Habitation Patterns of the Neolithic Agricultural Villages in Eastern Thessaly (Greece) Through Remote Sensing Applications


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13th Ephorate of Prehistoric and Classical Antiquities - Hellenic Ministry of Culture and Sports
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 Gallis’ catalogue of sites in E. Thessaly.

1990-present: Field survey in Almiros plain 13th EPCA & the Netherland Institute at Athens

1990-2005: Rescue excavations (national road, Lake Karla)

Registration and 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/
This paper presents the preliminary results of a multi-year geophysical and remote sensing fieldwork campaign to study the physical landscape and social dynamics of Neolithic settlements within the coastal hinterlands of eastern Thessaly (Greece).

IGEAN (Innovative Geophysical Approaches for the Study of Early Agricultural Villages of Neolithic Thessaly) project, is implemented under the "ARISTEIA" Action of the "Operational Programme Education And Lifelong Learning" and is co-funded by the European Social Fund (ESF) and National Resources (2013-2015).

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 project has been successful in documenting the diachronic development of Neolithic sites from core habitation mounds (≤ 1 hectare) to large, sprawling communities several hectares in size.
Methodologies – Multi-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

GEM2 - Geophex

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

Depth of investigation

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

8 channels MALA MIRA GPR, 400 MHz antennas
Sampling 10 x 2.5 cm
Penetration Depth ~2.5m

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

Before and after processing
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
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

4-500m

200m (good overlapping)
<table>
<thead>
<tr>
<th>SITE</th>
<th>COVERAGE (in hectares)</th>
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<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 – Magnetics

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

At least 2 circular ditches & 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 Susceptibility (HCP for 0-1.7 m depth)
Almiros 2 – EM Conductivity (HCP for 0-2.5 m depth)

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

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

marsh area
Magoula Almiriotiki – GPR (depth 0.7-0.8 m)
Magoula Almiriotiki – Details of Structures

- Low magnetic value probably indicates that the structure(s) has stone foundations

- Rectilinear form 38 m by 10 m.

- In GPR, the structure appears to be formed from three separate structures built side by side.

- Internal wall divisions are present
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
Perdika 1

Early Neolithic – Middle Bronze Age
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

- Extensive network of ditches 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.
Concluding Remarks

Successful Employment of Geophysical and Satellite 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.
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