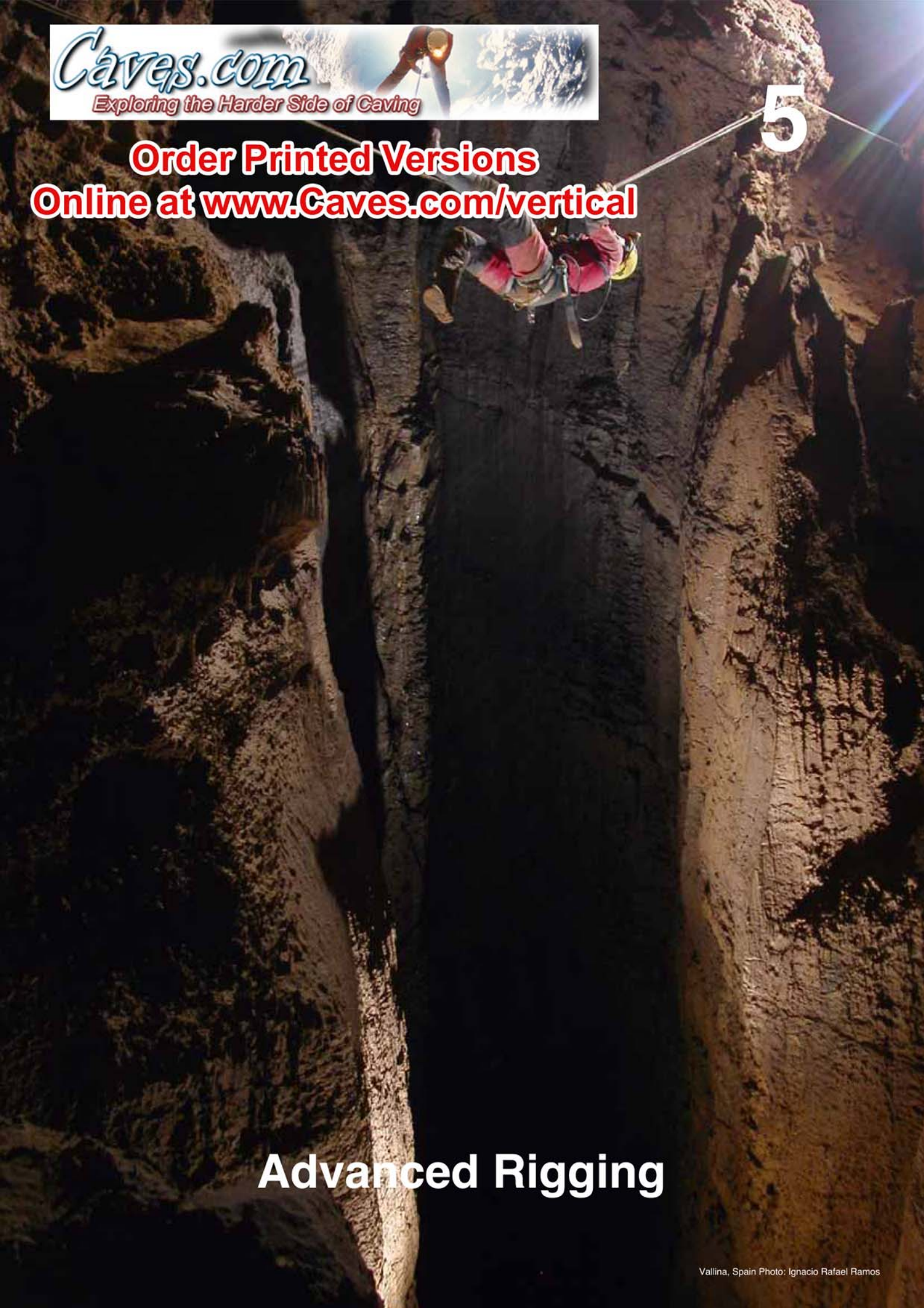
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Advanced Rigging
Vallina, Spain Photo: Ignacio Rafael Ramos

Ultralight and Cord Technique have a **reduced safety factor** when compared with traditional rigging. They therefore demand **totally competent** Alpine caving technique and even then extra precision. These rigging techniques are most useful for prospecting or light sporting trips when a small number of cavers will pass and wear on gear is not severe.

Ultralight rigging

Ultralight rigging is not so much a technique as a philosophy of reducing equipment weight, then rigging extra carefully to compensate. Rope makes up the bulk of your load so use the lightest available—8 mm, 7 mm and hopefully in the not too distant future even thinner 'super fibre' ropes. Deviations instead of rebelays and an absolute minimum of slack in rebelays give considerable rope savings. Thin ropes are not at all tough so use pure Alpine technique only, with **NO** rubbing of rope against rock.

Rigging gear can also be reduced. Seven millimetre aluminium maillons on belays and mini-krabs on deviations are lighter than standard karabiners. Direct attachment bolt hangers or tying the rope into the eye of hangers (aluminium with rounded attachment hole only please) will also save weight. Leave pitons and nuts at home and use jammed knots and slings instead.

The greatest risk in Ultralight Rigging is that 7 mm and 8 mm ropes cut very easily as they zip across rock edges under the weight of a falling caver. Rig ropes to avoid this by using tight backups and Y belays. This also keeps the chances of shock loading of the rope to an absolute minimum. Seven millimetre ropes made specifically for caving are rare and even when found, cannot be guaranteed safe. Take extreme care in choosing one, even to the point of shock testing prospective ropes until you find a good one.

Even with the lightest equipment, one caver can reasonably carry about 300 m of rope in an easy cave, making almost any cave possible with a group of four.

