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Exploring the Harder Side of Caving

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Personal Equipment

Krubera base camp, Abkhazia

Appropriate clothing and equipment for a cave increases safety by increasing comfort and reducing your energy expenditure for any given trip. While the condition of the life support components of personal gear has an obvious effect on your well being and the rest of your gear is of less immediate importance, considerable care should still go into its selection.

Clothing

Protection from cold, water, mud, sand and rock is needed to varying degrees in all caves. The selection of your caving apparel depends on the nature of the cave and your personal preference.

Undersuits

In caves colder than 15° C a one-piece undersuit of CoolMax, chlorofibre or polypropylene is ideal. Synthetic suits dry quickly, are reasonably comfortable when wet, are not too bulky to hinder movement and wash easily. One-piece fibrepile 'furry suits' are bulky and in all but the coldest caves are too hot when dry. Once wet a thick pile suit holds an enormous weight of water that is slow to drain and dry out. Clothing conducts heat away from your body much faster when it is wet. Fast drying, low bulk clothing is therefore better than wearing thicker but slow drying clothing if there is a high possibility of getting wet.

If you really feel the cold, multiple layers of light clothing are better than a single thick layer. You can augment any undersuit by an extra synthetic top should the cave be cold enough or the rate of travel so slow as to require it.

Woollen underwear is adequate but does not perform as well as synthetic fabrics. Do not use cotton in any form in cold wet conditions. Once wet it dries slowly, feels uncomfortably damp and removes a lot of your valuable body heat.

In warmer caves, use light polypropylene underwear. It removes water from your skin rapidly, keeping you feeling dry and is more comfortable against bare skin than an oversuit. Take care when drying synthetics; too much heat will convert them into crunchy miniatures of the real thing.

Sew light neoprene or fibrepile patch-pads onto the knees and elbows of your undersuit to provide protection without appreciably restricting movement. Position the pads carefully by marking their position with your suit on and arm or knee bent. The pads end up a little lower than you may expect but in the correct position to protect you.

Even the lightest undersuit is too warm in some caves and it is then necessary to wear nothing more than normal underwear as an 'undersuit'.

Oversuits

Protection from cold is rarely enough, warm gear must stay dry and clean for it to be effective. It also needs a tough covering to keep it in one piece.

Waterproof

Brightly coloured plastic suits have been the mode in Europe's cold wet caves for some years. Made of PVC coated polyester with welded or taped seams, velcro front and integral hood, they offer exceptional protection against water and abrasion, are tough, long-wearing and look good in photos. Being made from non-absorbent material they do not increase in weight by soaking up water and the smooth surface sheds mud and water rapidly to prevent heat loss through evaporation. The tough fabric has a certain 'suit of armor' feel about it, especially at low temperatures and you must ask yourself whether the lack of flexibility and increased effort moving in a PVC suit is worth the extra protection. Its impermeability can cause a good deal of condensation to form if you wear it in warm caves or when working hard. Nevertheless they are unbeatable in cold, wet caves when the water is not too deep. Repairs are easy. Glue a patch on the inside with the PVC glue normally used for plastic plumbing or with contact adhesive.

Non-waterproof

Suits made of nylon with no waterproofing layer or even 'proofed' nylon or cordura are more comfortable to wear than impermeable plastic suits. They are light, flexible and breathe so that given the chance, they dry out. Unproofed suits are the ideal choice for warm or dry caves. They have the added advantage that they can be home made in countries where impermeable suits can only be imported at great expense. In mild conditions ordinary cotton overalls are suitable.

Something in between

There is also a range of oversuits made from woven nylon that are proofed with a heavy PVC layer on the inside. These suits as you would expect fill a mid-way niche between PVC suits and unproofed suits. They rarely have sealed seams and typically let in some water when new, and more water as the proofing wears out. The proofing layer also makes them a little warmer while you're moving and more subject to condensation. They are however still relatively lightweight and comfortable to wear. Meander makes a nice hybrid suit that has PVC from the waist down and cordura on the top half. It works well to protect your legs from splashes while allowing you to move your arms more freely and not overheat so badly.

Extra clothing

For cold or slow trips (surveying, photography) a balaclava and undergloves make a world of difference. For colder conditions or for emergencies carry a thermal top in a waterproof bag until you need it.

Wetsuits

Wetsuits are excellent for wet caves where you are constantly in and out of the water or swimming. They offer an all over padded skin, buoyancy in deep water and a streamlined profile for nasty passages. However, there are some disadvantages. When inadequately designed for caving they restrict your limb movement considerably, making climbing difficult and adding to fatigue. A wetsuit is uncomfortable in a dry cave as it seals in sweat, keeping you constantly wet. After a long trip most cavers emerge looking as wrinkly as a prune. The efficiency and amount of insulation that a wetsuit provides is small, so it is necessary to stay active in order to keep warm. If you are forced to stop for some time it is easy to become dangerously cold. At the other extreme, prusiking or moving quickly through dry passage can cause severe overheating and it is not uncommon to find a wetsuit wearer taking a quick dip in some tiny pool in an attempt to cool down.

A 'surfsuit' made of soft neoprene with thinner patches behind the knees and elbows to increase flexibility is the better alternative to a diver's wetsuit. This design accommodates all prusiking movements and allows you to reach both hands above your head. The neoprene should be double lined, no thicker than 5 mm and even thinner for warm caves.

A suit that is a slightly loose fit gives better freedom of movement and allows you to wear an undersuit for cold conditions. One-piece wetsuits are lighter and cheaper but less versatile than two piece suits. Female cavers find two-piece suits more comfortable while males can get by in any suit with a fly zip. A hood for diving sumps completes the suit.

Wetsuits come in a wide variety of attractive colours and designs. You can also get ones like this.

Pontonniere

Pontonniere in action

The safest and most comfortable way to explore a cold cave is to stay dry. If you need to wade but not swim a 'ponto' is the way to keep your undersuit dry.

Pontonnieres are made of latex, polyurethane coated nylon or PVC. Latex versions are the most popular as they are made in one piece with no seams, feet included. Pontos keep you waterproof to the armpits with only minimal restriction of leg movement. A ponto weighs around 500 g and packs down small enough so you can carry it to the beginning of the wet section, then put it on over your undersuit but beneath your protective oversuit. Wear a pair of thin long socks and garters over the ponto to keep it fitting neatly and protect its feet.

Contrary to the popular belief pontos do not flood badly. I have swum 20 m or so in one and took in only about one litre of water that went straight to the feet, leaving me tolerably warm and 'dry'.

