CAA2015

KEEP THE REVOLUTION GOING >>>

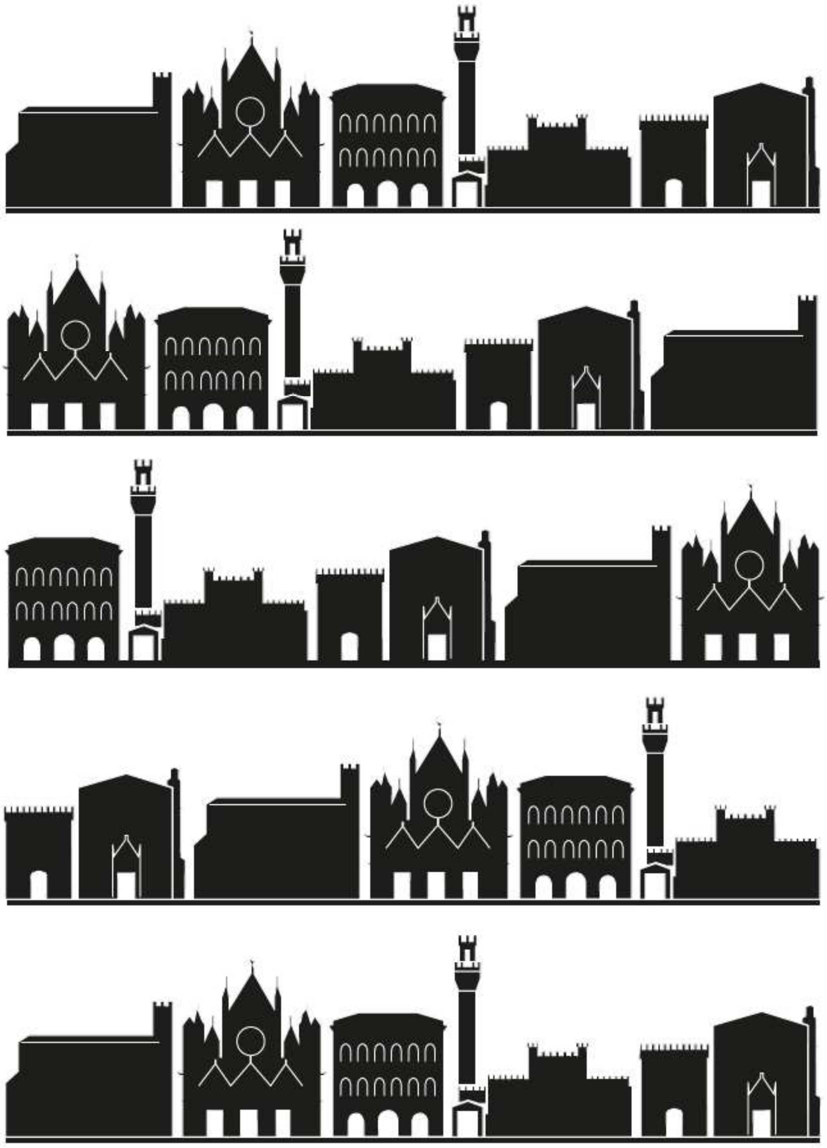
Proceedings of the 43rd Annual Conference on Computer Applications and Quantitative Methods In Archaeology

edited by

Stefano Campana, Roberto Scopigno,

Gabriella Carpentiero and Marianna Cirillo

Volumes 1 and 2



UNIVERSITÀ DI SIENA 1240

CAA Computer Applications & Quantitative Methods in Archaeology

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Introduction

Stefano Campana

Roberto Scopigno

Chairmen of the 43rd CAA

KEEP THE REVOLUTION GOING!

This volume brings together all the successful peer-reviewed papers that have been submitted for the proceedings of the 43rd conference on Computer Applications and Quantitative Methods in Archaeology that took place in Siena (Italy) from March 31st to April 2nd 2015.

The number of people who signed on for CAA 2015 really took us by surprise: 550 delegates registered for the conference, from many more places than we would ever have anticipated. Altogether, within the four days of the conference 280 papers were presented in 48 sections divided into ten macro topics, 113 posters, 7 roundtables and 12 workshops.

That number, in itself, has prompted a thought or two. Above all it says to us that CAA is very much alive and kicking, that it is in robust good health, and that it remains a wholly relevant force in the scientific community, fully engaged with the questions of the day, and a continuing focal point for the profession. All of that speaks well for the motto of CAA 2015: KEEP THE REVOLUTION GOING!

Although the significance of our motto is obvious, we think it is worth some thoughts. Few would deny that in the past 30 years or so, digital technologies have profoundly revolutionised archaeology – in the office and laboratory, in the field and in the classroom. The progressive introduction of digital techniques in the archaeological process has of course led to a general increase in efficiency. But perhaps more importantly it has provided a spur to the discussion of methodology and through that has strongly influenced not only the way we go about things but also the outcomes that we have been able to achieve.

The pioneering phase in the application of digital techniques in archaeological research has clearly been fruitful and today computer applications such as GIS, databases, remote sensing and spatial analysis as well as virtual and cyber archaeology are deeply embedded within our universities. This is all good, of course, but we must not assume that the task has been completed. An intrinsic revolutionary instinct towards technological development has been awakened. But it will only survive by virtue of the results that it brings about. Or using the words of our Chairman Prof Gary Lock: 'Computers not only change the way we do things, but more importantly they change the way we *think* about what we do and why we do it'. The general thrust of this statement can be summed up and reinforced by recalling a quote from the philosopher Don Ihde, who has argued we should never forget that all technologies should be regarded as '*cultural instruments*', which as well as strategies and methodologies implemented in our researches are also '*non-neutral*'.

