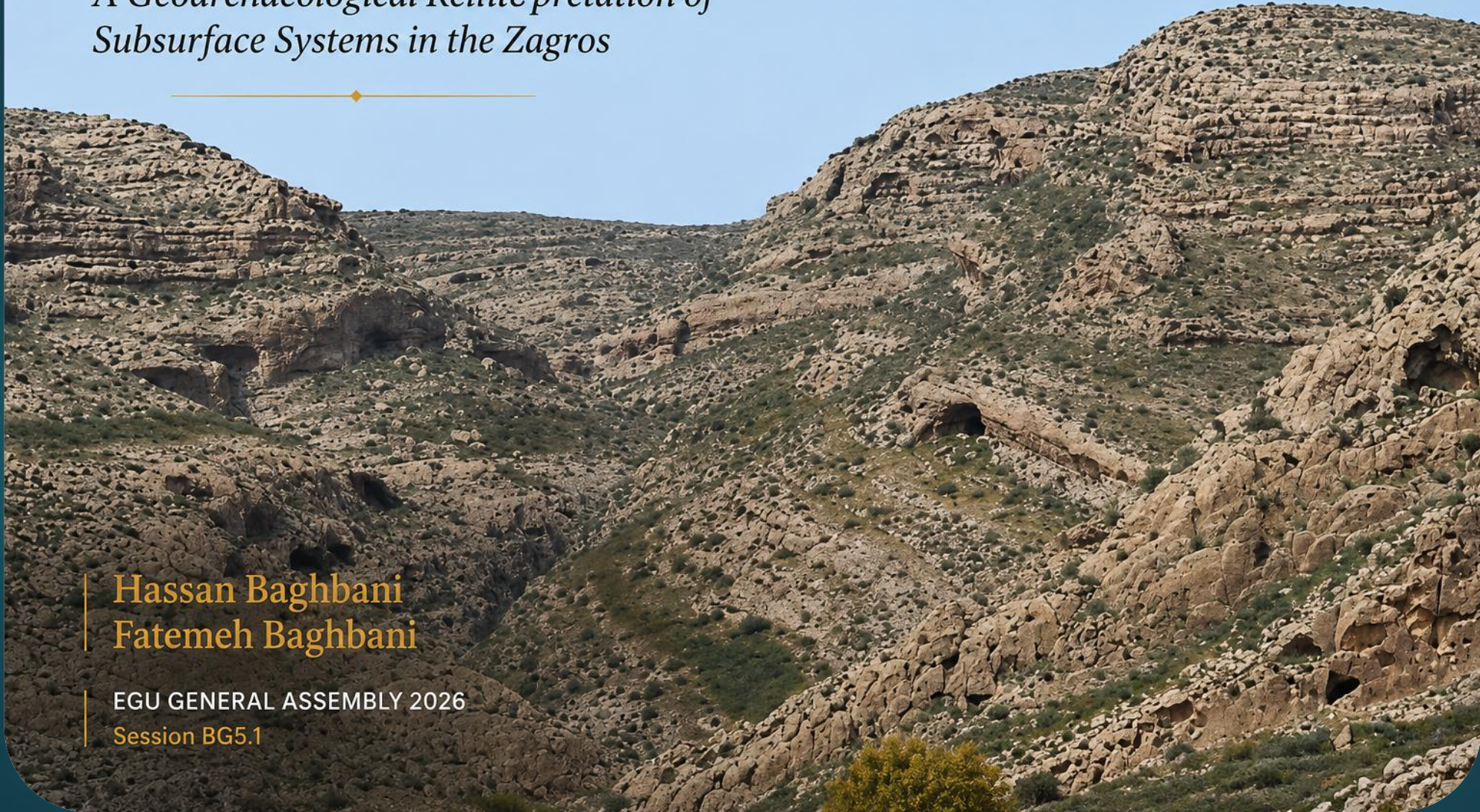


# From Cave to Civilization

*A Geoarchaeological Reintepretation of  
Subsurface Systems in the Zagros*



Hassan Baghbani  
Fatemeh Baghbani

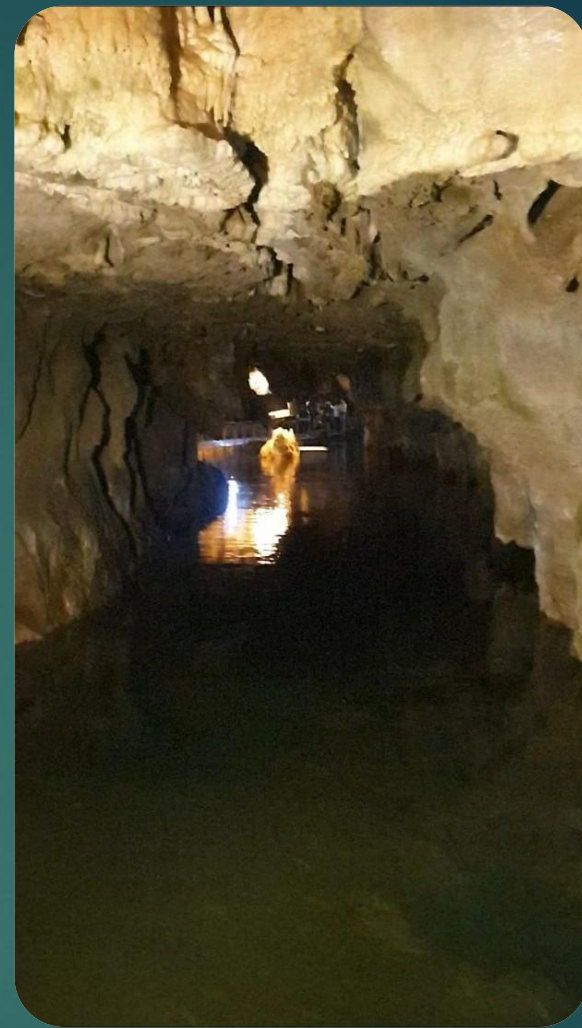
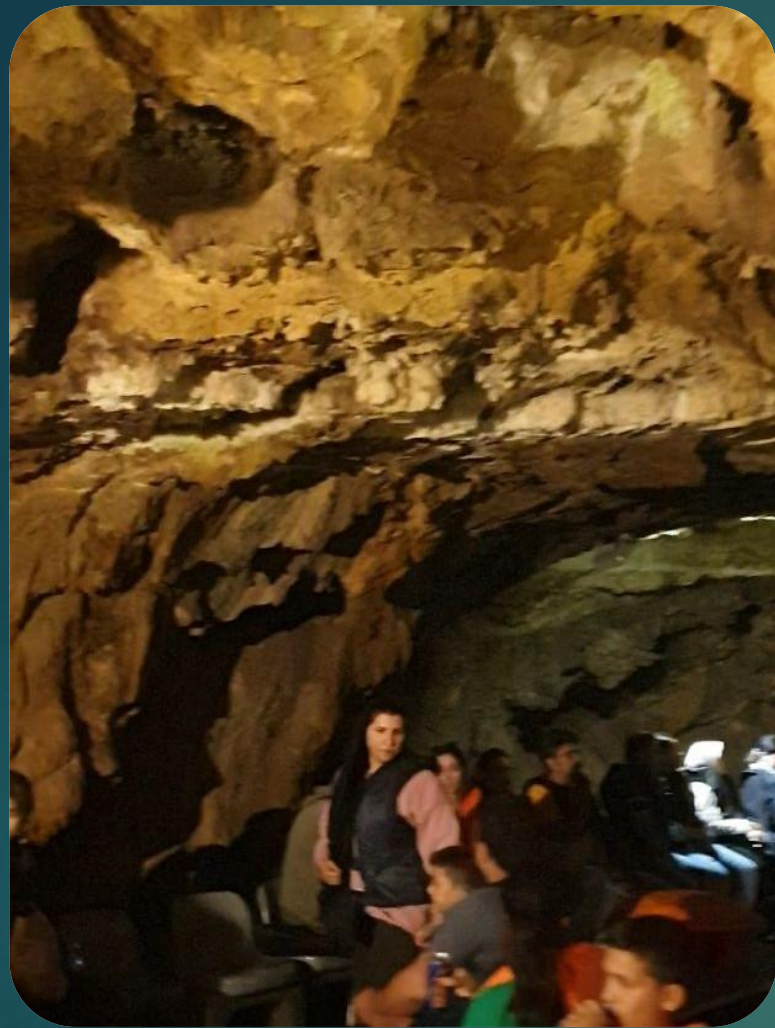
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**This document presents a geoarchaeological re evaluation of underground spaces in the Zagros Mountains. Rather than examining caves as isolated geological phenomena, the study explores their relationship with landscape-scale systems including terraces, watershed engineering, soil formation, infiltration processes, springs, qanats, and human settlements. Field observations, satellite imagery, and comparative analysis of Ali Sadr Cave, Sangtarashan, underground settlements, and terrace systems suggest that underground spaces may represent components of a broader environmental engineering tradition operating across the Zagros landscape.**