All pontos are delicate. Latex is tougher, more elastic and easier to repair than polyurethane (a repair kit comes with the ponto) but latex perishes if not adequately cared for. Polyurethane versions require less care and are lighter (350 g) although there have been some problems with the seams splitting.

After use, rinse your ponto in fresh water then dry it out of direct sunlight. When packing a latex ponto away, dust it inside and out with talcum powder to prevent it from sticking to itself.

Footwear

The most popular cave footwear must be rubber 'gumboots' or 'wellies'. They offer good protection to your feet and lower leg, are robust, keep your feet dry in most caves and are cheap.

Rubber soles grip better than plastic but wear out faster. If the boots are unlined they will dry out quickly. Wear the legs of your oversuit over your boot tops to keep out gravel and water. This works better if the boot tops maintain their shape. Rubber bands cut from car inner tubes are ideal for keeping your overalls from slipping down your wellies and restricting leg movement. They only keep your feet dry provided the water stays below 'welly-depth', once there is more than a little wading, the constant emptying is a nuisance and short lace-up boots are more practical.

If you don't like wellies, lace-up rubber boots are a good alternative. They do not keep out water as efficiently as wellies but are still durable and do not become soggy or heavy when wet.

For easy trips, clean caves, or where you need to swim a lot, running shoes are suitable. Leather walking boots cope very badly with wet caving. They become heavy when wet, are expensive and wear out too quickly to be good value for money.

Socks

Neoprene wetsuit 'booties' are very popular. They keep your feet toasty warm and well padded—and wet. Wetsuit booties go well with wetsuits but if your feet aren't constantly being dunked in the water they quickly become uncomfortable. If you wear wellies, long wool or synthetic socks are ideal. Even after long trips it is possible to emerge with dry feet.

Gloves

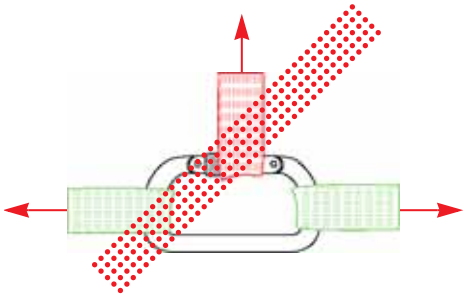
Perhaps on short trips into easy caves, you'll survive with bare hands. When caving day after day or on a long trip you can't afford to lose dexterity due to cold or damaged hands. Gloves are essential but good ones may be hard to find. Ideally a neat fitting pair of PVC industrial gloves with long gauntlet wrists are the best. Once you are used to the feel of gloves wear them as much as possible to keep your hands clean, dry and protected. The long gauntlets help keep water and dirt from getting in both the gloves and your sleeves. In really dirty caves you can put rubber bands or adhesive tape around oversuit or glove cuffs in an attempt to keep the cave out. If you can't find a good pair of gloves any gloves are better than none.

Seat harnesses

Seat harnesses are usually made from flat tape 25 mm to 50 mm wide. When well sewn or fastened with suitable buckles they are stronger than the caver who is wearing them. However, strength is not all that is necessary, there are other requirements:

- A harness must have at least two independent suspension points as a fail-safe. If one breaks there must be a back-up.
- A harness must be comfortable, you may have to sit in it for a long time.
- It must be lightweight, and not made with lots of bulky, water absorbent padding.
- It should fit neatly, even tightly, without restricting leg movement. Slack in a harness ultimately has an adverse effect on your prusiking efficiency.

A number of commercially available caving harnesses fit these requirements but you should be careful of climbing harnesses as they are almost always too loose for efficient prusiking.



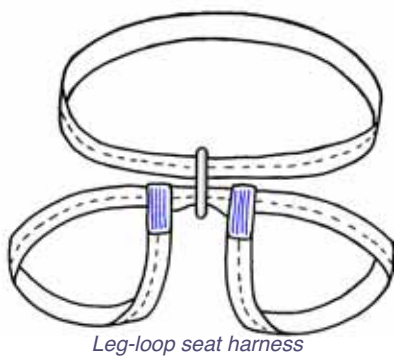
3-way loaded karabiner

Always use a maillon rapide or Petzl Omni to hold your seat harness together at the front. Never use a karabiner, the 3 way loads that can occur at the harness attachment point make it dangerously weak. Use a 10 mm diameter maillon made of either steel or aluminium in a delta or half round shape. An 8 mm steel delta maillon is also strong enough but has very little weight advantage over a 10 mm aluminium delta and will be very crowded by the time everything is clipped into it. You can loosen a seat maillon that is jammed closed by wrapping a piece of clean tape around the gate or use the nose of your Petzl descender as a spanner. A steel maillon also works as an adjustable spanner, but may damage the maillon.

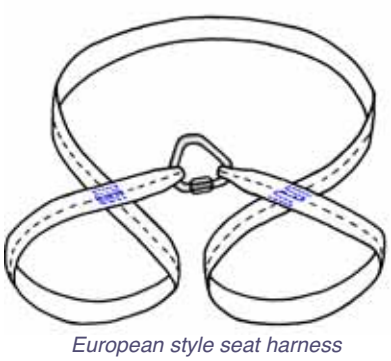
The 'seat maillon' can either sit flat against your abdomen like the 'European' style harness, or at right angles, as with 'Leg-loop' harnesses. Quite apart from comfort in squeezes and crawls the orientation of the seat maillon can have a significant effect on your prusik rig. Most cavers use a Petzl Croll as their chest-mounted ascender. The Croll has a preferred orientation so you must use a seat harness that complements the ascenders and prusik rig you use (See Chapter 7 on page 109).

Other features to be aware of are:

- Adjustment buckles —once set you will probably never need to touch them again but, if badly positioned they may dig into your hips or expose the tape to severe abrasion. In some cases turning the harness inside out can help.
- Harnesses specifically designed for caving often have patches or otherwise protected stitching. Be especially careful of exposed bar tacks that are strong when new, but can wear off very quickly.
- A good test of a harness is to prusik with it for at least 50 m. A test hang in a shop is better than nothing but only shows up a harness that **really** doesn't fit.
- On many people the legloops slip down and may need uplift straps at the back.
- Any harness can easily be modified at home if it is otherwise suitable.



