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THE USE OF FIRESETTING IN THE GRANITE QUARRIES OF SOUTH INDIA

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Abstract: The granite quarries of south India still employ firsetting to split out large slabs of stone. This paper describes the methods used and draws particular attention to the use of a small blunted chisel driven into the granite to direct the heat wherever it is required. Very small but carefully directed fires are used recalling some of the fireset work in the ancient mines.

INTRODUCTION

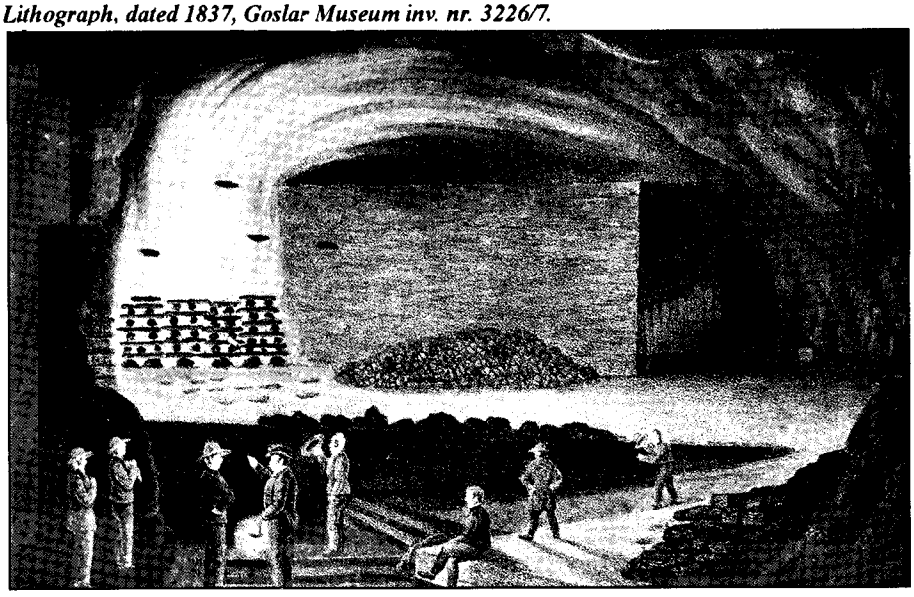
Firesetting was the universal method of breaking up hard rock from the inception of mining until the recent past. However there are few detailed records or contemporary instructions as to its use, with the exception of Collin's valuable 1893 article written just as firesetting ceased to be used at least in European mines. Agricola mentions firesetting briefly in *De Re Metallica* (Hoover and Hoover 1912, p.120), but in much less detail than other mine operations. Similarly there are some other brief records or mentions in mining works, some illustrated (Diderot 1959, for example), such as the operations performed at Rammelsberg in the Harz Mountains of Germany in the mid 19th century (Simonin, 1868, p.409) (Figure 1, from Hillebrand 1988), and at the silver mines of Kongsberg, Norway (Collins 1893, Berg 1992). Firesetting persisted there up to the end of the 19th century until finally the advent of cheap alloy steel for the drill bits and the replacement of black powder by Nobel's new more controlled explosives such as dynamite for the explosive made blasting more viable even in heavily wooded regions such as Scandinavia, where wood for fuel was cheap.

With the recent interest in all aspects of early mining there has been considerable attention paid to firesetting (Timberlake 1990a, Craddock 1992 and Willies 1994) coupled with some experimental work (Holman 1927 and Shepherd 1992), and in default of detailed old records a considerable number of firesetting experiments (Pickin and Timberlake 1988, Crew 1990, Lewis 1990, Timberlake 1990b). Despite this sustained interest considerable problems remain, particularly for the small scale use of the technique in antiquity, it is clear from the well preserved walls of many early mines, such as those at the early Bronze Age tin mine at Kestel in Anatolia (interim reports of which appear in recent issues of the *PDMHS. Bulletin)*, that the early miners were able to direct the firesetting operations very precisely in any direction with what must have been tiny fires (Willies 1994, p.7). Another problem encountered during the firesetting experiments was that the work face naturally tended to rise as the heat rose and it was very difficult to go down, but this had clearly not been a problem for the ancients who regularly sank shafts using fire and who mined by underhand stoping. Crew (1990) seems to have realised this in his experiments, noting that 'A major problem seems to have been directing the fire to the toe of the level.' (that is the lowest part) 'One answer maybe to use smaller more intense fires'.

