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## A New Approach to Church Liturgy in Byzantine Arabia / Palaestina Tertia: Chemical Analysis of Glass from the Petra Church and Dayr 'Ayn 'Abāṭa Monastery

This paper examines the contribution of chemical analysis to the question of supply of church glass in Late Antiquity, using the Petra Church and the monastic church of St. Lot (Dayr 'Ayn 'Abāṭa) as case studies. Excavated under the *aegis* of ACOR from 1992 - 1996, the Petra Church is likely to have been the metropolitan cathedral (Lehtinen 2002: 10). Its first phase as an ecclesiastical structure is likely to have begun in the 5th century AD, with an expansion into a triapsidal church with glass wall mosaics in the early 6th century (Fiema 2001: 53, 77). Its published glass report excludes some material found in the associated structures across the forecourt, where the papyri were located (O'Hea 2001: 370-376). The monastery of St. Lot was excavated under the direction of Dr. K.D. Politis for the British Museum from 1989 - 1996. It was a major monastic complex which served as a rural pilgrimage centre in the Dead Sea region during the 5th to 7th centuries AD (Politis 1992: 281, 285, 1995: 486). The final report on the glass is forthcoming (O'Hea 2011a).

Most of the glass lamps seem to have been still *in situ* when the Petra church was engulfed by fire in the 7th century, for they were found, heat-damaged, within the church. A partial clearance of the church after this destruction resulted in the collection of fragments within an adjacent building in the courtyard. At Dayr 'Ayn 'Abāṭa, the pilgrimage church seems also to have suffered damage affecting the glass lamps, and many were swept into a disused cistern adjacent to the structure. In this case, there was little evidence of fire, and an earthquake could easily have caused many hanging lamps to fall whilst not necessarily causing major architectural damage. These lamps were, however, replaced within the church. Although a 5th - 6th

century ecclesiastical structure probably existed here, the triapsidal church could be as late as the mosaic dated AD 606, with a second floor being laid in AD 691 (Politis 1992: 281). A slower period of disuse is probably reflected by the small amount of glass lamps which finally collapsed onto floors in the Abbasid period.

### Patronage and Supply

Together, the Petra Church and the pilgrimage church at Dayr 'Ayn 'Abāṭa provide a sizeable assemblage of Late Antique church glass from *Palaestina Tertia*. This particular kind of glass assemblage imposes, however, considerable restrictions upon any extrapolations about how glass was supplied or used in the wider Late Antique world. Our working assumption is that Roman and Byzantine glass was, like most other everyday Roman - Byzantine products, available through supply-and-demand consumerism, powered by a large number of local, urban-based glass workshops. Ecclesiastical and monastic glass was, on the other hand, predominately architectural material - lighting and window panes - and was therefore likely to have included assemblages which were pious gifts to that religious community, just as with contemporary synagogues and later mosques. This view is supported by copious anecdotal information from both western and eastern church texts, making it clear that church fittings were expected to be gifts of elite lay families; bishops also made donations, as well as requesting material from their own patriarchs which might be difficult to source locally. Mosaic inscriptions have drawn the attention of modern scholars to such lay benefactors (see Caillet 2003: 298-299); a late Byzantine example is the expanded upper church of the Prophet Elias



at Mādabā (Piccirillo 1998: 21). The most famous prototype of an episcopal benefactor was Pope Sylvester, who donated silver and bronze vessels, including lamps, to a church founded by himself, just as the emperor Constantine was the supreme example of an élite layperson donating goods for St. Peter's in Rome (*Liber Pontificalis*, XXXIV). Pilgrimage sites such as at Dayr 'Ayn 'Abāṭa, of course, could attract donations from visitors from even more distant locations. St. Catherine's monastery in the Sinai is the most famous example of Justinianic benevolence.

Until recently, scholarly interest has focussed on the mosaics and wall-paintings themselves as objects of devout donations, since they often survive when other church fittings have long since disappeared (Mango 1986: 4) summarises the textual information concerning the donation of both domestic plate and specifically-made liturgical items to churches. These items are more normally retrieved from 'hoards' than from archaeological investigations of church buildings, and none has been retrieved from either Petra or Dayr 'Ayn 'Abāṭa to date. Glass lamps and window panes, on the other hand, are commonly found within abandoned churches – if only because they tend to be the most difficult to remove, and had comparatively little value when compared with bronze or silver lamps. The evergetical function of glass vessels in churches is further rendered invisible by the lack of associated inscriptions; to date, no glass lamp prior to the celebrated 14th century series of enamelled mosque lamps bears an inscribed name of owner or donor.

