Terahertz Pulse Investigation of Paleolithic Wall Etchings

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***Abstract*—We examined flow rock-covered Paleoloithic cave art using time-domain terahertz reflectometry.**

I. INTRODUCTION

Terahertz time-domain imaging and spectroscopy has been evolving as an investigative tool in the field of cultural heritage conservation [1]. Our archaeological applications have included the study of corroded metal artifacts, sealed ceramic vessels, mummies, and stratified neolithic wall paintings [2]. We propose to further extend the repertoir of applications to include the imaging of prehistoric cave etchings partially-covered by by natural flow rock.

In 2002, the first evidence of prehistoric cave art in Great Britain was discovered at the Creswell Crags, on the Derbyshire-Nottingham border in England [3]. Much of this art comprised of etchings—i.e., patterns directly engraved into the rock using a sharp implement. Unlike paintings, etchings are difficult to recognize or see without a practiced eye. True prehistoric etchings can be distinguished from contemporary graffiti by the presence of stone patina—a result of prolonged weathering, exposure and precipitation—and Uranium-series dating of flow rock—i.e., calcium precipitate deposits—overlaying the art and Magnesian limestone. The figures are estimated to be approximately 12k-15k years before the present era.

Fig. 1. Photograph of panel of bird etchings in Church Hole cave [3].

We were given access to one such panel in the Church Hole cave at Creswell Crags (fig. 1). The figures are comprised of a series of semi-parallel lines, generally accepted to represent birds of indeterminate type. The lines are v-shaped grooves ranging from hundreds of microns to three millimeters in depth and width.

We used a Picometrix T-Ray 4000 time-domain spectrometer, with the transmitter and receiver antennas in a normal-axis reflection configuration, using a colinear adaptor fitted with a 75 mm focal length lens. The cave wall was raster scanned in twelve 50 mm x 25 mm and five 30 mm x 25 mm sections, in 0.5 mm x 0.5 mm steps, for a total scan area of 150 mm x 125 mm (6 in. x 5 in.).

II. RESULTS

Figure 2 shows the composite of contiguous generated from the minimum peak amplitude signal. The composite in figure 3 was calculated using the phase relative to a foil reference signal at 0.6 THz. The lines from the etching are clearly distinguishable from the other features of the rock. The more rounded, cloud-like shading could be a result of the non-flat surface of the cave due to weathering or flow rock.

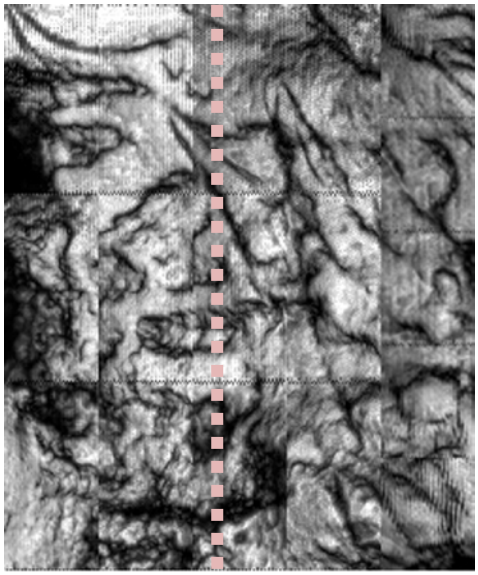

Fig. 2. Composites of the minimum peak amplitude for each scanned sections of the bird etching {dark color = low amplitude, dark color = low amplitude}.

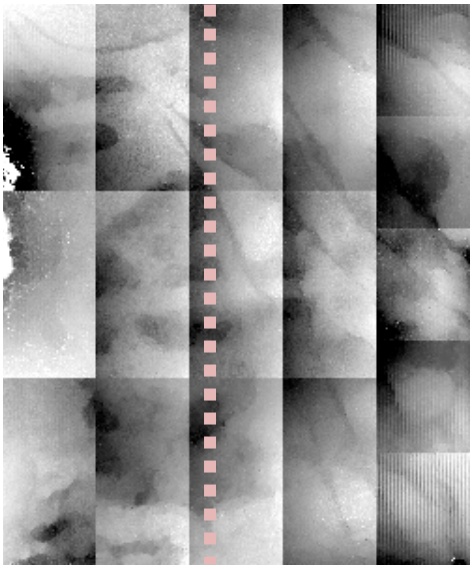

Fig. 3. Composites of the relative phase at 0.6 THz for each scanned sections of the bird etching {dark color = low, light color = high}.

The pink, dotted lines in both figures denote the location of the extracted b-scan cross-section in figure 4. Within the dotted square area, we can see variations in the signal suggesting two separate layers—the limestone sub-surface with the calcite flow rock filling into the grooves. However, it is also possible that the beam spot is covering wall regions in different planes.

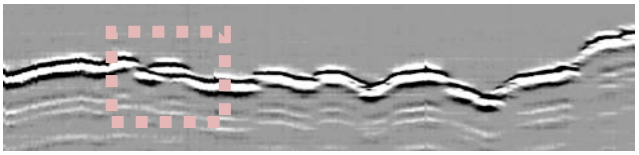

Fig. 4. B-scan cross-section denoted by pink line in figures 2 and 3 {dark color = strong negative peak, light color = strong positive peak}.

III. Summary

We examined Paleolithic rock art using terahertz pulses, which may penetrate through calcite flow rock to detect patterns etched into limestone cave walls. The non-uniform surface—both in flatness and in texture—and the similarity between the wall composition and the flow rock made the results difficult to interpret.

References

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