So KEEP THE REVOLUTION GOING! is a motto that lays stress on the need to maintain innovation in archaeology through technological advances. But innovation must have at its root the fostering of critical thought and the framing of new archaeological questions. So there is much work still to be done, and fresh challenges to be faced in the months, years and decades ahead.

One final thought. The date of this conference, and most of all the opening ceremony, has not come about by chance. The 30th of March, for the University of Siena and in particular for the human sciences and archaeology, represents a sad but enduring anniversary. Eight years ago on this day we lost a key figure in the Italian archaeological community of the last 50 years; a man who had an extraordinary influence on many aspects of medieval and archaeological studies. Not least we call to mind his role in the promotion and development of digital archaeology. Our thoughts and memories go therefore to our friend and mentor Professor Riccardo Francovich. He always inspired us to seek new horizons and without him we doubt that this conference would have found its way to Siena.

Introductory Speech

Professor Gabriella Piccinni

Dean of the Department of History and Cultural Heritage, University of Siena

First of all, on behalf of the Rector of the University, and as Dean of the Department of History and Cultural Heritage, I wish you all a very warm welcome to the University of Siena.

This greeting goes in the first instance to all of the distinguished speakers at this meeting but also to all who are here in our company to listen and to take part in scientific debate. A warm welcome, naturally, goes to all of the institutions represented at this table, to the Chairman of CAA International, Professor Gary Lock, to the National Research Council, our partner in the organization of this congress, and to the Ministry of Heritage, Culture and Tourism. Last but not least I extend my thanks to all who have committed their time and energy to the organisation of this meeting: the scientific secretariat, the conference office, our student volunteers, the institutions that have kindly agreed to act as patrons, and the sponsors who have so generously supported this initiative.

I confess that when Stefano Campana first told me about the opportunity for our university here in Siena to organise such a prestigious event as the international meeting of the CAA, now in its forty-third year, I was immediately excited and engaged because I strongly believe that events like this represent one of the most tangible and concrete demonstrations of how a University works, how it forms and reinforces knowledge; these kinds of events delight me as a scholar and as a teacher, as well as the director of a university department.

It is a great honour for us to host CAA International, bearing in mind the history of our university, and in particular its tradition of archaeological studies, within which it has played a pioneering and leading role in the field of Digital Archaeology. I cannot but recall how the University of Siena has, since the early nineties, played a central role both nationally and internationally in the development of computer applications in archaeology. My thoughts and deep gratitude go inevitably to our late colleague and friend, Professor Riccardo Francovich, who remains always in our work and in our hearts. His exceptional energy and his qualities as an innovator provided an extraordinary impetus in this area of studies; an impetus that lives on through the work of his students and through the many many people who were inspired by his example.

The conference numbers are frankly astonishing: roughly 550 delegates – the organizers were actually forced to close registration because the results were beyond their wildest dreams. The University's halls are overflowing, its facilities at full stretch to host this event. The congress has representatives from more than 50 countries and from all of the most prestigious universities and institutions in Europe and beyond. In the short space of the next four days the work programme will be intense, with 46 thematic sessions, 12 workshops, 7 panel discussions, 4 key-note speeches and all sorts of informal discussions and social activities that will promote the continuing exchange of ideas.

Let me end with a simple thought. Without entering into discussions and analyses that lie outside my role (or even competence) here today, I feel that seeing so much dynamism and so many young scholars, teachers and researchers coming together here in Siena from all around the world to talk about the new opportunities offered by the application of technology within archaeological studies should prompt a few moments of reflection about the ways and means through which we deliver our higher education and training. Today more than ever, in front of this audience, we see how vibrant and strong is the demand for discussion and training in these topics. In keeping with the motto of the conference, the future is still to be built, let us show the same commitment that enabled our predecessors to overcome the first heroic phase of the 1990s and the early years of the new millennium. Always, of course, keeping alive the flame of innovation that has from the outset been the guiding light of this of CAA International initiative.

Acknowledgements

It goes without saying that the organization of an event such as CAA is a complex and demanding task that only achieves success through real teamwork. So we will start by offering heartfelt thanks to all who have helped to make this meeting possible: the University of Siena. We are particularly grateful to the Rector prof Angelo Riccaboni and the Director of the Department of History and Cultural Heritage prof Gabriella Piccinni for their constant support and valuable advice. Particular thanks are offered to the conference office Giuliana Pasquini, Roberta Corsi, Elisa Pratali and Serena Mazza and to our many students volunteers, Mirko Buono, Marta De Pari, Valery Del Segato, Cesare Felici, Ilenia Galluccio, Nadia Messina, Michele Pellegrino, Sara Linda Russo. Last but by no means least we owe a deep debt of gratitude to all who have given their time and enthusiasm to the organisation of the meeting – to the Scientific Secretariat under the leadership of Dr Marianna Cirillo.

For the same reasons, I am most grateful to the Monte dei Paschi Foundation and to Verince srl for the outstanding work in organizing the social events including the 'ice-breaker' party, visits to various monuments and cultural activities within the city of Siena, the social dinner and the field trip. In particular I would like to mention Marco Forte, Laura Tassi and Laura Manzi, who have substantially contributed towards making CAA Siena unforgettable for their delegates.

