The southernmost authigenic karst plateau of the Levant

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Abstract

Karst plateaus with closed depressions, subterranean drainage, vadose shafts and other karst features are common in the north- and north-east Mediterranean regions, but absent in the desert belt of the south Mediterranean. The Ofra karst basin, located in the central ridge of Israel, is the southernmost karst plateau in the Levant. Tens of caves, dolines and karren fields stand in sharp contrast with the nearby Judean Desert. Developed in a plateau of Cenomanian dolomitic limestone, most caves are active vadose shaft systems, up to 93 m deep. Some cut into ancient phreatic systems with 3D development. Water flows in the caves during winter storms. Laminar sub-critical film flow of vadose water is dominant along shaft walls, developing from the epikarst downward. Concentrated flow occurs locally draining small catchments of terra-rossa soil covered karst surfaces. Remains of unroofed shafts indicate karstification over long periods of time. The occurrence of this well-developed authigenic karst close to the desert border suggests using similar relict and paleokarst plateaus as paleoclimatic indicators for delineating the extent of humid conditions in the past.

Keywords: vadose caves, Mediterranean karst, climate constraint, vadose shaft

1. Introduction

One of the most intriguing questions in karst geomorphology is the variation with climate. Climate (particularly precipitation) impact on denudation rates is generally well established, but karst landform variation with climate is complicated due to other effects, such as geology, which obscure the climatic effects (Frumkin 2013a). Daoxian (2013) suggested to overcome this problem, defining each environmental setting by its typical group of landforms, and introducing the karst feature complex concept. He defined this concept as a group of karst features, including surface forms and subsurface forms, as well as dissolutional forms and depositional forms, all of which developed under a similar environmental background. In this way he avoids the confusion of isomorphism (similar features that may result from different processes). By introducing geological modifications into the general concept, the group of features defining a climatic regime is robust enough also to overcome geologic variation.

The East Mediterranean karst plateaus includes features such as dolines and karren fields on the surface, and well-developed vadose caves with shafts and sub-horizontal vadose canyons in the sub-surface. Here we attempt to define the driest conditions which would still support such a karst plateau to develop. For this we discuss the southernmost well-developed authigenic karst plateau of the Levant at Ofra, Israel (Frumkin, 1993).

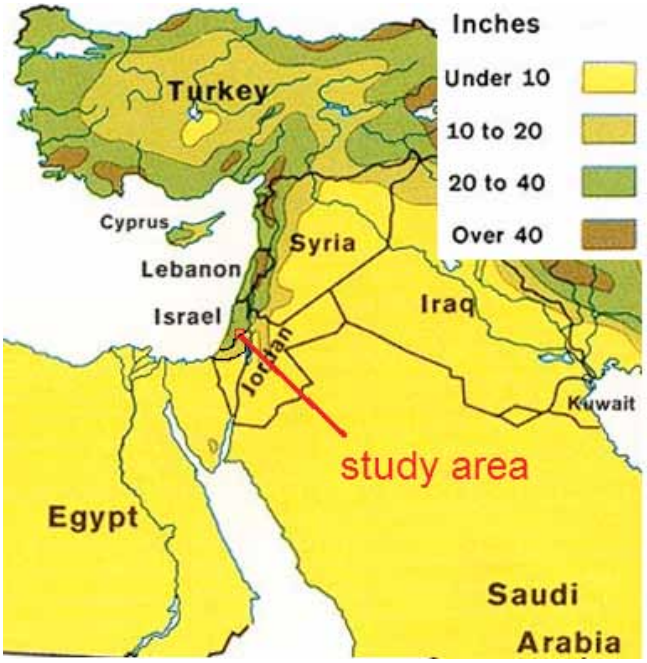


Figure 1. Study area on a precipitation map (inches) of the east Mediterranean region.

2. Environmental conditions

The humid northern fringe of the East Mediterranean basin demonstrates well-developed karst plateaus, while the southern East Mediterranean lacks such features, due to the arid climate of the Sahara desert belt. The transition between these climatic regimes occurs in the southern Levant, and is well represented in Ofra. Twenty km to the south of Ofra the climate still sustained karstification during the Holocene, (Frumkin et al. 2000; Frumkin 2013b), but the surface karst morphology is less developed, with hardly any dolines. Within a few km to the SE the semi-arid belt has only slightly active karst features, followed by the desert belt with hardly any active karstification of carbonate rocks during the dry Holocene (Lisker et al. 2010; Vaks et al. 2003, 2006).

