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On the use of percussion cartridges to extract fossils from hard breccia

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The use of percussion cartridges (caps) affords a simple, quick, controlled and safe way to remove pieces of hard breccia from around fossils or to remove breccia pieces that contain fossil material. We have demonstrated its use over two field seasons to remove pieces of breccia containing quite small animal bones and it is as good as, or better than, the use of jackhammer drills and other methods. Safety procedures are simple but must be strictly followed at all times.

Keywords: Makapansgat, percussion cartridges, breccia, fossils.

INTRODUCTION

Traditional methods of extracting fossil material from hard breccias, especially in the hominid-bearing caves of South Africa, have involved the initial use of a jackhammer to prepare a hole into which a small quantity of charge is placed, or the use of a straight plaster charge (Mason 1988) or, more frequently, metal wedges. The pieces of rock are further reduced, away from the site, using hammers, chisels, punches and acetic acid baths, in the usual way. Explosives are now seldom used because of their overall destructiveness. This is because, in addition to the destruction of archaeological or palaeontological material, fossils, bones, tools and flakes may become disassociated from each other and from their context. Modern excavation methods on archaeological sites in the last twenty years, in general, have become much more elaborate and painstaking and so the use of explosives has largely been discontinued. Jackhammer drills are effective with the use of wedges, but they are heavy and noisy and, for most excavations, they require two or more people to operate. Also drilling becomes quickly more difficult as the approach face becomes steeper and the terrain becomes rougher. Percussion cartridges are used in the construction industry and, since about 1990, have been adopted by cavers in Europe and the U.S.A. to widen narrow cave passages. We investigated their possible effectiveness on newly exposed breccias at the australopithecine site at Makapansgat and the results are presented here.

APPARATUS AND METHODS

Figure 1 shows the basic arrangement required to drill and cap 8 mm diameter holes in hard breccia. The apparatus consists of an electric drill with hammer facility, an 8 mm × 30 cm long bit, an anvil made of brass or mild steel rod that is at least 2.5 kg (5 lb) in weight with an 8 mm hole drilled centrally, several 8 mm screwed rods about 30 cm long (about 1 ft), each sharpened at one end to a V-shape to act as a firing pin, about 30 cm square (1 ft square) mat of heavy rubber (for example, a piece cut from an old conveyor belt), goggles, helmet and gloves and a box of Hilti™ cartridges (black is strongest). Ear protectors are optional (see later). The operator also requires a >2.5 kg (about 5 lb) lump hammer and various metal chisels.

An 8 mm hole is drilled to a depth of between six and nine inches such that the percussion of one or two cartridges placed at the base of the hole heaves or cracks pieces of rock breccia away from a free face. Cracked pieces can then be removed with hammer and chisel and the resulting pieces of rock are documented, taken away and treated as usual for any fossil material.

It is possible to use a 24-V hammer drill powered from its own re-chargeable batteries to make the holes in the rock. Depending on the amount of drilling, the two batteries that come supplied with such a drill can normally be used to prepare from five to eight holes before the batteries need to be re-charged. It is normally expected, however, that a drill will be powered from a nearby generator, in which case, as many holes can be prepared as necessary for the day's work.

Experience shows that the optimum depth for a hole is from six to nine inches depending to some extent on the

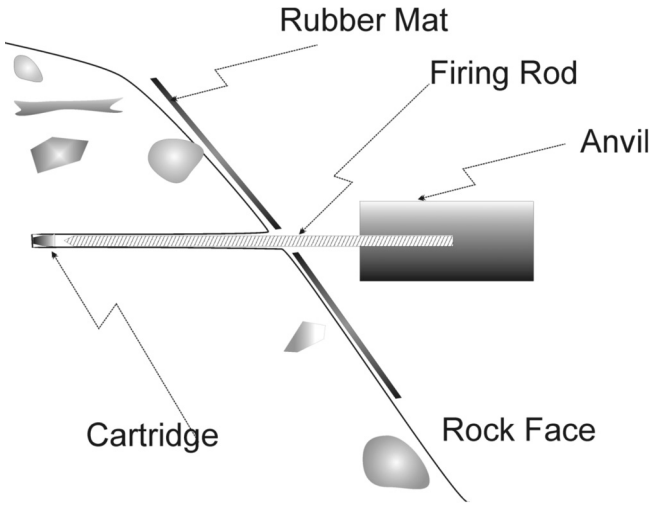


Figure 1. Ready for firing the cartridge. The position of the drill hole, cartridge, rubber mat, firing pin and anvil, ready for hammer strike into fossil-bearing hard breccia.

