

Chapter 2

ENVIRONMENT

Geology and Geomorphology

Mount Carmel is a structurally elevated, tilted, triangularly shaped area (Sass, 1980). It is bordered by a fault line scarp on the north-east (Fig. 6), which separates it from the Galilee, and by the Ramat Menashe (Menashe Plateau) syncline on the south-east (Fig. 7). To the west, a coastal abrasion escarpment borders a narrow coastal plain.

The total length of the mountain is about 30km, its maximum width about 25km, covering an area of 250sq. km (Inbar, 1984). El-Wad is located in the Lower, southern, Carmel (Fig. 7). The area is up to 300m high (Nir, 1980), with a rather gentle topography and a few inner valleys. Most of the area within a radius of 5km around el-Wad does not exceed an elevation of 200m (Fig. 7). The higher parts of Mount Carmel, to the north and north-east of the Lower Carmel, are more dissected, with deep valleys and cliff escarpments and a rather rough topography. The highest peak is Rom HaCarmel, 546m above msl.

The Mount Carmel lithology is composed of Cretaceous (mostly Cenomanian – Turonian) chalks, limestones and dolomites. The stratigraphic sequence, which is several hundred metres thick (Fig. 8), represents a variety of depositional facies, resulting from the unique palaeogeographic location of Mount Carmel, at the edge of a shallow platform (Bein and Sass, 1980). This variety is further reflected in soil and vegetation distribution in the area.

Karstic phenomena are common in the dolomites and crystalline limestones of Mount Carmel. At Nahal Me'arot, karstic caves were formed within a reef complex of Albian – Early Cenomanian age (the Yagur formation) (Bein and Sass, 1980). Various areas of the fossil reef are easily discernible within this complex (Figs. 9,10): the limestone reef core, which is built of mostly degraded radiolitids and chondrodonts; the fore reef talus, which is made of calcarenites and calcirudites and dips (initial dips) 25°-30° to the south-west, and the back reef, east of the reef core, which is represented by almost horizontal bedded dolomites and some biopelmicrites.

