this point we observed the right arm of the bobbin in a range of positions from slightly open (photo 7) to a point where an angle of about 45 degree exists between the two arms. When an angle greater than about 30 degrees exists between the arms the entire rope path around the outer (upper as shown in the photos) spool is visible.

If the caver is aware of this condition, he can hold the bobbin closed enough to prevent the rope from escaping and can continue descending, or can correct the condition. But it is likely that in this accident the condition only existed for a very brief time. Dick had stated that he was having difficulty getting the rope to slide through the bobbin, and was needing to force the rope up through it. While feeding the rope actually tends to move the free arm of the bobbin into a safer position (as if trying to close it), the subsequent sudden drop of the caver as a length of rope passes quickly through the device can swing the free bobbin arm open.

Several cycles of the stick-slip motion resulting from feeding the rope can result in the caver holding a curved segment of the rope (as results from the feeding action) at a time when the bobbin arm is at an angle that exposes the rope path around the outer (upper) spool (photo 9). At this point, if the caver has any amount of downward motion, a tiny amount of lateral force (photo 11)on the rope by the caver's brake hand will cause the rope to pop off the spool, followed immediately by complete detachment from the rope. In simulations we found that a lateral component of the braking force almost always exists in normal usage, due to the fact that the brake hand is generally held near the right hip. For discussion purposes, we will refer to the above scenario as "open-bobbin".

Scratches on the gear suggest the possibility of various gear misconfigurations, especially the deep gouges opposite the bobbin gate (photo 22), but one cannot rule out their resulting from impact damage. Dick used a triangular screw link at his harness, and an oval screw link between the triangle and the bobbin. This combination is somewhat prone to jams, as shown in photos 15-20. The equipment jams shown in photos 15 and 16 are only marginally stable. It is unlikely that either could be sustained for more that a few seconds before popping into the correct position. If the condition in photo 16 did persist, however, it would very likely lead to an open bobbin (note red arrow, photo 16). White arrows in these photos represent the forces that would be applied by rope and harness. In addition to the open-gate/bobbin-swings-open sequence described above, (photo 16), if the gate were open or damaged, could possibly lead to the oval link prying apart the arms of the bobbin as shown in photo 17. In simulations this condition did not result in the an open bobbin condition; the oval link did not pull completely through the bobbin arms.

Two jam conditions, shown in photos 18-19 and 20-21 are stable enough for

extended descent time, and are consistent with the straight-line scratches on both the bobbin gate and the screw links. It may appear that the jam shown in photos 20 and 21 would not be stable, and that the triangular link would soon pop into the correct position, but our simulations revealed otherwise. The twisting moments (torque "forces" - loosely speaking) surprised us. If the caver sees such a condition, and attempts to rotate the gear into the right position, the attempt can lead to the oval screw link popping immediately off the hook portion of the open arm of the bobbin.

Upon encountering this in simulations, we immediately wondered about a connection between this surprise and Dick's exclamation of "no, no". While this is very speculative, we lean toward the conclusion that this, or a very similar condition, existed, and that Dick noticed it and tried to correct it. "No, no" sounds to us more like a response to seeing a condition (jammed gear, open gate), taking an action, and being surprised at the outcome, than the result of noticing a condition (open-bobbin) as the rope was escaping it. Furthermore, our simulations of the open-bobbin sequence suggest that noticing the open bobbin at a time when it was too late to do anything about it but before a free-fall seems unlikely.

In either case, open-bobbin, or jammed-gear/open-gate (which then results in open-bobbin), incomplete closure of the bobbin's gate is a major component of the root cause. Taking additional care to ensure gate closure would also aid in detecting misconfigured descending gear.

Other contributing factors

Quick link connecting harness to bobbin:

The quick link, being slightly smaller in bar diameter and smaller across the short side of its oval than a carabiner, is far more likely to jam against the triangular link, and slightly more prone to getting stuck on the bobbin gate (as shown in photo 1) than a semicircular screw link used with a carabiner.

