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Prehistory and Tectonics on Mount Carmel

Claudio Vita-Finzi

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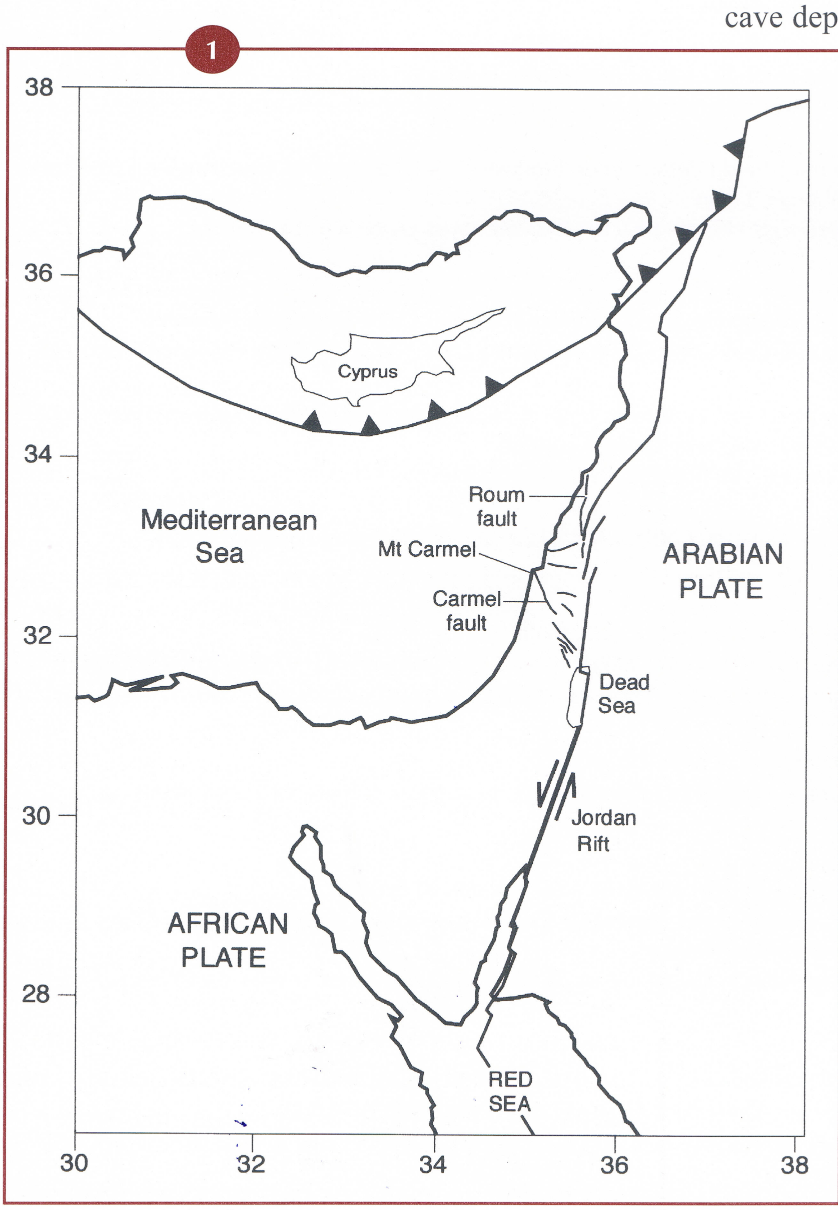
Abstract

Reinterpretation of the Palaeolithic deposits in the Wadi al Mughara caves yields a fossil shoreline which implies net uplift of Mount Carmel by about ~40 m during the last 120,000 yr. Although the data do not discriminate between compressive or extensional mechanisms they show that a significant part of the motion on the Dead Sea Transform system is dissipated along the Carmel Fault and that ecological change during human occupation of the caves had a major tectonic component.



Introduction

The aim of this paper is to reassess the Palaeolithic stratigraphies in the Wadi al Mughara caves, on the western flank of Mount Carmel, in order to explore the suggestion that some of the deposits have been reworked by wave action. In the 1970s and 1980s the notion seemed preposterous: the few available 14C dates suggested that the caves were occupied at a time when sea level lay tens of metres below its present position so that prolonged uplift at an average of ~ 2 mm/yr would have been required to raise the caves to their present elevation. The application of various novel dating methods to the cave deposits in the last few years justifies a fresh appraisal of the original excavation reports.