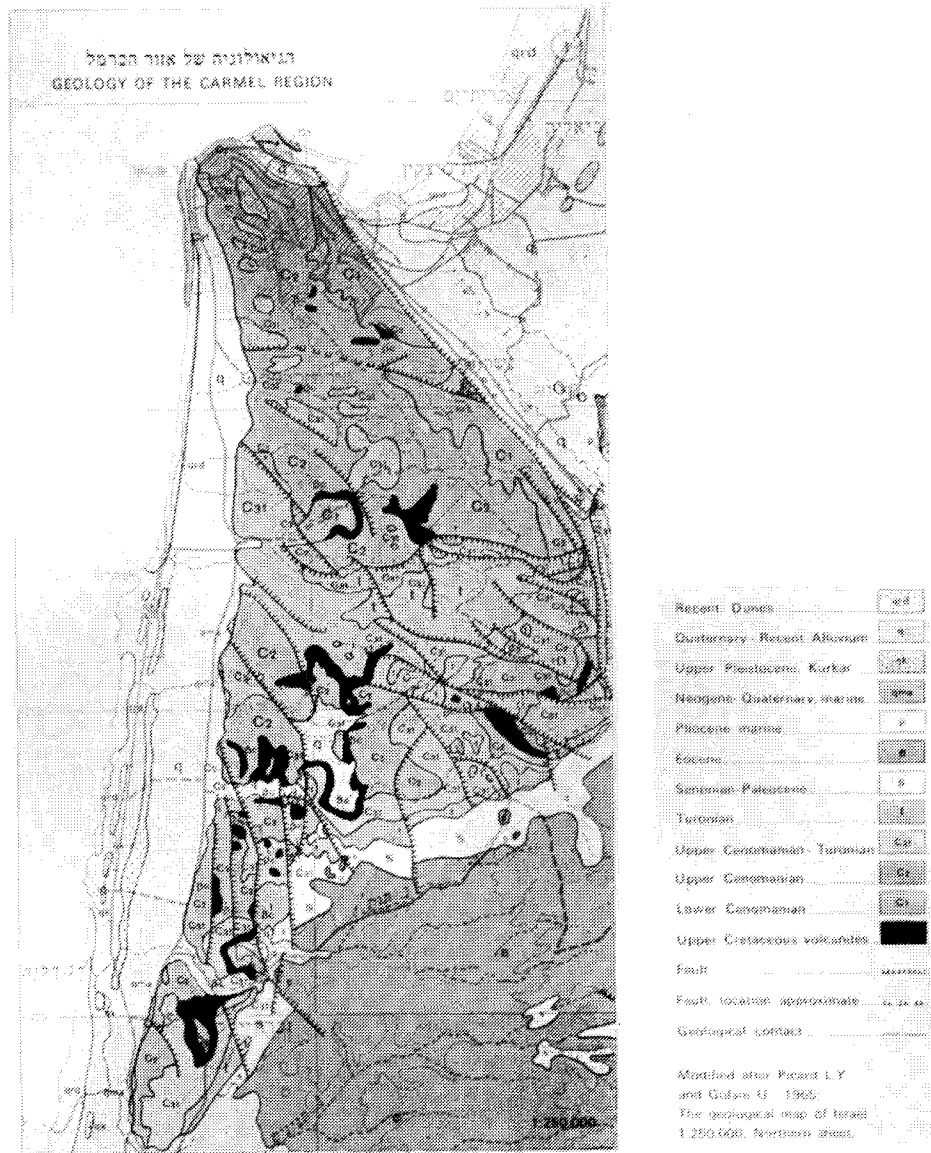


Fig. 6. Geology of the Mount Carmel region

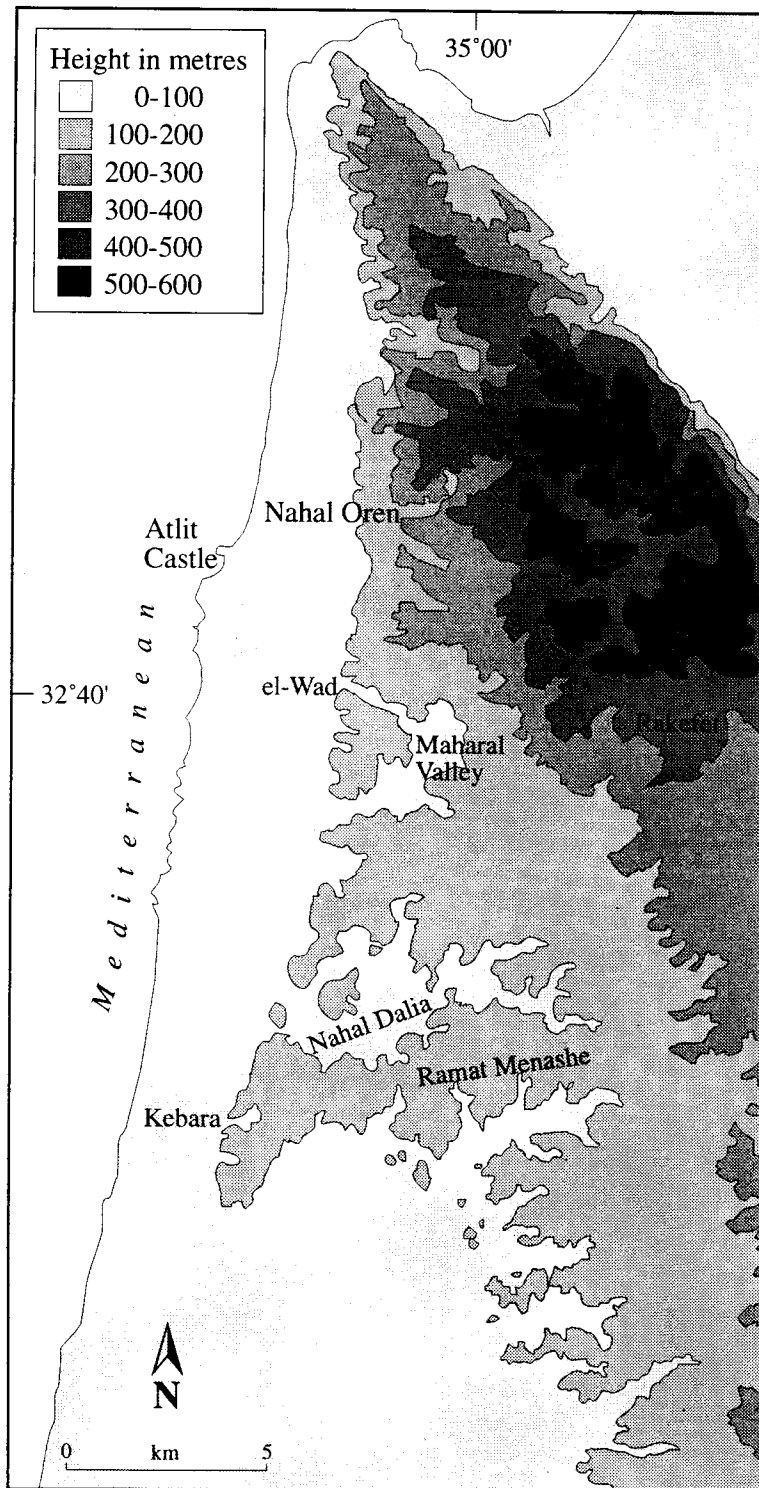


Fig. 7. Topographical map. El-Wad is situated at the southern, Lower Carmel, within a fossil reef. The Maharal Valley, east of the cave, was formed through the erosion of the rather soft, volcanic tuffs and is within easy reach (no topographical barriers).

