An Early Islamic Gold-Mining Industry in Wadi Tawahin in the Southern ʿArabah?

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In a recent paper, Zohar Amar 'presents evidence of a hitherto unknown gold-mining region in the tenth century C.E. — the ʿArabah Valley — and discusses ... its historical significance'.[1] Reviewing some early Islamic sources referring to gold mining in Midian (north-west Arabia), the Eastern Desert of Egypt, Nubia and Syria — none of which actually mention the ʿArabah as a source of gold, Amar bases his conclusions about the significance of the gold mine of Wadi Tawahin on a paper by Gilat *et al.*,[2] who claim to have identified a gold ore dressing location, dating from the Early Islamic period, in Wadi Tawahin in the Southern ʿArabah, some 5 km. north-west of Eilat. This is an extremely questionable claim which deserves significantly more professional considerations.

1. Wadi Tawahin has for some time been known as a site where a number of ancient millstones has been preserved.[3] The innovation in Gilat *et al.*'s paper is the suggestion that these millstones, as well as several structural remains, are evidence of the treatment of gold ores which were locally mined.

According to Gilat *et al.*, there is a gold geochemical anomaly in the Naḥal Roded area. Wadi Tawahin is a tributary of Naḥal Roded and could potentially be a source of such an anomaly. Regrettably, no detail of the location of the gold anomaly is given to enable a clearer consideration of the likelihood of this contention. The techniques for following streambed geochemical anomalies back to source are fairly well developed. If this professional work had been carried out, it is likely to have been so stated in the paper; thus, we conclude that the work was apparently not done. This is regrettable, considering the importance of the suggestion that this was a gold-mining area.

Only one quartz body of any size '(~ 15 m^2)' appears to have been identified in the area by Gilat *et al.* This was in Wadi Tawahin, downstream from the site of the

1 Z. Amar: Gold Production in the ʿArabah Valley in the Tenth Century, *IEJ* 47 (1997), pp. 100–103, quote on p. 100.

2 A. Gilat, M. Shirav, R. Bogosh, L. Halicz, U. Avner and D. Nahlieli: Significance of Gold Exploitation in the Early Islamic Period, Israel, *Journal of Archaeological Science* 20 (1993), pp. 429–437.

3 E. Frank: Aus der Arabah, *ZDPV* 57 (1934), pp. 191–280; B. Rothenberg: *Negev, Archaeology in the Negev and the Arabah*, Tel Aviv, 1967, p. 154 (Hebrew).

millstones. It is quoted as containing 'up to 9 ppm gold'. If 9 ppm is the highest value recorded, the average grade must be considerably less and at best could be of the order of 4 or 5 ppm. Other small quartz veins are mentioned as being present, albeit of a very small size '(up to 2×0.6 m.)' and 'most of the latter are barren...'. This description would lead the professional reader to assume that these 'lenses' dip steeply into the ground. Any mining which took place then could only have been pit mines on these very small quartz bodies. Since their extension in depth is not given — probably because it is not known — the depth of these pits can only be estimated. As one of the presently known bodies is 15 sq.m. (perhaps 10×1.5 m.) and since some of the others are at least 2 m. long, it would seem realistic to expect them to extend in depth up to similar distances. It should thus be possible, if any mining had been done, to find at least a few pit mines of between 2 m. and 10 m. deep. None has been identified by Gilat *et al.*, nor by any of the other investigators who have reported on the area.

2. The gold in the quartz is stated to be 'non-visible', and most of the quartz veins surveyed by Gilat *et al.* were barren, only one with any value being mentioned. This would have meant that the ancients could only have discovered the gold by random trial grinding and treating of the quartz veins. In this connection, it is interesting to read some paragraphs from Richard Burton's chapter 9: 'How the gold was found in Midian: The gold mines of Arabia':[4]

> 'It so happened that during the cold season of 1849, as Haji Wali, an item in the Cairo caravan, was returning from his second pilgrimage, he was led by the will of Allah to hit upon the gold ... Seeing the torrent-bed sparkle — he scooped up a double handful of the sand, probably the granite gravel which strews these fiumaras, tied it in his kerchief, stowed it away in his Sahhrah, pilgrim's chest, and rejoining his companions, went his way in the name of Allah to el-Akabah. ... Haji Wali .... showed his *trouvaille* to a Shishnji (assayer), one Zayni Effendi. The latter pounded the sand in a mortar, mixed it with water, and, by means of quicksilver, produced in his presence a bit of gold about half the size of a grain of wheat ...'.