The few recorded firesetting operations were all in large post-medieval European mines, where the fire was used on a very considerable scale in large galleries and the heat was either directed against the wall or against the roof as overhand stoping became the usual method of mining. Thus these examples were not much use for understanding the technique in the much smaller and tortuous mines where the direction of the working was almost invariably down.

Whilst working in India over the last ten years or so the author, in company with Lynn Willies, had frequently heard stories from mining engineers and geologists of firesetting still being used. Frustratingly these operations always tended to be reputedly taking place over the hills and far away. Thus whilst in the Kolar Gold Fields of southern India, we were told of well sinking by firesetting taking place in Bihar in the north, and conversely when we were at Zawar in the north we were told of firesetting being used in the granite quarries of the south! Once, whilst the author was on an interminable and unstoppable bus ride somewhere in the south, the bus passed a roadside quarry and a glimpse was momentarily caught of what seemed to be rather more than just domestic fires. At last in December 1994, by great good fortune, and the hospitality of his host, Mrs. A. Patel, the author was staying at Kothnur, some 15 km north of Bangalore, Karnataka in southern India, in an area of the granite beds which are being actively quarried. Through the good offices of Mrs. Patel it was possible to observe, record and photograph the use of fire in the quarrying process. It must of course be stressed that the objective

Figure 1. Large fireset as practised in the first half of the 19th century at Rammelsberg, Goslar in the Harz Mountains of Germany. Such illustrations are dramatic but do not tell us much about ancient firesetting practise. Note it is most unlikely that there really was an audience, as contemporary mining rules insist that the mine was to be evacuated once the fire has started. Lithograph, dated 1837, Goslar Museum inv. nr. 3226/7.



in the granite quarry was to split out large coherent slabs of granite, rather than just break up the stone for which black powder was used. However several aspects of this highly skilled technology would be applicable to the controlled application of firesetting as an underground mining technique.

THE QUARRY

The sheets of granite lie more or less horizontally, with some slight doming, and the principal natural faults are also horizontal (Plate 1). The sides of the quarry are extended by blasting with black powder packed in hand-drilled holes, exposing the top of the granite plates which are to be carefully quarried. The large flat slabs split from the beds are used for a variety of purposes, some are sawn and polished to form the decorative cladding sheets to be seen on modern buildings around the world. Smaller pieces can be split into columns if the slab is over 10 cm thick. Thinner pieces are split into stone fence posts which are widely used all over India. Other smaller pieces are split into building blocks or floor slabs.

