GeoTechnologies making sketches of the past landscapes

Apostolos Sarris

Laboratory for Geophysical – Satellite Remote Sensing & Archaeo-environment
Institute for Mediterranean Studies
Foundation for Research & Technology, Hellas (F.O.R.T.H.)
Geo-Technologies as a means for the Study and Reconstruction of the Archaeo-environment

- Experimentation with new algorithms
- Spatial analyses and new parameters
- Interpretation models

**Reconstruction of the Archaeo-environment**

- **Decoding of the memoirs of Archaeolandscapes**
  [memories of past events, routes, habitation, activities, territories, ancestry, etc]
For the last 20-25 years geophysical techniques have been advanced in terms of

- sensor technology (faster response, higher sensitivity, less power consumption, storage capacity, …)
- mobility of instrumentation (higher portability)
- semiautomatic navigation
- speed of coverage of the sites / fast reconnaissance

Recent emphasis to the multi+ sensor component of research:
- multi-magnetometer systems
- multi-antenna GPR platforms
- multi-electrode soil resistance configurations

BUT we also notice an overwhelming trust on using only one of these methods with emphasis to the quantity of data and coverage area.

“Why is it that you physicists always require so much expensive equipment? Now the Department of Mathematics requires nothing but money for paper, pencils and waste paper baskets and the Department of Philosophy is better still. It doesn’t even ask for waste paper baskets.”

Anonymous University President
(Barrow & Tipler, 1988:185)
THE “MANIFOLD” GEOPHYSICAL UNIVERSE:

In topological terms, a manifold is a topological space that has a local diffeomorphism (differences in distances and angles) with respect to the usual Euclidian space. At a small scale, a manifold bears a resemblance to the actual Euclidean topology, but in terms of a more global scale a manifold can be much more complicated.

It is like we imagine a sphere, each small tangential section of which can be represented in a 2D surface, the mosaic of which can provide a representation of the surface of the sphere.

Manifold geophysics employs a variety or diversity of methods to approach a variety of archaeological questions and topics (Sarris, 2012).

In our case MORE is with respect to the wealth of information.
IGEAN (Innovative Geophysical Approaches for the Study of Early Agricultural Villages of Neolithic Thessaly) project, is implemented under the "ARISTEIA" Action.

A multi-year geophysical and remote sensing project for the study the physical landscape and social dynamics of Neolithic settlements within the coastal hinterlands of eastern Thessaly (Greece).

**AIMS:** Application of non-destructive, remote sensing techniques to explore multiple settlements & extract new archaeological data on an extensive scale, to analyze the broader characteristics of Neolithic habitation in Thessaly.
THE SIGNIFICANCE OF THE AREA NEOLITHIC THESSALY (6800-3200 BC)

**Sesklo**
Early Neolithic (7th millennium BC) - Middle Bronze Age, with its peak in Middle Neolithic (5th millennium BC)

**Dimini**
Late Neolithic period (end of the 5th millennium BC) - Late Bronze Age
Chronology of Research in Neolithic Thessaly

1901-1903: Excavations at Sesklo and Dimini
1908: Excavations at Zerelia

1960-1977: Trial Excavations at several neolithic sites by D.R. Theocharis and Vl. Milojcic
1977-1979: Excavations at Dimini by G. Hourmouziades

1984: Halstead’s catalogue of prehistoric sites in Thessaly, based on a survey made by French

1990-present: Field survey in Almiros plain 13th EPCA & the Netherland Institute at Athens
1990-2005: Rescue excavations (national road, Lake Karla)

Registration and GPS mapping of Neolithic settlements in Thessaly & GIS analyses for:

- the management of the natural landscape &
- site distribution patterns among ecological and topographic zones of Thessaly.

- 342 documented magoulas
- 181 sites (53% of the total) are established on alluvial deposits & 81 sites on fluvial deposit areas.
- These formations are of low altitude & are ideal for cultivation.

http://neolithictessaly.ims.forth.gr/
Satellite Remote Sensing

Color composite RGB → 1,2,3 of Landsat image

PCA product of Hyperion image

Mosaic of IKONOS images.

Mosaic of aerial-photo images.
Microtopography Elevation Model around the “Magoules”
Height of “Magoules”
Cross section of Platia Magoula Zarkou from V. Andel et all.

