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The Geological Setting of Ḥorbat Nevallaṭ

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Introduction

This report focuses on the geo-archaeological setting of Ḥorbat Nevallaṭ and emphasizes the karstic nature of the chalk and *nari* manifested in the excavated rock shelter (Area A) and caves (Areas A and B).

Physiography

The site is located in the Shephelah foothills, in a wadi created by a tributary of Naḥal Nevallaṭ, which runs between Ḥorbat Nevallaṭ and Tel Dalit, north of Moshav Bet Neḥemya (see van den Brink and Lazar, this volume: Fig. 1). The main excavated areas (A and C) are located on the northwestern slope of a hill marked by Triangulation Point 122. A third excavated area (B) is located southwest of this hill, on the opposite side of the small wadi which continues northeast to join Naḥal Nevallaṭ.

Located between two major physiographic units—the Judean Mountains to the east and the coastal plain to the west—the Shephelah is a transitional zone (Yechieli 1997). However, the Shephelah Group chalks, the trademark of this physiographic unit, are missing; instead, the Judea Group rocks are exposed here. The boundary between the Judean Mountains and the Shephelah hills is a steep 50–70 m high slope, the north end of which lies at map ref. 654000 on the Israel Grid (Nir 1970). The route of Road 444 follows the boundary between the Shephelah hills and the Sharon coastal plain (see van den Brink and Lazar, this volume: Fig. 1). This is also a lithological transitional zone, between the limestone and dolomite rocks of the Judea Group and the much younger alluvium, sand and *ḥamra* soils of the coastal plain. The area west of this boundary slopes gently down from an elevation of some 80 m asl (above sea level) to the Mediterranean Sea.

Geological Setting

The northwestern slopes of the Judean Hills, south of Naḥal Shillo, occupy the mildly dipping flank of the Ramallah Anticline and some minor secondary folds, including the Modi‘in axis, a southwestward-plunging anticlinal extension which branches off the northeastern flank of the Ramallah Anticline (Livnat 1985). This structural undulation is bordered to the southeast by the *Graben* of Ni‘ilin-Qibya, and to the northwest, it meets the Ayyalon–Bet Neballah Syncline (Livnat 1985).

The geological map of this area (scale 1:50,000) was updated by Yechieli (1997), based mainly on a survey conducted by Livnat (1971; 1985). This map shows that the rock sequence of the Bina Formation (Kub) is exposed across much of the area, covered in places with small-scale outcrops of the ‘En Zetim Formation (Kue) and of the Bet Nir and Aḥuzam conglomerates. Chalk of the ‘En Zetim Formation outcrops was found in the main excavation Area A. A short description of the Bina and ‘En Zetim Formations is presented below, followed by an outline of the salient characteristics of *nari*.

Bina Formation (Kub)

The strata of the Turonian Bina Formation exposed in the Ḥorbat Nevallaṭ area consist of yellowish to light gray limestone with light gray patina and lapies morphology. Bedding is massive at the bottom and is reduced to 0.8–1.0 m thick in the upper parts. It contains some chert and quartzolite nodules. In places, the limestone becomes chalky and the surface is covered by a mixture of limestone and *nari* calcareous crust. Erosive unconformity is found at the formation's roof. The uppermost part was removed by pre-Senonian erosion and karstic activity, and the micro-topography is filled with the Senonian chalk of the ‘En Zetim Formation.

‘En Zetim Formation (Kue)

The Santonian-Campanian ‘En Zetim Formation consists of a basal unit (some 5 m thick) of well-bedded, white to yellowish and massive limonite-stained chalk and a main unit of marly chalk. The basal unit is exposed near Ḥorbat Nevallaṭ and is missing in the other outcrops, where the ‘En Zetim Formation disconformably overlies rocks of the Turonian Bina Formation. At these exposures the outcrop consists of marly phosphoritic and limonite-stained chalk. Minor components are glauconite pellets, selenitic gypsum and rounded quartz sand grains. A full section of the ‘En Zetim Formation is not visible at any single locality and exposures are normally mantled by a 1–3 m thick *nari* calcareous crust.