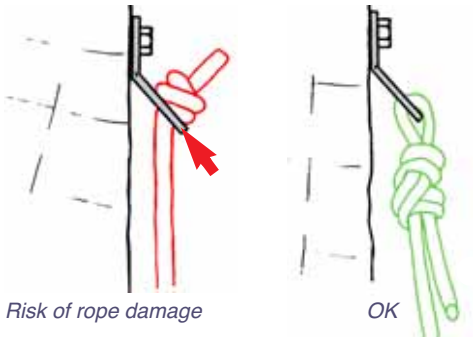
Cord technique

La Technique Cordelette or Cord Technique takes lightweight one step further. Instead of fixing rope down the entire cave, you retrieve the rope from each pitch and leave behind a double length of string so that you can replace the rope on your way out. It is a technique to use only when nothing else is possible—it is frustratingly slow, fiddly and demandingly precise but is also the lightest rigging style yet devised.

Poor judgement could leave you trapped below your mistake. Practise Cord Technique on the surface and in easy caves before taking the more committing step of using it in a deep cave.

It is rarely worth considering Cord Technique for rigging an entire cave. It is more convenient to carry as much light rope as possible, to be rigged as soon as possible and reserve the Cord Technique for when there is no more space for normal rope.

What is possible is quite subjective. There is usually no great problem with being overloaded for a series of entrance pitches where the load will diminish rapidly on the way down but dragging 300 m of rope 600 m or more down is a different proposition. The upper length limit for a Cord Technique pitch is 40 m to 50 m. You will either need to rig long pitches Ultralight or break them into smaller pitches, and this is not always possible. On longer pitches it is feasible to rig a fixed rope to within 50 m of the bottom and retrieve the last length using Cord Technique. In virtually all caves you will need to carry a certain amount of fixed rope for pitches that are just too messy for Cord as well as some shorter lengths for tiebacks and pitch-head handlines.



Risk of rope damage *OK*

Cord Technique is most suitable for solo or two person trips. More people only spend a lot of time waiting around and considerable problems occur on small ledges as the group is forced to keep close together.

Cord Technique may also be useful to rig on an 'up' pitch without the need to leave a rope on it. This is especially useful for flood prone pitches where the integrity of the rope will be in doubt after a flood or two.

Equipment

Cord Technique requires very little equipment that Alpine cavers would not already have. The lack of need for vast amounts of expensive rope means that it is cheaper to rig 'string' than any other method.

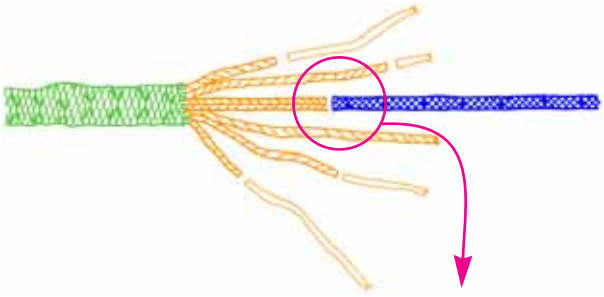
Cord Technique requires the normal range of Alpine caving slings, bolt hangers, etc, as well as one 6 mm steel maillon for each pitch. These open just enough to take a 9 mm rope, wear well and are strong enough. Seven millimetre aluminium maillons are also adequate but while lighter, they wear quickly when the cord runs across them, and are three times the price. For pitches in the 30 m to 50 m range the sliding friction through a small maillon makes re-installation of the rope difficult. It is then worthwhile using a 10 mm aluminium maillon or if none are available, two smaller maillons side by side.

The cord is usually 3 mm nylon 'venetian blind' cord although you can use 2 mm cord for small drops when the loads are low. Despite a considerable weight advantage, 2 mm cord tangles easily and makes a lumpy knot that pulls through maillons badly. Stuff the cord into light, proofed nylon sacks 30 cm long and 15 cm in diameter and fitted with a suspension loop at the top and a small loop inside at the bottom to tie the end of the cord to. Close the top with a drawstring and cordgrip. The only other equipment you need are a few 7 mm aluminium maillons as links where knots are not suitable.

The rope

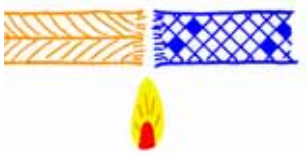
A 50 m rope on a 5 m pitch usually involves a tangle. In most caves you will find it convenient to use two ropes with specially prepared 'tails'. I normally take a long and a short one so that there is no need to handle a long rope on short pitches. The rope should be 8 mm and of a flexible design so that it runs through the rigging easily. Remember that you will be using the same rope over and over again, it will wear out faster than rope that is fixed and used once.

Preparation



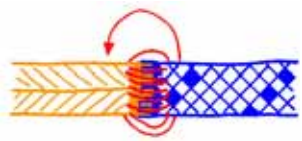
The rope must taper smoothly from 8 mm down to a 3 mm diameter, 30 cm long tail.

1 Push the sheath back to expose 30 cm of the core.

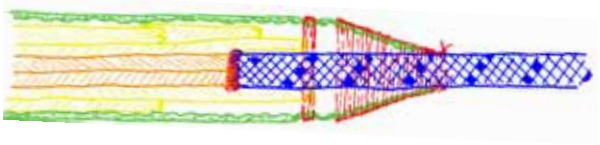


2 Select two central bundles of core and trim 15 cm off them.

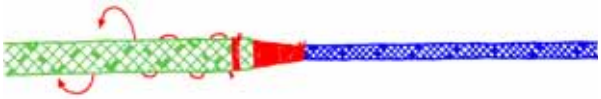
3 Fuse the trimmed bundles and the end of the 3 mm tail end-to-end over a small flame or 'hot knife'.