From Burton's further fascinating reports it is evident that the gold of Arabia was found as quite visible grains of gold. In most of the ancient gold mines known to us, the gold that was mined was visible gold, and when there is visible gold the grades would normally be an order of magnitude higher than the 9 or less gm. per ton indicated here. Incidentally, in our very extensive literary and site studies relating to gold exploration, we have not come up with any indication of the existence, in

4 R.F. Burton: *The Gold Mines of Midian and the Ruined Midianite Cities*, London, 1878, pp. 243–244.

those early days, of any survey method other than trial working, which would make it possible to identify invisible gold particles in solid rock formations. In our opinion, there would be signs of any such trials in the barren quartz veins that still remain.

Admittedly, Gilat *et al.* do suggest that 'Other similar bodies could have been mined-out (*sic*), leaving little or no trace of the operations after 1000 years of weathering and erosion'.[5] Since no evidence was found, the suggestion would be that remains of any ancient trial mining had also weathered away. The ore is indicated to have occurred in quartz veins, and these are very hard, competent rocks. Such veins would not have weathered away in a mere 1,000 years. The evidence should still be there. The failure to find evidence of ancient mines anywhere in the area is more likely to mean that there were no such mines, rather than to assume the unlikely scenario that they had all weathered away.

3. Gilat *et al.* identify on the side of the *wadi* a 'storage pit' cut into an ancient terrace of alluvial sediment.[6] It is rather unfortunate that the authors present the archaeological data not as found *in situ*, but as 'reconstructions'. Straightforward representation of the actual finds would have been especially useful in relation to this proposed 'bell-shaped storage pit'. From the point of view of geomorphology, this 'pit' is obviously not of the same stratigraphy as the 'main building' of the site. Whilst the latter is located, not on top of the ancient terrace, but at the very edge of the slope of a steep hill,[7] practically at the present level of the *wadi* bed, the reconstructed 'pit' is shown to have been cut into an ancient terrace, several metres above the present *wadi* bed.[8] The authors' reconstruction shows a bell-shaped pit, 2 m. high and with a diameter of 1.55 m. at the bottom. However, as shown in their Fig. 4, almost nothing of this 'pit' was actually found, since it was totally eroded. Only two flat niches in the conglomerate, separated by a 'rock ridge', were excavated by Gilat *et al.* and interpreted as the bottom of a storage pit. Why should there be such a ridge inside a bell-shaped storage pit? Our recent inspection of the site showed this 'ridge' to be merely a larger piece of rock in the conglomerate, with no 'gold ore' underneath it.

Gilat *et al.* suggest that this installation was cut high up into the surface of the ancient terrace, which was subsequently heavily eroded by floods, thereby destroying the 'bell-shaped pit' and forming the present *wadi* bed — where the evidently much more recent, quite well preserved 'main building' (A) is still standing.[9]

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5 Gilat *et al.* (above, n. 2), p. 436.
6 *Ibid.*, p. 432, Fig. 4.
7 *Ibid.*, Fig. 3; and, esp., Rothenberg (above, n. 3), Fig. 216.
8 Gilat *et al.* (above, n. 2), Fig. 4.
9 *Ibid.*, Figs. 2 and 3.

In light of the above, it does not seem credible that after approximately 1,000 years of aggressive erosional processes, which evidently caused great changes in the morphology of the area and almost totally destroyed the proposed 'storage pit', a very fresh looking, very thin and continuous layer of 'very fine-grained, powdery, light-grey material' was still found undisturbed — and showing up clearly in the photograph[10] — in the remains of the bottom of the 'pit'. It should be noted, in this context, that the Tawahin site was recently completely restored by U. Avner, the archaeologist of the Gilat group, as a tourist attraction. Much of the same fresh-looking light-grey powder is now visible around the millstones in the main building A, as well as at the bottom of several installations now located next to this building. The latter installations are not mentioned in the paper by Gilat *et al.*, and were also not recorded by any of the previous investigators of the site.

4. Furthermore, assuming that the 'storage pit' is a genuine archaeological find and of the same Early Islamic date as the main building, there remain a number of simple functional questions, which cast much doubt on the interpretation of Gilat *et al.*: the location of the pit high up on the cliff-like wall of the *wadi*, without a proper platform on which to work and to pile up masses of material; its bell shape, which may have been useful for the storage of water, but would have been very troublesome for the retrieval of such fine material; its relatively small size, considering the fact that a gold mine of such great significance for the economy of the region in the Early Islamic period, as outlined by Gilat *et al.* and Amar, must have dealt with tens of thousands of tons of rock (see below). Considering the likely scale of work, given the low grade of the ore, it is rather difficult to visualise the rationale for such a single and small ore storage pit at such a peculiar location. Incidentally, during our numerous and extensive surveys of mining areas in the ʿArabah, Sinai, Europe, the Middle East, the Americas and the Far East, we have never come across a bell-shaped pit for the storage of ores. For obvious practical reasons, the storage pits found were always cylindrical or square and wide open at the top, in addition to being mostly of enormous size, both in diameter and depth.