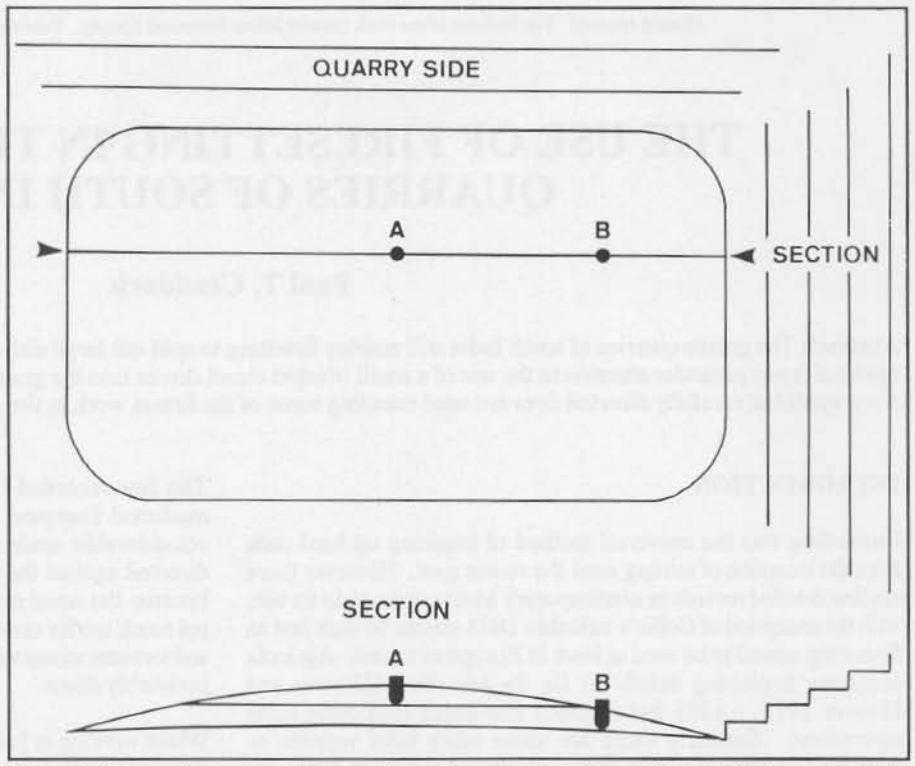


Figure 2. Schematic section of the granite surface showing the position of the firesetting holes and the resulting cracks. A centrally placed hole (A) will remove a scab of rock, flattening the surface, a side hole (B) will enable the crack to spread much more extensively.

The object then is to split out as large a horizontal slab as possible (these are typically about 9 to 12 square m, with thicknesses of between 7 and 20 cm). First the surface to be split is carefully brushed and inspected for any incipient cracks which might adventitiously develop during the splitting process. If the surface is deemed satisfactory then the site from which the crack is to be propagated is chosen (Figure 2). This is usually towards the edge of the plate but still about a metre from the quarry sides. If the

Plate 1. The Byrath granite quarry, at Kothnur, just north of Bangalore, southern India.

