LATE PREHISTORY OF THE NILE BASIN
AND THE SAHARA
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# The use of Landsat imagery for reconnaissance work in the Sahara

One of the more fascinating research problems for both the archaeologist and the human ecologist at the present time concerns the origins of the Neolithic in the Sahara (Wendorf and Schild 1980; Clark and Brandt 1984). Already by the 8th millennium B.C., for example, there appears to be evidence in the Bir Kiseiba region of the Western Desert of Egypt for a Neolithic complex which includes cattle pastoralism and pottery (Connor 1982; Wendorf *et al.* 1984). What were the forms of cultural adaptation in the Sahara that made occupation of this part of the world possible during the early Holocene? In order to answer this important question, we probably first need to have a better idea of what local conditions were like in the Sahara at the time (Williams and Faure 1980). This report is meant to draw attention to a line of environmental study, the use of Landsat imagery, whose potential has remained to date essentially untapped. Given the inherent difficulties that are normally involved in doing fieldwork in the desert, Landsat imagery may also prove to be of considerable use when it comes to the planning and conduct of archaeological surveys in the Sahara.

Examples of Landsat imagery will be presented for two regions of the Sahara: the Tadrat Acacus in Libya and Bir Kiseiba in Egypt. Specifically, the aim of this report will be to illustrate how Landsat images can be used in three ways: a) to provide environmental information on a region, b) to aid in the planning of reconnaissance work, and c) to aid in the mapping of sites and other features of the landscape during the course of surveys. While Landsat "paper products", photographic prints which present in summary form the information contained on Landsat tapes, have seen some previous use in Saharan archaeology, very little use had been made up to the time that our work started in January 1982 of the much more detailed images which can be obtained when the tapes are processed in a remote sensing laboratory. The comment should perhaps be made here that the delay in the Sahara basin contrast with the situation in the southwestern part of the United States where Landsat images were already in wider use (Lyons *et al.* 1980). One of the reasons for this would be the equipment that is required for a remote sensing laboratory. Another would be a more general lack of familiarity with developments in the field of remote sensing.

The study was done in collaboration with Prof. R. Lyon, who is in charge of the Remote Sensing Laboratory in the Department of Applied Earth Sciences at Stanford University. For a basic account of Landsat technology and also a description of image processing in the context of archaeological studies, reference is made here to various publications by the National Park Service (*e.g.*, Lyons and Avery 1977; Lyons 1981; Ballew and Lyon 1977). Desert areas of the world offer favourable conditions for Landsat imagery, since there are often times when an image can be taken with almost no cloud cover. This is one of the main factors to consider in the selection of a Landsat tape. The tape selected for the Tadrat Acacus region was that taken on 6 November 1972. In the case of the Bir Kiseiba region, the date was 20 February 1976. The whole area covered by a Landsat tape measures 180 km on a side. Displayed as a false colour image on a television screen (with its rectangular format), one can obtain scenes such as the 60 × 90 km image shown in Fig. 2. Different areas can further be enlarged on the screen down to a size of about 6.7 × 10 km, at which point the grain of individual pixels has begun to obscure the overall image. Good detail and resolution are provided by scales in the range from 10 × 15 km to 20 × 30 km on the television screen. On the system at Stanford, one of the ways to examine a tape is to scroll over the region at such a scale. In terms of what is seen on the screen, it is as if one were floating slowly over the region in a hot air balloon, looking down on different parts of the whole scene.

There are several ways in which the images that appear on the television screen can be recorded. One of these is by taking coloured slides of the images on the screen. Before taking a slide, it is possible to introduce notes and symbols on the screen (*i.e.*, over the image) by means of a computer program. In our case, a series of 35 mm slides was made for each of the regions. The slides are particularly useful for study purposes, since they can be projected as large images using a conventional slide projector. Another possibility is to make coloured photographic prints directly from the images seen on the television screen. Such prints may offer certain advantages for purposes of eventual publication. It is clearly unfortunate that so much is lost when the false colour images are printed in black and white as is often necessary for publications. A third possibility is to make maps in black and white where the values of pixels are displayed according to a grey scale using a dot printer. Several examples of geometrically corrected maps at a scale of 1 : 25,000 were made for selected areas in the Tadrat Acacus. For educational purposes, we also decided to make a videotape (on a Betamax recorder) of a session in which one of the Landsat tapes was examined. This was done with the aim of illustrating for the non-specialist how this kind of work is actually done. As one scrolls over the region, a running commentary is given on various things that the images reveal such as the occurrence of faults (and their implications for hydrology), large dune fields (and their implica-

