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Ground-penetrating radar investigations at Marj Rabba, a Chalcolithic site in the lower Galilee of Israel

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ABSTRACT

The Chalcolithic site of Marj Rabba, in the lower Galilee of Israel, features shallow limestone structures situated in a terra rossa matrix. Calcareous substrates such as terra rossa, common throughout the region, are often not considered amenable to ground-penetrating radar (GPR) studies due to strong attenuation, particularly within the relatively high frequency range most often used in archaeological GPR surveys. Energy loss due to scattering from small embedded stones also exacerbates attenuation at this particular site in addition to obscuring detected archaeological features, thereby complicating interpretation. Because features are fairly shallow (upper 1.5 m) and contrast well with the soil, however, GPR was successful in spite of poor substrate quality. The selection of a somewhat lower antenna frequency (250 MHz) than is often recommended for archaeology, played a role in the success of the work. The end result expands the known spatial extent of the site by five-fold, increasing our knowledge of architectural and village plans for a time period which is poorly understood in this region. The settlement scale and complexity shown by these new results indicates that Chalcolithic villages are not only present in the Galilee but are as extensive and architecturally sophisticated as contemporaneous settlements in other regions. In combination with excavation results, the structures detected with GPR at Marj Rabba provide the largest plan of an early Chalcolithic settlement in the Galilee.

1. Introduction

The site of Marj Rabba is a late prehistoric settlement in lower Galilee, Israel (Fig. 1) dated to the Chalcolithic period (c. 4500–3600 BC) based on ceramic typology and radiocarbon dates. This key transitional period between the Neolithic and Bronze Age established new social practices, such as secondary burial in formal cemeteries, and sophisticated technological skills, perhaps most dramatically evident in the earliest metallurgy. These indices of increasing social and technological complexity are complemented by a dramatic expansion in population, evident in both increasing size and number of settlements. Our understanding of life in the southern Levant during this period has been largely determined by limited survey and excavations conducted in the Jordan Valley, Negev Desert, and the Golan Heights (Rowan and Golden, 2009). Interpretations of these dramatic changes are thus based on very few fully published sites and a few methodical surveys. In some areas, such as the Galilee, very little data is available from this period; no radiocarbon dates or coherent architectural plans are available from another Chalcolithic settlement. The Galilee Prehistory Project, an Oriental Institute of the University of Chicago research program, seeks to fill in the critical gaps of this important transitional period. This effort has included recent investigations at the Chalcolithic site of Marj Rabba in the lower Galilee region (Rowan et al., 2012).

Situated on active agricultural land (Fig. 2), Marj Rabba is located in a region of Israel that exhibits a primarily Mediterranean climate in accordance with standard climate classification schemes (e.g. Köttek et al., 2006). This climate makes the region more suitable for agriculture than nearby arid areas such as the Negev of southern Israel, and also fosters the development of the clay-rich soil type found at Marj Rabba. The site features circular and rectilinear stone foundations (Fig. 3) in at least three different building phases, exposed over five seasons (2009–2013) of excavation (Rowan and Kersel, 2014). In 2011, the Galilee Prehistory Project team undertook non-invasive geophysical investigations at Marj Rabba in an attempt to understand the full extent of the site and the distribution of features therein (Fig. 2). These efforts

