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Forced Labour, Mines, and Space: Exploring the Control of Mining Communities

Hannah Friedman

Introduction

When discussing mining communities in the Classical world the conversation invariably turns to slavery. There are a number of reasons for this, not the least of which is the reliance on slave labour in extraction industries. However, mining operations and their workforces are more complex than often presented; there were varying degrees of slavery and different social classes (Burford 1972: 39). While there are some discussions of the free workforce at mines, their status and behaviour are not often critically examined by modern scholars. As a consequence of this, when examining mining communities evidence of slaves is expected and archaeological evidence is interpreted in light of this preconception. I would argue that our understanding of Roman mining communities needs to be expanded and that we are placing too much emphasis on the dichotomies between slave, convict and free labour. While we often assume the presence of the three, we do not discuss their interaction with the administration of the extraction industries. I propose that one way to explore the composition of mining communities is to study the spatial organisation of the landscape concentrating on the control of movement and use of surveillance. Combining ideas generated in American historical archaeology for the study of slave populations and theories about the control mechanisms of panoptic observation, new insights can be generated into the manner in which the administrations of mining communities interacted and controlled different segments of the population.

To explore these issues I will be using Faynan, a copper mining district operating from the second to the fifth centuries AD (Fig. 1). The Faynan is located on the eastern edge of the Wadi ‘Arabah in south-western Jordan, approximately 40km from the Israeli border, falling about halfway between the Dead Sea and the Red Sea. During the Roman and Byzantine period an estimated 40,000-70,000 tonnes of copper were produced (Hauptmann 2007: 147). To be this productive the mining administration had to manage and maintain the workforce. But, what workers could be expected in such a community?

Composition of the Workforce

The lowest social level is the one discussed by ancient historians such as Strabo and Diodorus; that is, chattel slavery in its worst form. These individuals took care of the laborious but unskilled tasks: directed digging, carrying ore and initial processing. Although these tasks were the majority of activities in mining, they needed supervision to be successfully accomplished (Thompson 2003: 131).

> ‘…slaves…wear out their bodies toiling night and day in the diggings under the ground, dying in large numbers because of the exceptional hardships they endure. For neither rest nor pause is granted from their labours but compelled beneath the

