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REPORT

RETHINKING SPACE AND POWER IN EAST ASIA: DIGITAL APPROACHES TO THE HISTORY OF INFRASTRUCTURE

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In this report we briefly introduce the rationale behind a pilot project that is meant to serve as a test case for the feasibility of a longue-durée historical investigation of large-scale material infrastructures. The larger project is aimed at a critical analysis of how large-scale infrastructures such as roads, city walls, and bridges have contributed to regional and empire-wide integration, but equally why and how processes of integration regularly broke down, and how large-scale infrastructure projects contributed to countervailing trends including local tension, local autonomy, and cross-border regional formations.

KEYWORDS: *material infrastructure, digital history, city walls, Henan, Shaanxi, Guangdong, local gazetteers*

THE PROBLEM

In varying degrees large-scale infrastructures such as border and city walls, roads, and bridges have shaped the spatial and economic organization, social structure, cultural identities, and power distribution in polities small and large throughout world history. Accounts of Chinese history rightfully equate the construction of wall, road, and canal systems in the last half of the first millennium before the common era with the creation of a durable blueprint for Chinese empire-building. The dynasties ruling after the Qin and Han empires rebuilt and expanded them, according to existing scholarship in the initial stages of consolidation, but also throughout their reign in centrally orchestrated waves of construction and restoration to face external and internal threats.

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Yet, as Roger Des Forges observed in one of the many case studies of city wall building, "To date, however, we have had no systematic explanation of the pattern of wall building over the entire course of Chinese history from early times to the present."[1] Des Forges took aim especially at a master narrative of modernization, namely, the idea that walls are symbols of pre-modern or feudal society, and a closed, traditional empire; and, were therefore deemed to have been continuous and ubiquitous in the Chinese past. The corollary to this idea holds that the tearing down of these walls in the early and middle decades of the twentieth century represented the leveling power of industrializing republics.

The problem of general histories of wall construction as well as other large-scale infrastructures is that they are largely based on centrally issued orders and present-day assumptions about the nature, durability, and efficacy of historical infrastructures. For example, Tonio Andrade, following Ronald Knapp and Roger Des Forges,[2] hypothesized that the Chinese did not build large cannon because city walls were too thick; cannon would have been useless. In contrast, the thinner and dilapidated walls of European cities made their development there worth the investment. Even though the case of European military innovation can now be made on the basis of comprehensive datasets about warfare, the same cannot be said of the features of city walls and other infrastructure. In contrast to assumptions that Chinese walls were uniformly formidable structures distributed throughout the Chinese landscape, archaeological reports and local historical records suggest that there was considerable variance in the materiality, size, and even the existence of Chinese walls, roads, and bridges across time and space. A GIS dataset I compiled based on a thirteenth-century private field report, for example, showed that most counties in the Huai and Yangzi regions then had no walls or only defunct ones.[3] Similarly, if we read between the lines in Ming case studies such as Desmond Cheung's partial investigation of town walls in Henan Province, it becomes evident that just prior to the promulgation of a central order for the construction of long walls and city walls in 1449, "cities [in Shandong and Henan] were … largely without walls and moats, and those that existed were in disrepair."[4]

When studies of Chinese roads, walls, or bridges[5] and existing datasets delve deeper into thicker historical descriptions of walls or archaeological reports, they focus on only one or two of these infrastructures, on individual case studies, or on disparate evidence from various regions. Through a systematic mapping of historical texts, and eventually archaeological reports and photographic materials, we aim to lay the groundwork for a multi-layered, multi-perspectival, and multi-scalar digital history of infrastructures covering the extent of the Chinese territories and border zones across time. Below we briefly outline the contours of the methodology we devised for the pilot project on wall construction in Henan, Shaanxi, and Guangdong from the Song through the Ming dynasties. We also offer some critical reflections on the difficulties we faced and some adjustments we made or plan to make going forward. And so, this short report should primarily be read as a digital historical field report inviting expressions of interest and critical reflection, and not as a preliminary report of historical findings.

Towards A Critical Digital History Of Large-Scale Infrastructures

The main goals of the pilot project were twofold. First, we wanted to examine whether we could map the appearance and disappearance of large-scale infrastructures across the Chinese and neighboring territories between 1000 and 1900 by digitally annotating the extant textual record. Secondly, we also aimed to explore whether we could derive new and meaningful historical insights through spatial analyses of the distribution of particular features of these infrastructures, their construction, maintenance, breakdown, uses, and cultural meanings. We selected three provinces with different locations and topographies: Shaanxi bordering on the western periphery included desert, mountains, the loess plateau, and riverine terrain; Henan constituting part of the North China Plain; and Guangdong on the southern coast boasting a long coastline and the Pearl River Delta. By selecting these three different locations we also aimed to test whether the project might allow us to draw the study of material infrastructure into local and regional histories of social and political practice as well as their relation to empire-wide and cross-border dynamics.

