

Lichenometric Studies of Cultural Formation Processes at Rogem Hiri*

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INTRODUCTION

ROGEM HIRI, a megalithic site probably of the third millennium B.C.E.,¹ is one of the most impressive stone monuments in the Southern Levant, consisting of a massive central cairn, c. 20 m. in diameter and more than 4 m. high, surrounded by several concentric stone circles interconnected by radial walls. The outermost circle is c. 156 m. in diameter, c. 500 m. in circumference and up to 2.5 m. in height. The circular complex has two openings: one facing the north-east and the other the south-east. A number of hypotheses have been suggested to account for the function of this unusual site: a ceremonial centre, a defence enclosure, a central storage facility, a large burial complex, and finally, an astronomical observatory.²

One of the main problems concerning Rogem Hiri was the difficulty in ascertaining the date of its construction and use. A major difficulty was in distinguishing the

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1 C. Epstein and S. Gutman: The Golan, in M. Kochavi (ed.): *Judaea, Samaria and the Golan, Archaeological Survey 1967–1968*, Jerusalem, 1972, pp. 244–245, 248, 271, 276, 282 (Hebrew). For a full report on the 1988–1991 exploration of Rogem Hiri, see this issue, pp. 167–195). Also see M. Kochavi: The Land of Geshur Project: Regional Archaeology of the Southern Golan (1987–1988 Seasons), *IEJ* 39 (1989), pp. 1–17.

2 S. Gutman and A. Drucks: Early Enclosures in the Golan, *Qadmoniot* 7 (1969), pp. 91–92 and Pl. 3 (Hebrew); Z. Ilan: The Megalithic Culture in the Golan, *Mada* 15 (1971), pp. 354–358 (Hebrew); A. Drucks: The Tale of a Discovery — Megalithic Bronze-Age Culture in the Golan, *Sal'it* 1 (1972), pp. 124–127 (Hebrew); M. Zohar: Rogem Hiri: A Megalithic Monument in the Golan, *IEJ* 39 (1989), pp. 18–31.

original architectural units and their subsequent modifications. In addition, some non-indicative flint flakes found there were of no aid in this matter.³ Of a handful of minuscule sherds unearthed from the floor inside the inner north-eastern gate area during the 1988 excavation, the few identifiable ones were datable to the Early Bronze and Iron Ages.⁴ A few additional sherds excavated in 1990 demonstrate that the site was occupied and/or visited from the latter part of the third millennium B.C.E. to modern times. It is clear that any other means of dating the site and its various building stages could be of the utmost importance. Among the various methods employed in the research of Rogem Hiri was the study of lichen and moss cover patterns, colonization and growth, discussed in this study.

Lichenometry — the use of lichens to determine the age of the substrate on which they grow — has commonly been used to date stone positions and movements.⁵ The principle of lichenometric studies is based on the slow growth rate of lichens on exposed surfaces, and on the long life expectancy of many of their colonies. Since lichens grow very slowly, they reach their final size only after a long time, probably after several millennia in certain habitats.⁶ Moss cover, on the other hand, has not regularly been used for dating purposes.

Lichenometry has been used as a dating technique in several archaeological sites. It has showed that the huge stone monuments on Easter Island (Pacific Ocean) have existed for at least 800 years.⁷ A relative date was proposed for ancient walls in Bradgate Park, Leicestershire, England, using this method.⁸ Recent stone movements

3 Zohar (above, n. 2).

4 Kochavi (above, n. 1).

5 J.L. Innes: Lichenometry, *Progress in Physical Geography* 9 (1985), pp. 187–254.

6 R.E. Beschel: Dating Rock Surfaces by Lichen Growth and its Application to Glaciology and Physiography (Lichenometry), in G.O. Raasch (ed.): *Geology of the Arctic*, Toronto, 1961, pp. 1044–1062; J.B. Benedict: Recent Glacial History of an Alpine Area in the Colorado Front Range, U.S.A. I. Establishing a Lichen-Growth Curve, *Journal of Glaciology* 6 (1967), pp. 817–832; R.R. Curry: *Holocene Climatic and Glacial History of the Central Sierra Nevada, California*, Geological Society of America, Inc. Special Paper No. 123 (1969), 47 pp.; G.H. Miller and J.T. Andrews: Quaternary History of Northern Cumberland Peninsula, East Baffin Island, N.W.T., Canada, Part VI: Preliminary Lichen Growth Curve for *Rhizocarpon geographicum*, *Geological Society of America Bulletin* 83 (1972), pp. 1133–1138; G.H. Denton and W. Karlen: Lichenometry: Its Application to Holocene Moraine Studies in Southern Alaska and Swedish Lapland, *Arctic and Alpine Research* 5 (1973), pp. 347–372; Innes (above, n. 5).

