

# SPATIAL APPROACH TO THE RUINS OF KHIRBET QUMRAN AT THE DEAD SEA

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## ABSTRACT:

The discovery of the so-called Dead Sea Scrolls in 1947 at Khirbet Qumran generated excitement and archaeological investigations on the western shore of the Dead Sea. The excavations from the late 1940s until 1956 revealed a settlement and a large cemetery. A common belief is that the Essenes who produced the manuscripts inhabited the site. A team consisting of Finnish and British archaeologists and a natural scientist was formed in 1994 to do a topographical and spatial study of Qumran. The goals of the study were to investigate the structural orientations of the settlement, which would indicate if a central planning existed. The objective of the field survey was to produce an initial reproduction of the topographic development of the site and its immediate surroundings. To achieve this old maps and aerial images were used. A tacheometric total station (EDM) was used to record and collect a set of coordinates from relevant surfaces and features in the area on the ground. The surveying and documentation also used traditional measurement techniques and photographic documentation. The use and chronology of Qumran has not been fully understood because the topographic development and the planning have remained unexplored. Our most important conclusion was that there was a central planning where axial orientations and astronomy played a central role in the shaping of the settlement and cemetery. From the new topographic and hydrological studies, we know that the site apparently was submerged under the Dead Sea in the 30s B.C., which interrupted the habitation.

## 1. INTRODUCTION

In 1947 the first ancient manuscripts were found in a cave at the shore of the Dead Sea by a young shepherd boy who was looking after his sheep. The news of the find spread quickly after the acquisition and purchase of the first manuscripts, which sparked a scientific expedition to the area of Khirbet Qumran. Archaeological fieldwork was conducted at Qumran and close by from the late 1940s until 1956 by the École Biblique et Archéologique Française, Jerusalem, and was directed by the late Dominican Father Roland de Vaux. Fragments of approximately 930 Hebrew, Aramaic and Greek manuscripts were found in eleven caves covering a period from about 250 B.C. to the late first century A.D. In the archaeological excavations a large enigmatic settlement and to a lesser extent a graveyard was investigated on the plain beneath the scroll-bearing caves (Tov et alii, 2000).

## 2. HISTORY OF RESEARCH

Qumran belongs to the best known archaeological sites in the world. Several thousand articles and monographs have been written mainly on the importance of the Dead Sea Scrolls to Judaism and Christianity. Most of the scrolls were found in the area of Khirbet Qumran. The fact that Biblical manuscripts were included in the ancient library discovered at Qumran lead the Christian scholars who were in charge of the expedition to concentrate the work on the publication of the textual evidence, resulting unfortunately in that the historical and archaeological context of the site, as well as the publication of the archaeological material were neglected. Most of the archaeological finds from Qumran are still unpublished. The picture that we had up to 2002 (See the Brown University Conference, 2002, at [www.brown.edu/Administration/News\\_Bureau/2002-03/02-031.html](http://www.brown.edu/Administration/News_Bureau/2002-03/02-031.html) and [www.kat.gr/kat/History/Txt/El/MsZ/Qumran.htm](http://www.kat.gr/kat/History/Txt/El/MsZ/Qumran.htm)) of Qumran was mainly based

on the work done by several generations of theologians and philologists.

The authors of this paper were granted access to the unpublished archaeological material of Qumran and the archives of R. de Vaux in Jerusalem in 1990s. This underlined the importance of initiating also a geographical, cartographical, spatial and an astronomical study of the settlement and the graveyard and the area of Qumran at the Dead Sea. A small team of Finnish and British archaeologists was brought together to conduct the first spatial archaeological survey study of Qumran. A professional mathematician, physicist and astronomer from The Observatory and Astrophysics Laboratory at the University of Helsinki participated in the project and analysed the raw data.