As noted above, it is today widely accepted that every sizeable regional centre probably had at least one glass workshop which supplied both everyday tableware and which also could and did undertake large-scale contracts for public buildings such as bath-houses. Baths were the only architectural form before the appearance of the Constantinian basilica and the Late Antique synagogue to have used considerable amounts of glass, initially in the form of windows (O'Hea 2008: 235-239). Unlike temples, both 4th century basilicas and synagogues also took up the use of fixed, closed window-panes. From the 4th century onwards, both churches and synagogues also introduced glass lamps, first in the form of goblets, which were then suspended, in various forms, from ceilings (O'Hea 2008: 242-244). This innovation in turn quickly moved to bath-houses, as can be seen, for example, at

Ḥammāt Gadara (Cohen 1997: 396) and at Petra itself (O'Hea 2011b). Temples, on the other hand, used neither glass panes nor – for chronological reasons – glass lamps.

It is a reasonable assumption that window panes were made and supplied locally for any public building, and not imported from afar. But they could amount to a sizeable donation towards either a public bath-house or place of worship. The AD 301 *Price Edict* of Diocletian listed two types of window glass: one at 8 *denarii* and a second-rate version at 6 *denarii* per Roman pound – roughly equal to 25 and 19 *dd* per kg respectively – which, at first glance, might not seem very expensive at all. Now, 8 *dd* equals 32 *drachmae* (Sperber 1965: 262), which means that high-quality window pane was officially worth only *ca.* 100 *drachmae* per kg. But this does not seem to reflect reality. In AD 318, the local glassworkers' guild (*koinou*) of Oxyrhynchus in Egypt posted an official price for blown glass at 750 *dr* per kg (Cole *et al.* 1987: P.Ox. 3742); eight years later, the same guild claimed that the requisition of 60 *kentenaria* of glass for a new urban bath-house cost them 1320 talents, which works out at an even more inflated 4125 *dr* per kg (Bowman *et al.* 1977: P.Ox. 3265, l. 13). This is 5.5 times the earlier price. Glass lamps – which could have been more expensive than the panes – might have added to the cost, but the difference can also be explained by the nature of both documents; one was, yet again, an official rate, whilst the other could be an ancient example of a deliberately-inflated estimate for a council tender.

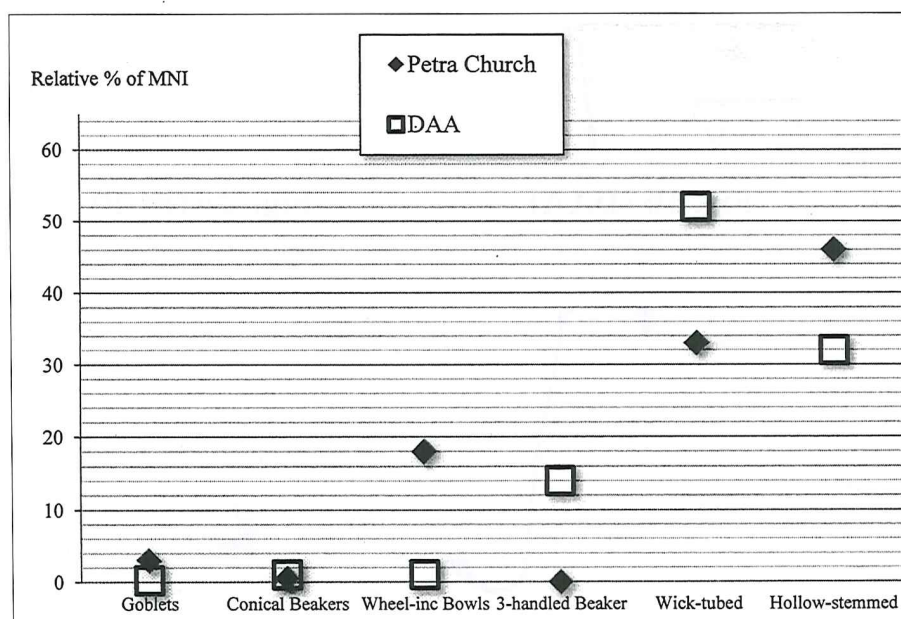
In any case, the Oxyrhynchus bath-house makes it clear that supplying lamps and window glass for one such building in a middle-sized provincial town could be claimed, on paper at least, as a sizeable expense. The architectural glass from the Petra Church and monastery of St. Lot was not, therefore, a negligible act of gift-giving.