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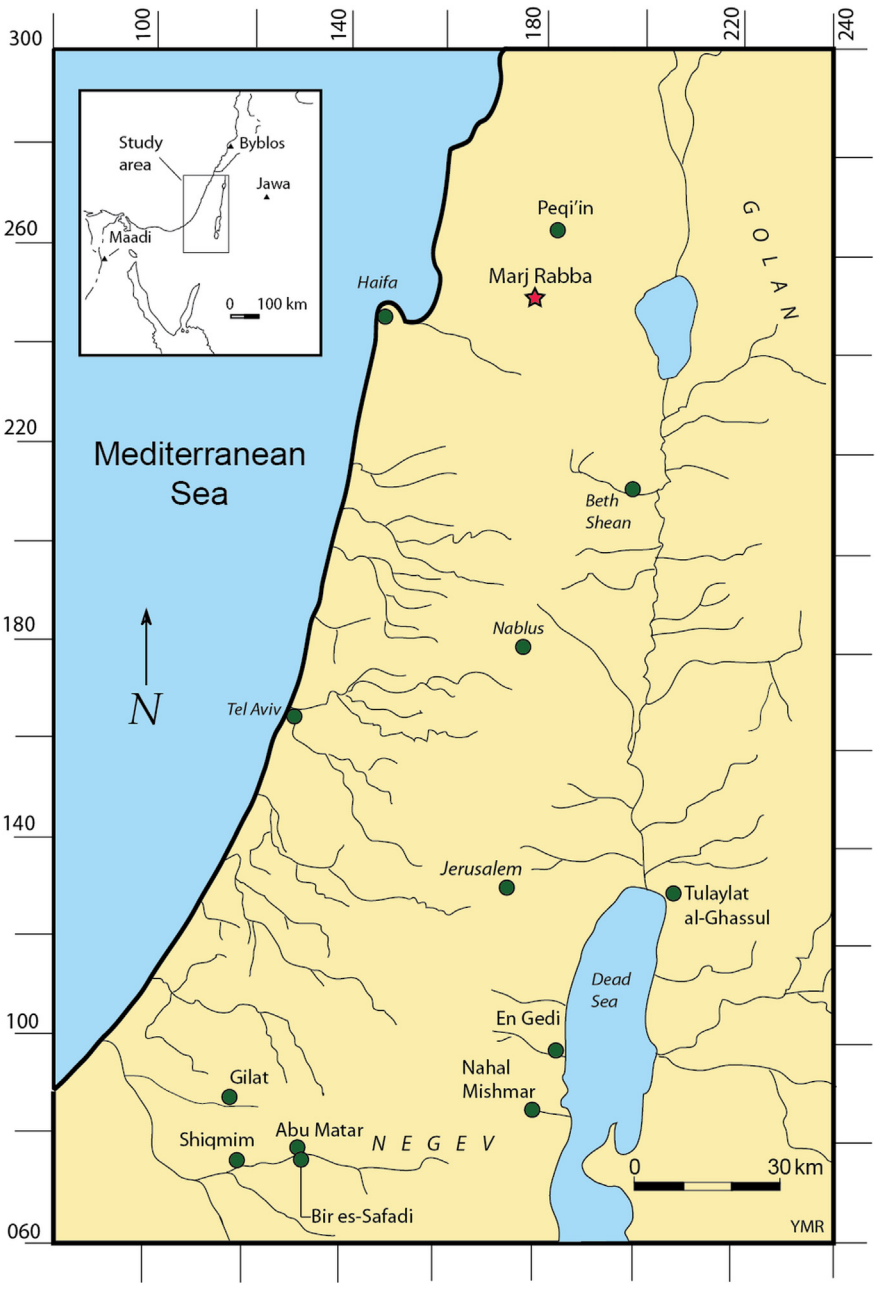

Fig. 1. Map showing location of Marj Rabba and select Chalcolithic sites in the region.

included broad surveying with ground-penetrating radar (GPR) and magnetometry, the latter of which failed to detect architectural features in suitable detail. The GPR survey required special consideration due to the moist, clay-rich, rocky substrate at the site as inferred from visual inspection of the soil type; a limestone derived *terra rossa* (Figs. 4 and 5). Conyers (2013:203–204) identifies the aforementioned soil conditions (wet clay, rocky) as substrate in which poor GPR performance can be expected in most instances, and previous researchers have noted poor GPR performance in calcareous substrates due to electrical losses (Grant and Schultz, 1994). In addition to this, the substrate at Marj Rabba is very rich in iron oxides, which give the soil its characteristic red color. High concentrations of magnetic oxides increase the magnetic permeability of the substrate leading to additional magnetic losses. Though normally a much smaller factor in attenuation (Ward and Hohmann, 1987), magnetic permeability has been shown to noticeably enhance attenuation when sufficient magnetic material is present (Van Dam et al., 2002). Beyond the electromagnetic loss mechanisms, the soil at Marj Rabba concealed shallow and variable limestone bedrock and exhibited incoherent limestone rubble. As the architectural features at this site are made of the same stone, an additional complicating factor was anticipated with the work; the difficulty of distinguishing fortuitous patterns of rubble and bedrock from architecture when interpreting the results.

As part of the plan to mitigate the anticipated effects of attenuation, a somewhat lower antenna frequency (250 MHz) than is typically recommended in archaeological geophysics was chosen