

USING A CARBIDE CAP LAMP

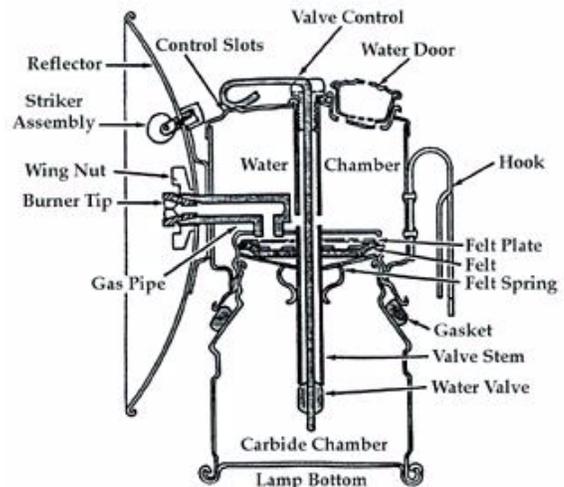
by Tom Moss

Since time immemorial, the finest cavers in the universe have utilized the wonderful carbide lamp. This often-balky critter features a low mean time between adjustments, but rewards its user with a very high mean time between failures, in addition to providing a friendly light, heat, and a warmly romantic ambience for your caving pleasure. The words of wisdom that follow cover many of the common problems that the uninitiated might have with carbide lamps, as well as some ways to fix and circumvent difficulties.

THEORY

The lamp consists of two major parts. The bottom is the chamber where the carbide, and eventually the spent carbide, resides. A gasket goes around the threads on the bottom.

The top consists mostly of the water tank, which is filled through a hole on top, which is covered by a door-like plug. A rotating valve goes vertically through the center of the water tank, and a lever on top controls the amount of water dripped into the carbide chamber. The "felt" filter and felt holder reside inside the threaded skirt where the top and bottom screw together; a round spacer fits in above the filter. The felt filters the gas produced, after which it goes through the gas tube (which runs inside the water tank) to the removable burner tip in the center of the reflector, which is held on by a wing nut.



The theory of operation is simple: water is added to calcium carbide, and the reaction produces flammable acetylene gas.

STARTING

Load the bottom chamber 2/3 full with carbide, then fill the top chamber with clean water. While the lamp is apart, adjust the lever on top until the water drips at the rate of about 1 drop per second. Put the lamp back together, and check gas flow out of the burner tip by putting the lamp up to your face, and feeling the gas against your lip. Light the lamp in whatever way turns you on. Remember that acetylene is lighter than air.

RUNNING THE LAMP

A carbide cap lamp runs 2.5 to 3 hours on the average from each charge of carbide. Most lamps will use more than one tank of water in this time.

The length of time that a charge will last is dependent upon the size flame that you generate. For efficient use, you can run a 0.75-inch flame with a parabolic reflector, a 1-inch flame with a 2.5 inch reflector, or a 1.5-inch flame with a 4-inch spherical reflector. The latter definitely gives you the most light, but the charge may only last 2 hours. But carbide IS cheap....

For assisting the electric caver in front of you through a tight spot when his battery is hung up, turn up the water momentarily until you achieve an impressive 4-6 inch flame. Apply where you think it will do the most good.

FUEL

An 8-ounce baby bottle full of carbide will run the average lamp for 18-24 hours, and is the standard container. Be sure that the container is waterproof. A gasket can be cut out of a nipple and the two pieces of the lid should be glued together. Nalgene bottles can be used for carbide also. The average lamp will use 1 to 2 ounces of water with each charge, so you have to bring enough water for yourself as well as your lamp.

