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Age determination of Petra's engineered landscape – optically stimulated luminescence (OSL) and radiocarbon ages of runoff terrace systems in the Eastern Highlands of Jordan

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ABSTRACT

The unfavourable mountainous environment of the Petra region in southern Jordan was modified by ancient engineers to supply the Nabataean/Roman city of Petra with food and water. The area was reclaimed by installing extended runoff terrace systems and hydraulic structures. The agricultural terrace systems have so far been dated based on surface pottery, and the chronology of the systems is under debate. In this study, optically stimulated luminescence (OSL) and radiocarbon dating techniques were successfully applied to date these terrace systems. Samples were taken from the fills of agricultural terraces and underneath their walls to determine the chronology of the construction, use and abandonment of the agricultural terraces. The results suggest that runoff farming in the Petra region started around the beginning of the Common Era, and construction, use and maintenance lasted at least until 800 AD.

1. Introduction

The diverse agricultural and hydraulic systems in the Petra region in Jordan are an impressive example of ancient dryland farming and water harvesting techniques. Archaeological evidence suggests that permanent and semi-permanent settlements have been present in the region since the Epipalaeolithic, c. 8300–7000 BC (Byrd, 1989). Petra is by far the largest and best preserved of the ancient settlements in the region. Petra was the capital of the Nabataean Kingdom and was a regional administrative and economic centre in the southern Levant from the 3rd century BC until the 4th century AD (e.g. Schmid, 2008). The city is located in the arid and rugged Eastern Highlands of Jordan, and its unfavourable environmental conditions made elaborate landscape modifications necessary to supply permanent settlements with local food and water (Ortloff, 2005).

The agricultural techniques applied in the area include runoff terrace systems (Lavento and Huotari, 2002; Gentelle, 2009; Kouki, 2009; and references cited). These systems are one of the various implementations of the agricultural terrace (reviewed in e.g. Spencer and Hale, 1961; Treacy and Denevan, 1994; Frederick and Krahtopoulou, 2000). As described by Evenari and Tadmor (1982), Nabataean runoff terrace systems in the Negev consisted of a series of stone walls and were built, for example, across channel beds and floodplains of periodically discharging rivers (*wadis*) and on slopes. These walls (commonly called *risers*) retain and collect water and sediments of episodic flash floods and runoff events. Initially, the upslope area of each of the retaining walls gradually silted up (the filling technique is called *self-filling*), and terraces developed. When sufficiently large, the terraces were used for cultivation (the cultivated area is commonly called *tread* and the sediment body is called *terrace fill* or *tread fill*). Occasionally, and in the case of a positive sediment budget, the farmers added a new row of stones on top of the walls in order to heighten the terraces and thus enlarge the water storage bodies and the cultivation area. This ancient technique has been reported from many archaeological sites in the arid areas of the southern Levant and especially for the Negev (e.g. Mayerson et al., 1961; Rosen, 2000; Avni et al., 2006; Hunt et al., 2007; Haiman and Fabian, 2009).

The Petra region is scattered with remains of such runoff terrace systems. Some of them are preserved and still cultivated by the local Bedouins, but most are abandoned and the walls and terrace fills are dissected by gullies. Most scholars attribute the initial construction of these systems roughly to the Nabataean/Roman time of occupation, mainly based on surface pottery and other relative dating techniques (e.g. Byrd, 1989; Lindner et al., 2000;

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Tholbecq, 2001; Lavento and Huotari, 2002; Gentelle, 2009; Kouki, 2009; Lavento, 2010). However, dating agricultural terraces using only these relative dating methods can be problematic because the pottery could indicate peak occupational phases rather than the initial time of construction. Moreover, sequent usage and maintenance work of the terraces could lead to an age underestimation (Treacy and Denevan, 1994; Frederick and Krahtopoulou, 2000; Krahtopoulou and Frederick, 2008 and references cited).

In this paper we present the results of a study to determine the chronology of selected runoff terrace systems and associated stone wall structures of the northern and western Petra region using optically stimulated luminescence (OSL) dating and radiocarbon dating.

The main goals of the study are to test the applicability of OSL dating in the Petra region and to gain first indications of the timing for the initial construction of the runoff terrace systems and phases of their usage. We therefore took OSL samples from profiles of the terrace fills and, if possible, from the sediments directly underneath the riser, assuming that (i) the tread stratigraphy generally corresponds to periods of filling by fluvial processes and (ii) the sediments underneath the walls had been reworked and exposed to sunlight during the wall construction (cf. Porat et al., 2006).

Two formerly intensively cultivated areas are investigated: the agricultural fields in the catchment of the Wadi al Ghurab, approximately 6 km north of Petra, and the cultivated fluvial terraces of the Seil Wadi Musa, the Roman Gardens, approximately 7 km downstream of Petra and next to the Roman fort of Um Rattam (see Figs. 1 and 2).