Consequently, the first comprehensive scientific study on the archaeology of Qumran carried out by professional archaeologists was published by the authors of this paper in 2002 (Lönnqvist and Lönnqvist, 2002). In 2003, our new theory was accepted as one of the five leading theories on the emergence, birth and development of the Qumran community by the editor-in-chief of the main publication series of the Dead Sea Scrolls, DJD (Discoveries in the Judaean Desert) (Tov, 2003).

## 3. SCOPE OF THE WORK

### 3.1. Objectives of the spatial study

The first goal of the spatial study was to see whether there were any structural orientations in the settlements of Qumran and the nearby Ein Feshka (assumed to have been used contemporaneously with Khirbet Qumran by the same people), which would indicate that there was a central and coherent planning of the sites. The relationship of the ancient settlement at Qumran to the large graveyard (50 m E of the settlement) of

about 1100-1200 graves had never been properly investigated. Therefore, its function, meaning and significance, especially religious, had remained unclear. The other central questions concerning Qumran were the dating of the settlement and the graveyard, and their subsequent function in the local, regional and international contexts of the ancient world. The final objective of the field survey was to produce an initial reproduction of the topographic development of the site and its immediate surroundings.

### 3.2. A brief description of the site

Khirbet Qumran is located ca. 22 km east of Jerusalem at the shore of the Dead Sea. Qumran is situated in the Dead Sea Rift (DSR) between two deep wadis, in an area where tectonic activity is frequent and where mean annual precipitation is very low. The environment of today is harsh and difficult to cultivate, but the arid climate and the remoteness of the site has contributed significantly to the preservation of the archaeological structures and material found in the region.

The settlement of Qumran is situated on a marl terrace just below the steep cliffs of the Judaean desert plateau, overlooking the broken ground and the plain of the Dead Sea. The size of the Qumran settlement is approximately 100 m x 80 m. The absolute height of the Qumran settlement is today ca. - 330 m below sea level (bsl), and nearly 90 m above the present day Dead Sea level (presently ca. - 418 m bsl). The Dead Sea is shrinking rapidly due to evaporation as well as other reasons and the drop is estimated to be close 70-80 cm per year.

It has been assumed that the settlement of Qumran was founded in the Hellenistic period in the second century B.C. and destroyed during the Roman military campaigns during the First Jewish War A.D. 68-73. There were no significant activities at the site following its destruction in the late first century A.D. (There are different opinions on the exact dating of the settlement, starting from a suggested occupation period that covered about two centuries down to only about one century).

### 3.3. Collection of data

The members of the team executed fieldwork during several weeks each year during four consecutive years. However, the collection of data was not limited to a specific period of the calendar year. Instead, work was done throughout all of the seasons because seasonal, environmental and climatological and cosmic effects also needed to be evaluated empirically in relation to the archaeological record of the site.

The survey of the Qumran area and the collection of data for a digitally stored map database began in the 1990s with the study of old cartographical material available. Especially helpful were the archaeological maps prepared by the British pioneers that visited Qumran in the 1870s and which were published for the Committee of the Palestine Exploration Fund (Clermont-Ganneau, 1874, 1896. See Fig. 1). Charles Clermont-Ganneau's map includes what could then be seen of the ruins of Qumran but also the graves in the cemetery. Extensive geographic surveys, maps and studies can also be found in the *Géographie de la Palestine* I-II by F. M. Abel (Abel, 1933, 1938), which were published in the 1930s. Their usefulness are based especially on the fact that names of ancient places, sites and areas are included, enabling the ancient and modern contexts to be related. Good historical maps are also available in the *Tabula Imperii Romani* (TIR), which came out in 1994 (Tsafir et alii, 1994). Other maps include the regional maps, such as the *Atlas*

*of Israel* (1970/1985), or the archaeological settlement maps or excavation maps of Qumran, which are included in the archives of R. de Vaux in Jerusalem (École Biblique et Archéologique Française), and which already have been partly published. The best publicly available topographic maps of Qumran are the maps in the scale 1: 50 000 (Qumran is located on the map Kalya 12-I, II 1995. UTM coordinates).

