

Network Analysis and Greco-Roman Prosopography

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Social network analysis as a distinct field of study had its genesis in the anthropological revolt against structural-functionalism in the late 1960s and early 1970s. It was born through an awareness among a new generation of scholars that structural-functional models failed to make adequate space for human agency. Attention to personal networks – who knew whom, and how closely they were connected – seemed better suited to understanding individual decision-making than the previous generation’s focus on groups and roles. It quickly became evident that any serious attempt to map social networks of meaningful size – the population of an entire village, for instance – would all but require a rigorous quantitative approach. Here, the mathematics of graph theory, growing in prominence since the 1950s, provided a natural fit. With the advent of computer technology, graph theory provides network analysts with relatively simple tools for answering complex questions: *e.g.* how many degrees of separation on average separate all members of a network? which member of the network is connected to the most other members of the network? how densely or loosely connected is the network as a whole? Such questions hold a natural interest for prosopographers, who can then begin to look for certain characteristics – class, office, occupation, gender – and identify patterns of connectivity that they might have otherwise missed when confronted with a mass of data too large for normal synthetic approaches.

And yet, network analysis has been slow to take root among ancient historians. Network analytical research on the Greco-Roman world has focused on questions of religious history and topography (Clark 1992; Mueller 2002, 2003a, 2003b). Nonetheless, the epigraphic and papyrological evidence beg a network analytical

approach to that material's prosopography. This paper introduces prosopographical network analysis of the ancient world through the co-authors' recent dissertations, Shawn Graham's study of brick-making in imperial Italy, and Giovanni Ruffini's analysis of the documentary papyri from sixth-century CE Egypt. These dissertations, while on considerably different aspects of the ancient world, have both approached the prosopographical material with a network analytic approach in mind. As a result, we have found ourselves in relatively uncharted territory for ancient prosopographers, and would like to share some of our methods and conclusions in hopes of expanding the scope of this sort of work in the future.

Prosopographers of Roman antiquity have been blessed with some admirable modern collections. We think of the ongoing *Prosopographie Chretienne* and the *Prosopography of the Later Roman Empire* for later periods, and for earlier periods, the monumental *Prosopographia Imperii Romani*, itself a topic of a paper yesterday at this very conference. But these are general works, cutting across wide chronological and geographic spans; to demonstrate the potential that network analysis has for ancient prosopography, more focused data-sets are necessary, data-sets which, unlike these massive multi-volume prosopographies, are more easily susceptible to computer-based quantitative analysis.

One such data-set is comprised of the individuals connected with the brick industry of Imperial Rome, studied by Shawn Graham. The brick industry is an important proxy for larger patterns in Roman society. The City of Rome during the Empire is a city built of brick. In the first three centuries AD, the construction industry in Rome was one of the biggest sectors of the economy. It was a major source of

employment, both for free and slave. It was a major source of income for land owners, since the extraction and production of building materials was viewed as part of agriculture, and hence perfectly acceptable for a land-owner to pursue. Because of the custom of stamping the estate and workshop names on the bricks, we know the names of at least 1300 individuals in the industry over this period, although the majority come from the second century. The players in the brick industry include all levels of society, from the lowly operator of a workshop, to the land-owner him or herself (including Emperors and members of their household). For this reason, many have studied the names to deduce the history of land-ownership in the Tiber Valley upstream from Rome (Bloch 1947, Steinby 1974).

The major collections of stamped brick from the first three centuries AD in central Italy are conserved in the Vatican Museums in Rome, in the warehouses of the archaeological superintendancy of Ostia, and the commune of Rome. (It is important to note that there were other brick industries in Roman antiquity which used literate stamps, in particular around the Adriatic and around Constantinople, but these are not discussed here). Other minor collections exist in the foreign research institutes in Rome (in particular, the British School at Rome's South Etruria Survey collection which contains nearly 200 examples; Graham 2002), and in some North American universities and museums.