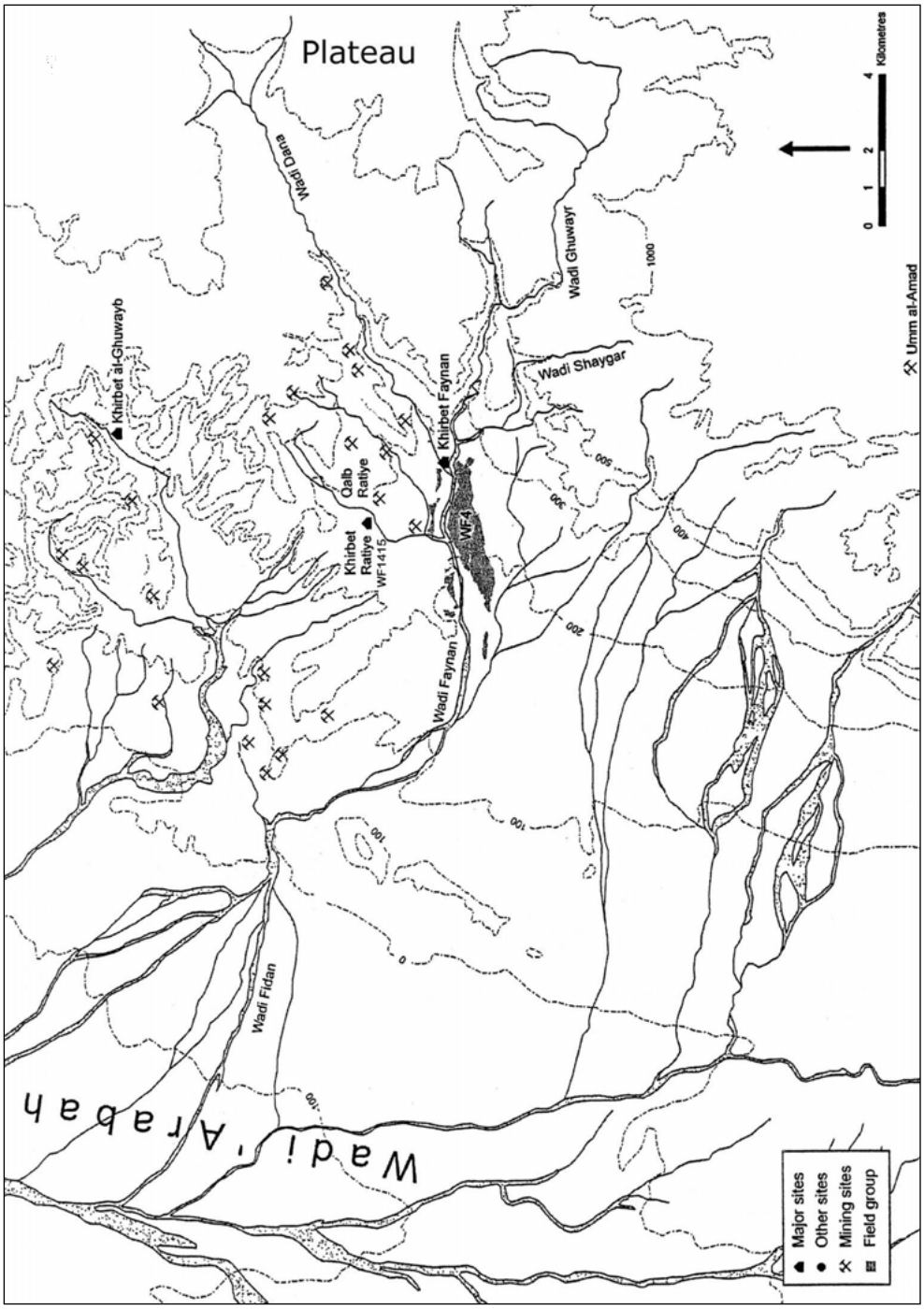

Figure 1: Faynan region and principal locations mentioned in text (after Barker et al. 2007, 5).

> blows of the overseers to endure the severity of their plight, lose their lives in this wretched manner…indeed such that to them death is far more desirable than life…' (Diodorus Siculus*, Historical Library* 5, 38)

While it is true that horrific treatment of slaves in mines was commonplace, they were only a portion of the population. The skills necessary to profitably work a mine, called mining engineering, are acquired and described as "…the art and science applied to the processes of mining and the operation of mines" (Hartman 1987: 2). In mines multiple factors must be regulated for successful industry to take place. Climate has to be taken into account, water drainage, air quality, and rock stability (Hartman 1987: 149, 182). Moreover, "Each operation is uniquely determined by the physical, geologic, environmental, economic and legal circumstances" (Hartman 1987: 3). All of these variables make running each extraction a unique, difficult task, one which unskilled slave labour was not able to perform. But who were these skilled individuals and how were they treated; what evidence exists to describe them?

Another category of worker in the mining community was free labourers, perhaps not the majority of workers, but definitely present. Procurators, officials, soldiers, engineers, suppliers, and skilled workers were a necessity to successfully work a mine. Even an illiterate labourer who possessed mining skills could earn comparatively high wages, such as the Dacian miner who earned 70 *denarii* for 6 months' work (Cuvigny 1996: 142). Such free individuals would collectively create all aspects of an ordinary community. One of the greatest sources of information on this subject is the Vipasca tablets. These bronze plates found at Vipasca (Aljustreal), a Roman mining district in Portugal, document that every profession from fullers, to barbers, shoemakers and school teachers was present and regulated (Cummings *et al.* 1956: 339). The town even had baths with separate hours for men, women and children.

The Vipasca tablets also detail the times the baths were open for slaves. This brings up the point that there would be gradations of slavery present, as so often found in the Roman world (Phillips 1985: 7). Skilled slaves were not a disposable labour force in the way chattel slaves were. They were more prized and were able to enjoy social institutions such as baths. Good examples of such slaves are mine bosses, who could be sold for considerable sums of money (Shepard 1993: 62). Household slaves would also be present in these communities. It is likely that families were present in many of these communities and they would have retinues (Jones 1956: 185). The Vipasca tablets record that women, children and schoolteachers were present in the community. The procurator's domestic slaves were included in this category. While not used directly in the extraction industry, they were still owned human beings and part of this greater mining community.