Leg-loop seat harness



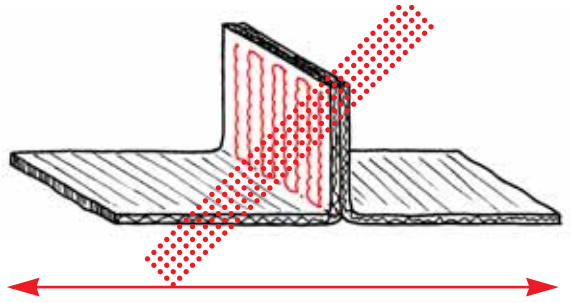
European style seat harness

Home-sewn harness

If a suitable harness is too hard to find or outrageously expensive, it is not too difficult to make one. As it will be a specific item, leave off adjustment buckles and make the harness to measure. It will end up lighter and neater than a comparable commercial version. Stiff flat tape makes the best harnesses as it is less prone to rolling than soft tape and maintains its width for better weight distribution.

Tape joints can be machine sewn as strong as the tape they are made of. The best stitch pattern is long parallel rows along the grain of the tape. This puts as many stitches through the tape as possible and allows the stitches to be pulled into the tape enough to protect them from abrasion. Stitches that run across the tape stand out from the surface and are in danger of being scraped off. On heavy wear areas or to stiffen the tape, sew a protecting patch over the surface. You can make a lighter but simpler protective patch by coating the stitches and tape with a layer of rubber glue. Stitch lines should be neat and parallel and each run should be the same length so as to keep load stresses even. The number of stitches required to form an adequate joint of similar strength to the tape will depend on the thread and tape used.

The following can be taken as a **rough** guide using good quality No 20 polyester or nylon thread (never use cotton as it rots).



Joints must not be formed so that they are ripped apart one line of stitches at a time

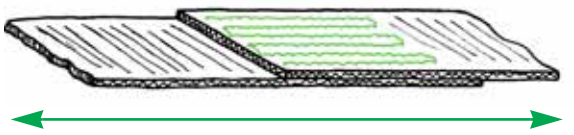
50 mm tape - 200 stitches

25 mm tape - 150 stitches

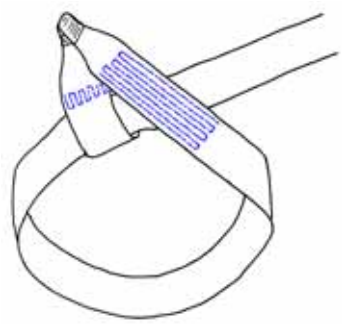
15 mm tape - 80 stitches

(At 5 stitches per centimetre and sufficient tension to pull the thread into the tape.)

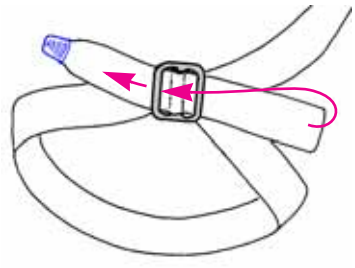
Very few of us can sew to CE standard tough. If in doubt, just buy one.



Stitched joints should be formed to load in shear so that all stitches bear the load



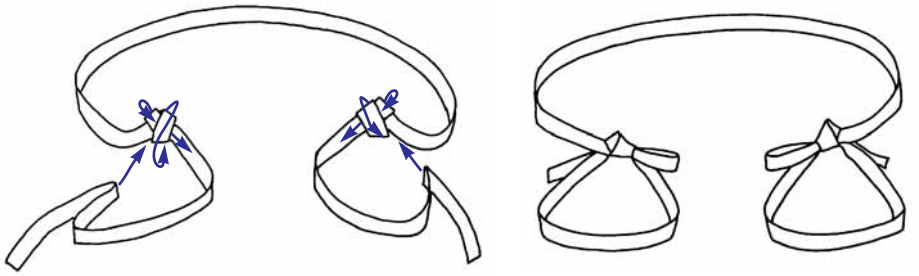
Sewn legloop



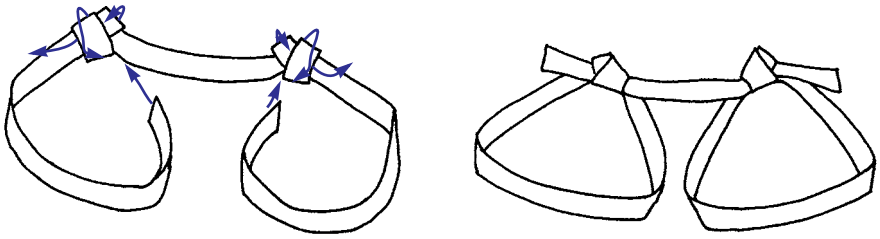
Buckled legloop

Knotted harness

If you don't trust their own sewing or have no access to a suitable sewing machine you can replace stitched areas with buckles or knots using sewing for only those parts that are not 'life support'. Always thread tape back through buckles as illustrated. As an extra precaution, tack the tail on both buckles and knots with stitches or tape to keep it from sneaking back. The most suitable knots are tape and overhand knots that reduce the tape's strength by around 50%. Knots are less suitable than sewing for making a harness because their bulk can make them uncomfortable and wear badly. Knots have one advantage over sewing—you can tie a knotted harness quickly and easily, even in a cave.

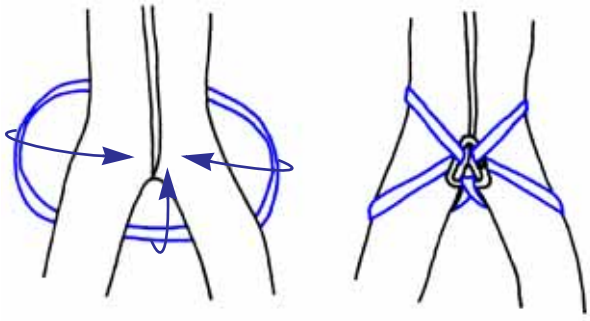


Tying a European style harness



Tying legloops

Improvised seat harness



Nappy seat

To improvise an adequate harness make a strong 'life support' belt or waist loop then take a short sling, twist it to form a figure-8 then put one leg through each loop and clip the crossed part to the waist loop.

With a longer sling you can be make a nappy seat that you can also clip to a waist loop to keep it from slipping down. Should there be some distance to go it could be worth the effort to tie a knotted harness from a length of tape or rope.

Seat harnesses are made of tape to spread the load comfortably over the pelvis but whenever tape is abraded its strength is reduced considerably as surface damage affects all the fibres. Replace your seat harness every few years, or more often if it is badly worn.

Waist loop

A waistloop is simply several metres of tape wrapped around your waist and tied with a tape knot. As well as forming the second suspension point of some harnesses, you can use a waistloop as a handline or re-tie it to make a harness in times of need.

Chest harnesses

Chest harnesses are not always 'life support' equipment. If not, they do not need to be heavy, overstrong or particularly well sewn. For this reason cavers often make their own, even though commercial models are readily available. Whatever chest harness you use, you'll normally wear it all the way through the cave just as you do a seat harness. It should therefore be comfortable, not slip off your shoulder or get in your way. A chest harness that you can hang things from is also useful when rigging.