**RESEARCH QUESTION** Underground spaces in the Zagros are generally interpreted through a binary framework: • Natural caves • Human-made underground structures However, several sites challenge this distinction. Should underground spaces be studied individually, or as components of larger landscape systems?



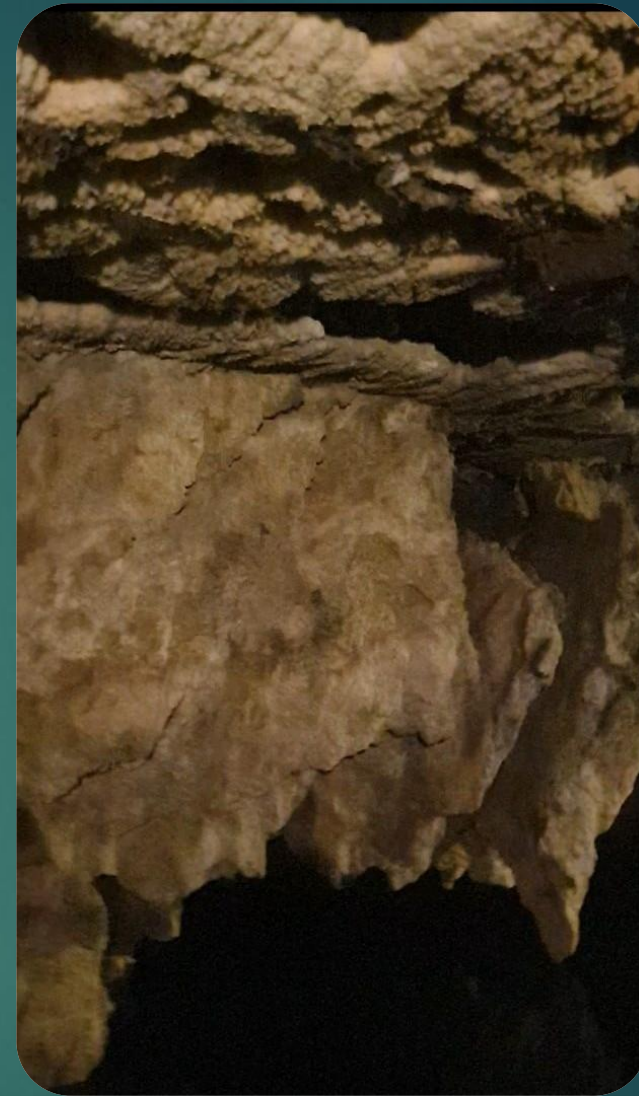
**ALI SADR: THE PARADOX** : Ali Sadr is commonly described as a karstic water cave. Yet several observations raise important questions:

- Long navigable corridors
- Repeated spatial geometry
- Stable water surfaces
- Large connected chambers
- Extensive internal continuity

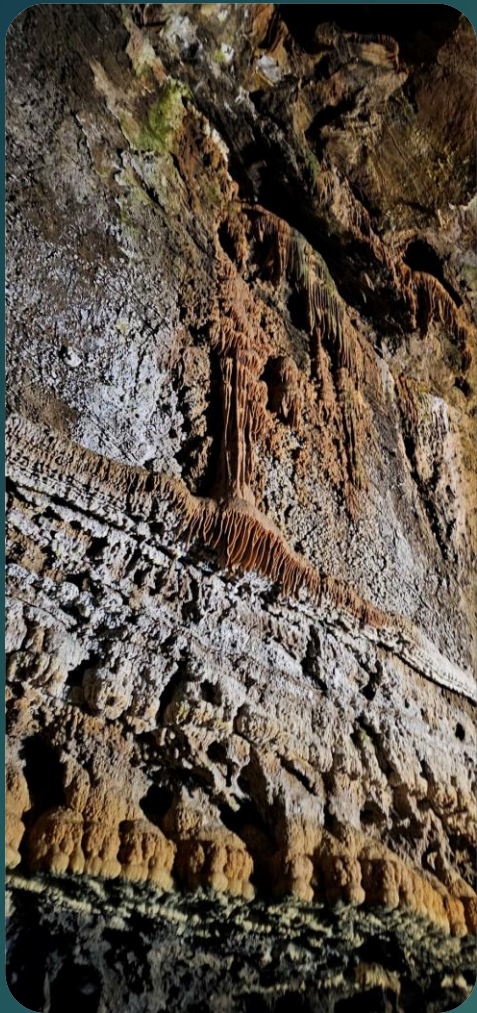
**These characteristics invite further investigation into its developmental history.**