4 Reinforce the fused joint with stitching.



5 Trim the rest of the core bundles to give a gradual taper over a length of 15 cm.

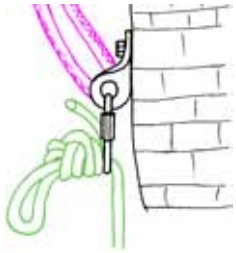


6 Pull the sheath back over the join and tie a 3 mm long whipping around it 5 cm from its end.

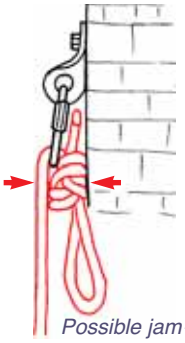
7 Trim out four strands of sheath to increase flexibility then start a tapered whipping 5 mm along from the first whipping. Once started, unravel the remaining sheath and progressively trim it to give a conical whipping no longer than 15 mm so as to keep the area flexible. A small amount of rubber glue will help hold the whipping in place as it is being tied and a coating of glue will protect the thread.

8 Stitch through the rope to further lock the tail in place, being careful to not stiffen the rope with too many stitches.

Rigging cord technique



Good



Possible jam—poor

Rig pitch heads as for Ultralight technique with double anchors and handlines to exposed anchors. This will require several 4 m to 5 m long ropes as well as shorter slings to tie between the easier to reach anchors.

On short uncomplicated pitches it may be possible to attach the 6 mm maillon directly to the last anchor. When this is a bolt it means that the maillon is very close to the rock. If so, be careful to orient the knot on the descent rope so that it is outwards and will not jam between the maillon and the wall. Hang the maillon itself with its gate uppermost so as to allow a maximum of space for the rope to pass at the bottom. Push the tieback to the top of the maillon and tuck any loose ends out of the way. For a rig that will run better, attach a short tail or sling to hang the final maillon in space.

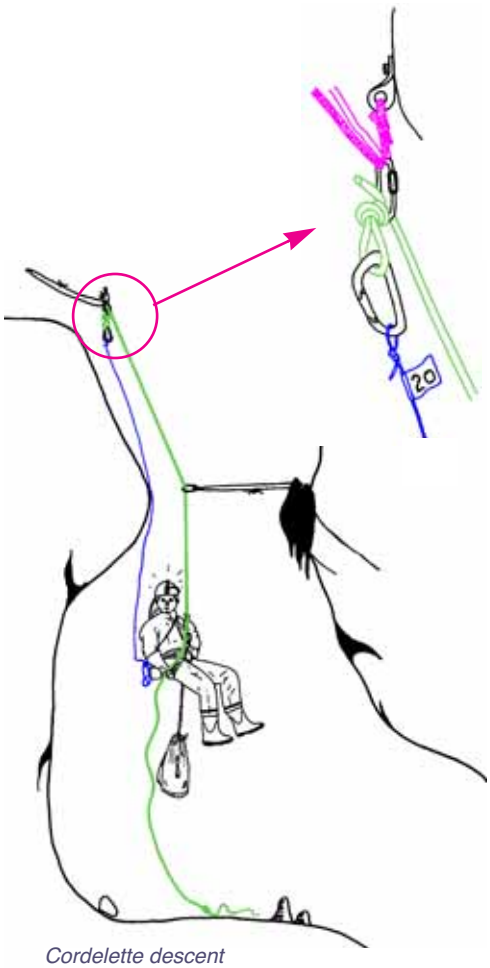
On pitch heads that round over it is better to fix a rope at the top down to an anchor that gives a freehang. Lower down, avoid rebelays, which you must treat as separate pitches, and replace them with deviations wherever possible. Arrange deviations so that you can pull the rope down without the cord fouling against the rope, rock or slings —this is usually possible simply by standing back a little from the base of the pitch.

Placing the cord

Cordelette descent
– with the cord running well clear of the descender

Initially pack the cord in bulk with joins tied by Round or overhand knots and the end tied to the tag at the bottom of the sack. On the first trip, cut the cord to suit as you rig each pitch. After the trip you can measure the cut lengths and tag them with small flags of adhesive tape at one end. On future trips, select appropriate lengths of cord just as you would choose ropes for any other trip. When exact lengths of cord are not available, tie several cords end-to-end with Round or overhand knots. The knots and the tape flags cause no problems sliding through the maillons.

To descend, jam the rope in place with a Figure-9 loop that is far too large to fit through the maillon. Clip a karabiner to this loop in order to attach the pull-cord. Allow this cord to run freely from its sack as you descend taking care not to spin and twist the cord around the rope. If you have the cord packed in bulk, it is simplest to use a separate pull-cord. At the bottom remove the end of the cord from its sack and tie it onto the tail with a Round or overhand knot.



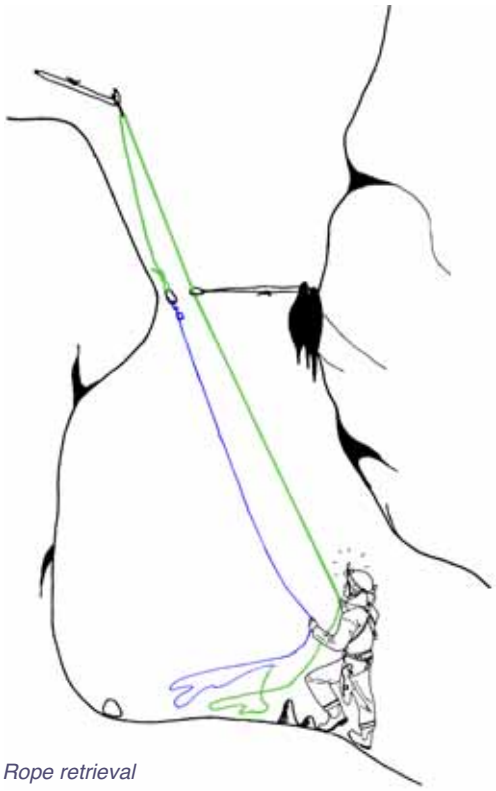
Cordelette descent

Retrieve the rope by pulling on the cord until all the rope is on the bottom and is replaced with a double length of cord. Cut the cord and code the ends by tying an overhand loop in the 'pull' end and attaching the end you've just untied from the tail to it with half hitches. Coding is not always necessary but it is a good habit to get into and avoids problems such as trying to pull the rope up through a deviation.

