Examination of the Use of Hubbing in Incuse Coinage

This numismatic note examines the historical dialogue around the use of hubbing in the incuse coins of Magna Graecia. It then extends an approach used by Schwabacher to determine if hubbing can be identified by looking for evidence of a two-stage process. The diagnostic principle is straightforward: if a hub produced multiple working dies, hub-derived elements should be consistent across those dies while elements applied subsequently at the die stage should differ. A hub match is therefore distinct from a die match, in which all elements are necessarily identical.

An initial corpus from Poseidonia was used due to the consistent ancillary symbols and ethnics used in those issues. An AI-enabled analysis of Poseidonia found no evidence of hubbing. As observed by Noe himself, this may be due to the relief heights negating the need for hubbing in the coins of Poseidonia. However, an analysis of Noe class V coins, selected for their consistency of ancillary relief symbols, showed evidence of hubbing in line with the principle outlined above. Mirroring the approach with the Noe class I coins of Metapontion using issues without ancillary symbols did not elicit any further confirmation of the use of hubs; however, the substantial difficulties in analysis due to limited corpus and low-resolution images from the main sources must be noted. A by-product of the examination was the validation of AI assisted analysis both to handle large volumes of die comparisons and image analytics. The analysis provides evidence for hubbing, though limited to die border application rather than ancillary symbols.

There has been much scholarly debate as to whether 'hubbing' was used in the production of Greek coinage. In his very readable treatise on the experimental minting of Greek[1] coins D. G. Selwood discusses the die materials, flan preparation and striking of Greek coins. His conclusions allowed for the fact that over time and in different places the techniques and materials may have changed due to local factors, but that the norm at least for early production would have been the use of bronze dies. These would have been created using a 'hub', which is a bronze pile with a relief image which had been hardened though heating and slow cooling. This hub would have been used to create the main image for multiple obverse dies, with finer details such as legends then engraved directly into the individual die. This would allow the work of a master engraver to focus on the main relief image and then for the more prosaic work to be undertaken by less skilled staff. *In this description the hub contains the main image, which is transferred to multiple dies, each of which is then completed in a secondary process.*[2]

George Hill proposes that there is evidence that this hub approach was used in the production of incuse coinage, using two examples. The first is from a stater of Poseidonia and is based on a series of observations around deformations in the trident. He describes furrows on the sides of the obverse trident i.e. while the trident is raised from the flan, there are grooves either side of the thorns. These grooves would have been raised on the die which would have been created if a punch was used (displacing the metal to the sides) but the formation was too irregular to be caused by a punch. Direct engraving would have removed rather than displaced the metal. The explanation proposed is that this is an example of a recut hub. The detail, in this case the trident, had become worn, and so the means to re-enforce the detail on the raised trident in the hub "was to go round them, making a little trench, cutting

[1] "Some Experiments in Greek Minting Technique," Selwood, *Numismatic Chronicle* 6th series, 3 (1963), pp. 217–231

[2] It is often hard to identify relief versus incuse in photographs of coins and so to get a feel for the technique used. However, recognising that the hub must have been engraved as per the finished coins, with the double impression being incuse to relief to incuse, means that you can see the form of the hub in the finished coin.

away the field, so as to throw them up into relief again"[3] This detailing, if accepted, requires the use of a hub.

Figure 1 – Partial enlargement of BMC Stater of Poseidonia object number 1946,0101.431

A review of the American Numismatic Society (ANS) and British Museum Collection (BMC) databases found only one candidate to illustrate this reasoning (Figure 1).

Having examined an obverse, Hill then turns to the reverse of an incuse stater of Metapontion for further evidence of hubbing. He notes that the "…dashes look as if they were impressed on the coins themselves with a punch of corresponding shape; but it is obvious that each coin would not be subjected to this tedious process. It is equally obvious from the appearance of this border that it was not carved in relief on the die. It seems certain, therefore, that the relief die which was necessary for striking the reverses of these curious coins was made with a sunk hub (which indeed exactly, save for the special border, resembled, and may have been identical with, the sunk die used for striking the obverses); and the special border was punched on to this hub"[4].

Figure 2 – Metapontion Stater, BMC object number 1946,0101.304

Therefore, specifically for the reverse of the incuse coinage, Hill proposes that the border forms part of the hub, rather than being separately applied to the die. Both of the examples used by Hill are inferring the production process from stylistic elements of the coins themselves.

