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Unearthing the History of Agriculture: Luminescence Dating of Mediterranean Terraces

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Abstract

Agricultural terraces have been a vital part of farming practices in the Mediterranean region for centuries. These terraces are used to create arable land on steep slopes, making it possible for farmers to cultivate crops in areas where traditional farming methods would not be feasible. The use of agricultural terraces has not only provided an efficient means of preserving soil and reducing erosion but also offers valuable insights into the history of agriculture in the region. However, determining the age of these terraces has been a challenging task for archaeologists and geologists. In this article, we will explore how luminescence dating can be used to determine the age of agricultural terraces in the Mediterranean. However, the chronology of construction, use, and abandonment of terraces in different regions remains uncertain. A more robust set of chronological data will allow better assessment of whether terrace agriculture was a resilient strategy in the face of past economic or ecological instability and, in turn, inform how terraces could be used to address future agricultural and environmental challenges. Terrace systems are inextricably linked to sustainable land use across the Mediterranean. Luminescence dating methods, therefore, have a crucial role to play in understanding the complexities of past and future landscape change.

Keywords: Agricultural terraces; Mediterranean; Luminescence dating; Landscape archaeology

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Introduction

Luminescence dating is a technique that is used to determine the age of archaeological and geological materials. This method relies on the fact that when certain materials are exposed to sunlight or heat, they absorb energy and become "charged". Over time, this energy is released as light, a process known as luminescence. By measuring the amount of luminescence released by the material, scientists can determine how long it has been since the material was last exposed to sunlight or heat. Agricultural terraces are often made up of layers of soil, stones, and other materials. By extracting samples of these materials, scientists can use luminescence dating to determine when the terrace was last exposed to sunlight or heat.

To date agricultural terraces, scientists use a technique called Optically Stimulated Luminescence (OSL) dating. This technique involves exposing the sample to light and measuring the amount of luminescence released. By comparing the amount of luminescence released to a known standard, scientists can determine the age of the sample.

The history of terraces in the Mediterranean remains poorly understood. GIS-based techniques such as Historic Landscape Characterization (HLC) have been used to map terraced landscapes in the eastern Mediterranean, and techniques such as retrogressive analysis have been used to define their temporal relationships, although such analyses tend to produce and rely on relative chronologies. Without robust absolute chronologies, it remains difficult to relate the construction of terraces to their original socio-economic and environmental context. Furthermore, terraces were maintained and reconstructed over long periods, so understanding construction phases can be complex and age estimates can be unreliable.

In earlier decades, before the advent of absolute dating techniques, indirect methods were frequently employed by landscape archaeologists to suggest chronologies for terrace construction; for example, on associations with nearby ancient buildings or other structures of known age, with surface finds, or according to the attributes of the terrace walls. Morphology and construction style may provide chronological indicators, but this could be frustrated by replication and re-use of established construction methods. Successive usage and maintenance work on the terraces can lead to an age underestimation in the common situation where terrace walls were refurbished but the soils behind them remained relatively intact.

An essential requirement for luminescence dating is the exposure of luminescent minerals to adequate light at deposition to completely bleach, or reset, the luminescence signals prior to burial. Bleaching can occur during cycles of erosion, transportation, and deposition; hence, the luminescence age should

represent the time elapsed since last burial. Due to the depositional histories to the sediment in terraces and earthworks, it is likely that the luminescent minerals are only partially bleached prior to burial, which can led to significant scatter in equivalent dose values and, hence, age. This is more of an issue which may cause an age overestimation of the burial event in contexts where exposure to light may be limited, particularly in terrace systems where sediments accumulate during episodic flash floods and runoff events.

There are several statistical approaches for reducing equivalent dose distributions to a burial dose, influencing the calculation of luminescence ages. Various arguments have been made on the most appropriate dose model for a given sample based on the protocol used to determine equivalent doses, the heterogeneity or observed over dispersion in the distribution, the geomorphologic setting, and or the stratigraphic context. A further complication to dating terrace sediments is the potential for post-depositional mixing caused by bioturbation or geomorphic processes. Bioturbated samples may exhibit multi-modal De distributions, with modes both higher and lower than the dose distribution associated with the true burial age. Beta-dose heterogeneity can also contribute to the scatter in equivalent doses: some grains in the matrix might experience a greater dose due to proximity to hotspots, whereas grains distal to these will experience a lower dose.

Conclusion

Luminescence dating is a powerful tool for dating archaeological and geological materials. By using OSL dating, scientists can accurately determine the age of agricultural terraces in the Mediterranean region. This information is essential for understanding the history of agriculture in the region and for developing sustainable agricultural practices that take into account the lessons learned from centuries of agricultural practices. There are now over 250 luminescence ages from the Mediterranean but there are marked biases in available temporal and spatial data. Over two-thirds of published ages are from Israel, whilst the ages from other regions currently show that terraces were predominantly constructed and used during the later middle Ages. Compared to other geological and geomorphological settings like arid or fluvial landscapes where large luminescence datasets are available, the lack of comprehensive chronologies from agricultural terraces could be attributed to the fact that dating these sediments is notoriously difficult. Major challenges include the incomplete bleaching or resetting of the luminescence signal which causes heterogeneity in generated datasets, necessitating more luminescence measurements and making the whole process more time- and cost-intensive. The recent adoption of GIS techniques like HLC has proven advantageous in identifying key sites for dating and contextualizing results. Furthermore, the combination of conventional luminescence dating with field profiling and calibration addresses the issue of having limited numbers of dating samples per section by providing a way to evaluate complete

stratigraphic profiles. This cost- and time-effective combination has been successfully demonstrated to date terrace systems in Spain, Turkey, and Greece. Studies of historic terrace systems are becoming increasingly important for understanding the complexities of human–environment interactions as the demand for sustainable land use continues to grow in the Mediterranean. Applications of luminescence dating in conjunction with allied geoarchaeological techniques are becoming more relevant than ever to provide a more comprehensive understanding of the evolution of a landscape over time and the role of human activities in shaping it.

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