The major published catalogues of stamped brick are the CIL XV.1 and the *Lateres Signati Ostienses* (Steinby 1977), the Finnish Institute's catalogue on the stamped bricks from Ostia. Margareta Steinby, who was a member of that team, published a chronology and study of the industry in 1974. It is one of the landmarks in the field. Her

later index and concordance for stamped bricks (1987) is a major aid to their identification and study. The significant prosopographical works on the brick industry were again the work of Finnish scholars: Setälä (1977) looked at the *Domini* or landlords, while Helen (1975) looked at the *officinatores* or brick-makers themselves as part of a larger discussion on the meaning of the stamps.

In terms of computerization of the catalogues, Giorgio Filippi of the Vatican Museums published schemata for the computerization of stamped brick catalogues in the early 1990s. In recent years, Philip Kendrick and Margareta Steinby have embarked on the computerization of the CIL XV.1. As part of his PhD thesis (Graham 2002, which was part of the BSR's Tiber Valley Project; see Patterson and Millett 1998), Graham created a database of CIL XV.1 using MS Access. This database was sorted more by archaeological concerns than epigraphic or prosopographic ones. Graham was interested in the number of examples and find-spots of the various stamp types. Janet DeLaine also created a similar kind of database for studying the stamped bricks in-situ at Ostia (DeLaine 2002).

In archaeological terms, the most common use to which stamped bricks have been put has been to provide dating material, for many carry the consular date. They are not much used for prosopography any more. This is unfortunate, because there is more information that may be obtained from stamped bricks. The information on the stamped bricks represents a nexus of power – the power to command resources to be exploited, to arrange for that exploitation, and to get the materials to where they are needed, where they will generate income. Power is sometimes about knowing the right people. This is

where social network analysis, as a methodology and a theory, has enormous potential to transform our understanding of how Roman society worked.

A network approach to this material is interested not just in individuals' names. It is interested in the connections between them. Sometimes, individuals appear on the same stamp as a particular *figlinae* or *praedia* (workshop or estate; the terms seem interchangeable); sometimes a workshop manager (*officinator*; there is still debate about what the term means precisely) is named on the same stamp as a *dominus* (landlord); sometimes the *dominus* is named with the *figlinae* or the *praedia*. This gives us three dimensions of that power nexus which we can model (include the geo-chemistry of the bricks themselves, and there are at least four dimensions; see Graham 2002: 128-158). With digital datasets, and the power of most personal computers available today, it is possible for a single researcher to undertake complicated analyses that previously would have required the tedious drawing of connections by hand.

There are a number of programmes available to build and analyse these networks (UCINET and PAJEK are the most usual ones used). In general, one simply lists the name in question and all the other names with which it co-occurs. The programme then stitches the network together from this data. Many statistics of use to prosopographers can then be determined, but sometimes simply visualizing the network itself can provide a 'eureka' moment. Some networks will have a number of 'hubs' and everyone else is connected like a 'spoke'; other networks will look more like a chain with interlocking circles of individuals. This is profoundly important.

For instance, we know from historical records that Domitia Lucilla is a woman of some importance in high Roman society (she was after all the wife of Annius Verus and

the mother of Marcus Aurelius). But when we knit her into the network and analyse her position vis-à-vis the other players, we find that she is the ultimate center of nearly 150 years of the brick industry, connected to every other person in only three steps (Graham, in press). Domitia Lucilla, the hub-of-all-hubs, would have been extremely knowledgeable because of this positioning; hence she would also have been powerful (given that there are many women known in the brick industry, a study of their network roles would be illuminating; cf Graham, in press, on Plotina, wife of Trajan).

To better understand the importance of hubs, consider airports (Buchanan 2002: 123-4). In the early days of aviation, the airports like Heathrow and Chicago's O'Hare Airport offered airlines a place to centralise their operations and also offered a range of destinations within easy reach. Because these airports were so much better connected than the later established airports, airlines, passengers, and flight planners tended to use the older airports more often. This self-reinforcing process, called 'preferential attachment', turned these airports into hubs. Hubs can become victims of their own success. Heathrow and O'Hare are now hampered by airspace congestion and planning restrictions on expanding their runways. Consequently, delays at these hubs have allowed other lesser airports such as Stansted to expand their own connections, becoming very hub-like themselves and turning the overall network into a more 'egalitarian' shape, where each 'node' has roughly the same number of connections. (See Watts 1999 and Barabasi 2002 on the theory of evolving networks.)

