Space Technology And The Discovery Of The Lost City Of Ubar

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Abstract: The location of the legendary city of Ubar, a desert caravansary which supported the ancient and lucrative frankincense trade, has likely been found at the edge of the Arabian Peninsula's Empty Quarter in modern day Oman. Legend was that Ubar perished in a sandstorm as divine punishment for wicked living. Actually, much of the fortress collapsed into a sinkhole, perhaps undermined by extensive ground water withdrawal used to irrigate the surrounding oasis. The archaeological site was located by a unusual combination of historical research, and application of space technology, in support of traditional archaeology.

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1.0 INTRODUCTION

While working in Oman, one of us (NC) became enchanted with a legendary account of a fanciful city in what is now the Empty Quarter of Arabia, one of the most inhospitable places on earth. The "city" of Ubar existed to support the frankincense trade which flourished in southern Arabia from about 2000 BC to about 300 AD. Ubar was a desert outpost where frankincense cargo was gathered and caravans were outfitted for the long trek across the desert. Frankincense is the dried sap of a scraggly tree (Boswellia Sacra) which grows principally in this region. in the ancient world frankincense was used for religious ceremonies, medical purposes, and cremations. Demand was such that it was literally worth its weight in gold in ancient Rome.

Although Ubar was widely regarded as mythical, trade routes across the desert had considerable economic appeal in that they avoided the dangers of sca travel (pirates and storms), and the dangers and expense of travel through more populated areas (thieves and taxes). Historical research into such varied sources as the Arabian Nights, the

Koran, and particularly writings of the Greek geographer Ptolemy, indicated the general region where the Ubar may have existed. In Ptolemy's time (ea. 150 AD), Ubar would have been a functioning trading center and caravansary. The research into the ancient accounts was compelling in supporting the notion that Ubar was not a fantasy. Unfortunate] y, none of Ptolem y's maps survived the burning of the library at Alexandria. Records which survived were lists of coordinates which did not specify Ubar's location precisely enough that a reasonable search could bc mounted though traditional ground exploration. This evidence however gave a logical basis to expect that a desert outpost did in fact exist to outfit camel caravans. The difficulty was focusing the search into a manageable area.

2.0 THE SEARCH

The most precise lead available at the outset of our efforts was the report by British explorer Bertram Thomas from his expeditions in the Empty Quarter in the late 1920s and early 1930's. During one expedition, Thomas was alerted by his Beduoin guides to the presence of a track leading northward into the Empty Quarter in an area where no reasonable person would now go [1]. The legendary account of Ubar was revealed to Thomas who carefully marked the track on his map. Along the projection of the track, he marked "probable location of the ancient city of Ubar" based on the Bedouin description. Thomas had planned to return to Oman and follow the track, but World War 11 intervened and he was unable to do so. Thomas also reported the track to T. E. Lawrence (Lawrence of Arabia), who gave it the moniker "Atlantis of the Sands". Ubar was forgotten until the 1950's when two expeditions rc-located Thomas' road, but were defeated by the dunes. Following Bertram Thomas' track, and perhaps finding Ubar, required something beyond traditional approaches.

In 1982, one of us (NC) read of the results from the Shuttle Imaging Radar-A mission, which flew in 1981. Radar images from that mission covering the Sahara, in the region near the Egypt-Sudan border, showed abandoned river channels in what is now the driest region on earth. The extreme dryness of the area had rendered the windblown sand cover, which blankets the old fluvial landscape with up to 2 meters of windblown sand, transparent to the radar [2,3,4]. Thus, the underlying landscape created in a wetter geologic time was revealed on the radar images. Because the legends were that Ubar was buried in sand, this technological edge might help locate the site.

Clapp contacted JPL, and after nearly being dismissed as a crank, convinced us that his search was both serious and possible. Charles Elachi, Shuttle Imaging Radar principal investigator, agreed to arrange radar data acquisition of the Thomas' Road area during the flight of SIR-B in 1984. While the resulting images showed intriguing fragments of what seemed to bc tracks, wc quickly realized wc would need regional coverage not available from infrequent Shuttle flights.