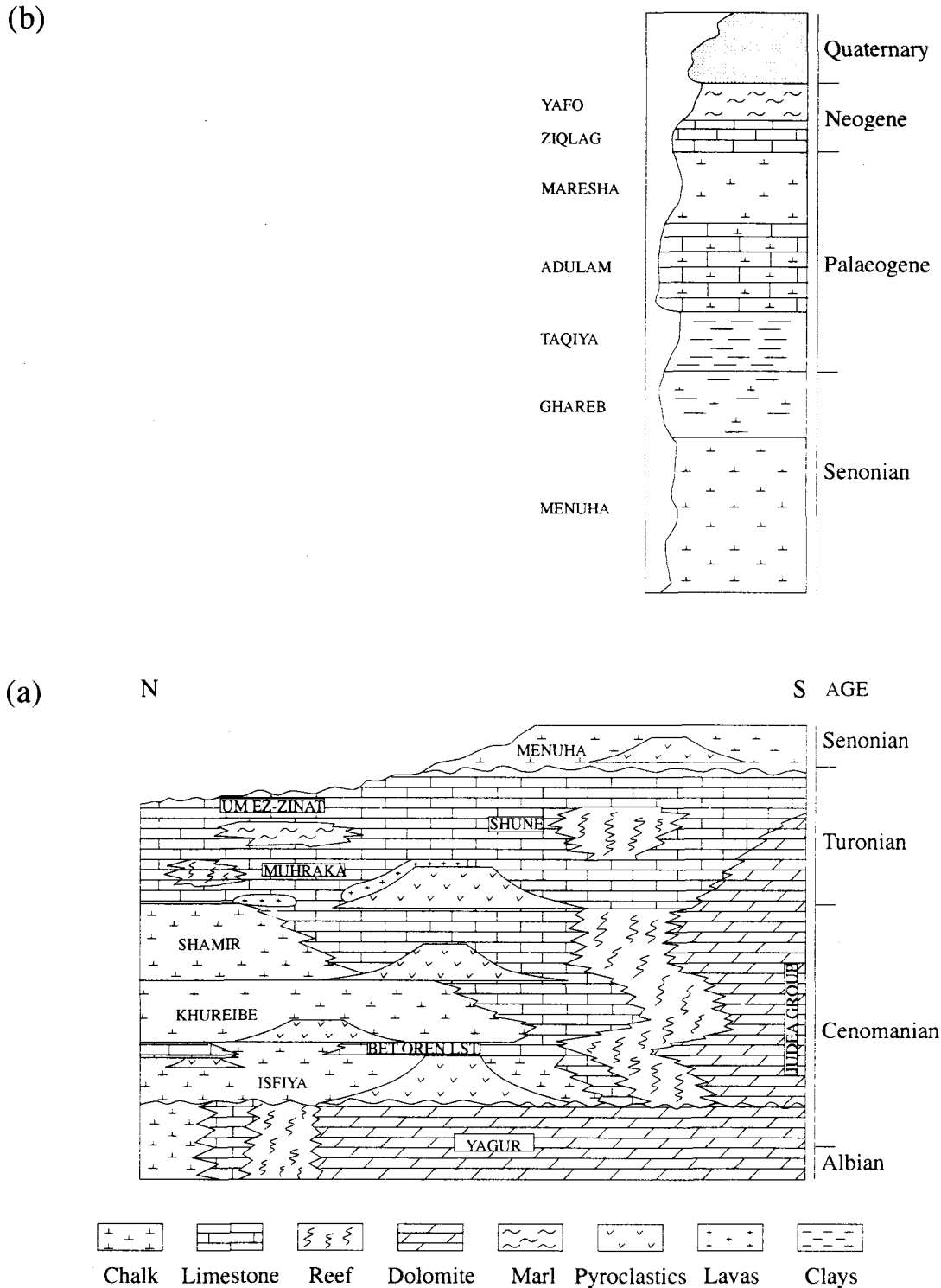


Fig. 8. Composite lithostratigraphic scheme of the Carmel region: (a) geological section of the Upper Cretaceous Judea Group; (b) columnar section of the Senonian to Quaternary sequence. Flint is abundant within the Cenomanian Shamir Formation (Karcz, 1959). Sporadic flint nodules occur in the Isfiya, Khureibe and Menuha formations (Karcz, 1959; Levy, 1995), of Cenomanian to Senonian age; flint layers also occur in the Palaeogene Adulam Formation (Levy, 1995).