Separate the knotted strands of cord and lightly anchor them with rocks or tie them to spikes to prevent tangling due to air or water movements. You are now free to move on, having left a minimum of equipment.

Ascent is simply the reverse of the descent procedure. Tie the rope tail to the end of the cord with a Round knot and the pull it back up until the Figure-9 loop is once again jammed against the maillon. As you pull the rope through it begins to move by itself and when the pitch is long or its walls are jagged, clip the free end of the cord to the Figure-9 loop so that you can ease the rope into place or retrieve it should it snag on the way up. Once the knot has jammed in place against the maillon, the rope is ready for you to ascend. Untie the string from the end of the tail before you leave the ground and progressively stuff the cord into its sack on your way up.

Organisation

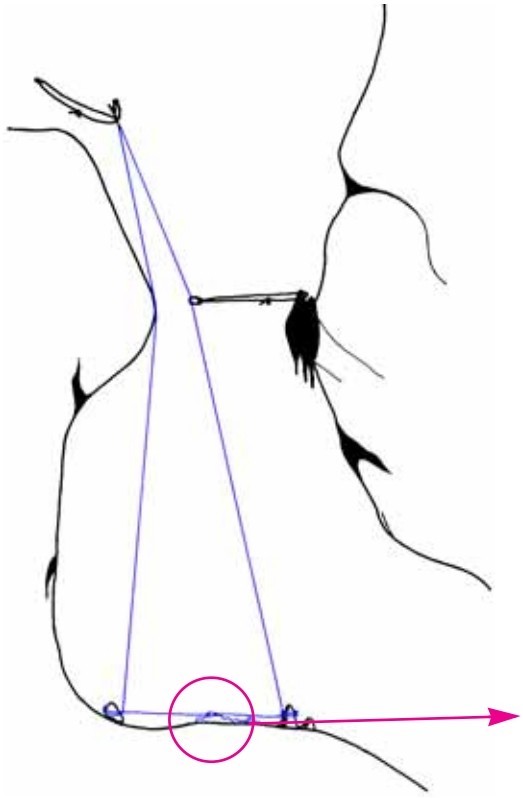


Rope retrieval

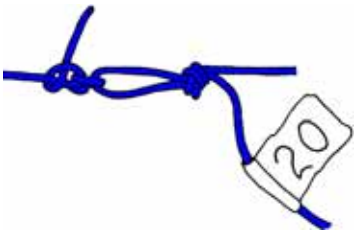
Draw up a detailed tackle list for both rope and cord (see Tackle lists on page 146). In the cave, stuff the rope directly into the sack between pitches so that it runs freely out and down (or up) the next pitch without needing to be rehandled. With so many bits and pieces, equipment organisation is of the utmost importance for a smooth trip.

Two cavers working together can move very fast using the Cord Technique—one can travel in front rigging while the other stays behind and fixes the cord. The result is very little dead time and rigging speeds almost as fast as for conventional rigging.

I can't over emphasize the need for care. The Cord Technique demands an attention to detail and neatness not necessary in any other rigging style. The string is especially prone to tangling or winding around itself. Should this happen on the way up and it becomes impossible to rectify, you will be unable to rerig your rope. At **best** you will suffer a long uncomfortable wait for your rescuers.



String coded...



...and ready to go

Rigging styles compared

Rigging that suits one caver may horrify another. Any comparison between rigging styles must be highly subjective, depending largely on which style the caver making the comparison prefers.

Issues such as safety, conservation, speed and enjoyment lead into pointless arguments that ultimately come back to the competence of the cavers concerned. A clear comparison that can be made is that of relative weight.

To this end, let us compare the loads required for Khazad Dûm, an Australian vertical classic - a cold, wet cave around 300 metres deep. It has a total of 170 m of pitches with several bolts.

Bear in mind that the lighter a rigging style is, the more care and time it takes to rig. Lighter styles only have an advantage over heavier ones when the equipment becomes too heavy for the group to carry.

For example: A group of two in Khazad Dûm would have a hard time carrying their IRT gear. Two and a half sacks of Alpine gear would be a reasonable load. Their two light sacks of Ultralight gear would cause them no trouble but they would spend more time or compromise safety rigging it. One sackload of Cord Technique gear between two would leave the cavers underloaded and they would be even slower rigging it.

However, triple the depth of the cave or halve the number of cavers and the balance is pushed in favour of the lighter styles.

Table 5:1 Weight comparison for Khazad Dûm

Equipment	Style			
	IRT	Alpine	Ultralight	Cord Technique
Rope (mm) Length (m)	11 250	9 210	8 210	8 3# 86 190
Weight (kg)	18.8	10.5	8	3.3 0.9
Protectors	10	–	–	–
Weight (kg)	0.6	0	0	0
Tape slings	–	8	8	14
Weight (kg)	0	1	1	1.7
Hangers **Links***	–	5 16	5 16	5 3Al 9St
Weight (kg)	0	1.1	0.5	0.1 0.4
Gear Sacks ##	4 (3.6)	2 (2)	2 (1.2)	1 (0.7)
Weight (kg)	3.4	1.7	1.7	0.9
Total Volume (L)	**90**	**47**	**31**	**18**
Total Weight (kg)	**22.8**	**14.3**	**11.2**	**7.3**

* Aluminium karabiners for Alpine. 7 mm aluminium maillons for Ultralight. 7 mm aluminium^{Al} and 6 mm steelSt maillons for Cord technique.