### Glass Lamps

A *minimum number of individuals* (MNI) can be estimated for lamps from the Petra Church (MNI 213) and from Dayr 'Ayn 'Abāṭa (MNI 469). Although all the main Byzantine types are represented at both churches, they vary significantly in proportions (FIG. 1), perhaps in part because the latter site underwent a refurbishment in the 6th or early 7th century.

The earliest glass lamp type anywhere was





1. Relative % of different types of lamps from Petra Church (MNI 213) and the Monastery of St. Lot at Dayr 'Ayn 'Abāṭa (MNI 469).

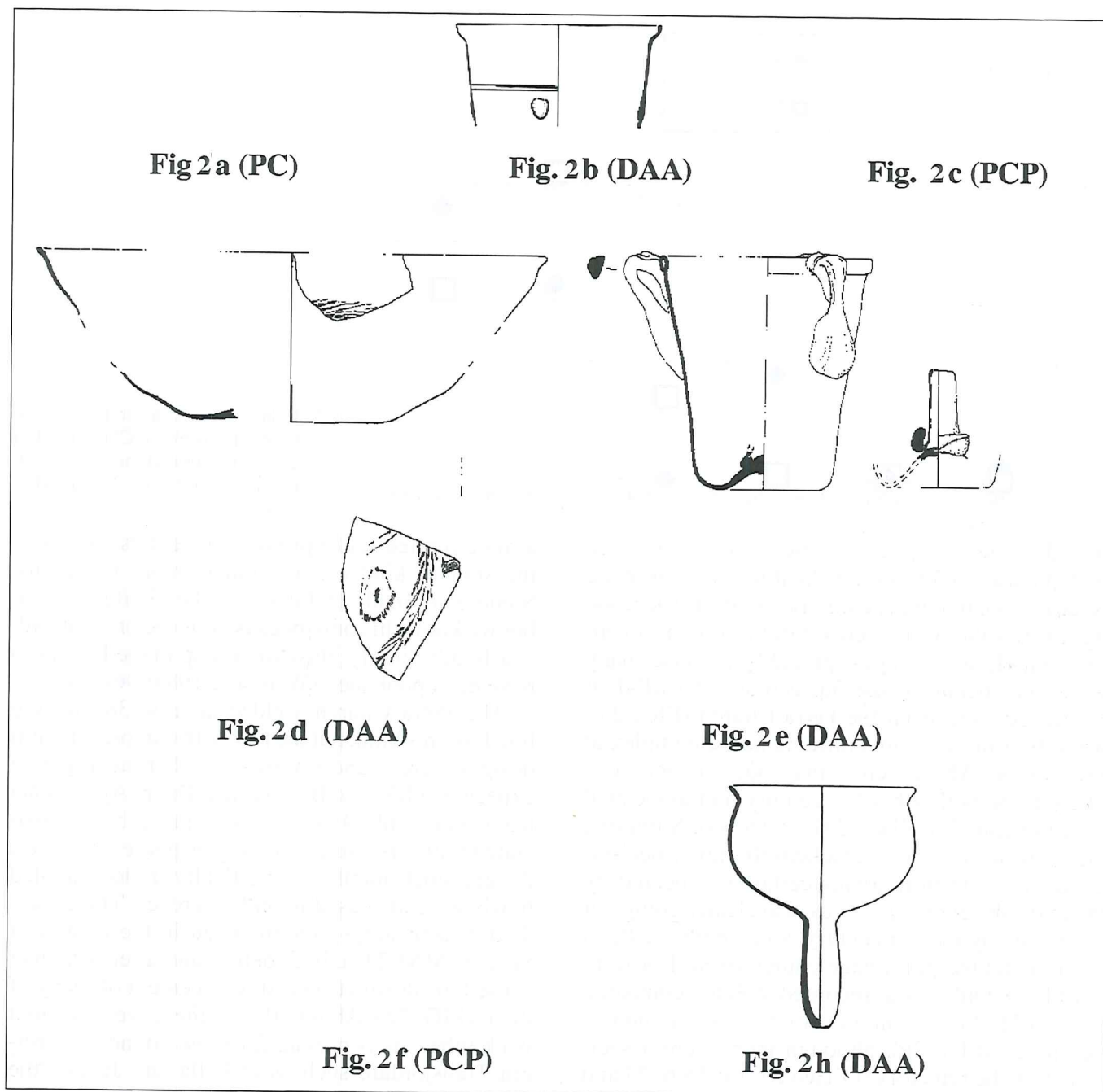
probably the 4th century goblet, which continued in popularity in 5th century Anatolia, such as at the Necropolis Church at Anemurium (Stern 1985: 44, fig. 3). But the form occurs more rarely in Levantine church assemblages, probably because many were only begun in the 5th century. An MNI of 6 was retrieved from the Petra Church (FIG. 2a), while 9 of the 12 from entire monastic complex at Dayr 'Ayn 'Abāṭa were Umayyad, and only 1 is likely to be both 4th – 5th century and associated with the church (O'Hea 2011a: TS 39). Similarly, the conical lamp with cracked-off rim, wheel-incised lines and blue prunts certainly appeared by the mid-4th century, and was also clearly going out of fashion by the 5th century, when both the Petra Church and the pilgrimage church of St. Lot were in full use. Only 1 was recorded at Petra, compared with an MNI of 5 from the environs of the monastic church (FIG. 2b), although more were associated with the refectory (O'Hea 2011a: TS 6, 73 and 119). By contrast, they appear in numbers during the AD 363 earthquake which shook the baths near the Great Temple at Petra (O'Hea 2011b) and at Aila (Jones 2005: 135-137).

