The activities of the LAMBDA (Laboratory of Milano Bicocca university for Dating and Archaeometry): what's new?

The activities of the LAMBDA (Laboratory of Milano Bicocca university for Dating and Archaeometry): what's new?

L Panzeri, A. Galli, F Maspero, M Saleh, M Martini

Dipartimento di Scienza dei Materiali, Università degli Studi di Milano-Bicocca, via R.Cozzi 55, 20125 Milano

laura.panzeri@unimib.it

Abstract. The LAMBDA, Laboratory of Milano Bicocca University for Dating and Archaeometry, has a forty-years experience started with the first thermoluminescence dating activities in Italy in the early eighties. Soon after, other dating techniques (Optically Stimulated Luminescence, OSL, Radiocarbon, Dendrochronology and recently Rehydroxylation) have been studied and dedicated laboratories have been set up, where the physical basis of the techniques are constantly under investigation, mainly for what concerns the role of defects in quartz in the luminescence processes. LAMBDA covers other prominent archaeometry fields such as dating of mortars by OSL and Radiocarbon, surface dating of bricks and rehydroxylation dating. In this paper we will present the recent results in dating field focusing on mortar and surface dating. Furthermore, the results of a recent dating campaign to rediscover ancient Milan will be presented.

1. Introduction

The Archaeometry Laboratory at the University of Milano-Bicocca was established in 1998 and has been working in the Cultural Heritage field with know-how that covers many archaeometry topics, in particular thermoluminescence (TL, ceramic materials) and optically stimulated luminescence (OSL, sediments) dating. Through the years the group started new research lines to develop innovative dating techniques, including the dating of archaeological mortars and surface dating method.

Compared to all other datable materials, mortar has the great advantage of existing in abundance in every stage of construction, it is manufactured at the time of the construction of a building and it can not generally be recycled. Dating mortar would represent a great improvement in historical building studies allowing the identification of different construction phases, interventions and modifications of a structure and allow to overcome the well-known phenomenon of re-use often found in the TL dating of bricks [1]. The application of OSL to mortar dating is possible because the quartz crystals contained in the aggregates are exposed to daylight during the mixing and laying of the mortar itself and could therefore be used as dosimeters, recording the natural dose since the end of the exposure to sunlight, which coincides with the edification. Several articles have been published on the application of OSL to mortars dating [2-14]. Nevertheless, this technique is not yet a routine method. In particular, the main issue is that the quartz grains contained in the mortar may be only partially or inhomogeneously bleached leading to an overestimation of the sample age. The development of the Single Grain technique [15] allowed a better identification of the well bleached quartz grains, which represents a fundamental

step for reliable dating. However, the identification of the bleached grains is not always successful, indicating that further investigation might be needed to assess the dating protocol.

The other innovative luminescence methodology recently developed is surface dating. It allows dating events resulting in the permanent covering of surfaces of buildings previously exposed to the light, like construction, destruction or landslides covering [16-19]. Surface dating could be applied to date building blocks such as stones, limestone, marble, granite, sandstone and basalt. The main critical points of this technique are the identification of the penetration depth of the light, the complete emptiness of the surface OSL traps (bleaching) and the evaluation of the possible residual OSL signal (partial bleaching).

In this work we present the recent OSL applications made at the LAMBDA on mortars of different provenance (Terme del Sarno, Pompei, ruins of the Teatro Zairo – Prato della Valle, Padova – and Castello di Cannero – Lago Maggiore) together with the results obtained with the application of surface dating to prehistoric stone wall structures at Monte Leoni (Grosseto, Tuscany). The strengths and weaknesses of both techniques will be highlighted.

In addition to the innovative dating techniques, the results of a dating campaign carried out in the city of Milan will be presented. The presence of an important archaeological stratification in the city of Milan has long been known. Recently, the excavation for constructing a new subway line (M4) in Milan revealed many ancient remains of the city in Roman age. The results obtained allowed to deepen the knowledge of the Roman city and to enhance the archaeological heritage of the city of Milan with new touristic routes that will integrate the existing ones [20].

2. Results

2.1 Mortar dating

In this work, mortars from sites of known age were dated with the OSL in order to validate the dating procedures used. The samples, belonging to three different sites, were analyzed using the coarse-grain technique (180-250 μm, 21]) and were measured applying the SAR (Single Aliquot Regenerative, [22]) protocol. The Multigrain (MG) method was used, and for the samples that have an intense luminescence signal also the Single Grain technique (SG) was applied. Different statistical methods were applied for the calculation of the equivalent dose (E.D.): average, weighted average, CAM (Central Age Model) and MAM (Minimum Age Model, [23]). The results obtained led to an overestimation of the expected age for most of the samples, regardless of the statistical model used for the calculation of the equivalent dose. The cause of this overestimation was the incomplete bleaching of the quartz grains during the mixing and laying as it is demonstrated by the non-gaussian distributions of E.D. obtained (Figure 1). An attempt was made to ascertain whether there is a relationship between the origin of the quartz and the goodness of the result obtained. Such a relationship could allow us to select the mortars that could be dated with OSL.

