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Rome, Italy, June 3, 2019.

Edited by

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Towards an ontology for investigating on archaeological Sicilian landscapes*

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Abstract

In this paper we present an ontology, called OntoCeramic 2.0, modelling new survey and legacy data concerning Sicilian ancient potteries collected in the archives of *Heritage Superintendence* of Syracuse and Catania, in the *Regional Technical Office* of Sicily, and in the *State Archives* of Palermo and Catania. OntoCeramic 2.0, developed using the Web Ontology Language 2 (OWL 2) and constructed according to the standard CIDOC Conceptual Reference Model (CRM), is a first step towards the definition of an ontology for representing and reasoning on the artificial and natural processes that shaped the archaeological Sicilian landscapes, their conformation and topographic information, the distribution of ancient rural sites, and the dynamics of the agrarian organization in Sicily.

1 Introduction

Digital representation of legacy information in open-data formats plays a crucial role in cultural heritage as it provides significant advantages in the dissemination, use, and comprehension of information stored in old publications, archives, collections, and museums. This holds particularly for the archaeological data on potteries of ancient rural landscapes in Eastern Sicily, since the majority of legacy data for this research area is available as old maps and paper catalogues.

Landscapes are cultural entities or "*a concrete and characteristic product of the interplay between a given human community, embodying certain cultural preferences and potentials, and a particular set of natural circumstances*" [12]. Archaeological landscapes carry an impressive amount of information since they consist of many layers made up over centuries, each one with specific characteristics and comprising a wide range of archaeological material (i.e., potteries, coins, glasses, metals, buildings, residues of conurbations, and so on) dated from different periods [19].

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In: Carlo Meghini, Antonella Poggi (eds.): Proceedings of ODOCH 2019 – Open Data and Ontologies for Cultural Heritage – Rome, Italy, 3 June 2019, published at http://ceur-ws.org

The case of archaeological data of Sicily is particularly interesting since studies carried out for over a century report on forgotten cities, necropoleis, monuments, artefact scatters, and several other landscape features. Knowledge collected in such context is still limited in quantity and variable in quality, especially in the countryside. Nonetheless, data nowadays available for the plain of Catania in Sicily, if appropriately represented and organized in a digital and global way, may be crucial for archaeologists of the field. Specifically, such knowledge consists of legacy and new survey data from the western edges of the Plain of Catania. A coherent digital integration process of data is fundamental to answer questions concerning Sicilian social behaviors in their spatial and chronological contexts.

One of the most important archaeological finds in landscapes is pottery. In fact, pottery and chronology are inextricably tied in archaeology [17]: dating processes of the archaeological context of finds are often related with the study of potteries (e.g., their overall shape and the material they are made of), in particular, when ceramic sherds are markers of specific chronological periods.

In addition, analysis of potteries helps in providing a clear image of rural population trends such as technological, social, economic, and cultural changes in ancient times, and in reconstructing the organization of the agrarian territory, in particular in the Hellenistic and Roman ages [16].

Currently, in the context of the *Ru.N.S. (Rural Networks in Sicily) Project*, a relational database on potteries of the plain of Catania is being developed.[1] The study area considered in this project is located in the western portion of the plain of Catania, the geographic area between the Simeto river to the north and the Margi river to the south. With an extension of 540 km^2, the area forms a perfect case study due to the number of excavations and survey projects carried out by the *Soprintendenza of Catania* and the *Chair of Ancient Topography* (University of Catania) over the last few decades (see [1, 18] for an overview).

Relational databases, however, even though well-assessed tools for organizing and querying information, do not support global and flexible data-integration mechanisms with other sources, and suffer from limited modelling and reasoning capabilities [13]. Moreover, to take advantage of the rich information collected from the plain of Catania, scholars require a representation system capable of dealing with the archetypal elements of reality, i.e., space and time. In fact, chronology and topography are of fundamental importance to compare old and new archaeological data, regardless of the accuracy degree in its acquisition and publication process.