The site bears on a wide range of issues both in geology and in archaeology. A key question in Levant geology is how the strain that accumulates along the Dead Sea Transform (DST) is distributed at its northern end. Ziad Beydoun (1977) showed that in southern Lebanon the DST branches into a number of strike-slip faults (Fig. 1). Some workers suspect that the Yammouneh fault, often viewed as the main active strand in Lebanon, has been inactive over the last 5 Ma, and that the Roum Fault, which extends as far as Beirut, is the active transcurrent structure (Butler *et al.* 1977, Griffiths *et al.* 2000); others (e.g. (Fleury *et al.* 1999, Gomez *et al.* 2001) favour the view that movement is distributed along several branches, including the Carmel Fault.

Fig.1 Location of Carmel Fault in relation to Levant plate geometry.

Fig. 2 Lower Wadi el Mughara (c. 1970). The cave of El Wad is above the bushes to the right of the hut.

Fig.3 Summary stratigraphic sequences for Carmel caves based on data in Garrod & Bate (1937).

THE CAVE RECORD

Picard & Kashai (1958) showed convincingly that the western cliffs of the Carmel (Fig. 2) are due to Pleistocene marine erosion, although they did not rule out a western fault offshore. Some authors consider that the caves of Kebara, Tabun and Wad originated in wave-eroded undercuts, and that the last two are related to a fossil shoreline at 35-45m (Horowitz 1979). The possibility that there was an active beach within Wad and Skhul during the period of human occupation was first

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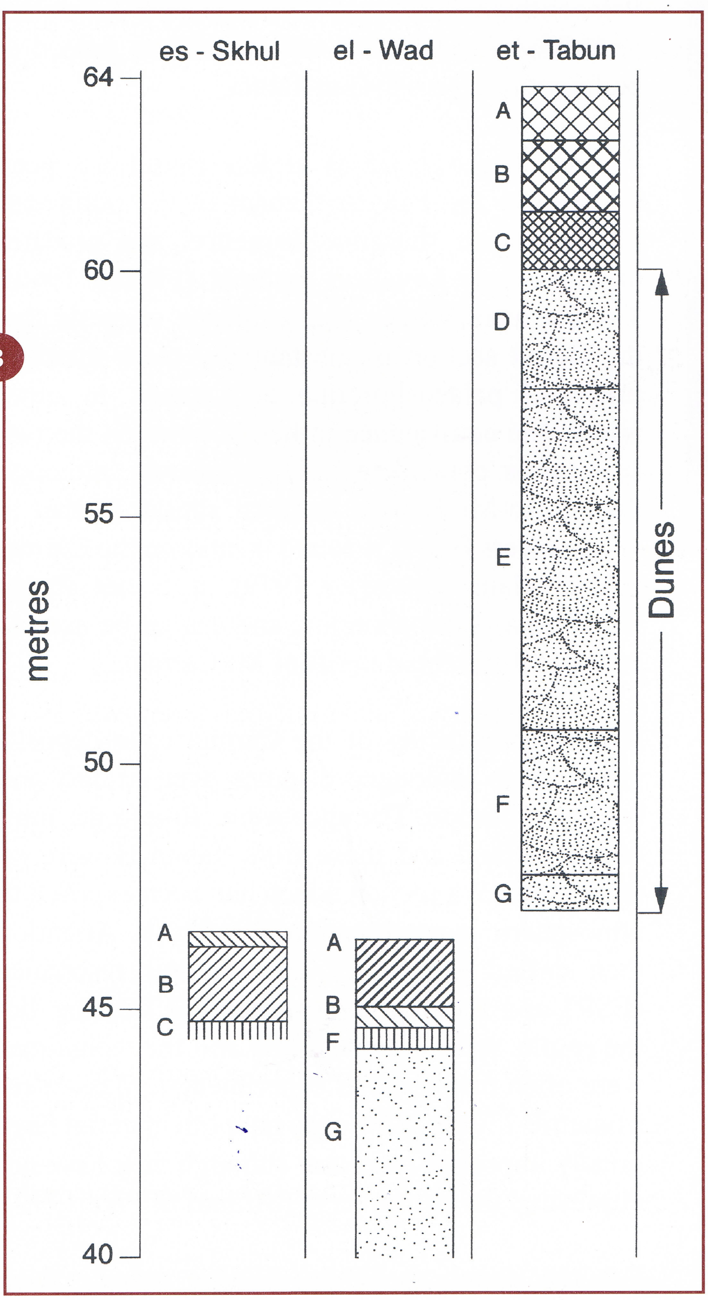

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raised in the context of a site catchment study of the caves (Vita-Finzi & Higgs 1970) in which the reconstruction of shifts of the coastline played a significant part.