MAINTENANCE

If you carry a repair kit with you, you will have very few problems that can't be easily fixed. This should include a spare felt, flint, gasket, tip and a tip cleaner. Take an old toothbrush for digging out the spent carbide and cleaning the lamp. A small piece of fine sandpaper is good for working on the tip seat or the gasket sealing surfaces. Ignition pliers are handy for changing tips, and good for other caving tasks as well. Always take a vented dump container with you; I use two nested Ziploc freezer bags. Spent carbide is a poison to cave life, and should never be dumped in or outside the cave. Be careful not to spill any when changing carbide.

After each 15-20 hours of use, clean the lamp thoroughly. In the kitchen sink, wash the lamp top and scrub the bottom of the water chamber with a toothbrush. Scrape carbide residue off of the threads, top and bottom, with a knife. Run water through the dripper mechanism to flush out any foreign material. Don't take the tip out unless you have to -- the tip seat is the most fragile area of the lamp.

PROBLEMS

A good, well-maintained carbide lamp will provide you with light and heat with very little trouble. Most problems are caused by improper use of the lamp. Some common ones:

CLOGGED TIP - This sometimes happens when firing up the lamp, and can cause gas to back up into the water chamber. Clean out the burner tip with a tip cleaner or a piece of wire (old telephone wire is the correct size). If the clog persists, take the tip out (carefully) and clean trash out of the gas tube.

WET FELT - Usually a result of running too high a flame; a wet filter prevents gas from coming out of the burner tip and can cause a "soupy" charge. This can be prevented by ensuring that the drip control lever is not set too high. To fix, change the felt and blow any water out of the gas tube.

LEAKY GASKET - This is always a fun thing to see, particularly when the whole lamp spectacularly bursts into flames. Do this occasionally to keep the electric cavers entertained. Change the gasket or turn the old one over; if the lamp still leaks gas, go over the entire sealing surface with fine sandpaper or emery cloth. I always carry a thick gasket with me in case of a dented skirt or

other irregularity, which may cause a lamp to leak. Sometimes a lamp doesn't catch fire, but just doesn't run as long on a charge because it is leaking just a bit. If you can smell acetylene, a lamp is not running efficiently. You can check for leaks by running a flame around the gasket.

TROUBLESHOOTING

Some common symptoms and their causes----

Water coming (sometimes shooting) out of the top of the water chamber: The gas is backing up due to a clogged tip or wet felt. Sometimes you just hear the gas bubbling up into the water chamber.

Flame goes up when you turn the water down, and vice-versa: you need to add water.

Low flame: Check the charge. If there are no lumps of carbide left, change carbide. If the charge looks ok, turn the water feed up momentarily and flush out any clogs in the water valve. Check also for clogged tip.

Sputtering flame: check for wet felt, or trash in the gas tube.

Sideways or double flame: clean the burner tip. If the problem persists, replace the burner tip.

MISCELLANEOUS SUBJECTS

A tip cleaner is a gadget with wires to clean the burner tip orifice. I prefer the stainless-steel type with the sliding cover. A tip reamer is a tapered circular file, used to enlarge the orifice. I like my orifices tight, so I never use 'em.

If you want to get the utmost out of each charge, you can stir it up and get a little more time before changing. I prefer to change a bit prematurely when practical, as it is easier to get the spent carbide out. Carbide IS cheap -- less than \$1.00 per pound at the moment.

Be careful with Premier bottoms -- they are notorious for splitting when overloaded. Always carry a spare bottom, or an entire spare lamp. A spare bottom, pre-loaded with carbide, makes for a fast carbide change. But if you leave the spent carbide in the old bottom, take the gasket off.

Always clean the spent carbide out of your lamp as soon as possible after using it. Spent carbide (calcium hydroxide) is corrosive, and will damage the lamp if you leave it sitting with a spent charge in it.

If you shoot compass, you will probably want a non-magnetic reflector. Use the 4-inch stainless steel parabolic, or the Premier 2.5 inch aluminum reflector.

TYPES OF LAMPS

The only decent lamp now manufactured is the Premier. It is worthwhile to search out a good antique lamp: Autolite, Justrite and Guy's Dropper are the most common types. Avoid the Butterfly lamp.