Semantic web offers powerful and well established methodologies, languages, and tools for knowledge representation systems in which data is published, accessed, and integrated with information from other sources at a global level, thus allowing coherence and dissemination of knowledge. Moreover, automated reasoning systems allow one to verify the consistency of the model, query the dataset, and infer implicit information from what has been already defined. The definition of a specific domain is commonly called ontology.

In the last decade, capabilities of ontologies have been widely recognized in many fields of Humanities [14, 15]. For instance, ontologies modelling specific kinds of archaeological finds such as ancient manuscripts [10] and epigraphs [11] have been developed. An RDF vocabulary for the intellectual concepts of Greek potteries has been proposed in [22], in the ambit of the *Kerameikos.org* project.[2] In [7] we presented OntoCeramic 1.0,[3] an OWL 2 (Web Ontology Language 2) ontology for potteries cataloguing and classification, originated by a cooperation between computer scientists and archaeologists to address the problem of correctly cataloguing ceramics in an automatic way and to make data easily accessible and usable by scholars in the field.

In this paper, we present OntoCeramic 2.0,[4] an OWL 2 ontology modelling the archaeological data of potteries discovered on the western sides of the plain of Catania in the ambit of the Ru.N.S. project. The ontology, whose taxonomy refines and extends OntoCeramic 1.0, models and integrates new survey and legacy data on potteries stored in the archives of *Heritage Superintendence* of Syracuse and Catania, in the *Regional Technical Office* of Sicily, and in the *State Archives* of Palermo and Catania. Moreover, it represents main features of potteries such as ceramic class, shape, type, dough, and chronological periods of production of the sherds. OntoCeramic 2.0, entirely mapped in the CIDOC Conceptual Reference Model (CRM), is a first step towards the definition of an ontology for the complex reality of Sicilian archaeological landscapes, the artificial and natural processes that shaped them, and the social, cultural, and economic Sicilian changes.

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[1] A description of the project and of the related database can be found in [2].
[2] http://www.kerameikos.org/
[3] https://github.com/dfsantamaria/OntoCeramic-1.0/blob/master/OntoCeramic1.owl
[4] https://github.com/dfsantamaria/OntoCeramic-2.0/blob/master/OntoCeramic2.owl

2 Preliminaries

2.1 OntoCeramic 1.0

OntoCeramic 1.0 is an OWL 2 ontology presented in [7] for cataloguing and classifying ancient potteries, designed with the purpose of efficiently addressing significant problems concerning knowledge management about potteries such as the classification by shape, type, and class, and the analysis of finds by their components and discovery places. The ontology has been designed on ICCD[5] (Istituto Centrale per il Catalogo e la Documentazione) data sheets taking into account relevant papers in the field [8,14]. It contains more than 90 classes, 33 object-properties, 20 data-properties, and 13 SWRL rules permitting several reasoning tasks on the knowledge base in a short time. The expressive power of the language underlying Ontoceramic 1.0 has been studied in [3, 20].

2.2 CIDOC CRM

The CIDOC Conceptual Reference Model (CRM) [9] is the international standard for the controlled exchange of cultural heritage information since 2006. It provides general specifications applicable in any cultural heritage context to construct a linked data-based information system, to serve as a guidance for good practices of conceptual modelling, and to improve information sharing. Many institutions such as galleries, libraries, museums, archives, as well as any other cultural environment based on cultural heritage data that publishes and shares knowledge in linked-data formats implement CIDOC CRM. CIDOC CRM covers many aspects of cultural information in a general way. For instance, it models general concepts such as material and immaterial objects, events, space, and time, which can be specialized, contextualized, and integrated in order to address practical aspects of cultural heritage issues. In addition, CIDOC CRM models several notions, such as participation, appellation, parthood and structure, material and immaterial stuffs, location, assessment and identification, motivation, and so on.

3 OntoCeramic 2.0

OntoCeramic 2.0 is an OWL 2 ontology for the classification of survey and legacy data collected in the ambit of the Ru.N.S. project, designed in such a way as to represent principal features of potteries such as ceramic class, shape, type, dough, and chronological periods of production of finds. It extends, enriches, and refines OntoCeramic 1.0, is defined according to the standard CIDOC CRM, and uses the LinkedGeoData [21] ontology for describing locations and for identifying the discovery place of finds.

