The Ceramic Technologies Digital Library (CTDL):

3rd Progress Report on the Internet-based Archive of 3D and 2D Ceramic Data from Central Europe

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Abstract: The Ceramic Technologies Digital Library (CTDL) has implemented an integrated approach to gathering 2D and 3D data on Early Medieval ceramic vessels from the Germania-Slavica study area for preservation and access via an Internet accessible visual database (www.ctdlib.eu www.ctdlib.org, *Not available anymore*). The CTDL website (in English, German, and Danish) is designed to broaden access to Early Medieval ceramics from the Germania-Slavica study area. The two years of the CTDL project (2006-2008) were used to develop the database and website and to obtain test datasets on a selection of ceramic vessels in museum collections in the study area. After completing the two year project, pending further funding, the CTDL will expand the database by gathering 2D and 3D data on more ceramic vessels at other institutions. The CTDL is a joint development of the Institute for Research in the Humanities (GWZO) in Leipzig, Germany, and the Institute for Historical Studies at EMAU Greifswald University, Germany, in partnership with the Archaeological Research Institute (ARI) and the Partnership for Research in Spatial Modeling (PRISM) at Arizona State University (ASU), Tempe, Arizona, USA, and Roskilde University (RU), Roskilde, Denmark. CTDL funding has been provided by the German Research Foundation (Deutsche Forschungsgemeinschaft - DFG).

Zusammenfassung: Das Konzept der Ceramic Technologies Digital Library (CTDL) wurde im Rahmen des Forschungsvorhabens „Germania Slavica“ für die Sammlung von 2D- und 3D-Daten von frühmittelalterlicher Keramik erstellt, um eine über das Internet zugängliche Visual-Datenbank (Objektdatenbank?) zu schaffen (www.ctdlib.eu, www.ctdlib.org). Die Entwicklungsphase des CTDL-Projekts (2006–2008) wurde dazu benutzt, die Datenbank und die Website zu entwickeln und Probedaten von ausgewählten keramischen Gefäßen aus Museen und Sammlungen im Forschungsgebiet zu erhalten. Sobald weitere Finanzierungsmittel verfügbar sein werden, wird die CTDL die Datenbank durch das Sammeln von 2D- und 3D-Daten über Keramikgefäße anderer Institutionen ausweiten. Die CTDL ist eine gemeinschaftliche Entwicklung des Geisteswissenschaftlichen Zentrums Geschichte und Kultur Ostmitteleuropas an der Universität Leipzig (Deutschland) und des Instituts für Historische Studien an der Ernst Moritz Arndt Universität Greifswald (Deutschland) in Zusammenarbeit mit dem Archaeological Research Institute (ARI) und der Partnership for Research in Spatial Modeling (PRISM) an der Arizona State University (ASU), Tempe, (USA) und der Roskilde University (RU), Roskilde (Dänemark). Die Deutsche

Forschungsstiftung (Deutsche Forschungsgemeinschaft – DFG) hat die Finanzierung dieser Phase des CTDL-Projekts übernommen.

Keywords: digital library, 3D scanning, database, medieval, ceramics

Introduction

The Ceramic Technologies Digital Library (CTDL) project is focused on ceramic collections from the Germania-Slavica cultural contact zone (Fig. 1) and has been designed to expand research regarding this important cultural reorganization period (6th – 13th centuries) (SIMON et al. 2006, 2007). Ceramics, as socio-temporal indicators, constitute one of the main categories of archaeological artifacts used for dating site complexes from different periods and locations. The CTDL (www.ctdlib.eu, www.ctdlib.org) is a digital database for online access to medieval ceramics from Central Europe and its goal is to enhance Internet access to these important collections among researchers, institutions, and a wide public audience.

The CTDL project developed and implemented the structure and process of acquiring visual archives of these ancient ceramic vessels using 2D digital photography and 3D digital scanning technology, storing both 2D and 3D data in a permanent digital archive, and making these medieval ceramic collections available to the widest-possible audience through web-based technology for visual and quantitative study.