In terms of the brick industry, preferential attachment is how patronage worked in the Roman world. One would not become the client of a patron who was not already well-connected (Wallace-Hadrill 1989: 83), thus increasing the number of connections

which that patron already had. The hub-and-spoke type of network is sometimes called an ‘aristocratic’ network (ie, most people only have a few connections, but there are a few who are exponentially better connected, making a power-law distribution of individuals and connections). Initially, the brick industry social network is ‘aristocratic’ in this sense, as we can see by simply plotting the connections. The hubs are the people who have many clients (or, indeed, patrons), tenants, friends and contacts, over and above what we would normally expect. They are the people with ‘their fingers in every pie’. Over the course of the second century the network seems to evolve from an aristocratic network into a series of interlocking circles, or what might be called an ‘egalitarian’ network. To which one may ask: “So What?”

When the underlying structure or patterning of social relationships changes, the traditional behaviours which have evolved to suit one set of circumstances are no longer appropriate. They can even be damaging. An interesting approach is to look at the Romans’ periodic bouts of elite self-extirpation, the purges and proscriptions of aristocrats. What are the implications for Roman society when the well-connected *dominus* is (forcibly) removed from a social network? What happens?

From a theoretical point of view, researchers have found that *randomly* connected networks are easily susceptible to ‘attack’. That is, after a certain number of nodes or individuals are removed at random, the network begins to fragment, disintegrating quickly (Barabási 2002: 115). But the brick industry is not wired randomly. Key individuals tie it altogether, shortening the overall distance from one side of the network to the other. This kind of network is called a ‘small world’, where clumps of people are connected by long-distance links. These small-world networks are noted for their

considerable robustness. In small worlds, random attacks have far lesser effect. Because most nodes in a small world have only a few connections, the chances of a random attack removing a critical node are rather remote (114). In the brick industry, the more or less random deaths of various individuals would be like a random attack on the network.

However, the very property of a small world which gives it strength is also its greatest weakness. The pattern of connections in a small world makes it robust to the various depredations which may randomly affect it, because on average, none of these will affect the ‘hubs’. However, if a concerted attack is made against a few of the hubs, then the entire network can fragment. This is the ‘Achilles’ Heel’ of small worlds (117). If the right hub is selected, or the right number of hubs, a chain reaction can be set off, resulting in network analysts call a ‘cascading failure’. One of the main properties of small worlds is that there are multiple pathways to and from any given set of nodes. When a number of these pathways go through a particular hub, the removal of that hub means that alternate paths have to be found. The ‘load’ for that hub is spread throughout the network, but this means that other hubs and other pathways have to take up the load. If the new load outstrips the ability of a node to carry it, that node can fail, spreading the load again. How far the avalanche reaches depends on the positioning of the first nodes and their capacity to fail (119-120; cf. also Albert, Jeong and Barabási 2000).

In the brick industry network, there are few connections across times of dynastic changeover, times when Roman high society was undergoing one of its periodic bouts of self-extirmination. Purges and proscriptions in the Roman world targeted the most visible or prominent members of families. Then, the obligations and responsibilities of patronage would be taken up by other members of those families. But if these individuals were not

as well connected or as capable as their predecessors, their ability to manage their families' fortunes, to generate new links, to take advantage of new opportunities, would correspondingly be lessened. However, the demands made of them would not be (if anything, they would be increased), and they would fail, starting the sequence over again.

