GEOLOGICAL STUDY AT TELL ḤESBÂN, 1974

A Preliminary Report

HAROLD E. JAMES, JR.

Geoscience Research Institute, Andrews University

The permanent or semi-permanent occupation of a given site by a human population as at Tell Ḥesbân had significant, even dramatic, effects on the geology of the inhabited area. Some changes were humanly purposeful whereas others were natural responses of delicately balanced, interrelated geological processes which moved toward equilibrium with changing conditions. In turn, these changes may have influenced certain decisions and actions of observant inhabitants.

Typical of the purposeful changes of surface morphology were erection of buildings, excavation for building sites and building materials, construction of roadways and excavation of chambers for various purposes. By contrast, the collapse of cave roofs or buildings during earthquakes at least temporarily rendered people the servants, not the masters, of natural events. The distribution and movement of water were purposefully controlled by means of channels and conduits which were constructed to minimize the accumulation of water in some locations or to concentrate and store water in other areas. At the same time some roadways probably diverted water from pre-occupation drainage routes, and the open framework of some walls provided numerous conduits for water to percolate through the accumulating sediment. Some subterranean chambers were excavated or modified to control the distribution of water, whereas the effects of others on water distribution may have been quite unimportant to the inhabitants. The apparently simple accumulation of occupation debris changed the nature of the sediment in the area of occupation and also affected the nature and volume of sediment transported by wind, water, and gravity on, beneath, and in the vicinity of the occupied site. Awareness of these changes could have influenced inhabitants to locate cisterns and dumps in such a manner that sedimentation rates within the cisterns and discomfort due to blowing dust would be minimized.

What geological criteria are proving useful in detecting changes and interpreting the practices and purposes of the inhabitants at Tell Ḥesbân?

Tell Ḥesbân is located in a carbonate terrain that is dominated by limestone, chalky limestone, and marl.[1] These, along with the resistant, weathered product *nari* and loose red residual soil, covered the surface when Tell Ḥesbân was first occupied. A portion of the loose residual soil was washed into subterranean passages to form pre-occupation fill composed of soft, red sand containing granules of *nari* and limestone with varying amounts of silt and clay. Fragments of carbon generated gray-colored sediment after human occupation of the site. This color change appears also in the post-occupation fill within subterranean passages.

Proper interpretation of this washed sediment is essential both for understanding its origin and for interpreting the complex history of some caves. The excavation of new caves or the trimming of the walls in existing caves exposed the washed fill on fresh surfaces. Where debris accumulated in caves, varying amounts of water-washed material may be present. Debris from dumping or occupation usually contains much larger fragments and a significantly higher proportion of silt and clay, all of which render it more poorly sorted than the sediment transported by water. Remnants of this poorly sorted debris in caves are distinguishable from the water-washed fill and provide one of the clearest geological evidences for the filling and clearing of

[1] Reuben G. Bullard, "Geological Study of the Heshbon Area," *AUSS*, 10 (1972): 129-141. F. Bender's *Geology of Jordan* (Berlin, 1974) is an English translation of his 1968 *Geologie von Jordanien*, which provides a regional setting for the geology of Tell Ḥesbân.

existing caves. Tool marks that extend across both cave fill remnants and limestone indicate some trimming of the cave walls at the time of, or subsequent to, cave clearing. Corresponding differences in the sorting of materials permits discrimination between mortar with clay or silt and plaster which contrast sharply with sediment washed through drains and some open framework walls. In addition, mortar and plaster often contain striated tubes where plant fragments served as binder.

Importation of quartzose sand and sandstone, marble and basalt further changed the nature of the accumulating sediment. The marble and basalt are very resistant to disintegration, but friable quartzose sandstone provided a ready source of sand for use in plaster, bricks and pottery. The ease with which the sand could disperse and its absence from the bedrock and preoccupation soil make it relatively easy to determine when inhabitants began to import a significant quantity of sand to Tell Ḥesbân. This determination has not yet been made.

Occasional strata up to one centimeter thick with slopes in excess of seven degrees contain coarse sand and granules. The slope appears excessive for deposition by running water. Furthermore the gradational contacts at the tops and bottoms of these strata and lack of sedimentary structures are problematic for water deposition on such slopes. Nevertheless, the good sorting of the sediment and consistent thickness of the layers require the operation of sorting process unless this sediment originally had very special qualities – a rather unlikely possibility. On modern surfaces near Tell Ḥesbân a similar texture forms where the loose surficial sediment is subjected to limited agitation by foot traffic and fine material is winnowed away by the wind. The location of the buried strata on the west side of Tell Ḥesbân, which is subject to westerly summer winds,[2] makes this interpretation particularly attractive.

Subterranean chambers range from irregular caves of various

[2] Bender, *Geology of Jordan*, p. 15.

sizes to plastered cisterns. One type of chamber is generally more symmetrical, between one and three meters in diameter with depths between one and two meters. Access was through circular holes at the tops of the chambers. Did these chambers serve as cisterns? Very careful cleaning of the rock surfaces is necessary to insure that all fill has been removed for study of the detailed configuration of the chamber walls and floors. Because of solution, numerous tubes and irregular passages are present on these surfaces. Limited resistance to the passage of air blown into many of these passages suggests that they would drain fluids from the chambers in a very short time. The identity of tool markings on the walls of solution passageways and the associated chamber walls suggests that these pasages were fully developed at the time of tooling.

It is possible that chambers were trimmed after solution had formed the passages. Often tool markings are preserved in fine detail but around the mouths of some cisterns the markings have been altered to varying degrees by abrasion or solution. In one case water several centimeters deep has stood in the bottom of a chamber with the result that tool markings are deeply etched by solution. Excellent preservation of many tool marks, and limited solution where water has been present, render it highly unlikely that the numerous passages could have formed in the relatively short time during which the chambers would have been in use as cisterns. Furthermore it is not clear why late wall trimming would be necessary in such small chambers.

Occasional chamber enlargment is present as though the chamber had intersected a larger, horizontal, lentil-shaped cavity. Cavities of this shape develop where a portion of a given carbonate layer is more susceptible to solution than the adjacent carbonate rock.

Larger chambers might have reduced water loss by increasing the ratio of volume to surface area. Most proven cisterns were much larger than the chambers under discussion and all known cisterns have one or more layers of sealing plaster. These factors plus the presence of tool marks in solution passageways, preservation of detail on tool marks, and probable cutting of chambers through lenticular solution cavities indicate that the chambers were intended for purposes other than water storage.

The inhabitants of Tell Ḥesbân probably utilized the most accessible source of quartz sand available for the manufacture of bricks and plaster. Whether pottery was imported or manufactured locally is not yet clear. If it was imported the quartz sand found at Tell Ḥesbân probably came from more than one source. The closest known source is eight kilometers west and slightly north of Tell Ḥesbân in Wadi Ḥesbân below ʿAin Sumiya. In this vicinity the stream gradient increases abruptly in a series of falls, and the valley narrows significantly where Lower Cretaceous sandstones[3] form very steep valley walls. If the steep climb at ʿAin Sumiya was too inconvenient, a more distant source may have been utilized. Geological and extra-geological criteria will be useful in evaluating this possibility

[3] Bullard, "Geological Study," Pl. XII, p. 136.