BUYING A USED LAMP

I try not to pay more than \$10.00 for a used lamp, unless it really looks good or I have an opportunity to fire it up. Often there is a hidden flaw, and you end up with a shelf model. When you see that dusty Autolite at the flea market, take the bottom off and check for cracks, holding it up to the light. Look for cracks in the skirt also. Take the wing nut and reflector off, and look for cracks in the threaded tip seat. Check the water feed; run water through it if the owner will let you. Look for vertical play in the water control, indicating a worn valve.

A Premier tip will fit the Autolite. If filed down, it will fit a Guy's Dropper. Justrite tips were available a few years ago, but are getting rare. Reflector braces for old lamps are hard to find, but you can probably fashion one. The felt, felt holder, felt plate and gasket from the Premier can be used in most antique lamps.

IN CONCLUSION

For those interested in a more technical approach, there is a great article on carbide lights in the NSS publication CAVING BASICS.

More wise words from the old cave ballad:

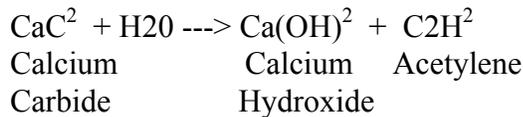
*Life is like a carbide lantern,
With a plugged-up water drip;
As you sputter through existence,
You will carbon up your tip.
Though you never make your closures,
And your stations wash away,
Keep your mind upon Life's purpose:
Try to map a mile a day.*

Caving...
It's like fun,
only different

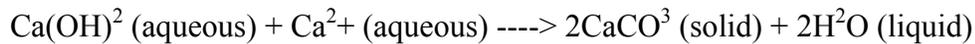
CARBIDE LAMPS -- Excerpts from mail-list conversations

Carbide: How it works

Calcium Carbide: The reaction of calcium carbide with water to form acetylene is as follows:



Thus, the gray white powder you have left is calcium hydroxide (slaked lime), which is not the same as the white powder in limestone gravel, which is CaCO_3 , or calcium carbonate. Calcium hydroxide is a strong base but is only slightly soluble in water. Many antacids (e.g., Tums) are alkaline earth hydroxides; they do not dissolve rapidly unless there is acid present. Calcium hydroxide is also commonly known as “slaked lime” and is used by water treatment plants for softening water. In the presence of bicarbonate ions the calcium hydroxide will react to form calcium carbonate.



In other words, dumping a few ounces spent carbide in a gravel road or in your yard/garden probably isn't going to screw up the local chemistry any more than the road already has. Within hours, in a humid environment, it will spontaneously decompose to lime, and eventually to calcium carbonate. Lime is frequently used by homeowners to adjust the pH of their yard/garden soil and improve its productivity; spread thin, it certainly will not contaminate or harm anything. (In fact, I use it regularly – both commercial lime and carbide lamp residue – in my yard to discourage the growth of moss and encourage a healthy lawn.) The only possibly poisonous element in spent carbide is either the remaining calcium carbide before it decomposes, or some impurity in the calcium carbide. In other countries, e.g., Mexico, the carbide available is less pure, containing traces of heavy metals and the like (some has even been known to ruin a carbide lamp), but this is not a problem with US-produced carbide. The frequently heard stories about farm animals being “poisoned” by dumped carbide, however, do have some truth. Animals are attracted to carbide dumps, and will eat the residue because ‘nature’ tells them calcium is something their bodies need. (Ever heard about the elephants that “eat” cave limestone for the same reason?) Partially decomposed carbide, however, in such quantities is toxic. Likewise, dumping spent carbide in a cave will alter the chemistry of the cave considerably and harm cave life. But spreading (emphasis here) a few lamp-fulls of fully spent carbide residue in your yard is definitely a benefit, and not a hazard.

(The above is a synthesis of information from Rane Curl and others on the internet.