The Ofra karst plateau is located on the backbone of the central mountain range of Israel, 20 km north of Jerusalem (Fig. 1). Annual mean precipitation is 500 mm (measured locally from 2000 to 2016), concentrated mainly in the winter, as rainfall and rare snowfall. Bedrock is Cenomanian dolomitic limestone of the 160 m thick Amminadav Formation. The carbonate rock is massive at the upper part of the formation, becoming well-bedded to laminar at the lower part. The overlying and underlying formations are rich in chalk and marls, without karst features.

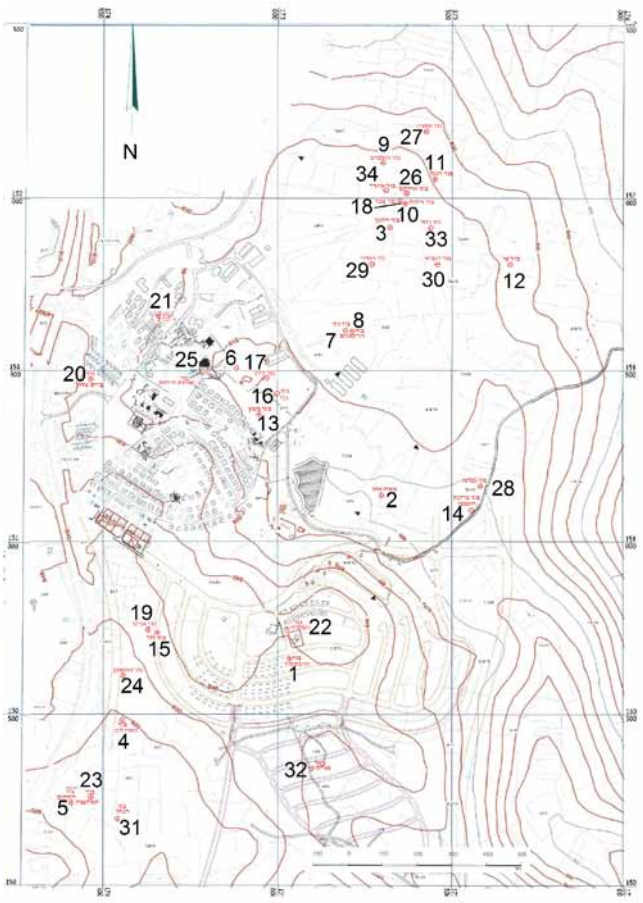


Figure 2. Distribution of caves (numbered) on a topographic map of Ofra karst. Coordinates are given in Israel Grid and contours are in m.

