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COMMUNICATION BY FIRE (AND SMOKE) SIGNALS IN THE KINDGOM OF JUDAH

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Abstract: This paper examines the use of ancient fire and smoke signals for communication in the Kingdom of Judah. Historical and biblical references are cited that discuss this communication system. The current physical and political landscape of Israel precludes testing of hypotheses using traditional techniques. The use of a GIS is enlisted to overcome these obstacles and predict line-of-sight patterns that are conducive for a fire signal communication system. Final demonstration of this predictive model will incorporate state-of-the-art technology and in-field data acquisition to provide the sufficient accuracy that is required for proof-of-concept. This research will provide insight into the technical capability of the ancient Israelites for communication across a mountainous, desert environment.

In 1935, during the excavations at Tell ed-Duweir (ancient Lachish) in a room near the Iron Age II city-gate, a collection of ostraca which became known as The Lachish Letters was found and brought archaeologists in direct contact with an ancient method of communication between sites by fire and smoke signals. The ostraca were dated to the time just before the fall of the city to Babylonian hands at the beginning of the 6th century BCE.

Lines 10-13 of Lachish Letter IV, which mention the fire signals, have had several interpretations all of which revolve around the use of fire signals. In his first publication of this ostracon, H.N. Tur-Sinai reads:

"And (let my lord) know that for the signal-stations of Lachish we are watching, according to all the signs which my lord gives, because we do not see (the signals of) Azeqah" (Torczyner [Tur-Sinai] and al 1938; Tur-Sinai 1987).

Tur-Sinai suggests that the letter writer was positioned between Azekah and Jerusalem at Kiryat-Ye'arim or its relay station at Beit-Mahsir (Torczyner [Tur-Sinai] and al 1938:86). Furthermore, the letter must be describing a situation existing after the fall of Azeka to the Babylonians, shortly after what is described in Jeremiah 34:7: "...the army of the king of Babylon was attacking Jerusalem and the remaining towns in Judah, namely Lachish and Azekah, the only fortified towns left there." H. Reviv supports Tur-Sinai on both issues, that the letter was sent from an outpost to Lachish and that Azekah could not have been seen, however not because it fell to the Babylonians but rather because of the topography (Reviv 1975:84). Smelik supports the idea that the signals of Azeka cannot be seen from the outpost because of the topography, but suggests that they were part of an exercise to determine which signals could be seen from which locations (Smelik 1991:127).

Y. Yadin reads these lines somewhat differently. Instead of "watching for" as read by Tur-Sinai and Albright (Albright 1969:322), he reads "watching over," thus identifying the site where the letters originated as Lachish and not one of its outposts. He agrees that the reason for not being able to see Azeka's signals is its fate (Yadin 1984; Borowski 1984).

Fire signals were used in the ancient world in general and in the ancient Near East as is documented in the 18th century BCE Mari Letters (Dossin 1938). The news of the fall of Troy (12th century BCE) was brought to Queen Clytemnestra by means of fire signals (Edwards 1989:1-3). Aristotle, Diodorus Siculus, Julius Caesar, Pliny the Elder, and Plutarch mention and discuss the use of fire and smoke signals.

The use of fire signals in ancient Palestine is well attested in the Mishna (Rosh Hashana 2:2-3), and is mentioned in the Bible (Judges 20:38, 40), particularly in relation to Judah in Jeremiah 6:1: "People of Benjamin, save yourselves, flee from Jerusalem; sound the trumpet in Tekoa, light the beacon on Beth-hakkerem, for calamity looms from the north and great disaster." Additionally, Yahweh's presence among the Israelites in the desert in the form of a cloud in the daytime and a pillar of fire at night (Exod 13:21-22; Deut 1:33) must also be reminiscent of the ancient communication system by fire and smoke signals. The ancient sources do not describe in detail the use of this communication system, however its existence might explain the repeated occupation of certain sites by the Kingdom of Judah. In addition to economic factors such as land and water resources, which were the primary reason for the occupation of certain sites in earlier periods (Early Bronze-Late Bronze Age), with the appearance of a political entity such as the United Monarchy (ca. 1000 BCE) and later the Kingdom of Judah, the need for territorial security became one of the important reasons for settling and fortifying certain sites. Not until the rise of the Davidic monarchy was there in this region a political entity that justified territorial integrity which had to be protected.(1) Thus, it seems that with the rise of the Kingdom of Judah, there was a good reason for the occupation, fortification, and maintenance of particular sites which were part of an overall defense system that could withstand attack and communicate with each other and with the capital city (see also Gichon 1964).