Date: 26 Aug 1996 11:44:11 MDT

From: "Earl, Scott W" EARLSW@inel.gov

Subject: Premier carbide caplamps, reliable? Yes

To: cavers@orion.ditell.com

Scott Askey asks in CD 5354 if Premier Caplamps have been improved and if they can be recommended as reliable.

If you use carbide, read on--otherwise skip this as we have all been through the carbide vs electric debate.

All of the Premiers I have played with were bought within the past 5 years. I use them whenever carbide is allowed (which is less and less nowadays). I don't know if quality has changed in that time, I have seen little difference but have only worked with about 8 of them. I have experienced only 2 problems.

1. The bottoms are not very ductile and will crack around the bottom rim if allowed to bulge several times.
2. Many of them leak water like crazy whenever in any position other than upright (which is almost always.)

I have found a fix for both of these problems that I have not seen addressed before.

Fix #1. The bulging is caused by expansion of the gray crud (no, I don't know the name), which continues expanding in the bottom after a change-out and will push the bottom out into a convex curve, greatly weakening the rim after a few cycles. Three things cause this expansion. Overfilling the bottom, trying to use up the entire charge of carbide, and leaving the lamp overnight (or longer) before emptying it. I never fill the bottom over 1/2 full and by thumping it occasionally during use to prevent compacting and by changing bottoms before every bit of the carbide is used up, the gray crud turns to a dry powder and cleans out nicely and without pressure. This pressure problem is present with all brands of caplamps, but the Premier is less forgiving of the stress it creates. Since I don't always get the bottom changed out in time for it to become real dry, I always clean the bottom the same day it was used.

Fix #2. HAH, This works GOOD!

The Premier leaks water in two places. First, around the often poorly fitting fill cap, and Second (much harder to find) around the top seam where the top is factory crimped onto the water container.

For the First leak, I bend the fill cap hinge to get the best fit. Then I scrape and scratch the mating surface of the fill cap to get it real rough and put a tiny bead of silicone caulk around the cap flange where it mates with the hole. Then coat the surface of the hole with Vaseline and close the cap and let it cure. This makes an excellent custom gasket. For the Second leak I close the water valve, turn the lamp upside down, apply cyanoacrylate (crazy glue) all around the crimp seal, and then SUCK HARD on the open fill hole to pull the glue down into the leak. Let it cure upside down.

Hope this helps. I have very few problems with the Premiers after this, but admit they are not quite the quality of the Justrites and Autolites.

Scott Earl, PCD
Idaho Cave Survey

To: cavers@orion.ditell.com (Jim Olsen)
Subject: Re: Premier Lamps
Date: Tue, 27 Aug 96 19:44:10 GMT

From: mwiles@sioux.sodak.net (Mike Wiles)

Premier lamps aren't as good as they used to be, but I've had good luck with them.

To keep the bottom from blowing out, solder the inside: Before it's ever used, just put it on an electric stove heating element, let it get hot, feed in enough solder to fill the groove in the bottom, and let it cool. I've never had one blow out since implementing this practice. During use I fill the bottom about two-thirds full of carbide to avoid erratic behavior with a fresh charge, and clean it out promptly when it's fully used.

You can keep the threads from jamming or cross threading by keeping them clean. Soak all metal parts in white vinegar every few trips and clean the threads with a nylon scrub pad. It only takes a few minutes. The vinegar treatment will also help the water flow easily through the stem and make your lamp nice and shiny, too. It makes cleaning the reflector a breeze, but don't soak the flint and spring.

The biggest problem is the leaky water door, even on new lamps. My quick and dirty solution is to use a piece of flagging tape as a gasket. You'll need to bite an air hole in it and push it down into opening just enough to keep it from laying flat against the bottom of the water door: if that happens and the holes don't line up, no air can get in and the water will not flow into the carbide. This is an admittedly inelegant solution. Maybe I'll try Scott Earl's method.

