Andrews, Tara L. 2025. "Byzantine Sigillography, Linked Open Data, and the Structured Assertion Record," in "Approaches to Medieval Sigillography," ed. Martina Filosa, Claes Neuefeind, and Claudia Sode, special collection, *Digital Medievalist* 18(1): 1–24. https://doi.org/10.16995/dm.16708.

Byzantine Sigillography, Linked Open Data, and the Structured Assertion Record

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One of the major challenges in the creation of a digital dataset for cultural heritage objects is the question of how to capture the differing interpretations and the changing state of our knowledge about the objects we are seeking to document and preserve. This article discusses a case in point, namely the thousands of Byzantine lead seals that survive in museums and private collections today. The seals are an important source of information and insight into a society whose copious administrative records we have by and large lost; their correct decipherment and interpretation, however, requires a particular expertise that few in the field possess, and the need for a more or less central source of information about these seals has been acknowledged for many years now. As part of the Prosopography of the Byzantine World (PBW) project, a database was created that aimed for as complete a coverage as possible of all seals dated to the eleventh and twelfth centuries, including an innovative organization of the seals according to the boulloterion (die) from which a particular seal was struck and a link between the boulloterion and its owner. The strength of this database is that it is a rich collection of sigillographic data unparalleled elsewhere; the weakness is one shared with almost every digital database in the historical sciences, specifically, that it presents a single interpretation of the data when multiple interpretations are possible.

The aim of the RELEVEN project has been to re-think how databases of historical information are structured; its central innovation is the "structured assertion record" (STAR) model, which is a Linked Open Data model based on the CIDOC-CRM standard. Here we discuss how the STAR model has been applied to the PBW seals database to express the information in a CIDOC-CRM-conformant way, and also to preserve information in all cases about who has made a particular interpretation of the data and what source material was used for the interpretation.

L'un des principaux défis dans la création d'un ensemble de données numériques pour les objets du patrimoine culturel réside dans la question de savoir comment capturer les interprétations divergentes et l'évolution de nos connaissances sur les objets que nous cherchons à documenter et à préserver. Cet article aborde un exemple concret : les milliers de sceaux byzantins en plomb qui subsistent aujourd'hui dans les musées et les collections privées. Ces sceaux constituent une source importante d'informations et de compréhension sur une société dont nous avons en grande

partie perdu les abondants registres administratifs ; leur déchiffrement et interprétation corrects nécessitent toutefois une expertise particulière que peu de spécialistes possèdent. Depuis de nombreuses années, le besoin d'une source d'information centralisée sur ces sceaux est reconnu. Dans le cadre du projet « Prosopography of the Byzantine World » (PBW), une base de données a été créée pour couvrir aussi complètement que possible tous les sceaux datés des XIe et XIIe siècles. Cette base intègre une organisation novatrice des sceaux selon le « boulloterion » (matrice) à partir duquel chaque sceau a été frappé, ainsi qu'un lien entre le « boulloterion » et son propriétaire. La force de cette base de données réside dans sa richesse en données sigillographiques, sans équivalent ailleurs ; sa faiblesse, en revanche, est partagée par presque toutes les bases de données numériques en sciences historiques : elle présente une interprétation unique des données, alors que plusieurs interprétations sont possibles.

L'objectif du projet RELEVEN a été de repenser la structure des bases de données d'informations historiques. Son innovation centrale est le modèle « structured assertion record » (STAR), un modèle de données ouvertes liées basé sur la norme CIDOC-CRM. Nous discutons ici de l'application du modèle STAR à la base de données des sceaux du PBW pour exprimer les informations conformément à la norme CIDOC-CRM, tout en conservant dans tous les cas des informations sur qui a fait une interprétation particulière des données et quelles sources ont été utilisées pour cette interprétation.

Background: The challenge of Byzantine sigillography

§ 1 At the International Congress of Byzantine Studies in 2006, Michael Jeffreys presented a major scholarly work then in progress: the "seals" module of the Prosopography of the Byzantine World (Jeffreys 2009). As of its latest version, released in 2016, this module contains information about more than 10,000 seals held in over 250 public and private collections around the world, primarily dating to the eleventh and twelfth centuries with a few from the late tenth and the thirteenth.

§ 2 The value of such a resource is hard to overstate. For all that the eastern Roman empire was a literate society and bureaucratic state, very little survives—even in comparison to the medieval West—of the documents, charters, reports, or all sorts of other texts that were produced and that would, if we had them, elucidate so much more about how the society worked than we can possibly recover now. One of the most evident remnants of this vast number of disappeared documents is the seals that were used to authenticate them. These seals could be made out of a variety of material, including wax, gold (for imperial seals), or silver, but the vast majority of surviving Byzantine seals are made of lead. Lead seals were used by people of almost all social classes, including imperial officials, most ranks of clergy, and tradesmen (Nesbitt 2008, 150–151); they could be used in both private and public contexts, not only to authenticate documents, but also to seal them in the sense of closing off the contents from access by a third party (Oikonomides 1983, 147).

§ 3 The vast majority of the seals we have, therefore, are no longer attached to the documents that once bore them. This means that the only information we have is that carried on the seal itself. In the Byzantine context, this would often have included—beyond the name of the bearer—an invocation, one or more official titles, or both (e.g., "Lord aid your servant/Ioannes, by the grace of God archbishop of Gothia" [B6281]), and in many cases an image such as a cross or the visage of a particular saint. The first task of the sigillographer is naturally the decipherment of the inscription on the seal and the identification of any image it bears; it may result that identical seals have been found and published in other catalogues, which can help this process. Once the seal is deciphered, then the more tentative work begins: who issued the seal, and what is its approximate age? Can we identify the person named in the inscription with any person mentioned in other sorts of sources, such as narrative histories or archive documents, and do we possess any other seals that are likely to have been issued by the same person? It is this latter point where the wording of invocations to Christ, the Virgin, or particular saints, and their images, are often helpful; since particular people often tended to favour particular holy figures, the similarity on these points between different specimens can help to confirm, or call into question, the ownership of the

seal. (See for example the presence of St. Peter on several seals of Hervé Frankopoulos, Seibt 2010; or the use of the figure of St. George to establish the identity of Sahak Brachamios, Cheynet and Vannier 1986.)

Digital models for Byzantine sigillography

§ 4 One of the most interesting aspects of the PBW "seals" module, and perhaps its defining feature, is the organization of sets of seals according to the *boulloterion* that produced them. A boulloterion is the pincer-shaped device with a die for each side of the seal to be produced that was used to imprint the lead blanks and compress them around the sealing string of the document. Even though it was barely mentioned as such by Jeffreys himself in the publication that arose from the 2006 Congress, the significance of this innovative organization of the seal data is difficult to overstate.