OntoCeramic 2.0 consists of more than 220 classes, 40 object-properties, 20 data-properties, and 9000 individuals, excluding entities imported by CIDOC CRM and LinkedGeoData.

Figure 1 summarizes the principal features of OntoCeramic 2.0. Classes (resp., properties) specifically defined for OntoCeramic 2.0 are represented in boldface, whereas corresponding superclasses (resp., superproperties) from CIDOC CRM are reported below them. Relevant classes of OntoCeramic 2.0 are listed in what follows.

- *Archaeological_Find*: contains individuals representing archaeological finds. It is defined as subclass of the CIDOC CRM class *E22 Man-Made Object*.
- *Ceramic_Class*: introduced to represent the fabric type of potteries, is the root of a class hierarchy collecting ceramic classes to which a find may belong to.
- *Facies*: models, together with its subclasses, all the ceramic classes in the Sicilian context. It is subclass of the OntoCeramic 2.0 class *Ceramic_Class*.
- *Shape*: models the shape of finds. One of its relevant subclasses is *Undistinguished_Shape*, introduced to deal with ambiguous shapes. It is defined as subclass of the CIDOC CRM class *E26 Physical Feature*.
- *ArchaeologicalType*: is defined as subclass of the CIDOC CRM class *E17 Type Assignment* and describes the type of finds. It specifies their shape and, when available, their ceramic class. Among its subclasses, a significant one is the class *Undistinguished_Type* modelling ambiguous types.
- *Decoration*: is defined as subclass of the CIDOC CRM class *E26 Physical-Features* and describes the decoration of archaeological finds.
- *Description*: contains a free-text description of finds and is subclass of the CIDOC CRM class *E73 Information Object*.
- *Functionality*: models functionalities of finds, i.e., usages finds have been originally intended for, regardless of their shape. For example, an archaeological find may have the shape of a basin and the functionality of an holy water font.

[5] http://www.iccd.beniculturali.it

- *Dimension*: is defined as subclass of the CIDOC CRM class *E54 Dimension* and defines the size of finds, usually determined by measuring the external diameter of the rim in millimeters.
- *Dough*: describes the elements forming the dough of finds. It is defined as subclass of the CIDOC CRM class *E26 Physical-Features*.
- *Conservation_State*: is defined as subclass of the CIDOC class *E14 Condition_State* and reports on the physical conditions of finds at their discovery time.
- *Sicilian_Period*: is the root of a class hierarchy modelling Sicilian historical periods and is defined as subclass of the CIDOC CRM class *E4 Period*.

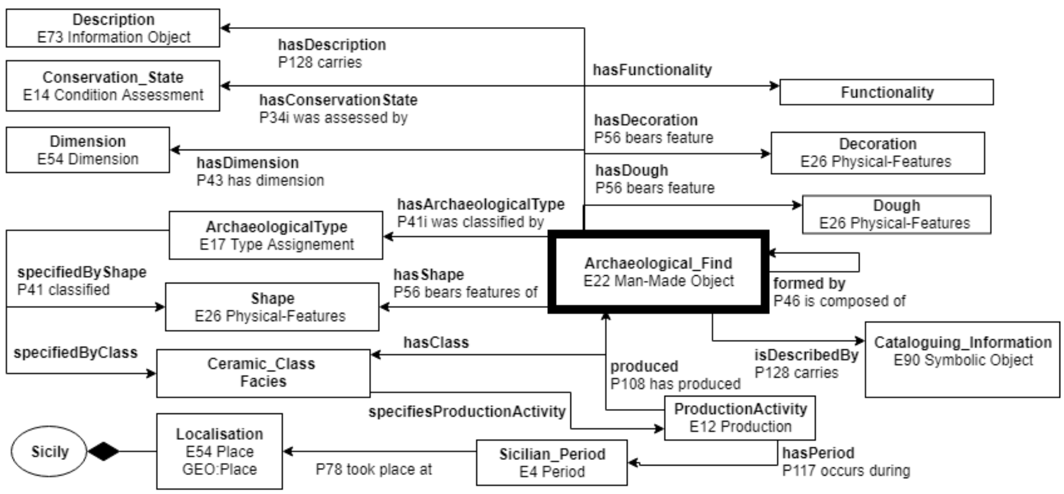

Fig. 1. Graphical model of the core of OntoCeramic 2.0.