[3] Ancient Methods of Coining, George F. Hill Source: The Numismatic Chronicle and Journal of the Royal Numismatic Society , 1922, Fifth Series, Vol. 2 (1922), pp. 1-42, vii

[4] ibid

Sydney P Noe continues the investigation (specifically in relation to the incuse coins of Metapontum) in his extensive reference work on its coinage.[5] After making the initial observation that if the engravers were working directly on the dies of the reverses of these coins then the formation of the relief barley ear would have required the excavation of the metal surrounding it to the depth of 4mm while avoiding any damage to the barley ear. He views this as possible, but "that it could have been carried out for so extended a coinage without having left some traces is almost inconceivable." The use of a hub *for the reverse* would have avoided this difficulty. Note that this does not imply that hubbing would have been used for the obverse as doing so would encounter the same challenges as noted for the fabrication of a reverse die.

Noe makes a further interesting inference based on an assumption that the creation of the die in a heated state from a hub would have drawn the temper from the hub, so softening it and making it unsuitable to create further dies. He states "The reverse dies are fully as numerous as the obverse ones and no evidence of re-using these hubs has been found…. We can hardly escape the conclusion, in the light of these facts, that the 'hub' which has been postulated was used simply to get around the difficulty of cutting the reverse die directly in relief." Noe does qualify this inference by excluding the mints of Poseidonia and Kaulonia as their incuse is shallower but does extend the use of hubs (for reverses) to Sybaris and Taras. It should be noted that the argument above applies to elements which appear as incuse on the coins; those that are in relief would therefore have been inscribed into the die itself. This argument is also related to the reverse of the die only; applying it to the obverse would lead you into the position of having to engrave the hub in relief, bringing doubt on the Poseidonia trident example cited by Hill.

The assumption of 1-1 hub to die alignment lacks supporting evidence, and it may be that one hub could create multiple dies. No hubs (or dies) for incuse coinage have survived and so it has not been possible to subject them to metallurgic analysis to determine if there is either evidence of degradation in the hub or evidence of re-annealing. Indeed, Selwood addresses this in a postscript to an article by W. Schwabacher[6], "I believe that it would have been possible to make a large number (certainly more than twenty) of dies from one hub without the hub breaking down".

If hubbing was used in this coinage the question arises as to whether hubs were used to form the complete die, or only for the main type on the reverse with any ancillary symbols, including the ethnic being added to the individual dies produced rather than to the hub. In this there is compelling evidence that the dies were finished directly. **Error! Reference source not found.** is the reverse of a stater of Sybaris, with the ethnic upsilon-san being seen in relief. To achieve this the hub would have contained the main image, with the ethnic being engraved directly onto the resulting die. Figure 4 illustrates the same approach on the reverse of a stater of Poseidonia, with both the ethnic and the dolphin being in relief.

[5] The Coinage of Metapontum Parts 1 and 2, Sydney P Noe with corrections and additions by Ann Johnston, ANS 1984 pp 3-4

[6] The Production of Hubs Reconsidered, W. Schwabacher, The Numismatic Chronicle (1966-) Seventh Series, Vol. 6 (1966), pp. 41-45

Figure 3 - Reverse of Sybaris Stater, Roma Numismatics, Auction 18, Lot 486

Figure 4 – Reverse of Poseidonia Stater, Stack's, Stack & Kroisos Collections, Lot 2029 (2008)

Based on the work of these earlier numismatists, the most coherent position is that hubbing was used for the reverse dies only, to avoid the problem inherent in creating a relief die. The case for use on the obverse proposed by Hill for the Poseidonia coinage is unclear, as in addition to the trident, the lettering in the ethnic often displays similar ridges and is accepted as ancillary designs added to the die rather than to the hub.

An interesting consequence of this two stage process is that it should be possible to confirm if hubbing has been used in the creation of more than one die if you could match the reverse main image between two coins, but see differences in ancillary symbols or ethnic, as these would then not be a die match, but a hub match. This approach was taken by Schwabacher in relation to coins of Poseidonia[7] although in his later work the evidence was reconsidered and he concluded that this was a die that had been recut[8]. Nevertheless, he left open the possibility that this approach could yield results "although this 'test case', afterwards added to my Rome lecture, must now be dismissed as a proof for the hubbing of dies in the incuse series of Magna Grecia, this does not, of course, by any means exclude the possibility that the dies for these early series were occasionally hubbed in the manner described". It is therefore worthwhile re-examining these coins to see if traces of the hubbing process can be found using this approach.