§ 5 The concept of publishing an edition of a boulloterion, as opposed to an edition of an individual seal, perhaps goes back to Oikonomides. In 1983, he did exactly this for four sets of identical seals in varying states of preservation, examining the specimens as a whole to produce a reconstruction of the decoration, iconography, and inscription of each of these seals (Oikonomides 1983). Within the PBW database, Jeffreys took the editorial approach of Oikonomides to a natural conclusion; in so doing, he and his collaborators invested a massive amount of scholarly work in finding and reconciling publications of seals in order to provide a data source that, to the best of their information and knowledge, reflected the current state of scholarship concerning seals that were produced in the eleventh and twelfth centuries, the devices that produced them, and the owners of those devices.

§ 6 This is not to say that other online resources ignore the question of whether seals are identical, or fail to make relevant links. The Dumbarton Oaks online catalogue is precisely a counterexample. Here, as in most print catalogues and as is the traditional way, the primary object of data organization is the seal itself, and the inscription published is that of the individual seal, not the boulloterion. The seals are, however, linked to other seals under two separate headings: the "parallel" seals for those that are believed to have come from the same boulloterion, and "similar" seals for those that are believed to have come from a different boulloterion, but belonging to the same person in a similar role. Moreover, the Dumbarton Oaks catalogue makes use of the PBW database by adding a reference where possible to the PBW ID of the owner of the seal.

§ 7 These data collections are both impressive in their thoroughness; however, as they stand, certain desiderata remain. The first issue that might be raised is that neither database provides an API for machine queries, nor any means of export for the data they hold into a structured or machine-readable format. At least in the case

of PBW, this is not a question of restriction of rights, as all data on that site is made available under a Creative Commons license. In both cases, the lack of aggregation or export functionality is unfortunate for anyone who might wish to carry out analyses over the entire set of seals data.

§ 8 Even if an API were implemented tomorrow on both sites, we would then encounter the second disadvantage, which is that each collection uses its own bespoke data model. While these models are legible enough to a human user, they again present a barrier to large-scale or automated analysis insofar as the human user must reconcile the two systems of expression of information and account for any disjointness. To our knowledge, two efforts have been made towards the creation and publication of a wider data standard for sigillography: these include the work of the DigiSig project, which focuses rather on wax seals of the medieval West (McEwan 2018), and the development of SigiDoc, an encoding standard based rather on TEI XML (Sopracasa and Filosa 2020). It is also worth mentioning the work currently undertaken by the DigiByzSeal project, which aims to create an overarching search portal for Byzantine lead seals, backed by SigiDoc XML, with the provision of APIs and implementation of LOD protocols (Sopracasa et al. 2024, in this volume).

§ 9 The CIDOC Conceptual Reference Model (CIDOC-CRM) provides another compelling means for a solution to this problem (Bekiari et al. 2021). CIDOC-CRM is an ontology—a formal definition of entities (things, whether concrete or abstract) and their properties (relations between the things, and data associated with the things such as measurements) that was developed in the context of cultural heritage and museum data collections. While the CIDOC-CRM is well-enough established as a standard that it was adopted as an ISO standard already in 2006 and has had two official revisions since, and it is growing quickly in terms of its areas of application to handle the representation of data from ever more fields in the humanities, its origins in the museum sector mean that the data model is particularly well suited to describing objects, such as seals and the boulloteria that produce them; it is therefore a little surprising that the more recent data models have not adopted the CIDOC-CRM framework. A fruitful way forward could thus be found by mapping the existing data models into a CIDOC-CRM conformant expression and releasing the resulting Linked Open Data collection for public search and query.

§ 10 This work would then leave us with at least one remaining issue, which was alluded to by Jeffreys as one of the main rationales for the creation of the PBW "seals" module, but which has remained a desideratum for more or less all digital collections of cultural heritage information since the databases first began to be developed. He observes that "editions of even the greatest of past sigillographers may go out of date

and need correction" (Jeffreys 2009, 21) and expresses his aim for the PBW information to reflect the current—as of 2007—consensus of scholarship on the seals that have so far been published.

§ 11 The trouble is then apparent: new seals have continually been published, and conclusions of old publications have continued to be overturned, during the intervening seventeen years. Apart from the references to PBW where applicable, the Dumbarton Oaks online catalogue appears to contain only internal links to other seals in its own collection; it is not clear when, how, or even whether updates based on newer scholarship are incorporated. PBW itself presents the best efforts of its editors to arrive at the conclusions they deem most likely, and provides a bibliography for each boulloterion of the publications that informed its addition to the database, but it is likewise not updated, and the scholar who uses the database must refer separately to the bibliography in order to understand how conclusions were reached.

Lead seals and the CIDOC-CRM

§ 12 Let us first deal with the issue of data standard. For the particular case of lead seals, CIDOC-CRM is a very suitable base vocabulary. A seal and its boulloterion are two different sorts of `E22 Human-Made Object`; the two faces (the obverse and reverse) of the seal and the boulloterion are instances of `E25 Human-Made Feature`. Such an object can be linked to an `E36 Visual Item` (e.g., figural images on the seal, or border decorations) and an `E34 Inscription` (any text on the seal). Moreover, the boulloterion can be linked to a seal it produced via an `E12 Production` event, with a `P16 used specific object` property pointing to the boulloterion and a `P108 has produced` property to indicate the seal. Since CIDOC-CRM is a heavily event-oriented ontology, and dates belong to events rather than directly to people or object, we also use the `E12 Production` event to record the dating of the seal (that is, the date range during which the stamping of the seal with the boulloterion is thought to have taken place). We can also define a shortcut property, `L1 was used to produce`, for a simplified expression when we wish to link the boulloterion to the seal but cannot specify when or where the production took place. In order to adapt the base definition of CIDOC-CRM for our purposes, we can create a small ontology that defines our shortcut property and also explicitly defines *boulloteria* and seals as distinct objects, each of which is a subclass of `E22 Human-Made Object`. A graphic of our small ontology is given in **Figure 1**.

§ 13 **Figure 2** demonstrates how a seal of Maria/Marem, daughter of Gagik of Kars (Spink 1999, #120), would be represented in our CIDOC-CRM adaptation. Since the auction catalogue makes no mention of *boulloteria*, we limit ourselves in this first instance to information given in the catalogue about the seal itself.