Combining the alluvial deposits height with the relief height of drill cores

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dy</td>
<td>=deposits height</td>
<td>y= drilcore relief height</td>
<td>dy</td>
<td>=deposits height</td>
<td>y= drilcore relief height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nomi</td>
<td>15</td>
<td>91</td>
<td>Stefanovikeion</td>
<td>60</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palaihorion</td>
<td>13</td>
<td>97</td>
<td>Lofiskos</td>
<td>40</td>
<td>57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ypereia</td>
<td>5</td>
<td>97</td>
<td>Eleutherion</td>
<td>56</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magouritsa</td>
<td>13</td>
<td>110</td>
<td>Falanna</td>
<td>12</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lofos</td>
<td>22</td>
<td>112</td>
<td>Giannouli</td>
<td>19</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krinou</td>
<td>10</td>
<td>155</td>
<td>Dendra</td>
<td>11</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
GIS Analysis

On the reconstructed DEM

Viewshed maps

Persistence in habitation by examining Clustering, Viewsheds & Communication
Moving from the regional scale to the local scale

Area of interest

- Rizomilos 2
- Nikonanou
- Visviki
- Bakalis
- Mati
- Kastro Kokkinas
- Eleutherochori
- Perdika 1
- Perdika 2
- Belitsi
- Karatsagliou
- Almiros 2
- Zerelia
- Karatsantaghi
- Kamara
- Almirotiki

GeoSat ReSeArch
IMS-FORTH
Neolithic Magoula

Manifold Remote Sensing Approach

Soil analysis – mag susceptibility & phosphate

Satellite Remote Sensing

UAV

DEM

Conventional geophysics

Multisensor Geophysical coverage
Methodologies – Multi-magnetometer &
Single sensor magnetometer
Techniques

Sensorik & Systemtechnologie (SENSYS)
MX Compact system

8 multi-channel measurement system
Equipped with FGM600 fluxgate
gradiometers separated by 0.25-0.5m &
connected to a DGPS navigation system

Ideal for large-scale scanning

Bartington single sensor unit also in use in
thick vegetation areas
### Methodologies – Electromagnetic Techniques

<table>
<thead>
<tr>
<th></th>
<th>GEM2</th>
<th>CMD Mini explorer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrical conductivity</strong></td>
<td>HCP 2.5 m</td>
<td>HCP 0.5 m 1 m 2 m</td>
</tr>
<tr>
<td></td>
<td>HCP 1.7 m</td>
<td>VCP 0.3 m 0.7 m 1.3 m</td>
</tr>
<tr>
<td><strong>Magnetic susceptibility</strong></td>
<td>HCP</td>
<td>HCP 0.2 m 0.5 m 1 m</td>
</tr>
<tr>
<td></td>
<td>HCP</td>
<td>VCP 0.3 m 0.7 m 1.3 m</td>
</tr>
</tbody>
</table>

Ideal for large-scale scanning
Methodologies – Ground Penetrating Radar (GPR)

8 channels MALA MIRA GPR, 400 MHz antennas
Sampling 10 cm x 2.5 cm

Penetration Depth ~2.5m

Sensors & Software
Noggin Plus System with 250 MHz antennas
Sampling 50 cm x 2.5 cm

Before and after processing
Methodologies – Soil Resistance Techniques

Geoscan Research RM85 resistance meter

Twin Probe array of electrodes with spacing a=1m

Penetration Depth ~1.5m
Methodologies – Magnetic Susceptibility Measurements

Coring and soil analysis in the Lab.

Bartington MS2B Double Frequency sensor

Low & High Frequency susceptibility & Frequency dependent susceptibility

Phosphate analysis / Petrographic
Quadrocopter DroidWorx CX4

- DJI navigation, viewpoint and failsafe
- Average altitude 100-200 m above surface
- Autonomy ~13-15min with camera load

Methodologies – Aerial Photography

- Canon S100 w/ GPS (or similar)
- Low budget to limit failure costs
- Canon: CHDK hacking system for intervallometer
- Mainly mounted for ortho-view with 2D stabilizing gimbal