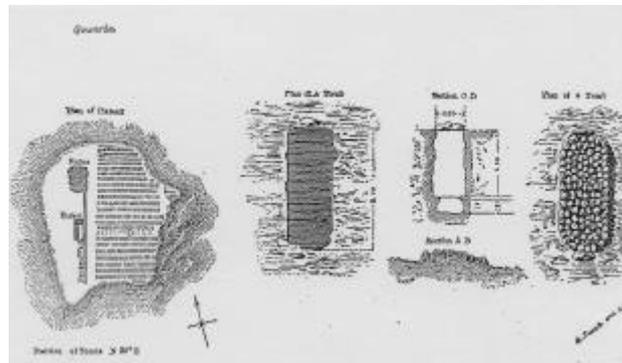


Figure 1. Charles Clermont-Ganneu's map of the Qumran settlement and graveyard from the year 1874 reveals the peculiar and coherent orientation of the structures. Courtesy of the Palestine Exploration Fund.

Excellent aerial photographs of Qumran were taken by the Jordanian Air Force in the 1950s (see, e.g., Fig. 2), and we thank the École Biblique et Archéologique Française, Jerusalem, for letting us have duplicates of them. These show the settlement of Qumran and the cemetery in a high-resolution image. The photographs were later transformed to digital form to improve the quality and detail of the photographs. CORONA declassified satellite photographs (optical panchromatic, pixel 1,8 m) are inexpensive (about 20 USD for a photograph covering perhaps as much as hundreds of km<sup>2</sup>), but as far as the area of Qumran is concerned, they are disappointing since the photographs taken in the 1960s and 70s are cloudy and blurred.



Figure 2. Aerial photograph of Qumran taken by the Royal Jordanian Air Force in the 1950s. The same orientation of the settlement and the main graveyard are clearly visible. Courtesy of École Biblique et Archéologique Française, Jerusalem,

The main problems, for instance, with the cartographic documents and language are well known. They constitute of separate map forms, sizes and objects, the differences between observation and the visual interpretation of the maps, as well as how the map details can be assimilated into one single database as to formalize the geographic information.

Another difficulty that faces scholars interested in conducting remote sensing, archaeological surveys and prospecting in the Dead Sea area are the extremely unusual atmospheric, climatological and topographical conditions prevailing, which means that even today, mostly manual, time-consuming methods will also have to be employed beyond classical remote sensing methods. This is mainly due to the circumstances such as the low altitude of the Dead Sea area, the mostly very high day temperatures and the differential between night and day temperatures, which usually disturb normal seeing conditions, occasionally also satellite images, as explained above. The seeing properties in the Dead Sea valley would also be quite different from what they are in a flat landscape, which means that calculations and evaluations would have to be followed by empirical observations, surveys and measurements in the field. The steep mountains, for instance, close to the settlement of Qumran limit normal visibility.

A third major difficulty which has to do both with the cartographical material and the overall archaeological interpretation of Qumran is that we have, in fact, little certain information on the description and interpretation of the stratigraphy of the settlement, since we do not know the basis of the recording system of the excavation and the principles that were used. The final excavation reports of the archaeological excavation of Qumran of the 1950s are still under preparation since the excavator Father R. de Vaux died before finishing the reports.

### **3.4. The spatial documentation**

The objective of the field survey was to produce a preliminary reproduction of the topographic development of the site and its immediate surroundings, both in a paleo-climatological and historical perspective, in a manner where the environmental factors that must have prevailed at the site in antiquity would also be better included in the archaeological explanation process. Therefore, we decided to use a computer-aided measurement technique, a high-precision tacheometric total station (EDM) to record and collect a set of coordinates from relevant surfaces and features in the area that were archaeologically meaningful.