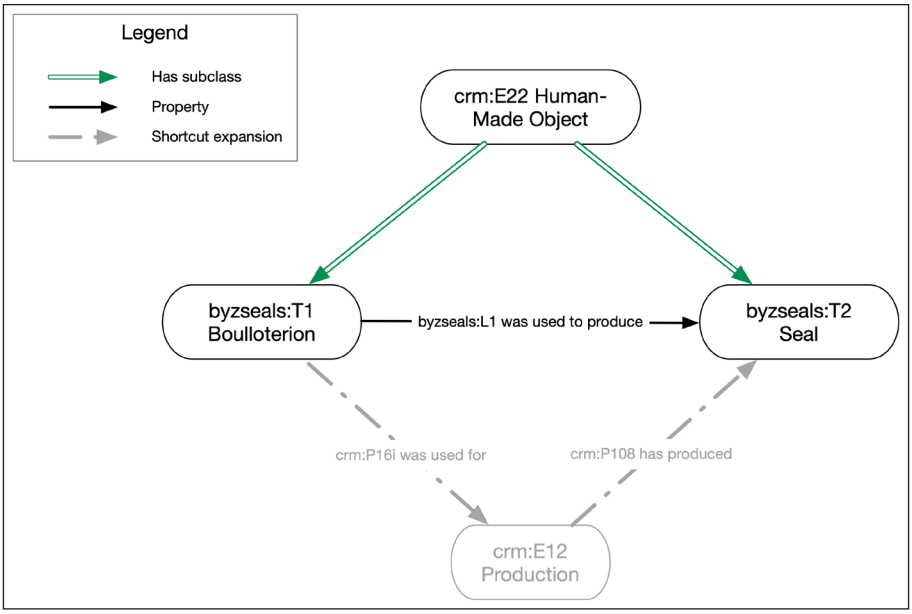

Figure 1: An adaptation of the CIDOC-CRM to the case of Byzantine lead seals. See Appendix for formal definition.

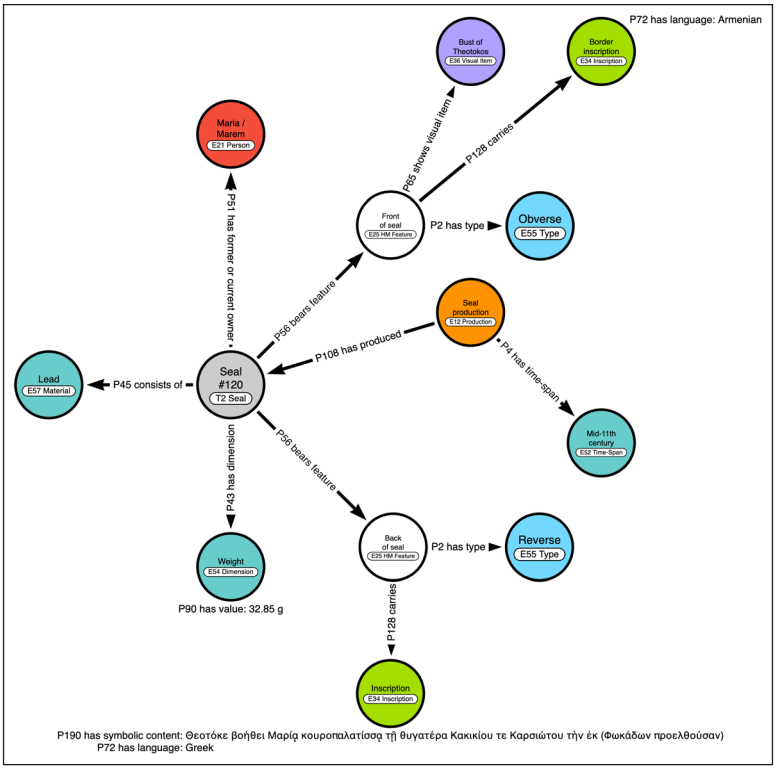

Figure 2: The seal of Maria kouropalatissa, daughter of Gagik of Kars, represented according to CIDOC-CRM. The complete RDF definition can be found in the appendix.

§ 14 This example can also be used to clarify the simple subject–predicate–object structure of statements made through ontologies and how these predicates can be read as somewhat clunky transitive verbs. We can say that the seal `P51 has former or current owner` Maria; while the property is arguably somewhat misleadingly named, we use it because it is a defined shortcut in the ontology for an `E8 Acquisition` event that we cannot further describe with the information we have. The seal `P45 consists of` its material, which is lead; it also has a weight listed, represented with `P43 has dimension`. The seal `P56 bears feature` its obverse and reverse, where the obverse `P128 carries` an inscription and `P85 shows visual item` the bust of the Theotokos. Likewise, the reverse, also connected to the seal via `P56 bears feature`, `P128 carries` another inscription. Finally, we can document the date of the seal via an `E12 Production` event, which has a time span of the "mid-eleventh century." Although this is not represented in **Figure 2**, it is easy to make additional statements, for example, about the inscriptions—each inscription can take a property `P72 has language` whose value is the name of the language it appears in, a property `P190 has symbolic content` whose value is the transcribed text of the inscription, and a property `P73 has translation` whose value is an object that, in turn, possesses its own language and symbolic content.

§ 15 This particular seal also appears in the PBW database; as such it has been associated with a boulloterion ID (Jeffreys et al. 2016); the information published about the seal has become, in PBW, information about the boulloterion itself. This is the only seal that is recorded in PBW as having been produced by that boulloterion. An expanded diagram that shows the addition of the boulloterion information to the information derived from the Spink catalogue is given in **Figure 3**. In addition to the information we have already modelled in **Figure 2**, we may begin by saying that the inscription and the visual element recorded for the seal is identical to the inscription and visual element to be recorded for the boulloterion—that is, the obverse and reverse of the boulloterion carry respectively the same inscriptions and visual elements as the obverse and reverse of the seal. We can also make a link between the boulloterion and the `E12 Production` of the seal, by claiming that the production `P16 used specific object` the boulloterion.

§ 16 The astute observer may notice that we now have a dilemma. On the one hand, following the logic of assigning seals to their boulloteria, it stands to reason that the image and inscription associated with the seal are identical (conceptually) to the image and inscription associated with the boulloterion. On the other hand, the record in PBW has been slightly altered from that in the catalogue, in that the abbreviation "ΜΡ ΘΟΥ" (μήτηρ θεοῦ, "mother of God") on the obverse, unremarked by the cataloguer, has been