**MORPHOLOGICAL OBSERVATIONS** Field observations reveal: • Corridor-like spaces • Repeated spatial rhythm • Connected chambers • Structural continuity  
The organization of space appears systematic over large distances.



**STRUCTURAL CONTROLS** Structural weaknesses clearly influence cavity development: • Fractures • Joints • Bedding planes • Rock discontinuities These structures may guide excavation, collapse, or subsequent modification processes.



**SECONDARY MINERALIZATION** Secondary cave deposits often form after cavity creation. The occurrence of ceramic material enclosed within calcite deposits indicates that mineral growth post-dates at least part of the cavity history. This raises important questions regarding chronological relationships between cavity formation and speleothem development.



**SANGTARASHAN ] Sangtarashan provides an important reference case. Unlike Ali Sadr, its anthropogenic origin is widely recognized. Large underground chambers, corridors, pillars, and excavated spaces remain clearly visible.**



**INTERNAL GEOMETRY OF SANGTARASHAN** The site demonstrates: • Pillar-supported chambers • Excavated corridors • Organized spatial layout • Repeated architectural patterns These features provide a comparative framework for examining other underground spaces.



**SURFACE EXPRESSION** The underground complex extends beyond the visible entrances. Multiple openings, excavated faces, and modified rock surfaces appear throughout the landscape.