7 G. Follmann: Lichenometrische Altersbestimmungen an vorchristlichen Steinsetzungen der polynesischen Osterinsel, *Naturwissenschaften* 48 (1961), pp. 627–628.

8 J.R. Laundon: The Use of Lichens for Dating Walls in Bradgate Park, Leicestershire, *Transactions of the Leicester Literary and Philosophical Society* 74 (1980), pp. 11–30.

in two Neolithic stone circles in Cumbria and in Oxfordshire, England, have been detected by using lichenometric procedures.⁹

Although the accuracy of lichenometry for dating purposes is far from that of C¹⁴ dating or dendrochronology because of changes in growth rate of lichen, a fair estimation of dates, especially within the range of several centuries, is obtainable in many cases. While absolute dating with lichenometry depends on a well-established, regionally-based growth curve from datable lichen-covered features, the method can be used as a relative dating technique in sites where other methods are not possible, e.g. in sterile architectural remains. Lichenometry may also be used to contradict or support relative dates obtained by other methods. In this study, we will report on our use of lichenometry and patterns of moss growth to distinguish between ancient and relatively recent structures and modifications found at Rogem Hiri.

MATERIALS AND METHODS

The patterns of moss cover and the distribution of size groups and patterns of lichen cover were studied at Rogem Hiri¹⁰ during 1988, 1989 and 1990. The architectural units of the site were classified according to moss and lichen patterns. Each structural unit was identified on the general plan;¹¹ stone size was measured or estimated; and finally, each unit was examined in order to define patterns of lichen and moss coverage and lichen size. Identification of moss and lichen species was carried out by experts in these fields.

In order to use these patterns for purposes of relative dating, it was necessary to calibrate colonization rates, cover and size. Thus, patterns of moss and lichen distribution, size and colonization from several dated sites in the region were examined. Two groups of sites were chosen: one in the immediate vicinity of Rogem Hiri, and the other c. 13 km. south-west of it (Fig. 1). The first group included 26 Bronze Age dolmens, two of which had been excavated previously, and dated to the latter phase of the third millennium B.C.E.,¹² 30 Mamluk stone walls and modern,

9 Winchester has shown that stones in these circles were re-erected or re-positioned during the last centuries, see V. Winchester: An Assessment of Lichenometry as a Method for Dating Recent Stone Movements in Two Stone Circles in Cumbria and Oxfordshire, *Botanical Journal of the Linnean Society* 96 (1988), pp. 57–68.

10 Fifteen lichen and three moss species were identified at Rogem Hiri. Lichen species: *Acarospora bornmulleri*, *Aspicilia* sp., *Caloplaca* sp., *Candelariella vitellina*, *Collema* sp., *Dermatocarpon miniatum*, *Lecanora atra*, *Lecanora bolcana*, *Lecanora muralis*, *Parmelia glomellifera*, *Parmelia tiliacea*, *Ramalina pollinaria*, *Rhizocarpon tineii*, *Xanthoria aureola*, *Xanthoria parietina*. Moss species: *Grimmia* sp., *Leptodon smithii*, *Tortula* sp. (the *ruralis* group).