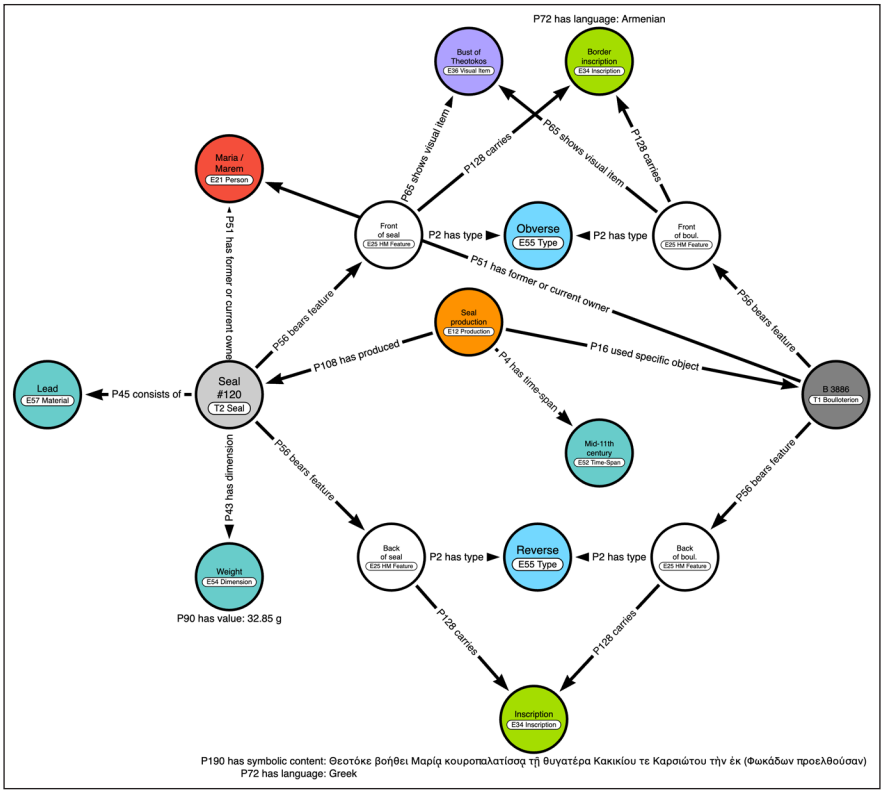

Figure 3: The seal of Marem, with boulloterion information added.

expanded and included by Jeffreys in his transcription. Jeffreys has also removed the parentheses from "Φωκάδων προελθοῦσαν" ("descendant of Phokas"), suggesting that the reading is more secure than perhaps the cataloguer intended.

§ 17 A further quandary is posed by the subsequent publication of a note concerning this seal, proposing that "hinter der rätselhaften Ligatur Pi-Rho könnte 'Bagratuni' stecken" (Seibt 2000). This proposition throws the already uncertain reading "Φωκάδων προελθοῦσαν" into question, though without fully proposing a replacement. How then should the uncertainty surrounding this reading be recorded in our structured data?

Structured assertion records for seals

§ 18 This issue, that of data provenance and the desirability of noticing and accounting for differences of opinion about the evidence we have, brings us to the RELEVEN project and its STAR data model. The broader aim of RELEVEN is to cast a clearer light on the connections between people, the places they inhabited, and the

texts they produced in the Christian world, especially its eastern half, in the "short eleventh century" (ca. 1025–1095). One of the major methodological challenges faced for this period is exactly that presented by scholarship on Byzantine lead seals: to wit, the scholarly consensus is subject to frequent change on the basis not only of new information, but of re-interpretation of existing information. This gives rise to the clear risk that the historical information gathered and published in more or less any usual data model will not only be out of date as soon as the project ends, but that the scholar who uses the data will not have an adequate way of identifying which information must be re-evaluated—that is, they will be unable to trace the provenance of individual pieces of information. In the Dumbarton Oaks online collection, for example, even if readings are updated according to newer scholarship, the reader would not be aware that it happened, much less on what basis or according to whose opinion.

§ 19 PBW as a whole is based on the concept of factoids, which should in theory help with the provenance issue. Briefly, a factoid database is one that includes only information that is expressly taken from primary sources, such as texts and seal inscriptions, in which interpretation of the evidence is kept to a minimum (Bradley and Pasin 2015). On the whole, this is a methodological improvement on the design of a database as a collection of unsourced and unprovenanced information, which is by far the most common way they are used, and still very common in humanities projects. This "simple" usage of databases gives rise to a host of problems throughout the cultural heritage sector when the contextualization of the objects being treated is discarded (Kahn and Simon 2020). The factoid approach can, however, leave the scholar who uses it open to the charge of what Eyers calls "neo-positivism" (Eyers 2013), insofar as primary-source statements are represented uncritically and no statement is recorded that is not directly backed by any source (Baillie 2021). Insofar as those who use digital methods for the humanities frequently have to contend with charges that we are overly positivistic and insufficiently critical in our data collection (Drucker 2012; Fuchs 2017), this is a problem that is in increasingly urgent need of a solution. The problem is magnified by the fact that ontologies tend to be designed to represent positive statements, and ontological reasoning is backed by an "open-world assumption" in which a proposition may be true even though it is not explicitly stated. For example, if an ontology specifies that a Parent is a Person who has one or more Children, the presence of a Person with no children will not lead a reasoner to conclude that this Person is not a Parent. The possibility will rather be held open that the Children have not yet been added to the dataset. This fundamental principle of ontological reasoning frequently leads to situations where it can be very complex and difficult to express a negative statement, such as "this event never happened"

or "this person never existed," and so it is all too easy for these data collections to become positivistic in the most literal sense.

§ 20 An attempt to address this problem for collections of historical data is at the heart of the RELEVEN project. Our approach is to organize our data in terms of *assertions* rather than facts or even Bradley and Pasin's factoids. All of our data points are in the form of "structured assertion records" (hence STAR), which are Linked Open Data (LOD) objects defined according to CIDOC-CRM and compatible vocabularies. A STAR assertion begins from a typical LOD statement consisting of a subject entity, an object entity or value, and a typed property (predicate) that links them. To this we add information about authority (that is, who has made the assertion) and evidence (on what basis it is made). We also keep track, in the case where we are recording assertions made by other scholars, from which publication the assertion arises.

§ 21 To do this, we reify the predicate and express the assertion as a CRM `E13 Attribute Assignment`. The definition for `E13` specifies properties to link it to its subject, predicate, and object via the properties `P140 assigned attribute to`, `P177 assigned property of type`, and `P141 assigned`, respectively. Since an `E13 Attribute Assignment` is a subclass of `E7 Activity`, we may add the information about the authority for the assertion via the property `P14 carried out by`, and the evidence via `P17 was motivated by`. The assertion is then linked back to its source in the scholarly record (an `E31 Document`) via the `P70 documents` property. An illustration of a statement in our vocabulary concerning Marem's seal, and its STAR equivalent, can be seen in **Figure 4**. We record, first of all, that the information for this assertion is taken from the PBW record for Boulloterion #3886. We know from that record that the seal we are describing was published in the Spink sale catalogue as item #120; we know from the bibliography of seal editions given on PBW that all assertions about the boulloterion itself were made by Jeffreys. We can likewise create assertions about the dating,