\# 3 mm blind cord

\## Figures in brackets indicate actual 25 L sackfuls. Alpine style may need an extra sack for food, spare clothing and batteries while all others should be able to fit this into the left over space in the sacks.
IRT would not necessarily require the rope to be in sacks but would need at least one for extra items.

Shock absorbent rigging

Caving ropes are often exposed to the risk of shock loading. What is required is a static rope and rigging that will survive shock loads and safely absorb their energy. Attempts have been made to solve the problem. One attempt was 'Dynastat' rope—a thin low stretch core surrounded by dynamic sheaths. A severe shock load would break the core and in so doing absorb some of the energy, thereafter the sheaths would act as dynamic rope, stretch a lot and absorb the rest of the energy. During the fall the rope would lose its static properties forever and become bouncy, an indication that it was time to throw it away.

Another possibility is to use shock absorbing slings—lengths of tape that are bunched and sewn 'concertina' fashion so that under shock loads the stitching progressively bursts and in so doing absorbs energy. The idea has not been thoroughly tested in caves, the slings are expensive and bulky, one or more may be needed for each pitch. Their reliability after a year or two of use in caves would be uncertain.

Shock absorbing knots

A third option, shock absorbing knots, at first appears more reasonable. Tie a suitable knot in a length of static rope and it gets some dynamic properties. Unfortunately they do not work reliably enough to be safe (see Table 5:2). The abnormal (ie. mid-rope) loading of **any** knot is exceptionally hard on the rope and almost invariably reduces the number of FF1 80 kg falls it will survive.

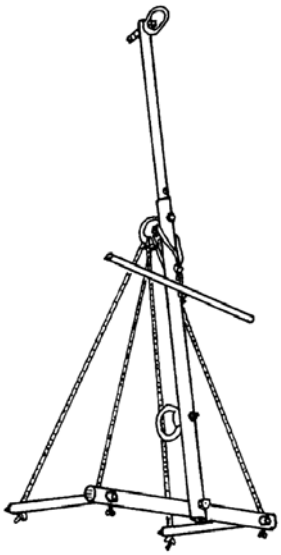
Shock absorbing knots have some chance of working in a new rope that normally fails within two FF1 80 kg falls (ie. 7 mm or some 8 mm ropes). Their performance however is so variable as to make them more dangerous than no shock absorbing knot. The only possible advantage a shock absorbing knot may give is that the extra 'end effect' created by another knot tightening may dampen the shock of the first fall and reduce the chances of your ascender biting through the rope sheath. The problem is that the shock absorbing knot may not slip as it should and the rope may break on its first fall instead!

Table 5:2 **Shock absorbing? knots**

Rope* (mm)	Age (years)	Shock Absorbing Knot	Falls FF1, 80 kg, 1 m
9	new	none	40
9	new	Overhand loop	4
9	new	Alpine Butterfly	3
9	4.5	none	3
9	4.5	Overhand loop	2
9	4.5	Double Bowline	1
8	new	none	1
8	new	Overhand loop	2
7	**1**	**none**	**1**
7	**1**	**Overhand loop**	**0**

* 9 = Bluewater II
8 = Bluewater accessory cord
7 = Beal accessory cord
In only one test (the 8 mm) out of thirteen did a Shock Absorbing Knot give a clear improvement. The 7 mm rope results are especially frightening. See also Marbach and Tourte, 2000, for a positive appraisal of Shock Absorbing Knots.

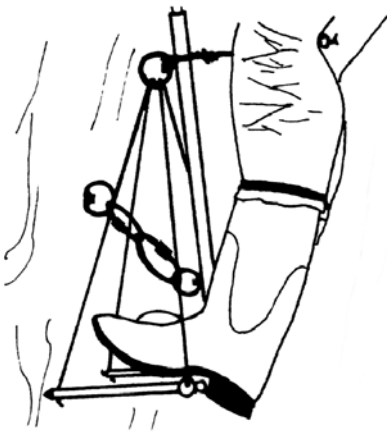
Climbing



Climbing platform

It occasionally becomes necessary to climb a pitch or wall to reach a continuation passage in a cave or for that matter an 'up' cave has to be climbed all the way. Most caving climbers use standard rockclimbing techniques and underground climbing should not be attempted without first gaining competence above ground.

Underground, climbers make extensive use of artificial aid—place more emphasis on security and less on good climbing style and ethics. The idea is not to put up a new route but rather to gain access to cave that you cannot otherwise reach. When aid climbing, make maximum use of quick anchors such as slings, nuts and pitons that may not be bombproof but will support body weight plus a bit. Caves often have blank walls with few natural lines of weakness to follow so climbing often comes down to placing a line of bolts up the wall to make a 'bolt ladder'. This was traditionally done by hand drilling and has been limited by the strength of the average caver's bolting arm that is only good for five to ten bolts per session. The appearance of portable battery-powered hammer drills that can place more than twenty 8 mm anchors on one battery has changed bolting tactics considerably.



In order to reduce time and battery power, half drill spits to hold body weight only and place a full depth one every fourth bolt for safety. Smaller bolts allow you to place more bolts for the same amount of energy. Six millimetre self drilling anchors are adequate if you are drilling by hand.

DBZ anchor

DBZ and concrete screw anchors can both use 6 mm holes and are fast to insert. For DBZs you'll need keyhole hangers to avoid abandoning your hangers and place a more solid anchor from time to time. Concrete screws are easy to remove, very strong, and you can remove and reuse them when you are finished. You can save further time on good rock by drilling shallow down-angled holes and using a skyhook in them to gain extra reach or for a move or two between good anchors if you are brave.

Concrete screw

Climbing platform

For long lines of bolts a you can construct a bolting platform from aluminium tubing (Marbach and Rocourt, 1980). Such compact, collapsible platforms weigh only 1.5 kg and make it possible to stand higher than with etriers and reach 1.5 m between bolts.