At the opposite end of the spectrum from chattel slaves were members of the *familia Ceasaris*, freedmen and slaves who belonged to the Emperor's household. Especially in the early empire they were the bureaucratic backbone in charge of a number of duties in mines this was often finances, record keeping or logistics. These were positions of considerable power (Weaver 1972: 2, 7). There were many degrees of slavery in this class. Such slaves could be in charge of sub-clerical positions or entire mining districts. They were members of the administration that directed the industry and production. They were upper class and in a sense they were alien to the slaves in the mines who were worked to death. However they were equally removed from the free worker population. There is an administrative building in the Faynan mining district; due to its fortified walls, it has been most often described as a fort and this has led to

the suggestion that the administration was made up mostly of military personnel (Kind *et al.* 2005: 191). However this building does not have a regular fort typology. An argument could be made that it is the administrative headquarters of the copper industry, run mostly by members of the *familia Ceasaris*. Inside the building are irregular sized rooms that could have functioned as offices for these different administrative officials.

Finally, unrelated to slavery is the legal category of convicts condemned to the mines (*damnatio ad metalla*.) Condemnation to the mines was a special, reserved form of punishment in Roman society. Some aspects of it changed throughout the imperial period but it never lost its legal ramifications or was considered anything less than a severe sentence. The danger of mining was such that being sentenced to the mines was considered a form of capital punishment (Millar 1985: 138). Persons of all social ranks including slaves could receive this punishment; it was therefore a status below that of slavery (Millar 1985: 138). These individuals were similar to the lowest form of slaves, except that they belonged to the state and were not able to be sold. The Faynan has particularly good evidence for this segment of the community. Eusebius, an early church father in the fourth century, chronicled the sentencing of Christians to the Faynan mines specifically (MP 7.2; 8.1; 8.13). These men, women and children, originating from Gaza, Caesarea and Egypt were made example of to prevent the spread of Christianity. Textual evidence then indicates the Faynan workforce was not composed solely of slaves.

If all of these social classes were present, then what evidence exists for them in the archaeological record? The study of convicts or slaves has been described as a stagnant issue in Roman archaeology (Webster 2005: 162). Often it is claimed that they are poorly represented in the archaeological record, thus they are 'invisible.' Differences in material culture and architecture are often used to differentiate between populations. However, many common objects are used by all segments of a population regardless of status. It is the manner in which these things are used that is different. These subtle variations are often difficult to detect. I would argue that another way to approach this topic is by studying the landscape. Patterns of spatial organisation can indicate the presence of populations that may have no unique material culture; there is evidence for mining populations, including slaves, in the landscape.

Evidence for Control Mechanisms

As the evidence from Faynan for the Roman and Byzantine periods consists mostly of survey data, the technique of closely examining material culture cannot be employed. However, another approach to this topic, that of space and landscape, has been put forward in American historical archaeology looking at slave populations (e.g. Whitley 2002). Although these theories were formed from 17th and 18th century archaeology, they can serve as a starting point for discussions about class-based control mechanisms. Similar issues are addressed when discussing slave populations regardless of the exact location or periods. Delle (1998), when studying Jamaican coffee plantations, identified a means of control she titled the 'spatiality of movement'. Restriction of movement was used by plantation owners to control slaves; from the absolute of physical restraints to the less intrusive 'permission to travel' (Delle 1998: 157).

Some of these mechanisms of control are documented in the textual evidence for the Faynan. Eusebius describes the physical maiming of the condemned Christians, "These had first their right eyes and the sinews of their left feet destroyed by branding irons and the sword, and afterward they were given over to the mines to dig copper" (MP 13.1). By limiting sight and destroying

the Achilles tendons, the convicts were rendered permanently lame, restricting their movement. However, no archaeological evidence has yet been found in the Faynan to substantiate Eusebius' claim. For example, none of the commonly sought indicators of slavery, shackles or skeletons showing distinctive physical trauma have been found (for skeletons see Findlater *et al*. 1998: 82). Nor were there identifiable prison buildings, *ergastula*, such as may have been present in the imperial quarries of Simitthus in Africa proconsularis (Mackensen 2005: 119).

Despite this lack of physical manifestations of abuse, there is evidence for the less intrusive concept of the 'spatiality of movement.' This theory may be applied to the areas of the landscape where convicts were likely to be found, the mines. The physical remains of the mines, especially the shape of the entrances, may indicate the status of the labourer (Davis 1979: 16).

