
January 2004
BATS news

Features

BATS News Jan. 2004

Editor,
Allan Weberg
14776 Arizona Avenue
Woodbridge, VA 22191
703-490-4882 (H)
aweberg@comcast.net

Art Director,
Michael Young

Proofreaders,
Sarah Richards
Meredith Hall Johnson

BATS
EXECUTIVE COMMITTEE

President,
Mike "TinY" Manke
300 Happy Creek Rd
Locust Grove, VA 22508
540-972-9034
NBR33FANS@aol.com

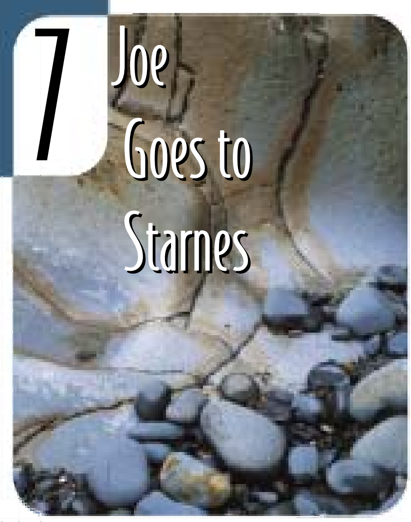
Vice President,
Jacque Miley

Treasurer,
Raymond Herlong

Secretary,
Nicole Bennett
Edenton Rd
Partlow, VA
540-895-5719 (H)
703-784-4030 (W)
roccapia@hotmail.com

Delegate-at-large,
Lee Rodrigue

Cover:Allan Weberg in Higgin Botthems Cave.
Cover Photo by:Rafi Reyes



From the Editor

This month's newsletter has a fascinating (but technical) article on aging carabiners. Check your biners V-BATs! Thanks to Bill Storage for permission to reprint the article. Our new trip coordinator, Joe Shepherd, provides us with a lively and engaging account of his trip into Starnes Cave.

Calendar

February 7-8	Grand Caverns re-survey, POC Carol Tiderman: ctider@usibm.com
February 10	BATS Monthly business meeting, Salem Church Library, 7:00 PM
March 6-7	Grand Caverns re-survey
April 10-11	Grand Caverns cleanup weekend, POC Andy Reeder: andrew.reeder@lynchburgva.gov
April 23-25	Spring VAR hosted by Tri-State Grotto at Grand Caverns near Grottoes, VA
May 8th	DC Grotto Bowden Cave cleanup, POC Pauline Apling 301-604-0764
July 12-16	NSS Convention 2004 in Marquette, Michigan, website: www.nss2004.com
Ongoing Events	Vertical Practice at TinY's house every Tuesday evening except the 2nd Tuesday when practice will be held the Thursday following the 2nd Tuesday

BATS November Meeting Minutes,

Present: Nikki Bennett, Debbie Frazier, Amanda Freund, Averie Giles-Allnock, Ken Hornung, Meredith Johnson, Bill Loutzenhiser, Mike Manke, Jim McCloud, Lance Mitchell, Robin Mitchell, Bart Mix, Kevin Quick, Chris Reasonover, Joe Shepherd, Allan Weberg

Trip Reports: Everyone who participated in Bridge Day shared their stories. Allan went to Sinnett-Thorn, Meredith and Kelsea went to the VAR Grand Caverns survey. See their articles in an upcoming BATS newsletter!

Trip Planning: The Endless Caverns trip on the 22nd will be the BATS official trip for the month. In December, it'll be Glade Cave on the 13th, led by Kelsea. Our new Trip Coordinator, Joe Shepherd, is planning to hold orientations before each trip, so if anyone you know wants to go on the trip and needs an orientation, talk to Joe.

Elections: Bart Mix is heading up the Nominations Committee. Give Bart all nominations before December. There is a member-at-large position open since Lee left. Elections will be in December.

Holiday Party/Fundraiser: The holiday party will be at Carlos O'Kelly's on Rt. 3, in replacement of the January Meeting (so Tuesday, January 13, 2004). If anyone has any items they want to donate to the silent auction (all proceeds go to the BATS grotto!) let Debbie Frazier know what they are so she can put them on the list.

V-BATS: Practice is every Tuesday at TinY's, except BATS meeting weeks, on Thursday instead.

