Availability of Chemical Data of Archaeological Ceramics - Proposal for an Internet Database

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Introduction

Chemical analysis is a commonly applied technique in provenance studies of ancient ceramics. This approach is based on the assumption that pottery of the same production series presents a homogenous chemical composition, which can be distinguished from pottery of other production series. The distinction is based on the chemical diversity of natural raw materials and production techniques. In this way pottery of unknown origin can be chemically assigned to reference groups, which are formed by pottery of known or assumed origin.
Large amounts of data have been collected in different laboratories with the aim to establish chemical patterns of reference groups. In order to avoid redundant measurements of the same material a data exchange among laboratories is desirable. But this data exchange usually is complicated mainly due to the following problems. First, it has to be examined how chemical concentration data measured in two different laboratories can be compared in terms of accuracy. Possible differences can be determined by analysing a set of identical materials in both laboratories. A second problem is often the variety of different data formats in use, starting from data in form of hardcopy, over electronic in-house database formats up to commercial standard database solutions. Converting these data formats can require considerable time and effort and produce mistakes. Hence, in many cases instead of single data only the average data of samples are exchanged, which already have been grouped in the particular laboratory. But in this way the information about the single samples gets lost and furthermore groups include the bias of the grouping procedure.
Ceramic analyses have been carried out since many years in the neutron-activation analysis (NAA) laboratories of the archaeometry research group at the University of Bonn and of the Laboratory of Archaeometry at the N.C.S.R. "Demokritos" in Athens. The respective databases contain chemical data of several thousand ceramic samples. Especially in view of complementary ceramic data it was decided to combine the databases and to use a common data format. Considering broader compatibility and the capability to include further types of data in the future, the concept of a relational database management system (RDBMS) was found to be suitable. In order to make this database available to other laboratories, access through the Internet will be provided together with a graphical user interface (GUI) for searching and data format conversion. It is planned to expand the current database including other materials and integrating also further laboratories' data.

Contents of the Database

Pottery Both the NAA laboratory in Bonn and that at N.C.S.R. "Demokritos" are working on Bronze Age ceramics from the Aegean since years. The data, accumulated until now, are rather complementary. Whereas the studies in Bonn covered mainly the Greek mainland and the Peloponnese (ca. 5000 samples plus ca. 900 samples from the Berkeley laboratory), the studies at Demokritos regarded rather Northern Greece, Crete and the Aegean islands (ca. 4500 samples). Therefore a combination of the databases and the analytical results is reasonable. Apart from this bulk of Greek ceramics the databases of the laboratories comprise analytical data of a large variety of pottery, from Maya ceramics from Central America up to Central European stoneware of the last centuries. Besides the chemical values of the pottery comprehensive supplementary information (metadata) is available, such as archaeological classification, finding sites or physical properties. This information can be used to sort and filter the analytical data. Finally a great part of the samples were described in publications and can be linked to the respective original references.

Other materials Various pottery-related materials have been analysed as well, such as clays or building ceramics. These materials have other kinds of supplementary information but should be part of the final database as well. Another important group of materials, which should be included, are the standard reference materials (SRM). These can be used to calibrate results of different analytical setups, in the case that they give systematically different concentrations for certain elements (Hein *et al.* 2002).

Relational Databases and SQL

Relational database structures were implemented already successfully in geochemistry (Lehnert *et al.* 2000) where, like in our case, not only large numbers of data records have to be stored but also the types of these data are very similar. A relational database consists of tables in which data records are stored. Each table consists of fields which represent particular types of information while a data record represents one set of data. Each data record must be uniquely identified by a primary key, which can be either a field or a combination of fields in the table. In a relational database a table is related to other tables through pointers on foreign keys.

SQL (structure query language) is a language which was developed for relational database structures to perform database operations. Data can be stored and accessed easily, even in large numbers, and for sorting or selecting data records complex criteria can be defined using information from several tables.

Structure of the New Ceramic Database

The design of the ceramic database followed the suggested structure of existing geochemical databases (Lehnert *et al.* 2000). Since the starting point of the discussion was the accessibility of chemical data these will build the preliminary core of the new database together with information about the analytical method. Tables with other types of analytical information can be added later, such as mineralogical or petrographic data. Another part of the database contains the supplementary sample data such as archaeological information in the case of pottery or information about clays. A third part of the database contains supplementary information about references.