Towards the end of the second century, when Septimius Severus gained the purple, he purged society of his competitors. He re-ordered Roman society with him as its focal point, which is shown clearly in the networks derived from our indicators in the brick industry. The network which previously had been more diffused in interlocking circles was reconfigured through Severus' pogrom against the elite. Despite this reconfiguration, networks are not deterministic. People still act with their own agency. Cascading failures happen when the individual actor chooses not to (or cannot) rise to the demands of the network. With the network of brick-stamps centered on Severus rather than on a wide number of links spread more evenly through society, Roman society as viewed through this particular social network seems dangerously positioned. It is tempting to infer from this change that the post-Caracalla cessation in the practice of brick stamping, our indicator for how power was networked in Rome, represents a collapse in the stability of this particular social and economic network. Rome of the third century is a very different creature than Rome of the second; it may be that the brick industry preserves an echo of the moment of transition and network analysis gives us an insight into why the transition took place. Graham's future research will be to test this hypothesis by modeling these networks dynamically in computer simulation, and by 'killing off' the key players to mimic the effects of purges and proscriptions. Networks

need individuals, and with the aid of simulation, we can explore how society emerges from, and effects, individual actions, including mass-murder and collapse.

Because network analysis also provides tools for exploring the interactions between various cliques and clusters within a social network, it is also well situated to assist in anthropological and prosopographical investigations at the village level, through the documentary archives of papyri that survive from a number of villages over the course of a thousand years of Greco-Roman history in Egypt (Carrié 2003). The state of computerization in papyrology is quite well developed relative to many other corners of ancient studies. For some years now, the Duke Databank for Documentary Papyri has provided a valuable resource to scholars in the field, with its online searchable collection of nearly all published Greek and Latin texts found on papyri, ostraka, and wooden tablet, over five million words worth of material. (<http://odyssey.lib.duke.edu/papyrus/texts/DDBDP.html>). This database can also be searched in convenient CD form (PHI 7 CD ROM from the Packard Humanities Institute). The APIS project (<http://www.columbia.edu/cu/lweb/projects/digital/apis/>) and the Heidelberg Gesamtverzeichnis (<http://www.rzuser.uni-heidelberg.de/~gv0/gvz.html>) also provide important online resources. APIS provides a searchable interface unifying texts, translations, images, and bibliography of papyrological holdings at eight major North American universities. The Heidelberg database offers powerful geographical and chronological sorting tools for over 35,000 published papyri. Finally, we must mention that monumental accomplishment of the Leuven school, a complete online version of their earlier printed *Prosopographia Ptolemaica*. This material has already been used for several articles on topographical

network analysis by Katja Mueller. Computer analyses of the social networks from Egypt's Fayum area coded in this online version of the *Prosopographia Ptolemaica*, and from other areas of Egypt in these other online databases, may one day offer considerable insight into the social hierarchies of the region, and contribute to our understanding of social divisions between Egyptians and Greeks, to name but one issue which has interested papyrologists in recent generations.

Because of the extent to which network analysis relies on computer technology, these digitized data-sets represent a prosopographical growth industry with enormous potential. To highlight what specific prosopographical advances can come from network analysis of documentary papyri, we will give a partial summary of Ruffini's recent dissertation on social networks in sixth century CE Egypt. The historiography of Byzantine Egypt relies most heavily on two groups of papyri, those from Oxyrhynchos in Middle Egypt, and those from Aphrodito, in Upper Egypt. The latter group of texts appears to represent the archive or archives of a single family of landowners and village officials who were active in Aphrodito throughout the sixth century. Most prominent in this archive is the lawyer/poet known as Dioskoros, whose Greco-Coptic bilingualism and interesting fusion of classicizing and Christian cultures have made him the center of much academic attention.

One of the central arguments of Ruffini's dissertation is the claim that natural scholarly interest in Dioskoros himself distracts the prosopographer from a true picture of the Aphrodito archive. Network analysis provides a number of centrality measures to identify the most central figures in the archive, measures whose quantitative nature hopefully removes the biases introduced by our own scholarly curiosity and prejudice.

A brief word about some of those measures before we discuss the results. Closeness centrality identifies the people with the shortest paths to all other actors in a network. Someone will be closeness central if he has a lower average number of social steps between him and everyone else in the village. Betweenness centrality identifies the people atop the most routes between others in the network; this is considered a good way to find out who influences information flow (Wasserman and Faust 1994).