Thick, stiff rope:

The 11 mm rope, very stiff from age and being dirty, resulted in the need to feed the rope through the bobbin. If not for this condition of the rope, the partially opened bobbin may have been noticed before the stick-slip movement resulted in detachment from the rope.

Bobbin gate geometry:

Newer Petzl designs have a pointed tip on the eye of the right arm of the bobbin, rather than the flat surface visible in photo10. In our testing the newer design was only slightly less prone to being partially open as shown in photo 2.

Original publication 5/5/2004. Updated 1/31/2005.

Git a Long Little Dogie

Paul Aughey

The large white truck idled up beside me as I stood on the cactus-lined gravel road.

"Hi", I said, "I'm Paul. I talked to you on the phone. John, right?"

"Yes sir." he said extending his arm out the window in greeting. I shook his hand, which was at my neck level as I stood by his truck. John was a ranch manager. The ranch was near...well, nowhere actually, being several tens of thousands of acres in the Texas hill country.

Am I okay to park here?" I said, adjusting my backpack of caving gear.

"Yup" he grunted, pushing his hat a bit further back on his brow. "That's fine. Jus' close the gates behind you ... and don't mess with the cows."

"No problem." I said. "So, you said the cave is about a mile and a half due north?" I said, fishing for a more specific location.

"About that," he said, "I put up a small fence around the hole after we lost a cow a while back, but there ain't no road to it."

"All right," I said, "Well, I guess I'll find it. Thanks. I'll see you in a few hours."

He slowly drove off down the road as I broke out a compass and started hiking. Other than the small hills, a few stubby trees, and numerous patches of prickly pears, there wasn't much to use for navigation. I walked down the narrow cattle trails to avoid most of the prickly pears, heading as close to north as possible.

Prickly pears and cedars, cedars and prickly pears, it seemed like that's all that was out here. Apparently before Texas was taken over by ranches, tall prairie grasses crowded out the cacti, and oaks were much more prevalent. But the cows ate the grass and the prickly pears and cedar thrived. The "cedar," as it's called out here, is actually a type of juniper and it's a menace for another reason: fire. Cedar burns as easily as paper, even while green, and fires out here are quite serious because of this.

I checked my compass again and was still heading more or less north on the winding cattle trails. I caught up to a small group of cows, maybe 50 or so. While cows are large, they usually get out of the way when you walk up to them. This group seemed content to walk in front of me as the sun started to sink lower in the late afternoon sky. I kept hiking, whistling "Happy Trails" as I went. Occasionally, I checked the compass. I laughed to myself; here I was following a bunch of cows to a cave in Texas. I felt like a cowboy. Then again, I looked like a hiker who somehow got lost in the mountains and ended up on the prairie.

A dust cloud in the distance came closer and a white truck emerged. A faint gravel road was ahead of me. "Hi John," I said as the truck pulled up.

"Wha'd I say about messin' with the cows?" he said in a serious tone.

"Excuse me?" I said, confused.

"I caught ya' running the cows. I thought you were goin' to the cave," he said, his face red. This is not a good situation, I thought.

"I've been heading to the cave." I said holding up my compass. "I've been going north since I left you and figured I've hiked at least a mile or so, maybe more."

"Ah, man." He moaned looking at my compass. "Ain't you ever heard of cow magnets?"

"Cow magnets?" I said with a confused look.

"Yeah," John sighed, "they're about three inches long. We get the cows to swalla them to collect all the nails and other things they eat. Better that way."

"Cow magnets?" I repeated, trying to understand what this had to do with the cave.

"Yeah," he said again. "You ain't been going north, you bin followin' the cows." Finally it dawned on me. There were about fifty cows in the small herd, all with a cow magnet; each cow magnet was slightly stronger than the pull of the Earth's magnet field.

"You mean," I said trying to explain, "that I've been following cows?"

"Yeah," he said pointing northwest, "thet way's the cave."

"Thanks." I said embarrassed.

"It's gettin' dark. You want a ride to your truck?" he offered.

"Yeah," I said. And he drove me back to my truck, we shook hands, and I headed home. I'll be back someday, I thought, and go caving despite the cows.