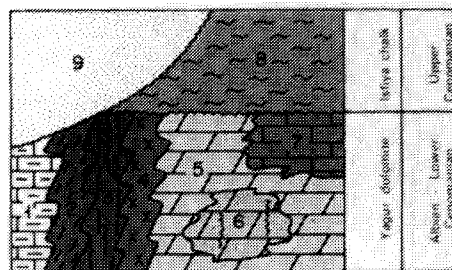
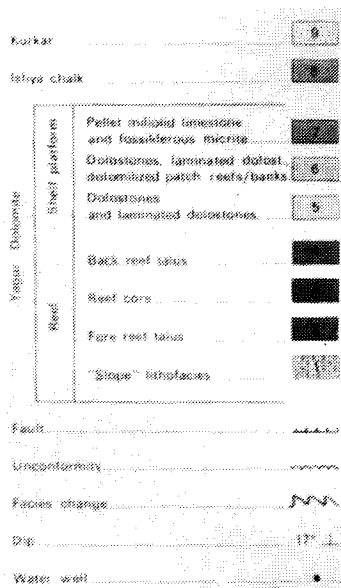
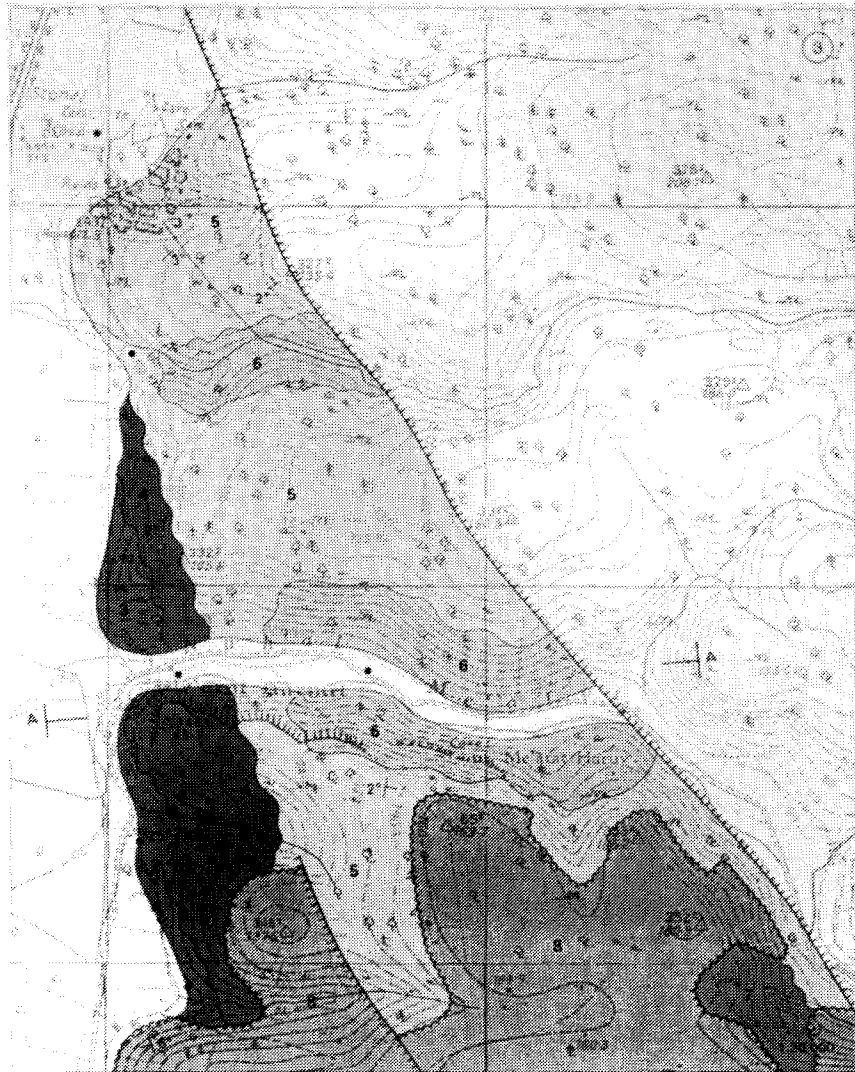


Fig. 9. The Geology of Nahal Me'arot area.