Particular thanks are offered of course to the Steering Committee of CAA International, and especially to its chairman Prof Gary Lock and treasurer Axel Posluschny, and all the many others for their unfailing support; they were always there when needed and they helped immensely in creating a happy working atmosphere. A special thanks is must also go to the OCS 'guru', Hembo Pagi, who patiently supported us while using the new CAA conference management system.

We would like to acknowledge the skill and generosity of our outstanding key-note speakers: Nicolò Dell'Unto (University of Lund,Sweden), Maurizio Forte (Duke University, USA), Martin Millett (University of Cambridge, UK) and Holly Rushmeier (Yale University, USA). A sincere thank you also goes to the special guest of the 43rd CAA, Professor Dominic Powlesland (Landscape Research Centre, UK).

We are indebted to the many bodies who have given us their willing support: Ministero dei Beni Culturali e del Turismo, Comune di Siena, Soprintendenza per I Beni Archeologici della Toscana, Regione Toscana, Provincia di Siena, Comune di San Giovanni d'Asso, Comune di Montalcino, Comune di Pienza, Accademia Chigiana, Opera del Duomo, Eurographics, Fondazione Ing. Carlo Maurilio Lerici, Archeologia e Calcolatori, Bruno Kessler Foundation 3DOM, Polytechnic of Milan, CNR Institute of Technology Applied (Cultural Heritage).

Special thanks are also due to all the many sponsors, whose generosity played such a crucial role in sustaining us in this enterprise: Monte dei Paschi di Siena (dott. Carlo Lisi), ESRI Italy (Paolo Gull) & ESRI Europe, IDS Ingegneria dei Sistemi (Paolo Papeschi), ATS srl (a spin-off company of the University of Siena), ArcTron 3D Expertise in Three Dimensions, Aicon 3D systems, Breuckmann 3D scanner, Beta Radiocarbon Dating, Geocarta, Geostudi Astier, Eurotec Pisa, INARI, V-must, Menci software, Archeopress, All'Insegna del Giglio,

Finally, heartfelt and grateful thanks must go to **Dr Marianna Cirillo** and **Dr Gabriella Carpentiero** for their tenacity, rigour and outstanding work done in helping to assemble and manage the preparation of the conference proceedings.

3D Technology Applied to Quantification Studies of Pottery: Eve 2.0

Miguel Busto-Zapico
bustomiguel@uniovi.es
University of Oviedo

Miguel Carrero-Pazos
miguel.carrero@usc.es
University of Santiago de Compostela

Abstract: In archaeological excavations, pottery fragments are the most common remains. As a consequence, it seems appropriate to propose a methodology that can help in their study. Therefore, we intend to propose a method that will allow us to identify from a fragment of pottery, the size of the vessel it came from, basing on partially completed pieces. This approach is not new, since between the 1980s and 1990s, C. Orton, P. Tyers and A. Vince started discussing about the estimated vessel equivalent (EVE). However, despite its advantages, it is a system which is not implemented fully. On this basis, we have designed a reviewed EVE, adapted to the new technologies (3D) that allow us to go further and talk of EVE 2.0.

Keywords: Methodology, Quantification, Pottery, Estimated vessel equivalent, 3D technology.

Introduction

In any archaeological excavation, pottery fragments are the most frequent quantitative remains. Specific approaches are needed for their study, which can include a precise quantification approach. For this reason, we considered it appropriate to plan a study, to revise and adapt the main methodologies that have been used for this purpose, because quantitative studies are necessary to obtain an accurate picture of the pottery that was used in a determined archaeological context and to compare that information with others.

Our aim is to propose a quantification method in which we could ascertain from a small fragment of pottery, the percentage of the complete pottery piece, by applying 3D technology on well preserved sherds. We are attempting to develop a new adaption of the EVE based on the application of new technologies that did not previously exist. As a result, we have developed the EVE 2.0 (Busto and Linares, 2013), a methodological approximation to pottery studies. It can be defined as a quantitative analysis system, which allows us to assign each fragment a percentage value with respect to the whole vessel of which they were part, regardless of other factors or variables that may alter it. Provided that, at the beginning, we have the full profile of the piece, because this method only applies to largely preserved materials which may be documented at some contexts. However, the Eve 2.0 should be implemented and applied only where it could serve to achieve the objectives in research, and when the pottery repertoire would make it possible.

1.1 The quantification studies on pottery

The basic need for a suitable quantification method is a well-known problem (Fletcher and Heyworth, 1987). Many methods have been used, but none have been successful. Over the last decade, the main quantification methods were: sherd count, sherd weight, sherd volume/area (n.b. not vessel capacity), vessels represented (minimum, maximum or estimated) and estimated vessel equivalents or EVEs (Orton 2009: 5). All of them have clear advantages and disadvantages that can convey some problems to research conclusions. In several occasions, the solution may lie in a combined study, which integrate some of these proposals.

In the 1980s and 1990s, C. Orton first, and then with the collaboration with P. Tyers and A. Vince started to implement the quantification methods with the 'estimated vessel-equivalent' (EVE). In the book *Mathematics in Archaeology*, C. Orton (1980) with the intention of resolving the quantification problems of the pottery, described the theory of the vessel-equivalents (V.E.), although that method had been presented before (Egloff 1973; Orton 1975). A few years later, C. Orton, P. Tyres and A. Vince, in *Pottery in Archaeology* (1993) further explained the 'estimated vessel-equivalent' (EVE). Recently, it has been published a second edition of *Pottery in Archaeology* (Orton and Hughes 2013) where it is revised deeply the first edition.