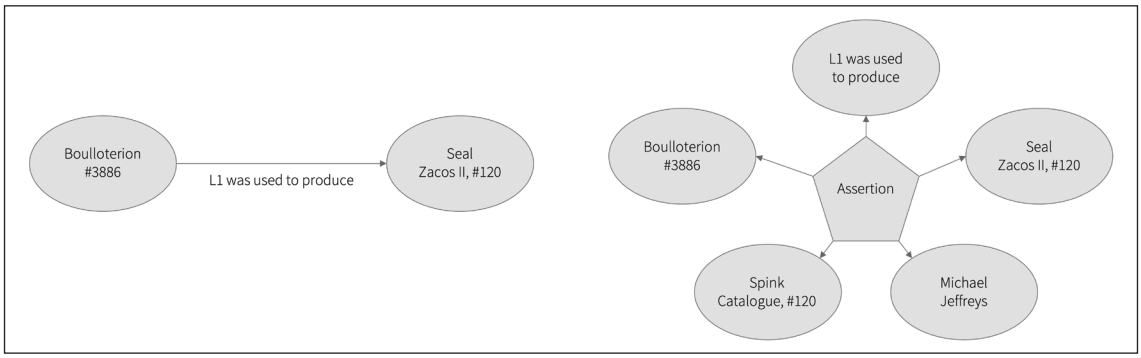

Figure 4: A simple LOD statement; the same statement with authority and provenance information in the STAR model.

dimensions, and features of the seal (according to the Spink cataloguers, of whom Cheynet was one, based on their reading of the seal itself) and about the features thus carried on the boulloterion (according to Jeffreys, based on the Spink catalogue).

§ 22 In an early stage of the RELEVEN project, we tested our data model by carrying out a large-scale automatic conversion of the eleventh-century data in PBW, including the seals module, into a STAR model representation. While we have not, thus far, added further information to most of the seals that are represented than can be found in PBW, our conversion efforts make it possible to access the seal data in a machine-queryable format, using a vocabulary that is aligned with the current standards for cultural heritage objects.

Tracing claims with the STAR model

§ 23 Even if the RELEVEN project has yet to take full advantage of the possibility, the STAR approach to data modelling allows for a much deeper data modelling of the scholarly conversation about seals, groups of seals, and *boulloteria*. Let us review the provenance of the information we have thus far collected about the seal of Maria *kouropalatissa*.

§ 24 Our description of the seal and identification of its owner appears in the Spink catalogue and should evidently be attributed, at least in part, to Jean-Claude Cheynet (Spink 1999); this is the source that Jeffreys has referenced for his publication of the boulloterion.

§ 25 The transcription given on PBW differs slightly from the one given in the Spink catalogue: brackets that denoted uncertainty of reading on the reverse have been removed, and the abbreviation on the obverse has been included.

§ 26 In a note responding to the publication of this catalogue, *inter alia*, Seibt posited that a pi-rho ligature appearing on the seal may suggest the family name Bagratuni (Seibt 2000).

§ 27 If we decompose the information we have gathered into its constituent assertions, we can say that the Spink cataloguer (probably Cheynet, given the acknowledgment in the front matter, but this is not stated explicitly) has produced the following assertions based on the seal itself (represented here in English and in LOD statements; it often happens that simple English statement must be translated into multiple LOD statements, as we will see).

- The seal is of lead.

  ```
  :Seal_120 crm:P45_consists_of :Lead .
  ```

- The seal weighs 32.85 grams.

```
:Seal_120 crm:P43_has_dimension :Weight .
:Weight crm:P90_has_value "32.85 g"
```

- The seal carries the figure of the Virgin on the obverse.

```
:Seal_120 crm:P56_bears_feature :Seal_front .
:Seal_front crm:P65_shows_visual_item :Theotokos_bust .
```

- The seal contains an Armenian inscription (untranscribed) on the obverse.

```
:Seal_front crm:P128_carries :Obv_Inscription .
:Obv_Inscription crm:P72_has_language :Armenian .
```

- The seal carries the longer inscription on the reverse.

```
:Seal_120 crm:P56_bears_feature :Seal_back .
:Seal_back crm:P128_carries :Rev_Inscription .
:Rev_Inscription crm:P72_has_language :Greek ;
                 crm:P190_has_symbolic_content "Θεοτόκε βοήθει Μαρίᾳ
κουροπαλατίσσῃ τῇ θυγατέρα Κακικίου τε Καρσιώτου τὴν ἐκ (Φωκάδων
προελθούσαν)" .
```

To this we can add the following assertion of the cataloguer, based both on the text of the seal and on the colophon of an Armenian manuscript, dated to 1077–1078 but not otherwise identified:

- The seal should be dated to the middle of the eleventh century.

```
:Stamping crm:P108_has_produced :Seal_120 ;
          crm:P4_has_time-span :Dating .
:Dating crm:P82_at_some_time_within "mid 11th century" .
```

- The seal belonged to Marem/Maria, daughter of the last king of Kars Gagik.

```
:Seal_120 crm:P51_has_former_or_current_owner :Maria .
```

§ 28 To transform these statements into assertions, we connect each one to its own `E13 Attribute Assignment`. We then connect each assertion entity to its authority (the cataloguers including Cheynet) and to its evidence (the seal itself) using the appropriate properties as described above, to obtain a graph. A short example is given in **Figure 5**, which illustrates the construction of one assertion from each group. The fuller graph would have many more assertions and thus be unwieldy to display here; however, the general idea should be clear.

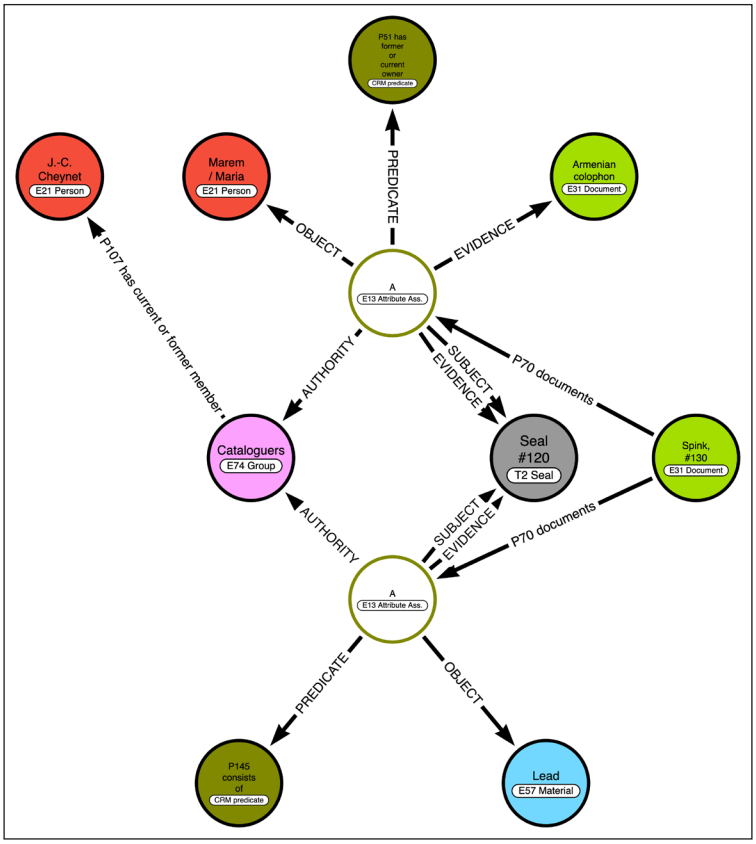

Figure 5: Two assertions taken from the Spink catalogue. The CIDOC-CRM properties of the STAR assertions have here been replaced with SUBJECT, PREDICATE, OBJECT, AUTHORITY and EVIDENCE respectively.