Restrictive mine entrances, either small in size or vertical shafts, were common across the Roman Empire, such as those at Milyes on Kythnos (Davis 1979: 14). This limited space meant that once within the shaft, movement could be controlled and openings could be blocked by a single guard. This has often led scholars to suggest that these mines were worked by individuals the administration wanted to spatially control convicts and slaves. It is unclear whether individuals were allowed to leave the mines often or at all, since this exit shape does not allow for easy passage (Grattan *et al.* 2004: 111). In Dacian mines skeletons were found as well as living spaces, suggesting that miners lived and died within the mines (Davis 1979: 16). The evidence for 'spatiality of movement' is confinement backed by the threat of physical violence. There are examples of this in the Faynan (Fig. 1). The Qalb Ratiye had the densest concentration of mines worked during the Roman and Byzantine period. Here there are mines that have to be entered by crawling (Hauptmann 2007: 114). If a slave or convict did try to escape, the guard at the entrance would be able to block him. The mine itself functioned as a prison.

Some of the mine entrances in the Qalb Ratiye were enlarged; in one case steps were formed to grant easier access (Hauptmann 2007: 114). Such entrances may have been provided for individuals who had some say in their working conditions. This type of entrance suggested frequent movement in and out of the mine. There are examples of this elsewhere in the empire where free workers may have been present, such as some mines in England (Davis 1979: 16). In terms of technical ability it would be possible to create a larger entrance; the amount of effort invested was greater, but the benefits would be ease in moving ore and greater air circulation. Clearly smaller, confining entrances were a deliberate choice.

The Wadi Ratiye has other lines of evidence for free workers; there are a group of small settlements and hamlets that were likely miners' accommodation (Barker and Mattingly 2007: 112). A coin was found at one of the hamlets and the nearby agricultural terracing suggests personal property and time spent away from the mines. This worker housing is structurally similar to the settlements on the road to the Umm al-Amad mines of the Faynan, also proposed to be the housing of free workers. The buildings have ashlar quality door lintels and multiple grinding stones. This suggests separate private houses that received grain supplies. One of the houses had pieces of marble suggesting high status decoration, perhaps the house of an official or engineer (Barker *et al.* 2007: 325).

However most of the mine entrances in the Faynan have the characteristic Roman small openings, even those in the Qalb Ratiye. Given that some of these mines very likely contained free workers, these findings would not fit into a clear pattern of free vs. restrained movement. It has been suggested that this is due to the long history of the Faynan as a copper mining district. Mines in Faynan were worked since the Chalcolithic and may have retained their original

diminutive entrances rather than the Romans expending extra effort to enlarge them when the mines were reopened (Hauptmann 2007: 114). I would argue that choosing not to enlarge entrances was a purposeful choice by the administration and its engineers. A good example to illustrate this point is Umm al-Amad that can only be entered by crawling for 10m (Fig. 6.8). After this restricted opening, the space opens up into a large gallery 4,000m³ in size with an average ceiling height of 1.7m (Meshel 2006: 231). This mine more than any other shows the great technical expertise and effort that could be expended on the creation of mines, yet entrances were purposefully kept small. The difficulty in exiting the mine is so great that it suggests that individuals rarely if ever left.

The small shaped mine entrances in the Faynan are in the majority and could be interpreted to suggest that the most of mines were worked by convicts and slaves. However, given the prevalence of such restrictive mine entrances across the empire, and the use of them in the Faynan even in areas where there is evidence for at least some free workers, implies that their creation may not have been only to control slaves.

It is often assumed that the administration would control 'spatiality of movement' to prevent slave or convict revolts. Yet free workers, although they were paid, would still have been exposed to dangerous and brutal conditions. Mining as a profession has always been subject to poor labour relations. Strikes, organised refusals to work, did occur in pre-industrial societies (Knapp 1998: 9). The free workers would have greatly outnumbered the administrative and technical staff and if they rebelled, the situation would have been difficult to resolve and copper production would certainly have suffered. Thus even the free workers may also have been seen as a threat to the administration. Yet, unlike slaves and convicts, they had rights and their 'spatiality of movement' could not be restrained through physical violence and prisons. We must look for evidence for less intrusive means of control, that of surveillance and panoptic control.

Panoptic Surveillance

Of particular relevance to the situation of supervision by observation is the notion of panoptic surveillance. Although this theory was developed by Foucault (1991) in specific reference to modern society, the underlying concepts can serve as a useful framework in considering the Faynan landscape. The central concept in this theory is that human behaviour can be modified by visibility (Foucault 1991: 187). That is, the sight or "gaze" of a figure of authority can influence people's behaviour, act as a strong deterrent to misbehaviour and lead to greater self-discipline. A few individuals, if placed at key points, can monitor and control the actions of many through the power of the gaze. Architecture is an essential element in this concept, both in providing the viewing area as well as in emphasizing the unequal power relationship that might exist between the viewer and viewed (Foucault 1991: 201). The structures themselves become a mechanism of power, further acting to control behaviour. Another central concept is that the viewers (in this case the authorities) are hidden and, although they can view everything, they are not reciprocally visible to the viewed (i.e., the workers) (Foucault 1991: 200). In fact, the hidden observer behind a 'blind' was considered to be a more powerful agent of control because the prisoners experienced uncertainty of privacy. Knowledge of the unequal power relationship and the idea of being viewed become so strongly entrenched that surveillance of separate individuals does not have to be constant, yet it remains effective. This creates a situation where fear of being viewed and subsequent good behaviour is continuous (Foucault 1991: 201).