Survey Activities: The Front Royal Grotto has monthly surveying trips, Janet Tinkham is the POC. Also, Gangsta Mappers for Breathing Cave (3rd weekend every other month). The next resurvey of Grand Caverns is scheduled for November 22-23rd. Carol Tiderman is POC. There is a letter writing campaign in KY to get letters of interest about projects slated for karst land (airfield, etc.) Get with Meredith for more info.

Presentation: Bridge Day Video

AND FINALLY.....Allan wants everyone to remember....WRITE UP YOUR TRIPS FOR THE NEWSLETTER!!!!

BATS December Meeting Minutes,

Trip Reports: Averie went to the Norman side of Bone/Norman Cave, Joe participated in the Grand Caverns survey.

Trip Planning: Crystal Caverns in January, Mystic in February. Get with Joe if you wanna go.

Elections: The nominating committee hasn't met, so nominations will probably be done by e-mail, with elections some time in January.

Holiday Party/Fundraiser: The holiday party will be at Carlos O'Kelly's on Rt. 3, in replacement of the January meeting (so Tuesday, January 13, 2004). If anyone has any items they want to donate to the silent auction (all proceeds go to BATS grotto!) let Debbie Frazier know what they are so she can put them on the list.

V-BATS: Practice is every Tuesday at TinY's, except BATS meeting weeks, on Thursday instead.

Survey Activities: The Front Royal Grotto has monthly surveying trips,Janet Tinkham is the POC. Also, Gangsta Mappers for Breathing Cave (3rd weekend every other month). The next resurvey of Grand Caverns is scheduled for January 3-4. Carol Tiderman is POC.

Other Activities: There is a cave rescue class in February for Level 1 & 2, see TinY.

Presentation: None

BATS January Meeting Minutes,

Present: Practically everybody Since this was the meeting/holiday party, the meeting was more general, and I didn't take any notes because I was busy stuffing my face. So this is from memory:

Treasurer's Report: Raymond gave the Treasurer's report for 2003 (I don't remember the details, but we had a good amount in the BATS Bucks. The pancake breakfast fundraiser wasn't in the total, so Raymond is going to redo his figures and submit them at the February meeting where I will take better notes).

BATS Bucks: Lee Rodrigue won the BATS bucks contest for 2003.

Elections: Nominations were taken from the floor for the positions. Nominations are:

PRESIDENT: TinY Manke
VICE PRESIDENT: Meredith Hall Johnson and Raymond Herlong
SECRETARY: Nikki Bennett
DIRECTOR AT LARGE: Allan Weberg
TREASURER: Seth Lake and Chris Reasonover

Holiday Party/Fundraiser: The holiday party at Carlos O'Kellys was a smash. The silent auction went especially well, raising over $200.00 for the Grotto. Thanks to Debbie Frazier for coordinating the silent auction.

V-BATS: Practice is every Tuesday at TinY's, except BATS meeting weeks, on Thursday instead.

Survey Activities: The Front Royal Grotto has monthly surveying trips, Janet Tinkham is the POC. Also, Gangsta Mappers for Breathing Cave (3rd weekend every other month). The next resurvey of Grand Caverns is scheduled for February 7-8. Carol Tiderman is POC.