The ancient engravers of Magna Graecia only infrequently added any additional detail to the reverse of incuse coinage and so having a corpus large enough to give a reasonable statistical chance of a hub match is a challenge. Though they do occur on the coins of Metapontion, Kroton, Kaulonia and Sybaris, the best candidate for such a study would be to continue the approach of Schwabacher by using Poseidonia, where the ethnic is commonly seen on the reverse. Therefore, to test whether hubbing was used to produce the central type while the ethnic was a secondary detail applied directly to individual working dies, we would expect to find examples where two dies share an identical central image, indicating derivation from the same hub, but differ in their ethnic. This hub-linked relationship is distinct from a simple die identity, in which all elements necessarily match. It would be expected that hub-linked pairs should substantially outnumber die-linked pairs in any corpus of meaningful size, since a single hub producing N working dies generates $N(N-1)/2$ hub-linked die relationships against the far smaller number of coins sharing any single working die.

[7] Congresso Internazionale di Numismatica , Roma , 11-16 Settembre 1961 , vol. ii (Atti) (Roma, 1965), 107-16.
[8] Schwabacher, op. cit., p. 4

The analysis in this numismatic note makes use of Claude AI (model Sonnet 4.6 medium) for image analysis. The results are then confirmed visually. Results have been repeated using alternative diagnostic approaches where possible to validate original analysis.

A corpus of the reverse of 77 staters of Poseidonia were analysed to identify matches in the central Poseidon figure and the border but excluding the ethnic in the right field. The coins images were taken from the British Museum Collection, ANS Mantis, the Fitzwilliam Collection, BNF Gallica, Berlin Münzkabinett and Harvard, supplemented by coins from auction houses listed on ACSearch.info (primarily Numismatic Ars Classica, Classical Numismatic Group and Künker). The script masked the ethnic and then did a pairwise comparison, listing the top matches as an output.

Each coin photograph was first normalised: the flan was detected automatically and cropped to a standardised circular canvas, correcting for variations in photograph scale and framing. A fixed sector covering the right field is then masked out, removing the ethnic inscription from all comparisons so that only the Poseidon figure and the border of dots were assessed. As the ethnic can appear in various positions in the right field this masking may in some cases have been incomplete.

Four independent similarity measures were then calculated for every pair of coins. Keypoint matching identifies specific points of detail on each die — the contours of Poseidon's musculature, the trident tines, drapery folds — and tests whether those points align geometrically between two images, providing the strongest signal for a true die link. A perceptual hash compares the overall tonal structure of the two images, functioning as a rapid broad filter. A histogram of oriented gradients captured the directionality of relief across the die surface, sensitive to the pose and proportions of the figure. Finally, structural similarity measured fine surface correspondence, picking up die flaws, rust, and wear progression shared between coins struck from the same die.

The four scores were combined into a single weighted composite. Pairs exceeding a configurable threshold are flagged as die matches and clustered into groups using a standard equivalence algorithm, so that chains of linked coins are consolidated into a single reverse die identity.

The top 10 matches were then examined visually to identify whether the coin was a duplicate (important to filter out in the auction images) or a die match. The algorithm in the analysis was demonstrated to be operating correctly by identifying eight duplicates and one die match, with all elements including the ethnic matching (Berlin Münzkabinett 18215996 and BnF Gallica btv1b113156488, formerly in the de Luynes collection).

Figure 5 – Reverse of Poseidonia Stater, BnF Gallica object number btv1b113156488

Figure 6 - Reverse of Poseidonia Stater, Berlin Münzkabinett object number 18215996

There were no examples identified of matches for the Poseidon where ethnic was not also identical and therefore attributable to the same die. No additional evidence for the use of hubbing on the reverses of the Staters of Poseidonia in this period (approx. 530 to 500 BC) was determined. Of course, the absence of evidence is not evidence of absence and the limited corpus available for analysis may have been insufficient statistically to obtain a hub match. However, as noted above, if they were used then hub matches should be more common than die matches, which the algorithm did discover even within this limited data set.