Source Identification

Construction projects are described in a range of sources including court archival compilations (*shilu* 實錄), comprehensive gazetteers (*yitong zhi* 一統志), and the collected writings of individuals (*wenji* 文集), but given that a broad range of documentation about wall projects can be found in local gazetteers we opted to first collect and explore materials on wall construction in the large (but still vastly incomplete) electronic database of 4,000 gazetteers (*Zhongguo fangzhi ku* 中國方志庫).[6] With the support of the Max Planck Institute for the History of Science, and making use of the LoGaRT platform[7] under development there, we first collected references to city walls through a series of keyword searches. The spatio-temporal visualization of search results allowed for an intuitive comparison of the total number of gazetteers included in the database and the number of gazetteers in which relevant search results could be found.

Our review of the research results further revealed that more extensive records on walls and wall construction tended to appear in particular gazetteer sections, especially sections such as "walls and moats" (*chengchi zhi* 城池志) and "literary arts" (*yiwen zhi* 藝文志); when faced with overwhelming number of hits, such a preliminary review can be used to focus search results in LoGaRT on those appearing in the most relevant gazetteer sections. For the three selected provinces, we searched 98 gazetteers (not including Qing and later gazetteers) and collected the full text of all relevant records (282 files) from the 81 gazetteers that contained relevant records (30 for Shaanxi, 23 for Guangdong, and 28 for Henan).

The structure and information included in such records varies according to the administrative level covered in the gazetteer (with county gazetteers typically including more detail than prefectural or provincial gazetteers) and changes over time (with Ming records becoming more extensive). Because the order in which information is organized can furthermore differ among gazetteers of the same subgenre, we decided to focus the pilot on a careful analysis of these complex records and created a separate file for each continuous record. We included the metadata in the name of each file (full gazetteer title, *juan* number, section title, and, in the case of full inscriptions (*ji* 記), inscription title). In cases where multiple walls in different locations were mentioned, we divided the full text into separate divisions or paragraphs — given that in the pilot the method of annotation focused on walls as entities this strategy allowed us to differentiate between the main data points and group all annotations within a paragraph under the main entity.

DIGITAL TEXT ANNOTATION

With the research questions and text corpus well defined, we used digital text annotation in MARKUS[8] to gather and normalize the broad range of information covered in wall records and to link it with external datasets and platforms.[9] Most relevant for examining the potential of a spatial history of infrastructure was the functionality to export any spatially referenced content in MARKUS to the associated Docusky and DOCUGIS[10] platforms (National Taiwan University). Three steps were involved in this process.

First, based on a careful close reading of a few dozen inscriptions we designed a basic markup or annotation schema. We compiled an ontology, essentially a hierarchical list of categories, and for each identified vocabularies and patterns in which information relating to wall construction was articulated in the source texts. The list included the following categories: (a) the wall complex (e.g., wall names, types, and facilities); (b) the dimensions of the complex (length, height, width); (c) cost (labor force, budget); (d) materials (e.g., soil, brick, tile); (e) time references; (f) place names; (g) agents involved (official titles, bureaux, social types, personal names); (h) activity (new construction, restoration, destruction); (i) causes for each activity (flooding, external threat, banditry, piracy, official order, earthquake, hail, typhoon, etc.); (j) additional information such as references to external sources.

Second, we used MARKUS automated markup to annotate all time references (and to automatically add western dates) and to create structural markup for longer texts within which multiple wall complexes were described. Then, we used batch markup in MARKUS to simultaneously annotate all texts, including both keyword lists and regular expressions to capture strings of information whose slight variations can be well described, such as dimensions or labor cost.

Finally, we spent most of the project time on curating the annotated information in the MARKUS manual and keyword markup modules, making corrections where necessary, creating custom tags. We fed the experience gained in making these revisions back into the batch markup package of keyword lists and regular expressions that can be used in future stages of the larger project. We also added the appropriate IDs for all place names—since place names change over time, MARKUS uses historical spatial datasets (TGAZ, TWGIS, Dharma Drum place name authority dataset)[11] that can be converted to the appropriate longitude and latitude in DOCUGIS. We also manually curated, as much as possible, textual errors resulting from faulty OCR.

