Distribution of Copper Ores in the Carpathians. Data Management With Relational Databases

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Introduction

This paper is part of a large project, which aims to study the "Beginnings of bronze metallurgy in Transylvania". The area we are taking into consideration is an important region, for the prehistory of Central and south-eastern Europe, Transylvania being well known for its rich gold, copper and salt deposits, which represented the basis or the starting points for the prosperity of this area, during the Bronze Age.(Ciugudean, 1997) Archeaologists have already pointed out the important role of the Transylvanian communities, describing the long-trade relations, which made possible the exchange of ingots and metal artifacts, in the neighboring regions and to far, distant places, as well.

The Early Bronze Age is still an obscure period in Transylvania, the beginnings of the new "era", remaining one of the most debated problems among Romanian archaeologists (Ciugudean, 1997). The opinions concerning the origins of bronze metallurgy, in the Transylvanian area, are disputed, and this situation has induced us to carry out a detailed study on the distribution of copper ores and alloy elements (arsenic, lead, antimony, tin , etc.), which, in combination with copper, produce the alloy, called bronze.

Although the Middle Bronze Age cultures (Wietenberg, Otomani, Suciu de Sus, Mures) (FIG.1) have been widely studied, in archaeological syntheses and monographs, the Early Bronze Age still raises a lot of questions. (FIG. 2) Some authors consider the local origins of bronze metallurgy to be doubtful, but recent discoveries are beginning to change these opinions. Proof of the local extraction and primary metallurgy of copper ores, artifacts which typologically can be dated to the EBA, have motivated us to begin a systemic investigation in the Carpathian area.

Background and research design

This application was developed for the use of archaeologists, geologists, and archaeometallurgists, who were involved in this project, and was aimed to be a rapid and complex means of obtaining information.

In order to approach the problems of bronze metallurgy in its full complexity, following the determination relations in the "ore-metal-object" transformation process, we considered that the establishment of a database was necessary. Since information volume was too big and its character very diverse (geological, geographical, chemical, physical fields), we decided to use the relational system, as this system offered complex data interconnections, further required in metallurgical processes. ·

Relational systems are apropriate for research activities, offering such advantages as: high independence of programs, regarding data management, effective control of coherency and redundancy of data, by using the 4GL, and a relational model doesn't require special theoretical knowledge; the user is not required to define means of data processing; it is enough to define the object of interest, within the framework of the relational database, e.g., the properties and the meaning of the required data.

The architecture of RDBMS is defined on three levels: conceptual, internal, and external. The conceptual level is the central level, and corresponds to the semantic structure of data, without computer implementation. The conceptual scheme allows the definition of data types, which set the elementary properties of the entities, of the composed data types, in order to reorganise the attributes, for the description of model entities (and the relationships between them), the definition of the rules which have to be respected, etc.

The internal level refers to the internal structure of the stocked data, and it allows data type descriptions. Regarding the external level, this part describes the data which is important for the user.

The universe we are attempting to model consisted of objects, jointed by relationships, and represented an assembly of values, called here, domain. The concepts with which we were operating, were attributes, and relationships.

One of the most important tasks for the designer, user and administrator of a database, is modelling the database. We would like to emphasise, here, two aspects: the static and the dynamic aspects of the modelling process. The first one refers to the structure of data (relations, filters, restrictions), while the second, deals with the operating actions, within the structure of the database. We have to mention here, also, the operators of the relational model (relational algebra and relational calculus), and the integrity rules, which command the keys. These correspond to three components of software engineering : information, process, and integrity.

Results of the queries applied to the database

Query is a Microsoft Access 2.0 object, which represents the interrogation addressed to the database. The result of such an interrogation is a number of records, consisting of one or more tables, in the database. This is represented by the dynamic set of a query. A good facility of Access 2.0 is the possibility of creating several types of queries.
We made some selective queries, applied to the distribution of copper ores . The data was organised into three mountain groups: the eastern Carpathians, the western Carpathians, and

the southern Carpathians, which were introduced into the database as OLE objects. The method we adopted was elaborated by Mr. Edgar F. Codd, and is called the analytical method. The data manipulation was achieved in SQL language, which allowed the user to define relations and visual output, and to verify and to update the input.In FIG. 3, we have a map of the Western Carpathians, as an OLE object of the database. The values and the map's description can be found, among the attributes of the mountain groups, and further, in a selective, progressive query, among the elements of the places, in that zone.

By a further selective query, the user can pick a place of interest, in the zone described by the map. The disclosed information is complex and can be obtained as a report.

