Isotopic evidence for age of intense spring activity in the Arava Valley, Israel, during Quaternary times

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The age distribution of travertines in the Arava Valley indicates that the last glacial and the preceding interglacial (oceanic oxygen isotope stages 5 and 7) were periods of greater pluviation than at present day. Several periods of increased deposition of spring travertines within the Arava valley coincide with periods of formation of sapropel in the Mediterranean. This suggests the influence of a northward shift of the African Monsoon. A second, smaller cluster of younger ages coincides with the period of pluviation and groundwater recharge in the Levant that resulted from precipitation derived from the Atlantic Ocean during periods of the last European pleniglaciation.

Introduction

The Arava Valley is the southernmost part of the Syro-African Rift system in Israel. At present it has a hot, dry climate with precipitation of 20–50 mm/yr. There are no lakes and the few springs deposit gypscrete. Therefore, the occurrence of remnants of spring deposited travertines, locally associated with lacustrine limestones within the Quaternary Sayif Formation, along the western margin of the Arava Valley is all more striking. In a preliminary study the ages of spring deposits from the Arava were found to be similar to ages of travertines of the Negev Highlands which were the major recharge area for the Arava springs during the warm isotope stages 5 and 7. Here we present ages from virtually all of the known travertine occurrences in the Arava Valley in order to broaden the understanding of the climatic changes in the Levant during the Quaternary and their relation to those of Europe and North Africa.

Forty Five new travertine samples were dated by the Th-230/U-234 method using standard techniques. These samples were taken from sites along 100 km on the western margin of the Arava Valley between Makhtesh Katan and Nahal Hyyon. Individual travertine horizons within typically 0.5 to 5m thick patches were sampled in each site. In most cases, at least two samples free of allogenic material were analysed to ensure consistency of superposition or constancy of an age. The amount of detrital thorium contamination was small. The Th-230/Th-232 ratios typically ranged from 8 to 100. Therefore, especially in the older sections, the contamination could be readily corrected for. Of the 45 samples, six were older than the limit of the method taken as 300 k yr., while 7 were rejected as exhibiting open systems or yielding non-calculable ages.

Results

Fig. 1 shows the new and the previously reported ages of the Arava Valley and the Negev Highlands travertines. The samples are presented in the order of increasing age. The oxygen isotopic stages for the given time interval are shown as well. The results show that the ages of travertines of the Arava Valley and the Negev Highlands fall within the same groupings, which indicate that periods of increased pluviation and travertine formation in the Arava Valley and the Negev Highland coincide. Samples taken from individual travertine sections show a systematic increase in $d^{13}C$ and $d^{18}O$ with stratigraphy. For the time interval older than 80 Kyr. there are two dominant groupings corresponding to isotope stages 5 and 7. Petrographic analysis of the micro lamination suggests that the process of travertine formation did not extend over a period longer than a thousand years. The analytical precision of the dating method did not allow the identification of specific substages in stages 5 and 7. Stages 6 and 8 were apparently arid with little travertine deposition, though a cluster of travrtines have ages around 180 Kyr. (stage 6). No travertine sample gave a Holocene age, which is in agreement with the present aridity of the Arava Valley. The fact that samples with ages greater than 300 Kyr. were

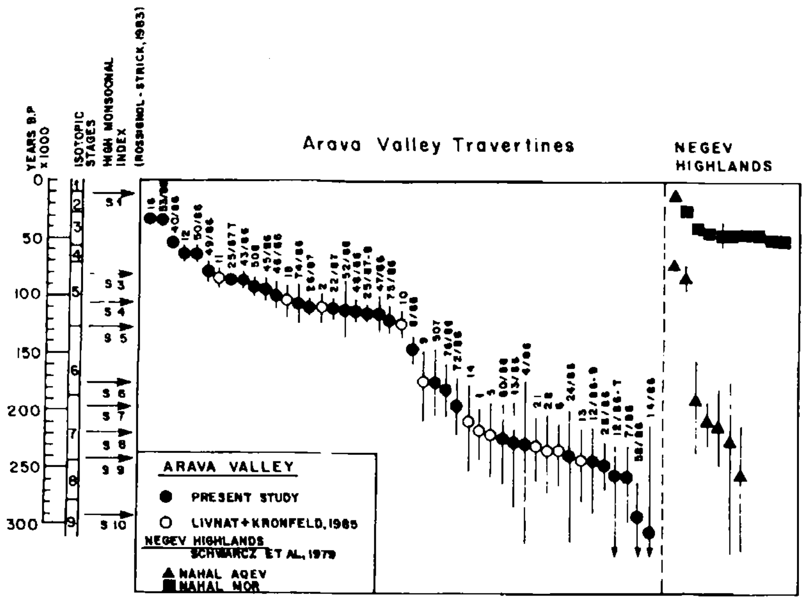

FIG. 1. The distribution of the ages of formation of travertines of the Arava Valley and the Negev Highlands.

encountered lent confidence to the working hypothesis that the complete suite of representative ages was encountered.

Discussion and conclusions

The distribution of travertines cover the period of sapropel formation in the Mediterranean, which is interpreted as an indication of High Monsoonal Index. This distribution is explained by a northern shift of the African Monsoon that extended into the Levant, leading to a higher degree of rainfall and spring discharge. The High Monsoonal Index (sapropel formation) is generally coincident with the warm isotope stages, though a high monsoonal condition with its attendant sapropel is found also in the Cold Stage 6 at approximately 176 Kyr. It is therefore assumed that the age distribution of travertines is related to orbital precession causing a northern shift of the African Monsoon. The present study suggests that the same cause is responsible for the formation of travertines in the Arava Valley. Extensive development of lakes occurred at 130 Kyr. within what is today a highly arid desert of Libya, and was followed by more modest lacustrine phases at 90 and 40 Kyr. There is a smaller group of dates that fall outside of the sapropel intervals, between the Holocene and the last interglacial. This time corresponds to the last European Glacial (60 to 20 Kyr). This contains pluvial stages in the period of approximately 45–50 Kyr. which left a record of increased groundwater recharge in Egypt through Sinai to the Negev. Isotopic evidence derived from fossil groundwater of this age indicate that this pluvial was characterised by less intense (non monsoon) year-round rainfall fed by precipitation derived from the Atlantic ocean. At present the precipitation mainly originates as cyclonic thunderstorms in the Eastern Mediterranean during the winter. During the last glacial climate belts shifted southwards, the westerly winds brought rain from the Atlantic Ocean, depositing rain over the Sahara and the Levant.

There are thus two pluvial conditions recorded by the travertine deposition in the Arava Valley; one is correlated with orbital precession of the earth and the resulting African Monsoons migrating northwards. This is correlated with the warm (odd) substages of the global oceanic oxygen isotope record, while the other correlates with the last glaciation which was sustained by moisture from the Atlantic Ocean. Therefore, within both glacial and interglacial times there existed pluvial phases. Previous attempts to correlate pluviation in the Levant with European cold stages is therefore incorrect.