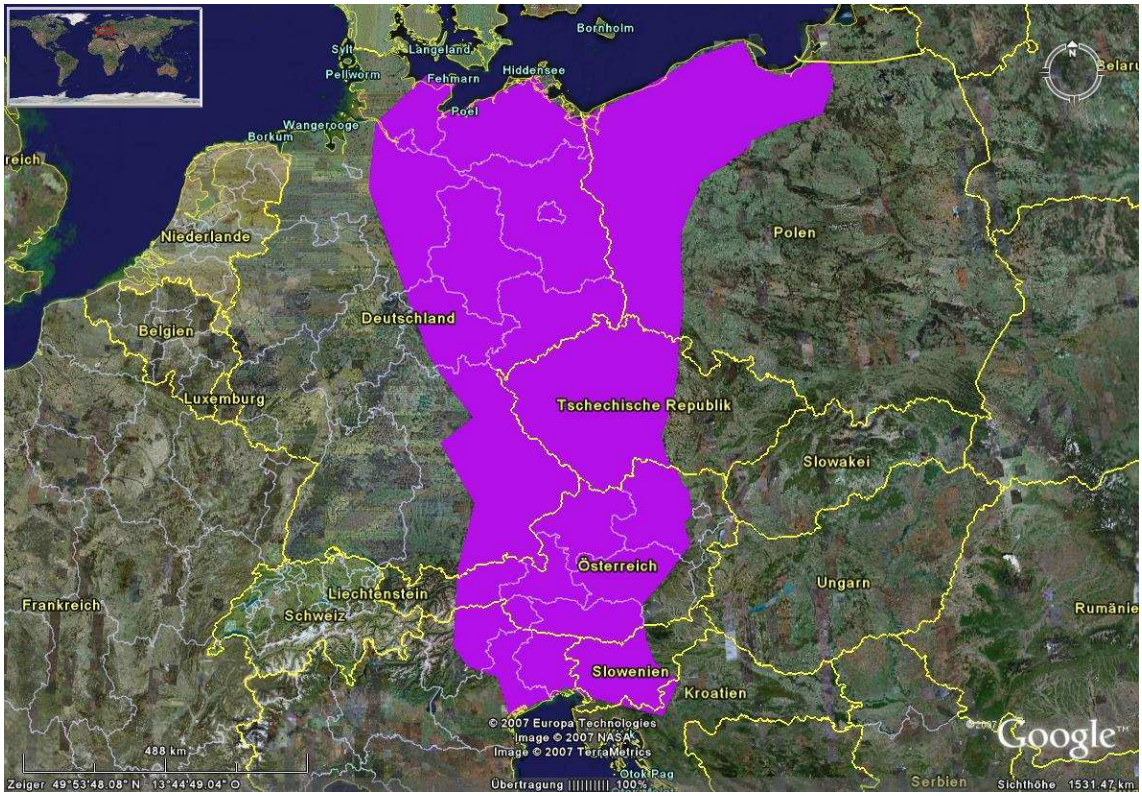

Fig. 1 – Map of Germania-Slavica study area showning area of cultural contact.

The main goal of the CTDL is to develop a classificatory database for ceramic collections from the Germania-Slavica research area (Fig. 1) for the Early Middle Age period following the end of the Roman Empire in the 6th Century. New cultural patterns that developed during this reorganization period are reflected in the material objects manufactured during this time. In the void of complex state structure, Avar control contributed to the distribution of “Slavic ceramics” among other goods throughout Central Europe. Regional variants of the ceramics are recognized, but are usually studied within those respective regions; the CTDL is designed to advance broad regional comparative synthesis of these distinctive wares.