The existence of a fire signal system, as suggested by Lachish Letter IV, can be tested in the field. To prove its existence it would be necessary to locate fortified sites within the area claimed to be part of the Kingdom of Judah that can be observed by each other to facilitate communication by fire and smoke. The existence of such a system can explain the choice of sites for occupation and its nature. Sites central to the system with several lines of observation to other sites and with appropriate natural resources might be bigger and better fortified than other sites. Sites located in hospitable areas but without lines of communication might require alternate routes of communication through secondary (or relay) sites (for example see Mazar 1982, especially 107-108; Mazar 1990:96-101).

In today's conditions, the main problem in conducting such a field test is the ability to distinguish and recognize fire signals from great distances even when substituting them with flares.(2) To surmount technical difficulties, the facilities of NASA's Global Hydrology and Climate Center were enlisted. Topographical data will be entered and stored in the Center's computers then added as a layer into a geographical information system (GIS). Within the GIS, viewshed modeling(3) allows one to determine if Site A is visible from Site B. If Site A is not visible from Site B, a series of secondary viewsheds with common intersections can be constructed to determine a relay route. In other words, it can be determined if there is an overlap in the viewsheds of Sites A, B, and C. When such an overlap exists, communications between Site A and Site C could be relayed through the commonly visible Site B.

Accurate determination of viewsheds relies upon pinpointing the latitude, longitude, and elevation of each pertinent site. The most efficient and accurate system for determination of latitude and longitude is the Global Positioning System (GPS). GPS functions by carefully measuring the time differential between signals received from several of the NAVSTAR satellites. The satellites transmit coded, synchronized signals. By receiving signals from several satellites, ground-based receivers can use simple trigonometric functions to determine an extremely precise location on the earth's surface.

The receivers are nominally capable of resolving locations to within a centimeter, but, in order to impede military use, the signals are degraded by slightly varying the periodicity of transmission which introduces random positional errors of up to 100 meters. (These errors are more pronounced in altitude than in latitude and longitude, so much so that other means must be used for altitude measurements.) The major portion of the introduced error may be removed by using a differentially corrected GPS signal. Differential correction compares a GPS-derived position of a location to its known, surveyed position. That difference is then used to broadcast a local signal which compensates for the introduced degradation of the original signal. Differentially corrected positional error is commonly less than 5 meters.

A preliminary survey to demonstrate a "proof of concept" was conducted in 1993 (4). A Magellan NAV5000PRO GPS receiver was used to acquire GPS coordinates. This 5-channel navigation-type receiver, when used with the post-processing software supplied by Magellan, yields acceptable positions, whether stated in latitude/longitude or universal transverse mercator coordinates. We used two receivers to obtain a total of 120 position fixes (readings) per site. Each set of readings was downloaded to a ZEOS 386-25 Notebook computer and the data were processed to eliminate "wild" fixes caused by changing geometry of the NAVSTARs. Wild fixes are defined as fixes that fall outside of a user-defined radial error.

In order to accurately ascertain the elevation of each location, precision altimeters will be used. The altimeters we will be using are essentially precision aneroid barometers, utilizing the inverse relationship between altitude and atmospheric pressure. Inside the sealed, compressible altimeter container is a mechanism for translating the compression and expansion of the container into rotary motion. The magnitude of the rotary motion is amplified through a series of gears connected to a pointer on a calibrated dial which indicates altitude to a very high accuracy (typically less than ±0.5m in the range within which we will measure).