3.0 IMAGE DATA AND ANALYSIS

To search for potential sites where Ubar might have existed, remote sensing data acquisition was targeted by historical research. Remote sensing data from the Shuttle Imaging Radar, the Shuttle based Large Format Camera, and Landsat and SPOT satellites were acquired, enhanced, and analyzed. Ultimately, wc used every type of remote sensing data available which had the necessary resolution to perhaps detect something useful. Remote sensing data from the Shuttle Imaging Radar, the Shuttle based Large Format Camera, and the Landsat and SPOT satellites, covering a broad swath across the southern margin of the sands of the empty quarter were enhanced and analyzed. It is useful to review the key features of each.

Shuttle imaging Radar:

As the name implies, this instrument is a radar carried on board the Space Shuttle. The capability of this relatively long

wavelength (23 cm) radar to image features in the immediate sub-surface under extremely arid conditions such as in the Sahara, and the Empty Quarter of the Arabian peninsula, was in fact original reason that JPL was called in to help in the search for the lost city of Ubar. Because the instrument is developmental, it does not fly regularly on the Space Shuttle (in fact, it has only flown four times, 1981, 1984, and twice with a multi wavelength, multipolarization system in 1994). Limited coverage of the area of Bertram Thomas' road in Oman was obtained during the 1984 flight of SIR-B aboard the Challenger. Intriguing fragments of tracks were seen in the images, but the lack of regional coverage was a disadvantage.

Landsat Thematic Mapper:

We have made extensive usc of Landsat thematic mapper images for geologic studies in the southwestern US. Landsat satellites 4 and 5 both have Thematic Mapper instruments onboard and are in 830 km high sun-synchronous polar orbits, with a morning overpass. Each pixel (picture element) in the image represents a 28.5 by 28.5 meter area on the ground, and records reflected light in six wavelength bands (plus one thermal channel which wc don't usc because of poor spatial resolution). There arc three channels in the visible, and three in the reflective (i.e. non-thermal) infrared. The reflected light at wavelengths longer than the visible turns out to be most useful for geology and other applications in arid areas because many landscape features, such as the old desert tracks, arc more distinctive at these longer wavelengths. Among the advantages of these images arc large regional coverage spanning over 30,000 square km. in a single image. Properly enhanced images from the Landsat TM instrument were critical to the success of the expedition.

SPOT

The SPOT (Systeme Probatoire d'Observation de la Terre) satellites were launched and arc operated by the French. Three SPOT satellites arc currently in 700 km high sun synchronous orbits, with morning overpasses. SPOT has two modes, a color mode with 20m pixels, and a back and white mode with 10m pixels. The color mode is less useful than the Landsat data because, although the spatial resolution is better, the spectral coverage is not as good for our work. Instead wc usc the black and white images which have the highest spatial resolution generally available to the science community from a satellite. We digitally combined the high resolution SPOT images with Landsat Thematic Mapper images to achieve high spatial resolution with the spectral information from the Landsat images. Images resulting from this technique enabled us to detect and follow old tracks into the Empty Quarter. Detection of Bertram Thomas' road required the resolution of the SPOT images, the track is not detectable on the Landsat images alone.

Large Format Camera:

This is a Space Shuttle borne photographic camera system, capable of very high spatial resolution. Unlike the other data sets, LFC photographs arc not digital. During its 1984 flight, some black and white photographs were acquired of portions of Oman and these were analyzed in conjunction with the satellite images for a more comprehensive view of possible trading routes. As with the other shuttle borne data, lack of regional coverage was a great disadvantage.

