WALL PAINTINGS OF THE TOMB OF NEFERTARI

SCIENTIFIC STUDIES FOR THEIR CONSERVATION

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Geographic and Geologic Setting

Farouk El-Baz

This paper is one result of a preliminary survey of the tomb of Queen Nefertari. The survey is part of a study jointly undertaken by the Egyptian Antiquities Organization and the Getty Conservation Institute. Prior to the field survey, conducted on 8-13 September 1986, a Thematic Mapper image of the site and its environs was computer enhanced and photologically analyzed. This resulted in establishing patterns of structure and drainage, which follow three major trends: NE-SW, NW-SE, and E-W. Local topography, however, controls the microdrainage patterns of surface water from occasional rainfall.

Observation within the tomb and two other shallow tombs on either side indicate that the limestone rock is highly jointed. The resulting spaces are filled with fibrous crystals of gypsum at right angles to the joint planes. The content of rock salt in these joints appears to increase with depth. This suggests the possible leaching of rock salt from higher horizons to lower ones, where it recrystallizes behind the plaster layer of the wall paintings. The salt crystals appear to force the plaster layer outward, resulting in severe damage.

The tomb of Nefertari is number 66 in the Valley of the Queens, a small wadi bounded by a high escarpment at the edge of the hills in western Thebes, the ancient name of Luxor. To fully understand the setting of the Valley of the Queens, one is advised to review photographs and images obtained from spacecraft as a prelude to the examination of the larger-in-scale aerial photographs. The best space photographs of the region are those obtained by Gemini XII in 1966, by Landsat satellites starting in 1972, and by the Space Shuttle Large Format Camera (LFC) in 1984.

The hills that surround the Valley of the Queens are part of an extensive plateau that forms the eastern boundary of the Western Desert of Egypt. This boundary also represents the edge of the Nile Valley, which encloses the agricultural strip along the banks of the Nile River.

A study of Gemini XII photographs (Yehia, 1973), established that the region is characterized by dendritic and subdendritic to subtrellis drainage. It also recognized that drainage lineations are controlled by gravity, structure, and/or lithology.

Images obtained by Landsat were used to delineate geographic features of the
Figure 1. Thematic Mapper image of the Luxor region showing the Thebes Plateau west of the Nile Valley. Major fracture systems and drainage lines are clearly delineated. Bright areas, particularly in the lower left corner, are deposits of sand carried by the wind from farther west.

Figure 2. Enlargement of part of the Thematic Mapper image of the Luxor region showing the scalloped nature of the scarp that forms the western border of the Nile Valley. Most of the drainage lines in the Thebes Plateau trend in a northwesterly direction.

Figure 3. Enlargement of part of the Thematic Mapper image of the Luxor area showing the airport in the lower right corner and road that leads to the tomb of Nefereti on the west side of the Nile (arrow). The escarpment closest to the western bank of the Nile separates the area of the Valley of the Queens from the regional drainage system to the north and west.

Figure 4. Photograph of the southwest edge of the escarpment that bounds the Valley of the Queens, showing part of the highly fractured limestone rock of the Nile Valley fault zone.
region (El-Baz, 1979). Earlier Landsat images were characterized by relatively low ground resolution, about 80 m. Later images obtained by the Thematic Mapper have 30 m resolution. An image of the study area was requested from the Earth Observation Satellite Company. The image, obtained on 22 January 1986 (50069-20746-TMWNO; N26-00 E32-21; path 175, row 42), was specially computer enhanced by the Earth Satellite Corporation of Chevy Chase, Maryland; details from this image are discussed here. The high-resolution photographs (about 20 m) by the LFC are yet to be studied.

Study of the Thematic Mapper images of the Luxor area (figure 1) indicates that the Thebes Plateau on the west bank of the Nile is characterized by three major fracture systems: (1) the E-W fault system which appears to be the oldest because it is truncated in several places by the two other systems; (2) the NW-SE fault system, emphasized by numerous primary drainage lines and wide valleys; (3) the NE-SW fault system, mainly followed by major escarpments, but also parallel to secondary drainage lines.

These trends reflect the major fracture pattern of the Western Desert of Egypt as previously deduced from studies of space photographs, particularly from the Apollo-Soyuz mission (El-Etr, Moustafar, and El-Baz, 1979).