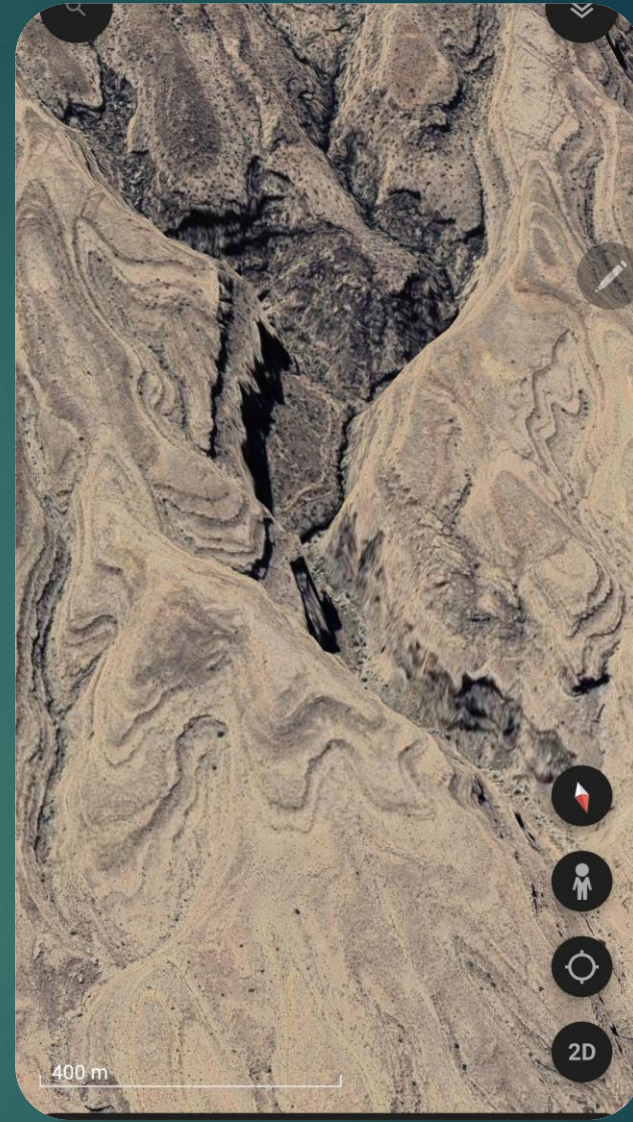
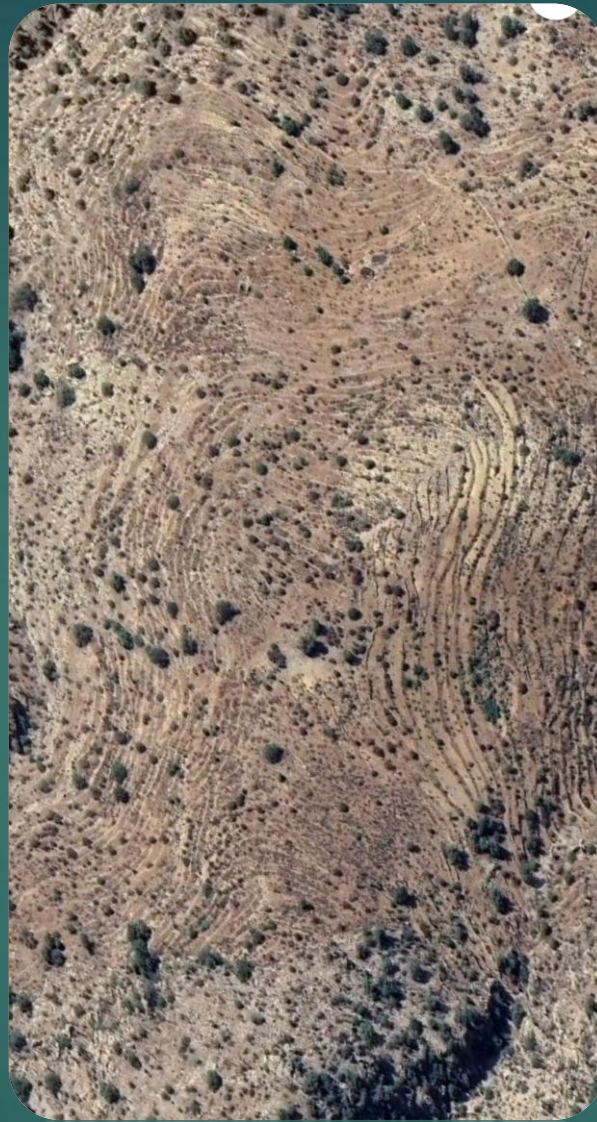
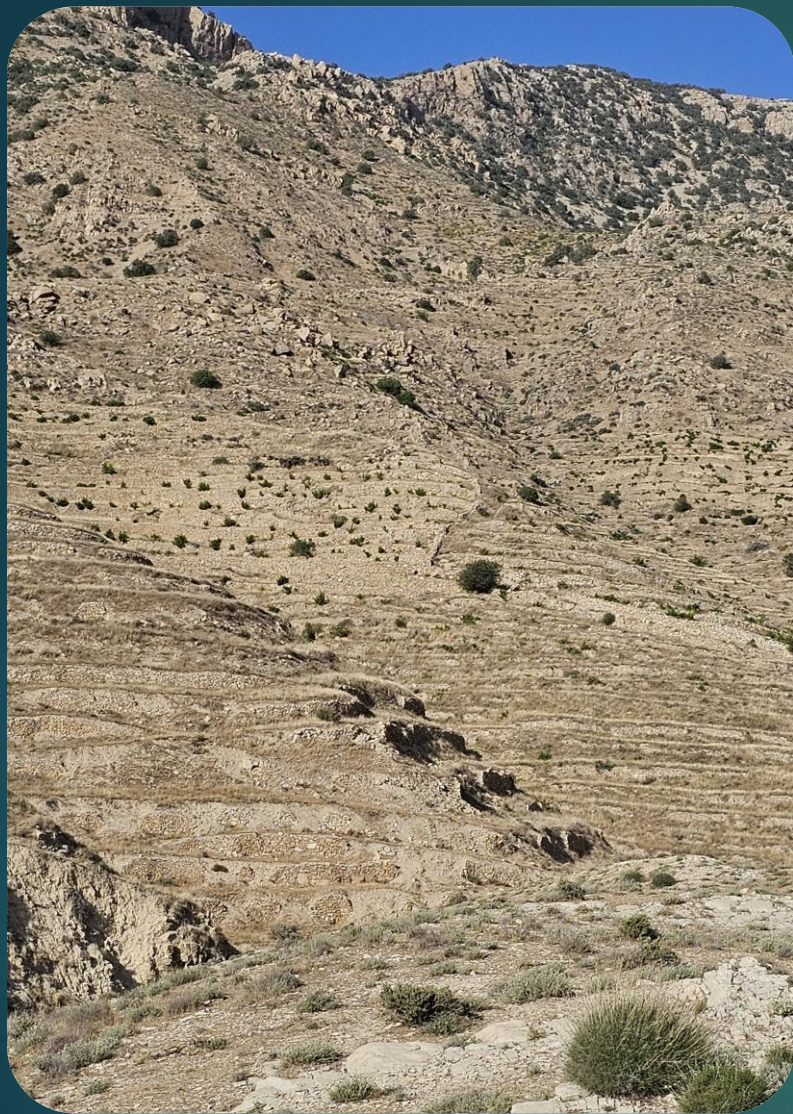