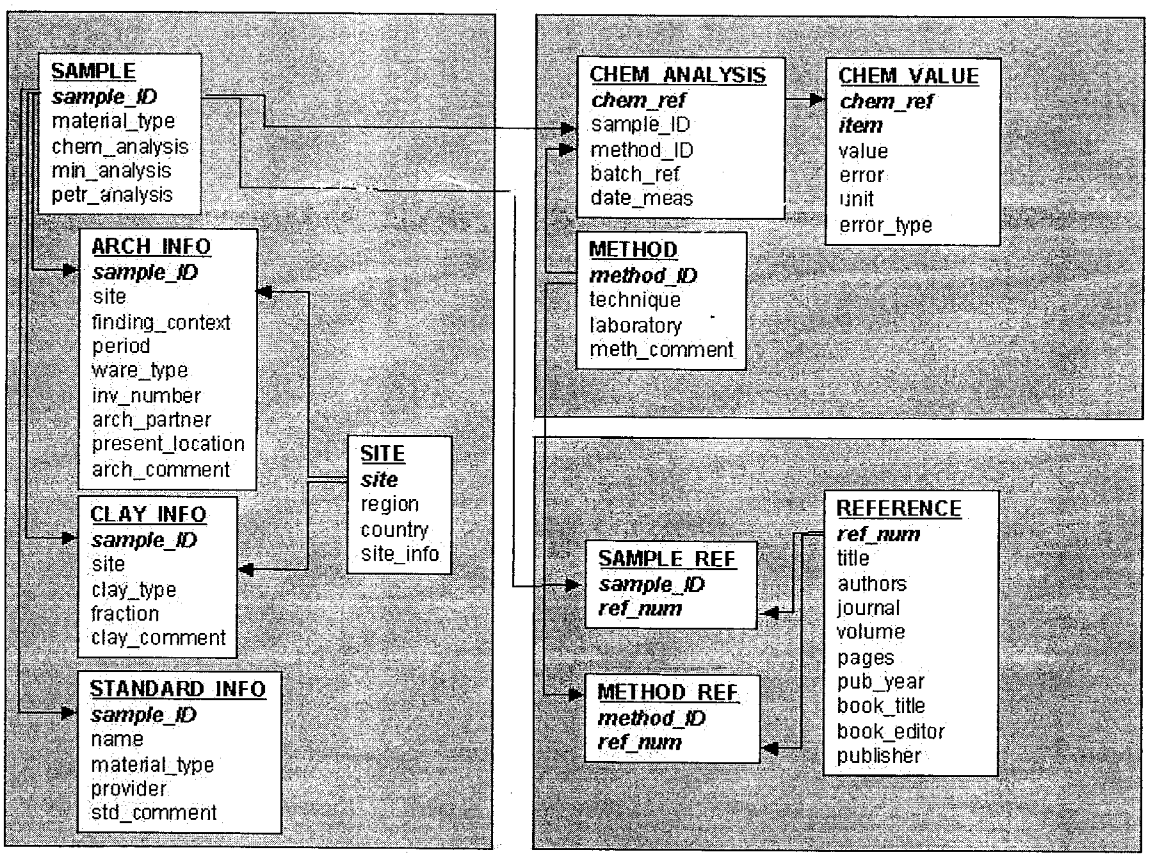

Figure 1 Preliminary structure of the ceramic database.

The preliminary data model contains 11 tables; see Figure 1. For example the actual data table is *CHEM_VALUE*. The primary key is a combination of the fields *chem_ref* and *item* where the measured item can be an element or the respective oxide. Furthermore, the value, the error, the unit (ppm or wt%) and the type of error (absolute or relative) are given. Searchable archaeological information about the samples is provided in table *ARCH_INFO*. The database structure will be flexible to changes and additions.