4.0 MAPPING ANCIENT AND MODERN TRACKS, GUIDING EXPEDITIONS

We acquired Landsat scenes and as the data were enhanced and analyzed, many tracks began to emerge. We determined that even ancient tracks across the little changing desert floor could be mapped using suitably enhanced image data. Some tracks were demonstrably old because they went directly under very large sand dunes. Analysis indicated that detection of the tracks would be improved with higher resolution than that

provided by the 28.5 meter pixels (picture elements) of the TM sensor. We then acquired images from the French SPOT satellite SPOT (Systeme Probatoire d'Observation dc la Terre), which has 10 meter pixels in a black and white mode. To achieve the best possible detection, we combined the Landsat and SPOT image data by registering them digitally, and using the landsat spectral information for image color, and the black and white SPOT data for improved image detail. Because of the report of a possible location for Ubar by Betram Thomas, we initially targeted this area. In the resulting images, we were able to follow and map Thomas' road out into the Empty Quarter. Our enthusiasm and suspicions were both aroused by image analysis of the Thomas' road area. We were excited by the appearance of an "L" shaped feature next to the track at some distance into the dunes. This unnatural looking feature in our fantasies might actually have been the site. However, the track to the "L" site seemed rather small to have been the highway to the locus of desert frankincense transport. It is interesting to note that using the enhanced satellite images, we had actually rediscovered Bertram Thomas' road while sitting in Pasadena.

Despite our misgivings about the narrowness of the track, this "L." site was one of our prime targets in the reconnaissance phase of the expedition in July of 1990. We were generous] y provided with helicopter support from the Royal Oman Air Force. Using the image data and a Magellan Nav Pro GPS receiver, we were able to fly a direct intercept to Thomas' Road, and then fly the road directly to the "L" site. The track and the L were more distinctive on the image data than to the eye, and had we not had both the images and the GPS navigation tool, we could have very easil y missed the site. As it turned out, the mysterious "1 ," was a natural feature resulting from the sand dunes. Only a few minutes at the site were necessary for Zarins to conclude that this was not the site of Ubar. In fact it was a major Neolithic site, with many, many stone tools scattered about. This in itself was a remarkable, and unexpected find. But it wasn 't Ubar.

Upon returning from the reconnaissance expedition, just before the unpleasantness in the Gulf, we realized three things. First, we had determined that one could see even very old tracks in the desert, based on the Bertram Thomas' road results. This meant it was unlikely that a major trading center could escape our detection if we acquired the right image data. Second, unlike the Sahara, the sand cover was not continuous, and therefore shuttle dependent radar data were not necessary, we could make very effective use of the satellite images which show only surface features. Third, the amount and ages of archaeological material at other known, but poorly studied, sites we investigated strongly supported the notion that there was in fact a desert frankincense trading center. The difficulty now was finding it and we needed to expand the search area greatly. We acquired additional Landsat image data and began enhancing and plotting additional tracks.

Analysis of the image data enabled us to eliminate very large regions of the desert from consideration, and indicated precisely where to look in the field for significant sites. Continued analysis revealed that the major tracks followed well defined routes to a limited number of places. These sites were targeted for a subsequent ground based expedition which took place in late fall of 1991. Most useful were the Landsat image data which revealed a network of tracks that converge at the modern day village of Shisr (Figure 1). Archaeological investigations of the ruins at Shisr indicate that it is most likely the site which inspired the Uhar legends.

Figure 1. Sub-scene of Landsat Thematic Mapper image of the Ubar site. Note the minor tracks near the major dirt roads. Although used in modern times, the tracks arc ancient. Original in color.

5.0 PRELIMINARY ARCHAEOLOGICAL FINDINGS

Although no definitive inscriptions have been found at the site which conclusively prove that Shisr is in fact Ubar, archaeological material recovered at Shisr in three seasons of excavation demonstrate that this site was clearly not an isolated desert watering hole. Pot shards, glass, coins, and even fragments of an oil lamp, all testified to a long period of occupation and commerce with truly distant lands. Material from Rome, Greece, Mesopotamia spanned a time period from perhaps as long ago as 2800 BC to about 300 AD. The cessation of activity at about this time is in broad agreement with legend accounts, and also with the probable decline in the frankincense trade at about this time. Frankincense was consumed in large quantities in cremations, which were banned when the Roman emperor Constantine made the Roman empire Christian in about316 AD.