§ 29 More or less all of these assertions have been adopted by Jeffreys for the PBW database, and he has extended them as follows based on his own reading of the catalogue. For the statements below we may define `pbwboul:` as a namespace abbreviation for the URL prefix `https://pbw2016.kdl.kcl.ac.uk/boulloterion/`; in this way, our data maintains the direct link to its source.

- The seal was produced by a specific boulloterion.

  ```
  :Stamping crm:P16_used_specific_object pbwboul:3880 .
  ```

- The boulloterion carries the figure of the Virgin, the Armenian inscription, as well as the abbreviation "ΜΡ ΘΟΥ" on the obverse.

  ```
  pbwboul:3880 crm:P56_bears_feature :Boul_front .
  :Boul_front crm:P65_shows_visual_item :Theotokos_bust ;
              crm:P128_carries :Obv_Inscription ;
              crm:P128_carries :Obv_Inscription2 .
  ```

```
:Obv_Inscription crm:P72_has_language :Armenian .
:Obv_Inscription2 crm:P72_has_language :Greek ;
            crm:P190_has_symbolic_content "ΜΡ ΘΟΥ" .
```

- The boulloterion carries the longer inscription on the reverse (with no uncertainty expressed).

```
pbwboul:3880 crm:P56_bears_feature :Boul_back .
:Boul_back crm:P128_carries :Rev_Inscription .
:Rev_Inscription crm:P190_has_symbolic_content "Θεοτόκε βοήθει Μαρίᾳ
 κουροπαλατίσσῃ τῇ θυγατέρα Κακικίου τε Καρσιώτου τὴν ἐκ Φωκάδων
 προελθούσαν" .
```

- The boulloterion belonged to Marem/Maria.

```
pbwboul:3880 crm:P51_has_former_or_current_owner :Maria .
```

Assertions can be formed from these statements in the same manner as those above, with the difference that the authority will be Jeffreys, and the evidence will be the Spink catalogue itself. These assertions are documented in the text of the boulloterion entry on PBW.

§ 30 Lastly, we must record a further assertion by Seibt, based on his reading of the Spink catalogue, documented in the issue of *Byzantinische Zeitschrift* (Seibt 2000) already cited:

- The inscription on the reverse should contain the name "Bagratuni" at the end.

```
:Rev_Inscription crm:P165_incorporates :NewReading .
:NewReading a crm:E33_Linguistic_Object ;
             crm:P190_has_symbolic_content "Bagratuni" .
```

Evolution of scholarly consensus with CRM$_{inf}$

§ 31 At this point, the reader may feel a little overwhelmed at the sheer quantity of elements in the graph that are needed to express ideas that seem much simpler, and may with some justification ask, what is actually the added value of such a fine-grained and, quite frankly, complicated representation? Is all this work actually worth it?

§ 32 We would argue, first of all, that the assertion approach is worth it simply for the ability to store and even detect competing interpretations of our historical information. One of the complaints that can be levelled against factoid databases is that, while they are good at providing an overview of what is said in the sources about a particular entity (in the case of a prosopography such as PBW, the entity is generally

a person), they give no insight into what the scholarly consensus is concerning that person's life and career, nor do they make it particularly obvious when consensus is lacking. The great advantage of an assertion approach is twofold: first, that secondary scholarship may be included in the data; and second, that it leaves the way open for finding these points where conflict arises. One of the areas of ongoing work in the RELEVEN project is experimentation with ontological reasoning software to detect where assertions conflict with each other—for example, where readings of a seal inscription differ, or where opinions about the dating of an event differ, or where inconsistent information about personal kinship is recorded.

§ 33 Another more ambitious target, and one whose feasibility we are only beginning to explore, is to represent the evolution of these scholarly conclusions directly in the data. Here a promising possibility is the CRM_{inf} ontology, an extension of the CIDOC-CRM specifically for argumentation (Doerr et al. 2023). Let us sketch out, briefly, a possibility for the application of CRM_{inf} to our assertions.

§ 34 We have seen in the previous section that, while some English statements can be represented with a single assertion, others require multiple assertions in the CIDOC-CRM vocabulary. Each set of assertions representing a single statement may be collected into an `I4 Proposition Set`. In our example above, the Spink cataloguer has produced seven such `I4 Proposition Set` objects; each of these is the object (via `J4 that`) of an `I2 Belief` whose `I6 Belief Value` (via `J5 holds to be`) is "true." These beliefs, in turn, are expressed in the `I1 Argumentation` that we find in the Spink catalogue, carried out by the cataloguer.

§ 35 For the PBW record of Marem's boulloterion, we may say that Jeffreys has carried out an `I7 Belief Adoption` of almost all the `I2 Beliefs` produced by the Spink cataloguer, with the possible exception of that concerning the inscription on the reverse. Here, if we wish to be pedantic, we must say that Jeffreys has produced a new `I1 Argumentation` advancing the `I2 Belief` that holds the `I4 Proposition` Set with the new assertion concerning the content of the inscription. Even if we choose to overlook the slight divergence in inscription, we should record an `I1 Argumentation` made by Jeffreys, which encompasses the `I2 Beliefs` (held to be "true") about the `I4 Proposition Sets` concerning the boulloterion.

§ 36 We finally come to the observation of Seibt. Here, there is no question that he is challenging the reading of the Spink cataloguer concerning the inscription on the reverse; we must say therefore that he makes an `I1 Argumentation` encompassing a different `I2 Belief` whose value is "possibly false," pointing to the `I4 Proposition Set` that concerns the Spink cataloguer's reading of the inscription. At the same time, his `I1 Argumentation` advances a new `I4 Proposition` Set with the new partial reading,

which is the object of an `I2 Belief` whose value is "possibly true," and which belongs to the same `I1 Argumentation`.