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proximity of a second free face, such as a root hole or unconsolidated ground. Each hole is reamed and cleaned out with the bit in order that the cartridges will slide to the base of the hole with minimum of resistance. Each hole therefore needs to be cleaned of rock powder and the easiest way to do that it to use a small piece of plastic tubing (two to three ft long) and blow down it. The hole may also be cleaned with the bit as it is brought in and out of the hole. The blunt end of the screwed firing rod can also be inserted into the hole in order to assist in further cleaning and to ascertain the actual depth of the hole.

Next, wearing goggles, helmet and gloves, one cartridge is place into the hole, point first and the blunt end of the rod is used to push it to the end. Note that if there is resistance to the movement of the cartridge, and it has not gone the whole way then the following procedure must be followed for safety. It is very unlikely that the cartridge will detonate as it is inserted into the hole but it must be assumed that this could happen. First the mat must be placed over the rod and made flush to the face (Fig. 1). The anvil must be placed over the free end (the V-shaped end) of the rod in order to assist in sending the cartridge to the far end of the hole, and it may be lightly tapped with the hammer to sink the cartridge.

The rod is then extracted and turned round so that the V-shaped end points down the hole as the firing pin. The mat must be placed over the rod flush to the face, and the anvil placed over the rod. The anvil is then struck with the hammer to detonate the cartridge(s). The mat prevents small rock from flying back toward the operator, and it is for this reason that the hole must be greater than six inches in depth. The percussions are not strong enough to lift larger pieces. If the anvil is loose over the rod then a single loop of tape (or paper) can be wrapped over the end of the rod before the anvil is placed over it.

If necessary, two cartridges may be use to good effect but it is inadvisable to use three cartridges. Obviously, all safety precautions must be followed including the use of goggles, helmet and gloves, safety boots and, particularly, the anvil.

OBSERVATIONS AND NOTES

The danger of the technique arises mainly from the firing pin (rod) coming out of the hole at high speed. The reason that the 8 mm rod is screw threaded is that the threads act as a binder in the hole so offering some resistance to the percussion from the detonation, that is, to prevent the rod flying out of the hole. But it is known that the threads do not always offer enough resistance on their own to the detonation. It is, therefore, *imperative* that when either the blunt end or the V-shaped end of the screwed rod comes into contact with the cartridge in the hole, the mat is placed over the rod flush to the face and the anvil is placed over the free end of the rod. The anvil not only acts as the striking surface through to the rod but also absorbs any momentum that the rod acquires from the detonation. The rod does not have enough mass of its own to absorb the detonation and instead it can become a missile. Hence the anvil must be used at all times when the rod is against the cartridge. The authors know of three accidents, to 2002 worldwide, with this technique when, in each case, the rod was used *without the anvil.*

The anvil is held by its sides quite safely when the top is struck. If the anvil is struck at arms length from some distance away without it being steadied, the blow is not likely to be as 'clean' on the top surface of the anvil, and experience shows that the rod soon becomes bent and unusable. It is also not advisable to make rods that are too long since they may bend too much under the weight of the anvil when the rod and hole are not vertical.

Eventually, after a few holes have been detonated the screwed rod will become bent anyway. Hence for a day's session of drilling, it is usual to make up four or five lengths of rod. An angle grinder can be used for cutting up a 2 m length of rod, into the required pieces and to grind a V-shaped end on each. Burrs need to be removed so that the rod slides easily into the hole by either rod end. Unless the rod can be made dead straight again on a workbench it is usual to jettison bent rods.

In some arrangements, the rod is actually screwed into the anvil, which adds the extra precaution that the anvil and rod do not get separated. The disadvantage is that the screwed threads tend to become damaged which necessitates more maintenance. So as each rod becomes too bent to insert into the next hole it is unscrewed from the anvil and a new rod is inserted.