The site also makes geographic sense. It is the only source of near surface water for a very long distance, and clearly the water table was higher in the past. Indeed the reason the modern village is at the site is because of water. Water clearly was key in ancient times as well. The site is also in an advantageous position with regards to the frankincense source regions to the south, and while being an isolated outpost from which to launch camel caravans across the desert.

The site is in accord with the legendary accounts if some allowance for exaggeration is made. In the Koran, Ubar is described as a many towered city. Excavation revealed an eight towered fortress which surrounded the water well. Ubar supposedly perished in a calamity. While no definitive evidence has emerged on this matter, the fortress did in fact collapse into a sinkhole at about the time indicated by legend. This may have occurred in a sandstorm, or perhaps triggered by a distant earthquake. In any event, the collapse would have rendered the water well useless until it was dug out, which may not have been possible with the water supplies on hand at the time of the collapse.

In summary then, circumstantial evidence indicates the site is likely the location of the Ubar of legend. It is also unlikely that this site existed alone. Current research centers on additional sites possibly related to the frankincense trade to the west in Yemen.

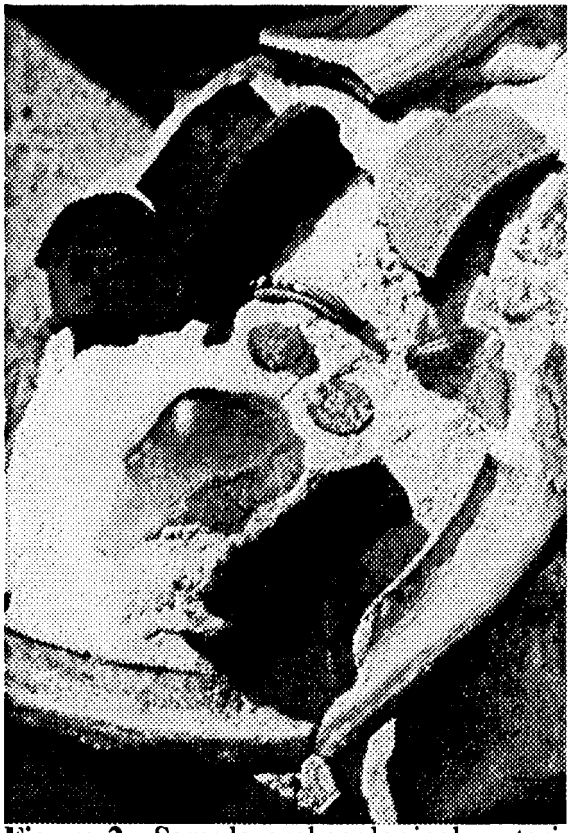

Figure 2. Sample archaeological material from the Shisr site. Among the potshards, glass, coins and other material, the ONLY local piece is the circle and dot pottery at the upper right.

6.0 SUMMARY

The legendary lost "city" of Ubar has likely been found on the edge of the Empty Quarter of the Arabian peninsula in what is now modern day Oman. Ubar was a desert outpost which existed as a caravansary to support the shipment of frankincense across the desert.

While the original reason for the involvement of JPL was the Shuttle imaging Radar, and its potential to see beneath a thin sand cover, the critical data set was in fact from the Landsat satellite's "Thematic Mapper" instrument. The ability to image subtle features, such a old trails, and image a vast area in onc scene, were essenti al in determining that the rather modest site at Shisr was likely the Ubar site of legend.

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BIOGRAPHIES

Details and photographs to be supplied with final manuscript

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