In this article, we present the third report on the progress of the CTDL project summarizing the second year of funding from the German Research Foundation (Deutsche Forschungsgemeinschaft - DFG) and building upon the initial project description (SIMON et al. 2006), preliminary progress report (SIMON et al. 2008) and second progress report (SIMON et al. 2007). The work over the two years of the CTDL project has been distributed among Data Collection, Data Management, and Data Dissemination phases (SIMON et al. 2006, 2007, 2008). Each of these related phases of the CTDL are integrated and have been developed in articulation with each other over the duration of the project grant period. The developments and advances of each phase of the CTDL are discussed and summarized in the following sections.

Data Collection

The Data Collection Phase of the project began at the start of the grant with the acquisition of the equipment for the project including a Konica-Minolta 3D scanner, a Plustek flat-bed scanner, and a Panasonic digital SLR camera. Geomagic Studio 9 software is used to clean and process the 3D data into its finished form. The first year of the project time was necessarily devoted to the development and testing of data collection methods and establishing protocols for effective and efficient gathering of 2D and 3D data on the ceramic collections (SIMON et al. 2007, 2008).

Data collection emphasized the integrated collection of both 2D photographs and 3D scans of ceramic collections so that both types of data are available for study, but also so that the 2D photos can be wrapped onto the 3D scanned model providing the visual color and texture of the original object.

For each scanned vessel high-resolution 2D digital photographs are taken simultaneously with 3D scanning so that the angles and distance are compatible between the photographs and the scans. The 2D digital photographs are obtained with a Panasonic Lumix DMC-FZ 50 digital camera.

For each ceramic vessel, 3D laser scanning is used to acquire precise measurements of the 3D shape, decoration and texture of the artifact. The 3D data are captured with a Konica Minolta Vivid 9i non-contact laser scanner and a PC laptop computer.

The first step taken for data archiving is the registration of each vessel into a FileMaker Pro database on a Mac laptop. The CTDL database provides tracking of data acquisition and permits storage of both text and visual information gathered during workflow. Data are archived for long-term storage:

2D and 3D data files are stored in two file sizes: the original high-resolution data for long-term archiving, and the decimated (reduced file size) data of presentation quality to be used in the online database and website.

Back-ups of data are consistently made at each stage of the process: data acquisition, archiving, and loading files into the database and website.

All data and metadata are transferred online from the project laptop computers through a terminal-server to the main-server at the EMA University in Greifswald, Germany.

During the second year of the project, the CTDL database design was further developed using variables conforming to Metadata Standards. The data descriptions and the cataloguing procedures for the CTDL project are consistent with the technical collaborative standards (W3C, Dublin Core, and CoPAR). These guidelines derived from computer science, library, museum collections management, and archaeology incorporate professional and technical standards and promote consistency in database recording.

For cataloguing purposes we use 16 variables of the high-level descriptive metadata categories known as the Dublin Core (http://dublincore.org). The CTDL attributes (Fig. 2) and the database design they address are ACID-conformant in that each record is characterized by: Atomicity, which means that either all of the transaction requirements are fulfilled or none of them are, Consistency, which means that each transaction respects all the rules set forward in the database, Isolation, which refers to the property of any active transaction as being isolated from other operations, and Durability, which refers to the fact that once done, the transaction and its results are there to last, and will not be reversed or lost.