2.2 Surface dating

On the top of Monte Leoni, at an altitude of 616 m. above sea level there is a large wall within which there are some huts. It is a fortified high ground settlement that in a reconnaissance made in 2018 was chronologically attributed to the late-recent Bronze Age, on the basis of stylistic evidence of various ceramic fragments luckily discovered. These structures made with local stone seem to extend well

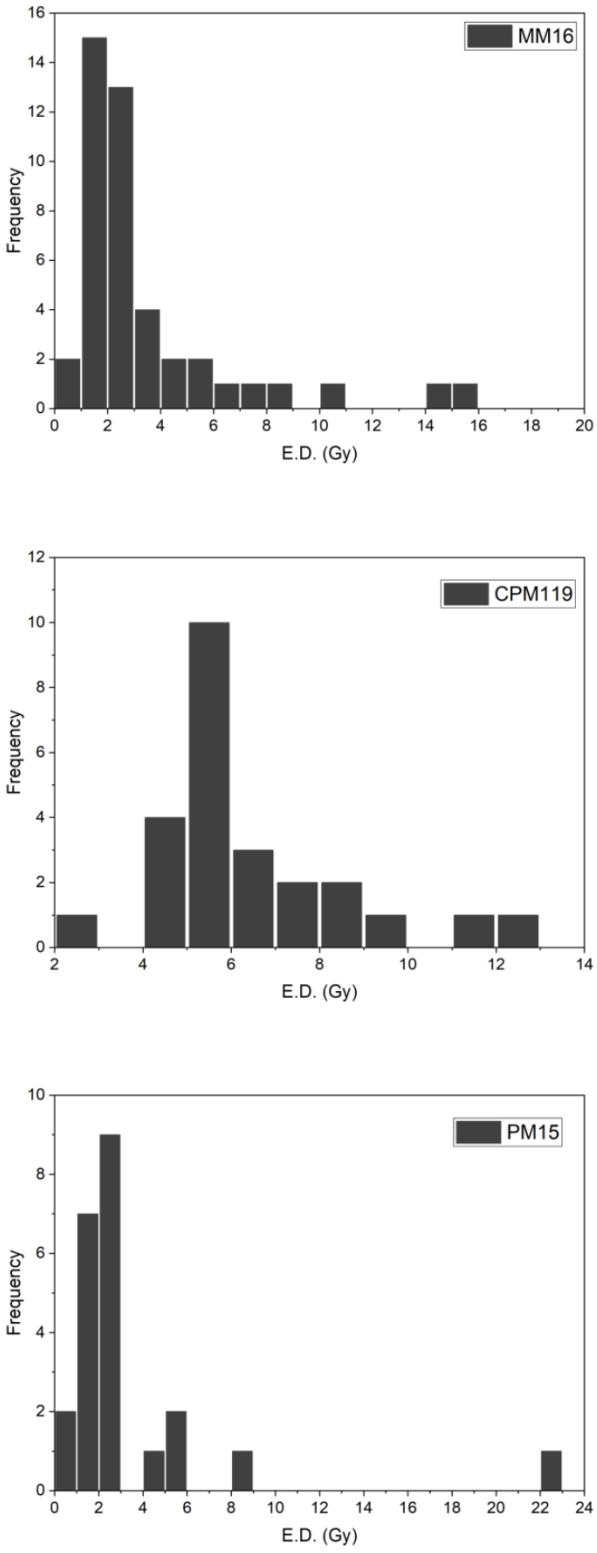

Figure 1. Example of E.D. distributions obtained on mortars from Cannero Castle (MM16, PM15) and from Teatro Zairo (CPM119).

beyond the high ground walls with a system of embankments, the so-called "murals" that are scattered throughout the mountainous elevation.

The surface dating technique is in principle well suited for the chronological determination of the construction phases of this site. In this work, a feasibility study of the application of OSL surface dating to these local rocks was performed. In particular, the dosimetric properties of the quartz extracted from the stones were checked together with the emptying of the OSL traps by sunlight. The decrease of luminescence signal at the rock surface was measured in order to determine the bleaching efficiency as a function of depth.

In addition to dating the surfaces of the rocks, in some cases it was also possible to take sediment samples under the rocks. On the assumption that also the sediment hasn't been exposed to light since the placement of the rock, we checked the predictability of reconstructed luminescence profiles into the buried rock surface. Moreover, the discovery of ceramic fragments at the site allowed the application of the TL as well. The use of different dating techniques applied to different materials allowed us to validate experimental techniques not yet routinely applied and to improve the error range.