Automatic georeferencing with AutoGR-SIFT

Manual Georeferencing

Production of georeferenced DTM (and pointcloud), orthophoto and georeferenced individual frames
<table>
<thead>
<tr>
<th>SITE</th>
<th>COVERAGE (in hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Magnetics</td>
</tr>
<tr>
<td>1. Almiriotiki</td>
<td>8.42</td>
</tr>
<tr>
<td>2. Almiros 2</td>
<td>6.60</td>
</tr>
<tr>
<td>3. Bakalis</td>
<td>0.45</td>
</tr>
<tr>
<td>4. Belitsi</td>
<td>1.32</td>
</tr>
<tr>
<td>5. Eleutherochori</td>
<td>-</td>
</tr>
<tr>
<td>6. Kamara</td>
<td>0.88</td>
</tr>
<tr>
<td>7. Karatsangliou</td>
<td>2.96</td>
</tr>
<tr>
<td>8. Karatsantagli</td>
<td>2.71</td>
</tr>
<tr>
<td>9. Kastro Kokkinas</td>
<td>1.08</td>
</tr>
<tr>
<td>10. Nikonanou</td>
<td>2.91</td>
</tr>
<tr>
<td>11. Mati</td>
<td>3.33</td>
</tr>
<tr>
<td>12. Perdika 1</td>
<td>5.19</td>
</tr>
<tr>
<td>13. Perdika 2</td>
<td>3.90</td>
</tr>
<tr>
<td>14. Rizomilos 2</td>
<td>10.48</td>
</tr>
<tr>
<td>15. Visviki</td>
<td>5.12</td>
</tr>
<tr>
<td>16. Zerelia</td>
<td>4.83</td>
</tr>
<tr>
<td>TOTAL (&lt;5 weeks fieldwork)</td>
<td><strong>60.18</strong></td>
</tr>
</tbody>
</table>
Almiros 2

Early Neolithic – Middle Neolithic
Almiros 2 – Magnetics

Core habitation zone: 15-20 rectilinear structures with high magnetic values (mudbrick?)

At least 2 circular enclosures & multiple possible entrances

A few features outside the core habitation zone

Mudbrick fragments
Magnetic susceptibility indicating different usage areas within the settlement?
Almiros 2 – EM Conductivity (HCP for 0-2.5 m depth)

High conductivity area to the south → possible evidence of flooding susceptibility ??
Rizomilos

Early Neolithic – Late Neolithic Period

GeoSat ReSeArch
IMS-FORTH
Perdika 1

Early Neolithic – Middle Bronze Age
Perdika 1

Magnetics
Perdika 1
Early Neolithic – Middle Bronze Age

- Extensive settlement (>200x100m) that greatly expands beyond a core habitation zone on the highest level

- 50+ rectilinear structures

- The majority of structures have high magnetic values (mudbrick), but others have low magnetic values (stone) with 2-3 rooms (similar to Almiriotiki)

- Ditches and or walls preserved on the northern side of the settlement
Perdika 2  Early Neolithic – Middle Neolithic
Perdika 2

- Extensive network of enclosures built on a natural hilltop
- A sequence of openings that gave access into the settlement
- Little evidence for individual structures (some have high magnetic values)
- Large rectilinear structures with low magnetic value (stone structures?) were identified with GPR
Magoula Almiriotiki

Early Neolithic – Late Bronze Age
Magoula Almiriotiki
Early Neolithic – Late Bronze Age

- Extensive settlement built around a core habitation zone on the highest topographic level

- 60+ rectilinear structures

- Structures on the top have high magnetic values and are probably built in mudbrick

- Structures with low magnetic values have 2-3 rooms

- Large “megaron” structure may be three structures built side-by-side

- Extensive network of ditches (at times double) surround the settlement
Concluding Remarks

Successful Employment of remote sensing techniques – Importance of using an arsenal of various approaches (manifold geophysics)

Conceptualize a landscape of variation: Similar and divergent characteristics of settlements in planning and structural materials
- Dimension of settlements and structures
- Internal organization of the structures, clusters of structures
- open/unbuilt spaces, pits, a.o.
- burnt and unburnt structures / mudbrick & stone structures?
- Corridors and entrances
- Existence of enclosures (ditches/fortifications)

Existence of ditches in terms to the surrounding geomorphologic features (e.g. proximity to palaeochannels).

Implications regarding the sustainable population, the study the spatial context and organization – intra site, local and regional level, the chronological continuation of habitation, persistency in occupation, etc.
Geotechnologies making sketches of the past landscapes

Apostolos Sarris

Laboratory for Geophysical – Satellite Remote Sensing & Archaeo-environment
Institute for Mediterranean Studies
Foundation for Research & Technology, Hellas (F.O.R.T.H.)