We recorded the absolute heights and coordinates of some of the most important scroll bearing caves (in relation to the settlement of Qumran and the sea level), such as Cave 1 north of the settlement, and Cave 4 below the settlement of Qumran. The relationship of the architectural and archaeological structures within the settlement of Qumran, on one hand, and the relationship of the settlement of Qumran and the cemetery located east of the settlement, on the other hand, was one of the primary research goals. The accuracy of the coordinate points and height points were controlled against the mapping information on the 1: 50 000 maps of the area and other information made available to us. What interested us in particular was the positioning of the building structures of Qumran and their axial directions within the settlement plan, and how they possibly might indicate that there was a central planning. The direction of the longitudinal building elements, in

this case, the walls of the settlement, were measured and determined within 0.5° accuracy.

The building surveying and documentation also used traditional measurement techniques such as tape measures, measuring sticks, plumb lines and a hand-held sophisticated digital compass based on military technology. The digital compass provided high accuracy and the taking of bearings was easy with the gun sight in the compass. Based on this information 2D -plans were produced of the most important structures at Qumran. The photographic documentation of the same objects was done analogue with a Canon F-1, 35 mm B&W and colour prints, in different lighting conditions and repeatedly, year after year to produce a sequence of photographs. The longest photographic record of the same objects that we have extends to about 40 years (the first photographs were taken in the 1950s, next ones in 1976, and the last photographs were taken in 1996). Some of the images were later digitalized and formed a basis for the raw data for GIS.

## **4. REMOTE SENSING, FIELD SURVEYS AND ANALYSIS**

### **4.1. The results of the collection of data**

The measuring of the azimuths of the Qumran building complex and the tombs in the main cemetery showed, first of all, that the northern axis of the settlement does not point to the true north (geographic north), as often is claimed. The northern axis follows a direction, which is 20° east of north, meaning that the azimuth formed between the true north, and the central northern axis is 20°. The skew east of north can be followed by observing the long eastern wall of the main building structure bordering to the cemetery, loci 111 and 121, 30, and the main water installations (loci 47/49, 71, 91, 117, 118), which all have the same azimuth. Surprisingly, the position of the tombs in the cemetery are arranged according to the same northern axis and the same azimuth as the Qumran settlement, i.e. they follow the identical 20° east of north arrangement. The cemetery consists on an average of 1100-1200 tombs. Each of the individual tombs is aligned, with few exceptions, according to the central northern axis of the cemetery, which is the 20° east of north cardinal point on the horizon. There is a correspondence in the alignments of the Qumran settlement and the cemetery, and the relationship of the direction of the Qumran settlement the Ein Feshka settlement follows the 20° east of north direction (Lönnqvist and Lönnqvist, 2002). This is a most significant discovery, as will become evident.

The second important observation was that the settlement of Qumran had a two-axial grid system, with an almost perpendicular E-W axis in relation to the main northern axis. This direction or alignment is represented in the settlement plan of Qumran by the largest single room called locus 77, which the excavator R. de Vaux believed to be a main dining or assembly hall. The south of east north of west orientation follows a sight line of 106°-286°. In addition, a few arbitrarily chosen baselines, which were mostly baths or walls, were investigated for the alignments.

Our preliminary impression was that we could not find any clear topographical, architectural or archaeological explanations alone for why the Qumran settlement and the cemetery were given meticulously the same peculiar skew and orientation, other than it obviously must have had some very specific meaning to the people who built and inhabited the site in the Hellenistic and Roman periods. Therefore, we decided to

consult a professional mathematician, physicist and astronomer who would study the data from our fieldwork in order to reveal its possible relationship with astronomy and cosmic phenomena.

#### 4.1. Orientations

The raw data that had been gathered with the tacheometric total station (EDM) and our azimuth measurements was allocated for further studies. Our astronomer R. Anttila simulated the sky over Qumran as it was between two-three millennia ago, starting from the Iron Age (about 800 B.C., which is assumed to be the earliest period of habitation at Qumran) to the Hellenistic-Roman period (2<sup>nd</sup> century B.C. to 1<sup>st</sup> century A.D.). The computer-aided sky-simulation was executed with a high-power computer of the Observatory and Astrophysics Laboratory at the University of Helsinki in 1994, which was equipped with a Sky Map planetary program (see Fig. 3). The sky-simulation program shows the planets and the star fields of a specific time as seen from a certain geographic location (in this case at Qumran) by using advanced mathematical formulas. The computer program calculates then the declination of star and thereafter the position of it, or a planet, at any point in the past or in the future. In practice this would mean that the spatially and archaeologically measured and determined azimuths of the Qumran building structures and the tombs would be related to the calculated declinations of a celestial object. A correspondence between the structures and the celestial objects would suggest intentional planning, according to celestial geography.