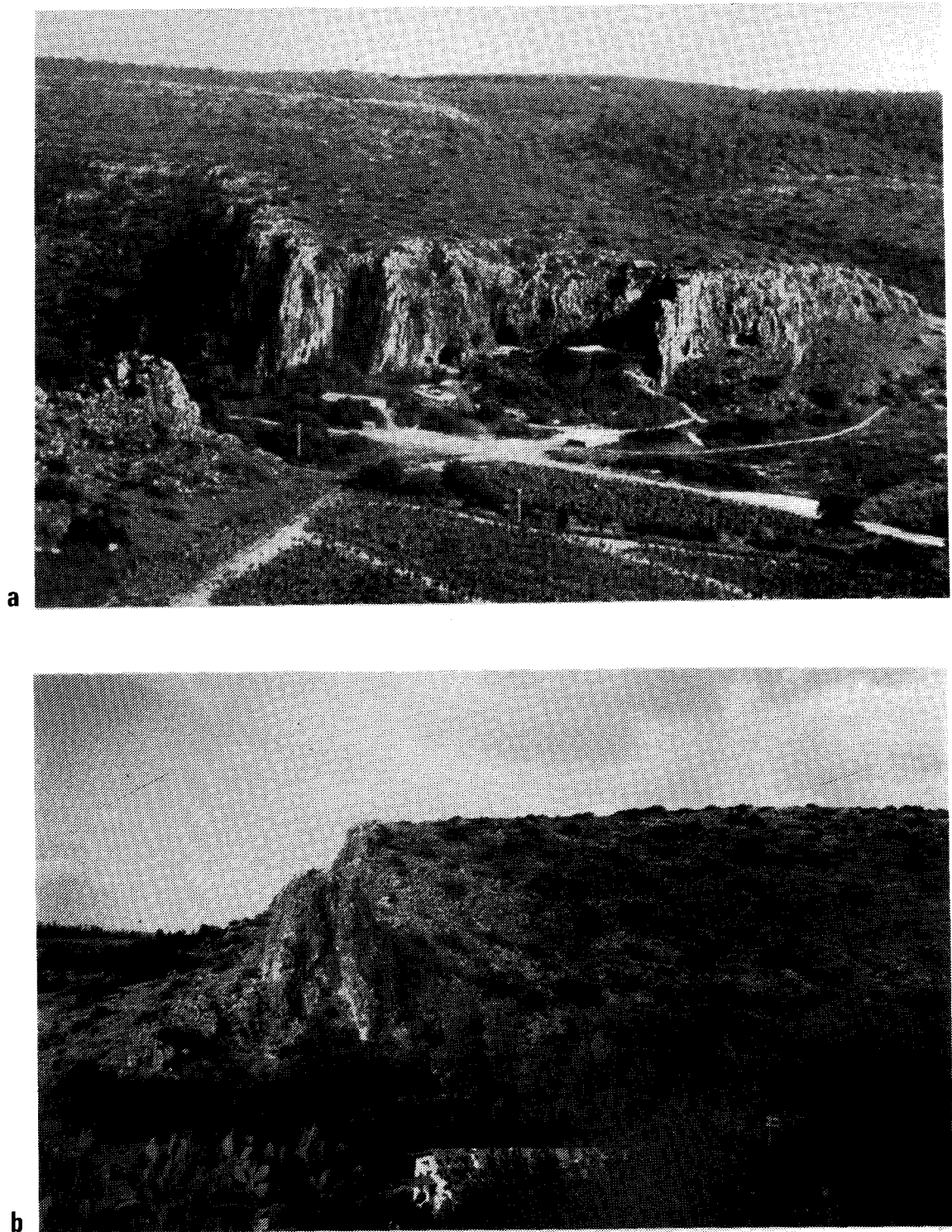


Fig. 10. The fossil reef of Nahal Me'arot: (a) An ariel view of the caves' cliff. In the foreground el-Wad, Jamal and Tabun caves, situated within the reef core, with the back reef talus at the background; (b) The fossil reef of the southern bank of Nahal Me'arot, north of the cave. Today, the reef core and especially the fore-reef calcareous talus supports many *Euphorbia dendroides* while on the dolomitic back-reef talus *Calicotome villosa* is abundant.

Volcanic rocks of Late Cretaceous (Cenomanian – Turonian) age are found mainly in the Lower Carmel (Fig. 6). They appear as lenticular bodies, mostly consisting of basic pyroclastics, which are occasionally associated with basalt lavas (Bein and Sass, 1980). Epigenetic iron oxides (Ilani et al., 1985) and manganese (Ilani et al., 1990) mineralizations occur in contact with or in close proximity to volcanic rocks within Cenomanian – Turonian limestones and dolomites of the Judea Group. Volcanic tuffs may create broad, intermontane valleys (Nir, 1980), such as the Maharal Valley, 3km to the south-east of the caves (Fig. 7).