5. The recovery method quoted in the Gilat *et al.* paper as being used — and as described in the Agatharchides,[11] where the gold is processed by 'running water on a slanting table ... the rocky material washes away while the gold dust, being heavier, remains on the table' — would have been massively inefficient. Even in a modern operation, using gravity recovery methods similar to those available to the ancient peoples (but significantly more efficient), the gold recovered would be substantially less than 100% of that contained in the ore, with the major portion of the losses being of the very fine grains of gold! In addition, the lower the head

10 Gilat *et al.* (above, n. 2), Fig. 4.

11 F.D. Adams: *The Birth and Development of the Geological Sciences*, Dover, 1954.

grade, the lower the percentage recovered. The percentage of gold recovered by even the most modern gravity methods — methods definitely not available to the ancients — seldom exceeds 90% and is often as low as 55–80%. In mines running today in less developed parts of the world, which may be assumed to be using methods closely resembling those used by the ancients, the recoveries under such conditions are usually much worse, in the range of 35–65% of the gold.

Furthermore, the finer the size of the gold particles, the more difficult it is to recover them by gravity methods and the worse the recovery percentage is likely to be. The difficulty of recovering very fine gold is aggravated by the fact that the particles are likely to be not only very fine, but also platy in shape, particularly after having been ground in a mill of the type found in Wadi Tawahin. Very fine gold particles and platy gold particles both tend to wash over sluices of the types used by the ancients. In fact, the *tailings* of such gravity plants, when starting with high grade ore, often range in the order of 5 to 10 ppm.

Certainly, fine gold would be recovered, as the use of the words 'fine meal' and 'gold dust' in Agatharchides suggests. However, if the gold particles were '< 10 mm.' in size, then the recovery percentage is much more likely to have been at the lower, rather than the upper, end of the range — closer to the 35% figure. The same is true of the riffled sluice table described by Al Hamdani.[12] It is therefore considered most unlikely that the Early Islamic people would have been able to recover more than 1.5–3 gm. per ton, from such ore, at the very best. A recovery of 2 gm. per ton, for instance, is a ratio of two parts per million. That is not much return for the effort of mining a ton of very hard rock using hand-hewn methods, after which the 'ore was brought to the work station and first crushed using the anvils and the large, two handed stone hammers. Following this, the material was further crushed with the smaller stone hammers, and finally ground to fine powder using the hand turned millstones'.[13] The ore then still had to be loaded onto a transport medium and taken 'from the Tawahin site' to be 'treated adjacent to a water source, near the coast at "Aila" (Ancient Elat, located in the present day Aqaba, Jordan...)'. The distance must have been at least 15 km. And all this assumes that they knew the invisible gold was there in the first place.

To produce a cubic centimetre of gold, 10–15 tons of this ground ore would have to be so produced and treated. To produce any really significant quantity of gold, enormous tonnages would be required. However, the largest potential ore body indicated in the Gilat *et al.* paper was 15 sq.m. in surface area. If we assume it was 7 m. deep, there would be a volume of 105 cu.m. Taking the density of quartz as 2.7 gm/cu.cm., this would come to a mere 284 tons, producing some 568 gm. of gold

12 D.M. Dunlop: Sources of Gold and Silver in Islam according to Al Hamdani, *Studies Islamica* 8 (1957), pp. 29–49.

13 Gilat *et al.* (above, n. 2), p. 436.

at best. To produce any reasonable amount of gold, much larger tonnages would be needed — in which case, evidence of the mines would surely have survived.

Generally speaking, for all mineral commodities, the grades of ore which were treated in the past had to be much greater than those treated today, or else the physical effort involved in the production of the commodity would have been too great for the value of the product. The fact that the gold particles were so small as to be invisible would also mean that the ancient people would not be aware of the gold they were losing and how much there was.

6. Gilat *et al.* also state that amalgamation was used: 'This was followed by filtering and further washing and the concentration of the gold grains using mercury'.[14] However, in this case, this would have to have been done with the whole of the ground rock if it was to improve the recovery at all, that is, before the 'concentration process' had already lost more than half the gold. This, in turn, implies the mixing of mercury with very large tonnages of ground rock, then stirring the material to make sure that the mercury comes into contact with all the possible minuscule gold particles, and subsequently recovering the resultant amalgam and unused mercury.

Given the large tonnages of ore required to produce any significant amount of gold, even at a 90% recovery by amalgamation, would have meant that enormous quantities of ore would have to have been transported the distance of 15 km. to Aila, where large quantities of mercury (from whence?) would also have been required. It would surely be simpler and more efficient to bring the mercury to the ore. Unfortunately, there is no evidence at Tawahin to suggest that any such method was used.