In their opinion, this new method was 'the only measure that is unbiased, both for measuring proportions within an assemblage and for comparing them between assemblages' (Orton *et al.* 1993: 171; Orton and Hughes 2013: 207). The scientific community, especially in the United Kingdom and Ireland, has mainly accepted this quantification method. Despite its advantages, it is a system whose applications are constrained.

C. Orton starts from the premise that 'if one has one sherd, its vessel-equivalent is simply the proportion of the vessel that it constitutes' (Orton 1980: 164), and for this reason 'every sherd is a certain proportion of the whole pot of which it once formed part' (Orton *et al.* 1993: 21; Orton and Hughes 2013: 22). However, to estimate the complete pottery that a fragment represents, C. Orton falls back on approximation methods, and here is where we can find, in our opinion, the main limitation of EVE. What C. Orton, P. Tyers and A. Vince measure is the percentage that a fragment from the rim represents with respect to the complete pottery piece using a rim chart. So 'one can

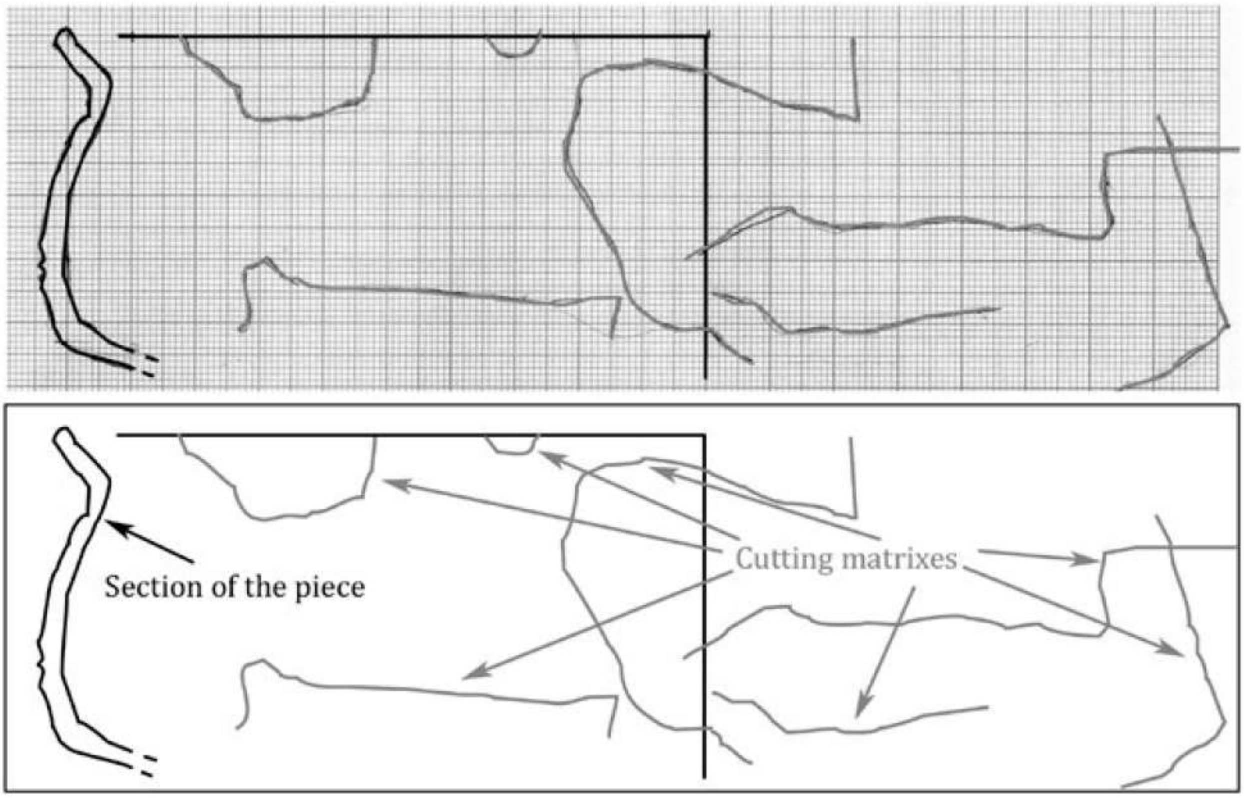


FIG. 1. EVE 2.0 CREATION: PHASE I.

then let the rim stand representative of the whole pot and use this figure as the EVE' (Orton *et al.* 1993: 172; Orton and Hughes 2013: 210). The same method will be applied to the base of the pottery (Orton and Hughes 2013: 210). However, this statement can be understood as excessive, an attempt to avoid system restrictions.

1.2 Walking towards to EVE 2.0

Starting from this theoretical approach, we tried to develop an EVE that integrates new technologies.

Nowadays we are able to develop some changes, not to the aims of the system, but to its application method. It is therefore not only a matter of change and an adaptation of forms, but also a methodological revision that uses three-dimensional representations of sherds as an informative element. In this sense, we can get a more accurate quantification studying specific pieces. Sometimes this can lead to a more accurate interpretation, having considered a part of a set of pieces.