The important thing is to take care of the lamp. It is amazingly trouble-free if you give it 15 minutes of maintenance each month. I just got a new Premier lamp. (Water began leaking intermittently from around the gas tube of the old one after a twenty-foot drop, and I don't have the equipment or skill to solder it). The workmanship looks pretty good. Even the water door seems to have a good fit. Guess I'll find out soon!

Mike Wiles

P.S. Another recommendation is to straighten the blade so it bends straight down. The lamp will rest closer to the hardhat and you'll be much less likely to jam it into low ceilings. It really adds to the life of the lamp.

Date: Tue, 1 Oct 1996 19:09:06 -0400
To: cavers@ditell.com
From: Martin Sluka <tvmagazn@astrosat.anet.cz>
Subject: Re: Carbide Flare-Up

I use thick-walled silicone tube (inner diameter 6 mm, outer diameter 12 mm) and because the silicone is not only heat/fireproof but is quite soft, I have poked in the tube the thick string (nylon one, 2 mm diameter - from grass cutting machine) which prevents "strangulation" of the tube and breaks the bubbles of condensing water.

Martin

.....
Martin Sluka, Astrosat, Sokolska 64, 120 81 Prague, Czech Republic
tel.:+422-24224867, fax: +422-24231826

.....

Subject: Re: calcium carbide
From: reid@indiana.edu (Frank Reid)
Date: Sat, 11 Jan 1997 11:27 EST

Carbide is made by heating coke (the carbon kind) and limestone in an electric furnace. If you could recover the electricity used to make carbide, you could have a far brighter light! Calcium carbide was discovered serendipitously in an attempt to make artificial diamonds. Less of it is made now than in the past, because there is now a catalytic process for making acetylene from natural gas.

I recently learned that a major use of calcium carbide is for removing impurities in the steel making process. A caver who's a paramedic in Ohio attended an overturned and spilled truckload of powdered carbide bound for a steel mill. The HAZMAT people were overreacting until she explained that it's harmless unless wet.

-- Frank reid@indiana.edu NSS 9086

Subj: Re: Carbide efficiency?
Date: 97-01-14 13:19:37 EST
From: guy.van.rentergem@skynet.be (Van Rentergem Guy)
Sender: owner-speleonics@altadena.net
To: Speleonics@altadena.net

Industrial carbide is about 80 % pure carbide the rest is lime (CaO) and 2 - 5 % other impurities.

To make carbide lime (95% pure) and coke (88% fixed carbon) is needed. 2 tons of limestone is used to produce 1 ton of lime. To make the lime there is also a lot of energy necessary. The energy input is dependent on the type of kiln

:

- Rotary kiln : 6.4 - 13.9 GJ/ton lime
- Vertical kiln : 4.2 - 4.6 GJ/ton lime

The carbon is delivered by coke. The process to make coke is exothermic so no energy input.

And now the production of carbide.

865 kg of lime and 494 kg of coke is needed for 1 ton carbide.

The input of electricity is 2800-3100 kW.h (theoretical : 2200 kW.h)

(Consumption of 14 - 26.8 kg Soderberg elektrode for 1 ton carbide)

There is a production of 280 cubic metre (15 °C) carbon monoxide (75-85 %) and Hydrogen (5-12%). This gas can be used for the production of lime.

1 kilogram of industrial carbide with theoretical 0,59 kg of water gives:

- 0.31 cubic metre acetylene (101 kPa, 20 °C)
- 1,18 kg of residue (calcium hydroxide)
- < 0.06 % phosphine
- < 0.15 % hydrogen sulfide

- < 0.001 % arsine

Normally an excess of water is used to absorb the heat of reaction, otherwise explosions can occur. In the dry type of generator (working at more than 100 °C), like cavers use, the evaporation of water is used to absorb the heat of reaction.

That's it !!

