



In a recent holiday it occurred to me that I had visited several different types of mine during my life, and in each of them one of the major technological problems was that of removing the water which inevitably enters the mine. In fact, guides in mines almost always try to impress visitors by quoting figures for the enormous quantities of water involved. That this must also have been a problem in Moria is confirmed by the text of "A Journey in the Dark" (LoLR II,4): "When they halted for a moment they heard nothing at all, unless it were occasionally a faint trickle and drip of unseen water" -- and that was fairly high up in the mines, the problem would have been far worse deeper down. Did the mines somehow drain themselves, or did the Dwarves drain them mechanically?

The Geology of the Mines of Moria.

The first factor we must consider is the amount of water involved, and this will be determined chiefly by the geology of the mines. Roger Mason (Mallorn 9) considers the basic material of Caradhras to be granite, which characteristically weathers to a red colour (cf the Red Hills of Skye, or several peaks in the Alps called Rothorn [-Red Horn-Caradhras]), and this agrees well with Sam's comment on the industry of the Dwarves digging Moria, "and most of it is hard rock too", although he may have been comparing it to the material Hobbits usually worked (probably soft, unconsolidated or poor consolidated sands), rather than other types of rock. A granitic country rock also ties in nicely with P't. W. Sargeant's views on the mineralisation (personal communication): "The mines of Moria are, in the old fashioned terminology of ore geology, evidently located on a stockwork, and present a classic instance of ascending mineralising fluids, with the least precious metals nearest the surface, gold and silver at depth and mithril -- obviously a very high temperature mineral -- deepest and most precious of all.*"

However the area of mines cannot have been entirely granite, as there were caves there before the coming of the Dwarves (LoLR, Appendix A, part III), which would not be typical of Granite mountains. It would therefore seem most likely that the chief dwelling places of Moria were excavated in limestone, probably somewhat metamorphosed both by the intrusion of the granite and by the orogenic activities leading to the formation of the whole Misty Mountain chain, while the chief mines (and the passage toward the West Door) would have passed into the mineralised granite. Readers will be familiar with the occurrence of stalactites, underground



rivers, etc., in limestone caves, although these may not have caused too much problem in Moria, as most of the 'living' areas appear to have been well above the level of the doors, and so, perhaps, above the water table. Granite, though not as susceptible to attack by water as limestone, can still be porous, especially if jointing has occurred as a result of pressure release following uplift and erosion, and it is certain that much of the mines were dug well below the water table, since following the departure of the Dwarves the treasures in the deep places became "drowned in water", as reported by Gandalf, presumably on the basis of his own experience when he was searching for Thráin. Thus it seems certain that, left on their own, at least part of the mines would have become flooded, and thus that the Dwarves must have had some method of removing the water.

Removal of Water from the Region.

The next point to consider is how, having removed water from the mines, it would have been removed from the region altogether. The map in *FoTR* shows only one river leaving the vicinity of Moria, that is the Celebrant or Silverlode, which is shown flowing out of Mirrormere. However, this is plainly wrong on two accounts. First the map does not show the Sirannon or Gate-stream, which flowed from the West Gate of Moria. Although at the time of the war this was no more than a trickle, it had, in the past, been "swift and noisy". Secondly the Silverlode did not flow directly from Mirrormere; the company had descended "some way below the mere" before they came on a "deep well of water, clear as crystal", which Gimli identified as the "spring from which the Silverlode rises".

I believe that the water removed from the Mines of Moria was ejected via the Sirannon for three reasons:

- 1) Mirrormere was 'sacred' to the Dwarves, and I cannot believe that they would have polluted it with water from the Mines.
- 2) Mirrormere must have been fed by water falling down the Dimrill Stair in a great torrent. The cold, clear water must have been meltwater from the snows higher up the mountain. However the rim of the mere is described as "unbroken", and the surface is perfectly still, so both the entrance and the exit must have been underwater (the mere would not have remained clear and pleasant for long if it had been stagnant). Thus the water which later found its way into the Silverlode may have come from the same source: certainly the description of the Silverlode as "icy cold" implies that it originated as meltwater rather than in the mines.
- 3) Most significantly, the reasons given for the drying up of the Sirannon cannot be correct. As anyone who has ever tried to dam a stream will be aware, however good the dam is, it is only a matter of time before the pool fills and the water begins to escape somewhere. Yet the pool at the West Gate of Moria appears to be stagnant, apart from a small trickle out of the falls, and a narrow, almost stagnant creek flowing in. The only way this could be the case would be if the supply of water to the Sirannon had stopped. This could be as a result of it being silted up after the dam formed, but this again would only result in a channel shift, which seems unlikely for what must have been an underground river. The only other possibility is that the supply ceased, and my conjecture is that it happened gradually as the mechanisms of the Dwarves fell into disrepair following the coming of the Balrog.

The Mechanism for Draining the Mines.