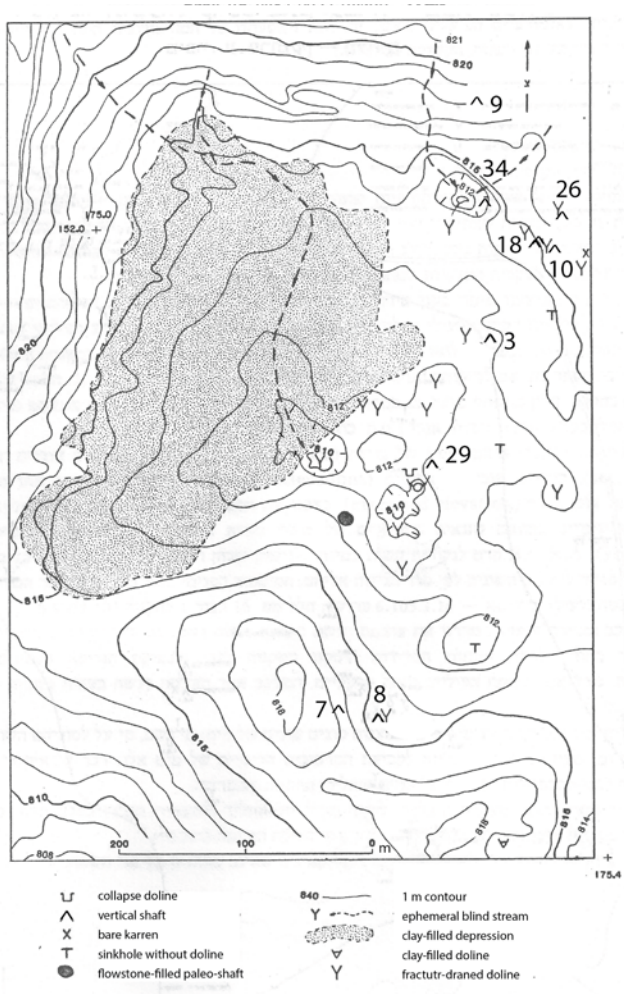


Figure 3. Karst features in the northern part of Ofra plateau.

3. The karst system

The studied part of the Ofra karst plateau is 2.3X1.1 km large (Fig. 2), within a larger karst basin whose area is 5 km^2. (Frumkin 1993). It demonstrates the entire set of features of active epigenetic karstification, including dolines, karren fields, sinking streams, as well as vadose caves with vertical shafts and short sub-horizontal passages (Fig. 3). The deeper dolines are associated with collapse or subsidence of epikarstic decomposed bedrock above vadose shafts (Fig. 4).

This karst plateau is active during the presently dry Holocene, as indicated by aggressive water with increasing solutes along the flow route.

Thirty four vadose caves are known (Figures 2, 5). They consist typically of series of vertical shafts with short sub-horizontal, canyon-like sections (Fig. 6), reaching maximal depth of 93 m. The caves include active dissolutional features, such as scallops, as well as speleothems, indicating various types of water and changes in aggressness. In one case (cave 26) the vadose cave clearly dissects a maze cave, probably of hypogenic origin. Other cases of ancient phreatic or hypogenic cavities are less distinctive.

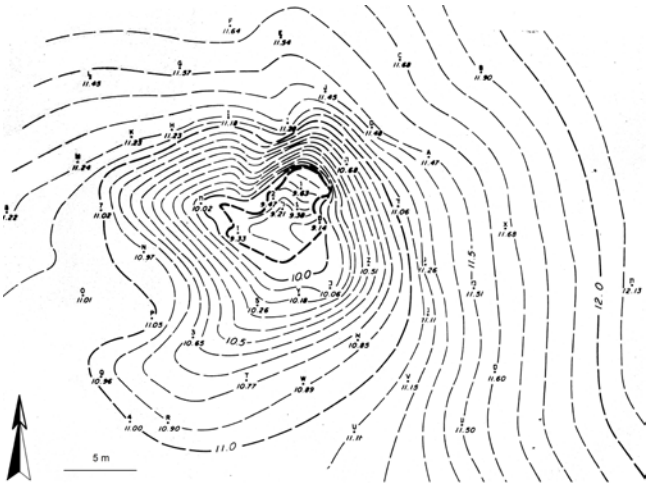


Figure 4. Relief of a sample doline (over cave 29) formed by epikarst subsidence into a vadose shaft. Contour interval is 10 cm.

4. Conclusion

The studied southernmost authigenic karst plateau of the Levant demonstrates a karst feature complex which is basically similar to other Mediterranean karst plateaus. The local environment indicates that such karst plateaus can develop under relatively dry conditions of winter rainfall amounting to 500 mm per year.