Greetings from Belgium! Guy Van Rentergem

Date: Wed, 27 Sep 2000 13:37:36 BST

From: CaverForum@pennine.demon.co.uk (Andy Waddington on Cavers' Digest)

To: cavers@caversdigest.com Subject: re: 5690:12 Carbide lamps

Matt Morrison says

- > Premier cap lamp. I get gas bubbling up into the water compartment
- > It also drips water when upright

These are classic symptoms of a restricted path for the gas to get from the carbide container out of the jet. At its simplest, the lamp just needs pricking. But if this is not enough, then it needs a good cleaning out.

Take it apart - replace the filter with a new piece of "green bit" (green scouring pad - I don't know a trade name in the UK, let alone in the US) cut to fit - make sure it is as big a circular piece as you can get in, as they shrink over time and eventually dust gets up round the edges as well as through the matrix. Replace the filter fairly often so it is always relatively clean looking. Green scouring pad is much better than the silly bits of felt in a brass mount that originally came with these lamps, as well as being very cheap and available "everywhere". Scrub all the accessible parts of the lamp with a stiff toothbrush (ideally one you don't use for teeth any more).

Now remove the jet - you can usually do this by twisting and pulling with a pair of pliers. Clean out any dust and gunk from inside the jet, and prick it thoroughly. Clean out the passage behind the jet from both ends (it has a right angle bend) - pipe cleaners are good for this, but you may also need to use something hard to clean off tough bits (damp spent carbide gets in there and sets solid). Ream it out really well and then make sure there is *no dust* left to get into the jet. But don't be too brutal - if this pipe develops a leak you will also get gas coming out of the top of the lamp and it will be hard to cure.

It may be worth emery-papering the jet and its seat to make it is easier to get a good seat when the jet is replaced. Put the jet in your mouth and make sure you can blow and suck through it easily (sucking the jet hard is a good technique in the cave too, if you haven't got a pricker). Make sure you do get the jet well seated before taking the lamp caving - the lamp is no use if the jet falls out the first time you whack your helmet on the roof...

Incidentally, if you are prone to running into rocks head first, put a large jubilee (hose) clip round the top of the lamp. This stops the stress from a front impact from gradually ripping the lamp bracket off the back of the lamp.

It all works best if seals are tight, so polish the threads and the surfaces where the gasket sits (emery paper if really bad, then something like Brasso). Old gaskets get stiff and leak - replace (you can make new ones from tractor inner tube - car inner tube is too thin).

Now check that the water feed is clean (fill the top of the lamp with water and turn it on - there should be a steady flow). If not, get your head under the lamp, put your mount round the water drip and blow to get the gunk out. After each breath, invert the lamp, tip out the mucky water and start again with clean.

One final tip. Do you find that the bottom of the carbide container rots, splits or develops gas leaks? When you get a new base, put a layer of epoxy in the bottom (just mix up an inch or so from each tube and drop it into the base, then put it on top of your boiler, stove or hot radiator. It will go very runny and flow into the tight corner, then set. Don't bash the base on this edge when emptying the lamp. You can use this epoxy technique to cure a leaking base too, provided you get the inside really clean first (which is difficult). I recently fixed up a premier which had accidentally been put away still full of spent carbide a couple of years previously. It showed all the symptoms you described as well as having a split base. It works really well now.

Oh yes, remember to use safety glasses when hammering gobbler-carbide into small enough pieces to use in your fig 85 head lamp :-). It really isn't good for your eye to get fast-moving carbide chips in.

Happy caving - and remember to take spare carbide for trips over 6 hours.

Andy

Date: Fri, 29 Sep 2000 12:40:18 -0500
From: rod perry <rod@swbell.net>
Subject: Leaks
To: Jim Olsen <cavers@caversdigest.com>

I would recommend JB Weld for the odd repair on low-pressure leaks. 1-2 hours setup time and go. I repaired my glasses with it and it worked for over 2 years (yes, I'm a geek). I actually have a gas line under my house repaired with it. Best to put the goop on the pressure side of the leak.