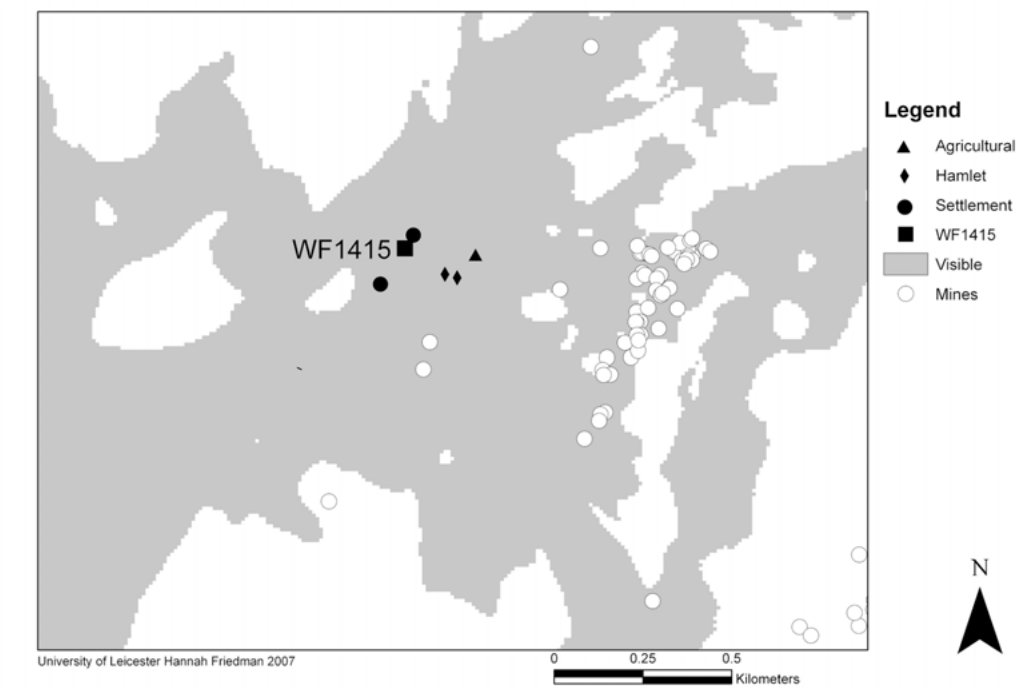

Figure 2: Viewshed generated from the towers of WF1415. Areas in gray are within sight, this encompasses the settlements and most of the mines.

Essential to this discussion is Foucault's application of this theory to industry. "Surveillance thus becomes a decisive economic operator both as an internal part of the production machinery and the specific mechanism in the disciplinary power" (Foucault 1991: 175). A key point is that the power exercised through surveillance can be used not only for the exercise of discipline but for economic means. This appears to be the situation involving observation in the Wadi Ratiye (Fig. 1).

Returning to Wadi Ratiye, we have the miners' community and the Khirbet, a fortified structure with large stonewalls (WF1415). Now, this building has been described as a movie set, solid and imposing on one side and a back lot movie set on the other. Despite the obvious fortifications on this site, defence does not appear to have been the main concern. The eastern wall had two towers, yet it was the west side of the wall that was vulnerable and unguarded. The towers however did face a blind valley, Qalb Ratiye, and could monitor the copper mines located there (Barker *et al*. 2007: 319).

In exploring the topic of surveillance and what visual coverage the towers of WF1415 may have had, a GIS was employed. Esri's ArcMap 9.1 provided the tools necessary to study the exercise of the State's administrative control (on use of viewsheds see Wheatley and Gillings 2000; 2001). Viewshed analysis was used for this research, if a representative height of 10m for the towers is used, then the viewshed generated encompasses a large portion of the landscape and the surrounding workers' settlements. But of most importance is the ability to view most of the mines from WF1415 (Fig. 2).