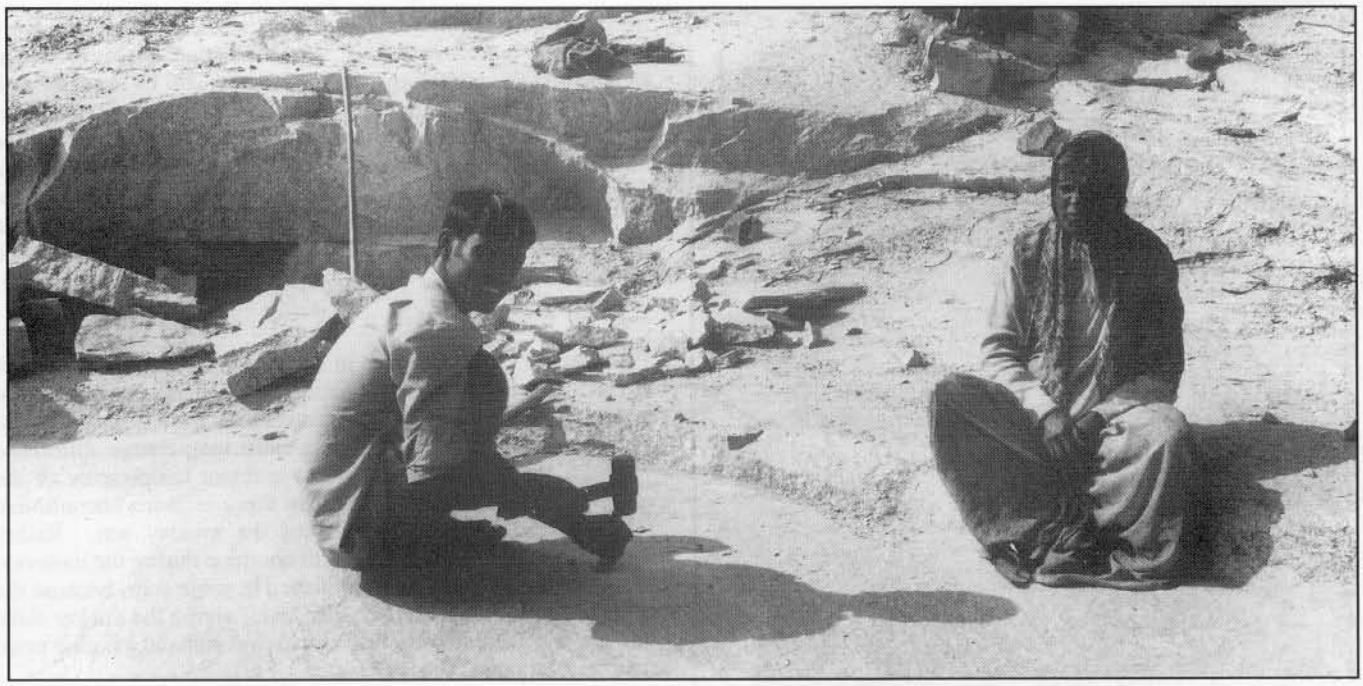


Plate 2. Hammering the haap chisel into the cleaned surface of the granite.

crack is propagated from the centre of the dome then the slab removed will be quite small, in effect just a thin scab of about 5 to 10 cm thickness, flattening the top. If a site is chosen nearer the edge then the crack will commence at a deeper level, and be capable of almost indefinite propagation, at least over the domed sheet. The experienced fireman chooses his site according to the dimensions of the stone slab required.

To commence the crack a vertical hole is cut in the granite slab with a special blunt chisel (Plate 2), known as a *haap* chisel, hammered in with an iron hammer, the *sutti*. The chisel is about 10 cm long and the blunt tip is about 0.5 cm by 2.5 cm wide (Plate 3). This cutting edge is almost squared off. The chisel is hammered for about 8 cm into the granite, and at about this depth the blunted tip causes incipient horizontal cracking to occur in the granite. This is all important and the quarry man checks that this has happened by lightly placing his thumb over the end of the firmly wedged chisel and tapping the stone nearby with the hammer (Plate 4). If splitting has commenced then the wedged chisel vibrates in a very recognisable fashion. The split is then developed in a controlled fashion by heat. A small fire of the slow-burning wood *casuarina equisetifolia* (horse tail casuarina or south sea ironwood) is built over the protruding chisel (Plate 5) and the heat is transmitted down the shaft to the blunt tip causing the incipient crack deep in the granite to spread. Note the fire is small, no more than about 30 cm square, and very carefully tended, even to the extent of periodically picking up the burning wood and sweeping away the ashes to ensure good contact between the source of the heat and the stone. After about an hour the crack will have spread out for about 30 cm back to the slab edge in one direction and out towards the domed centre in others, and the stone will be thoroughly hot. At this stage the fire over the chisel is discontinued and the expanding crack is developed in a controlled manner by moving a small arc of burning brushwood directly over it (Plate 6), the crack propagates at about a metre an hour at this stage. At this stage the blunt chisel is removed, causing a sharp inrush of air into the vacuum created by the crack, and the hole sealed with cow dung. The arc of fire is carefully tended, the ash being carefully dusted away, and never allowed to get out of control. Sometimes towards the end of the fireset a quick blaze is required for which toppings and loppings from the nearby eucalyptus plantations are an ideal and very cheap fuel (Plate 7). Sometimes quick and slow-burning fuels are alternated as the situation requires. The progress of the crack beneath the

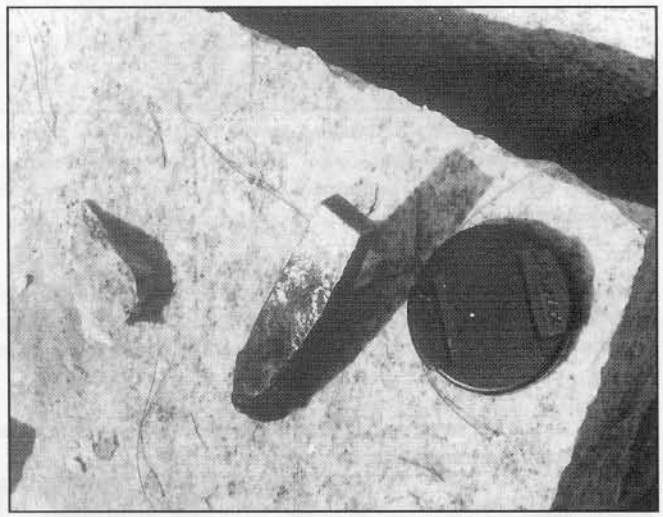


Plate 3 (above). The haap chisel with the blunt cutting edge raised.