Read the directions and carry some with you - could even patch a helmet/lamp setup.

On the side here, super glue will adhere a torn bit of flesh without any pain. Don't put it where it could block blood flow, just around the edges of the wound. Directions: realign torn tissue, wipe dry, apply glue to outer edges, wait 5 minutes and get on with it. Been there, done that and will probably repeat it.

Rod,
The Tail-gate Caver

Date: Fri, 29 Sep 2000 13:14:15 -0600
To: Jim Olsen <cavers@caversdigest.com>
From: Mark Minton <minton@mail.utexas.edu>

Subject: Carbide Lamp Cleanup

There has been much discussion lately about how to clean up an old carbide lamp. One thing I haven't seen mentioned is that it is very easy to clean out hardened bits of spent carbide by soaking in vinegar. Vinegar is a weak acid and it will eventually dissolve or at least loosen all of the spent carbide (which is basic) by chemically neutralizing it. If you need to do any soldering, it is important to get the metal really clean so that the solder will stick well. The best thing for this, if you can get hold of it, is nitric acid. Use a dilute solution (about 20%, or one-third full strength) and do not leave the lamp in the acid very long. Wear gloves and do not spill any acid on you! Nitric acid can easily eat right through the brass (and your skin) if you leave it in contact too long. A brief immersion followed by a thorough rinsing with water is usually all that's needed to get the metal really bright and clean if it's been pre-cleaned as above.

Mark Minton

From: WLewis6373@aol.com
Date: Sun, 1 Oct 2000 18:01:19 EDT
Subject: Carbide Mine Hoax
To: cavers@caversdigest.com, WLewis6373@aol.com

Cavers, Hi!

To those interested in tall tales, this is the notorious article on the alleged Swedish Carbide Mines.

**The Carbide Mines of Svenstavik, North Sweden
by A. O. Oldham**

Last year, during the course of a caving holiday, the author was fortunate enough to have the opportunity to visit the Carbide Mines of Svenstavik, which lie to the north of the small industrial town of Hammerdal deep in the ranges of the Arvidsjauer Hills and at an altitude of about 1500 meters. They are unique as this is the only site in the world where Calcium Carbide is found native. The mineral occurs in a bed of carboniferous limestone which has been metamorphosed at an early date forming, at the junction of the Skjon series, a band of solid carbide two meters thick, extending for kilometers.

The mines are entered by spacious horizontal drifts, extending far into the hills. The mineral is obtained in a fashion similar to that of coal, although the workings are not as modern as some coalmines, the mineral being excavated from the working face, which is about two meters high, with a pick. The working faces are continually sprayed with paraffin to keep down the dust and this also gives the carbide its characteristic black glossy look.

The mines are quite dangerous places of employment with the combined action of the choking dust and the gas, which is both inflammable and poisonous. A few years ago a Laplander employed in the workings very nearly caused a nasty accident by obeying the call of nature at the working face. The resulting explosion brought down a good part of the roof but fortunately there was no loss of life.

The carbide is removed by conveyor belt and then by trolleys with brass wheels to the surface. There it is screened and sieved in large sheds and then washed in paraffin and packed in airtight containers ready to export to all parts of the world.

The mines are privately owned and sad to say there is only one large working left, the others having gone out of production as today this commodity can be obtained much more easily and safely from an electric furnace.

The Baltimore Grotto News
Vol. VII, No. 8, pp., 244-5
Reprinted in the Speleo Digest 1964

The article is a beautifully constructed presentation, full of almost clues and false leads. It appears to be free of internal contradictions. However there is no reference to a further source of information. In no way is it to be taken as anything but an elaborate joke. The editors perpetuated the gag by placing it in the Science Section of the 1964 Speleo Digest, pp. (2) 56-57. It deserves a high place in Science Fiction.

"Everything that deceives may be said to enchant"
--Plato, 4th Century BC

Warren Lewis

End