A more complex visual model can be created through what has been termed a Cumulative Viewshed analysis (CVA) (Wheatley 1995: 173). Cells of the raster map, in this case the DEM, record the total number of other viewpoints from which it is visible (i.e., how many times it is seen). This process can identify the areas of the landscape that are the most visible (i.e., these are included or overlapped by the most viewsheds from the site locations), or the areas that provide the best field of view of the selected point (Llobera 2003: 33). A Cumulative Viewshed Analysis created using the mines of the Qalb Ratiye as observation points indicates that WF1415 was in a place of high visibility, one that could be seen often (Fig. 3). The mines of the valley were visible from the towers; equally the towers were visible from many of the mines. The conditions of a panoptic system, that individuals are under surveillance and know that they are being watched, were fulfilled.

Foucault argued that architecture is an active part of any surveillance system and that the structures themselves encourage discipline. The scale of construction emphasises power disparity between the administration and workers, and psychologically this serves to further inhibit delinquent behaviour. The towers and walls of WF1415 certainly conform to this aspect of the theory, as they were designed to be seen. WF1415 is impressive and imposing from one point of view, yet in terms of defence it is insubstantial. The walls were large and conveyed messages of power from both near and far, which added to the effectiveness of the panoptic control. The view of the towers would make the workers' awareness that they were under surveillance an ever present reality and remind the workers of the power the administration held over them.

Another component of the surveillance is that, while the towers were constructed at a large-scale, capable of being seen from a distance, individuals on them would not be as visible. The Faynan often experiences bright sun and the glare would make picking out an individual difficult, especially if the towers had shades constructed over them. At certain times of day, one would at best be able to make out a silhouette. Workers would therefore be unable to tell if they were being viewed or not. This would act as the 'blind' discussed by Foucault, encouraging good behaviour through uncertainty (Foucault 1991: 201). A worker would know there was a possibility of someone watching and behave accordingly.

The view from the towers is not all encompassing, there were parts of the valley that would have been invisible. The inability to view a particular segment of the valley from WF1415 does not mean that panoptic surveillance was not applicable. No worker was ever likely to climb the towers and discover just what their observational capabilities were; in other words they would not know if an area were visible or not. The scale of the towers combined with the uncertainty of privacy would encourage discipline. Most importantly the entrances and exits to the Wadi Ratiye and the Qalb were visible from WF1415.

There are also exceptions to the reciprocal view from the Qalb; as an individual moves through the landscape, even small changes in topography can block line of sight or reveal features (Tilley 1994: 77). There were areas where the towers were not visible. For example mine WF1465 can be seen from the towers, but WF1415 cannot be seen from the mine.

However, a panoptic system would have encompassed the majority of the valley, including the likely miners' settlements that can see WF1415 (Fig. 2). Although workers at mines like WF1461 would not see an architectural representation of the administration when they looked west, the psychological message of control would still be repeated when individuals travelled to and from the housing. Even if there were a rebellion at a mine out of direct sight of WF1415, the workers or convicts would have known they had to exit Wadi Ratiye in full view of WF1415.