This ore transport to Aila would have required a huge and costly organisation with rather complex logistics. However, the real problem would have arisen on arrival at Aila, because there is no running water anywhere 'near the coast of Aila'.[15] There is, of course, the sea, but it seems doubtful that suitable installations were available in the area of Aila, which is now well known from recent excavations and surveys. Obviously, the tailings of such a large and significant enterprise would have been enormous, but no traces of such have ever been reported from Aila/Aqaba and its vicinity.

7. Finally, the main argument against the presence of a gold-mining enterprise in Wadi Tawahin is the total absence of any mining debris in the area. Nor do we hear about stray ore lumps around the buildings and in the *wadi* of the millstones. Neither Frank nor Rothenberg,[16] nor any of the modern mining experts who have

14 Gilat *et al.* (above, n. 2), p. 436; Dunlop (above, n. 12).

15 Gilat *et al.* (above, n. 2), p. 436.

16 Frank (above, n. 3); Rothenberg (above, n. 3).

studied the area, found any material evidence of mining of any kind. Gilat *et al.* clearly raised the question of the origin of the gold ore they claimed to have been processed on the millstones of Wadi Tawahin. They found gold anomalies, which they surveyed; on the basis of these surveys, they claim that the mining must have taken place relatively close to the archaeological site (the 'millstone' site), despite the fact that they did not find any obvious mining debris in the area. They sum up the situation thus: 'Shallow Fe-bearing quartz bodies may have been exploited ... other similar bodies could have been mined out, leaving little or no trace of the operation after 1000 years of weathering and erosion'.[17] After having repeatedly surveyed the area with mining as our main objective, no signs of any kind have ever been located by our teams.

From the discussion above it should be clear that for any reasonable quantity of gold to have been produced from the grades of ore postulated, very large tonnages indeed would have had to be mined. The narrow *wadis* and rugged hills would have easily shown any artificial workings on such a large scale as that proposed by Gilat *et al.* There is no way that they could have been entirely eroded away. In recent years, Willies, Rothenberg and Shaw investigated Early Islamic and earlier mining sites in Wadi Amran, close to Wadi Tawahin and in a landscape very similar to the Wadi Roded–Tawahin region, and here very extensive mining debris of copper were found and excavated.[18] Even the large mining dumps and tailings of the very fine debris of ore dressing were found well preserved, covering the steep slopes and filling the entire large valley between the mine workings.

These mining areas, like the ones postulated by Gilat *et al.* in Wadi Tawahin, had been subject to more than 1,000 years of weathering, and, given the proximity of this site to the Wadi Roded–Tawahin area, probably had been affected by almost identical weathering processes. Nevertheless, extensive evidence remains in the Wadi Amran region. It must also be recalled that the Wadi Amram remains are not in the hard granites such as those of the Wadi Tawahin area, but are in a relatively soft sandstone. Despite this, they remain practically untouched by the forces of weathering and erosion. Had there been any mines in the Wadi Tawahin area, traces would no doubt have remained and would have been recognised by the various groups of mining specialists who visited and surveyed this area, including the team of Gilat *et al.*

Furthermore, in the Eastern Desert of Egypt, in most respects very similar to

17 Gilat *et al.* (above, n. 2), p. 436.

18 L. Willies: Exploring the Ancient Copper Mines of the Wadi Amran, *IAMS* 15–16 (1990), pp. 12–15; B. Rothenberg and C.T. Shaw: The Discovery of a Copper Mine and Smelter from the End of the Early Bronze Age (EBIV) in the Timna Valley, *IAMS* 15–16 (1990), pp. 1–8.

the Wadi Tawahin region, some 200 ancient gold mines are known,[19] and during a recent survey in this region,[20] numerous gold mines in similar geological formations as observed in Wadi Tawahin, and even as early as the Old Kingdom, were found in a very good state of preservation.

In conclusion, it must be stated that there is extreme doubt that there was ever an important — or indeed even an unimportant — gold-mining industry based in the Wadi Tawahin area.

19 See, already, R.J. Forbes: *Studies in Ancient Technology* VIII, Leiden, 1971, p. 162; and, more recently, R. Klemm and D.D. Klemm: Chronologischer Abriss der antiken Goldgewinnung in der Ostwüste Ägyptens, *Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo* 50 (1985), pp. 189–222.

20 B. Rothenberg, C.T. Shaw, F.A. Hassan and A.A. Hussein: Reconnaissance Survey of Ancient Mining and Metallurgy in the Mersa Alam Region, Eastern Desert of Egypt, *IAMS* 20 (1998), pp. 4–9.