Plate 4 (below). Testing if an incipient crack has begun to develop by tapping the granite whilst feeling the vibrations transmitted up the firmly wedged haap chisel.

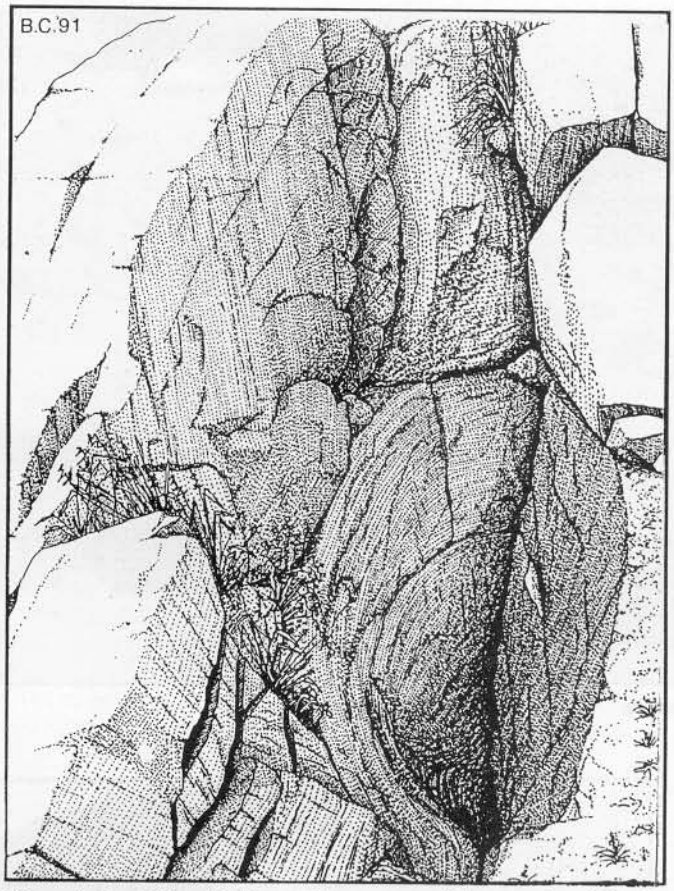


Figure 3. Small fireset hole exploiting a pre-existing crack on Mochia (east), at Zawar in Rajasthan, India. Note the relative narrowness of the hole, most of the splitting action of the heat has somehow been directed downwards.

fire is periodically checked by holding a wooden pole firmly to the surface of the stone and tapping the stone with a hammer, where the stone is cracked beneath the pole vibrates in a very distinctive

Plate 5. Small fire burning over the chisel which transmits the heat down into the granite making the incipient crack spread.

fashion, and the note struck by the hammer has a very recognisable 'hollow ring' to it. When the crack has spread as far as required the operation is brought to an end by dousing with water. This has nothing to do with developing the crack, but is done merely to extinguish the fire and cool the rock so that the next stage in the operations could continue, thereby saving a little fuel and time. One suspects that firesets in the mines were doused for similar pragmatic reasons. The slab was then split out at the edges by feathering with wooden wedges and then carefully lifted with chain hoists.

The firemen prefer to work in the early morning or in the late afternoon, when although a little more fuel is required than at midday there is apparently more control over the splitting process. This could because there is a greater temperature difference between the heated rock and the ambient temperature of the granite in the morning or because there is more uncontrolled strain in the rock in the heat of the midday sun. Rather surprisingly the operations can still continue during the monsoon season, in fact this season is preferred in some ways because the cracks tend to initiate at a deeper level, giving the thicker slabs that are more suitable for pillars which command a higher price than the ubiquitous fence posts.

THE QUARRY STAFF

At the Byrath quarry three fire controllers worked at rates of pay varying between 75 to 90 rupees (about £1.50 to £1.80 at the then current 1994 exchange rates) per 5.5 hour day, depending on their experience and work achieved. The skilled quarrymen who marked out and split the stone into pillars or blocks received 46 rupees per 100 blocks, which averaged around 60 rupees per day. The women who tended the fires and brushed up the small rock debris and broke it up with hammers for road chippings etc, received around 25 rupees a day.