Thus far we have a situation where water is collected in the depths of the Mines and ejected via the Sirannon, but the most significant problem still remains: how did the water get to the West Gate? The problem of collecting the water would have been relatively simple for the Dwarves, who would have constructed a system of sloping troughs and trenches to remove it to collection points. But after they enter the Mines the company descends almost continuously

throughout the first leg of its journey and yet remains well above the deeps, and in relatively dry passages. When Pippin drops a stone down the well in the guard room "many heartbeats" pass before a sound is heard, implying that the water is some distance below. Thus there must have been some sort of pumping system to lift the water out of the deeps and into a channel which exited at the West Gate. How was this pumping system driven? Unfortunately, in the absence of perpetual motion, it is not possible to use the water itself to drive the pumps, so some other source of energy must have been available.

One possibility, though I admit it, an unlikely one, is that there was a massive water-wheel complex under the Dimrill Stair, which used the energy of the waterfall to lift the water into a channel cut right through the mountain to the West Gate. However, I do not think that the channel was this high in the mountain. When the company crossed the widest of the fissures they encountered in their first march (i.e. well to the West of the Mines), they heard "the noise of churning water... as if some great mill-wheel were turning in the depths". I do not think that this was in fact a mill-wheel -- more likely it was a bit of debris lodged in the channel, churning up the water -- but I do think that this may well have been a feeder taking water into one of the collecting pools. This means that the 'pumps' must have been towards the West end. So how was the water lifted to the level of the gate? The only reported power sources in Middle-earth are waterwheels, windmills and the (presumably steam) engines used by Saruman. However there are problems with all of these. There are no reports of waterfalls near the West Gate to provide water power -- in fact there were no streams at all except the Sirannon itself. Nor is there any mention of batteries of windmills on the flanks of Caradhras. This seems to mean that steam power is the only possibility, but the problem is here one of fuel. Dwarves had a strong dislike of mining coal, and anyway, the geological environment of the Mines makes the likelihood of coal occurring there very small. But neither is there any record of large forests ever having grown close to the West Gate, and even if there were, the amount of wood required would be fantastic.

There is, however, a solution to this problem, and once again it is the geology which comes to our rescue: geothermal power. We know that the misty mountains were a geologically active region (for example the fissures across the passage which the company has to cross imply that there had been considerable earthquake activity since the Dwarves left), and it is reported that after the company entered the Mines the air quickly became "hot and stifling", although this can occur in areas with rather low geological activity. Thus I propose that the Dwarves discovered an area near the West end of the Mines where the rocks were heated by geological activity below, and used this energy to drive steam engines (in the same way as electricity is generated in Iceland**); cold water is pumped down one hole, is heated by the hot rocks, and returns to the surface via a second hole as steam, which can be used to drive a turbine or steam engine), which would then be used to pump the water to the surface. This mechanism has the advantage that it could, in principle, keep running for some time after the Dwarves left until, in time, some part wore out and broke; thus the stoppage of the flow of the Sirannon could have happened long after the Dwarves left, which would help in explaining why it came as a surprise to Gandalf, who left by the West Door 800 years after the coming of the Balrog.

An Aside: Fresh Air and Water.

As an aside to this discussion, I consider the question of the provision of fresh water and air in Moria. When the company stops in the guardroom, Gimli identifies the hole in the floor as "a well for the guards' use", but the time taken for a stone to fall down indicates that it was of a depth which would make it impractical to collect water in a bucket. There may have been some kind of pump again, but I think it is more likely that there had formerly been a trough running across the well at some lesser depth, which indeed carried water. The trough would probably be wooden (and under constant repair), and would carry

running water, thus ensuring the best possible chance of clean water. This would have been part of a system of channels reasonably high up in the Mines which would have circulated drinking water around the main inhabited areas, probably from a source at the Eastern side to the same collecting point in the West as the waste from the depths. Coupled with this could have been a waste disposal system; toilets and waste disposal points could have fed into the main water disposal channel, and this may explain why the "well" continued to such great depths, as it may have doubled as a waste disposal point. There may also have been a ventilation system; the air inside the Mines was certainly fresher than one might expect of a set of caves stretching over forty miles from one entrance to another, and this might also have been driven by geothermal power, either by using fans to draw air through the Mines, or setting up temperature differences which would help to keep the air moving.

Conclusion.

The Mines of Khazad-dûm are described in The Silmarillion as "greatest of all the mansions of the Dwarves", and this is by no means an understatement. The technical achievements in providing water and fresh air for a community of several thousand Dwarves, and of removing water from the deeper mines, makes Moria one of the most 'advanced' places in Middle-earth, rivalling and, indeed, probably surpassing the works of Saruman or Sauron. Whether their machinery was indeed driven by geothermal power we can never be certain, but it seems to be a possible solution to an otherwise difficult problem.