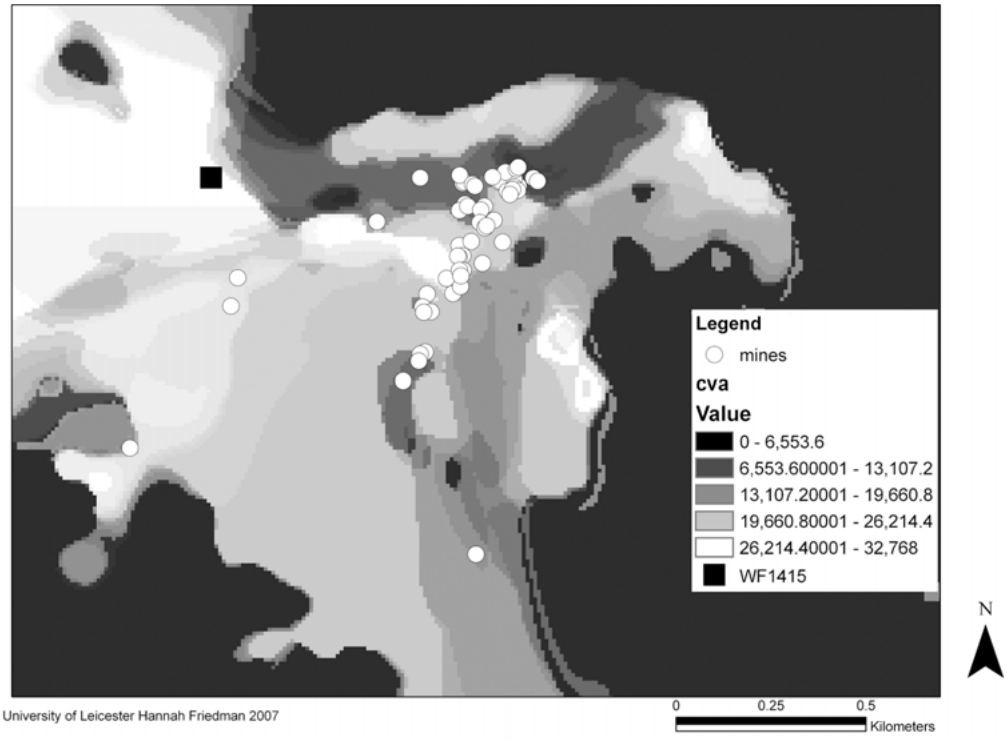

Figure 3: Cumulative Viewshed from the mines of the Qalb Ratiye, areas in white are most visible.

These towers may also have had other practical aspects in addition to their surveillance role; for example, signals from the mines would be visible. Within the mines, supervisors would be in charge of controlling the workers and convicts through physical violence if necessary. Only a few supervisors would have been sufficient; many of these mines had the small openings that prevented free movement. A small group could block these entrances, trapping workers in the mines. If a disturbance did occur, staff at the surface of the mines could signal for help.

What can be clearly shown by this visual model is that the majority of the Qalb Ratiye was under surveillance. Moving across the landscape, individuals would be visible heading to and away from the mines. Certain areas would always be invisible, but to get to those areas, travel through visually monitored zones was necessary. If most of the local areas were visible from the towers most of the time, this visibility would have been sufficient to create and confer the social or political message of observation structures. The panoptic system, if working properly, is a psychological form of control; as long as the idea of surveillance is present, the actual physical reality is of lesser importance.

Building on Foucault's proposals, it can be argued that the administration used surveillance for economic reasons, as a control mechanism to encourage hard work and honesty in managing the ore. The reciprocal view creates a panoptic system which could have been employed to encourage discipline, preventing convict uprisings or worker disputes.

Conclusion

The population of the Faynan was almost certainly varied. Convicts are attested to in Eusebius' texts: this segment of the community, and perhaps slaves as well, are archaeologically visible in the creation of confined spaces. The mines themselves were used to control the 'spatiality of movement' of individuals, rather than building prisons. Backed up with physical violence, these spaces would have functioned as an effective method of control. Another form of spatial control is seen in the surveillance systems overseeing the mines. The landscape was changed for the benefit of the administration with the deliberate placing of structures to facilitate view in industrial areas. These functioned as a less intrusive manner to control the workers using physiological restraints. Management of convicts and free workers would have been of paramount importance and a means by which the administration successfully produced copper.

What this study indicates is that the argument that mining communities were simple to define is not the case. There were multiple types of slavery and free workers were present. The presence of surveillance structures near what are likely free settlements suggests that chattel slaves or convicts were not the only individuals mistrusted by the administration. Anyone without power and who could be a threat to copper production was suspect and that included free workers.

School of Archaeology and Ancient History, University of Leicester

Bibliography

Ancient Sources

Diodorus Siculus (Translation C. Oldfather, 1935) *Library of History, Volume II, Books 2.35-4.58.* Cambridge, Mass.: Harvard University Press.

Eusebius (Translation H. Lawlor and J. Oulton, 1927) *The Ecclesiastical History and the Martyrs of Palestine, Volume 1*. London: Society for Promotion of Christian Knowledge, 1927.

Eusebius (Translation H. Lawlor and J. Oulton, 1928) *The Ecclesiastical History and the Martyrs of Palestine, Volume 2*. London: Society for Promotion of Christian Knowledge.

Lex Metalli Vipascensis. In H. Dessau (ed.) *Inscriptiones Latinae Selectae*, *Volume 2* (1). Berlin: Weidmann, 1902.

Modern Sources

Barker, G., Gilberson, D. and Mattingly, D. 2007. *Archaeology and Desertification; the Wadi Faynan Landscape Survey*. Oxford: Oxbow Books.

Burford, A. 1972. *Craftsmen in Greek and Roman Society*. London: Thames and Hudson.

Cummings, A., Chalmers, W. and Mattingly, H. 1956. A Roman mining document. *Mine and Quarry Engineering*: 339–342.