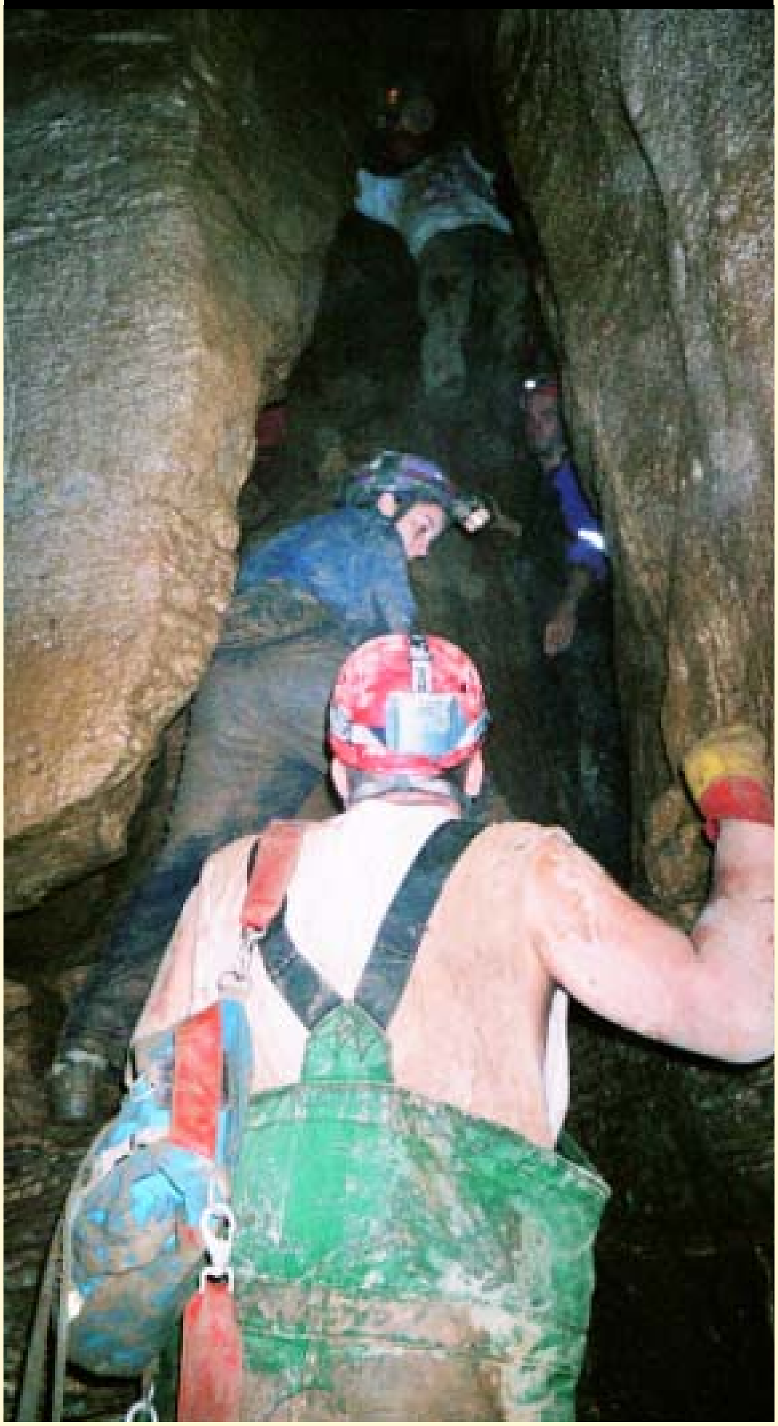
Joe Goes to Starnes

photos and article
By Joe Shepherd

I had no idea just how addictive caving could be. The weekend of the 4th of July, I went on my first caving trip with some friends to Sinks of Gandy and Stillhouse Cave. I was hooked immediately and couldn't wait to get wet and muddy again. Soon thereafter I found the BATS on the internet and attended a meeting, having no idea there were so many others with this same addiction. I became a member in September and was soon on my way to VAR. Chris Reasonover volunteered to ride down there with me and made sure I found my way around. Friday night I signed up for the trip to Starnes Cave the next day. We also convinced several other BATs—Chris, Kelsea, Carrie and Jacque—to sign up as well. We were off the next morning at 9:30 AM, minus Jacque—we had forgotten to wake her up.

Starnes cave was about an hour's drive, but was well worth it. I learned that Starnes is continually being surveyed and the total length of the cave to date is about 4.34 miles. We would be staying in the upper level with visits to several 35-foot high waterfalls that plunge into the lower level. Access to these extensive lower levels would require a rappel and connect to New Starnes through the Humble Pie crawl, Suction Sewer, Birth Canal, and Belly Flop. I guess I will have to slither through those the next time!

"We continued up, through and around muddy terrain, which eventually led to the top of the first waterfall."