11 Zohar (above, n. 2), p. 22, Fig 3.

12 Site No. 25, see C. Epstein: Dolmens Excavated in the Golan, *'Atiqot* (English Series) XVII (1985), pp. 20–58.

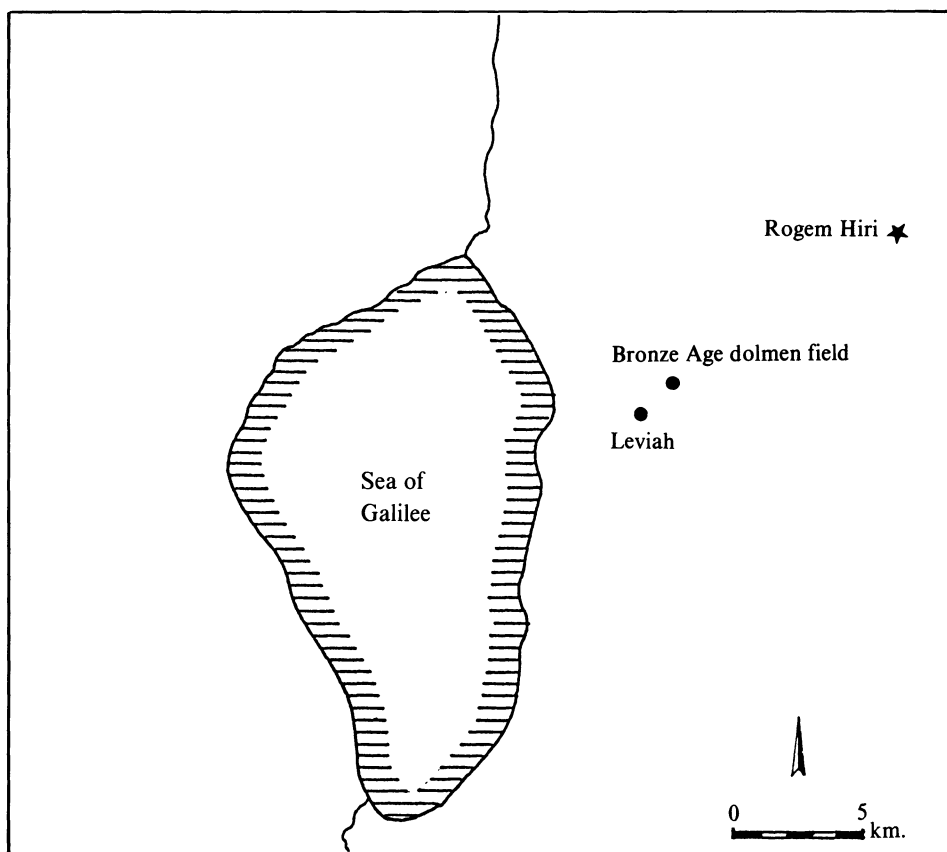


Fig. 1. Golan Heights.

post-1967 constructions. The second group consisted of the EB site of Leviah, where the upper debris of the massive EB eastern wall and a fourteenth-century C.E. stone building were examined.¹³ The second group also included a Bronze Age dolmen field east of Leviah. Nevertheless, both dolmen groups may have had an earlier EB date, and may have possibly been in repeated use later on.¹⁴

RESULTS

The following observations were made for the first group of sites. The 26 Bronze Age dolmens near Rogem Hiri were covered to a great extent with mosses and large lichen colonies. In the two excavated dolmens, the stones removed during

¹³ Kochavi (above, n. 1).

¹⁴ For their dating, see L. Vinitzky: The Date of the Dolmens in the Golan and Galilee — A Reassessment, *EI* 21 (1990), pp. 167–173, 107* (Hebrew, with English summary).

excavation had been piled; most of their surfaces were not covered by mosses and lichens. A few large lichens were observed on ancient surfaces that had remained exposed in the stone piles. The intact parts of these two dolmens were covered with mosses and lichens, as were the unexcavated dolmens. The 30 Mamluk walls were not covered by mosses, and the lichens, which covered only parts of the stone surfaces, were mostly small (less than 2 cm. in diameter). Only infrequently were larger lichen colonies found on them. No substantial lichen colonization was detected on the post-1967 constructions.

The following observations were made for the second group of sites. The debris of the earlier structure at the Leviah site (Fig. 2), the EB outer city wall, consisted of small to medium-sized stones (smaller than 50 cm.), which were exposed to the sun. These stones were covered with numerous orange-coloured *Xanthoria aureola* lichens, several centimetres in size, and by other lichen species (Fig. 3). Another structure examined at the Leviah site, a Mamluk house, re-used in the twentieth century, was constructed of small stones (generally 20–30 cm.), and some of its walls remained standing to their full height (Fig. 4). The stones were partially worked, and the worked surfaces had no visible lichens on them. On the native stone surfaces of this building, tiny lichen colonies were observed. In the late third-millennium dolmen field, east of Leviah, the dolmens were generally constructed of two large standing basalt boulders with a large flat slab on top (Fig. 5). The boulders and slabs were covered by big colonies of lichens and partially by mosses.