Instances of the class *Archaeological_Finds* are associated with their types, shapes, and classes, by exploiting the object-properties *hasArchaeologicalType* (subproperty of the CIDOC CRM relation *P41i was classified by*), *hasShape* (subproperty of *P56 bears features of*), and *hasClass*, respectively. In its turn, the class *ArchaeologicalType* is linked to the classes *Ceramic_Class* and *Shape* by means of the object-properties *specifiedByClass* and *specifiedByShape* (subproperty of *P41 classified*), respectively.

Finds are related with their functionality, with related free-text descriptions, and with their conservation state by means of the object-properties *hasFunctionality*, *hasDescription* (subproperty of *P128 carries*), and *hasConservationState* (subproperty of *P34i was assessed by*), respectively.

Archaeological finds are associated with their dimensions, represented as instances of the OntoCeramic 2.0 class *Dimension*, by means of the object-property *has_dimension* (subproperty of the CIDOC CRM relation *P43 has dimension*). Since dimensions of finds can be irregular and measurement errors may occur, OntoCeramic 2.0 provides two subclasses of *Dimension*, the classes *Max_Dimension* and *Min_Dimension*. The object-property *has_value* (subproperty of *P90 has value*) relates each dimension with its value, represented by a double. Moreover, instances of the class *Dimension* are related with instances of the CIDOC CRM class *E58 Measurement Unit*, representing the measurement unit, by means of the object-property *has_measurement_unit* (subproperty of *P91 has unit*). Finds are related with fragments composing them by means of the object-property *formed by* (subproperty of the CIDOC CRM property *P46 is composed of*).

The classes *Undistinguished_Shape* (subclass of *Shape*) and *Undistinguished_Type* (subclass of *ArchaeologicalType*) have been introduced to model finds that have not well-identified shapes and types, respectively. The class hierarchy having as root *Undistinguished_Shape* is partly depicted in Figure 2 together with an example on how to model the shape of archaeological finds in case of uncertainty on the fact that they have the shape of a bowl or of a dish. The *Bowl-Dish* class contains individuals belonging either to the class *Bowl* or to the class *Dish*. The object-property *identifiedAs* relates such "hybrid" individuals with instances of the class *Bowl* or with instances of the class *Dish*, which define different shape classes. An analogous hierarchy has been introduced for the class *Undistinguished_Shape*.

Ceramic classes are good chronological markers of potteries production activity: determining them helps in correctly dating finds and in reconstructing the chronological information of the corresponding archaeological contexts [17]. Hence, the task of reasoning on the relationships among ceramic classes, archaeological finds, and

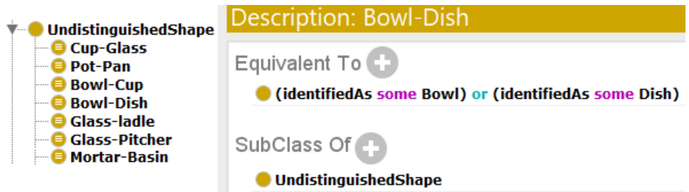

Fig. 2. Example of modelling the uncertainty of shapes in OntoCeramic 2.0.

historical periods turns out to be crucial to recognize the production activity of finds and to collocate them in the correct chronological context. The production activity is represented in OntoCeramic 2.0 by means of the class *ProductionActivity* (subclass of the CIDOC CRM class *E12 Production*). Ceramic classes and facies are related with production activities by means of the object-property *specifiesProductionActivity*. Archaeological finds are related with instances of the class *ProductionActivity* by means of the object-property *produced* (subproperty of the CIDOC CRM *P108 has produced*).