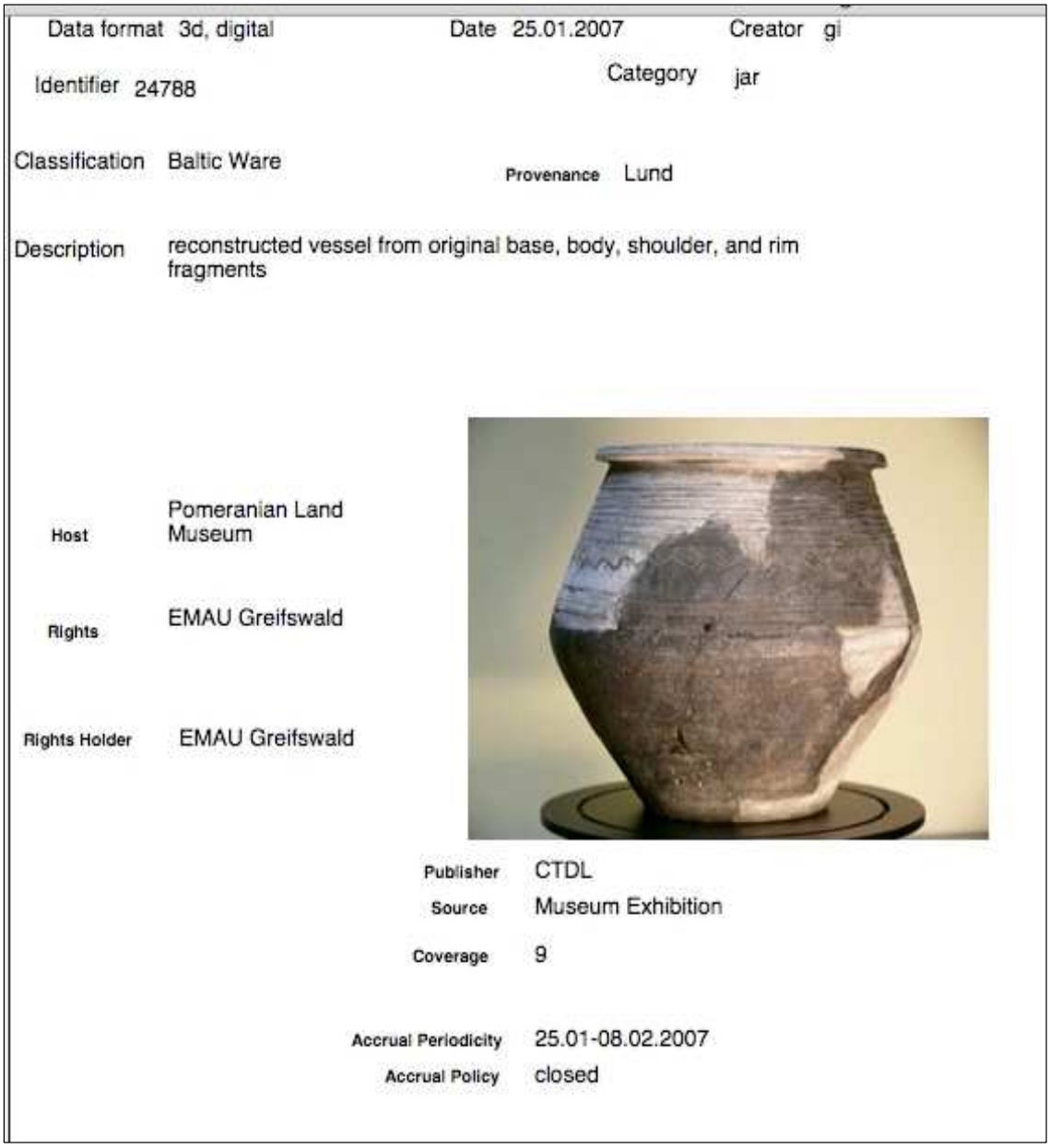

Fig. 2 – Example of CTDL data entry page with digital photograph of early medieval ceramic vessel.

Over the two years of the project, in addition to developing the CTDL system architecture and online website and database, 3D Scanning and digital photography of ceramic vessels were carried out at three museums in Germany and four museums in Denmark who generously agreed to participate in the project. These partnerships resulted in the acquisition of data on nearly 100 ceramic vessels in the CTDL. The CTDL appreciates the positive responses of these museums to allow portions of their ceramic collections to be included in the project.

The CTDL website presents a catalog of vessels that have been scanned for each institution that may be viewed by the public (http://www.ctdlib.eu/4images). Inclusion in the CTDL website brings added visibility to the museums, their collections, and the value of these artifacts for research, study, and

historical and artisitic appreciation. Additionally, by increasing available information, visitors seek out museums to view the real artifacts and related collections.