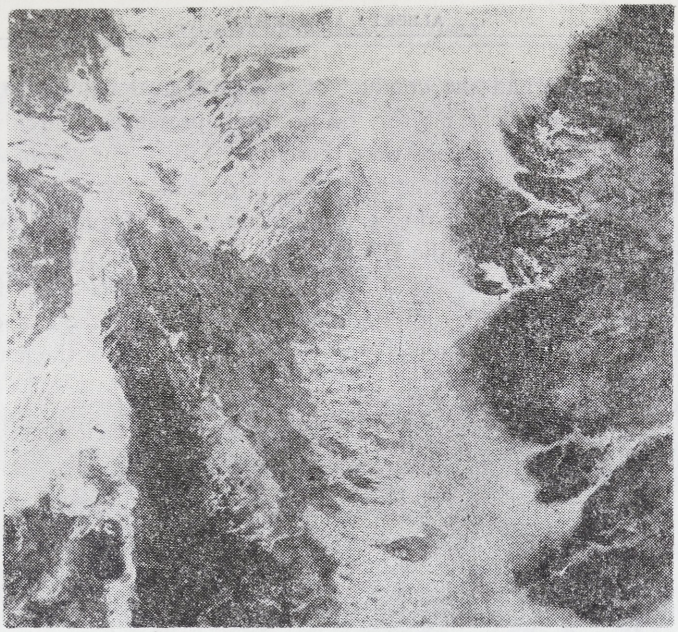

FIG. 1. Landsat image of the Tadrat Acacus region of Libya. It shows the whole area covered by the Landsat tape. The image measures 180 km on a side. The geographic coordinates of the center of the image are given in the text

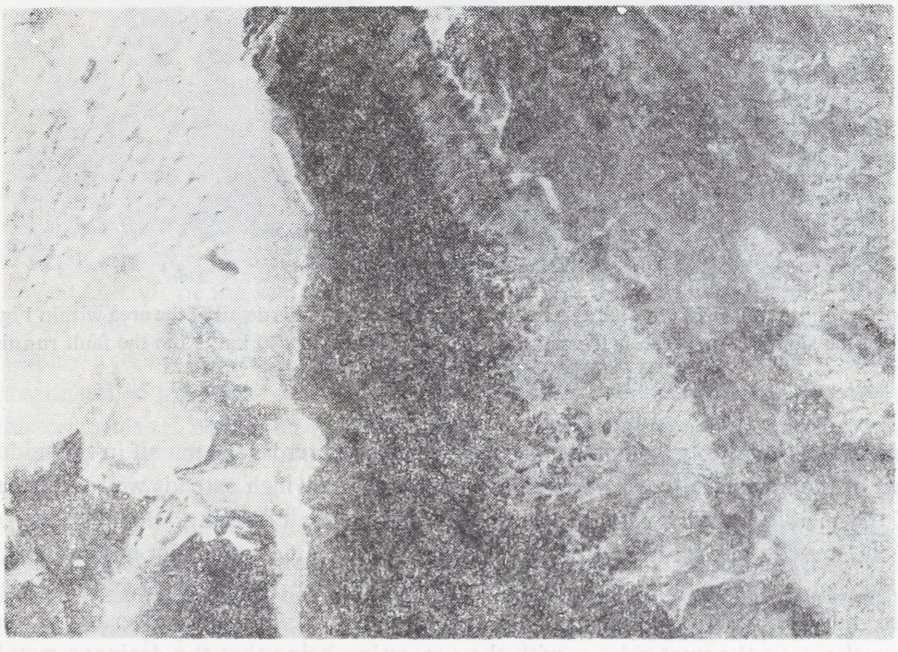

FIG. 2. Landsat image of the Tadrat Acacus region of Libya. This is a detail of the left side of FIG. 1. The image measures 60 × 90 km. The massif appears in the darker colours here and runs essentially in a N-S direction

tions for site visibility and the conduct of archaeological fieldwork), and playa sediments (and their implications for the potential presence of prehistoric sites).