To sum up our observations from both groups of sites, the Bronze Age structures showed a massive moss and lichen cover, the latter composed of very large colonies.

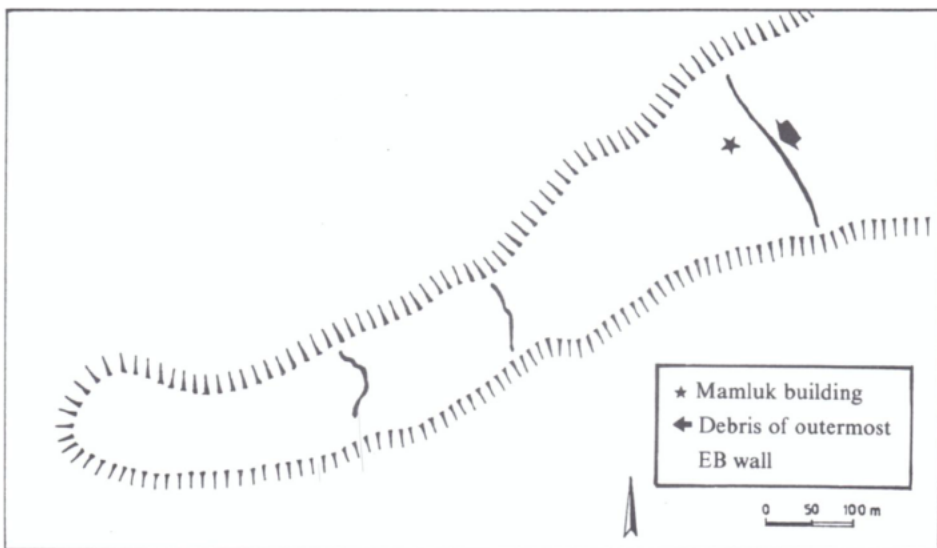


Fig. 2. Leviah.



Fig. 3. Debris of outer EB wall at Leviah. Large lichen colonies cover stones.



Fig. 4. Remains of Mamluk house, Leviah. Stones free of lichen colonies, or partially covered with small, light ones.

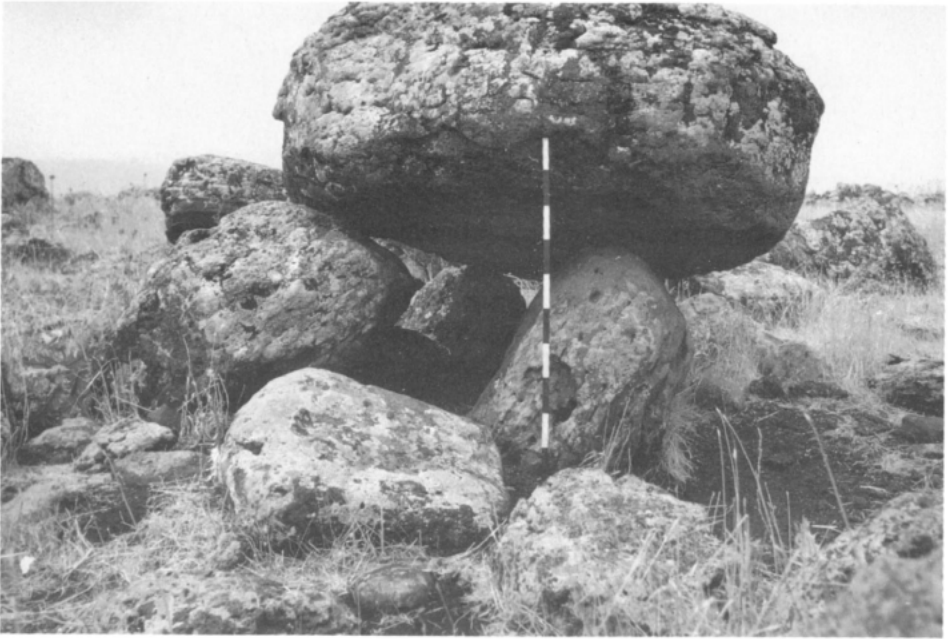


Fig. 5. Dolmen from late third-millennium dolmen field.



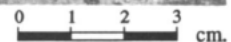
Fig. 6. Large moss colonies on stones of ancient wall at Rogem Hiri.