It occasionally happens that the end of the hole becomes over widened slightly due to the drilling procedure, especially if the bit is made to linger at its maximum depth; the cartridges also have rims and the result of both of these factors means that, sometimes, the cartridge may become skewed at the end of the hole. The result is that the cartridge may not detonate immediately upon being struck by the firing pin through the anvil. It should not be necessary to strike the anvil so hard as to bend the screwed rod. It is better to take the rod out an inch or so and rotate it to between 45° and 90° and reinsert it so that the V catches a new position on the rim of the cartridge. Occasionally it may be necessary to do this a second or a third time.

If the rock face containing the fossils is of sufficient bulk then it is better not to place the hole into the mass of the rock body but to drill the hole about parallel to a second face. In that way the rock is shattered or cracked off from the other free face. If the hole is too shallow (less than six inches) then rock tends to be blown off the top of the drilled face. This is the reason for having the heavy mat.

The technique should not be used in breccia that is too soft, has holes or has soft (uncemented) pockets in it. Cartridges may either be lost in unconsolidated breccia which means that they have to be fished out carefully by breaking up the rock the long way round (obviously, for safety reasons, they cannot be left in), or the caps may detonate uselessly (see later).

Hilti™ cartridges come in strengths, yellow, red and black (strongest). We have used all three strengths and found it is safe to use two blacks cartridges together in drill holes greater than 6 inches deep. The cartridges are supplied separated from one another in plastic holders in boxes of 100.

RESULTS

Dr Kuykendall and Jeff McKee cleared the surface of deposits comprising Member 2 and layers below Member 2, above the so-called Original Ancient Entrance of the Limeworks in 2001, in preparation for *in situ* sampling. In the 2003 field season, we tried the capping technique on the cemented breccia of Member 2 with the following results; the first author, who had used this technique in caves in the U.K., was the 'capjack', and the second author took over later in the field season. Fossil-bearing pieces from the harder parts of the breccia were removed as effectively as, and more easily than, could be removed by a jackhammer that was being used at the same time. On two occasions, however, we drilled into pockets of less well-cemented breccia with no result. In one case we made a new hole near to the first and fired the rock so that the original cartridge was eventually retrieved intact. In the second case, we began to extract the cartridge by making a series of drill holes and breaking up the rock with hammer and chisel away from the cartridge. We then found that the cartridge had in fact fired but the sound had been muffled by the unconsolidated rock. Despite these two 'dud' holes, we made good, controlled progress, frequently using old tree root-holes as the free face. In the 2004 field season, we confined our use of the technique more to the highly cemented sediments and calcites below Member 2 on which, we found, the technique was ideally suited. The second author was the capjack. There were no misfires or pockets of softer material and control was sufficiently good that we were able to extract an articulated skeleton of a small bovid with little damage. Because of the disposition of the face, one or two of our holes were drilled at quite steep angles. We ran into trouble drilling one layer of this Member when the drill bit hit clasts of detrital silica. It was then necessary to re-site the hole and try again. The detonations did not produce lots of small pieces but a few large ones. We subsequently examined the country rock again to see if new cracks had opened up so as to usefully place and direct the next hole.

Ear protectors may be used but occasionally some detonations may not be heard. It is necessary, of course, to know that all firings have actually occurred, and therefore we did not use ear protectors and we have suffered no discomfort.

CONCLUSIONS AND RECOMMENDATIONS

In two field seasons at the Limeworks, Makapansgat, we have successfully demonstrated the use of percussion cartridges to remove lumps of hard breccia, containing fossils, under controlled, safe, conditions and with minimum damage to the fossils. The capping technique can be used in places where it would be impossible or difficult for other techniques to be used, such as in the interiors of caves (as, for example, in the lower reaches of Gladysvale, Gauteng, South Africa), on vertical walls or in confined spaces. We do not recommend the technique be used in situations where there is a chance that the cartridge holes may end up in soft material. Directors of excavations who intend to use the technique should not allow undergraduate students or junior persons to 'have a go'. As some situations may require extra judgement involving considerations of safety, it is recommended that the capjack be sufficiently senior at the excavation and that he or she be in charge of the capping equipment (drills, bits, anvil, rods, mat and cartridges) both in its use, transport and storage.

REFERENCES

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