For example (FIG.4), if a query is applied to the place, "BUCIUM", the following information will be disclosed:

BUCIUM, Gilau Mountains
* Jurassic, cretacic, neogene vulcanism

- oxidation zone of different types of copper ores
- A. fixed in crystalline shales

B.corelated with Mesozoic magmatism
C.corelated with banatitic magmatism
D.neogene magmatism
Paragenesys: supergene mineral with malachite
==============================
Mineral_code: 3
Mineral name: azurite
Chemical formula: Cu3[(OH)]CO3]2
Copper %: 55 %
Info: Palache, Berman, Frondell

Mineral_code: 4
Mineral name: bornite
Chemical formula: Cu2S.(Fe,Cu)S
Copper % : 60 %
Info: In mesothermal copper mineralisations

Mineral_code: 5
Mineral name: bournonite
Chemical formula: 2PbS.Cu2S.Sb2S 3
Copper % : -

Info: neogene hydrothermal ores

Mineral_code: 9
Mineral name: Calchopirite
Chemical formula: Cu Fe S 2
Copper % : 34 %
Info: Crystalline shales, phirometasomatical veins

Mineral_code: 14
Mineral name: coveline
Chemical formula: CuS
Copper %: 66.4 %
Info: Primary mineral, supergene

As far as the information about the minerals found in a place (e.g. Bucium, in the Gilau Mountains, Western Carpathians), is concerned, more selective queries will disclose information about the chemical, physical, and morphological properties of the required mineral.

A report for "bornite" reads:

Mineral_code: 4
Name : bornite
Chemical formula: Cu2S.(Fe, Cu)S
Info: Mesothermal copper mineralizations
Colour: black
Print: black-grey
Transparency:opaque
Glistening: metallic
Wearing: soft
Specific weight: 4.9...5.3
Hardness: 3
Morphology: compact
Cleavage: 100
Breach: conchoid
Optical symmetry: easily anisotropy
Scale of fusibility: 2.5
Typical reactions: in closed tube decrepitates, emits SO2
Chemical reactions: hepar reaction.
Pyrognostic reactions; green pearl in combination with copper and iron
Other info: hydrothermal, sedimentary

Synthesis queries

Due to their compact form, synthesis queries are important for large monographisms, in our case, bronze metallurgy in the Carpathian area. Below, there is a table with all the types of copper ores, which can be found in the Western Carpathians (Table 1).

Conclusions

This study, of the distribution of copper ores and alloy elements, serves as a useful tool for researchers, involved in this project,concerning the beginnings of bronze metallurgy in the Carpathians.

Our goal was to create a database model, to provide information about the geological sequences of copper ores, information which will be further corroborated, by the results of archeaological finds, in order to complete the picture of available data, regarding the beginnings of the "metal era", in the Carpathians.

The database will be useful in further metallographical and chemical investigations, which will aim to study the chemical, crystalline structures, and mechanical and physical properties of artifacts, as a method of identifying the possible origins of the metals, the technology, and the evolution, during the Early Bronze Age.

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cod minereu	denumire	formula chimica	continut Cu
1	algodonit	Cu6-7As	
2	auricalcit	(Zn, Cu)5[(OH)3|CO3}2	
3	azurit	Cu3[(OH)|CO3]2	55 %
4	bornit	Cu2S.(Fe,Cu)S	60 %
5	bournonit	2PbS.Cu2S.Sb2S3	
6	brochantit	Cu4[SO4(OH)6]	
7	calcantit	CuSO4.5H2O	
8	calcofilit	Cu18Al2[AsO4.SO4|(OH)9]3.36H2O	
9	calcopirit	CuFeS2	34 %
10	calcozina	Cu2S	
11	caledonit	Cu2Pb5[(SO4)|CO3|(OH)6]	
12	cianotrichit	Cu4Al2[SO4|(OH)12.2H2O	
13	colusit	Cu3(Fe, As, Sn) S4	
14	covelina	CuS	66,4 %
15	crizocol	CuSiO3.nH2O	
16	cubanit	CuFe2S3	
17	cuprit	Cu2O	88,8 %
18	cupru	Cu	
19	dioptaz	Cu6[Si6O18].6H2O	
20	dognacskait	Cu2S.2Bi2S3	
21	domeykit	Cu3As	
22	ehlit	Cu5[PO4|(OH)2]2 H2O	
23	emplectit	Cu2S.Bi2S3	
24	enargit	Cu3AsS4	48,3 %
25	eukairit	Cu2Se . Ag2Se	
26	germanit	Cu3(Fe, Ge)S4	
27	jalpait	Cu2S . 3Ag2S	
28	libethenit	Cu2(OH)|PO4)	
29	linarit	Pb Cu[SO4|(OH)2]	
30	malachit	Cu2(OH)2CO3	57,4 %
31	pisanit	(Fe, Cu) [SO4] . 7H2O	
32	polibazit	8(Ag, Cu)2 S . Sb2S3	
33	pseudomalachit	Cu5[(OH)2]|AsO4]2	
34	rezbanyit	2PbS.Cu2S.nBi2S3	
35	seligmannit	2PbS . Cu2S . As2S3	
36	stanina	Cu2FeSnS4	
37	stromeyerit	Cu2S . Ag2S.	
38	tennantit	Cu3AsS3-4	
39	tenorit	CuO	
40	tetraedrit	Cu3Sb S3-4	
41	tirolit	Ca9Cu9[(OH)10|(AsO4)4].|10 H2O	
42	valerlit	Cu3Fe4S7	
43	veszelyit	(Cu, Zn)3 [(OH)3|PO4] . 2 H2O	
44	whitneyit	(Cu, As)	
45	wittichenit	3Cu2S.Bi2S3	

Table 1. Copper Ores in the Western Carpathians

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