Archaeology

Radar Investigation of Angkor Wat Temple in Cambodia

The Project

Angkor Wat, considered one of the most outstanding religious structures in the world, was built in a relatively short time during the first half of the 12th Century. In 2004, the World Monuments Fund (WMF) hired Atkinson-Noland & Associates as a consultant to assist a team of conservationists and engineers deployed to evaluate the material and structural aspects of one gallery in the immense complex. This gallery consists of bas relief panels covered with a stone roof. The carved stone panels depict the Churning of the Sea of Milk, which produced the elixir of everlasting life.

Project Description

The equipment used for the World Monuments Fund's project at Angkor Wat was a GSSI SIR-3000 with a 1500 MHz antenna and hand cart. GPR was used to identify subsurface features such as cracks, delaminations, voids, and metals, as well as to locate zones of low stone quality and deterioration. Radar was also used to obtain a general idea of the distribution of moisture and/or salts within the stone.

All radar data was gathered as 2D traces along the stone components of the gallery. The radar data taken on several of the stone columns identified metal inclusions (stone ties) within the columns and detected the presence of moisture at the base of one column (Figures 1 and 2).

Figure 1 . GPR scanning at "small" column at east column line. The metal ties are evident at the radar trace (below) as is the signal attenuation near the base of the column.

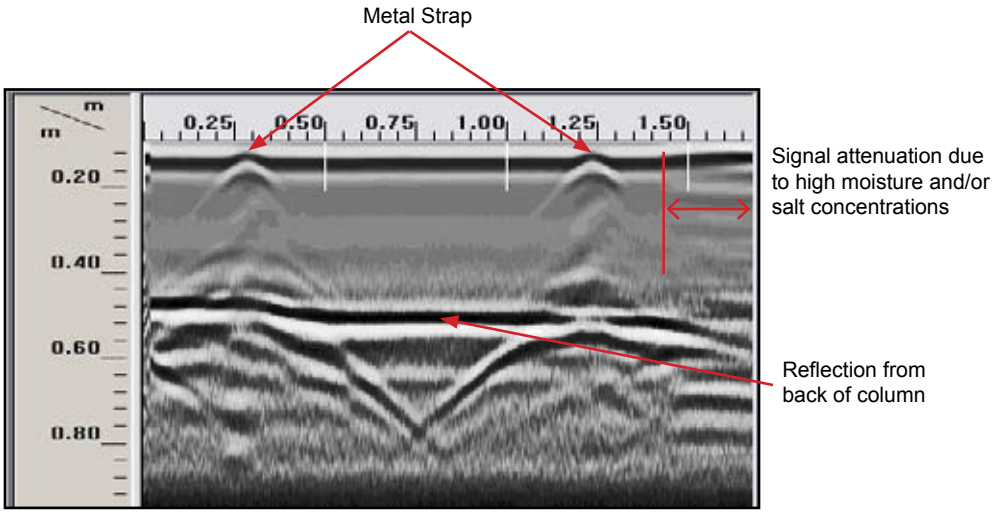

Figure 2. Radar trace from top to bottom of small column, scanning from the north face. Locations of the metal straps show clearly; note also the effect of moisture/salts near the column base.

Courtesy: Atkinson-Noland & Associates
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World Monuments Fund
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Project Description (continued)

Radar traces were also recorded at many of the roof "nagas" (serpents) to identify the depth of patches and locate any subsurface cracking or patch delaminations. Scans were conducted by rolling the radar antenna down over the naga ridge from its apex to the first bed joint (Figure 3). Results of one roof scan are shown in Figure 5 below.

Figure 3. GPR search head was rolled over the ridge of each scanned naga to investigate subsurface conditions.

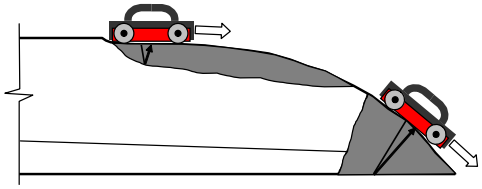

Figure 4. Radar reflections at patches or delaminated roof nagas provide an indication of the depth of the delamination or the patch thickness.

Scans on the bas relief sculpture gallery confirmed the relatively good condition of the stones, outside of localized areas that had salt/moisture damage (Figure 6).

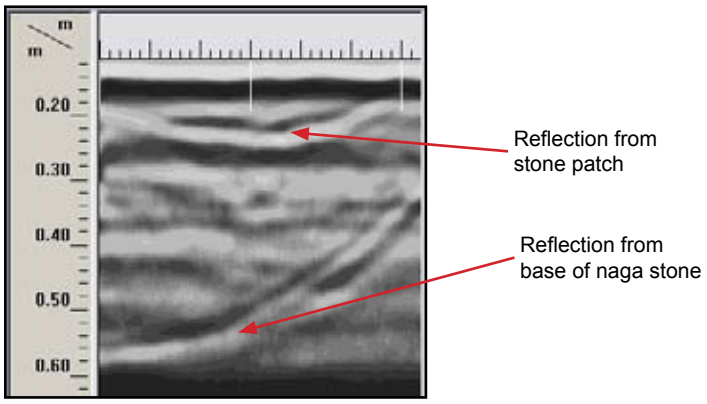

Figure 5. Radar trace at a stone with a patch. Based on the signal interpretation, the patch measures approximately 6 cm in depth and is delaminated from the stone beneath.

Figure 6. Microwave radar scanning on the gallery interior was complicated due to the deep relief of the carvings.

Outcome

GPR provided valuable information on how the Sea of Milk gallery was built. The survey also provided data on the structure's condition and the extent of cementitious patches installed during previous interventions. The radar results were also useful for qualitative evaluation of the stone integrity and detecting the presence of areas of high moisture content.

The nondestructive nature of GPR was particularly suitable for this significantly historic structure because the resulting data is being used by stone specialists to plan for long-term conservation of the sculpture.

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