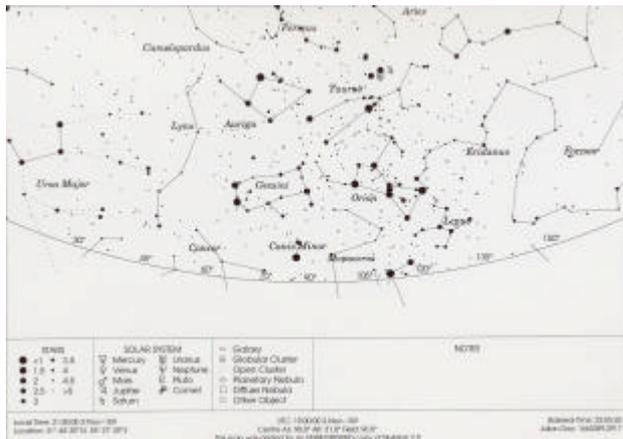


Figure 3. Computerized map of the sky over Qumran in the year 160 B.C., evening sky. Prepared by Reino Anttila.

#### 4.2. Empirical study

As the sun, the planets and the stars were considered to be possible points of reference for the Qumran azimuths and the structures, it was, first of all, important to observe and compare the rare, the once-a-year astronomical appearances, but also the regular cosmic occurrences in their proper geographical, archaeological, architectural, topographical and spatial contexts at Qumran. This goal was achieved by observing the behaviour of the heavenly bodies, and measuring and calculating their azimuths (their risings and settings) in the field with optical and mechanical instruments, to see if there were any correspondence between the archaeological azimuths and measurements and the astronomical declinations of the celestial objects (declination = angular distance on the celestial sphere north or south of the celestial equator, measured in degrees, minutes and seconds

along the hour circle passing through the celestial object, which is similar to latitude in geography). What interested us in particular was how the sun would behave in relation to the archaeological structures at Qumran. We observed therefore the equinox sunrises and sunsets, and the summer (see Fig. 4) and winter solstices during several years with the precision that could be achieved in the field. Control calculations were made later by the mathematician to verify the field observations.



Figure 4. The summer solstice sunset in relation to the main ritual space of Qumran, Locus 77. Photo by Kenneth Lönnqvist 1996.

It was noted that the largest room at Qumran, locus 77, which is a ritual space, was oriented according to the summer solstice sunset (above, fig. 4).

#### 4.3. Geoarchaeology

We also used recent geoarchaeological studies done in the Wadi Araba fault and the Dead Sea basin to enlarge our understanding of the topographical development of the area in antiquity. These geoarchaeological studies are based on surveys of Quaternary mapping, description of landforms, sedimentary deposits and soils which shed new light on the paleoenvironment and paleoclimate also on the area which is of interest for this paper (Niemi and Smith, 1999). Aerial photo analyses, studies of the sediments, soils, past ethnographical descriptions and morphology, as well as the paleoclimatological investigations (Watzman, 1994; Klein, 1965, 1982), strongly suggest that the paleoenvironment and paleoclimate at the region between Qumran and Masada was different in the Hellenistic and Roman periods from what it is today, less arid and more suitable both for living and agriculture. Because this has not been fully understood, we also believe many inadequate and even false conclusions regarding the use and chronology of Qumran have been drawn.