The Nile Valley in this region follows the NE-SW direction (figure 2). It is clearly evident that the Nile itself occupies a course in the lowest part of the fertile valley; it is unlikely that its water has much to do with the moisture in the Theban hills at higher altitudes.

Closer examination of the environment of the Valley of the Queens shows that the region is controlled by one major fracture parallel to the Nile Valley fault zone. The fracture also shows the distinctive scalloped appearance of other parts of the fault zone as it truncates a protrusion of rock that extends into the Nile Valley (figure 3). This particular setting has resulted in the separation of the region of the Valley of the Queens (along with the area of the temple of Hatshepsut) from the regional drainage pattern to the north and west.

This setting is particularly lucky because it will simplify the establishment of a hydrological model for the region. It may also simplify the potential damming of wadis to minimize the amount of water that reaches the vicinity of the tomb of Nefertari from future occasional rainfall. This would have been much more difficult if the area were fed by the regional drainage pattern.

The rock in which the tomb of Nefertari is located is a clayey limestone, with concoidal fracture. It is very fine grained and highly fractured by several joint systems. The extensive fracturing and jointing appears to be due mainly to the fact that the region is part of the Nile Valley fault zone. Most fractures developed at the time of the Nile Valley formation; more recent fractures and joints, however, are present.

The most pronounced joint system is that which parallels the main escarpment of the Nile Valley. The distances between joints are at times only a few centimeters. All the resulting spaces appear to be filled mainly with gypsum, the crystal growths of which are normal to the joint planes. In most cases the joints themselves are a few millimeters wide, but a few can be measured in centimeters.
The second most pronounced set of joints cuts across the latter joint system, forming a rhomboidal, "baklavalike" pattern. The joints of this set are on the average much thinner and are filled with a powderlike layer of salts, most likely gypsum.

The very high density of fractures indicates a porosity that allows rainwater to seep downward through the joints. This in itself is an important factor in the general setting of the tomb of Nefertari. No one is certain about the cause of deterioration of the wall painting. The possibilities include: (a) rainwater from above; (b) groundwater from below; and (c) humidity from the air inside. If the latter is the main cause, this would speak in favor of closing the tomb to visitors because their presence would significantly increase the humidity inside the tomb. From my preliminary observations, however, it appears likely that the largest amount of moisture reaches the tomb as rainwater seeping through the numerous fractures and joints. Nonetheless, the resolution of this very important point must await conclusions drawn from the hydrological model.

The highly fractured nature of the rock that encloses the tomb of Nefertari suggests that microseismicity can be dangerous in the area. Induced shaking by vehicles and large tourist buses, for example, may dislodge loose pieces of the wall. Further damage may be caused by thixotropy (the property of becoming more fluid when shaken), particularly if water becomes mixed with clays and/or other fine particulate material in the fractures and

Figure 5. Floor plan (top) and cross-section (bottom) of the tomb of Nefertari; 10m deep.
joints. Therefore, it is here recommended that the present paved road that leads to the tomb be shortened by at least 200 m and a new parking lot be established away from the tomb entrance.

For the same reason, disposition of water or any other fluids at or near the surface of the tomb should be prohibited. Any fluids at the surface will eventually make their way to the tomb walls through the fractures and joints in the country rock.

Local structures in the escarpment that trends NE-SW and borders the Valley of the Queens on the north side may play a major role in the structural setting, drainage pattern control, and ultimately the channeling of rainwater to the walls of the tomb. These features, including an open fissure and tilted block, are clearly illustrated in figure 4.

The open fissure is a few meters wide, and from it emanate minute drainage lines that lead to the level of the tomb entrances below. One of these lines runs parallel to the edge of the major rockfall, which forms a deltlike pattern that covers part of the scarp. This fissure and associated features should be studied in detail to establish their effects on the porosity of the rocks in the region and on surface and subsurface drawings.

The tilted block bounds the region of the tombs on the south side (figure 4). The considerable degree of tilt indicates a major event that must have affected the microtectonics of the region. Thus, this block should also be studied in detail to establish its effects on the region.

To establish the particular setting of the tomb of Nefertari, two tombs—one on either side—were visited for comparison. It was immediately noticed that both tombs are at higher levels than that of Nefertari and that their wall paintings and plaster layer are not as badly affected by the same processes that have caused deterioration in the tomb of Nefertari.