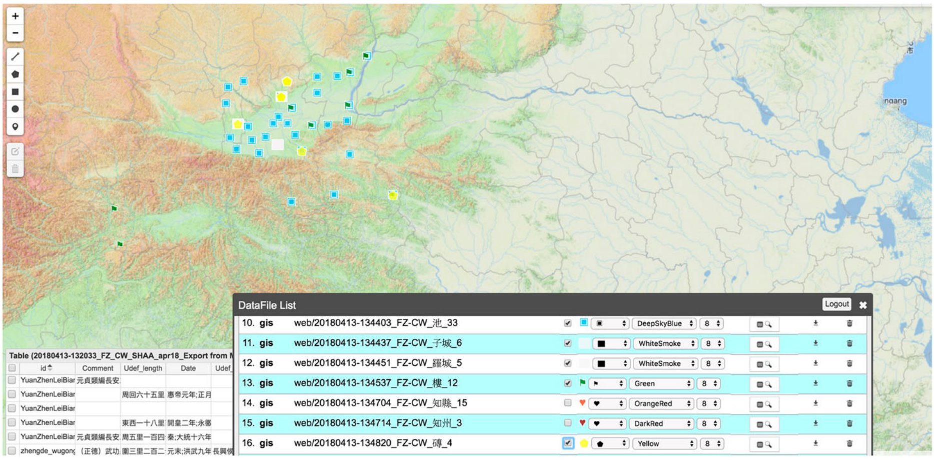

FIG 1. Screenshot showing how the annotation of particular features such as moats (using the light blue square icon), watchtowers (green flag), reinforced walls (yellow square), etc. can be converted to spatial layers in Docusky and DOCUGIS. Here data for Shaanxi is mapped on a present-day topography base layer.

PRELIMINARY DATA ANALYSIS

Upon examining the tagged data in all 282 files in DOCUGIS we were able to assess the potential contribution of a comparative or macro-scale digital spatial history of

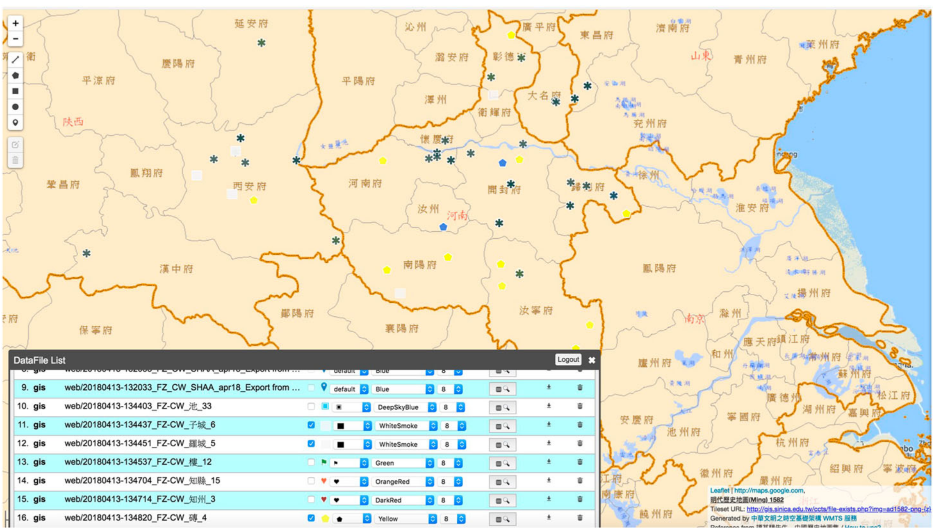

FIG 2. Screenshot showing how different types of annotated data (wall features such as complex walls in white squares, reinforced walls in yellow squares on one hand, and causes for damage such as rainfall or flooding mapped with a star icon on the other hand) can be explored in relation to each other in Docusky and DOCUGIS. Here data for Shaanxi and Henan is mapped on a Ming-dynasty administrative organization base layer.