Of the original study of the Carmel caves by Garrod & Bate (1937), the only parts devoted explicitly to geology are Appendix II, by A. Brammall and J. G. C. Leech, and Appendix III, by A. Reifenberg. The former is a lithological and mineralogical analysis of some samples of matrix from Skhul and Tabun, and the latter a chemical analysis of six samples from Tabun. Neither includes any consideration of environmental or stratigraphic problems beyond reference to the horizons delineated by the excavators. The main text deals with geological matters only in passing, and the use of terms such as 'earth' or 'hardened deposit' hampers reinterpretation of the cave sequences. Even so, a close reading of *The Stone Age of Mount Carmel* suggests that some of the deposits removed during excavation of the caves were marine in origin.

The stratigraphy of Wad is summarised in Figure 3. Garrod & Bate (1937) report that, on the NE side of Chamber I, layer A (Bronze Age-Recent) rested on a floor of flint flakes and implements, many of them abraded and some 'heavily rolled'. Most of the material in this layer (F) was Levalloiso-Mousterian in type, although some of it could be assigned to what was at the time termed the 'Lower Aurignacian.' The layer had an average thickness of 0.10 m and rested on 'the somewhat irregular surface of a deposit of hardened grey grit'

(G) which contained Upper Levalloiso-Mousterian material and in one locality was at least 7.2 m thick. Layer F was later found at the base of the Upper Palaeolithic sequence in the inner part of the cave.

Abrasion of the flints in layer F and of some of those in the Upper Palaeolithic layers was ascribed by Garrod & Bate (1937) to the work of an intermittent spring in the inner part of the cave, although the only evidence for such a spring was the discovery of water in a sounding in Chamber IV and there was no indication that any of the deposit had been removed by flowing water.

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Fig. 4 **Wind blown sand in Tabun (c. 1970). Ruler measures 1 m.**

The lower part of the Tabun fill has all the characteristics of a fossil dune (Figs. 3 and 4), although Garrod & Bate (1937) simply refer to it as an 'archaeological deposit'. It contains material ranging in style from 'Tayacian' at the base (layer G) to Lower Levalloiso-Mousterian at the top (layer D). The dune is covered by colluvium which, as the excavators recognised, was probably derived from the cliff surface through a chimney. It contains material ranging from Lower Levalloiso-Mousterian at its base to Bronze Age and later above.

The deposits which yielded the celebrated human remains of Carmel (McCown in Garrod & Bate 1937) filled the cave portion of Skhul to about half its height. Inside the cave the surface of the deposits was level while outside it dipped to the NW by about 5°. The base of the deposit (C) was rich in quartz sand which contained abraded Levalloiso-Mousterian artifacts analogous to those of layer D in Tabun. Layer C of Skhul is overlain by cemented breccia, a situation reminiscent of the stratigraphy at Abri Zumoffen near Adlun on the coast of southern Lebanon (Zeuner 1961).

All three sequences can be reconciled by postulating a marine relative stillstand at what is now the 44.5 m contour. Layers G of Wad and C of Skhul would then represent beachrock which was overlain by an abraded beach (layer F of Wad); the latter is 1.10 m below a well developed notch within Wad. As a foreshore is required as a source for the Tabun dune sands, aeolian deposition presumably occurred before submergence had reached the 44.5 m level and cut off the sand supply. The earliest Palaeolithic industries at Carmel (Upper Acheulian or Yabrudian and pre-Aurignacian) are indeed to be found in layers E-G at Tabun.

A fossil beach at 45 m at Ras Beirut has been ascribed to the Paleotyrrhenian of the outmoded Mediterranean shoreline sequence, and predates unrolled early Levallois material (Fleisch 1960). Though inconclusive, this evidence suggests that the Beirut section is substantially older than the proposed palaeoshoreline at Carmel; in other words, the equivalence in height between the two sections is coincidental. Unfortunately, although Levalloiso-Mousterian material similar to that in Tabun layers B & C is found in sites on the Carmel coastal plain (Horowitz 1979), it is not firmly linked to a palaeoshoreline and cannot be used to evaluate differential uplift of Mt Carmel.