§ 37 How might such a detailed representation of the structure of historical argumentation actually serve a useful purpose? Certainly one desideratum, if this is ever to be feasible, would be a suitable method for automatic extraction of argument structure (see Lawrence and Reed 2020 for one example) from scholarly texts in our field, perhaps with appropriate use of a large language model adapted to the task. We might also find that the overall structure can be simplified; it is already possible to see a certain redundancy between the authority responsible for a STAR assertion and the originator of an `I1 Argumentation`, and there may be scope for a shortening of the chain from argumentation to belief to proposition to assertion.

A reconciliation system for historical information?

§ 38 Let us end on an optimistic, if ambitious, note. For over a decade now, this author has had a vision for a historical information system that could track the connections between source evidence, interpretation of that evidence, inferences based on those interpretations, assertions drawn from general background knowledge, propositions, hypotheses, and conclusions that rest on all of the above. For centuries, scholars of Byzantine and medieval eastern Christian history in particular have had to rely on the relatively few and often lacunose written histories that have come down to us in a variety of medieval languages, of which the vast majority of scholars read only a few. We may add to this the clues that arise from a very limited number of objects and their inscriptions, of which lead seals are a prime example.

§ 39 In recent decades, we have seen a great deal of new evidence surface, as previously unpublished texts are produced, as archaeologists have become more sensitive to the value of medieval finds at sites of classical interest, and as updated ideas and frameworks are applied to the evidence and sources that we already had. Despite all of this sterling work, the weight of tradition, blind faith in source material, and outdated ideology all retain more of a grip on the field than we always realize, and too many of our initial historical assumptions remain inadequately questioned when we approach a particular topic. The end result is that, even when a new collection of seals or a new translation of a previously inaccessible text is published, the significance of the new evidence can be slow to make its way into our historical understanding. We lack a way to track what we know, what we infer, and upon what evidence our knowledge and inferences depend. It serves simply to imagine the benefit if such a system existed, that could not only take in a new piece of evidence or new interpretation, but detect what inferences, propositions, and conclusions then come into conflict with the new evidence.

§ 40 The most exciting possibility that arises from modelling our data as assertions, and from preserving the source and provenance of the data we have directly within the data store, is the prospect that it brings us a few steps closer to this dream. When we have a way to record different perspectives and different interpretations about the same historical subject side by side, without having to choose one over the other in advance, but with the ability to see what propositions have been supported by whom, the way is even opened for a truly inclusive, multi-perspective, and open means to investigate our history.

Appendix

Ontology definition for Figure 1 – definition of boulloterion and seal

```
@prefix byzseals: <https://r11.eu/ns/seals/> .
@prefix crm: <http://www.cidoc-crm.org/cidoc-crm/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@base <https://r11.eu/data/seals/> .
<https://r11.eu/data/seals> rdf:type owl:Ontology ;
                          owl:imports crm: .
#################################################################
#     Object Properties
#################################################################
byzseals:L1_was_used_to_produce rdf:type owl:ObjectProperty ;
                                rdfs:domain byzseals:T1_Boulloterion ;
                                rdfs:range byzseals:T2_Seal ;
                                owl:propertyChainAxiom (
crm:P16i_was_used_for
crm:P108_has_produced
                                                        ) .
#################################################################
#     Classes
#################################################################
byzseals:T1_Boulloterion rdf:type owl:Class ;
                         rdfs:subClassOf crm:E22_Human-Made_Object ;
                         owl:disjointWith byzseals:T2_Seal .
byzseals:T2_Seal rdf:type owl:Class ;
                 rdfs:subClassOf crm:E22_Human-Made_Object .
```

RDF definition for Figure 2: the seal of Marem of Kars

```
#################################################################
#      Individuals
#################################################################
###    https://r11.eu/data/seals/Armenian
:Armenian rdf:type owl:NamedIndividual ,
                  crm:E56_Language .
###    https://r11.eu/data/seals/Dating
:Dating rdf:type owl:NamedIndividual ,
                 crm:E52_Time-Span ;
        crm:P82a_begin_of_the_begin "1035"^^xsd:positiveInteger ;
        crm:P82b_end_of_the_end "1065"^^xsd:positiveInteger .
###    https://r11.eu/data/seals/Greek
:Greek rdf:type owl:NamedIndividual ,
                crm:E56_Language .
###    https://r11.eu/data/seals/Lead
:Lead rdf:type owl:NamedIndividual ,
               crm:E57_Material .
###    https://r11.eu/data/seals/Maria
:Maria rdf:type owl:NamedIndividual ,
                crm:E21_Person .
###    https://r11.eu/data/seals/Obv_Inscription
:Obv_Inscription rdf:type owl:NamedIndividual ,
                          crm:E34_Inscription ;
                 crm:P72_has_language :Armenian .
###    https://r11.eu/data/seals/Obverse
:Obverse rdf:type owl:NamedIndividual ,
                  crm:E55_Type .
###    https://r11.eu/data/seals/Rev_Inscription
:Rev_Inscription rdf:type owl:NamedIndividual ,
                          crm:E34_Inscription ;
                 crm:P72_has_language :Greek ;
                 crm:P190_has_symbolic_content "Θεοτόκε βοήθει Μαρίᾳ
```

```
κουροπαλατίσσᾳ τῇ θυγατέρα Κακικίου τε Καρσιώτου τὴν ἐκ (Φωκάδων προελθούσαν)" .
###    https://r11.eu/data/seals/Reverse
:Reverse rdf:type owl:NamedIndividual ,
                 crm:E55_Type .
###    https://r11.eu/data/seals/Seal_120
:Seal_120 rdf:type owl:NamedIndividual ,
                  byzseals:T2_Seal ;
          crm:P45_consists_of :Lead ;
          crm:P51_has_former_or_current_owner :Maria ;
          crm:P56_bears_feature :Seal_back ,
                                :Seal_front .
###    https://r11.eu/data/seals/Seal_back
:Seal_back rdf:type owl:NamedIndividual ,
                   crm:E25_Human-Made_Feature ;
           crm:P128_carries :Rev_Inscription ;
           crm:P2_has_type :Reverse .
###    https://r11.eu/data/seals/Seal_front
:Seal_front rdf:type owl:NamedIndividual ,
                     crm:E25_Human-Made_Feature ;
            crm:P128_carries :Obv_Inscription ;
            crm:P2_has_type :Obverse ;
            crm:P65_shows_visual_item :Theotokos_bust .
###    https://r11.eu/data/seals/Stamping
:Stamping rdf:type owl:NamedIndividual ,
                  crm:E12_Production ;
          crm:P108_has_produced :Seal_120 ;
          crm:P4_has_time-span :Dating .
###    https://r11.eu/data/seals/Theotokos_bust
:Theotokos_bust rdf:type owl:NamedIndividual ,
                         crm:E36_Visual_Item ;
                crm:P3_has_note "bust of the Virgin, orans, the medallion of
the Christ child on her breast" .
###    Generated by the OWL API (version 4.5.26.2023-07-17T20:34:13Z)
       https://github.com/owlcs/owlapi
```

Acknowledgements

The RELEVEN project is supported by the European Research Council under the Horizon 2020 research and innovation programme (Grant agreement #101002357). The author also wishes to thank the organizers of the 2023 PROSOPON workshop—Zachary Chitwood, Niels Gaul, and Ekaterini Mitsiou—for the opportunity to present the work that is published here.