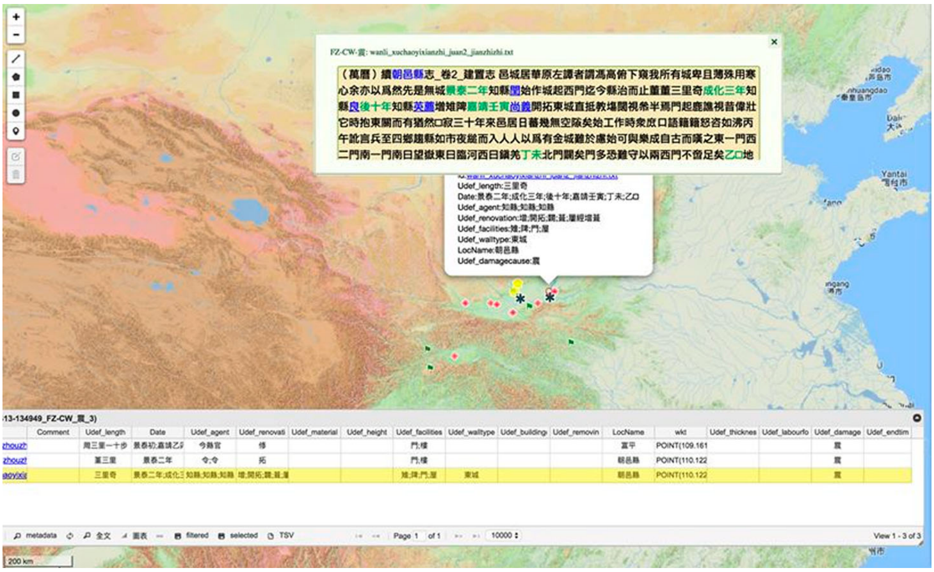

FIG 3. Screenshot showing how each data point on the map in DOCUGIS can be linked to both all the tagged data for the original textual division and the original text as annotated in MARKUS.

infrastructure to the existing literatures on the topic as well as other fields. On the other hand, we were also prompted to rethink and adjust the research design and methodology.

As illustrated in Figures 1–3, by establishing direct links between annotated texts and a spatial analysis platform we can indeed facilitate a multi-layer, multi-scalar, and multi-perspectival analysis of the available documentation on particular features of historical infrastructures. First, as shown in Figures 1–3, the data extracted from the annotated texts can be converted into layers that allow us to examine correlations between them. Wall features such as towers, moats, or secondary walls; materials such as bricks and tiles; and, the main causes for damage (rain, typhoon, or banditry) can thus be examined in relation to each other. By filtering the associated tables on other types of data such as time or location, we can furthermore examine such correlations over time and zoom into particular regions. As shown in Figure 3 we can call up the original source text to verify the data and interpret it in context — in this way differing accounts of the same construction or destruction event can also be read against each other and selections can be made for which sources to include or exclude.

Second, we can examine the data captured in the different spatial layers on varying scales: we can zoom into adjacent counties, prefectures, or larger zones; or compare construction events and wall features in locations of different size across a distance. The features of particular places can be examined in the context of the data gathered for all or neighboring jurisdictions: in DOCUGIS the distribution of subcategories for each category (e.g. the use of different types and sizes of labor force (workers and soldiers), the use of materials (Figure 4), the main

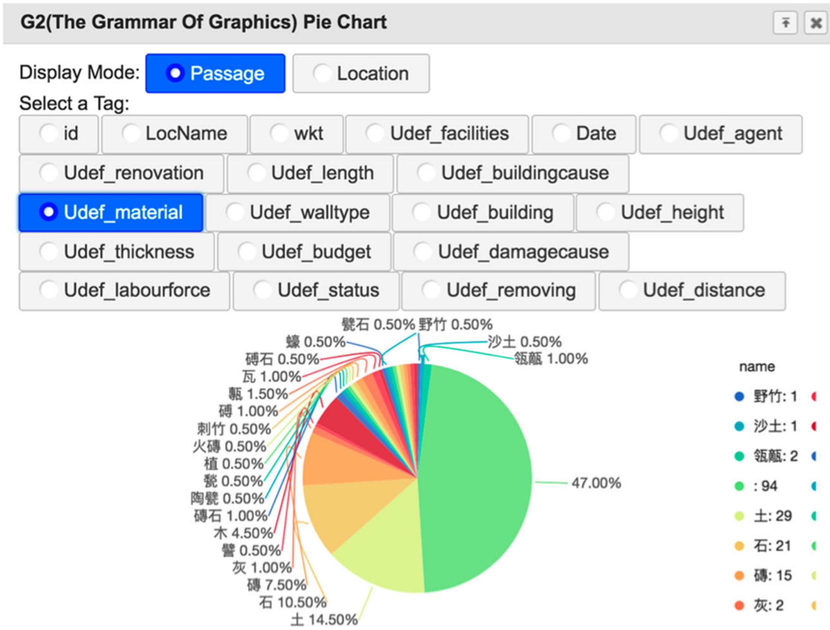

FIG 4. Screenshot showing the frequency of materials mentioned per annotated passage. This screenshot illustrates how quantitative results of annotated content can be obtained in DOCUGIS per annotation type, either based on their frequency per passage or the frequency per location. Those passages or locations for which no information is available can also be shown.