Some of the recent structures were covered with small lichen colonies, while others showed only early stages of lichen colonization. The latest, post-1967 structures were not covered by lichens. None of the recent structures were covered with mosses.

The various architectural units at Rogem Hiri were classified according to lichen and moss coverage into two groups. Group A contained units in which mosses (Fig. 6) and big lichen colonies (Fig. 7) covered the stones to a large extent (Fig. 8); Group B consisted of units which had exhibited the same type of coverage as those in Group A exclusively on their lower parts, whereas their upper parts were covered with only small (Fig. 9) and/or non-continuous lichen colonies. Sometimes



Fig. 7. Large lichen colonies from ancient wall at Rogem Hiri.



stones in the upper parts of structures belonging to this group showed no lichen colonization. The organization of the two lichen size and coverage groups reflects a chronological sequence. Thus, structural elements classified as Group A are regarded as the older ones. The lower parts of the structural elements of Group B may be dated with Group A. The upper parts of the Group B structures are regarded as a much later phase. Fig. 10 illustrates the plan of the site, summarizing the early and the late phases of construction at Rogem Hiri.



Fig. 8. Ancient wall at Rogem Hiri: general view. Large, dark moss colonies are clearly seen.

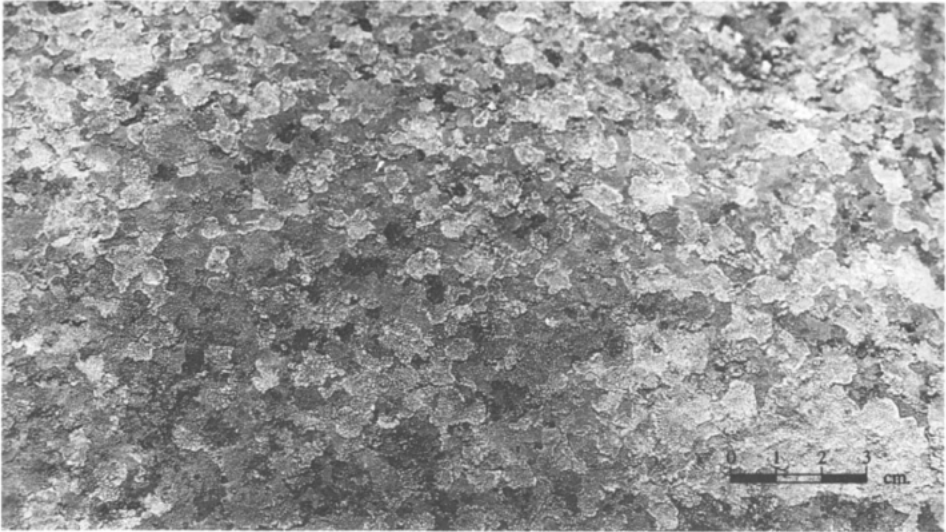


Fig. 9. Dense, small lichen colonies on stone from recent part of wall at Rogem Hiri.