### 4.3. Data processing and calculations

The reproduction of the topographic development of the site based on the heights of the caves (and the archaeological material found originally in them), the settlement and the terraces and the shingle bars in the nearby area, and the geological substance that had been discovered by natural scientist on the walls of the settlement at Qumran (Klein, 1982), in the sediments that were excavated at the site, and residues excavated and discovered in connection with skeletons in the graveyard, and found also on the scroll material deposited in the caves, revealed many most unusual things. Our most important conclusion regarding the development of Qumran was that the site – as we know it and understand it today – probably was the scene of a paleoflood ca. 33 B.C. (Klein, 1982, Lönnqvist and Lönnqvist, 2002) with a significant magnitude, several times larger than peak discharges, causing landslides and fissures in the ground.

As far as the astronomy of the site is concerned, the lack of true east-west aspect of the Qumran settlement excluded from the beginning that any of the major alignments observed at Qumran would have anything to do with the equinoctial days. When the winter solstice sunrise ( $114^\circ$ ) and sunset ( $230^\circ$ ) had been observed, measured and documented in the field, it became clear that an important solar alignment might be found around the summer solstice for the south of east-north of west orientation or the  $286^\circ$  sight line at Qumran. Initial mathematical calculations predicted this. Eventually this was proven right by empirical observations, measurements and photographic documentation conducted 6 months later in 1994. The summer solstice sunset lined up exactly with the central axis of locus 77, indicating that it had a solar alignment. As the settlement and the cemetery brought further evidence for this, we conclude that they must have had a religious function in relation to solar cult. Computer-aided astronomical calculations supported our identification of the solar alignment at Qumran for the E-W axis or the  $286^\circ$  sight line, but presented also stellar references for the  $106^\circ$  direction.

The arcs of the sun between the extreme points in the horizon and the solar declinations for the solstices were calculated with the aid of astronomical algorithms and trigonometric functions (Karttunen et alii, 1990; Meeus, 1991, 2002). The results of the calculations indicated that the Qumran main azimuths of  $20^\circ$  and  $106^\circ$  correspond to the direction and the rising angle of the very well known stars  $\gamma$  Draconis (popularly called Eltanin) and  $\beta$  Orionis (popularly called Rigel). The computer calculations showed further that the star  $\gamma$  Draconis would have been in an azimuth of  $20^\circ$  around 800 B.C. In 160 B.C., precession would have moved the star a degree and half to  $21.5^\circ$ . The ancients frequently used  $\beta$  Orionis as it always rose from the same point on the horizon, and it was of great importance for several reasons, one of them religious. The arbitrarily chosen directions that we measured at Qumran may well have astronomical importance, as we have suggested, but due to the short space available, this discussion will be omitted from this paper.

The cardinal geographical directions of the Qumran settlement that we measured point approximately in the direction of Damascus ( $22^\circ$ ) and Jerusalem ( $282^\circ$ ), both of which we know from the Dead Sea Scrolls were important to the community. However, we do not believe that a geographical explanation is sufficient to elucidate the precise astronomical data and the central planning of the settlement and the cemetery.

An inventory of plans and spatial studies of excavated archaeological sites in the Near East, the Eastern Mediterranean and North and Central America made us also realize that there were geographically, chronologically and archaeologically scattered sites, which bear remarkable parallels and solar seeing (Fig. 5) to the layout of the Qumran ruins.

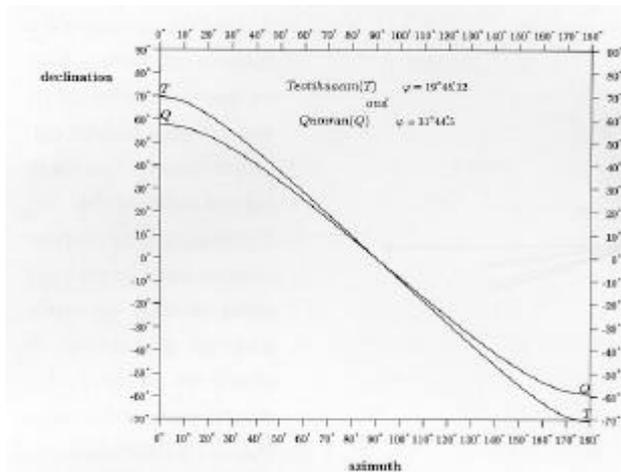


Fig. 5. Solar seeing and observations at Teotihuacán, Mexico (T) and Khirbet Qumran (Q). Based on table of declinations and azimuths. Prepared by R. Anttila. Note the similarity in the solar seeing. Teotihuacán, Mexico, is a famous solar worship place.