The first images to be processed were those from Libya. The whole scene for the Tadrat Acacus study, whose center is located approximately at 11°0′ E, 25°45′N, is shown in Fig. 1. Archaeological research has been carried out in this part of the Fezzan (Fig. 2) by a team from the University of Rome for more than twenty years (Mori 1965). Of particular interest in our case is the site of Ti-n-Torah which has produced levels with microlithic tools dating to the early part of the Holocene (Barich 1978). The rock shelter is located in a Wadi on the eastern side of the massif (Fig. 3).

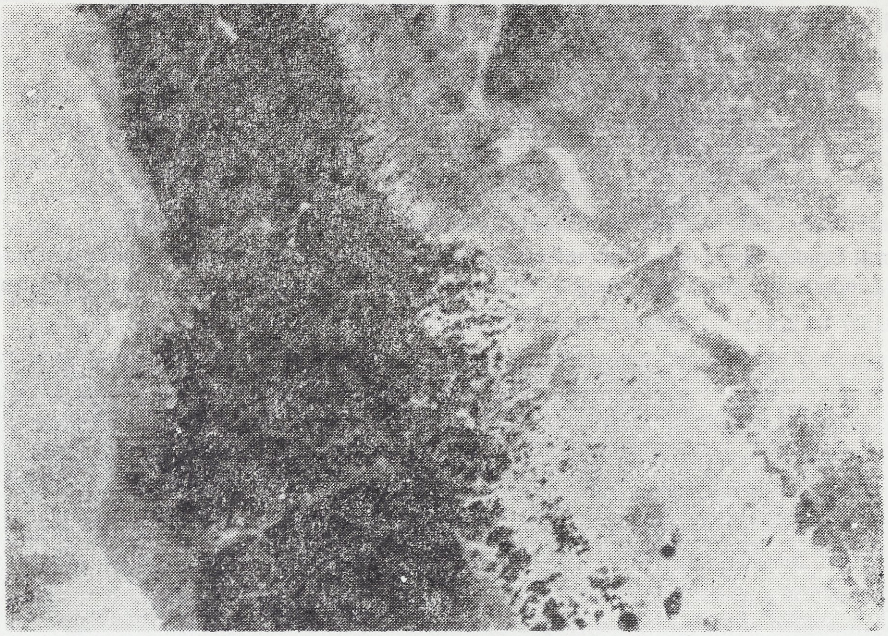

FIG. 3. Landsat image of the Tadrat Acacus region of Libya. In this detail of the area within Fig. 2 where the site of Ti-n-Torah is located, the image measures 20 × 30 km. Note the fault running in an E-W direction through the massif

One of the things to note here is the fault which runs across the massif in the middle part of the image. In terms of hydrology, such a fault which extends well to the east of the massif would be conducive to the occurrence of spring lines on this side of the massif. The fault also produces a pathway for movement by human groups in an east-west direction across the rugged relief of the massif. The Landsat images also indicate that the slopes on the east side of the massif are in general less steep than those on the west side – with the suggestion being that the drainage may be more favourable in terms of potential for human settlement on the east side. Notwith-