We have tried to change the system to make it more current. It is an upgrade or a new version of EVE that adds new features to the method. Therefore, the revised EVE that we are proposing, or EVE 2.0 as we have called it, is not an end in itself, but a tool to allow Archaeology to continue developing, although in small-scale approach.

2 The EVE 2.0

In order to apply the EVE 2.0, we must carry out a previous typological study of pottery vessels, trying to rebuild them in order to get all the profiles as many of them as possible. Also, we must create the ceramic types basing on a set of specific attributes, derived from morphometric factors, because the EVE 2.0 starts from the 3D model of the piece, to quantify it.

The most useful morphometric variables for the application of EVE 2.0 may be those relating to diameters (border, base and maximum diameter), height (of the whole piece and maximum diameter), a variable range of thicknesses and, above all, the weight. Our aim is to create a pottery collection that could allow us to connect the largest number of fragments with the different types that are in it.

The working process to obtain the EVE 2.0 is easy, and we will only have to go a few steps further than a usual pottery study. In order to make the text comprehensible, it is necessary to explain three concepts:

- Section of the piece (A). This term refers to a perpendicular cut from the rim to the centre of the base, which allows us to establish the different thicknesses of the pottery piece.
- Cutting Matrices (B). This term refers to all cuts and breaks that contain the pottery piece.
- Real piece (C). With this term, we are referring to the shreds of pottery, or group of them that constitute our pottery piece.

According to our theory A-B= C. To demonstrate this simple hypothesis, we have set in motion a methodological work that

FIG. 2. EVE 2.0 CREATION: PHASE II.

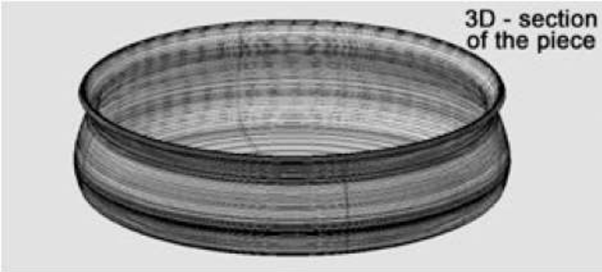


FIG. 3. EVE 2.0 CREATION: PHASE III, 3D SECTION OF THE PIECE.

we have divided in different phases: Drawing, Vectorisation, 3D creation and Calculus of the EVE 2.0.

Phase I: Drawing (Fig. 1). For EVE 2.0 we need the section of the piece (A) and its diameter. At the same time, we need to mark all the cuts and breaks on our fragment, recording their real dimensions real dimensions and positions, to develop the cutting matrices (B).

Phase II: Vectorisation (Fig. 2). Once the image is inserted and scaled, we vectorise it. To do so, we use the polyline to redraw A and B.

Phase III: 3D creation (Fig. 3-8). The fragment will be submitted to the rotation axis at its centre 'A' (3D-A). Thus, we will construct series of different objects in 3D from B (3D-B). To create the 3D section of the piece we will use the *CAD revolution* command. Thus, we will be able to create surfaces and revolution solids, submitting them to the rotation axis at a feature centre. Therefore, in our case, the fragment will be submitted to the rotation axis at its centre. In this way, we will obtain a 3D solid (Fig. 3). We will build a few objects from our cutting matrices, with the command *extrusion*. The new piece built has the same section than the matrix one (Fig. 4).

Finally, the last step of this method is perhaps the most complicated one. To create the 3D of the real piece (3D-C) we will carry out *boolean* operations with solids, especially with a *difference*. The entity that results will be another object with all the points of the first one, except for those that were occupied by the second (Fig. 5).

Then, we have to place the 3Ds on the cutting matrices (3D-B) in those parts that we want to eliminate from the 3D copy of the section of the piece (3D-A'). In this sense, we will be able to eliminate the unwanted portions of the entity. Therefore, we are dealing with a solid that approximates to the piece that we have found in reality. With 3D we have obtained a virtual model that reproduces the volume of the real object. We will repeat the procedure but choose the solids in an inverse way, to obtain a representation of the fragments which have not been preserved (Fig. 6-8).

Phase IV: The calculus of the EVE 2.0 (Fig. 9). To summarise, with 3D we have obtained a virtual model that reproduces the volume of the real object. Through the vectorisation

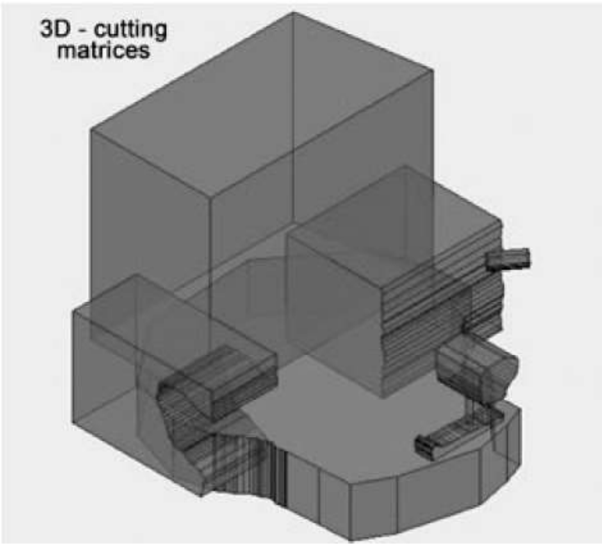


FIG. 4. EVE 2.0 CREATION: PHASE III, 3D CUTTING MATRICES.