Cuvigny, H. 1996. The amount of wages paid to quarry-workers at Mons Claudianus. *Journal of Roman Studies* 86: 139–145.

Davis, O. 1979. *Roman Mines in Europe*. New York: Arno Press.

Delle, J. 1998. *An Archaeology of Social Space: Analyzing Coffee Plantations in Jamaica's Blue Mountains*. New York: Plenum Press.

Findlater, G., El-Najjar, M., al-Shiyab, A.-H., O'Hea, M. and Easthaugh, E. 1998. The Wadi Faynan Project: the south cemetery excavation, Jordan 1996: a preliminary report. *Levant* 30: 69–83.

Foucault, M. 1991. *Discipline and Punish the Birth of the Prison* (A. Sheridan, Trans.). London: Penguin.

Grattan, J., Gillmore, G., Gilbertson, D., Pyatt, F., Hunt, C., McLaren, S., Phillips, P. and Denman, A. 2004. Radon and 'King Solomon's Miners:' Faynan Orefield, Jordanian Desert. *The Science of the Total Environment* 319: 99–114.

Hartman, H. 1987. *Introduction to Mining Engineering*. New York: John Wiley and Sons.

Hauptmann, A. 2007. *The Archaeometallurgy of Copper, Evidence from Faynan, Jordan*. Heidelberg: Springer.

Kind, H., Gilles, K. Hauptmann, A. and Weisgerber, G. 2005. Coins from Faynan, Jordan. *Levant* 37: 169–195.

Knapp, B. 1998. Social approaches to the archaeology and anthropology of mining. In B. Knapp, V. Pigott and E. Herbert (Eds.) *Social Approaches to an Industrial Past: the Archaeology and Anthropology of Mining*. London: Routledge: 1–23.

Philips, W. 1985. *Slavery from Roman Times to the Early Transatlantic Trade*. Minneapolis: University of Minnesota Press.

Llobera, M. 2003. Extending GIS-based visual analysis: the concept of visualscapes. *International Journal of Geographical Information Science*, 17.1: 25–48.

Mackensen, M. 2005. *Simitthus Band III: Militärlager oder Marmorwerkstätten*. Mainz am Rhein: Verlag Philip Von Zabern.

Meshel, Z. 2006. Were There Gold Mines in the Eastern Arabah? In P. Bienkowski and K. Galor (eds.) *Crossing the Rift: Resources, Routes, Settlement Patterns and Interaction in the Wadi Arabah*. Oxford: Oxbow Books: 231–238.

Millar, F. 1985. Condemnation to hard labour in the Roman Empire, from the Julio-Claudians to Constantine. *Papers of the British School at Rome* 52: 124–147.

Thompson, F. 2003. *The Archaeology of Greek and Roman Slavery*. London: Duckworth.

Shepherd, R. 1993. *Ancient Mining.* London and New York: Elsevier.

Weaver, P. 1972. *Familia Caesaris: a Social Study of the Emperor's Freedmen and Slaves*. Cambridge: Cambridge University Press.

Weber, J. 2005. Archaeologies of slavery and servitude: Bringing 'New World' Perspective to Roman Britain. *Journal of Roman Archaeology* 18: 161–179.

Wheatly, D. 1995. Cumulative viewshead analysis: a GIS-based method for investigating intervisibility, and its archaeological application. In G. Lock and Z. Stančič (eds.) *Archaeology and Geographic Information Systems: a European Perspective*. London: Taylor and Francis: 171–186.

Wheatley, D. and Gillings, M. 2000. Visual perception and GIS: developing enriched approaches to the study of archaeological visibility. In G.R. Lock (ed.) *Beyond the map: Archaeology and Spatial Technologies*. Amsterdam: IOS Press.

Wheatley, D. and Gillings, M. 2001. Seeing is not believing: unresolved issues in archaeological visibility analysis. In B. Slapšak (ed.) *On the good use of geographic information systems in archaeological landscape studies*. Workshop on COST Action G2, Ancient Landscapes and Rural Structures. Luxemburg: European Communities: 25–36.

Whitley, T. (2002) 'Landscapes of Bondage: Using GIS to Understand Risk Management and Cognitive Spatial Dynamics in a Slave Society', paper presented to Computer Applications in Archaeology 2002 Conference, Heraklion, Crete, Greece, April. 2–6. available online http://www.brockington.org/research/papers/CAA2002-Whitley2.pdf (accessed November 2008).