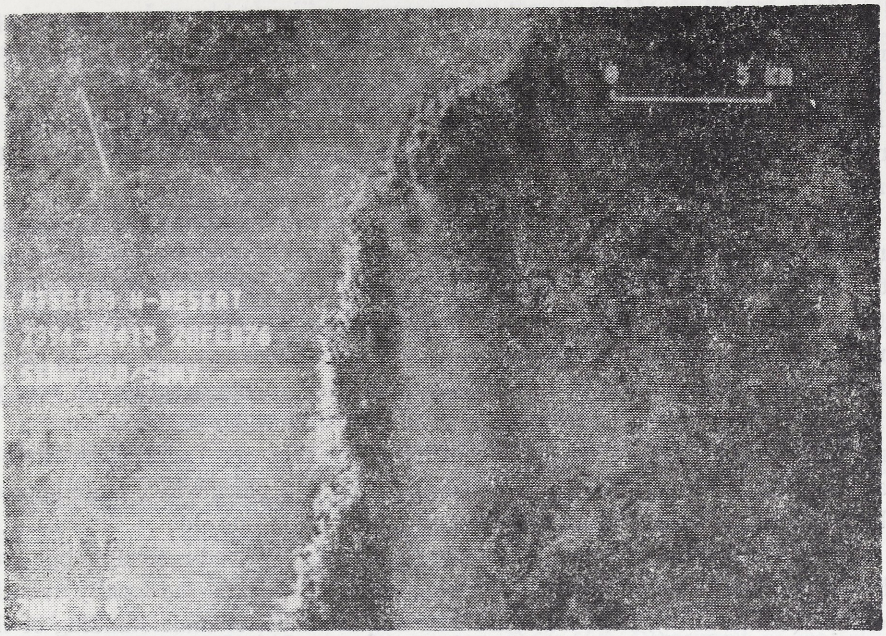

FIG. 4. Landsat image of the Bir Kiseiba region of Egypt. The Kiseiba Basin with its sequence of playa sediments is located to the south of central part of the image

standing these observations, it would seem to be well worth while looking for open air sites on the west side of the massif at its outer edge.

The other series of images to be processed was that from Bir Kiseiba. Only one image from this study (Fig. 4) will be presented here. Others have appeared in a recent publication (Wendorf *et al.* 1984 : Fig. 3 : 5). In Fig. 4, the place known as Two Hills (after two promenient conical outliers along the scarp) is located immediately to the left of the scale on the east side of the Kiseiba scarp. This Landsat image can be compared directly with the one for the same area presented by McCauley and co-workers (1982 : Fig. 8) in their Shuttle Radar study. Located approximately 5 km to the south of the right end of the scale is the area where five prehistoric sites (E-79-8, E-80-1, E-80-2, E-80-3 and E-80-4) have been investigated. These sites occur in the central portion of the Kiseiba Basin where a sequence of playa silt pans are observed. Site E-79-8 appears to be the earliest one in date and has produced a group of six C-14 determinations which fall in the range between 9,840 and 8,920 B.P. This site also yielded a good sample of faunal remains which included a small proportion of *Bos* (Gautier 1980). For our purposes here, it is worth noting that the playa sediments in this area of the Bir Kiseiba region show up as a distinctive colour (in comparison with other rock and dune surfaces in the region) on the Landsat imagery. It should be added that in the Shuttle Radar study (McCauley *et al.* 1982) ground control as seen in pit A which was dug in a nearby area confirmed the presence of alluvium. The more general point that needs to be made here is that remote sensing provides a means for recognizing areas with playa sediments within the Sahara. Since such areas seem to be attractive ones for early occupation, we may have a useful tool for guiding reconnaissance work in this part of the world.

In bringing this report to a close, it is worth briefly reviewing the three ways mentioned earlier in which Landsat imagery can be used for archaeological research in the Sahara. It should be added here that these three ways by no means exhaust all the possible uses of Landsat imagery. In terms of our knowledge of environmental conditions, the Landsat images would definitely seem to give us a chance to gain a sense of what the terrain is like in a given area of the Sahara before we ever go there. The images also help to place known sites in a wider regional context. A prime example here would be the site of Ti-n-Torah in the Tadrat Acacus. It is located on the eastern fringe of the massif and close to a place where there appears to be a line of movement in an east-west direction from one side of the massif to the other. If early Holocene adaptations in the Sahara involved a semi-mobile way of life, which was oriented in part to chasing rainfall as it occurred locally over the landscape (Smith 1984), then we could now acquire a better understanding of the favourable location of Ti-n-Torah. This line of interpretation would also encourage us to look for sites occupied perhaps on a more short term basis within the line of movement created by geological faulting. This brings us to the use of Landsat images in the planning of reconnaissance work in the Sahara. Another example that was mentioned above would be the identification of areas with playa sediments. A third example related to reconnaissance would concern the avoidance of areas with extensive dune covers. Finally, there is the possibility of using Landsat generated maps for recording the locations of sites during the course of survey work. This could be done in cases such as the Fezzan where there is a lack of aerial photographs or geographic maps at an adequate scale. The problem of recording the locations of sites in different parts of a region with a rugged relief like that of the Tadrat Acacus can be a serious one. As mentioned above, it is possible using the Landsat tapes to generate geometrically corrected dot print maps at a scale of 1 : 25,000. Such maps now need to be tested in the field to see how well they actually work.

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