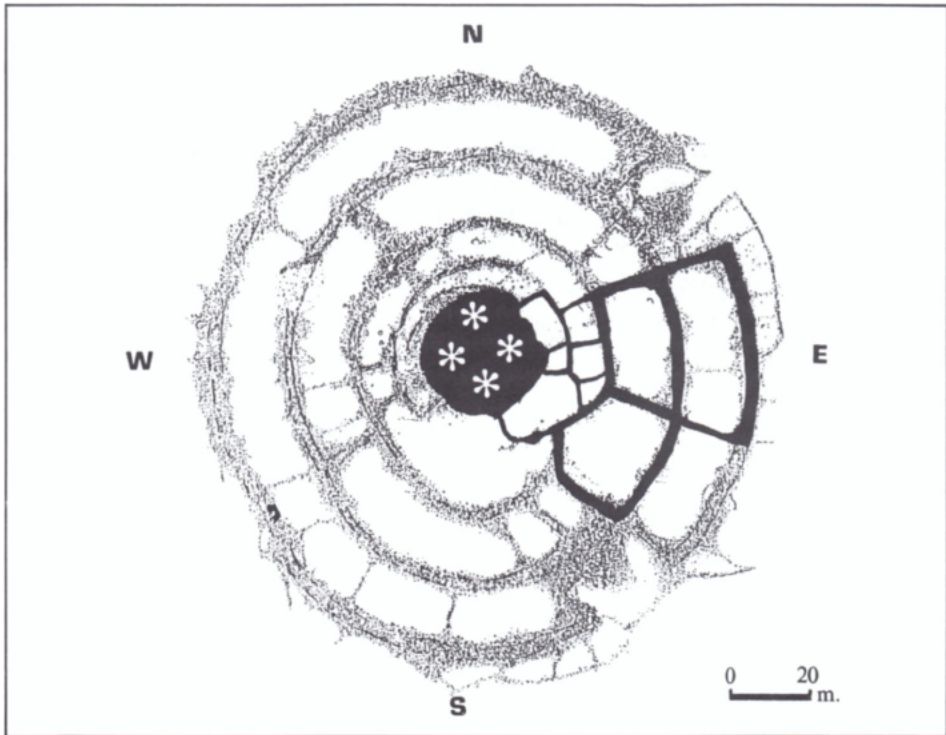


Fig. 10. Rogem Hiri: phase-based plan, based on lichen and moss data. Dark areas indicate upper, later phases. Asterixes in central cairn indicate that not all stones in central cairn were repositioned by recent human activity.

DISCUSSION

On the basis of our findings, we conclude that substantial initial colonization of lichens tends to last several decades. Moreover, even after such a long period, the established colonies usually reach only several millimetres in size. We must note, however, that stone size is an important factor in lichen colonization. Large stones have greater heat capacity, and their nocturnal temperature is not low enough to generate dew condensation.¹⁵ Since the basalt stones are dark, their diurnal temperature is higher than that of light-coloured stones, resulting in additional differences in the water regime. The amount of available water on stone surfaces determines lichen establishment in hot arid regions.¹⁶ Therefore, lichen colonization will appear first on light-coloured small stones, or shaded stones of all colours, and will appear later on large or dark stones exposed to the sun. Furthermore, using this logic, we were able to detect cultural formation processes at the site.¹⁷ When a stone with large lichen colonies appears between others with small colonies, a repeated usage of the former is safely assumed. Likewise, the dating of walls as ancient depends on the existence of complete horizons of mosses, and large lichen colonies, rather than on sporadic ones.

Extrapolating from the data that we have gathered on moss cover and on lichen growth rates and colonization patterns in this region, we may safely assign two chronological phases for the structural elements of Rogem Hiri. The larger lichen colonies, i.e. colonies of 10 cm. or larger, are at least several hundred years old, if not older than a millennium. Hence, structural elements bearing large lichen colonies and dense moss cover may be grouped as belonging to an early phase of construction. Conversely, structural elements relatively free of lichen and moss coverage may be grouped as belonging to a late construction phase. We may safely distinguish between two clear chronological phases in Rogem Hiri: an ancient phase and a relatively recent one. The former is at least many hundred, and probably several thousand years old. The later phase is relatively recent, and probably dates from the last two centuries. The low resolution of this dating method, however, limits our ability to safely distinguish between sub-phases within the early and the late construction phases of the site, although such sub-phases probably existed.

Relatively recent changes were detected in the eastern sector of Rogem Hiri, as well as on the top of the central cairn (Fig. 10). The relatively recent modifications in many of the walls in the eastern sector are probably due to the easy access to this

15 A. Danin and J. Garty: Distribution of Cyanobacteria and Lichens on Hillsides of the Negev Highlands and their Impact on Biogenic Weathering, *Zeitschrift für Geomorphologie* 27 (1983), pp. 423–444.

16 J. Garty and M. Galun: Selectivity in Lichen-Substrate Relationships, *Flora* 163 (1974), pp. 530–534; Danin and Garty (above, n. 15).

17 M. Schiffer: *Formation Processes of the Archaeological Record*, Albuquerque, 1987.

area *via* the north-eastern entrance. The south-eastern entrance is now blocked, and the presence of lichen colonies indicates that it has probably been blocked for at least several centuries. Disturbances to the upper stone layer on the top of the central cairn and on some of its slopes were probably caused by the many visitors to the site during the last few decades and probably even in earlier times.

In conclusion, we suggest that almost all the existing walls seen today at the site belong to the early phase, as defined above. Modifications were made during the last century in the upper parts of many of the early walls, especially in the eastern sector, as well as in the upper part of the central cairn. Although admittedly, the approach proposed in this study may not be advantageous for many sites, it is of clear value at sites with dating problems similar to those of Rogem Hiri.