The shallower tomb is on the right side of Nefertari’s. It is assigned number 68 and belongs to Queen Merit-Amon, who is believed to have been the daughter of Rameses II. On entering this tomb one is struck by the ordered nature of the joint systems in the clayey limestone rock. The rhomboidal fracture pattern is particularly pronounced in the ceilings of the entrance hall and two chambers on either side. The tomb has been inhabited in recent times, and parts of its walls and most of its ceilings are covered by a thick layer of soot from cooking fires. The joints in this tomb are usually thin (a few millimeters wide) and contain gypsum. Tasting of the gypsum filling indicates the lack of rock salt (NaCl). This is true even when the joints are only hair thin.

The tomb to the left of Nefertari’s is deeper than number 68 by a few meters and is similar in its fracture pattern. Its limestone appears to be more clayey, however, and its concoidal fracture is not as obvious as in the shallower tomb. The ceilings in this tomb are comparatively high, which hampers observation of their texture. They appear to be even higher than the ceilings of the tomb of Nefertari.

The joints in the deeper tomb appear to be more closely spaced and contain just as much gypsum as in the shallower tomb. A most interesting observation, established by tasting, is the presence of minute amounts of rock salt mixed in with the gypsum that fills the joints.

Cursory comparison of the three tombs suggests a distinct stratigraphic layering in this
section of the limestone in the Valley of the Queens. It appears that in the uppermost horizon the limestone is denser and the joints are more widely spaced. The deeper the horizon, the more irregular and, in most cases, more closely spaced the jointing pattern becomes.

The most significant change with depth appears to be the increase in the NaCl content in the gypsum filling the joints and fissures in the rock. Preliminary examination of the plaster in these tombs indicates that its deterioration increases with depth; it is least affected in the shallower tomb and most deteriorated in the deepest burial chamber of the Nefertari tomb. This condition strongly suggests a correlation between the presence of rock salt and deterioration of the plaster along the walls of the tomb of Nefertari.

It is perhaps significant to note that there are several degrees of deterioration in the tomb of Nefertari. On entering the tomb one immediately notices the vast network of minute fractures in the ceiling, which is painted blue, a color that is believed to be "synthetic" (Jaksch, et al. 1983). This fracturing is unlike any elsewhere in the tomb and is not duplicated in the ceiling of the lower burial chamber.

The second—and unique—deterioration is that which accompanies the dark green color in the wall paintings. This is most noticeable in the figure of the goddess Hat-hur painted in the stairway that leads from the upper to the lower chamber. This particular deterioration appears to affect a paper-thin layer and may be related to the paint or its binding medium. Therefore, it may be one case in which moisture in the air may be playing a role in deterioration.

The third and most damaging type of deterioration is related to the crystallization of rock salt. This takes several forms. The most common is where salt crystallized along the line that separates the plaster layer from the rock. In most cases this induces buckling of the plaster layer with its paint layer until it cracks and falls off. In some cases this causes a segment of plaster, usually a few centimeters in diameter, to separate from the wall and protrude on a pedestal of rock salt crystals.

A further type of salt crystallization is what appears as pustules on the outer surface of the paint layer. This is particularly visible in the side chamber to the right of the burial chamber. This type may also be related to the humidity inside the tomb. Therefore, examination of the microclimate inside the tomb chambers would be significant in establishing such relationships.

The observations here discussed were made during a few days of site inspection and must not be considered conclusive. These observations, however, point to the need of several courses of study that may shed more light on the geographic and geologic setting of the tomb of Nefertari. A full understanding of this setting is essential to the planning of any consolidation and treatment, temporary as well as permanent, of the wall paintings of the tomb.
References


བོད་ཡིག་ཀྱི་ཆོས་རྣམས།

ལོ་ཐོང་བསྟན་ཟོལ་ནུས་སེམས་ཐི་བོ་ རྗུ་བཞི་རྣམས་ཞེ་ནད་དག་ཆི་བ་ཀྱི་ཤུ་རྒྱས་ི་བཞི་བོད་ཡིག་ཀྱི་ཆོས་རྣམས་བྱ།

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هيئة الآثار المصرية
ومعهد جيتي للصيانة

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