The chest harness you use depends on your prusik system. If you may only need it to lift a chest ascender and support some of the weight of a pack, light tape is ideal. However, if you need it to keep your body upright and tightly against the rope it will need to be of wide, strong tape to spread the load. Some prusik systems do not even need a chest harness (See Chapter 7 on page 109).

Neck loop

Neck loop

The simplest chest harness is a loop of shock cord (bungee cord) or tape threaded through the top of the chest ascender and put over your head.

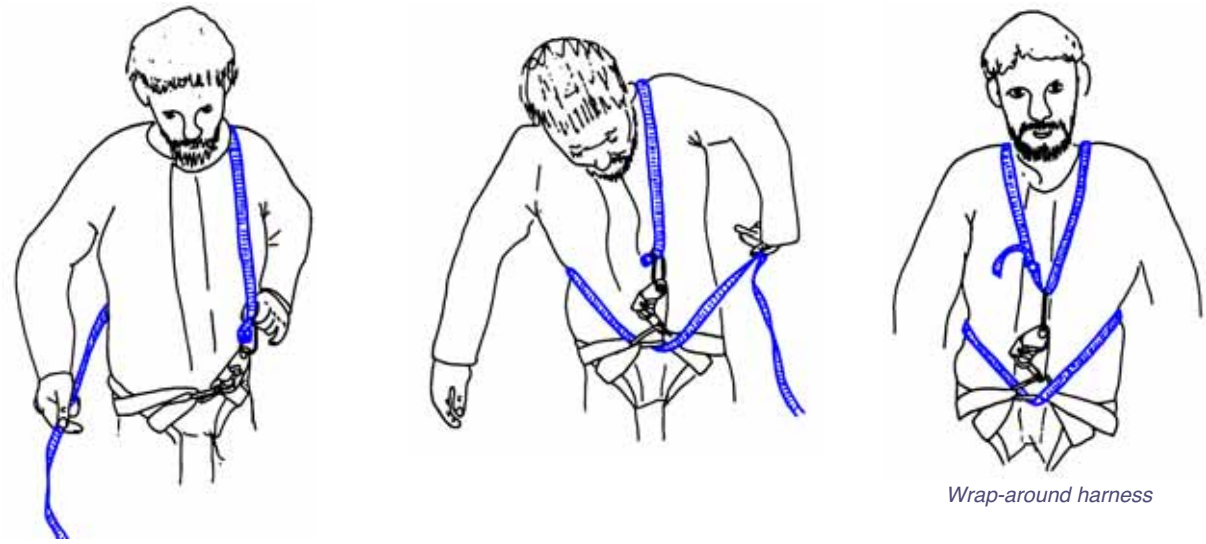
A neckloop works fine except when prusiking with a heavy pack or leaning back to rest. It is however, never especially comfortable. More sophisticated versions use a tape with a buckle or even a quick release buckle so that you can convert instantly from tight for prusiking to loose for walking.

Sash

Sash

A tape over your shoulder like a bandolier gives you a convenient, light chest harness for short drops when not carrying heavy loads.

However the diagonal nature may give problems because it pulls your chest ascender to one side, which can affect its running. The chest ascender will probably run best with the harness over your right shoulder so the rope runs hard against the shell of your Croll rather than against its cam—but some prefer it over their left shoulder. For small pitches and emergencies, short chest ascenders also run adequately with their top eye clipped directly into a short carbide lamp sling, your top pocket, or velcro/zipper oversuit closure.



Wrap-around harness

Wrap-around

The Wrap-around harness needs about three metres of flat, 15 mm tape with a good, easily adjustable buckle at one end.

Thread the tape through the eye at the top of the chest ascender so that the buckle is just to the right of the ascender. Alternatively, connect it to the top of the ascender with a small maillon or mini-krab. Throw the rest of the tape over your left shoulder, collect it from behind your back with your right hand, pass it under your right armpit and thread it under your seat maillon. Next, run it around under your left arm and across your back and over your right shoulder down to the buckle. It may sound complicated but once on it is an exceptionally comfortable harness even when carrying a cave pack.

In use, pull the harness as tight as possible without restricting your breathing. When walking between pitches, loosen the harness by feeding tape through the buckle, or releasing the mini-krab from the top of the ascender.

The biggest problem with a Wrap-around harness is that is that it has a tendency to slip off your shoulders when you wear it loose for descending the cave or moving between pitches.

Figure-8

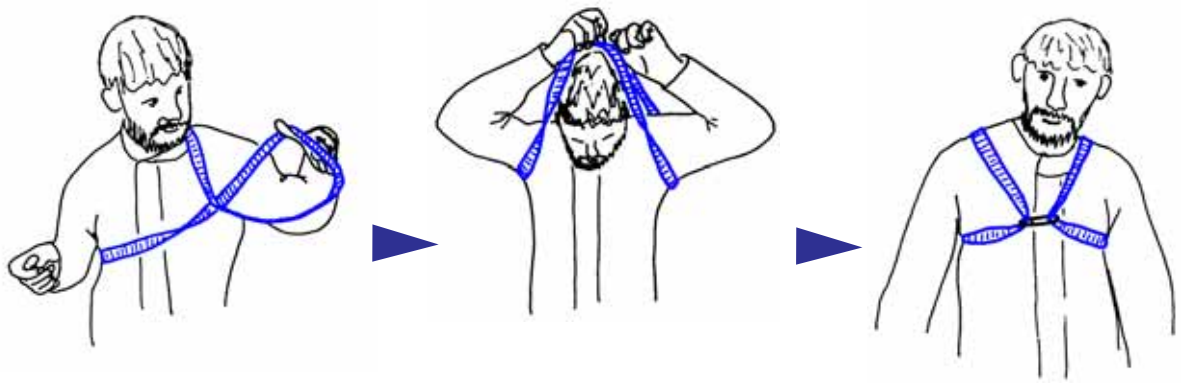


Figure-8 harness

The Figure-8 chest harness is a simpler and popular alternative to the Wrap-around harness. All you need is a correctly sized pre-tied tape loop or bicycle inner tube and a karabiner.