The Carmel Coastal Plain is rather narrow (Fig. 7), about 3.5km wide at its southern part, gradually diminishing to the north, from Nahal Oren, c. 5km north of el-Wad, up to the point where the hills touch the sea (the Carmel “nose” or Haifa Cap). The region is composed of three Quaternary aeolianite (locally called *kurkar*) ridges (Fig. 6), two of which, to the north of Atlit, are presently submerged. The eastern, most continuous ridge is 20-25m high. A flat, alluvial plain, sloping from 30-40m altitude at the feet of Mount Carmel to 10-15m in the west, separates the eastern ridge from Mount Carmel (Fig. 11). Nahal Me’arot drains into the Mediterranean some 3.5km west of the cave.

Soils

Mount Carmel soils are of two main types. The reddish-brown terra rossa soils are associated with Cenomanian and Turonian limestones and dolomites. Pale rendzina soils are derived from chalks, marls and tuffs of a Lower Cretaceous to Senonian age (Singer and Rabikovitch, 1980). Colluvial soils deposited along the foothills in a narrow strip that separates the mountain from the coastal plain are derived chiefly from terra rossa and contain varying amounts of stones. Rather deep, alluvial soils occupy the major part of the Carmel Coastal Plain; sandy red loams (locally termed *hamra*) can be found on the aeolianite ridges. Commonly, a narrow strip of sand dunes occurs between these coastal hills and the sea.

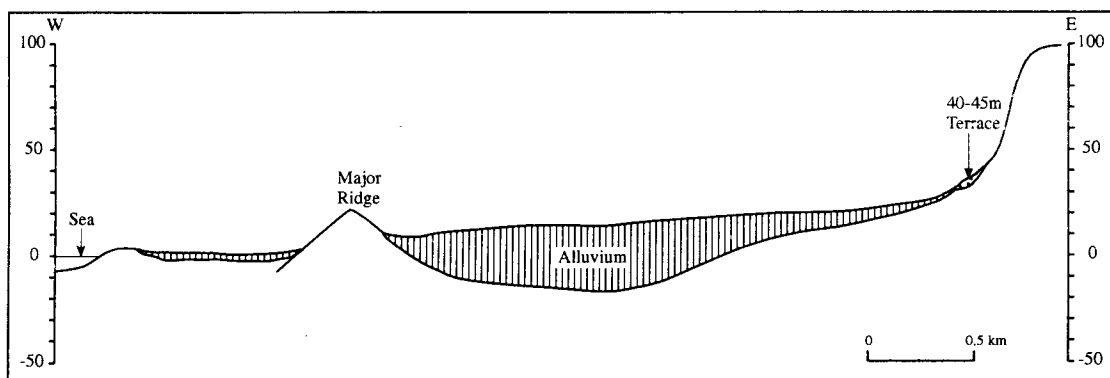


Fig. 11. Schematic section across the Carmel coastal plain in front of el-Wad.

Vegetation

Mount Carmel vegetation is primarily East Mediterranean (M. Zohary, 1980; Pollak, 1984). The distribution of the main plant formations (Fig. 12) is on the whole determined by the lithology and derived soils, but is also influenced by altitude.

The lower belt of the mountain, up to 300m., is occupied by the *Ceratonia siliqua* – *Pistacia lentiscus* association. (M. Zohary, 1962). This association is particularly widespread on the western parts of the mountain. It is an evergreen park forest, characterized by a high diversity of species, including trees (e.g., *Quercus calliprinos*, *Rhamnus palaestinus* and *Crataegus aronia*) and shrubs (e.g., *Majorana syriaca* and *Salvia fruticosa*). A special variant, with *Olea europaea*, occurs in areas with high precipitation (more than 600mm). Stands of this association are also present on the aeolianite ridge near Atlit.

Quercus calliprinos – *Pistachia palaestina* maquis association is characteristic of hard limestones and dolomites and the derived terra rossa soils of the central and eastern Carmel, and among the plant associations in the area it is the most widespread. It is represented by a series of variants, with *Quercus calliprinos*, *Pistacia palaestina*, *Pistacia lentiscus*, *Ceratonia siliqua*, *Arbutus andrachne*, *Crataegus aronia*, *Rhamnus palaestinus*, *Cercis siliquastrum* and *Phillyrea latifolia* as the main arboreal species. The latter was apparently heavily coppiced as a preferred fuel source for charcoal production and domestic uses in the past (Naveh, 1984). In recent years it has re-established itself within the Mount Carmel Nature Reserve, where it co-dominates in many places with *Quercus calliprinos*. On the humid northern slopes and the highest elevations it includes high proportions of *Laurus nobilis* and *Quercus boissieri*, accompanied by *Pyrus syriaca* (Waizel et al., 1982). Deep, shadowed and humid cliffs and canyons support dense *Quercus calliprinos* maquis, with *Cercis siliquastrum*, *Melissa officinalis* and *Laurus nobilis*. Stands of *Myrtus communis* can be found in mesic habitats, especially on northern slopes.