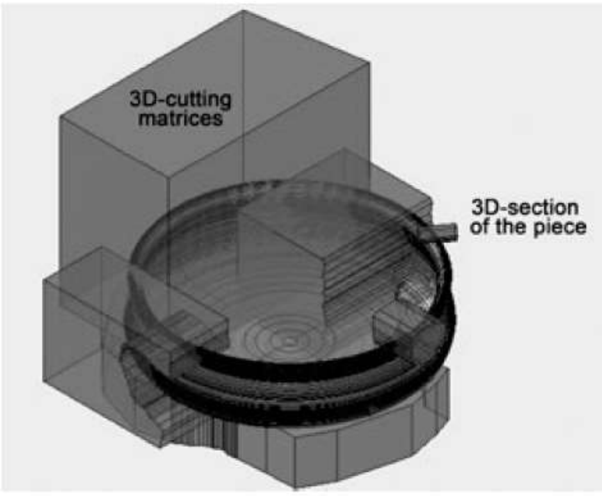


FIG. 5. EVE 2.0 CREATION: PHASE III, *BOOLEAN* OPERATIONS WITH SOLIDS.

FIG. 6. EVE 2.0 CREATION: PHASE III, 3D-C.

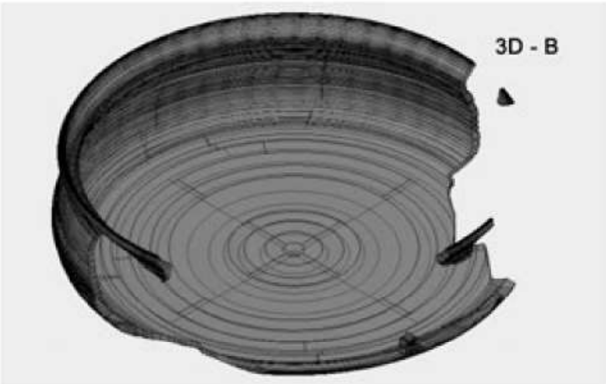


FIG. 7. EVE 2.0 CREATION: PHASE III, 3D-B.

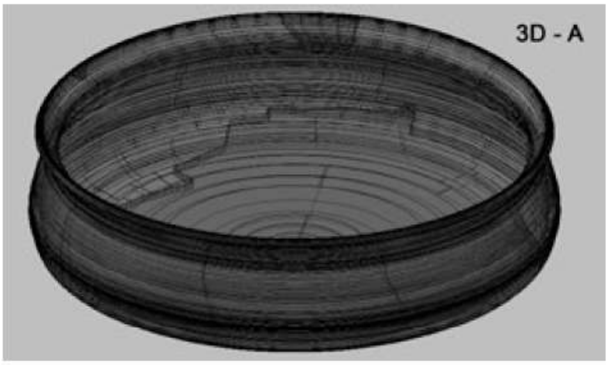
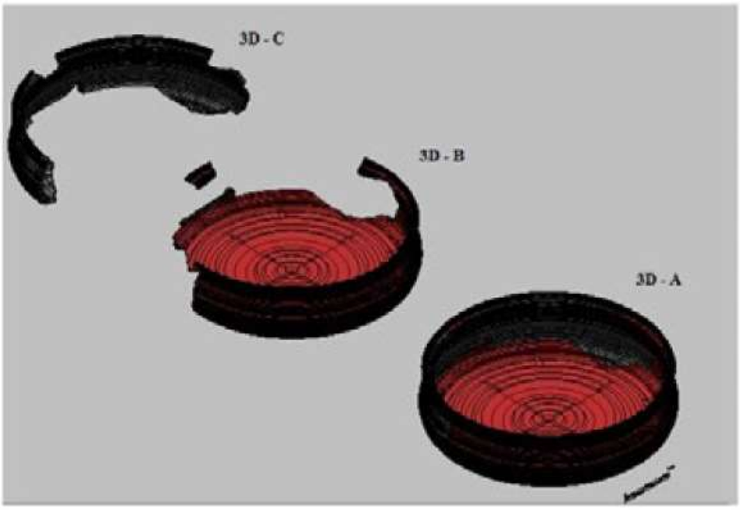


FIG. 8. EVE 2.0 CREATION: PHASE III, 3D-A.

of the fragment (A) we have created a three-dimensional representation of the complete piece (3D-A). Through the 3D-A, using simple mathematical operations, we can obtain the specific 3D of our initial fragment (3D-C). Furthermore, we can study the volume and mass of all these objects, so we could know the percentage of the piece that we have in relation to the totality. In this sense, if we know the weight of the different fragments we have analysed (C), we could deduce the approximate weight that that piece could have (Fig. 9).

In other words, with the vectorisation, the realisation of the 3D model and the use of Boolean algebra, we have enough data to calculate the EVE 2.0 of all ceramic types recreated in 3D. This is because we have recreated this objects, even those that do not exist, in a specific 3D space.

Accordingly, we are able to know the volume and mass of all of them, and calculate the EVE 2.0, which is the percentage of the piece that we have with respect to the whole. Besides, to facilitate the rapid quantification of the pottery sherds, the EVE 2.0 has another key application. If we are able to know the weight of the fragments, we would be able to infer the approximate weight that would have had the piece that existed at some point, due to the proportionality between these quantities.