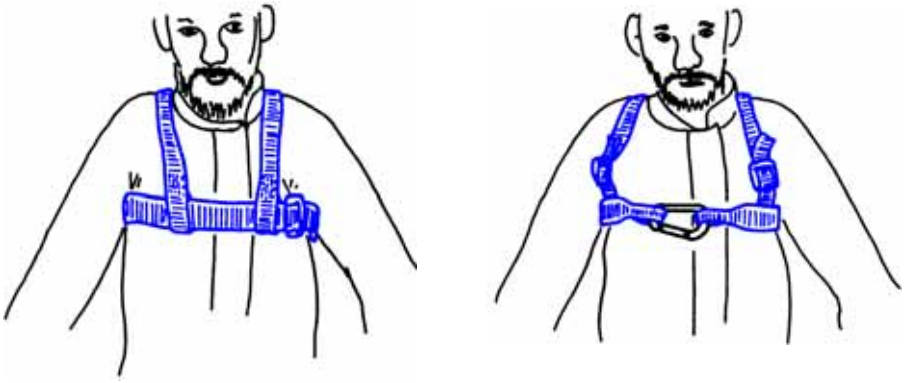
Put one arm through the loop, then cross the loop in front of your body to make an '8'. Put your other arm through the other hole. Next, put the crossed part back over your head. Gather the two loops that sit in front of your shoulders and clip them at the front with a karabiner.

The harness should be a snug fit without being tight and you may have to experiment to get it just right. To ascend, simply bend over and clip the karabiner through the top of your chest ascender. The system works well, it is light, simple and will not slip off your shoulders,

so you can comfortably wear it throughout the cave. It is not as comfortable as the wrap-around and can be quite uncomfortable when prusiking with a pack.

The chest harnesses so far described are most suited to prusik systems that require a chest ascender lifted rather than the harness holding you close to the rope (See Frog system on page 119).

Climbing Chest Harness



Climbing chest harnesses

Most climbing chest harnesses have a wide adjustable band that goes around your chest just below your armpits and two lighter shoulder straps to hold it in place. Often a karabiner holds it together at the front. One ingenious variation on the climbing style chest harnesses the MTDE 'Garma'. It has a length of tape and quick release bicycle toe-strap buckle that allows you to tighten and adjust perfectly, or release your Croll very rapidly.

While they work with any prusik system, climbing chest harnesses can also hold your body close to the rope rather than just lift a chest ascender. As such they are a must for some Rope-walking systems and sometimes overkill for Sit/Stand prusik systems (See Ropewalk systems on page 121). For a climbing chest harnesses to be effective for ropewalking it must be tight, that may restrict your breathing, and comfortable, that means using wide tape (50 mm+), thus making it bulkier and heavier than simple lift harnesses.

MTDE 'Garma' climbing chest harnesses

Sash chest harnesses

Cowstail

Double cowstails: rope, Petzl 'Spelegyca'

Cowstail to karabiner: barrel noose, Figure-8 and tyre tube

Figure-8 loop

Overhand loop

'Expé' Cowstail plate

Clove hitch

Cowstail to harness maillon

A cowstail is a **must** for crossing rebelays efficiently and for safety on traverses, pitch-heads and knot crossings. The main requirement is that the cowstail is strong enough. It is conceivable that you could subject it to a Factor 2 fall so **anything less than 9 mm dynamic rope is unsafe** (See Properties on page 21). 'Dynamic' rope is very important for a cowstail. It must be able to absorb the shock of a fall without damaging you or the belay. There is nothing better than 9 mm to 10.5 mm dynamic rope tied with a Barrel noose to the karabiners. A dynamic rope cowstail is strong enough and shock absorbent enough that if you are foolish enough to clip an ascender just below a belay, then climb above the belay and fall off, there is a reasonable chance that nothing will break.

Low stretch fibres such as Dyneema, spectra and kevlar, either as rope or tape, are exceptionally dangerous. **Don't use them!**

25 mm (1 inch) tubular tape is almost as bad. In tests done by Long, Lyon & Lyon, 2001, 25 mm tube tape broke every time. It just doesn't have the shock absorption of a dynamic rope. Doubling it won't help either. It just increases the impact force. Also to be avoided is the Petzl Spelegyca. It is not made as a shock absorbing device—but if you use it caving, you are potentially using it as one. The Spelegyca is made of low stretch tape stitched with 'burst stitching' that rips to absorb extreme shocks. Even so a Spelegyca will give you over twice the shock load of a good dynamic rope cowstail. Caving rope too has insufficient stretch for a good cowstail but is still better than **any** tape cowstail.

The classic double cowstail is made from 2.0 to 2.5 m of rope tied with figure-8 loops. The short length should be about long enough so that the attachment point reaches to your elbow with the karabiner held in the palm of your hand. The other measure is that your short cowstail should be just long enough to reach past your Croll and clip into the rebelay as you ascend. The long cowstail is about 50% longer. If you intend to use the long cowstail as a safety for an ascender it should reach from your seat maillon to your upstretched wrist when hanging on the rope, but never be so long that the ascender is out of reach (See Frog system on page 119). Experiment a little to get these lengths just right. A good starting point is:

- short 40 cm long
- long 55 cm long

The only reason to have a double cowstail is to use a minimum of rope and carry a minimum of bulk. Two separate cowstails allows you to replace them separately, and to put one on each side of your maillon.

You also have some choice over the attachment point. A figure 8 loop is most popular although some people use an overhand loop to reduce bulk. A clove hitch is another option. It uses less rope and theoretically at least, it will slide under a heavy load. At worst, a clove

hitch is no weaker than an overhand loop. An attachment plate uses a minimum of rope and is very nice —if you can find one.

Should you feel that the normal cowstail is not strong enough, use 10 mm, 11 mm or even 11.5 mm multifall climbing rope, though of course it is bulkier and heavier. As will be explained in Rigging Equipment, strength is not all it seems to be, a very strong or doubled cowstail does survive more test falls than a single one in the same rope, but due to lower stretch, these falls also generate considerably higher shock loads that could in turn damage you, your harness or the belay.

The karabiners you use must be of the highest quality, you do after all hang everything off them. Snaplinks are the most commonly used as any sort of locking gate hinders efficient use. A steel karabiner on the long cowstail can double as a brake karabiner during descent (See Autostop bobbins on page 93), although dedicated karabiners are better for both the cowstail and the brake. The best cowstails karabiners have a small 'nose' so that they don't tend to get caught when you unclip them.

Keylock detail

A 'keylock' as on the Petzl 'Spirit' and others is ideal. For convenience, tie your cowstail to its karabiners with a barrel knot or fit them with a bar, clip or rubber bands to keep them oriented correctly for quick action.

Use a belt or chest harness loop to clip the cowstail's karabiners out of the way when you aren't using them.

Replace your cowstail regularly. While you normally load it gently, one slip could subject a cowstail to a severe shock load. Nine millimetre dynamic rope is only a minimum, 10 mm is even safer. Do not wait until the core is peeping through the sheath and.....