- During the first year of the project, scanning of ceramic vessels first began with the EMA University Greifswald (http://www.uni-greifswald.de), Germany, which gave permission for the scanning of one gray ware (non-Slavic) vessel as a pilot study for the museum's collection use and is not displayed online at this time because it is a different ceramic ware.
- Scanning was then conducted of nine vessels at the Pommersches Landesmuseum (http://www.pommersches-landesmuseum.de) in Greifswald, Mecklenburg-Vorpommern, Germany (viewable at http://www.ctdlib.eu/4images).
- The Slavic ceramic collection at the Gottorf Castle of the Land Museum of Schleswig-Holstein, Germany, (http://www.schloss-gottorf.de/alm/index.php *Not available*) gave permission for the scanning of 63 whole and reconstructed ceramic vessels (viewable at http://www.ctdlib.eu/4images).

These two collections of complete and nearly complete ceramic vessels illustrates the accessibility and usefulness of the CTDL for examining and studying ceramic collections of various sizes that have been reconstructed and are well documented.

Data acquisition continued in 2008 with the 3D scanning of selected ceramic collections of medieval period Baltic Ware ceramics from Denmark. The available whole and reconstructed, or partially reconstructed, ceramic vessels at four Danish museums were examined and scanned (viewable at http://www.ctdlib.eu/4images):

- Guldborgsund Museum (http://www.museumlollandfalster.dk/) Nykøbing Falster, Falster, Denmark, eight ceramic vessels scanned.
- Naestved Museum (http://www.aabne-samlinger.dk/naestved/), Sjaelland, Denmark; four ceramic vessels scanned.
- Lolland-Falster Museum (http://www.museumlollandfalster.dk/), Lolland, Denmark; eight ceramic vessels scanned.
- Sydvestsjaelland Museum (http://www.aabne-samlinger.dk/svm/), Sjaelland, Denmark; four ceramic vessels scanned.

The ceramic collections at the Danish museums contained a limited number of ceramic vessels that had been completely or partially reconstructed to date and thus were available for 3D scanning. However, each museum has extensive ceramic sherd collections and there is the potential for more vessels to be reconstructed in the future, at which point 3D scanning could be conducted and added to the CTDL archive.

Partial reconstructed vessels (ones that have holes or gaps in their surfaces from missing sherds) that display enough of their original base, body, and rim areas to provide a full profile of the vessel can be considered for scanning and further analysis. The 3D scanning and photography of the original surface curvature of a partial reconstructed vessel permits not only the visual modeling and display of those vessel parts present, but also allows computerized spatial projection of the original curvature to those areas where the vessel is broken and/or was erroneously reconstructed. The 3D scans of partial reconstructed vessels provide documentation of the archaeological record of the artifact, but also

provide the structure upon which to build a virtual reconstruction of a complete ceramic vessel, should the host institution choose to do so at a future time.

The collections scanned during the two years of the CTDL project successfully demonstrate the feasibility of programmatic scanning of collections of whole and reconstructed ceramic vessels and the utility of the archival quality 2D and 3D representations of the individual pieces for a variety of purposes: documentation, research, and public dissemination and education. There are many additional collections at other museums and institutions in the study area and surrounding areas that could be added to the CTDL in the future, should funding for these data acquisition activities be provided from potential sources at the international, national, and/or local levels.

Data Management

The CTDL system architecture (Fig. 3) for the project has its server space at EMA University Greifswald, Germany, an additional mirrored server space at Roskilde University, Denmark, and a test site at Arizona State University, Tempe, AZ, USA. Data are collected at museums and other institutions using laptop computers and backups are immediately made to an external storage device. The data files are then uploaded into the MySQL database via the Internet to the mainframe server-system at EMA University Greifswald. The MySQL database for the CTDL includes multilevel storage for digital data; the first level is reserved for the 3D data, while the second contains all the 2D and other additional data.