Two of these altimeters will be used to take elevation readings. Before readings are taken, the altimeters will be calibrated at a surveyed site of known elevation. One instrument will remain at the site to act as a benchmark while the other instrument will be used to make field measurements. Radio contact will be used to coordinate times of readings so that any drift in the benchmark reading can be noted and factored out of the field measurement values.

One basic assumption underlying this investigation is that visual communication was necessary when there was in the region a political entity interested in territorial integrity and security. This fits well with the period of the Judean monarchy (ca. 920-586 BCE) and therefore, the team visited sites that were occupied during the Iron Age II in areas located within Judean territory surrounding Beersheba, Arad, Halif, Lachish, and Beth Shemesh. Twenty-five sites, where GPS readings were taken, were visited. These do not include all the sites possibly belonging to the system, but they provide a starting point. The data from the visited positions will be input into a GIS which will contain Landsat satellite map information as well as a layer of topographic data. The latter will be accomplished via automated ingestion of digital topography data files into the computers. The GIS does not require any other information for the individual sites.

The entire data set will be analyzed using Intergraph Corporationís suite of GIS tools called Modular GIS Environment (MGE) which contains a system of components for data ingestion, map projection, projection translation, areal query, topological query, terrain modeling, image processing, and several other tools both central and peripheral to common GIS operations.

Then comes the test, can Site A be seen from Site B? The output data will demonstrate which sites can see each other directly as well as locate potential intermediate locations (relay points) that would connect the sites.

Future work will require more GPS readings at the remainder of the sites in the region and visits to places suggested by the computers as relay stations. The GIS can also be expanded in the future to include additional layers of information such as soils, roadways, drainages, meteorology, etc. The GIS could then be used for various other research applications.

What may the studies initiated by Lachish Letter IV reveal? The letter suggests the possibility that there was direct communication by letters with Jerusalem; was there also a line of communication by fire signals? There is a possibility that the system was set-up so fire signals were used by groups of sites for intra-communication within the group. Inter-communication between the groups could have taken place only between certain selected sites. This means that a group of 3-4 sites could be in communication with each other, but to communicate with another group of sites only one site out of each group needed to be able to signal to one member of another group. In the case of Lachish, this means that only one site outside of its group (maybe Azekah) could be seen from Lachish. Then when Azekah fell, the only means of communication from Lachish with Jerusalem and the other groups was probably by letter. Lachish Letter IV suggests that all communication points between Lachish and Jerusalem fell into the hands of the enemy and the only way to communicate with the capital city was by letter.

While this seems most reasonable for the case of Lachish Letter IV, the question of why the defenders of Lachish continued to maintain the fire signals (as mentioned in the letter) still remains. Is it possible that the fire signals were only meant to be signs of survival while more complex communications were made by letter?

Other questions raised by the study are:

*Were cities mentioned as fortified by several of the kings of Judah part of the fire signal system?

*Could the fortified cities of Rehoboam (2 Chr 11:6-12) communicate with each other?

*Could other systems such as the Negev fortresses studied by several archaeologists (e.g. R. Cohen, Z. Meshel, M. Haiman) communicate with each other? If yes, then the study of the Negev fortress system may lead to a better understanding of the road systems in the region and their use for trade and other purposes.

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Footnotes:

1. The city states of earlier periods in this region did not have a need for such a communication system since each was an independent entity and, as seen from the Amarna letters, did not have common interests to be defended.

2. An experiment using flares to test the existence of such a communication system was first suggested in 1983 by Jeffrey A. Blakely, then of
the Join Expedition to Tell el-Hesi, but was not carried out for technical reasons.

3. The construction of 2-dimensional maps which describe the areal extent of the visible landscape from a point, line, or area.

4. During 2-12 January 1993, a reconnaissance team including Oded Borowski (Lahav Research Project), Daniel Lee and Thomas L. Sever (NASA), and Frank Miller (Mississippi State University) surveyed the region. Help was extended by Avi Navon (Kibbutz Lahav).

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