Joe Goes to Starnes

As we entered the cave through the slippery 15-foot entrance, I realized that I had forgotten my gloves! I suppose I can write that off as a rookie mistake and a lesson learned. It took a while for all 12 of us to enter the cave. We made our way into the darkness only to find a 20-foot fissure climb down to the main trunk of the cave. This again took awhile for all of us to get down but the big spiders kept us company. The pace picked up a bit as we traversed the 1,000-foot long 60 x 40 trunk passage. We continued up, through and around muddy terrain, which eventually led to the top of the first waterfall. After we each had a look, we continued on toward another waterfall where we would get a view from the pool at the bottom. To get there, we had to traverse a bunch of breakdown and then choose one of two paths—wet or dry. I chose the wet path, of course, and was soon gazing at a really cool waterfall, 35-feet in height, pouring into a pool about four feet deep. In the adjacent waterway were several ghost-white salamanders—my first troglobite sighting.

We then started our trek out. We stopped to take a 15-minute break, in complete darkness and silence. This was very relaxing, to the point that I think several people dozed off—damn those hangovers! We hit another slow spot when we all had to climb up the 20-foot fissure that had proved relatively easily to slink down. Several of us—myself included—would have definitely fallen and busted our tails if it had not been for an assist by those behind us.

As we climbed out into the light we were surprised to find it thundering and raining. You would think that my time in the cave would have been the scariest part of my day—not so! I let Kelsea drive my truck back to the VAR camp—definitely a graying experience for me! (Just kidding Kelsea!) But I must say that being welcomed back to VAR with a great burrito dinner was the perfect ending to an excellent day.

Aging Carabiners

© 1997 William K. Storage

Artwork by Michael Young

Updated Sep. 97 from an article of the same name originally published in the September 1994 NSS News, Techniques & Safety column. A grey-box sub-article, Carabiner Engineering, also appeared in the original printing, and appears at the end of this document.

The vast majority of carabiners used in caving are made from aluminum alloy 7075-T6. This alloy was chosen by manufacturers to provide the lightest possible equipment for rock climbers at a reasonable price. Other basic materials such titanium, magnesium and some steel alloys could potentially have a greater strength-to-weight ratio. Aluminum alloy 7075 tempered to the T6 condition generally yields the highest strength-to-weight ratio practical if reasonable ductility and toughness are to be retained.

Unfortunately for cavers, 7075-T6 and other high strength aluminum alloys likely to be used for vertical equipment are not very corrosion resistant. No amount of excess strength capability in a new carabiner is sufficient to compensate for the reduction of strength that will occur if aluminum carabiners are left in caves for a long period of time. Deciding what "long" means requires some understanding of the mechanism of corrosion at work

Aluminum is a chemically active metal, which immediately oxidizes if exposed to air. A protective oxide film builds to a thickness of about 100 angstroms. In pure, unalloyed aluminum this film seals and protects the underlying metal from oxidation.

In alloys however, millions of microscopic particles containing other metals such as copper and manganese penetrate the oxide film formed on a surface. These particles, precipitated intermetallic compounds (figure 1), cause a flow of electrical current in moist environments, because they differ in electrochemical potential from that of pure aluminum. In this manner a galvanic cell exists even if no other metal objects touch its surface.

Fig.1 Keller's Reagent etched aluminum alloy surface (approx. 400x) showing intermetallic compounds precipitated from solid solution during the final step (aging) of heat treatment.

The most common form of corrosion reported to us on carabiners is generally called pitting. Exfoliation, a similar condition caused by undermining and lifting of layers along a surface, sometimes occurs when corrosion travels along elongated metal grain boundaries, parallel to a surface, forming a blistering effect. On a microscopic scale (figure 2) pitting produces an extremely irregular surface as it eats its way into the core of the material.

A common method of reducing aluminum corrosion is anodizing. The standard coating used on carabiners is chromic acid anodize. While we often call this a coating, it is in fact a chemical transformation of the aluminum material itself. Passing current through the carabiner in an acid bath produces a porous aluminum oxide surface layer. The layer is often dyed; then it is sealed by a secondary chemical treatment. Another type of anodizing, with sulfuric acid, can produce a hard, wear resistant surface. Paint is sometimes added for additional protection, particularly for marine uses.