EXAMPLE	3D-A	3D-B	3D-C
Volume CAD	205.9176	142.3304	63.5872
Estimated weight	**304.4 g**	**210.4 g**	**94 g**
EVE rim	100%	55%	45%
EVE base	100%	85%	15%
EVE 2.0	**100%**	**69.12%**	**30.88%**

FIG. 9. EVE 2.0 CREATION: PHASE IV, CALCULUS OF THE EVE 2.0.

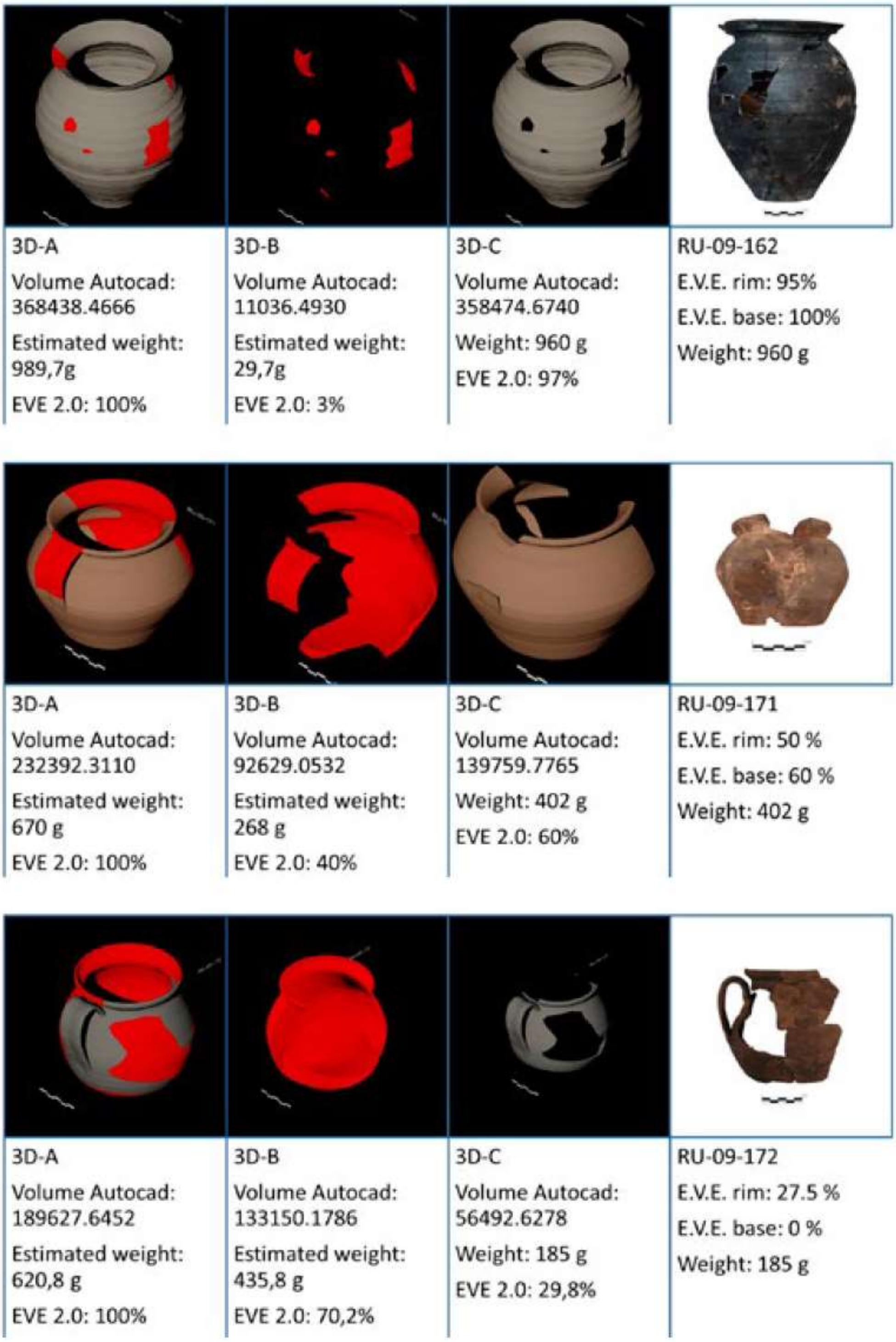


Fig. 10. Different case studies.

2.1 Practical example

Every methodology has its beginnings in experimental parts, and in this paper, we intend to plan an empirical demonstration through a repetitive trend. To put it in another way, we want to show that EVE 2.0 can be put into practice with different samples. In order to test our method, we have chosen the pottery of the excavations that have been carried out at the *Museo de Bellas Artes de Asturias* (Oviedo, Spain). They are pieces with a high level of conservation and with a timeline stretching from the mid-sixteenth century to the mid-seventeenth century (Busto, 2013). Starting the treatments with these varied pieces (with a diverse pottery profile) we obtained the following data:

The EVE 2.0 has allowed us to study with a more in depth approach the percentage of the piece that we managed. In addition, we were able to determine the approximate weight of a particular case, information that was previously unknown (Fig. 10).

2.2 Improvements and limitations of EVE 2.0

Perhaps the most important improvement of EVE 2.0 compared with the previous EVE is the substitution of an estimation index for a percentage. Replacing the estimate (EVE) with the actual measurement (VE= Vessel-Equivalent), it would greatly improve the accuracy of pottery quantification. But unfortunately its application is only possible under certain pieces.

