Shallow GPR and Seismic Surveying in a Carbonate Environment: Belize, Central America

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Outline

• Objectives
• Geographical setting
• Maya culture and history
• GPR survey and theory
• Modeling and survey results
• Comparison between near-surface methods
• Conclusions
Objectives

- Improve quality of the 2-D and 3-D GPR images
- Interpret near-surface structure and stratigraphy
- Highlight possible anomalies or buried features for excavation
- Evaluate the results from the GPR survey and micro-seismic survey
Belize is located in southeastern Central America.

(Reader’s Digest, 1993)
Ma’ax Na is one of 800 Maya sites.

(The Ma’ax Na Archaeology Project, 2001)
Schematic of plaza at Copan and a modern day example at Altun Ha.

(National Geographic, 1989)  
(photo - Rob Stewart)
Buried features may contain Maya artifacts such as pottery and ceremonial vessels.
Acquisition of GPR swath using Noggin system with a 250 MHz antenna
Acquisition layout over the last three field seasons
GPR 3-D

7 x 7 m

Line Interval - 0.50 m
Station interval 0.05 m

X-direction
Y-direction

Forward Reverse Acquisition Set-up
Field Observations

• 2002 observed velocities = 0.072 – 0.106 m/ns (saturated conditions)
  * Depth of penetration = 1.8 m

• 2003 observed velocities = 0.122 - 0.140 m/ns (drought conditions)
  * Depth of penetration = 3.4 m

• 2004 observed velocities = 0.058 - 0.084 m/ns (saturated conditions)
  * Depth of penetration = 1.8 m
  * based on a 50 ns record
Velocity determination from curve fitting using Reflexw
Filtered deconvolved stacks

2003 data
(V = 0.122 m/ns)

2002 data
(V = 0.072 m/ns)

Stretched dataset 2003
\[ V = \frac{c}{(\varepsilon_r)^2} = \frac{0.3}{(\varepsilon_r)^2} \]

Conversely, this may be written as:

\[ \varepsilon_r = \frac{c^2}{V^2} = \frac{0.09}{V^2} \]

Permittivity of humus/soil = 16

Velocity of humus/soil = 0.075 m/ns

Permittivity of limestone = 8

Velocity of limestone = 0.106 m/ns

Permittivity of water = 80
Archaeological pit in Ma’ax Na plaza with Dr. Eleanor King indicating floor level or lot.
Comparison of filtered, deconvolved and migrated stack of 2002 data with synthetic radargram.
Grid in X- direction
Cross-section in Y-direction
Cross-section in X-direction
Amplitude time slices from GPR 3-D volume
2004 GPR data (Line 2) at Maax Na with anomalies highlighted
Ceremonial altar discovered on plaza surface

Wiggle trace display of Line 4 showing structural anomaly in vicinity of altar.
Elevation and coordinate map of plaza based on the Total Station survey.

GLI3D Elevation display of 3C-3D micro-seismic survey
A comparison between near-surface geophysical surveys

Micro-seismic survey

GPR survey
Comparison of the micro-seismic (left) and GPR (right) surveys at depths 0.7 - 1.75 m.
Conclusions

- The GPR method provides coherent and interpretable images of the plaza.
- A number of interesting features have been identified.
- Interpretation should be evaluated using team approach (archaeologist and geoscientist).
- Gain and “programmed” parameters must be monitored during acquisition.
- Potential in combining GPR and seismic surveys to resolve and image deeper into the near-surface.
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