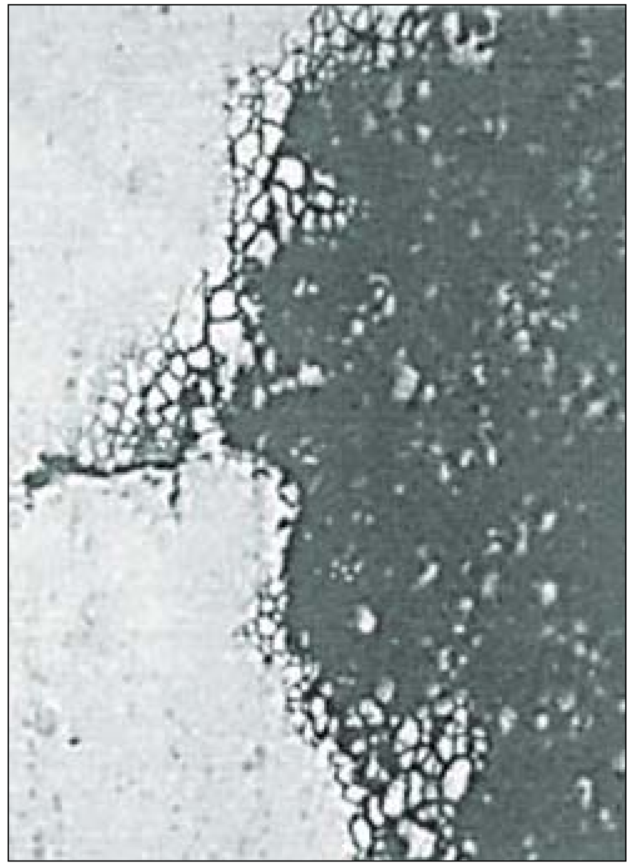


Fig. 2 Irregular surface of a pit with intergranular corrosion (approx 300x).

No coating can prevent corrosion of carabiners in many cave applications. Any nicked or scratched surface, such as that which invariably results when a carabiner is loaded on a steel bolt hanger, will allow corrosion to begin. The commonly recognized type of galvanic cell then exists between the steel hanger (even if it is stainless) and the carabiner. The situation is aggravated by the large cathodic surface of the hanger concentrating the current flow through the small anodic area of the scratched anodize on the carabiner.

As part of our study of carabiner aging, we placed new carabiners in a number of caves and left them for up to three years. We also retrieved carabiners from a number of Appalachian caves for testing, as well as a number from caves in Carlsbad Caverns National Park. These carabiners showed a variety of types of exfoliation and pitting corrosion. One carabiner removed after eight years from a wet Appalachian cave (figure 3), showed a 15% weight loss due to corrosion. It failed at about 50% of the normal strength of that model of carabiner.

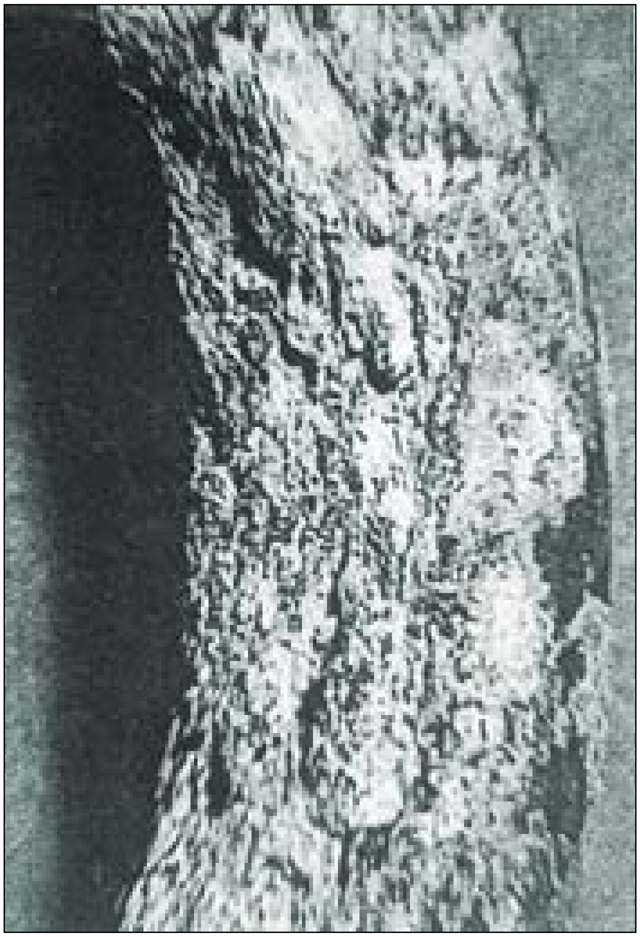


Fig 3 Badly pitted and exfoiated carabiner after eight years in an Appalachian cave.