On the other hand, 3D modelling makes other approaches possible, like the statistical analysis of the obtained data (Esquivel *et al.* 2008). Moreover, there is the possibility to create visual galleries, and to plan studies of the potential of artefacts (Rubio *et al.* 2009). However, we are dealing with a methodology that shows an approximate perspective. 3D representations that we have studied often offer perfect geometric features. Of course, it does not correspond to real vessels. Pottery is not usually perfect, and therefore, the accuracy of results always depends on the study area.

This limitation can be clearly rectified with the use of a 3D scanner or photogrammetric techniques, which provide more accurate information about the piece, and let us apply the method to every piece. In this moment, some phases of the method are too slow in some of their phases, but we are still improving them to make them faster. Perhaps the introduction of the photogrammetric techniques might be faster.

On the other hand, EVE 2.0 is not applicable to all fragments. It is a very restricted method that can only be applied to specific pieces. To apply it, we need pieces with a complete section, that is to say, we need parts of the rim, wall and base in the same fragment. However, it is readily applicable to ceramics with high level of standardisation, demonstrating, in these cases, large quantitative profits (Busto 2014). Similarly, if we can group fragments around typologies, getting the weight of some types, we could be able to work with almost all of the material, reducing initial restrictions. In this field, it can yield great advances in quantification studies.

Although none exists at present, the EVE 2.0 allows us to obtain the approximate weight of a complete piece of a specific typology. Therefore, this quantitative technique provides data hitherto unknown and inaccessible at present (Fig. 9-10). In fact, such data may become as a key part in technological and productive analyses of pottery. In addition to this, the weight is a quantification method which allows avoiding the distortion problems derived from other quantitative methodologies.

3 Conclusion

EVE 2.0 reinforces a path within archaeological studies. The appropriate method of analysis is that which combines different techniques and instruments for each case to complete the archaeological information record. Each method provides different information and complements the others, and for this reason, it should not be exclusive or prioritise one over the others.

This method of quantification or EVE 2.0 is able to assign to each fragment, a percentage value with respect to the whole vessel which were part, regardless of other factors or variables that may alter it. Therefore, we can relate these units of analysis (or pottery sherds), with a basic device (or pottery container). It also allows to know the approximation weight of a complete piece.

From a quantitative point of view, although the EVE 2.0 is not applicable to the entire material, it is an impartial measure unaffected by fracturabilty, which in fact is able to obtain data on the proportions of a specific type within a set, and allows to compare the proportions between it and other groups. The use of a percentage values is a procedure required, which allows to start more sophisticated quantitative methods.

Bibliography

Busto, M. 2013. *Conjuntos cerámicos del Oviedo bajomedieval y moderno. Los materiales de la casa Carbajal Solís.* Unpublished Degree dissertation, University of Oviedo.

Busto, M. 2014. Una aproximación a las cerámicas recuperadas en la excavación arqueológica del restaurante de El Polinario. *@rqueología y Territorio* 10: 117-32.

Busto, M. And Linares, M. J. 2013. EVE 2.0: Una revisión y adaptación de un método para el estudio cerámico. In Padilla, J. J. and Alarcón, E., *II Congreso Internacional de Estudios Cerámicos. Etnoarqueología y Experimentación: Más allá de la Analogía*, Granada, 5-9 March 2013.

Egloff, B. J. 1973. A method for counting ceramic rim sherds. *American Antiquity* 38:3: 351-3.

Esquivel, J. A., Esquivel, F. J., Alemán, I. 2008. Análisis estadístico de los parámetros morfométricos de un vaso carenado utilizando un láser escáner 3D. *Cuadernos de Prehistoria y Arqueología de la Universidad de Granada* 18: 357-70.

Fletcher, W. and Heyworth, M. P. 1987. The quantification of vessel fragments. In Gaffney, C. F. and Gaffney, V. L. (eds.), *Pragmatic Archaeology Theory in Crisis?* British Archaeological Reports, British Series 167: 35-46. Oxford, British Archaeological Reports.

Orton, C. 1975. Quantitative Pottery Studies: some progress, problems and prospects. *Science and Archaeology* 16: 30-5.

Orton, C. 1980, *Mathematics in archaeology*. Cambridge, Cambridge University Press.

Orton, C. 2009. Four pots good, two pots bad?: exploring the limits of quantification in the study of archaeological ceramics. *New Perspectives on Ancient Pottery Conference, University of Amsterdam*: 1-10.

Orton, C. and Hughes, M. 2013. *Pottery in Archaeology*. Second Edition. Cambridge, Cambridge University Press.

Orton, C., Tyers, P., Vince, A. 1993. *Pottery in Archaeology*. Cambridge, Cambridge University Press.

Rubio, D., Martínez, J., Baena, J., Fernández, J. J., Finat, J. 2011. Nuevos métodos para viejas tecnologías: análisis y documentación de los materiales arqueológicos mediante la aplicación de sistemas de Láser-scanner 3D. In A. Grande, V. M. López-Menchero, A. Hernández-Barahona, (eds.), *I Congreso Internacional de Arqueología e Informática Gráfica, Patrimonio e Innovación, Arqueología 2.0. Sevilla, 17-20 june, 2009*: 345-9. Sevilla, Sociedad Española de Arqueología Virtual.