Hemispherical bowls without handles and with wheel-cut lines or figural compositions also straddle the 4th and early 5th centuries. They could function as either drinking bowls or lamps suspended in a metal band on chains. Both the figured and linear-incised bowl-lamps share the same fabrics and forms, and have the same wide distribution, so it is difficult to prove that the latter might have had

a more limited set of production centres. Bowls of the simpler kind are, of course, more numerous. Some were made at Jalame in the Galilee region, but we know this only because it is the only late 4th / early 5th century glass workshop in the Levant to have been published (Weinberg 1988: 96-97).

The Petra Church yielded at least 38 hanging bowls of this kind, but the few with elaborate figural designs were found towards the altar, as might be expected (FIG. 2c). By contrast, Dayr 'Ayn 'Abāṭa has yielded only 9 vessels, with just 5 being associated with the church in its later phase (FIG. 2d). A very small number of vertically-trailed handled bowls were also used in both churches. Three-handled beaker-lamps predominated in the church of St. Lot (MNI 242), both before and after whatever caused the destruction and replacement of many of them (FIG. 2e). About 20% of these were without wick-tubes, as is normal for those found in northern Transjordan, such as at Pella and Jarash; the rest (MNI 242) have wick-tubes. This was a long-lived type, and the earliest here may be 5th century. They seem to have been more widely used in the church than in the refectory at Dayr 'Ayn 'Abāṭa.

Only the wick-tubed variety can be identified in the Petra Church, where they were concentrated in the northern apse and in the eastern part of the nave / chancel area (FIG. 2f). However, most of the lamps here were hollow-stemmed types (MNI 98). At least 79 (FIG. 2g) were concentrated at the western end of the nave and in the narthex and southern aisle (O'Hea 2001: 372). They occur, too at Dayr 'Ayn



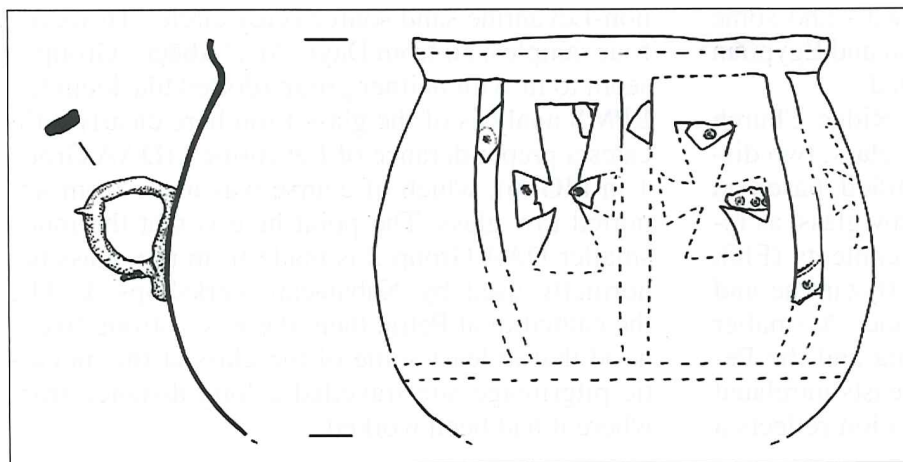
2. A selection of lamp types from the Petra Church (PCP) and Dayr 'Ayn 'Abāṭa (DAA) (scale 1:3) (NB images in red will be sent, along with full jpgs, after Feb 4th, as they are in Australia, and I am still in Jordan!)