Fig 4 Deep corrosion pits in carabiner removed from Carlsbad Caverns.

More interesting, and more scary, were samples removed from various places in Carlsbad Caverns. We removed seventeen carabiners from one location where their ages were well documented. Four of the carabiners, which were in the cave for less than one year, had noticeable pitting corrosion in the areas where they contacted rope or webbing. The remaining thirteen dated from 1985. These showed significant corrosion over most of their surfaces, although the pits appeared to be shallow, with no measurable weight loss. We later examined these in detail and found that while they each had but a few corrosion pits, the pits were deep-- up to 3 millimeters -- or 1/3 of the diameter of the carabiner (figure 4). Destructive tests we have performed on a few of these carabiners showed 50 to 70% reductions in strength. Considering the intergranular nature of this corrosion (see photos) it is likely that some of the carabiners left in Carlsbad had almost no strength left. Subtle differences in chemistry produce large changes in corrosion rates. The chemistry of the Carlsbad caves seems to cause more rapid corrosion than even the wet caves of Appalachia.

ALTERNATIVES

You can find stainless steel carabiners in marine equipment catalogs. There are a few places - permanent rigging left after a lead climb has been done, for example - where these would be a good choice. Unfortunately they are very heavy and extremely expensive.

Other aluminum alloys offer marginally better performance. As part of this study, several years ago Black Diamond Equipment (then Chouinard) manufactured some carabiners for us from 7075-T7351 material, as opposed to the normal T6 heat treatment. These have the same chemical composition as the ones they normally make, but are overaged in the heat treatment process. This overaging reduced the strength by about eight percent, but were still within Chouinard's spec range for that particular design.

We evaluated corrosion by placing these experimental samples along with otherwise identical T6 samples in a few corrosive environments. The tests included sea water, garden dirt, tap water and a streamway in a Virginia cave.

After about nine months in the cave the T7351 carabiner had corrosion on roughly 20% of its surface. Corrosion on its T6 partner covered about 50% (figure 5). The sea water samples showed more dramatic results; the others similar but less dramatic. An aggressive outdoor equipment supplier might see an opportunity here.

Fig 5 Test carabiners after nine months in a Virginia cave streamway. The one on the left was heat treated to the T7351 condition, while the one one the right received normal processing.

We also did some testing on chunks of aluminum that nobody makes carabiners from. Oddly enough we found, from the aerospace world, a few alloys that are actually a bit stronger than 7075, having similar corrosion properties. This could result in a slightly lighter carabiner.

While the possibility for a slightly lighter, less corrosion-prone carabiner exists, we are unlikely to ever have an aluminum carabiner that can safely be left underground.

Alexander Klimchouk, from Ukraine, has provided us with some incredibly well made titanium biners. While heavier than aluminum, they are somewhat lighter than steel and have excellent corrosion resistance. These seem to be made of an alloy equivalent to what we call 6Al-4V in the U.S. This alloy, as most titanium, is extremely tricky to work with. The U.S. aircraft industry went through years of growing pains, experiencing disasters after problems with intergranular corrosion and embrittlement. Don't try making these in your home laboratory.

Our limited analysis of carabiners we got from Alexander (stamped "Ibris" on the side) indicates first rate fabrication. Grain structure is uniform and surface finish is fine. We pull-tested four of them, seeing fractures of the gate notch at an average of 6100 pounds. Far more interesting than the strength value was the fact that the observed standard deviation was 70 pounds. The tightly grouped failure values indicate close manufacturing controls and dimensional tolerances.

While the makers get an A for manufacturing and processing, the design is a bit inefficient. They are, in fact, the theoretical titanium biners discussed above- round cross section, as thick as normal aluminum carabiners. The round cross section adds needless weight, and the gate-notch interface could be improved. Also, strangely, the hinge pin is carbon steel; it rusted heavily after six months in sea water.