Calcareous Crust

Nari is a local name for a calcareous crust (calcrete) that forms a hard crust over existing topography in soft calcareous rock terrain (Dan 1977). Calcrete, or *nari*, is the last development stage of a petro-calcic soil horizon, which develops in Mediterranean climate conditions with 300 to 500 mm precipitation per year (Dan 1977; 1992; Machette 1985). This durable crust forms just below the surface, at the interface between the soil and the bedrock. It fossilizes the landscape and causes massive subsequent erosion of the soil mantle. The formation of *nari* crust was probably initiated during the Pleistocene or maybe even at the late stages of the Plio-Pleistocene and currently, it is undergoing a process of disintegration (Dan 1988; 1992). Yaalon and Singer (1974) distinguished between three *nari* layers: (a) uppermost laminar *nari*; (b) upper hard *nari*; and (c) lower soft *nari* that overlies bedrock.

Karstic Features

The most prominent natural features at the archaeological site of Nevallaṭ are karstic in nature. Such features are widespread in this area, and indeed across the wider region (Diamant 1971; Livnat 1971; Arkin and Kafri 1986). These include caves, sinkholes, solution channels and collapse structures, as well as exokarst (Miron 1990). All these features are formed through natural dissolution processes working upon limestone and dolomite rocks by rain and groundwater (Bogli 1980). Subterranean karstic features are common in Judea Group limestone and dolomite strata, especially within the ‘Aminadav, Weradim and Bina Formations (Arkin and Kafri 1986; Frumkin 1992), where fossil phreatic caves have been found along the wadis incised into these strata. Furthermore, the nearby Rosh Ha-‘Ayin springs are indicative of such a partly karstic system in the foothill region.

Karstic caves in chalk are relatively rare and are generally of modest size and degree of evolution (Frumkin 1990). The reason for this is the high porosity of the chalk, combined with the low permeability of fissures within the chalk layers (Dreybrodt 1988). Chalk karst systems are generally linked to shallow karst systems which are characteristic of the overlying *nari* (Dan 1977). Such shallow systems develop between the hard *nari* crust and chalky bedrock. The dissolution and re-crystallization processes, which are involved in the formation of *nari* initialize the caving. These mechanisms create forces that deform the upper *nari* crust. As a result, the upper *nari* separates from the lower *nari* and creates domes. The center of these domes,10–15 m in diameter, rises up to as much as a meter in height (Yaalon, pers. comm., 1996). Fissures appear between the domes and develop into shallow karst systems. Brown *rendzinas* develop in the depressions of this micro-topography. Fine earth penetrates and fills the karst system.

When compared to caves in hard limestone or dolomite, the *nari*-capped caves are easier to adapt to human needs due to the softer bedrock, but tend to collapse more rapidly. These small *nari* caves were used extensively in antiquity (see, for instance, van den Brink and Gophna 2005). While the *nari* serves as a sound ceiling, the soft chalk can easily be cut according to the needs of the occupant.

GEOLOGY OF THE SITE

The main excavation area at the site (Area A) was originally a rock shelter or *nari* step facing the wadi. In the relatively level area above this step the *nari* is exposed on the surface (Area C), where it overlies a small chalk outcrop of the ‘En Zetim Formation. Limestone rocks of the Bina Formation—which formed the landscape—occur as outcrops immediately down slope and east of the excavation area.

Feature 20 of the excavation consisted of an open space in front of a shallow *nari* cave that had graves cut into its floor (see van den Brink and Lazar, this volume: Plan 1: Sections