2. Study site

2.1. Occupational history

The main settlement phases before the Nabataean period have been related to the Natufian period, approximately between 10,800 and 8300 BC (e.g. Byrd, 1989), the Pre-Pottery Neolithic, from about 8500 to 5500 BC, e.g. at Beidha (e.g. Byrd, 1989), and the Iron Age, at the time of the Edomite Reign, ca. 1200–540 BC (e.g. Bienkowski, 2001). Settlements during these phases were primarily isolated agricultural settlements, located at environmentally or strategically favourable spots such as springs or hilltops (e.g. Tholbecq, 2001). After the Iron Age the archaeological record lacks indications of permanent occupation in the study region for almost 300 years (Schmid, 2008).

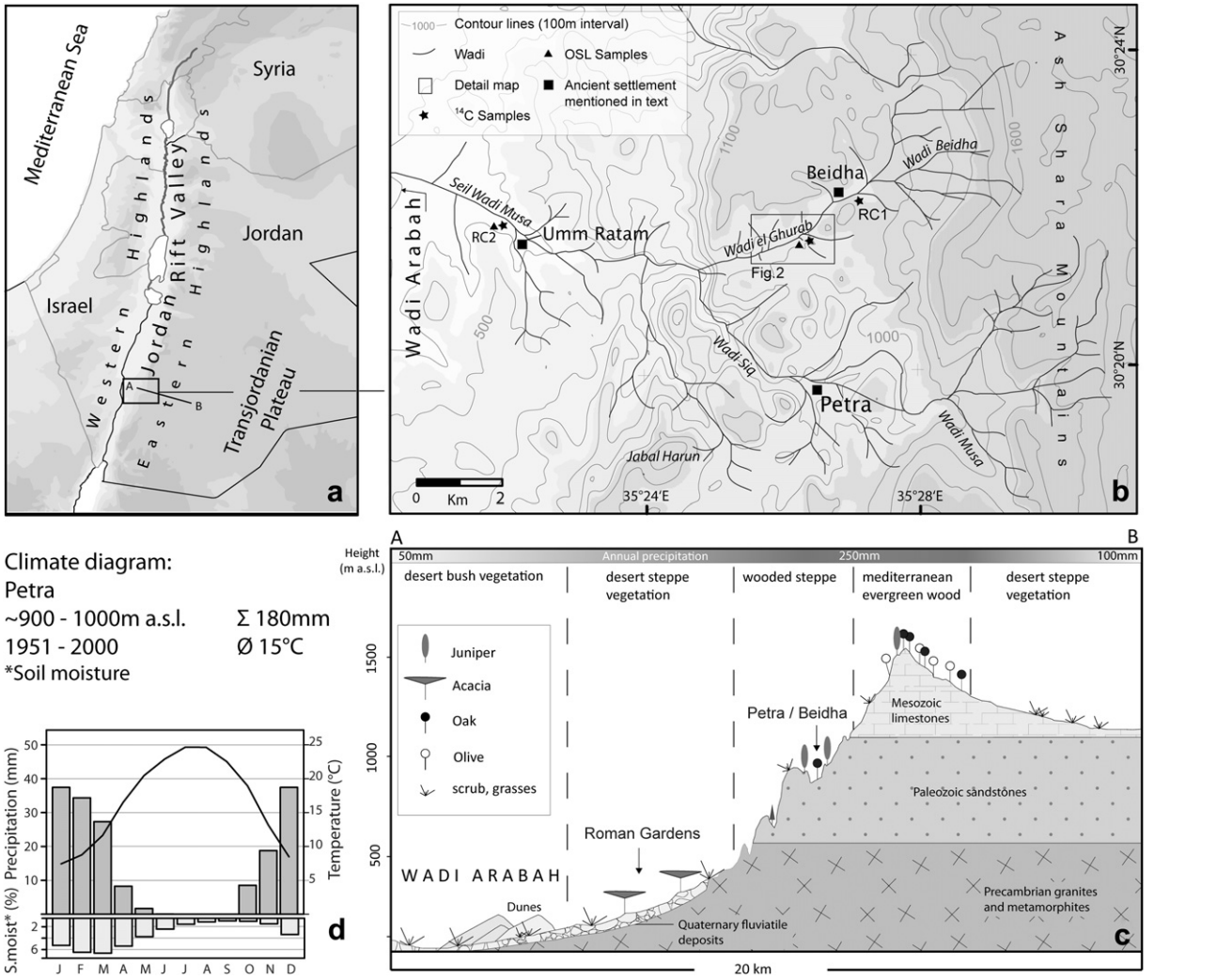

Fig. 1. 1a: Location of the research area in the southern Levant, A–B indicates the approx. extent of the profile in 1c (Database: GTOPO30); 1b: Detail map of the topography, major drainage systems and sample locations in the Petra region (Database: AsterDEM); 1c: Schematic profile of the major ecoregions, annual precipitation and major geological units, from the Wadi Arabah and the Eastern Highlands to the Transjordanian Plateau adapted from Hunt et al. (2007); and Cordova, 2007) 1d: Climate diagram and soil moisture of the Petra region (data sources and methods see Section 3.3.3).