NEOLITHIC DITCHES IN THESALLY

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Water resources have played a critical parameter in human occupation and the location of the settlements since the prehistoric times.

Many settlements, especially in prehistoric periods have been located either along the course of main streams or in a close vicinity to them, exploiting the water resources for their immediate needs and for cultivation purposes.

At the same time this proximity to water resources has often endangered the habitation quarters and even the whole settlement.

The floodplains of major rivers are dynamic environments and their past study poses particular difficulties.
Fluvial activities influence archaeology in two ways.

First, the choice of locations for settlements was part of a cultural formation process predetermined to some extent by the population's understanding or appreciation of local stream activity.

Second, cultural remains and site preservation and ultimately their discovery and recognition may have been affected with stream flow and flooding.

The main aims of the study are to develop new methods of investigation and to reconstruct the environmental and settlement history.
Exploration Techniques and Methodological Approaches

Employment of a variety of methods: Field walking, geophysical prospection, examination of sections exposed in field ditches, and coring for soil and sediment samples.

These methods are complemented by a range of remote sensing techniques: analyses of satellite and aerial photographs and Digital Elevation Models (DEMs).

Reconstructed (from coring) Digital Elevation Models (DEMs) regarding the period, were considered in this study.

Reconstruction of the Künzing-Unternberg rondel, Museum Quintana, Lower Bavaria

Neolithic habitation in Europe
Ground zero

- Spread of farming communities into Central Europe (c. 5800–5400 B.C.)
- Spread of farming to Old Europe (c. 6200–6000 B.C.)
- Spread of farming (c. 7000 B.C.)
Case study: Thessaly

Neolithic settlements, so called Magoules, were constructed between the Early Neolithic and Bronze Age (6800-3000 BC). ~350 Thessalian tells (magoulas) have been documented in alluvial plains of Trikala and Larissa.

Recorded rate of subsidence of 1.5 m/1000 years for the Larisa basin, is important to study flooding susceptibility.
NEOLITHIC TELLS

Magoules: small hills, within the plain, with a relatively few meters height.
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://neolithichessaly.ims.forth.gr/
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).

Application of non-destructive, remote sensing techniques to explore multiple settlements & 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.
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 – Ground Penetrating Radar (GPR) & Electromagnetic Techniques

Penetration Depth ~2.5m

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

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

GEM2 - Geophex
CMD Mini explorer – GF Instruments

GEM2: HCP 2.5 m Conductivity / 1.7 m susceptibility

CMD: HCP 2 m Conductivity / 1 m susceptibility
Methodologies – Magnetic Susceptibility Measurements_ Soilscape

- Coring and soil analysis
- Bartington MS2B
- Low & High Frequency susceptibility & Phosphate analysis

Methodologies – Aerial Photography

Quadrocopter DroidWorx CX4

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

- Automatic georeferencing with AutoGR-SIFT
- Manual Georeferencing
- 200m (good overlapping)
- Production of georeferenced DTM (and pointcloud), orthophoto and georeferenced individual frames
Almiros 2

Early Neolithic – Middle Neolithic

GeoSat ReSeArch
IMS-FORTH
Almiros 2 – Magnetics

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

2 large circular ditches & multiple possible entrances

Mudbricks fragments

GeoSat ReSeArch
IMS-FORTH
Almiros 2 – EM Conductivity (HCP for 0-2.5 m depth)

High conductivity area to the south → possible evidence of flooding susceptibility ??
Multiple concentric ditches with various breaks that represent entrances.

Another smaller satellite or older settlement to the east
A 1.5m flooding simulation could have reached the outer ditch of the main magoula. Oral testimonies of the villagers mention that the area was repeatedly flooded in historical period, due to the vicinity of the magoula to the Lake Karla.
Magoula Almiriotiki - Magnetics

- Core habitation zone on the highest topographic level
- 60+ rectilinear structures (mudbrick and stone structures)
- Extensive network of ditches
Magoula Nikonanou – Magnetics & EM

Magoula Velestino 4 – Visviki - DEM
A low cost approach to assess flood vulnerability using ASTER DEM.

**DEM Derivatives**
- Amplitude relief (Ar)
- Slope gradient (Sg)
- Terrain wetness index
- Drainage density
- Stream frequency
- Multi-resolution index of valley bottom flatness
- Flow accumulation

**ASTER DEM (30 x 30m)**

**Hydrologic data**

**CORINE Land use**

**Extraction of Manning’s coefficients**
(flow calculation)

**Flooding zones**

**Flood susceptibility**

**Flood prone areas**

- Low slope
- High TWI for high moisture
- Low Ar for subsidence

**Flood model simulation**
Geomorphometric information using ASTER DEM

The *Topographic Wetness Index (TWI)*, determines the spatial distribution of soil moisture and surface saturation. V-shaped valleys (tectonic active) vs U-shaped valleys (erosional dominated).

- **Region A**: high values of TWI (flat surface with high moisture accumulation and alluvial deposits).
- **Region B**: high values (but lower that region A due to lower stream ordering and water discharge).
- **Region C**: intermediate to low values, revealing steep slopes, major longitudinal ridges and V-shaped valleys.

*Slope gradient (Sg)*, shows maximum slope steepness i.e. the change in elevation between each cell and its neighbors.

- **Region A**: flat regions
- **Region B**: foot slopes
- **Region C**: undulating terrain & intermittent valley zones; rolling plains
- **Region D**: escarpments & dissected ridges.
Predictive floodplains

Based on selected threshold values in order to isolate the information of the DEM derivatives being relevant to flood impact, the final prone floodplains were determined.

Weighted overlay approach & Analytical Hierarchy Process (AHP) were employed for the definition of the weights.
Flooding zones

- The reconstructed ASTER DEM was used to “flood” the region.

- Flooding zones of 1m & 3m were created and most of the magoules remain flooded.

- Based on the geophysical prospecting, a significant number (if not all) of Magoules characterized by ditches were found within those flooding zones.
Concluding Remarks

- Conceptualize a landscape of variation: Similar and divergent characteristics of settlements in planning and in structural materials
  - Internal organization of the structures, clusters of structures
  - Corridors and entrances
  - Existence of enclosures (ditches/fortifications)

In areas where frequent or periodic flooding could have been anticipated, it is possible that Neolithic people might have applied variable criteria in choosing sites for temporary or for long-term occupations – almost always in close proximity to palaeochannels.

Manifold geophysical prospection approaches indicate a persistence of habitation even in flood prone areas and the existence of multiple enclosures and ditches around these settlements may suggest counter measures against periodic flooding events.
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