Scaling pole

The scaling pole is the traditional solution to reaching high passages. It is assembled from tubular aluminium sections held together by threaded or angle-section joints and a ladder or rope hung from the top. A scaling pole has a height range of around 10 m under good conditions, often making a climb feasible in one hit. In narrow pitches the pole can be hauled up to the high point and used again.

Scaling poles are heavy and bulky and therefore unsuitable for use in difficult, very deep or tight caves or when a large team is not available to carry the pieces and help support the pole while the climber is ascending. It probably won't be possible to use an independent belay so the pole cannot be allowed to fail. Also consider the conservation aspect: four or five 1.5 m long aluminium pipes and their fittings can make quite a mess of a cave. Grey aluminium scrapes don't clean off easily and a large metal bar is hardly a good thing to have in a delicate cave.

With rotten rock there may be no alternative to a scaling pole.

Mini-climbing pole

Mini-climbing pole

A mini-climbing pole as sold by Raumer (*Allonge Stick-up*) is an 80 cm length of aluminium tube with attachment holes at the top and bottom and a hole about 1/3 of the way along.

Attach oval karabiners to the top and bottom and preferably a fifi hook, or karabiner, to the centre hole. Hook the centre into the highest anchor and two etriers to the bottom, then climb the etriers as high as possible while using the top point for your cowstail, short chain of karabiners or tension from below. You can use the mini-climbing pole up either way—to give a little extra reach and good stability or 50 cm extra reach at the expense of some stability. What you can't do is take your weight off your etriers and sit back on you seat harness. If you try, the pole will invert.

The main advantage of the mini-climbing pole is its compactness—a few hundred grammes of pole 80 cm long is the only extra equipment you need.

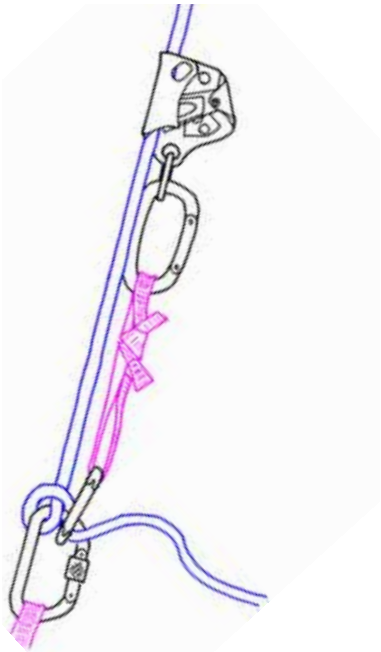
Platforms and especially scaling poles, give valuable increases in reach on vertical or near vertical walls, but become unstable on overhangs. They also involve a considerable amount of extra paraphernalia that must be brought into the cave, assembled and organised and later removed. Before using one, also consider the danger of being injured in a fall while attached to a big hunk of metal.

Aid climbing

On an expedition or for a short climb, slings or etriers will gain you around a metre between aid points.

A handy device for aid climbing is a 'cheat stick'. In its simplest form, this is any light stick with a rubber band or hook on the top that you can use to place a sling or skyhook onto a hold that is out of reach. Aluminium tent pole wands and ski stocks both make great cheat sticks.

The technique for aid climbing with etriers is simple but strenuous. Double ropes clipped into each anchor give much greater safety than a single rope or even a double rope clipped to alternate anchors, as they continuously provide a belay that has as little slack as possible plus a backup rope.



Belay rope locked off with an ascender

Begin by placing an anchor as high as possible and fitting it with a karabiner. Then hook an etrier and **one** rope into the karabiner and climb up until you are able to clip in a cowstail as well. Move up the other etrier to the top karabiner to provide one for each foot, then climb as high up the etriers as possible and clip yourself to the anchor with a karabiner, chain of karabiners or short cowstail, depending on the angle of the wall. Only now do you clip your second rope to the upper anchor—any earlier would have introduced excess slack into the system at the same time as you're about to weight the untested anchor for the first time. Once standing in the top of your etriers you can once again place an anchor as high as possible. When climbing with a single rope, clip it as for the second rope.

The ideal etriers are made of the lightest 25 mm tape available with four or five steps 30 cm apart at the bottom, reducing to 15 cm apart at the top. A stiffener bar keeps the steps open so you can insert your feet, and a fifi hook with haul cord allows you to easily hook and unhook the etrier by tugging the cord from the anchor above. Etriers are normally used in pairs but on difficult climbs and overhangs, a third can be handy.

Placing a bolt at arm's length above your head is slow and tiring and it is often better to stretch a little less in order to place the bolt more easily, especially if you have a number of them to place. The reach between anchors depends largely on the angle of the wall and to a lesser extent on the strength and height of the climber. Despite its appearance and abundance of insecure anchors, aid climbing is usually safer than free climbing as the runners are rarely more than a metre apart.

Avoid using the belay rope for direct support. Tension from the belayer can double the loading on the top anchor, increasing its risk of failure.