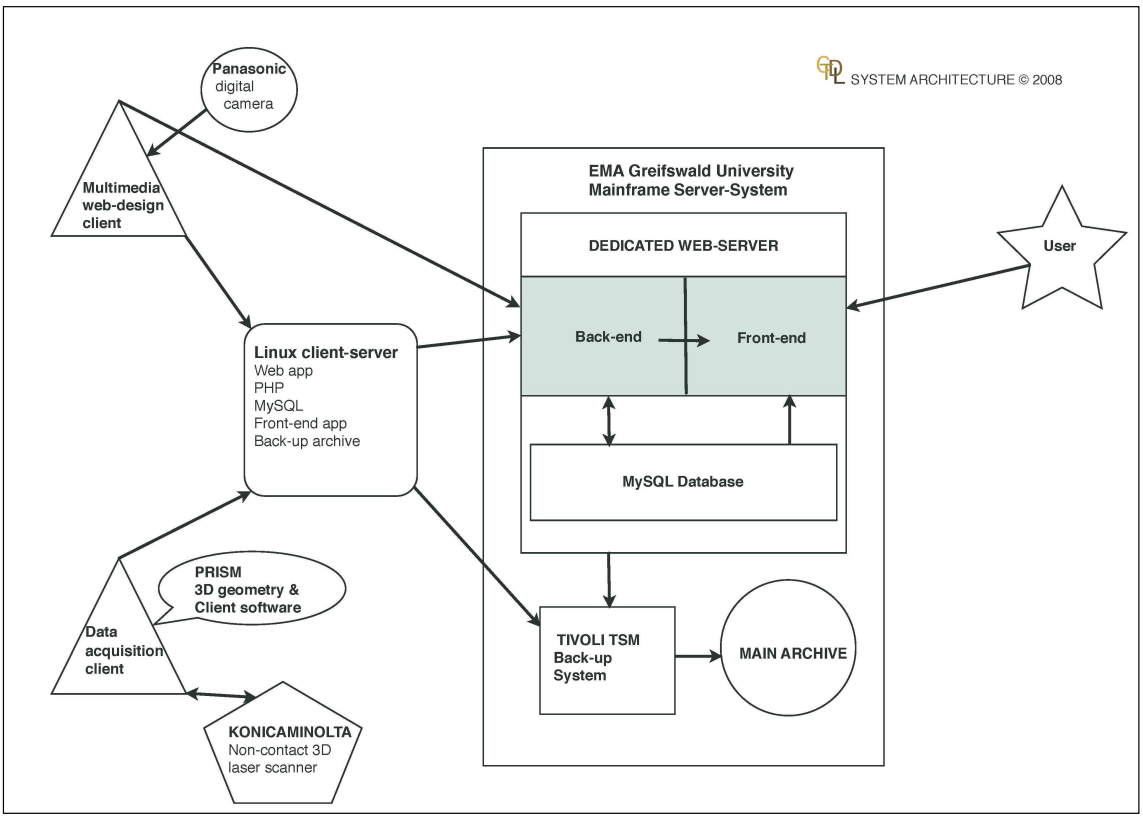

Fig. 3 – Schematic drawing of CTDL work flow: data processing, archiving, and access.

The Greifswald Server at the Computing Centre of the EMA Greifswald University is the primary repository of the CTDL data and is accessible via a local Linux-based terminal server at the Institute for Historical Studies. Data are archived on both the terminal server and the mainframe at the Computing Centre. The data that are fed into the terminal server are backed-up every 24 hours by IBM's Tivoli server application, which stores the copies on the mainframe server located at the Computing Centre.

