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Mid-Cretaceous climate change in Israel: no evidence of greenhouse

V. Krassilov

Institute of Evolution, University of Haifa, Israel (krassilo@research.haifa.ac.il / Phone +04-824-9799)

Greenhouse climate implies more heat residing in the atmosphere as a whole rather than re-distribution of heat over the globe resulting in the warmer than now high latitude climates. There is ample evidence of high latitude heating in the Cretaceous, whereas regional estimates for low latitudes are less convincing. Two mid-Cretaceous climatic cycles of alternating dry/humid phases are inferred from the Aptian to Turonian paleofloristic successions in the central – southern Negev, Israel. Fossil plants are found in non-marine to paralic deposits overlain by or alternating with fossiliferous marine carbonates. Age assignments of the lower horizons are also based on radiometric dating of basalts and magnetostratigraphy. The Aptian plant assemblage from interbasaltic playa lake deposits of Makhtesh Ramon, central Negev, consists of xeromorphic cycadophytes, conifers and gnetophytes. In the next, early Albian humid phase, *Weicheselia* prevails in the tidal flat deposits containing also remains of marshy and aquatic angiosperms. Allochtonous elements are represented by araucariaceous conifers, broadleaved angiosperms and occasional ginkgophytes suggesting a mesomorphic dryland forest. Recurrence of xeric environments is indicated by the Cenomanian localities of Judean Mountains, dominated by a xeromorphic angiosperm *Sapindopsis* forming single-species leaf assemblages or, in the richer localities of Lebanon and Jordan, associated with small-leaved dryland species. The preponderance of compound leaves with narrow leaflets suggests comparison with a drier type of Mediterranean vegetation. A rich Turonian flora of Gerofit and Qetura, southern Israel includes a species-poor mangrove assemblage with autochtonous root remains associated with a diverse marshland - aquatic plants of the back-mangrove wetlands. Among the dryland contributions, *Cercidiphyllum*-like and *Dipteronia*-like plants have their modern equivalents in the broadleaved mountain forests of eastern Asia. The northern shores

of Red Sea provide a modern analogue for a joint occurrence of stunted mangroves and marshes. Yet, in the richness of freshwater aquatic macrophytes, the Turonian flora of Negev matches the extant vegetation of northern Israel and the leaf morphology of allochtonous upland elements indicate a considerable increase of precipitation over the Cenomanian level. It is concluded that cyclic vegetation changes through the mid-Cretaceous corresponded to alternation of dry/humid subtropical climates. Presently, the boundary between the respective vegetation zones in Israel occurs at about 31˚N, whereas during the humid mid-Cretaceous phases it might have been displaced degrees to about 30˚N. Temperate elements in the Turonian flora indicate temperature conditions similar or cooler than now, which casts some doubts on greenhouse interpretation of Cretaceous climate.