Competing interests

The author has no competing interests to declare.

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References

Baillie, James. 2021. "Alternative Database Structures for Prosopographical Research." *International Journal of Humanities and Arts Computing* 15(1–2): 117–132. Accessed October 21, 2024. https://doi.org/10.3366/ijhac.2021.0265.

Bekiari, Chryssoula, George Bruseker, Martin Doerr, Christian-Emil Ore, Stephen Stead, and Athanasios Velios, eds. 2021. "Definition of the CIDOC Conceptual Reference Model." CIDOC-CRM. Accessed October 21, 2024. https://www.cidoc-crm.org/Version/version-7.2.

Bradley, John, and Michele Pasin. 2015. "Factoid-Based Prosopography and Computer Ontologies: Towards an Integrated Approach." *Digital Scholarship in the Humanities* 30(1): 86–97. Accessed October 21, 2024. https://doi.org/10.1093/llc/fqt037.

Cheynet, Jean-Claude, and Jean-François Vannier. 1986. “Les Brachamioi.” In *Études prosopographiques*, 57–74. Paris: Éditions de la Sorbonne. Accessed October 21, 2024. https://doi.org/10.4000/books.psorbonne.1933.

Doerr, Martin, Christian-Emil Ore, Pavlos Fafalios, Athina Kritsotaki, and Stephen Stead. 2023. “Definition of the CRMinf: An Extension of CIDOC-CRM to Support Argumentation.” CIDOC-CRM. Accessed October 21, 2024. https://cidoc-crm.org/crminf/sites/default/files/CRMinf%20v1.0%28site%29.pdf.

Drucker, Johanna. 2012. “Humanistic Theory and Digital Scholarship.” In *Debates in the Digital Humanities*, edited by Matthew K. Gold. Minneapolis: University of Minnesota Press. Accessed October 21, 2024. https://dhdebates.gc.cuny.edu/read/untitled-88c11800-9446-469b-a3be-3fdb36bfbd1e/section/0b495250-97af-4046-91ff-98b6ea9f83c0.

Eyers, Tom. 2013. “‘The Perils of the ‘Digital Humanities’: New Positivisms and the Fate of Literary Theory.” *Postmodern Culture* 23(2 January). Accessed October 21, 2024. https://doi.org/10.1353/pmc.2013.0038.

Fuchs, Christian. 2017. “From Digital Positivism and Administrative Big Data Analytics towards Critical Digital and Social Media Research!” *European Journal of Communication* 32(1). Accessed October 21, 2024. https://doi.org/10.1177/0267323116682804.

Jeffreys, Michael. 2009. “The Seals Module of the Prosopography of the Byzantine World.” *Byzantinoslavica – Revue internationale des Etudes Byzantines* 67(1–2): 17–23. https://www.ceeol.com/search/article-detail?id=199464.

Jeffreys, Michael, et al., eds. 2016. “Maria, Daughter of Gagik of Kars, Kouropalatissa [Boulloterion details].” *Prosopography of the Byzantine World 2016*. Accessed October 21, 2024. https://pbw2016.kdl.kcl.ac.uk/boulloterion/3886/.

Kahn, Rebecca, and Rainer Simon. 2020. “Feast and Famine: The Problem of Sources for Linked Data Creation.” In *Graph Technologies in the Humanities – Proceedings 2020*, edited by Tara Andrews, Franziska Diehr, Thomas Efer, Andreas Kuczera, and Joris van Zundert, 86–100. CEUR Workshop Proceedings. Vienna, Austria: CEUR. Accessed October 21, 2024. https://ceur-ws.org/Vol-3110/#paper5.

Lawrence, John, and Chris Reed. 2020. “Argument Mining: A Survey.” *Computational Linguistics* 45(4): 765–818. Accessed October 21, 2024. https://doi.org/10.1162/coli_a_00364.

McEwan, John Alexander. 2018. “The Past, Present and Future of Sigillography: Towards a New Structural Standard for Seal Catalogues.” *Archives and Records* 39(2): 224–243. Accessed October 21, 2024. https://doi.org/10.1080/23257962.2017.1353412.

Nesbitt, John. 2008. “Sigillography.” In *The Oxford Handbook of Byzantine Studies*, edited by Robin Cormack, John F. Haldon, and Elizabeth Jeffreys, 150–156. Oxford, England: Oxford University Press. Accessed October 21, 2024. https://doi.org/10.1093/oxfordhb/9780199252466.013.0017.

Oikonomides, Nicolas. 1983. “The Usual Lead Seal.” *Dumbarton Oaks Papers* 37: 147–57. Accessed October 21, 2024. https://archive.org/details/DOP37_09_Oikonomides.

Seibt, Werner. 2000. “Kataloge und Beiträge zu Einzelfunden: Auktion Spink (London) 132, 25.5.1999 (Zacos II).” *Byzantinische Zeitschrift* 93: 397.

———. 2010. “Übernahm der französische Normanne Hervé (Erbebios Phrangopolos) nach der Katastrophe von Mantzikert das Kommando über die verbliebene Ostarmee?” In *Studies in Byzantine Sigillography*, vol. 10, edited by Jean-Claude Cheynet and Claudia Sode, 89–96. Berlin: Walter de Gruyter. Accessed October 21, 2024. https://doi.org/10.1515/9783110227055.89.

Sopracasa, Alessio, Jan Bigalke, Numa Buchs, and Sima Meziridou. 2024. “Creating a Sigillographic Search Engine for Byzantium: Preliminary Results.” *Digital Medievalist* 17(1): 1–32. Accessed December 2. https://doi.org/10.16995/dm.15235.

Sopracasa, Alessio, and Martina Filosa. 2020. “Encoding Byzantine Seals: SigiDoc.” In *La svolta inevitabile: sfide e prospettive per l’Informatica Umanistica. Atti del IX Convegno Annuale dell’Associazione per l’Informatica Umanistica e la Cultura Digitale (AIUCD)*, edited by Cristina Marras, Marco Passarotti, Greta Franzini, and Eleonora Litta, 240–245. Milan: Università Cattolica del Sacro Cuore. Accessed December 4, 2024. https://doi.org/10.6092/unibo/amsacta/6316.

Spink. 1999. “Byzantine Seals from the Collection of George Zacos, Part II with Ancient and Gaulish Coins.” *Spink Auction 132*. London: Spink.