The uploaded digital files are replicated on the mainframe server at the Computing Centre with the corresponding metadata stored in the MySQL database. The replication is performed automatically and periodically ensuring the incorporation and immediate presentation of new and existing data. The data files on the mainframe server are kept indefinitely on high-storage magnetic tapes, which are also backed-up on a separate internal server at the Computing Centre. The multiple servers and redundant backups provide safe storage of the CTDL data at present and for the future.

The Roskilde Server (www.ctdlib.ruc.dk *Not available anymore*) was added in 2008 as an additional CTDL server and project node at Roskilde University, Denmark, that mirrors the main CTDL infrastructure installed at Greifswald. The Dell server is driven by an Intel Quadcore Xeon CPU with 2.5 GHz and 2 GB RAM; in addition it has a multiple hard drive mounting configuration. The Server OS is provided by RUC-ENSPAC at Roskilde University.

The 2D and 3D acquired data are uploaded from laptops directly onto the local server at Roskilde University through a VPN connection. The data stored on the Roskilde Server has a manual backup which is regularly implemented.

The Tempe Server is test space provided by the Archaeological Research Institute (ARI) at Arizona State University (ASU), Tempe, AZ, where a development model of the MySQL database for the CTDL is viewable (http://gaialab.asu.edu/CTDL/index.php *Not available*). This CTDL database model is designed to follow the ARI Whole Pots database (http://ari.asu.edu/wholepots/ *Not available*) where 2D photographs and 3D models of scanned vessels are viewable by the public, in this case ceramics from the U.S. Southwest region. The databases are designed with query features for the metadata.

Data Dissemination

Once data are secured and ready for presentation, these are made available online through the CTDL website (www.ctdlib.eu, www.ctdlib.org) where information about the project, collections studied, and ongoing work are posted. Additionally, the data and metadata are exported and transferred to the development CTDL web-based archive where a MySQL/PHP database provides online availability of the records with search and query capabilities for selecting subsets of records. The prototype may be viewed on the ARI server (http://gaialab.asu.edu/CTDLWholepotsRecordView.php *Not available anymore*).

The CTDL archive makes use of different state-of-the-art viewers to aid online access to the 2D photographs and the 3D models of the ceramic vessels. Viewers were installed (server-side) in the web archives during the second year of the project and details are explained below; in some cases the user will need to download a free client viewer to fully use the CTDL archive for 3D data.

The CTDL website (www.ctdlib.eu, www.ctdlib.org) uses a 2D viewer to aid access to the online database of photographs of the documented ceramic vessels. The 4images image gallery

management system was chosen (http://www.4homepages.de/) for use by the project. The CTDL website uses 4images technology to seamlessly integrate the photographic records of the vessels documented at the different museums. The user does not need to download anything to view the images (http://www.ctdlib.eu/4images/index.php); the CTDL provides effortless access to the photographs. Registered users with passwords can access the 2D database inside the CTDL website. The developmental 3D database makes use of a 3D viewer and is cross-platform (viewable from PC or Mac computers). Users may download the viewers (for PC or Mac platforms) from links on the CTCL website (http://www.ctdlib.eu/eng/hd1/hd1pg1.html) or directly from the providers below. Both viewers work with a variety of browsers and both install either as independent applications and/or as browser plug-ins.

- For PC platforms using MS Windows (IE, Opera, Google Chrome, Mozilla (Firefox), Safari), the CTDL uses the 3DCT Viewer from 3D Compression Technologies (http://www.3DCompress.com *Not available anymore*). The free 3DCT Viewer download is available at: http://www.3dcompress.com/web/prod_view.asp *Not available anymore*
- For Mac platforms (OS X, Safari), the CTDL uses the FreeWRL/FreeX3D Viewer created by the Canadian Communications Research Centre (CRC). The free WRL Viewer is available at (http://freewrl.sourceforge.net/download.html).