DISCUSSION

Clearly this is a very different operation from firesetting in mines, both in objective and in execution. The very fine degree of predicted control is only possible with a hard coherent rock with few faults whereas most mineral veins, although hard, are usually heavily fissured and fractured, and thus the predetermined removal of specific pieces of rock would not be possible. The use of a blunt metal chisel is an extremely simple but effective way of directing the heat deep into the rock wherever and whatever direction is required. The technique would be especially useful for mining vertically, in operations such as shaft sinking, where the heat could be channelled down, which has previously been found very difficult in the firesetting experiments. It is possible that the miners would seek to exploit pre-existing natural cracks by driving the chisels firmly in and then firing, as exemplified by a small (incipient ?) shaft on Zawar Mochia, of post-medieval date (Willies 1994, p.6) (Figure 3). Without some means of directing the heat it is difficult in this instance to see how the action of the fire could have been predominantly down, leaving the sides relatively unscathed especially at the bottom. Many of the small fireholes found in the ancient mines are not only very precisely directed but clearly could only have accommodated very small fires (see illustrations of such fireholes in previous issues of the *PDMHS. Bulletin*; from northern India, Willies 1987, Plate 11, p.101 and from Kestel, Willies 1990, p.93, Plate 4). This too has resonances with the practices at the granite quarries. Willies has noted in more than one mine the very precise and gentle nature of the firesetting technique used, very different from the huge works of the last century, but an appropriate description of the work in the stone quarries.

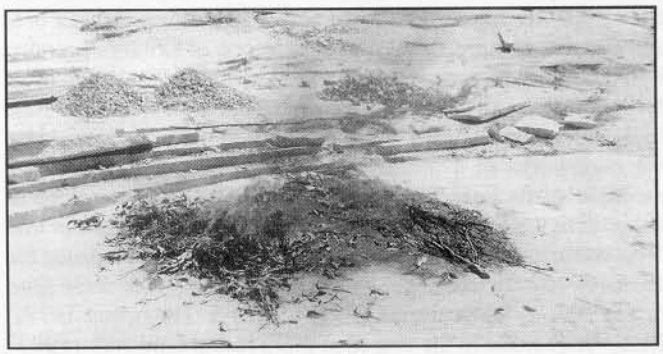
If such a technique was used in the mines of antiquity it is natural to speculate on what evidence would be left. In normal circumstances very little would survive on the mined rock wall itself as the crack should have spread out from the very tip of the chisel. Where the crack developed out from further up the chisel hole the end of the cut would be preserved, but this would difficult to differentiate from an ordinary gadd cut made after firesetting.

One could expect to find the very occasional blunt wedge or chisel and indeed a very few have been recovered on early mines around the world. Thus very blunted copper wedges or gadds have been recorded in the Lake Superior mines for native copper which were dug by the ancient Amerindians using firesetting followed by mining with stone hammers and antler tools (Drier and du Temple 1961, p.51 & 53, p.132). Similar blunt bronze flat axes of Early Bronze Age date have been recovered from ancient mines in Spain (Sandars 1910); a copper axe-adze and very blunted axe-hammer was excavated from the Chalcolithic mine at Ai Bunar in Bulgaria (Černych 1978, Plate 20, p.213), and finally a very blunt bronze chisel tip of Bronze Age date (BM PRB 1853, 10-31, 8) was found in the Great Orme mine in the 19th century (Lewis 1990b, Dutton and Fasham 1994, Fig. 12, p.270). The flat axes from the Spanish mines appear to have been deliberately blunted.

Even so there is no direct evidence for the use of a metal chisel to direct the heat, but their use could explain the extremely neat and precise firesetting work, maximising the penetration and the amount of fracture from what could only have been tiny fires in many instances, appropriate to the confined workings of the early mines.

Plate 6. (above). Fire of brushwood burning over the crack and controlling its spread. Note the granite pillars in the background split from a thick slab.

Plate 7 (below). Quick blaze of eucalyptus toppings provides some extra heat. Note the steps where previous slabs have been terminated.



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