Another possibility is that Noe was correct in his assertion that while the amount of metal that need to be removed to construct a reverse die of Metapontion strongly indicated the use of a hub, that argument did not apply to the shallower incuses of Poseidonia and Kaulonia. To address this, a further analysis was undertaken using the coins of Metapontion. The reverses of the incuse coins of this polis are fairly simple, typically consisting of the main barley ear, the awns (and in Noe class I coins, the bracts) and the border. It is evidence from a brief examination of the coinage that the barley ear, awns and bracts form a coherent integrated design and so are extremely unlikely to have been constructed from two separate processes. It is very rare to find an ethnic on the reverse, and it is for this reason that they were initially overlooked as a test corpus. However, Noe class V does have a reverse symbol of a dolphin, and it is this specific issue that will be used.

This issue is fairly rare and only four examples were found in the sources used in the Poseidonia analysis[9]; an additional five were therefore added from auction records. Three of the coins appear to be die matches on the reverse in relation to the barley ear/awns. Given the nature of auctions, the first concern to be addressed is whether these were not the same coin. A visual examination indicated that there were evident differences in the barley design as well as wear and damage to the coins to confirm they were separate examples[10]. This was confirmed using an AI analysis of the images.[11] Further image analysis of the reverse supported the conclusion of a visual comparison that the central barley/awns design was consistent as originating from a single engraving. The auxiliary reverse symbol of the dolphin was also

[9] Berlin Münzkabinett objects 18203392 and 18215945, Ashmoleon HCR6177 and ANS SNGANS.2.207

[10] Additionally, no indication of placement in prior auctions was indicated in the listings. The Astarte and Roma coins were provenanced to private collections prior to 2005 and 1970 respectively and the Leu coin was not provided a provenance.

[11] Obverse barley ear axis angles differ substantially: Astarte −17°, Leu −28°, Roma −35°. On a shared obverse die these would be identical within ±1–2° (allowing for slight photographic tilt).

identical across the three coins and the spacing between the dolphin and the central design was also consistent, indicating that this formed part of the coherent design of the reverse.

Figure 8 - Leu Auction 81 Lot 14

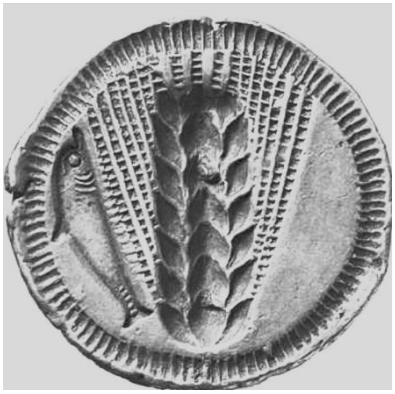

Figure 9 - Roma Auction 13 Lot 28

Figure 7 - Astarte Auction 26 Lot 156

However, it was also noted that the placement of the dolphin on the reverse was different in relation to the border. The position of the dolphin in relation to the centre of the coin, normalised by radius indicated a position of Astarte (-0.325r, +0.011r), Leu (-0.318r, +0.060r) and Roma (-0.251r, -0.041r). Visually you can see this if you compare proximity of the nose of the dolphin in Leu (Figure 7) to Roma (Figure 8). This result implies the use of a hub which contained the barley ear, awns and ancillary image with the border being separately applied to the die. The dolphin is fixed relative to the ear because they are co-transferred from the hub, but variable relative to the border because the border is applied separately at the die stage. If it could be established that the borders were from separate dies then it could be asserted that a hub was used to create at least 3 dies, with the centring of the hub strike being slightly differently centred on each. However, two of the images are below the quality threshold to establish this with a high degree of confidence.

The hub proposition was tested on Noe class I coins on the basis that incuse coinage arrived without evolutionary or prototyping phases and with some exceptions degraded in terms of stylistic complexity and flan preparation until the double relief becomes norm. A novel technique such as hubbing does not seem to fit within that continuum and so is more likely to have been in place at the inception of the coinage. A sample of 53 coins was tested using AI for central image matching on the reverses but did not identify a central match. Given this central match would represent only a die link this is most probably associated with a paucity of examples with sufficiently high-quality images.

The analysis of Noe class V has provided corroborating evidence for the use of hubs in the coinage of Metapontion. The same central image plus ancillary symbol appears on three coins which are not die matches. This is consistent with the use of a hub to create the three dies with a secondary process creating the border on each die.

A further significant positive from this investigation is that the algorithm used to perform the pair matching and identify similarities in the core elements of Poseidonia appears to be robust as evidenced by the identification of a die match. Beyond the specific question of hubbing, the approach taken in the Poseidonia analysis has broader application: without the ethnic masking, automated pairwise comparison could serve as an efficient first pass in the construction of die linkages across a corpus, for both obverses and reverses.