'Abāṭa (FIG. 2h) and have a broad 5th – 6th century date range for manufacture, although many of course collapsed from ceilings during the AD 749 earthquake destructions across the Transjordan region.

So far, the range of lamps at both churches varies in proportion but not forms. However, two extraordinary glass vessels stand out amongst the Dayr 'Ayn 'Abāṭa assemblage: a painted small shallow bowl, which might have served as a type

of church icon (O'Hea 2011a: TS 123) and a cobalt blue handled bowl-lamp with metal appliqué crosses adhered to its surface (O'Hea 20011a: TS 61). All extant metallic strips are stamped intermittently with tiny double-concentric circles, between diagonal pairs of lines above and below (FIG. 3). The metal strips and any residue adhesive have yet to be analysed, but the metal appears to be extremely thin (less than 0.5 mm thick), and its present col-





3. Cobalt blue glass bowl-lamp with metal appliques, DAA (scale 1:3)

our and matte appearance suggests either lead or a lead alloy, such as pewter, rather than silver. The form has parallels in both glass and metal from the later 6th and 7th centuries. Both items were found, fragmented and incomplete, in the vestibule of the church. Whilst the painted image has strictly regional parallels (all from the Negev), the blue lamp is, to date, absolutely unique. It was clearly made for a Christian setting, and its form is one which extends, in limited numbers, across the Levant to Anatolia. It is tempting to see it as a donation from a region with quite a different glass-working tradition to anywhere in the Levant, even if it is as yet impossible to identify it.

### Sourcing the Glass

Roman and Byzantine raw glass was probably made in relatively few places, where furnace fuels, sands and the availability of imported natron were all appropriate. Glass was then transported as chunks broken-up from very large slabs; these could travel overland by pack animal – the *Babylonian Talmud* deals with sacks of glass chunks (*tebel*) transported by animal in the 3rd century (*Tractate Shabbath*, Ch.XXIV, Folio 154b). As a result, chemical analysis of glass objects is no help in identifying where the vessels were made; at best, it can indicate different sources for the raw glass.

Analysis of trace elements show that between the 4th – 7th centuries, there are at least four distinctive compositional groups of glass in the eastern Mediterranean (Freestone 2005: 3, 2006: 203, table 2). These Byzantine groups are labelled as HIMT (that is, with high iron, magnesium and titanium), a group that typologically seems to belong to the 4th and 5th centuries, Levantine I (5th – 7th

centuries) and Levantine II (7th into 8th centuries). Levantine I and II glass compositions have been tentatively associated with two different regions of the central to northern Levantine coast; no-one can with certainty pinpoint the source of HIMT glass, although Egypt / the Sinai is a strong candidate (Freestone 2005: 10).