initiative takers (court orders, local or regional officials, local gentry), the ratio of rain and other factors as causes in a given selection) can be calculated, shown as a pie chart, and exported as a spreadsheet — in order to allow for a well-contextualized reading, results include all cases for which no relevant information is available. In contrast to existing studies that tend to generalize about the causes for wall construction and destruction across entire dynasties and across one or more provinces, this allows for a far more granular analysis and comparison based on a broad range of criteria set by the historian.

Third, because the spatial layers created from the annotated texts can be examined against topographical basemaps, historical administrative maps, or layers generated from other spatial datasets such as the historical meteorological datasets linked to DOCUGIS, we can also examine the data from various perspectives. Figures 1 and 2 suggest, for example, that particular features such as towers may be correlated to topography (location in mountainous regions) as well as location in a given jurisdiction (on an administrative boundary); complex walls tended to be relatively rare and concentrated in atypical, large or historic cities like Xi'an — in other words, the elaborate walls of Xi'an cannot explain why no large cannon were developed as they are rather unusual. Similarly, location near the Yellow River or other flood-prone rivers may lead to cycles of destruction and construction; and, as illustrated in Figure 3, unlike Henan and Shaanxi, walls in Guangdong in particular tended to be reinforced in Ming times and in some places vulnerable to particular challenges such as typhoons. Such observations are here merely intended to illustrate the potential of this work for the history of infrastructures, but also to highlight its relevance to other fields such as comparative urban development, architecture, military construction and geography, the history of technology, urban-rural relations, labor, climate and environmental history, etc. Furthermore, even though DOCUGIS offers only basic quantitative analysis of the spatial data resulting from the annotation of gazetteers, all data can be downloaded in a variety of formats for further quantitative, statistical, or network analysis in standalone GIS and other packages.

RETHINKING DATA STRUCTURES

While highlighting the potential of such a comprehensive mapping of the available records of construction inscribed on city wall steles and included in local gazetteers and literary collections throughout Chinese history, the pilot also alerted us to key constraints and weaknesses of the current research design. The data can at this point not be taken at face value, not only or not mainly due to source limitation, but especially due to inaccuracies that are caused by extracting and representing data based on structural divisions.

It first appeared that the strategy of organizing extracted data based on a structural division of the source text, a default setting in MARKUS, was in line with the way in which compilers of Chinese local gazetteers described walls and construction activity. Usually, they first listed the names of all city wall complexes in a given region, described the present condition of each complex, its size and associated facilities. In many cases, they quoted inscriptions and similar materials to trace the wall's historical development. One could, as in the case of LoGaRT, model the order in which information is presented in gazetteers as a tabular structure.[12] Such an interpretation represents all information in a particular structural unit as related to one entity, a unique city wall complex: all the wall buildings or associated facilities that were constructed at the same location are then seen as part of the same complex, regardless of the time when they were constructed and the particular features at that time.

However, the results clearly revealed that such a data model results in the aggregation of multiple events into one data point. In hindsight, data on infrastructure in gazetteers is usually not presented in a tabular structure, but can better be represented as a tree or nested structure. Typically, there are many events listed per location covered in one textual division. Moreover, construction activities initiated at different moments throughout the history of a given city wall complex are described in an asymmetrical way (for example, length may or may not be repeated). We were prompted to rethink how we can better capture and represent data that is embedded in such tree or nested structures. A solution to this problem would allow us to produce a far more accurate and fine-grained history of construction activity — the idea that had been at the core of the project since the start.