OntoCeramic 2.0 also models Sicilian historical periods by means of a hierarchy of classes having as root the class *Sicilian_Period*. Instances of the latter class are related with the individual *Sicily*, instance of the class *Localisation*, by means of the CIDOC CRM property *P78 took place at*. The class *Localisation* is defined as subclass of the LinkedGeoData class *Place* and of the CIDOC CRM class *E54 Place*. The data-properties *start_date* and *end_date* link each period with its start and end dates, respectively. Each period is described by exploiting an OWL expression modeling the time interval between its start and end date. For example, the East Adriatic Iron Age is defined as the period included within the years -1000 and -200 (in absolute value), and is represented by means of the class *East_Adriatic_Iron_Age* which contains the individual *east_adriatic_iron_age* (see Figure 3). Such definitions force automated reasoners to place individuals representing specific sub-periods in the correct subclass of *Sicilian_Period*. This is useful when one wants to relate historical periods of different regions of the world. Historical periods, indeed, vary from region to region, since social-cultural and environmental events take place in different moments. For example, the Archaic Age in Sicily, starting in -733 and ending in -476, occurs during the Iron Age in the East Adriatic: this fact is correctly deduced by the Pellet automated reasoner, which places the individual *sicilian_archaic_age* in the class *East_Adriatic_Iron_Age* (see Figure 3).

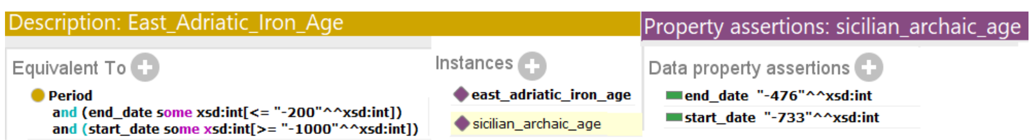

Fig. 3. Example of reasoning with chronology in OntoCeramic 2.0.

4 Conclusions and Future Work

In this contribution, we presented OntoCeramic 2.0, an OWL 2 ontology modelling archaeological data on potteries collected in the ambit of the Ru.N.S. (Rural Networks in Sicily) project and stored in the archives of *Heritage Superintendence* of Syracuse and Catania, in the *Regional Technical Office* of Sicily, and in the *State Archives* of Palermo and Catania. The ontology, defined according to the standard CIDOC CRM, is part of a broader project consisting in studying and understanding artificial and natural processes that shaped the conformation of archaeological Sicilian landscapes, the distribution of ancient rural sites, the dynamics of the agrarian organization, and the social, economic, and cultural changes in Sicily. To achieve such goals and to improve our understanding of Sicilian archaeological landscapes, we plan to enrich OntoCeramic 2.0 with new and legacy data collected from Sicilian ancient settlements concerning diverse social, cultural, and economic aspects, thus limiting problems of partial availability and overfitting of archaeological information. These problems are particularly prevalent in the countryside, since traditional archaeological studies focused on urban landscapes disregarding rural landscapes. Such trend has reversed only recently, also thanks to the huge amount of information coming from the excavation projects on the western portion of the plain of Catania.

However, to gain a clear understanding of the processes that shaped Sicilian landscapes, it is necessary to reassess all the available archaeological data. Therefore, we plan to integrate OntoCeramic 2.0 with stratigraphic excavations, production factories, and topographic units, which represent the basilar elements of surface archaeological reports, bibliographic references management, and epigraphic and numismatic evidences.

The results obtained from the ontological modelling of the Ru.N.S. knowledge base and its dissemination in open-data format will provide a vivid image of the development of ancient landscapes in Sicily. Moreover, the ontology will help in reconstructing the trajectories of social, economic, and cultural interactions of the Mediterranean basin networks, in which the Sicilian island was involved from prehistory till nowadays.

Finally we plan to define a set-theoretical representation of OntoCeramic 2.0 in the flavour of [3] with the purpose of using the reasoner presented in [6] to address its principal reasoning problems. However, since OntoCeramic 2.0 contains existential restrictions, not supported by the automated reasoner introduced in [6], we need to modify the set-theoretic fragment and the procedure underlying the reasoner in such a way as to allow a restricted form of composition operator. This task will be carried out by exploiting the techniques introduced in [4, 5] in the area of relational dual tableaux.

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