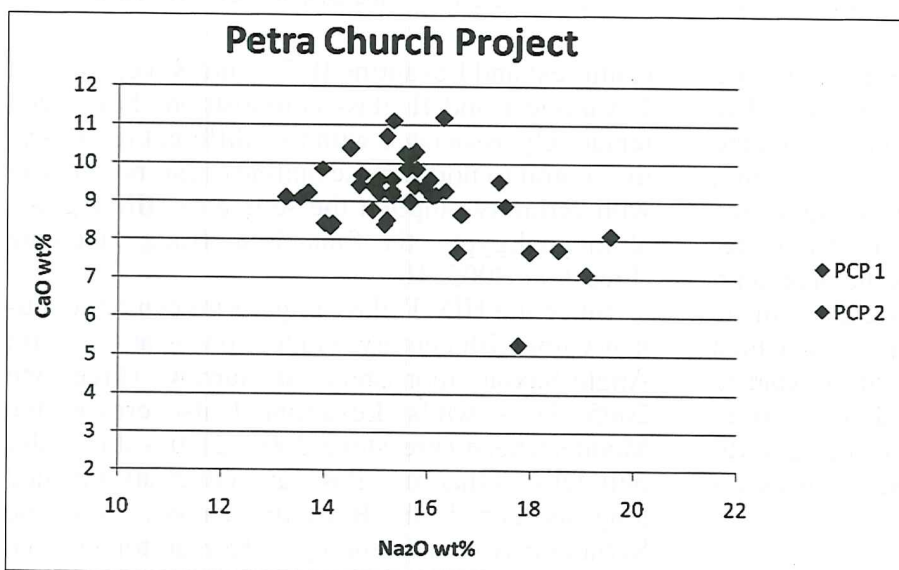
Since the HIMT glass fingerprint can be identified within 7th century window panes at the north Anglo-Saxon monastery at Jarrow (Freestone 2005: 11) – whilst Levantine I also crosses the Mediterranean (Freestone 2006: 210) – this really only tells us that raw glass and cullet all travelled long distances in the Byzantine period. Byzantine Syrian glass vessels end up in Korean tombs (Lee 2009: 172, 179); raw glass from the eastern Mediterranean continued to be exported to India over many centuries (Stern 1991). In addition, glass was widely recycled in antiquity, further muddying any chemical analysis (for example, some glass from the North Ridge Church in Petra; see Marii 2008: 185). So let us be clear. Chemical fingerprinting of glass provides an indication of where glass might have been made, but not where it was worked into vessels or window panes.

That said, Marii has used backscatter electron microscopy with energy dispersive spectrometry examination and electron microprobe analyses (EPMA) to examine glass from both Petra churches as well as the Petra Great Temple. In conjunction with Lucy Stanford, MA student at the Institute of Archaeology in London, she has also studied glass samples from the church of Saint Lot. The broad picture again yielded absolutely no surprises: Petra's Byzantine period glass fell into two groups (Marii 2008: 184-185): mostly Levantine I - which has higher calcium

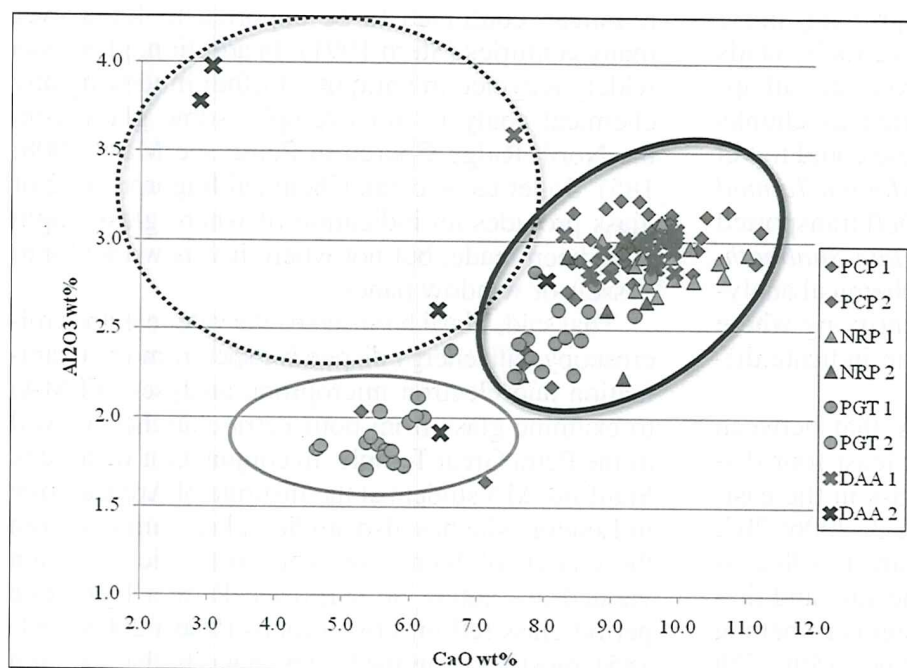
and sodium oxides than the other two - and some HIMT glass (FIG. 4). A mix of coastal and Egyptian sources for raw glass is not unexpected.