**UNDERGROUND SETTLEMENTS** Across Iran, numerous underground settlements and rock-cut complexes have been documented. These sites demonstrate that large-scale subsurface excavation formed part of a long standing regional tradition.

## COMPARATIVE ANALYSIS

The recurrence of similar characteristics suggests that multiple formation pathways may coexist.

Feature	Ali Sadr	Sangtara shan	Undergro und Cities
Corridors	✓	✓	✓
Chamber s	✓	✓	✓
Openings	✓	✓	✓
Spatial Organizat ion	✓	✓	✓



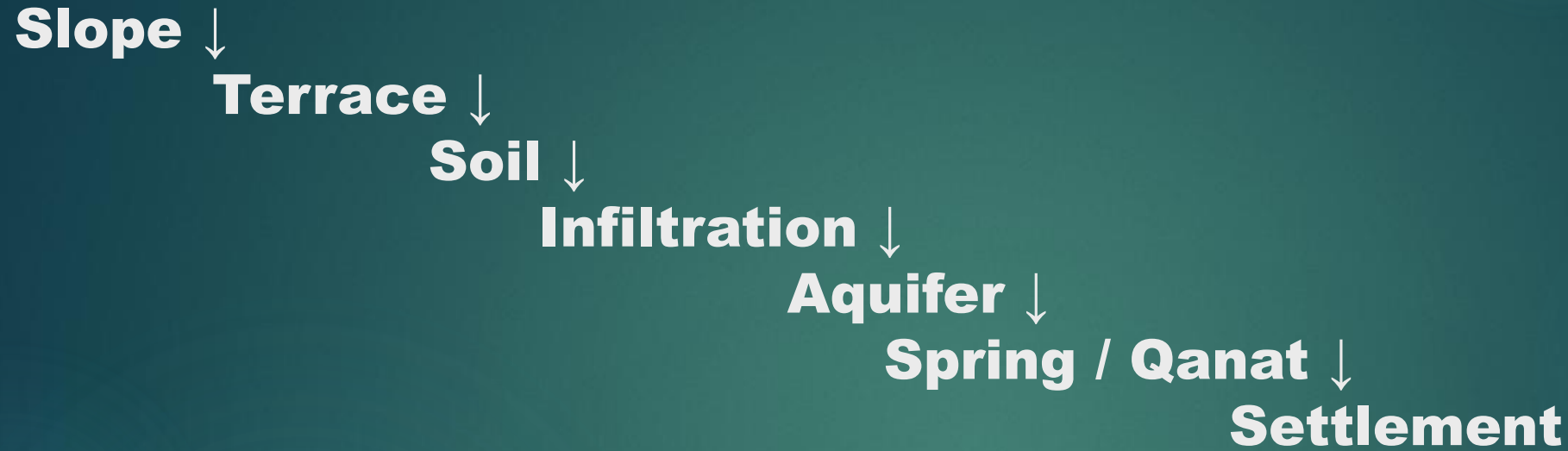
**LANDSCAPE EVIDENCE** Evidence extends beyond underground spaces. Large-scale contour-following patterns appear throughout the Zagros landscape. These features frequently occur across entire hillslopes and watersheds.