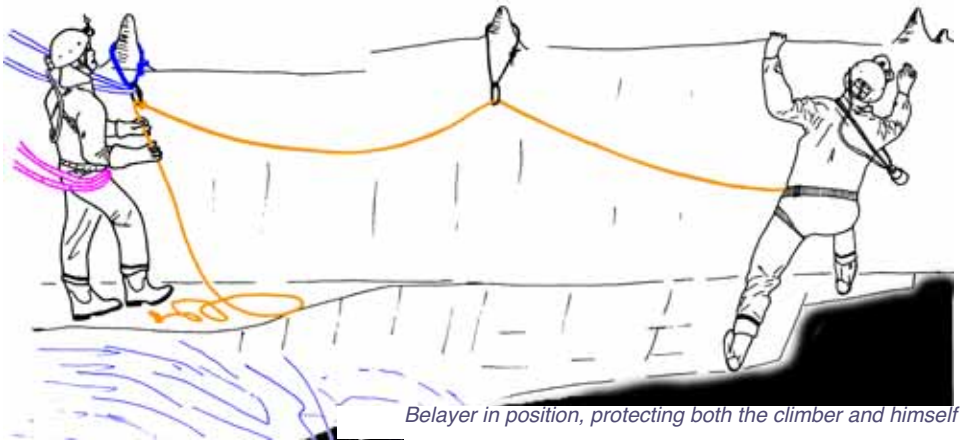
Desperate measures

At times more desperate measures are called for. You can try to lasso a projection or throw a rope with a big knot in the end and try to jam it in a crack. The problem, apart from getting the knot to jam at all, is that you never know exactly what you have caught until you get up there —or you pull it down!

Moving up from a jammed knot, you can use a grappling hook for getting a line across a fast flowing river or up a small pitch. Use three equally spaced small replaceable ice axe picks bolted to the end of a short handle twice the length of the picks in order for the hook to obtain a positive grip. Grappling hooks get good grip in rotten rock and have a tendency to become snagged wherever they hit, so a spare may be necessary.

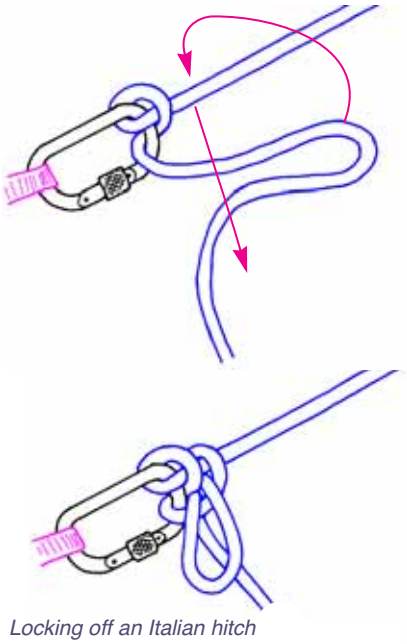
When climbing a rope whose anchors are dubious always use a separate rope with a dynamic belay and runners. Climbing with a static rope as a belay is dangerous and not recommended.

All climbing should be done with a good belay using a proper climbing rope.



Belayer in position, protecting both the climber and himself

Belaying



Locking off an Italian hitch

Some rig points are in such precarious positions that you need a belay to place them. The chance of holding a fall using **any** body friction belay is negligible and in the fall both belayer and climber would probably be injured. **Always** belay using a well anchored Italian hitch on a locking karabiner or a Sticht plate, ATC, or similar belay device. If using double ropes, tie separate Italian hitches on separate karabiners for each, or a double Sticht plate.

When belaying anchor yourself separately from the climbing rope in a comfortable position to one side of the anchor. This allows you to escape from the belay and aid the climber in the event of a fall. Seek a position that is sheltered from both falling water and rock yet still provides a view of the climber.

Pay out the rope straight towards the climber or first runner so that in the event of a fall the rope will not be whipped sideways out of your hands.

Another approach is to tie on with no slack and to attach the belay device directly to your seat harness. This has the advantages that your body will absorb some of the shock and reducing the possibility of you losing the rope should the climber fall. It should however be weighed against the greater risk it exposes you to and the difficulty of escaping from a belay that is loaded by a fallen climber (always keep a prusik sling or ascender and sling handy).

You must wear gloves and **never** let go of the slack end of the rope unless you tie it off or the climber calls "safe". Should the climber fall and not be able to regain the rock, you must tie-off the rope or lock it with an ascender before going to his aid.

Most rockclimbing manuals contain a more detailed treatment of belaying but take care to avoid out of date books that describe body belays. Any prospective belayer is well advised to take a practise session on a drop test rig before trying the real thing.

Increase safety by using runners, a high belay and having the belay set up well back from the pitch edge. Anything that reduces the possible fall length is a help. In any case never allow the Fall Factor to approach FF1 unless a you are using a good climbing rope. If the rope is not new and less than 10 mm, use it doubled.

Using a descender as a self belay for rigging is popular and acceptable if you do it correctly. Never use an ascender to give a self belay when you are rigging – the shock load you could generate from even a short fall would be dangerous (see Strength of descenders on page 99 and Strength on page 114).

Fixed rigging

There are many reasons for leaving a cave wholly or partially rigged. A cave in the course of exploration is easier to work on if it does not need re-rigging for each visit. Some rigging, traverses and climbs especially, can be difficult to derig and once derigged may be difficult or dangerous to repeat. Then again some caves are so horrible that the rope is left in them until someone finally summons up enough enthusiasm to remove it.

Ropes can wear dangerously with repeated usage and floods, yet the damage may not be apparent until you use the rope. Even rigging that receives no apparent wear in the course of normal usage is suspect after five years due to the ageing of the rope, tape and anchors. Once equipment is left any number of people may use it and their competence may not be all it should be. Fixed rigging should be as idiot proof as possible. Don't rely on an unknown caver who may not understand what he is doing to replace a deviation or rope protector.

Back up all fixed rigging exceptionally well and make it totally abrasion free, even when using 11 mm rope. Protect potential rub points, notably those on traverse lines, with unsplit plastic hose threaded onto the rope. In popular caves use wire or steel cable for traverse lines to reduced wear.

On low-level traverses across pools it may be acceptable for a caver to cross wires attaching himself only by a steel karabiner (aluminium wears rapidly).

When the consequences of failure are more serious than a dunking in cold water belay the first person across and then fix a rope to separate anchors from the wire for the rest of the party.