There are other titanium biners around, some of which don't look as nice as the ones we got from Alexander. Without knowing their history, it is probably a good idea to keep those as museum pieces and curios. With the big business that rockclimbing has become, we may soon see an American made titanium carabiner.

QUICK LINKS

The best carabiner for many situations is not a carabiner at all, but a quick link. Quick links are found in a wealth of sizes and shapes, made from a variety of materials. The common steel variety are often used as permanent rigging. A nice thing about these mild steel links is that they corrode visibly and uniformly. They look bad before they lose strength.

Better still, quick links can be found in 303 and 316 stainless steel. These austenitic alloys, though not particularly strong, will be around long after we are dust and our cities and infrastructure have rusted into oblivion.

With quick links you get the added advantage that load direction is not so important. Carabiners have a bad habit of breaking when you load their gates. This irritates people who use carabiner-brake bar descending systems. If you do this, wake up; it's 1994. Buy yourself a rack or a bobbin.

Another benefit of quick links is that it takes a lot of turns of the screw-gate to open them. This can be attractive in situations where aggressive water tends to loosen things while your back is turned.

CONCLUSION

Carabiner corrosion and subsequent failure represents a significant risk to explorers of caves. In some locations, aluminum carabiners left as little as a few years have been weakened to the point where they could fail under loads applied during normal caving. Based on available engineering and metallurgical data, the risk of corrosion-induced failure can be completely eliminated by the use of austenitic stainless-steel components. Properly manufactured titanium carabiners can also eliminate the risk of corrosion failures in known cave environments. All equipment made of other materials and left in caves should be considered to be of finite (possibly very short) life.

ACKNOWLEDGMENTS

This study took a long time and a lot of work by some very good people. John Ganter has been assisting this project continuously for the last five years. Additional help with placing and retrieving samples was provided by Mike and Andrea Futrell, Herb Laeger, Matt Oliphant, Nancy Pistole, Mike Rogers, Ron Simmons, and Tommy Shifflett. The staff of Carlsbad Caverns National Park and Ron Kerbo have been particularly supportive. Special thanks to Jason Richards for staying up all night to assist us in Carlsbad.

Photomicrographs were generously provided by AlliedSignal Aerospace, Aircraft Landing Systems. We're grateful to Chuck Brainard and the folks at Black Diamond for giving us special (heat) treatment . We are indebted to the people at Tension Member Technology, who gave us special deals on destructive testing, and helped to analyze data.

Carabiner Engineering

Some Principles of Mechanics of Solids

In engineering mechanics, common terms have very specific meanings. The terms load and force refer to the product of mass and acceleration; in some circles this relationship is expressed as F=m*a. Mass is a measure of the amount of matter, closely related to the number and size of molecules. Acceleration is a measure of change in speed, or simply the effect of gravity on stationary objects. Weight is exactly equal to force or load, commonly measured in pounds.

Stress is a measure of the load carried across some area of material. Since area is measured in units such as square inches, stress is measured in pounds per square inch. 7/16-inch diameter rope has a cross-sectional area of about 0.15 square inches. So a resting 180 pound climber puts a stress of about 1200 pounds per square inch on the rope. (180 lb./0.15 sq. in.= 1200 lb./sq.in.). This type of simple stress is known as tensile stress.

In rigid bodies there may be other types of stress. Bending stress is dependent on several factors in addition to load and area. Most importantly, bending stress is proportional to bending moment, a perpendicular distance between the point of load application and the point where the stress is being measured or calculated. Doubling the bending moment will double the bending stress.

Other types of stress include shear and torsion. The different types of stress are not directly additive, but combine vectorially- in a manner dependent on direction and orientation.

The term strength has two meanings, depending on usage. The strength of a component is the amount of load or force needed to break it. One usage refers to component strength, and involves ultimate and yield strength. Ultimate strength directly refers to the load causing fracture, where yield strength is used to describe the load just at the onset of permanent deformation. In brittle materials, these two values may be equal.

Material strength is also discussed as ultimate or yield strength, expressed as a stress measurement. But for a raw material, it refers to the stress value causing permanent deformation. Regardless of the shapes of different components, if made from the same material, they will yield at the same stress value, even though the load values will be different. This characteristic of materials allows the predictive calculations that make design possible. So if we know from tests what load breaks a 7/16 rope, we can fairly accurately calculate the load needed to break a 3/8 rope, provided their materials are the same.