Pine forests, the main association of which is *Pinus halepensis* – *Hypericum serpyllifolium*, on the whole are restricted to the soft, pale rendzina soils, derived from the chalky rock beds of the Middle Cenomanian of the Upper Carmel. Characteristic components of this association are *Thymelea hirsuta* and *Genista fasselata*. In Israel, the latter grows only in the Carmel area, where it is accompanied by *Cistus salvifolius* and *Cistus creticus* (M. Zohary, 1955, 1973). A thermophilous Tabor Oak (*Quercus ithaburensis*) open park forest is limited to the south-eastern parts of the Carmel and the Menashe Plateau. This type of forest once also covered large areas in the Sharon coastal plain, south of the Carmel coast (Eig, 1933; Karschon, 1982), remnants of which (together with *Desmostachya bipinnata*, for example) can be found today especially on hamra soils. The main components of the Carmel dwarf-shrub formations, garigue and batha, are *Sarcopoterium spinosum*, *Calicotome villosa*, *Salvia fruticosa*, *Cistus spp.* and *Satureja thymbra*. Exposed, rocky biotopes support many *Stachys palaestina*, *Micromeria nervosa*, *Ceterach officinarum* and *Podonosma orientalis* plants. The volcanic rocks and tuffs are covered with a sparse batha, with *Coridothymus capitatus*, *Calicotome villosa* and *Asphodelus ramosus*. Hydrophilous biotopes include *Nasturtium officinale*, *Inula viscosa*, *Rubus sanguineus* and *Nerium oleander*. Large areas of Mount Carmel, as well as most of its coastal plain, are subject to cultivation and afforestation.