We assume that this means that there was in many cases a central planning where geography, astronomy and perhaps solar religion played an important role. This is clearly demonstrated by the remarkable similarities in the calculated or measured latitudinal and the solar seeing of the sites in our case studies presented in 2002 (Lönnqvist and Lönnqvist, 2002. See also Fig. 6 below), and in many cases the periodical similarity.

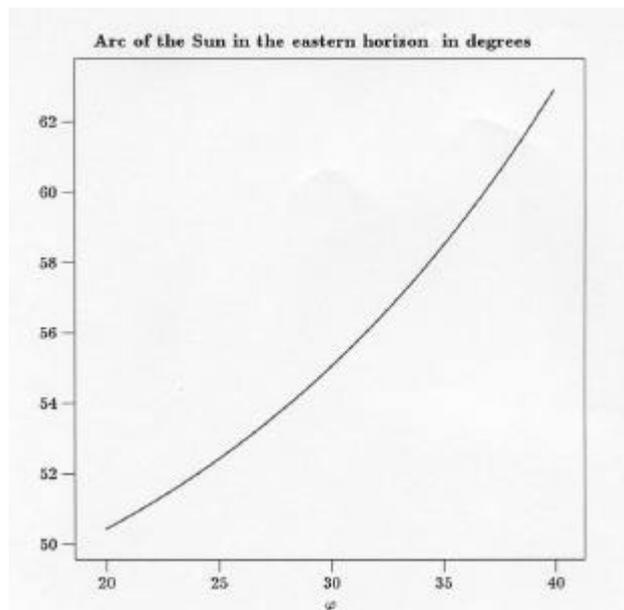


Fig. 6. The arc of the Sun in the eastern horizon at Qumran in degrees. Prepared by Reino Anttila.

The bodies in the graves of Qumran were, for instance, placed according to a sophisticated celestial geography. The bodies were oriented in the direction of north which was the source of rebirth and life, and the south, where the souls were believed to be dwelling, and the east where the sun rose from. Most of the excavated bodies have the face turned east, the direction where the stars and the sun were reborn, as to emphasize the impact of celestial bodies on man's life.

## 5. CONCLUSIONS AND RESUMÉ

Before our survey, the settlement of Qumran had not been studied in its archaeological and environmental context before. The central planning that we have determined that existed at Qumran in the Graeco-Roman period can be seen in the two-axial grid system and the astronomical layout of the grids. These demonstrate clearly that the settlement and the cemetery at Qumran are contemporary and are produced by the same community. Solar thinking and ancient solar and stellar hierophanies must have influenced the builders of the settlement and the cemetery at Qumran, as the axial directions measured follow the solar and stellar declinations of the important celestial bodies. This is confirmed by the solar calendar found in the Dead Sea Scrolls (Tov, 2000), and recently published sun-dial of an astrolabe type (Albani and Glessmer, 1997).

The effects of the geoarchaeological processes that affected the region in antiquity should be re-evaluated. We have, for instance, been able to show that a damaging earthquake did not affect the area of Qumran in 31 B.C. as the excavators of the site originally claimed. They thought that the main reason for the 'abandoning of Qumran' in the late Herodian period was the earthquake. Instead, the marl terrace where the settlement of Qumran is located was affected by corrosion through weathering processes. This can be seen already from the photographic documentation done during the past 40 years, for instance, of the same water used as ritual baths. The photographs revealed clearly that sediment structures at the site are unstable, easily swelling and desiccating causing fissures, rills and landslides, which at a first sight resemble tectonic fractures but which are not. Also a devastating paleoflood that lead to the submerging of the site of Qumran under the Dead Sea around the turn of the millennium, is a possibility detectable in the deposits of minerals found in the walls of the Qumran ruins, the skeletons in the graveyard and the scroll wrappers in the scroll caves that had been affected by salts from the Dead Sea.