When combined with the North Ridge Church (NRP) and the Great Temple (PGT) glass, two distinct compositional groups can be identified, based on the sand sources used to make the raw glass, as indicated by their lime and alumina contents (FIG. 5). The majority (black circle) are Byzantine and share a common source for the sand. A smaller number from both Dayr 'Ayn 'Abāṭa and the Petra Church site are Early Roman upcasts unrelated to either church's use; their composition reflects a

non-Levantine sand source (grey circle). However, four samples, all from Dayr 'Ayn 'Abāṭa's Group 2, seem to fit with neither group (dotted black circle). EPMS analysis of the glass from here clearly indicates a preponderance of Levantine I (DAA Group 1 in FIG. 6), which of course was made from imported raw glass. The point here is that the much smaller DAA Group 2 is made from raw glass not normally used by Nabataean workshops. Unlike the cathedral at Petra, then, there is a strong likelihood that at least some of the glass at the monastic pilgrimage site travelled a long distance from where it had been worked.

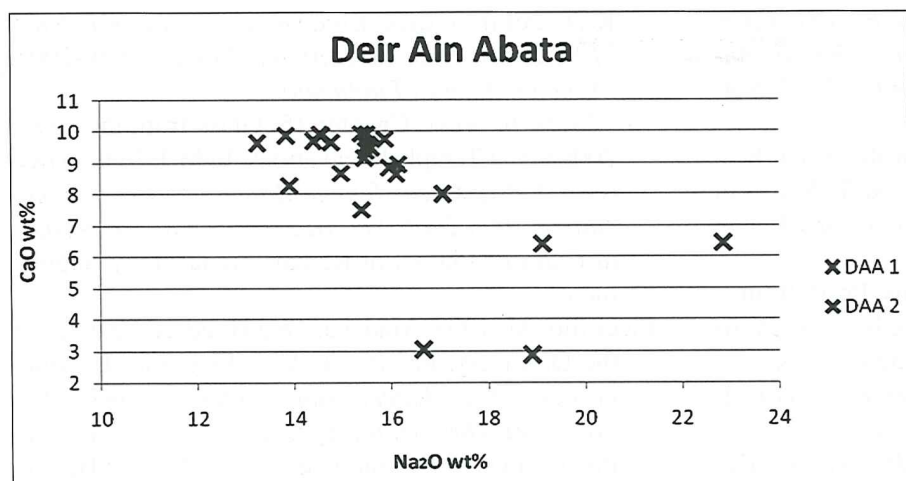


4. Two compositional groups can be identified from the Petra Church, based on their soda and lime contents.



5. Compositional analysis of alumina and calcium oxides, indicating clusters of glass which share the same sand-source.





6. Two compositional groups can also be identified at Dayr 'Ayn 'Abāṭa, based on their soda and lime contents.

### Conclusions

When combined with a survey of their forms, chemical analysis of the glass from the churches at the monastery of St. Lot and in the heart of Petra hint at different histories for their acquisition. Despite the likelihood that it was an episcopal see, the Petra Church seems to have relied on locally-supplied glass donations from its community, whereas at least some of the monastic church's lamps were acquired either through visiting pilgrims or through long-distance connections established by its abbots. What and where those connections were is, at present, anyone's guess.

What also sets the monastery of St. Lot apart from more 'normal' Levantine ecclesiastical basilicas (including the Petra Church) is the relative scarcity of window panes here. Far too few panes have been retrieved from the entire site to have ever filled in its windows, even when we take into account the difficulty in identifying so-called 'crown' glass – in reality, simply shallow, blown plates – or the fact that a considerable amount of the building has simply collapsed down the hillside. There are at least 47 circular panes, totalling 209.9gm, or a fifth of 1kg, plus another 60.5gm of rectilinear glass. Note that the 4th century provincial bath-house in Oxyrhynchus required 1920kg of glass, most of which would have been window pane. The majority of the panes at St. Lot came from a dump heap used by subsidiary monastic buildings rather than from the church itself, although circular panes were retrieved from there. But small fragments of thin calcite slabs within the church and its immediate environs suggests that perhaps many of the basilica's windows were closed by thin sheets of stone rather than glass, just as they were in imperial buildings at

Ravenna. It serves yet again to reinforce the differences between the endowment and use of glass in a Levantine pilgrimage church from that in an urban cathedral situated less than 90 km to its south.

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