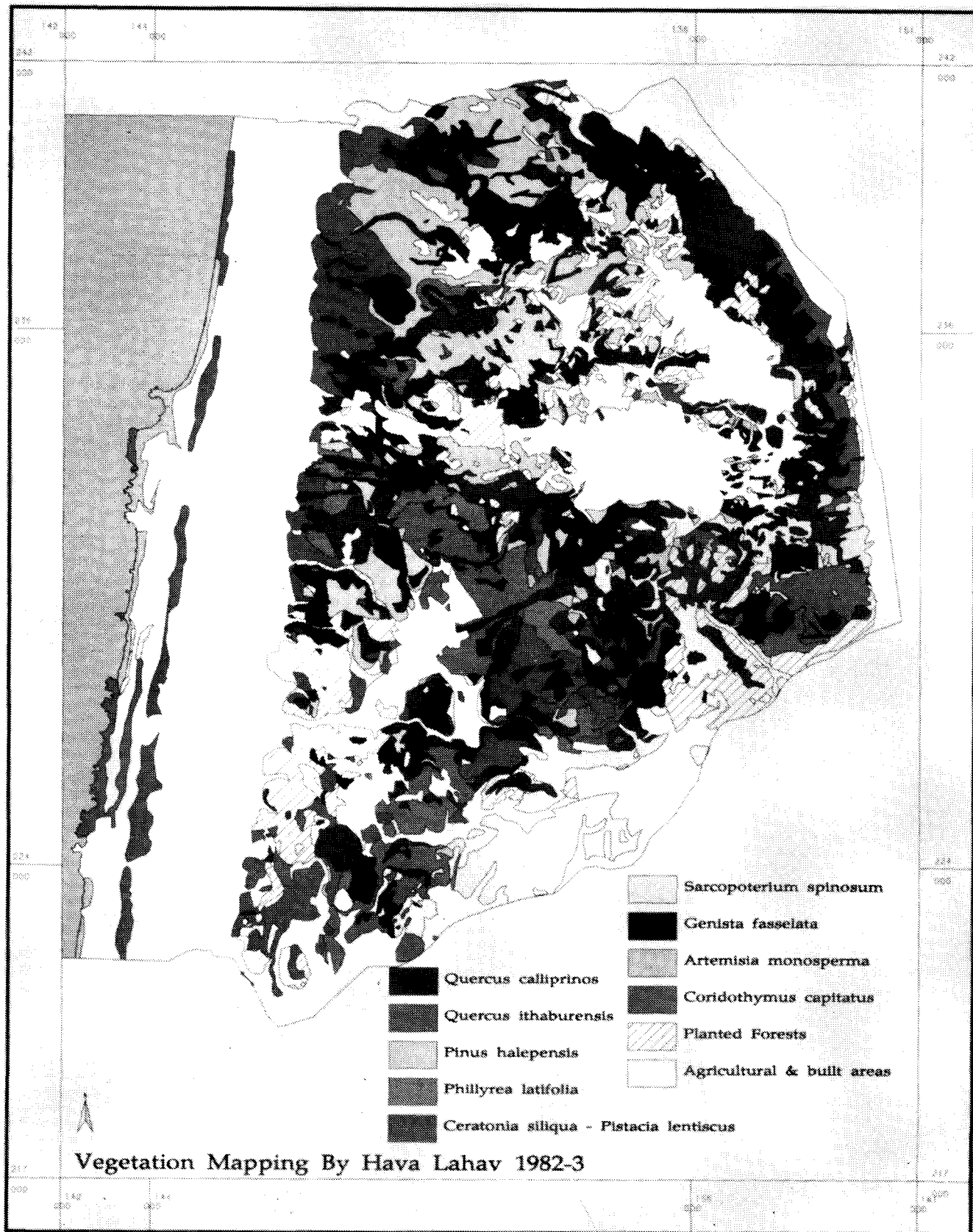


Fig. 12. Vegetation map, Mount Carmel.

The Carmel coastal plain supports vegetation types confined to sand dunes associations (mainly *Lotus creticus* and *Artemisia monosperma*), kurkar hills (*Ceratonia siliqua* – *Pistacia lentiscus*, with *Coridothymus capitatus*, *Critmum maritimum*, *Lavandula stoechas*, *Calicotome villosa*, and *Thymelaea hirsuta*), marshes (e.g., *Phragmites australis*, *Juncus fontanesii*, *Typha domingensis* and *Tamarix nilotica*) and salines (*Imula crithmoides*, Chenopodiaceae, *Tamarix tetragyna*).

Climate

Climatic conditions on Mount Carmel are temperate and are influenced by both the topography of the mountain and its proximity to the coast (Scharlin, 1980).

Average annual rainfall is 600-800mm (Katzenelson, 1967). A single rainy season extends from October to April (Fig. 13), though occasional rains may occur in September and May. Rainfall distribution depends mainly on altitude (Scharlin, 1980). The region is further characterized by heavy, localized (torrential) rains, especially at the beginning and end of the rainy season.

The mean annual temperature is 18.8°C, with a day time average of about 11.9°C in January and 28°C in August (Katzenelson, 1967). The prevailing winds are westerlies during the summer and easterlies during the winter, when strong winds are relatively common (Lomas et al., 1973). Local winds are also influenced by the mountain's special topography, i.e., high frequency of winds parallel to the mountain ridge and strong winds in wadis that cut through its western slopes (Scharlin, 1980).

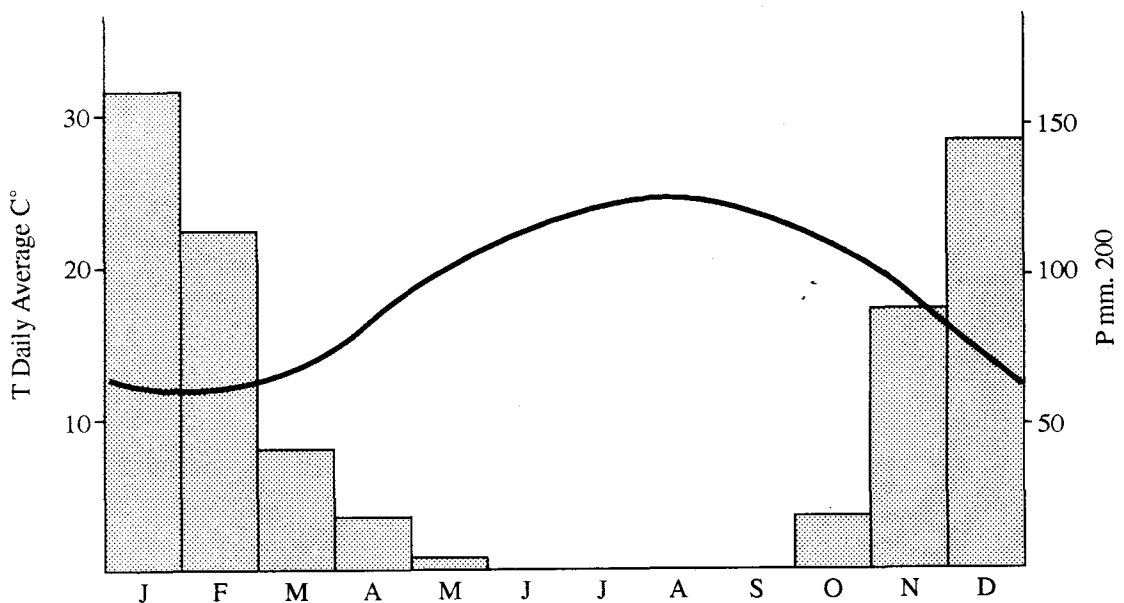


Fig. 13. Mount Carmel climatograph (Data: Israel Meteorological Services).