2.3 TL dating

During the years of activities, the LAMBDA was involved, in collaboration with the "Soprintendenza Archeologia, Belle arti e Paesaggio per l'area metropolitana di Milano", the territorial authority in charge, in the study of the ancient *Mediolanum* with the aim to reconstruct the chronology of the Roman city and its successive growth.

For this purpose, fired clay bricks and ceramic artifacts were sampled from four excavation sites, among which the city walls (via Cavallotti) that are known to be upgraded in different chronological periods, the thermal baths (terme Erculee, corso Europa), the Palazzo Imperiale (via Santa Maria alla Porta) and the Roman ruins in via Rovello. The samples were dated by TL. The measurements were performed on the polymineral fine-grain fraction [24] extracted from each brick; the E.D values were evaluated through the Multiple Aliquots Added Dose (MAAD) procedure [25]. This study highlights the potential but also the limits of the application of the TL for the dating of buildings: in some cases this technique is able to respond to the doubts of the archaeologists, while in other cases it couldn't give additional information on the site due to the high error associated to the poor dosimetric properties of the samples, or to the well-known reuse of ancient bricks.

3. Conclusions

This research work has highlighted the potential and limitations of recent luminescence dating techniques. Much research work is still to be done to improve the precision and accuracy of the results obtained. Moreover, in order to be able to answer the archaeological questions, it is necessary, where possible, to apply different integrated dating techniques to different types of materials.

References

[1] Martini M and Sibilia E 2006 *J Neutron Res* **14** 69–74.
[2] Bøtter-Jensen L, Solongo S, Murray A S, Banerjee D, Jungner H 2000. *Radiat. Meas* **32** 841–845.
[3] Zacharias N., Mauz B, Michael C T 2002. .*Radiat. Protect. Dosim* **101**, 379–382.
[4] Goedicke C 2003. *Radiat. Meas* **37**, 409–415.

[5] Panzeri L 2013. *Il Nuovo Cimento* C, 205–216.
[6] Stella G, Fontana D, Gueli A, Troja O 2013. Geochronometria **40**, 153–164.
[7] Urbanovà P, Guibert P, 2017. *Geochronometria* **44**, 77–97.
[8] Urbanova P, Hourcade D, Ney C, Guibert P 2015. *Radiat. Meas* **72**, 100–110.
[9] Urbanova P, Delaval E, Lanos P, Guibert P, Dufresne P, Ney C, Thernot R, Mellinand P 2016. *ArchéoSciences* **40**, 17–33.
[10] Panzeri L, Cantù M., Martini M, Sibilia E, 2017. *Geochronometria* **44**, 341–351.
[11] Panzeri L, Maspero M, Galli A, Martini M, Sibilia E 2020. *Radiocarbon* **62**, 657- 666.
[12] Tirelli G, Lugli S, Galli A, Hajdas I, Lindoos A, Martini M, Maspero F, Olsen J, Ringbom Å, Sibilia E, Caroselli M, Silvestri E, Panzeri L 2020. *Radiocarbon* **62**, 667- 677.
[13] Tirelli G, Bosi G, Galli A, Hajdas I, Lindroos A, Martini M, Maspero F, Mazzanti M, Olsen J, Panzeri L, Ringbom Å, Sibilia E, Silvestri E, Torri P, Lugli S in press. *International Journal of Architectural Heritage*
[14] Urbanová P, Boaretto E, Artioli G 2020. *Radiocarbon* **62**, 503- 525.
[15] Bøtter-Jensen L and Murray A S 2002 Radiat Protect Dosim **101** 309-14
[16] Galli A, Panzeri L, Rondini P, Poggiani Keller R and Martini M. 2020. *Applied Science* **10**, 1-9.
[17] Sohbati R, Murray AS, Chapot M S, Jain M, Pederson J. 2012. *Geophys. Res*. **117**.
[18] Vafiadou A, Murray A S, Liritzis I 2007. *J. Archaeol. Sci*, **34** 1659–1669.
[19] Laskaris N, Liritzis I 2011. *J. Lumin*. **131**, 1874–1884.
[20] Fedeli A M 2015 *Milano Archeologia*
[21] Fleming S J 1970 *Archaeometry* **12** 133-47
[22] Murray A and Wintle A G 2000 *Radiat Meas* **32** 57-73
[23] Galbraith R F, Roberts R G, Laslett G M, Yoshida H, Olley J M 1999 *Archaeometry* **41** 339-64
[24] Zimmermann D.W 1971 *Archaeometry* **13** 29-52
[25] Aitken M J 1985 Thermoluminescence Dating, Academic Press London