In Aphrodito, the interest for the prosopographer lies in identifying figures other than Dioskoros and his family who rank highly by these centrality measures. An analysis of the sixth century Aphrodito papyri awards first place by closeness centrality to a landowner named Enoch, who is also fourth place by betweenness centrality. Third place by closeness centrality goes to Abraam, a scribe who also placed fifth by betweenness centrality. Fifth place by closeness centrality goes to Pilatos, a notary. These results (Ruffini 2005) came as something of a surprise, as none of these three figures are widely known or discussed in the modern scholarship on Aphrodito. Indeed, it was not immediately clear why any of them should have occupied any particular place of prominence in Aphrodito's social network.

First, Enoch. In one text, dating to 521 CE, Enoch issues a guarantee that Isakos, a shepherd and fieldguard, will "keep watch over matters of peace" for the following year. The second text, dating to 548 CE, is a petition drafted by Dioskoros himself to the Empress Theodora protesting the aggression of the Antaiopolite pagarch, or local tax-collecting official. The signatories to this petition are some of Aphrodito's most prominent elite. Enoch's appearance as a landowner or *ktetor* in this text does not tell us anything about him as an individual: each *ktetor* has the roughly same formula following

his name. But the text as a whole does impress us with the corporate identity of Aphrodito's landholding elite. This corporate nature of village life in Aphrodito may account at least partially for Enoch's centrality here. His role as a *ktetor* put him in close social proximity to Aphrodito's elite; yet, at the same time, he served as a guarantor for a shepherd, thus in turn serving as a social bridge to an entirely different segment of Aphrodito society.

Abraam the scribe appears in texts covering a period of some three and a half decades. He appears in 514 CE, in a fascinating agreement between the community (*koinon*) of Aphrodito's village headmen and landowners on one hand, and Aphrodito's shepherds on the other. There, Abraam signs the agreement on behalf a group of illiterate shepherds. He then appears thirty-four years later, in a land agreement between Psais, son of Besios and Tasais, a deacon, and Dioskoros himself. He was only a witness to the agreement, which was itself drawn up by the notary named Pilatos. Abraam appears also in the petition to the empress which we have already discussed, there in his capacity as a *ktetor* or landowner. Abraam is also attested as a *boethos*, a sort of administrative assistant, in a series of rent receipts issued to Apollos, father of the poet Dioskoros. All told, this is an interesting biography: a *ktetor*, a *boethos*, and an intermediate in a transaction for Apollos, an absentee landlord. But presumably Abraam's high closeness and betweenness centralities are not due to factors of social status, but due merely to his ability to write, as a scribe for a large landowner or even for shepherds.

In the case of Pilatos, we see no evidence of any high social status whatsoever. His high level of social centrality here seems to be solely because of his notarial role. He signs the petition to the empress Theodora in his own right, but also on behalf of three

other men, one a guild chief and another a landowner, who are all illiterate. He has ties to the family of Dioskoros and other members of the local elite also owing to his literacy. This pattern, that literacy improved one's social connectivity as we perceive it through these documents, is one that was repeated again and again in Ruffini's analysis of Aphrodito society.

Moving on from individual centrality analyses, prosopography is to some extent group biography. One aspect of group biography is analysis of occupational groups, and the characteristics of social connectivity that differ or remain constant between occupational groups. Social network analysis provides us with a number of new methods for quantifying these social characteristics. Remaining in Aphrodito, we can investigate the extent of corporate unity within that village's occupation groups. In other words, members of which occupation groups tend to be more connected with each other than with members of other groups? Are there occupation groups whose members tend to be more isolated from one another, less collectively united than other occupation groups? Here, the concept of density becomes useful. Skipping the math involved, density is a measure of the ratio of a network's actual connections to its possible connections. As Rudo Niemeijer put it, density is also "the probability of a member chosen at random having a relation with another member of the network similarly chosen at random" (Niemeijer 1973: 49).

So, occupation groups with a high density to their internal networks are occupation groups for whom the written record documents considerable interconnectivity with their peers. Occupation groups with a low density would appear, at least in the written record, to have interacted with one another to a much more reduced degree.