Examples of CTCL 3D data of the ceramic vessels can be viewed online after downloading the appropriate free viewer for the user’s computer platform, OS, and internet application (see above). Once the viewer is installed on the user’s computer, the 3D data may be viewed on the CTDL website:

- Link to CTCL 3D Gallery on page: http://www.ctdlib.eu/eng/hd1/hd1pg1.html (allow popups).
- Direct link to CTDL 3D Gallery http://www.ctdlib.eu/web3darchive/index3d.html (allow popups).

We note that 3D models available online are reduced resolution (decimated files) to expedite transfer speed and facilitate users viewing these examples from a variety of personal computers. However, the server-side license for 3D Compress Professional http://www.3dcompress.com/web/prod_professional.asp (*Not available anymore)* aids the efficient access to the 3D gallery by its ability to compress 3D files by 95% for web-based transmission and viewing.

Conclusion

Since late autumn 2007, the developed version of the CTDL website was linked with the domain name, and from that date on the multi-language CTDL website (English, German, and Danish) has been available at the following web URLs: http://www.ctdlib.eu and http://www.ctdlib.org

- In addition to its own CTDL website, the project may now be accessed through the broader cultural portal for research in the humanities - VifaOst (http://www.vifaost.de/texte-materialien/quellen/ctdl/).

The project participants have made active contributions in public outreach and dissemination of the progress and results of the DFG-funded CTDL project (SIMON et al. 2006, 2007, 2008). Most recently,

in 2008, results of the CTDL project were presented at professional meetings and conferences held in Naestved and Roskilde, Denmark, in Tempe, Arizona, USA, and in Vienna, Austria.

The CTDL project has successfully completed two years of development of the multi-language website and archive of 2D and 3D data on early medieval ceramics from the Germania-Slavica study area. The emphasis has been on the development of data acquisition protocols, thorough testing through the gathering of several datasets from three museum collections in Germany and four museum collections in Denmark. The challenging task of integrating diverse project datasets into a common structure has been established. The infrastructure of the CTDL provides for long-term storage of the archival files in an active server environment, protected by multiple layers of systematic backups, and mirrored servers at secondary nodes.

The Ceramic Technologies Digital Library (CTDL) has been established to serve the scientific community and public audiences through the creation of an online database on medieval ceramic technology. The main goal of this community-service project is the initial development, support, and long-term curation of a Central European ceramic digital library, fully accessible through the Internet to both the interested specialists and the general public. Data access to this virtual repository through the Internet is unrestricted; including all organizations and individuals engaged in non-profit activities such as academic and secondary-level education, public outreach, or online museums activities.

The virtually indestructible 3D models of ancient ceramics, made available online through the CTDL website, can thus be used as visual educational and/or research tools, especially when presented together with the proposed GIS-based contextual archaeological information. Future funding will allow the expansion of the CTDL to include locational and provenance data regarding the ceramic vessels in collections. In addition to information regarding the institutions that curate the collections, expanded metadata and data may provide contextual details regarding each ceramic vessel and their site contexts.

We note that the CTDL infrastructure is designed for growth of the digital archive and expanded usage by researchers and the interested public. It will be possible for additional institutions and/or interested researchers to contribute more 3D scanned vessel collections and relevant data to the CTDL database as funding becomes available.

Acknowledgements

The CTDL is a joint development of the Institute for Research in the Humanities (GWZO) in Leipzig, Germany, (http://www.uni-leipzig.de/gwzo/) and the Institute for Historical Studies at EMA Greifswald University, Germany, (http://www.uni-greifswald.de/en.html) in partnership with the Archaeological Research Institute (ARI) (http://archaeology.asu.edu) and the Partnership for Research in Spatial Modeling (PRISM) (http://prism.asu.edu *Not available*) at Arizona State University (ASU), Tempe, Arizona, USA, and Roskilde University (RU), Roskilde, Denmark (http://www.ruc.dk/ruc/ *Not available*). The German Research Foundation (Deutsche Forschungsgemeinschaft - DFG) (http://www.dfg.de/en/) has provided two years of funding for the CTDL.

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