We are, therefore, developing an event-based data model in which all information mentioned in the text related to one particular event or activity (construction, demolition, restoration) can be grouped together as attributes of that particular event. As a first step, we developed relational markup[13] in MARKUS, which can be used to establish direct relationships between tagged content, and qualifying it with both the type of relationship established and metadata or additional information. Because relationships are binary, however, we aim to further develop an event-based annotation method that can accommodate relationships between multiple tags at once; this event-based method will also require further development on the conversion and mapping of the resulting data. Furthermore, we envision that event-based and relational markup can be used in sync in order to establish relationships between different events and activities (e.g., relationships between events undertaken by the same people, or caused by the same climate conditions) — currently, relationships can already be established within and across MARKUS files. The pilot further highlighted other more minor problems such as the need to clean up error-prone OCR results in the textual databases used and to standardize and normalize tagged content (e.g., different names for bandits) through, for example, the use of a standard vocabularies and tag IDs.

Conclusion

Infrastructures are essential features of human settlements throughout history, highly ambivalent as they connect, and divide. As President Trump's wall and China's One Belt One Road Initiative poignantly demonstrate, they remain objects of perpetual desire, imagination, alliances, and conflicts. With this report we aimed to introduce the concept and potential of a comprehensive spatial history of infrastructures that might begin to answer the challenges posed in Roger Des Forges's critique of modern imaginaries of city walls as symbols of traditional imperial infrastructures. The multi-faceted exploration of the histories of construction and demolition events that a well-designed digital approach can afford ties in well with critical infrastructure studies and recent work on local Chinese politics and cross-border contact zones. It should allow us to draw the study of large-scale material infrastructures into local histories of social and political practice, develop comparative histories of different kinds of infrastructures across the northeast, northwest, southwest, and northern and southern central regions across time, and to examine local and regional projects, technologies, and the uses and cultural meanings of infrastructures within empire-wide and cross-border dynamics. The latter will require additional research in the triangulation of textual data with data extracted from archaeological reports and with other graphic materials. Much remains to be done but we hope that with this pilot on city walls in Shaanxi, Henan, and Guangdong we have started a project that can inspire further work on the history of material infrastructures and their interrelations. Befitting a digital history field report, we also highlighted the challenges of designing a methodology that best matches the research goals in mind. We hope that the solution we arrived at, namely relational and event-based annotation, can also prove useful for other Chinese historical research projects.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Endnotes

1 Des Forges, "Tales of Three City Walls," 37.
2 Ibid., 43; Knapp, *China's Walled Cities*, 22; Andrade, *The Gunpowder Age*.
3 De Weerdt, *Information, Territory, and Networks*, 268–78.
4 Cheung, "Chinese County Walls," 99.
5 Select examples include (1) on bridges: Knapp, *Chinese Bridges*; Kong, *Zhongguo guqiao jiegou kaocha*; Miura and Okamoto, *Hashi no Bunkashi*; (2) on roads: Ge et al., eds., *Zhonghua da dian jiaotong yunshu dian*; Lan, *Gudai jiaotong shengtai yanjiu*; Xu ed., *Daolu jiaotong shi*; (3) on city walls: Cheng comp., *Difangzhi chengqiang ziliao huibian*; Zhang, *Zhongguo chengchi shi*; Steinhardt, *Chinese Imperial City Planning*.
6 Erudition Digital Technology Research Center, Zhongguo fangzhi ku.
7 Chen et al., "LoGaRT: Local Gazetteers Research Tools."
8 De Weerdt and Ho, MARKUS; and MARKUS Code and documentation. The development of MARKUS has been funded by the European Research Council under the European Union's Seventh Framework Programme (FP7/ 2007–2013)/ERC grant agreement no. 283525 (initial development by De Weerdt and Ho, and COMPARATIVUS development by De Weerdt, Mees Gelein, and Ho), the National Endowment for the Humanities /JISC–Digging into Data Challenge (machine learning module developed by Miao Shengfa), and an Asian Modernities and Traditions Large Grant, Leiden University (development of K-MARKUS by De Weerdt, Gelein, Ho, Hu Jing, Kim Hyeon, and Kim Baro).
9 For a brief explanation of the rationale behind MARKUS, see De Weerdt, "Digital Text Annotation in MARKUS and COMPARATIVUS." For illustrated examples of the MARKUS project, including the city wall project, see De Weerdt, "The Uses of Digital Philology," and "Creating, Linking, and Analyzing."
10 Tu et al., Docusky; the National Taiwan University Research Centre for Digital Humanities, et al., "Docusky shiyong shuoming."
11 Bhikṣu et al., Buddhist Studies Authority Database Project; Bol et al., China Historical GIS; *Academia Sinica*, Taiwan lishi wenhua ditu xitong 1.0.
12 Chen et al., "Treating a Genre as a Database," 53–54.
13 For a brief explanation, see De Weerdt, "Relational markup."

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