Footnotes

- * As a corollary, Pr. Sarjeant also observes "A puzzling feature about this is what and where were the gangue minerals? One would have expected spectacularly colourful displays of barytes, flourspar or some other gangue: yet Tolkien, though so conscious of colour in rocks, says not a word about this."
- ** [The argument Mike Percival presents in favour of geothermal power as source of energy in Moria seems all the more persuasive in the light of the new HoMe volume: The Return of the Shadow, pp.454-5. Indeed, though the Mines are already in existence at the beginning of the writing of LotR and fissures duly noted, there is no mention of the "mill-wheel". However, I have been told that the '40s and '50s, during which LotR was still being rewritten, saw the first large-scale use of geothermal power, in Iceland, which among other claims for posterity is, of course, the place of origin of the Eddas, in which Tolkien found the Dwarves' names and many other revealing features of their character. It would be quite logical for Tolkien to incorporate the new data from Iceland into his depiction, however discrete, of Dwarvish technology and thus to add to his world's self-consistency. Ed.]



First of all I wish to thank those of you who wrote to me about last issue. I would be grateful if you would write to me about the present one and its contents. Feedback is of great importance to me. How would I learn otherwise, whether you liked or disliked such or such article, or whether it left you cold?

There has been somewhat of a dearth of letters this time, although those who did write sent longer letters than usual.

First of them is Jeff Stevenson who wrote 'A Delusion Unmasked' in Mallorn 24.

...The Stone of Erech' was very absorbing, drawing attention to one of the more obscure relics of Middle-earth. 'A Merry Fellow' also got me thinking, and I have submitted to Amon Hen a brief article on Tom Bombadil and related matters.

I would however be grateful for the opportunity to clarify what might appear to be a serious contradiction in my article 'A Delusion Unmasked'. Under the heading 'Frodo and Jesus' I questioned Kathleen Jones' assertion (in 'The Use and Misuse of Fantasy' Mallorn 23) that Tolkien punished his characters. Later however (under the heading 'Peaceful Endings') I suggested that Tolkien did punish some of his characters.

Tolkien was well aware that his Secondary World "may be fundamentally 'wrong' from the point of view of reality" and even that it "may be bad theology" (Letters, n^o 153). Tolkien had no real fear that any part of his Subcreation (as such) was a blasphemy and therefore he certainly would not punish any of his characters for this. This explains my first point. Tolkien seemed rather more concerned to maintain internal consistency within his Middle-earth. Therefore whenever any of his characters broke the fundamental Rules of Arda, that being would be punished. It was only a matter of how and when. This explains my second point.

Elsewhere in my essay I leapt to the defence of Ms. Yates. I do not however apologise for my "unscholarly" use of her Christian name alone (although I will try to remember not to use it in future). Mallorn is undoubtedly the more serious publication of the Tolkien Society, but surely, after an appropriate introduction, members can treat each other with friendly (but respectful) informality? Of course, certain members' names have appeared so frequently in the Society's publications over the years that one feels that, in a way, one has come to know them. And when they invariably proffer their Christian names, it seems that one is expected to use them.

With regard to your request in Mallorn 24 for opinion on the content of Mallorn, I can only agree with yours, except that I prefer to read Tolkien articles, poems, stories and artwork (whether by you or anyone else) in the publications of the Society. That is, I don't particularly wish to join half a dozen other societies even should they issue highly recommended journals such as Weather-top.

By the way, you mentioned in your Editorial in Mallorn 24 that 'Yes, Mr. Chairelf' was "illuminating of British Society". You can rest assured that Britain does not have a monopoly on bureaucracy; this is evidenced by the world-wide success of the television series 'Yes, (Prime) Minister'.

I, for one, welcome the occasional "threatening" article (such as the one by Kathleen Jones), "so that people will remember the Great Danger and so love their beloved [Middle-earth] all the more." (LotR III.6.1x)

I agree with Jeff Stevenson's opinion on smial magazines (though I am Editor of one), and it is for this reason that I make a plea to magazine editors to send me copies of their magazines, for some of the material they contain may be suitable for reprinting within the pages of Mallorn. If so, the reprint will mention the date of first publication and the magazine it was first published in. Remember that Society publications should always take priority over smial publications.

Another letter is from Jenny Coombs, another up-and-coming member who seems bound to go far. This is what she says:

I must say how much I enjoyed reading Mallorn 24 and the back issues I bought at Oxonmoot. It's beautifully produced, and although you apologised for the paucity of artwork, there were many superb pictures. I particularly liked Edward Holmes Eagle on p.30, and the Green Elf by 'M' on p.33, although I think (human) archers usually hold the bow vertically. And, of course, there was the lovely Lay of Eowyn. I agree that the justified typing makes the text look neat and professional.

"The Stone of Erech" presents some very interesting ideas; but I am not sure that the Stone of Erech was necessarily the Isil-stone. Jenny Curtis gives some thought-provoking evidence for its being a palantir, presumably disoriented so that it would be blank. Otherwise any passing traveller, being drawn to the Stone, would surely have noticed its powers. But this would mean that