Implementation

For the moment the ceramic database is implemented on a *PostgreSQL* server in a *Linux* environment. *PostgreSQL* is an open-source object-oriented relational database, which makes considerations about software licenses unnecessary. On the server side applications were developed, concerning mainly the database management and the data input, including conversion of existing data formats.
Apart from direct access for authorized users, the database will be accessible later via a common web browser. For this purpose a package of applications is in development. In its final form it will include various query options, such as searching for labels, sites, ware types and periods or searching for a sample set from a certain reference (Fig. 2). Two different output files are produced, a detailed sample list, including a site list and a reference list, and a data sheet with the analytical values. For the time being the output files will be in ASCII format, but also other formats such as ODBC (open database connectivity) can be implemented.
The next step will be a facility for other laboratories to submit their data to the database as well. The web access to the database will be controlled by user rights. A normal user will have the right to filter and read those data, which are classified for common access. The input and change of data will be allowed only for authorized users, who also can classify which of their data are for common access.

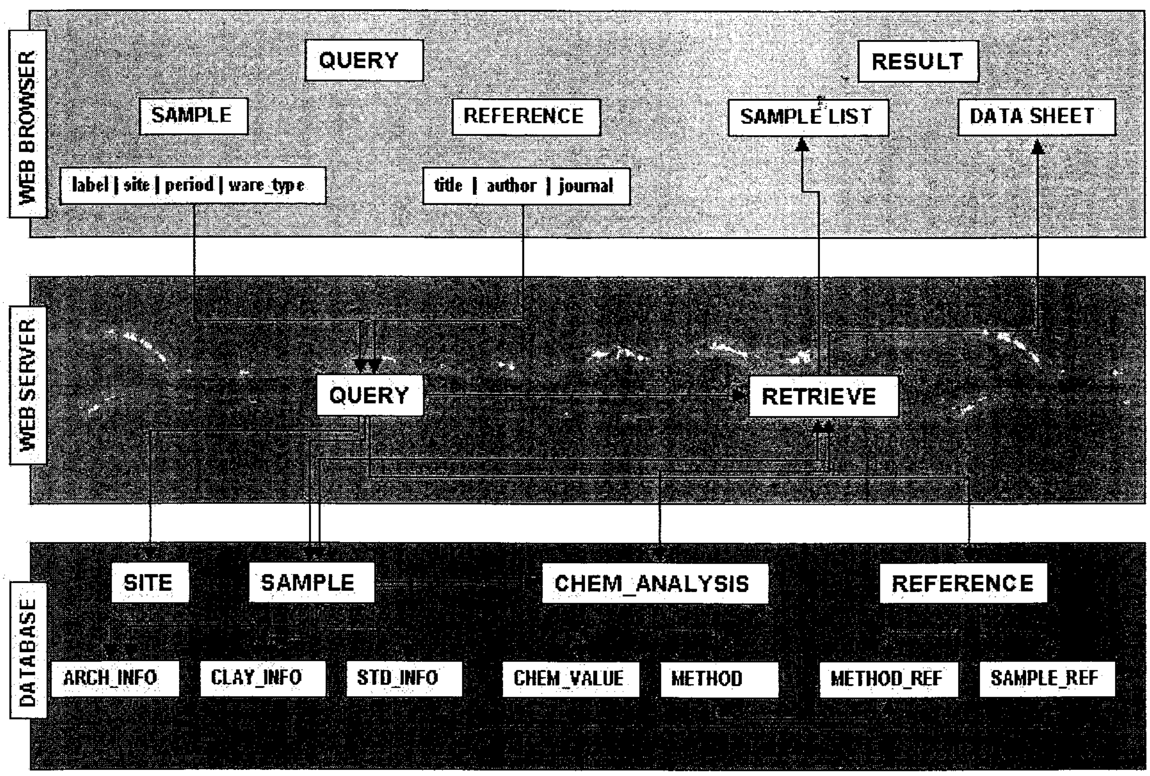

Figure 2 Schema for the web query in the ceramic database.

Conclusions and Prospect

The large number of accumulated analytical data of archaeological ceramics requires an organized concept of storing and evaluating. Otherwise information will get lost or redundant measurements will be performed. In order to simplify the data exchange between laboratories it is reasonable to agree to a common concept and to combine databases. Therefore, the use of up-to-date database technology was found to be suitable.

The presented concept is based on a collaboration between two NAA laboratories and it has to prove its final practicability yet. However, a demand exists also in other ceramic laboratories and the concept was and will be open to input and discussion.

References

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