Replace any cowstail after 2 years, 'worn out' or not.

If you do take a more than F F 0.3 fall on your cowstail, you should replace it. If you can't replace it immediately, loosen the knots that took the fall and re-tie them as the knots themselves pay an important role in shock absorbtion, especially in shorter falls.

Cavers who never cross rebelays (or perhaps never used to cross them), often use a single ascender on a sling to give protection when needed. While this practice is popular in the USA, a shock load could damage the rope, sling (especially a tape sling), or the ascender, and cannot be recommended.

A single ascender with footloop can be very handy for crossing difficult rebelays or when carrying a load.

Quick attachment safety (QAS)

The QAS is the IRT caver's answer to the cowstail. It is an arm's length sling tied to a handle ascender that you can easily and quickly use to attach yourself to the rope. A QAS is probably still a good option for IRT rigging where there may be nothing suitable to clip a cowstail karabiner to at a pitch head. The Mitchell system and Ropewalk systems need something more for resting and getting off a pitch head safely. For anyone using a Frog system, or Texas system a QAS only complicates your prusik rig. In both cases your top ascender is identical to a QAS anyway. Your Frog system by design uses a cowstail as a third point of attachment. For a Texas you will also need a cowstail or QAS for that third point.

If you make a QAS, use the same rules as those above for making a cowstail. Use dynamic rope tied with a Barrel noose to a linking karabiner or maillon. You can tie directly to ascenders like Jumars that have a large radius tie point, but Petzl Ascension ascenders are made of thinner metal and form a severe radius for the knot—use a small rapide or a karabiner. Never (never ever!) use 25 mm (1 inch) tape. The high impact force that you could generate with a fall onto tape is directly applied to you and your ascender-rope contact point. This greatly increases your chances of cutting the rope if your tape QAS doesn't break first. Ascenders are not made to catch falls. They are the weakest part of your caving rig. Don't use a QAS for traverse lines or anywhere they may be subjected to a shock load—get a cowstail, the karabiner on the end is made to catch falls. In the end, a QAS isn't near as quick as a cowstail, and often not as safe.

Helmet

The functions of your helmet are to protect your head from falling rocks, blows from a fall, standing up when you shouldn't and to support your lamp.

CE[1] approved climbing helmets can withstand blows from all directions and have a strong chinstrap that if kept tight, keeps the helmet from falling off under all conditions. Any CE approved helmet is safe, though not all are ideal for caving. If you protect your head with a construction helmet to save money you are making a definite statement about the value of its contents.

A good caving helmet

There are some special features worth looking for when you buy a helmet:

- It should be CE approved.
- Lightweight (less than 400 g) and not lined with water absorbent padding.
- It should be small and not ride high or it will be a nuisance in tight passages.
- It should sit well on your head, be comfortable and have jugular straps that do not block side-vision.
- A quick action 'Fastex' type buckle that is far more convenient than a thread buckle but can be fitted after purchase.
- It should not fall off the back of your head, nor should the weight of a lamp drag it down at the front.
- Fit lamps so that the mounting screws, nuts or rivets do not project into its interior.

Moulded plastic helmets appear to survive the bumping and scraping of caving better than the fibreglass models that tend to crack. This may be largely cosmetic. Limited testing indicates that fibreglass helmets, even old ones, transmit less energy to the head below. Fibreglass helmets absorb the energy of a severe blow by delaminating while moulded plastic helmets rely mainly on the head cradle to absorb energy.

It is not reasonable to use a battered old helmet for caving when you would never consider it for climbing. Discard any helmet that becomes cracked, badly knocked about or receives a severe blow.

Lighting

One of many prototypes. A single central 'Luxeon' for spotting surrounded by 18 x 5 mm LEDs for normal use. Each set of LEDs is separately powered and switched to provide redundancy

Caving lights have changed considerably over the past ten years. The only light seriously worth considering today is an LED light. The advantages leave every other type of light in the speleo museum. The only decision to make is which one? LEDs are experiencing rapid development with light output for energy used doubling every 18 months or so. What you read here is probably already out of date! The basic principles however remain the same.

1. The CE has standards for just about everything to do with safety. See CE certification on page 22 for further details.

LED —light emitting diode

LEDs come in two basic types:

- 5 mm LEDs. You'll need 10 or more for a decent caving light.
- 'Luxeon' style LEDs. These come in 1 Watt, 3 Watt and 5 Watt. 3 W is the most suitable.

Contrary to popular belief, LEDs are not exceptionally efficient. Yes, they can give out light for a long time, but whether that light is particularly useful is quite another story. LEDs have a similar efficiency to halogen bulbs. The great advantage of LEDs is that they are efficient at low power whereas a halogen needs to burn at 50 Watts or so to be truly efficient. As cavers, low power is what we need. We have to carry the energy source for our lights with us. A single 3 Watt LED or an array of 5 mm LEDs running at 2 watts is more than you'll need for most caving and most of the time you'll be happy with much less.

Power

There are two parts to powering a LED light: the batteries and the circuit.

Batteries

3 x D cell pack,

1 & 2 cell Lithium packs

Alkaline or lithium disposable cells in AA size are convenient and carry easily on your helmet. They are fine for shorter trips, but for long trips or expedition use you'll use a lot of them. A longer duration alternative is a pack of D or C cells in a pack hanging from your waist of chest harness. These carry enough energy to last a very long time. My 3 x D cell pack lasts me a full month of expedition caving. Having such long lasting batteries may seem excessive, but it does have the advantage that you can just pick up your lamp and use it without ever being too concerned that it has enough power left.

Rechargeable lithium cells are currently the ideal solution. A 7 cm x 3.5 cm x 1.5 cm pack gives you light for up to 50 hours caving, depending on the light that you connect it to. Lithium cells are very fussy about how they are charged and discharged. Charging with the correct charger presents no problems. Lithium cells should never be completely discharged as it ruins them. A short circuit can cause them to overheat and destroy them—perhaps explosively. Any battery pack should therefore have a discharge protection circuit in it. This circuit disconnects the power if it is short circuited or the current drain is too high. It also switches off the connection if the battery voltage is too low. A lithium rechargeable may therefore suddenly stop as it runs down when the protection circuit cuts in.

NiMH (nickel metal hydride) are cheap, common robust rechargeables that you can directly substitute for AA alkaline cells.

Charging may be problematic in truly remote areas and may be solved with a 12 V charger and solar panel.

Circuit

There are two basic families of circuits for LED lights: Regulated and unregulated. Each has its advantages and disadvantages.