Radiocarbon dating of the Carmel cave deposits gave rise to prolonged disputes over artefact and human evolution. The ages were close to the limit of the method and those from Tabun B were on material from a section which had been exposed to atmospheric contamination for 28 yr. Attention then shifted to U-series, electron spin resonance (ESR) and thermoluminescence (TL) dating but the results were not consistent and the techniques were often dismissed as experimental. Mass-spectrometric 230Th/234U ages on tooth material have greatly improved precision although they have not eliminated the controversy (Millard & Pike 1999).

For the dunes at Tabun, U-ages range from 168.1±2.6 (layer E) to 110.7±0.9 (layer D) kyr

(McDermott et al. 1993). For layer B of Skhul, the TL method gave an average of 119±18 kyr (Mercier et al. 1993), consistent with the ESR results; U-series dates for this layer are viewed as unreliable by Bar-Yosef & Pilbeam (1993). It thus appears reasonable to conclude that the western Carmel was progressively submerged 168-110 kyr ago until aeolian sand supply to Tabun was cut off by 119 kyr ago when Skhul and presumably Wad too were occupied by a shoreline. This is the reverse of the conclusion reached by Farrand (1979; see also Jelinek 1982), who argued that the sea lay nearer the cave during the deposition of the lower sandy layers than later in the sequence. Re-emergence, probably through the combined effects of marine regression and uplift, followed at a date still to be determined.

Discussion

If this assessment is valid, the period of maximum submergence coincides with Stage 5e of the isotopic timescale, when average global sea levels were in the region of 5-6 m above their present-day position. Tectonic uplift in the last ~110 kyr thus amounts to ~39 m, equivalent to 0.4 mm/yr. In support of the geological evidence that uplift was localised, we may note that a cave site associated with a marine terrace at Ras el Kelb (Lebanon) has yielded lower Levalloiso-Mousterian material and a 14C age of >52 kyr (GRO-2556: Wright 1960) and is still 6 m above sea level.

The seismic evidence suggests that the DST is linked to a fault running along the Levant coast by the Carmel Fault, also known as the Carmel-Tirtza, the Carmel-Farah and the Carmel-Jizre'el Jordan Fault (Freund 1965, Achmon & Ben-Avraham 1997). Focal plane solutions for 1984-1994 show that the coastal and nearshore parts of the fault are characterized by predominantly strike-slip motion (Hofstetter *et al.*1996), but according to Butler *et al.* (1997) the orientation of the fault relative to its parent structure is such that any significant displacement along it will be accompanied by substantial extension. Indeed, an important normal component is commonly attributed to those portions of the fault that trend NW-SE. On the other hand, high-resolution seismic imaging suggests that the segment east of Mount Carmel is characterised by compression (Rotstein *et al*. 1992).

The Carmel Fault separates the Kishon graben from Mt Carmel, an asymmetric upwarp with a NNW-SSE alignment (Picard & Kashai 1958). Various lines of evidence suggest that Mount Carmel is undergoing uplift (e.g. Picard 1943). Evidence for ~400 m of emergence since the Miocene was found by Picard & Kashai (1958), a Pliocene surface has been noted at about 200 m, and terraces and fossiliferous beachrock are reported at various elevations (e.g. Slatkine & Rohrlich 1965). Although archaeological remains indicate submergence or stability on the Carmel coast in historical times (Galili & Sharvit 1998), geodetic data for 1936-1963 indicate uplift of the Carmel block at a few mm/yr and possibly accompanied by northwestwards tilting (Kafri 1969)

It remains to be seen whether this is a compressional effect of strike-slip movement on the Carmel fault, as suggested by Rotstein *et al.* (1992). In any case one might expect it to be at least partly coseismic. From an archaeological point of view tectonic emergence is significant mainly because it accelerated shoreline retreat and the associated shift away from coastal resources (Vita-Finzi & Higgs 1970). And, as with the Lisan Marls (Copeland & Vita-Finzi 1960), this case study shows that archaeology can still play a useful part in linking laboratory dating methods with geological events.

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