Some of our results here are really quite interesting. Consider the respective network densities of those people described as priests, and those described as monks: 12.5% in both cases, not a particularly high number, one indicating that any given member of either group had a roughly one in eight chance of being linked directly to one of his peers, at least in the documentary record. Then consider another pair, farmers on one hand and landowners on the other. Farmers have an 11.02% internal network density, landowners, an 11.15% internal network density. The similarity between the two figures is suggestive, perhaps indicating that both farmers and landowners leave comparable traces in the written record.

What about the guilds, the *koinons* which modern scholars have noted to have been so important in Aphrodito's social landscape? First, the shepherds, the subject of much penetrating analysis by James Keenan, who has drawn attention to the social tensions caused by their pastoral lifestyles. Because Keenan's scholarship has focused on the shepherds as a corporate entity, and because we often see them acting as a group, signing collective agreements with Aphrodito's leading landowners, we intuitively expect the shepherds to be a strongly interconnected group. And yet they have an internal network density of only 8.28%, one of the lowest densities of any Aphrodito occupation group. This is a surprising result, but perhaps it should not have been. Many of these shepherds lived on the fringes of Aphrodito society, and would have had little reason to appear together in the village's written record. Compare these results against the network densities of some other Aphrodito occupation groups. The coppersmiths are at the low end, at 12.5%. The shipwrights have a 20% network density, the goldsmiths a 25.44%

network density, the linen-weavers 28%, the bee-keepers 33.33%, the mill-masters a staggering 62.5% network density.

What are we to make of these results? To some extent, the frequency of any given occupation's attestations in the record will effect our results. Larger networks – for instance, the shepherds, many of whom are attested in our records – have a more difficult time reaching higher levels of density, because more and more social ties are needed to increase the density of larger networks. But this is unlikely to be a mere mathematical phenomenon; these results presumably reflect some sort of sociological reality. Why should the shepherds, the farmers, and the landowners have network densities in one particular range, and the goldsmiths, the linen-weavers, and the bee-keepers have network densities in much higher ranges? Perhaps the economic activities of these latter groups predispose them to interact with each other rather than with members of other occupation groups. Perhaps those with occupations more closely tied to the village than the countryside are more likely to form social networks leaving traces in the village's written record.

These comments are purely speculative, and demand further work. Our only intent here is to highlight the curious nature of the results derived through network analysis of ancient evidence, and to argue that these results suggest a considerable role for network analysis in future prosopographical research. Network analysis in prosopography is a relatively new science, and many methodological kinks remain to be ironed out. In the case of Aphrodito, we may wonder what sorts of distortions creep into our analyses simply by virtue of reliance on the archive of Dioskoros: what if this man had an obsessive neurotic hatred of shepherds and a fondness for mill-masters? And how

far can we push results arguing for the centrality of scribes and notaries when we are in fact relying only on the written record?

It is the nature of the record which raises problems in the case of the central Italian brick industry. Stamped bricks are proxies at best for wider patterns. How far can we push them? Only the broadest patterns visible were discussed here, but if we were to study the fabrics and sources of bricks, and correlate those relationships with the information in the stamps, it would be possible to present a fuller picture.

Once some of these concerns have been addressed, we can set our sights on future avenues of research. For instance, network analytic concepts of structural similarity provide ways to analyze the social interchangeability of different actors. This invites attempts to identify homonyms and restore lacunose names by looking for high levels of structural similarity between actors. Network analysis also permits a more robust discussion of social distance, something traditional prosopographers find difficult to quantify. Asking which social groups were furthest from each other is the intellectual equivalent of asking for a way to measure the absence of evidence. But network analysis can do this. Think again of our Aphrodito occupation groups, but instead consider the possibility of measuring density and distance between groups, rather than within them. Did the gold-smiths get along better with monks or priests? Were the linen-weavers more socially distant from the boatwrights than the carpenters? Answers to these questions would be small gains, but interesting ones, and worth pursuing. The work on the brick industry so far has been concerned with global dynamics, leaving local dynamics unexplored. The actors in this industry are known historic individuals. Understanding their local positioning should allow us to explore otherwise unrecorded

aspects of their lives. What we can do with the networks as we have drawn them is to use them as a basis for simulation, for exploring ‘what-if’ scenarios, to move from a static to a dynamic picture of ancient society.

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