Regulated circuits give a constant light output for the life of the battery—no more fading light as your batteries get old—then they die, or at best drop to an emergency mode that's enough light to find your spare batteries. A good circuit will suck every last joule of energy out of your battery and give you the maximum total quantity of light, but perhaps not maximum burn time, from your lamp. A convenient feature of regulated lights is that even though they are normally designed for a specific battery, they often accept a range of battery voltages. The biggest disadvantage of a regulated light is the complexity of the circuit. If the light malfunctions it is very difficult to figure out what has gone wrong and how to fix it. If the circuit gets wet it will probably fail.

Unregulated circuits have a simple resistor to control the maximum current through your LED(s). As the battery runs down and its voltage drops the light output also drops. The advantage is that as this happens, the light uses less power and will go for longer. With alkaline batteries it can be, in effect, a lamp that will never die. Unregulated lights are generally battery specific, but cheaper and more robust than regulated lights.

Incandescent electrics

Some cast a strong more focused beam than a LED light can manage. This is useful for spotting up and down pitches and looking for leads in the roof and walls. Many diving lights are suitable as well as being waterproof and robust. Their disadvantages are expense, poor burn time to weight ratio and the consequent need to frequently recharge or replace used cells, especially on long trips.

Lead-Acid lamps

If you still have a lead-acid miner's light, put it beside your carbide light in your caving gear museum. They long ago priced themselves off the market, and are also heavy, leak acid onto caving gear too often, and troublesome to maintain.

NiCad/NiMH lamps

'Speleo Technics' electrics with NiCd and NiMH batteries from Britain have effectively replaced lead acids for caving. Designed specifically for caving, their cells are sealed into a block of plastic while the headpiece is the traditional solid miner's light. The older versions were a bit dim. Newer versions with LEDs give more light and are longer lasting. The battery packs are designed to unclip easily for charging and for longer trips an extra battery can be carried and just clipped on when the first one dies.

Carbide lamps

Premier, Fisma and Ariane carbide lamps

Carbides still get some use, mainly on expeditions. However with LEDs now so good, carbides belong in museums, not caves. Carbide produces waste that must be disposed of and is often left in the cave. Even on the surface, waste carbide is a pollution hazard. And then there are the black stripes along the roof and above so many rebelays... Carbides don't light instantly, don't like spray or wind, take some practise to run and are banned for conservation reasons in many areas. They also lose on weight grounds. In Table 1:1. Lamps is the Ariane, the lightest carbide lamp available. A fully loaded Ariane will last you eight hours at best. For the same one kilo you can carry enough batteries to run even the heaviest LED light for over three days on a higher setting than you'll want to. The carbide plus water reaction and the flame produce enough heat to be a valuable asset in emergency situations—so does a candle.

What lamp to get?

For serious caving there is an ever increasing number of possibilities.

Stenlight

The Stenlight is from the USA (www.stenlight.com). It is a neat, compact and robust light that is designed to work with a dedicated lithium battery. It uses two 3 W Luxeon LEDs. One gives a wide beam while the other gives a narrow beam, but you can change them. It has several brightness levels. You cannot operate the two LEDs separately.

The Nova comes from the FX-2 people in the UK (www.speleo.co.uk). It has a single Luxeon LED in a robust waterproof case that's waterproof to 50 m. The Nova is powered by a range of Speleo Technics rechargeable batteries or by alkaline batteries.

LED caving lamps from Britain (www.ledcavinglamp.co.uk) makes a lithium powered traditional miners light body with LEDs instead of incandescent bulbs.

Less serious contenders include lights in the Petzl Duo range. These are made with the typical Petzl view to marketing and smooth looks but are somewhat lacking in durability and waterproofness. The general lack of a 'truly best' LED light at a reasonable price means that homebuilt light abound. LED lights typically don't have a built-in backup. In days gone by, the unreliability of carbide lamps meant that everybody had a backup electric mounted and ready to go. LED lights are more reliable, but perhaps harder to repair than carbide lamps. Electronics and caves don't mix so make sure you have a backup.

Table 1:1 Lamps

Lamp	Weight (g) Empty	Full	Duration (hrs)[a] High	Normal	Low	Comments
Prototype LED	460 320	880[b] 320[c]	30 12		100 48	Empty weights include the built-in backup light. Back-up battery = 80g
Stenlight	125	275	4	7 24	72	Normally run on 24 hr setting
NOVA 3 Speleo Technics	- -	- -	15 10		25[d] 22[e]	Lithium battery outputs a brighter light on high and therefore uses batteries faster.
Fixo Duo LED 14 Duo belt LED 14 Petzl	180 270	280 550	3.5 10	10 24	63 125	Duo LED 14 uses 4 AA cells Duo belt has a separate 4 x C cell battery pack
NiCad FX-2 Speleo Technics	1250	1250	8-10			Virtually maintenance free May be too dim
Ariane+Aceto Carbide Petzl	495	1000	8		11	21 L or 14 L jet. Uses 400g of carbide per fill/6-8 hrs light
Tikka Petzl	78	111	8		20	Good light for 8 hrs. Usable light for about 20 hrs
Tec 40[f] Princeton Tec	180	280	5			Robust Good spotlight for its size
Weights and durations from manufacturers published data.						

a.Alkaline batteries unless noted otherwise
b.3 x D alkaline + empty weight includes battery holder
c.lithium rechargeable + empty weight includes battery holder
d.3 x AA alkaline batteries
e.lithium rechargeable battery
f.4xAA cells, halogen bulb

Back-up lights

Many lights have more than one LED or bulb built-in and if caving in a group this is usually adequate, although you can still be left in the dark due to a failure in the battery or cable. Your backup light must be electrically independent of your main light. There is no shortage of small LED lights that are suitable for backup lights or for prospecting. A popular backup is a small one-piece headlight like Petzl's Tikka slung around your neck. It's almost ready to use and in an easy to reach position.

If your lamp does not incorporate a backup (and most don't), you can easily mount a simple backup by attaching two rubber rings to the side of your helmet to hold a robust 2 to 4 x AA light that you can remove when you don't need it. Cave divers mount one or two electrics on each side of their helmet using this type of fastening. A 1-5 LED torch is ideal as a backup. In drier caves it is possible to get by with a small hand-torch on a neckstring but for serious work nothing beats a helmet mounted back-up.

Lamp problems

Lights that use a flat 4.5 V battery and mini-Mags may run an overrated bulb. ie, a 3.5 V bulb on a 4.5 V battery, to increase their light output. For this reason they burn out about every 20 hours or so. There is usually some warning as the bulb gets a shiny grey appearance when it is old. Reduce the possibility of failure by replacing grey bulbs before they fail, especially before you visit a section of wet cave where a blown bulb could have serious consequences. By using the correct bulb for a battery, it is possible to increase bulb life at the expense of light output and battery duration.