Wire ladders are often fixed and they are particularly suspect due to electrolytic corrosion of their aluminium/stainless steel/copper joints in the presence of water—copper is especially bad. Their failure rate is unacceptably high for them to be used without a self-belay rope. Always leave one rigged for this purpose.

Bolts have their own particular problems. Self-drilling anchors were originally designed for single usage rather than the repeated use they get in popular caves. After several years the thread degrades with corrosion or wear to the point where it no longer holds and the bolt pops from the anchor under the weight of a caver. Anchors may also suffer from misuse such as cross-threading and over-tightening that can leave the anchor plugged with a sheared-off bolt stub. It is good practise to quickly inspect the anchor for cratering, chipped casing or hairline cracks before using it and with a hanger in the way this is not possible. Should the bolt/nut screw in very easily or with a lot of play the anchor is definitely suspect. Use it with a tight backup or not at all. If the bolt/nut jumps its threads on tightening it definitely should not be used. Greasing the anchor helps reduce corrosion on fixed anchors and bolts. The bolt (as opposed to the spit anchor) threads also wear out. Inspect them regularly for wear and damage and replace them with 8 mm, stainless steel set screws if necessary.

12 mm Loxin with angle iron hanger

Heavily trafficked caves can and have been equipped with heavy duty bolts and even metal bars for belays. While perhaps a little unsightly, heavy bolts are infinitely better than the 8 mm bolt farm that may otherwise appear. There are several long term possibilities: 10 mm+ self drilling anchors with stainless steel set screws and hangers, 10 mm+ stud anchors with stainless steel, angle iron or for larger studs, welded eyebolt hangers or Petzl 'longlife' anchors and hangers or double expansion stainless bolt by Fixe or Raumer. Some have the advantage that you can remove the anchor for inspection and replacement thus making the bolt last 'forever'.

The best by far are glue-in anchors. They require a 12 mm dia. x 100 mm deep hole and special epoxy. They are expensive, but very long lasting and strong, even in poor rock. More important for conservation reasons, they are easily replaced. Just heat them with a blowtorch, then put a lever through the eye and twist them out. You can then drill the glue out of the hole and glue in a new one. For more information on glue-in and other long lasting bolts, visit: www.climbinganchors.com. See also Bolts on page 34.

Never leave equipment in a cave without careful thought. Fixed equipment may make a cave easier and perhaps safer for everyone who follows but inevitably reduces the challenge as well. Remember also that the person who places fixed rigging has a responsibility to leave something that is neither dangerous to others nor junk that someone else will eventually have to carry out.

Ice build-up on fixed ropes occasionally causes problems in alpine areas. Apart from rendering the rope unusable for a time an ice coating does no real damage. The only potential danger occurs in spring if the ice melts first in contact with the rock and leaves a heavy blob of ice hanging on the rope to stress the rigging.

On a less spectacular although considerably more dangerous scale, there have been instances of a rope becoming lightly iced, causing cavers to lose control on their way down and get ice clogged ascender teeth on their way up. On more heavily iced ropes it may become necessary to break the ice crust off a rope before being able to use it.

Pull-down rigging

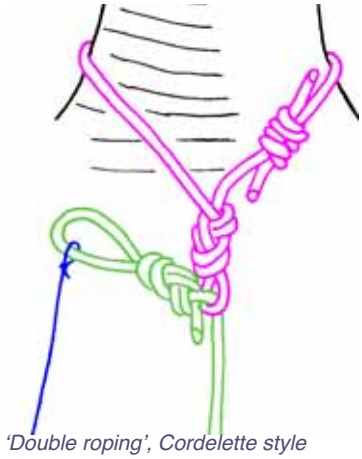
Through trips done *en rappel*, or derigging a rope from a climb to leave behind a minimum of gear are special cases in vertical caving. A through trip is easier if the cave has already been rigged with eyebolts or steel rings. If not, you can leave double ring hangers or backed-up slings on natural anchors. To rig 'on the cheap', tie light cord or tape hero loops to 2 cm long bolts (no hangers). You will usually need slings for pull-downs from natural anchors so as to reduce friction.

Try to use a thicker rope than usual on through trips. You need far less rope than for a normal trip but it will get considerably more wear with the repeated use. The rope must be twice as long as the longest pitch and you can knot two equal lengths rather than carry a double length rope. For safety it is a good idea to carry extra rope or cord so that if the rope becomes stuck you can continue your descent. Once you've pulled that first rope there is no turning back!

Observe standard rigging safety precautions such as double anchors and avoiding abrasion points, although you can tolerate slight abrasion for a single descent. Rig so that you can pull the rope down with little risk of it jamming as it falls down the pitch and abseil in a manner that does not twist the ropes. To be sure that the rope will pull freely a test pull of a metre or so should be routine before the last person descends. Do not forget to untie the stopper knot from the end of the rope before pulling it down and be sure to pull on the correct rope! Never climb a jammed rope as it may suddenly unjam with a climber on it.

Most bobbins only work on single rope (see Descenders — bobbins on page 92). Use a rack or double bobbin for double rope descents. Figure-8 descenders can also be used but they may twist the rope and make the pull-down difficult.

Cordelette style



'Double roping', Cordelette style

Fix a single rope with a jammed knot at the top just as you would do for the Cord Technique. Retrieve the rope using 3 mm cord or a collection of shorter ropes and slings. There is no need for a special Cord Technique tail on the rope unless you intend leaving a string in place but you still need some means of jamming the knot at the top. This can be a ring hanger, small maillon or closed ring attached to a sling or simply a knotted eye tied in the sling itself.

Decrocheurs are mechanical devices that allow you to unhook the descent rope from the belay once you have reached the bottom of the pitch. None of them offer any advantages over a cordelette style pull-down.

Single rope descender (Petzl Stop) on one strand of a 'double' rope held in place by a stopper knot.