## REFERENCES

Abel, F. M., 1933-1938. *Géographie de la Palestine. Vol. I, Géographie physique et historique and Vol. II, Géographie politique. Les villes.* Études Bibliques 28/1-2, Paris.

Albani, M. and Glessmer, U. *Un instrument de mesures astronomiques à Qumrân*, Revue Biblique, **104:1**, pp. 88-115.

*Atlas of Israel. Cartography, Physical Geography, Human and Economic Geography, History.* (No authors or editors mentioned) 1970. Published by Survey of Israel, Ministry of Labour. Jerusalem and Elsevier, Amsterdam.

*Atlas of Israel. Cartography, Physical Geography and Geography of the Land* (in Hebrew). (No authors or editors mentioned) 1985. Tel Aviv.

The first international archaeological conference on the archaeology of Qumran, Brown University, Providence,

November 17-19 2002, entitled 'Qumran: *The Site of the Dead Sea Scrolls, Archaeological Interpretation and Debates, November 17-19, 2002*'. Congress volume forthcoming 2004. Leiden Brill.

Clermont-Ganneau, Charles, 1874. The Jerusalem Researches, Letters from M. Clermont-Ganneau III. Jerusalem, October 5-10, 1873. *PEFQS*, April 1874, pp. 80-83.

Clermont-Ganneau, Charles, 1896. *Archaeological Researches in Palestine during 1873-74, Vol. II*, pp. 14-16, London.

Kattunen, Hannu, Kröger, Pekka, Oja, Heikki, Poutanen, Markku, Donner, Karl Johan (Eds.), 1990. *Astronomie – Eine Einführung*. Berlin.

Klein, Cippora, 1965. *On the fluctuations of the level of the Dead Sea since the beginning of the 19<sup>th</sup> century, Hydrological Paper No. 7*. Jerusalem.

Klein, Cippora, 1982. Morphological Evidence of Lake Level Changes, Western Shore of the Dead Sea. *Israel Journal of Earth-Sciences*, **31**, pp. 67-94.

Lönnqvist, Minna and Lönnqvist, Kenneth, 2002. *Archaeology of the Hidden Qumran The New Paradigm*. Helsinki University Press, Helsinki.

Meeus, Jean, 1991. *Astronomical Algorithms*. Willman-Bell, Inc.

Meeus, Jean, 2002. *More Mathematical Astronomy*. Willman-Bell, Inc.

Niemi, Tina M. and Smith II, Andrew M., 1999. Initial Results of the Southeastern Wadi Araba, Jordan Geoarchaeological Study: Implications for Shifts in Late Quaternary Aridity. *Geoarchaeology: An International Journal*, **14**, No. 8, pp. 791-820.

Tov, Emanuel et alii, 2000. *The Texts from the Judaean Desert, Vol. XXXIX, Indices and An Introduction to the Discoveries in the Judaean Desert Series*. Oxford.

Tov, Emanuel, 2003. Controversies around the Dead Sea Scrolls. *Teologinen Aikakauskirja/The Theological Review*, **5**, pp. 387-400, especially pp. 394-395.

Tsafrir, Yoram, Di Segni, Leah and Green, Judith (Eds.) with contributions by Roll, Israel and Tsuk, Tsvika, 1994. *Tabula Imperii Romani (TIR), Iudaea - Palestine, Eretz Israel in the Hellenistic, Roman and Byzantine Periods, Maps and Gazetteer*. Jerusalem.

Watzman, Haim, 1994. Lusher times at Masada. *New Scientist*, **143**, September 3, No. 1941, p. 5.

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