## **TERRACE SYSTEMS Terraces exhibit:**

- **Contour alignment**
  - **Repeated geometry**
  - **Watershed-scale distribution**
  - **Long-term persistence**
- Their distribution suggests systematic landscape modification.**

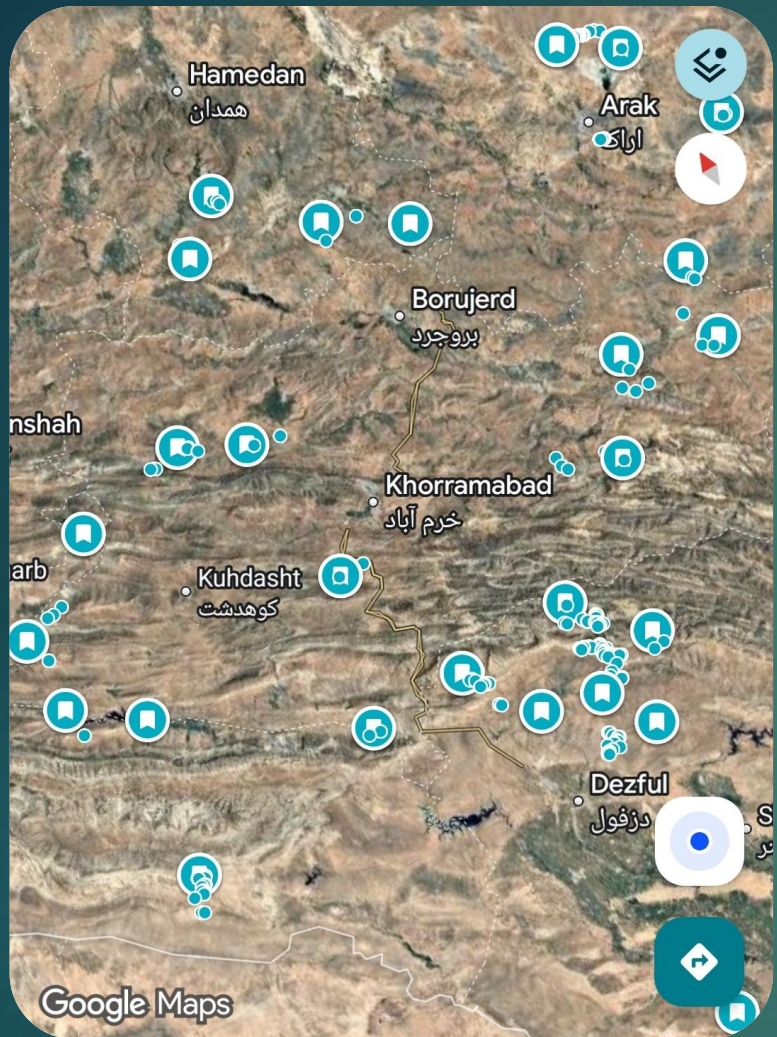
# WATERSHED ENGINEERING MODEL



**This sequence represents the central environmental model explored in this study.**



**SURFACE–SUBSURFACE RELATIONSHIP** Rather than isolated features, terraces, springs, underground spaces, and settlements may represent interconnected components of a single environmental system.




**REGIONAL CONTEXT** Ali Sadr is not unique. Numerous underground spaces occur throughout the Zagros region including:

- Samen
- Kord Olya
- Arzan-Food
- Saleh Abad
- Sangtarashan



**WORKING HYPOTHESIS** The evidence presented here supports a working hypothesis: Underground spaces may constitute components of broader mountain-scale environmental engineering systems that integrated water management, soil conservation, and human settlement.



**DISCUSSION** This interpretation does not seek to replace geological explanations. Instead, it proposes that underground spaces should be investigated within a broader geoarchaeological framework combining: • Geology • Archaeology • Hydrology • Landscape analysis • Remote sensing

**FINAL STATEMENT** The evidence presented throughout this study reveals recurring associations between underground spaces, terrace systems, watershed modification, and landscape organization across the Zagros Mountains. Viewed separately, caves, terraces, springs, qanats, and settlements appear as independent features. Viewed together, they form components of a coherent spatial system extending from mountain slopes to human occupation. If future multidisciplinary investigations confirm these patterns, the implications would extend beyond the interpretation of individual caves. They would require a fundamental re-evaluation of the relationship between humans, landscapes, and underground spaces throughout the Zagros region. The Zagros emerges not simply as a natural mountain range occupied by ancient societies, but as a landscape whose visible and invisible structures may preserve the legacy of one of the largest long-term environmental engineering systems in human history.