Batteries usually give a few minutes of yellow light in which to find a spare before they die completely. LED electrics solve both of these problems.

Whether the lamp uses disposable dry cells or is rechargeable, you should keep track of how many hours it has been running so as to have some idea when it will run out. Unregulated LED lights fade slowly with alkaline cells, but be careful of NiMH and lithium cells as they can die very quickly. Perhaps the most common cause of failure in any electric light is dirty contacts either at the battery end or at the base of the bulb. This problem is easily avoided by regular maintenance and drying after the lamp has been wet.

If your regulated LED light gets wet inside, it may not work until you have dried it very well. You may need to wear it inside your clothing for a night, or pack it with a dessicant before it works well. If you will be caving in wet caves, use a waterproof lamp—'waterproof' to 1 m or even 5 m isn't waterproof...

In general

When short of light, try and economise—stay near someone else with a light and make sure the person with the good light is coming out last. In the event of total light failure it is almost always impossible to find the way out unless there is a rope to follow **all** the way. The only real choice is to get comfortable and safe and wait...

Extras - cave pack

Cave packs can be bought or home-sewn on a robust sewing machine. The model of pack you choose will depend on supply, ability to make one and the caves you want to take it in.

Features of a good cave pack are:

- Made of heavy PVC coated fabric that wears well, is waterproof and non-absorbent.
- Two shoulder straps of stiff tape that will not bunch up. You may not need both straps all the time but that is better than suffering a heavy single strap pack in a walking passage.
- Round bottomed sacks are the easiest to manage in awkward situations. Being symmetrical they jam less often than other shapes and have no preferred orientation in squeezes.
- Maximum diameter of 25 cm, any greater and the pack may not fit through a tight cave. Large cave packs need to be oval or rectangular with a short axis 25 cm or less to make them practical.
- Seams protected or reinforced against wear, especially those around the base.
- A handle on the side so you can carry it like a suitcase, and another on the bottom to hang it upside down and make it easier to handle in squeezes.
- Closed with a thin cord fastened by a cord grip or 5 mm cord through at least 6 eyelets and tied with a Reef knot.
- A lid flap to keep most of the water and dirt out and the contents in.
- Permanently attached knotted haul cord that hangs the pack just below your feet.

Many cavers also prefer a small personal pack to carry their lunch, spare batteries or who knows what that hangs from their waist or carried as a shoulder bag. Shoulder bags are a nuisance, try anything else and you'll soon change.

Survival blanket

Do not even walk to the entrance without it! There are robust re-usable models or single use 'chocolate wrapper' ones that lose their silvery coating in a year or less (though this has little effect on their efficiency). For budget cavers a large plastic garbage bag is better than nothing. Carry it in a boot, pocket or helmet.

Kneepads

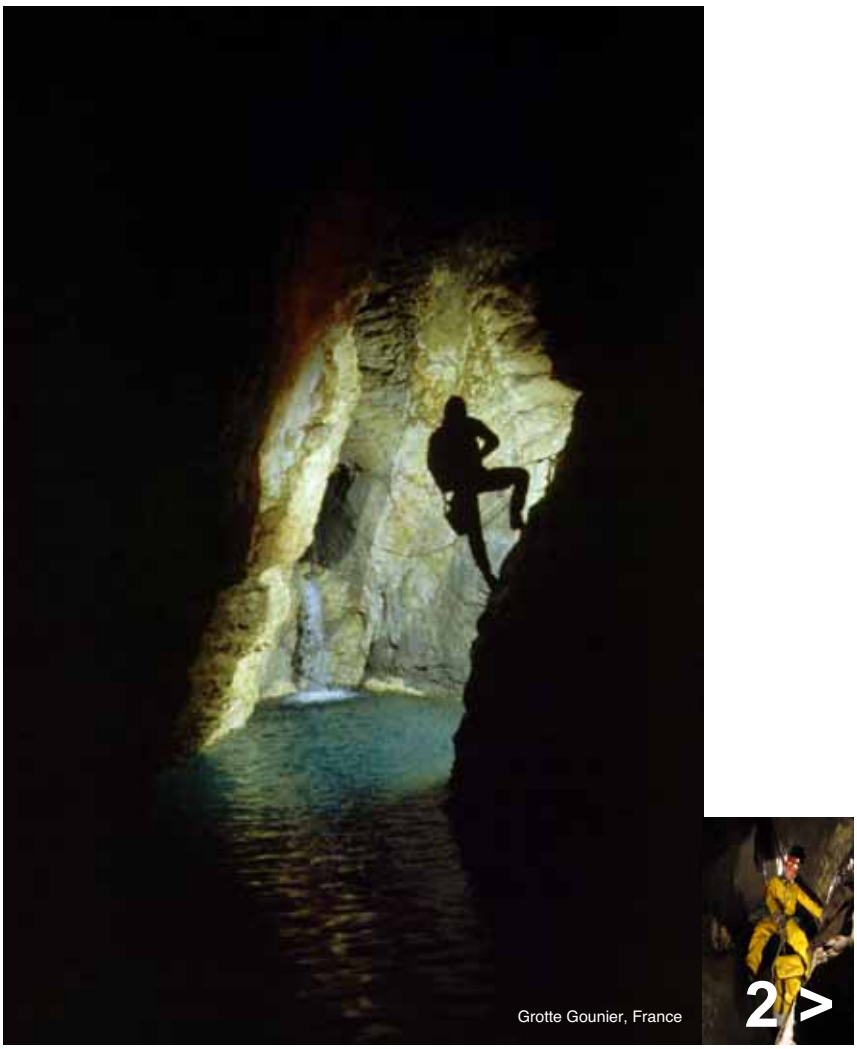
Light padding for your knees and elbows makes caving a lot more comfortable as well as reducing damage to these joints. Small patch-pads sewn to an undersuit or fitted into pockets on the knees and elbows should be adequate for all but the worst caves. For those worst caves, basketballer's knee and elbow pads are good but bulky. Diving shops sell neoprene pads that go quite well with wetsuits without the need to sew on permanent pads.

Knife

A small Swiss army knife is useful in emergencies, makes a handy portable tool-kit and opens sardine tins more easily than a bolt-hammer.

Whistle

Some cavers find a whistle useful for signalling on big or wet pitches and when navigating from the cave back to camp after dark. In most cases however, yelling is more than adequate (See Calls and signals on page 154).



Grotte Gounier, France