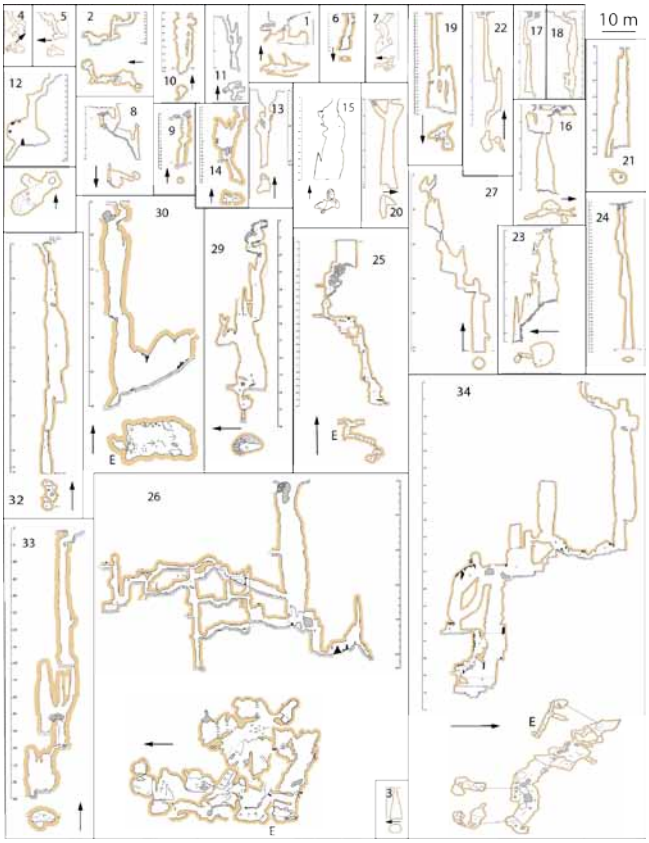


Figure 5. Profiles and horizontal sections of caves at Ofra karst plateau.

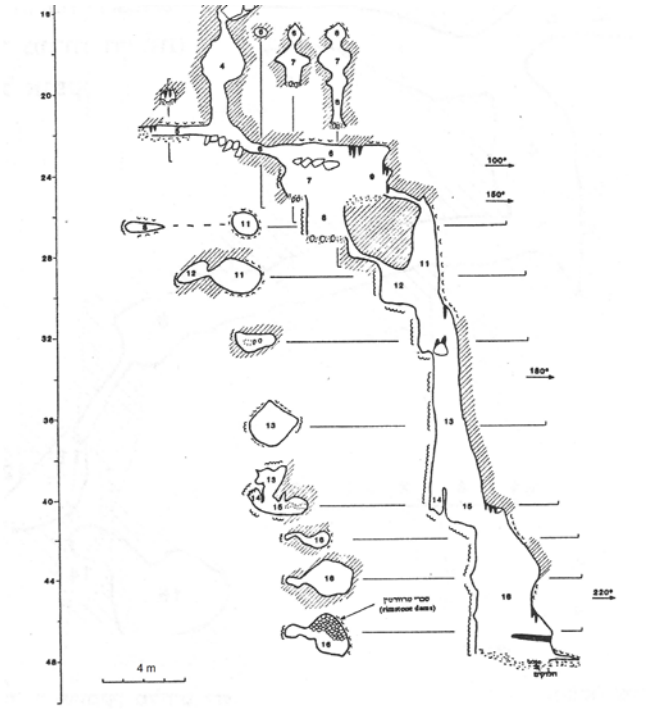


Figure 6. Enlarged profile and horizontal sections showing detailed morphology of cave 25.

Table 1.

Num	Cave name	Depth [m]	Length [m]
1	Haftaot	7	21
2	Achu	9.5	26
3	Katan	9	8
4	Sandalim	~7.5	??
5	Satum	8	15
6	Caravilla	11	11
7	Nir	12.5	28.5
8	Rimonim	15	30
9	Shfanim	16	16
10	Zikit	17	22
11	Naal	18	19
12	Shay	20	26
13	Beton	21	21
14	Brechot Chimtzun	22	23
15	David	24	34
16	Gabi	25	31
17	Biuv	25	27
18	Tzemed	25.3	33
19	Arcko	30	32
20	Beit Sefer Sadeh	26	28
21	Kalab	32	34
22	Shluha	33	36
23	Machtzeva	33	61
24	Meuban	43	43
25	Morot Hayalot	48	76
26	Achikam	50	457
27	Ofra	51	65
28	Nof Amona	~53	??
29	Sinee	59	68
30	Navie	60	104
31	Nachal	~60	??
32	Arieh	66	80
33	Rachel	79	108
34	Uzrar	93	250

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Back Cover : The Khan and Beagum in Kubla Khan Cave Tasmania (Photo by Garry K. Smith)