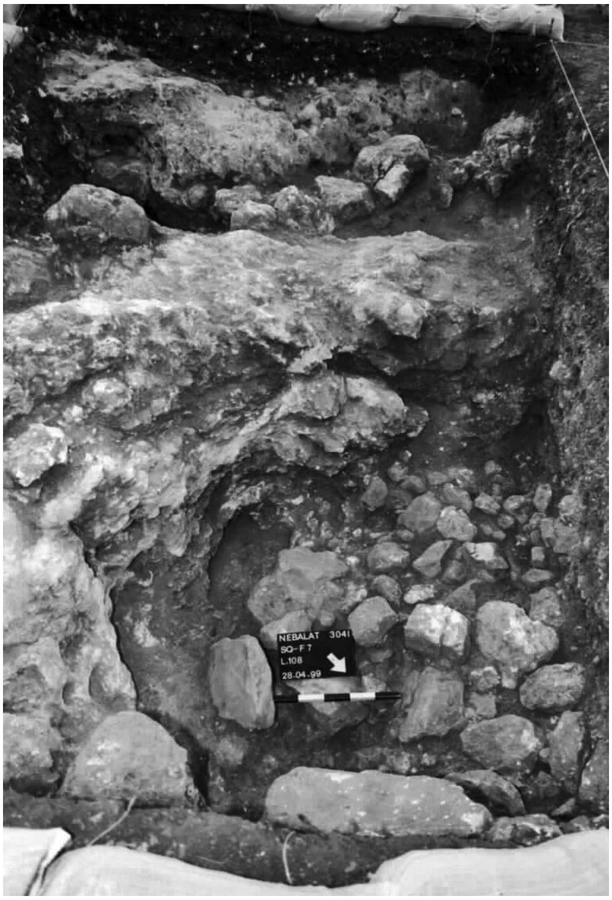

Fig. 1. Area A, L108: top of natural shaft filled with limestone and *nari* debris and Chalcoltihic pottery.

2–2, 3–3, 4–4, 5–5). When the open area was excavated, the tops of two natural shafts were exposed. One of these (L108, L120; Fig. 1), small and deep, was filled with limestone and *nari* debris, loose fine earth sediment and Chalcolithic material. The other shaft (L110, L117) was much larger, and occupied most of the cave's entrance. It was filled with small *nari* and chalk stones and ceramic sherds of the Chalcolithic period within a calcareous matrix. The fill consisted of sloping gravelly lenses that dipped toward the shaft sinkhole (Fig. 2). No traces of the natural walls of the shaft could be distinguished.

The two shafts, part of the regional fossil karst system, were probably filled during the Chalcolithic period, as indicated by the ceramics within the fills. The smaller shaft (L108) contained large fieldstones (Fig. 1) and fine earth, which had washed in from the surface. This shaft could not be excavated to its full depth. Apparently, it was not part of an active system draining water into the nearby groundwater table; otherwise, it would have fed a spring that would have been evident near the level of the present wadi bed. The larger

Fig. 2. Area A, L117: cross-section through shaft fill, which comprises superimposed gravely lenses mixed with Chalcolithic pottery, dipping toward sinkhole of shaft.

shaft (L117), on the other hand, was excavated down to bedrock, and underwent different anthropogenic treatment (Fig. 2; see van den Brink and Lazar, this volume: Figs. 44–46). Initially, it was used for an unknown purpose that involved cleaning and enlarging the shaft. Subsequently, it fell into disuse and was filled with fist-sized gravel chunks. The time lapse between these two phases must have been short, as the new surfaces left at the end of the first stage did not mature and there were no traceable signs of natural weathering and sedimentation. The shaft fill most probably comprised quarrying waste from the cave interior. This suggests that the cave was modified and improved during the Chalcolithic period. The nature of the sediments indicates that the shaft was filled rapidly and in a single episode. Other leveling works dating to the same period were carried out along the *nari* step, as indicated by gravel fills (e.g., L179).

Another cave, with its roof intact, was excavated on the opposite side of the wadi (Area B; see van den Brink and Lazar, this volume: Figs. 29–31; Plans 6, 7). The cross-section of the cave shows a different sedimentary nature. The cave is filled with fine brown earth mixed with well-included fieldstones (see van den Brink and Lazar, this volume: Fig. 30). This sediment indicates a long time span of natural redeposition of eroded material from the slope into the cave. Thus, the cave fill mostly comprises sediments from the surface, along with a minor component deriving from collapse and weathering of the cave's walls and ceiling.

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