Material strengths vary over a wide range. Steel can be extremely strong. Aluminum is usually somewhat weaker, although the material strength of some aluminum is higher than that of some steel. The strength of materials depends on composition and the processes used to prepare them- things like heat treatment and cold working. The strength values of all types of materials are catalogued and used by engineers in the design of products.

Fundamentals of Design Optimization

Density is a measure of weight per unit volume. Steel is more dense than wood, so a cubic inch of steel is heavier than a cubic inch of wood. As area is measured in square inches, volume is measured in cubic inches. Density is therefore measured in pounds per cubic inch. Steel weighs about .28 pounds per cubic inch. Titanium is less dense; aluminum is even less dense at about 0.1 pounds per cubic inch.

Material strength and density combine to form the concept of strength-to-weight ratio. For tensile strength, strength-to-weight ratio can be useful in selecting a material in design. But since the other types of stress, bending for example, are dependent on geometry of the particular loading situation, strength-to-weight may not be a useful concept.

Bending stress, for example, is inversely proportional to the third power of the width of a member, in the direction of bending. That is, if you made it twice as thick, you would reduce bending stress by a factor of eight. Such a deal. This phenomenon strongly favors less dense materials as a light weight solution when bending is important.

For example, consider steel cube with one-inch faces. Its cross-sectional area is thus one square inch, and its length is one inch. The steel has a material yield strength of 200,000 pounds per square inch (psi). Since the steel cube weighs about .28 pounds per cubic inch, you could support

714,000 pounds per pound of steel, for a one inch long bar. Now with an aluminum material of strength 60,000 pounds and a density of 0.1 pounds per cubic inch, we get 600,000 pounds per pound of aluminum, in a one inch long bar. In this case, considering tension only, the steel looks like a better choice.

The tricky part comes when we start comparing equally heavy parts in bending. Since aluminum's density is lower, an equally heavy aluminum bar would be quite a bit wider than a steel one. As mentioned above, bending stress is inversely proportional to the third power of thickness. Stated differently, bending strength is proportional to thickness cubed. So if we shaped our aluminum bar to resist the bending- like trying to bend a ruler into a disk (see illustration) , as opposed to a hoop- we'd get a huge increase in bending strength. Or you could say there is a great reduction in bending stress. The bending strength is proportional to the quantity h cubed times b (b times h times h times h), in the illustration. This phenomenon is why I-beams exist; material is strategically placed to resist bending.

In the above example, if we increased the aluminum bar's diameter- or better yet made an I-beam shaped cross section- we could get a much stronger component for a given component weight than if we used steel.

Titanium then presents an interesting challenge. It is lighter and weaker than good steel; and heavier and stronger than good aluminum. Many titanium alloys have higher tensile strength-to-weight ratios than any aluminum or steel. But we can't necessarily get a lighter carabiner by using titanium. Since it is more dense than aluminum, to reduce weight, a titanium carabiner would have to be thinner than its aluminum rival. But the reduced cross-sectional area loses its bending strength rapidly. So titanium carabiners may have a tough time in the weight-loss competition.

Simply making a titanium biner in the same size and shape as an aluminum one will result in a weight increase of about 50% over aluminum, as titanium has a density of roughly .2 pounds per cubic inch.

But if corrosion is a concern, aluminum may not be a valid choice anyway, and we are then left with the choice between titanium and steel. The weight advantage of titanium over stainless steel could be attractive for those carrying a lot of rigging gear into a cave.

TRIP LEADERS WANTED

By Joe Shepherd

As most of you probably know, I have recently volunteered to be the BATS Trip Coordinator. This does not mean that I am expected to lead the trip each month. It means that I am counting on all BATs to step up and volunteer to lead a monthly trip. There are currently over 40 BATs and only twelve months in a year. The requirements are simple:

- **Pick a cave that can accommodate all skill levels**
- **Try to pick a cave that can facilitate a day trip or where easily accessible overnight accommodations exist**
- **Provide me with:**
  - A description of the trip
  - Directions to the meeting location
  - Start time and duration of the trip
- **I will take care of all the other details: coordination,publicity, etc.**

Monthly cave trips are an important part of our grotto. Please help to make them happen each month.