SUPPLEMENTARY MATERIAL

Beyond the modelled terrain visually and statistically resembling the target landscape, it is possible to further corroborate that the Type-2 depressions formed in a Holocene wet-period, given known variables that dictate dissolution of carbonate landscapes and rates of reef accretion. A simple forward calculation to ascertain the approximate denudation (*D*) per unit area during sub-aerial exposure takes the form:

$$D = \frac{P \times [Ca^{2+}]_{eq} \times T}{\rho CaCO_3} \qquad [1]$$

where, P is the rate of precipitation, $[Ca^{2+}]_{eq}$ is the typical dissolved concentration of calcite, T is the duration of the pluvial period, and $\rho CaCO_3$ is the density of calcite. Taking P to be 1m/yr (as suggested by climate reconstruction), $[Ca^{2+}]_{eq}$ as 0.16 kg/m^3 (equivalent to 4.1 mol m^{-3}, (Fleurant et al., 2008)), and $\rho CaCO_3$ to be 2,400 kg/m^3 (Fleurant et al., 2008; Kaufmann and Braun, 2001), yields a D of 0.07 m/kyr. This value is in broad agreement with modelled literature denudation rate values obtained using comparable precipitation and temperature regimes and with $P_{CO2} \approx 0.01$atm (Fleurant et al., 2008; Kaufmann and Braun, 2001). In keeping with equation 1, the averaged D calculated for the surfaces produced by the CHILD model is 0.06 m/kyr, similar to observed values for karstified reef terraces (Marshall and Davies, 1984; Spencer, 1985). In terms of denudation, this provides evidence that the CHILD model is performing realistically.

Taking the 500×500m plot depicted in Figure 5a as representative of the real-world karst terrains considered by this study, the credibility of the model can be further validated based on the volume of carbonate presumed lost to dissolution during the pluvial period, versus that gained by reef growth following inundation. Equation 1 predicts that after the 500×500m plot has been exposed to rainfall for ~5kyr, the total volume of dissolved carbonate will be ~85,000m^3, a value corroborated by the model with a diffusion constant (K_D) of 0.01m^2/yr operating atop an initial surface with ±0.5m random topographic variation. The CHILD simulation further forecasts that the majority of this loss will be in the form of multiple pond-and-sill Type-2 depressions. Upon inundation, reef growth will initiate and given an accretion of ~1.5 m/kyr, a total framework volume of 50,000m^3 will be added atop the sills of the plot in the ~5kyr that the platform has been submerged. Accumulated sediment will strongly retard reef growth in depressions with the result that the pre-existing karst template will be accentuated (Macintyre et al., 2000; Purdy et al., 2003; Searle, 1994). Henceforth, from initiation of sub-aerial dissolution to the termination of marine accretion, the 500×500m plot has suffered a net loss of ~35,000m^3 of carbonate. Averaged over the entire plot, this accretion rate (A) is 0.04 m/kyr, as compared to a karstic D of 0.07 m/kyr.

If the karst dissolution had developed over a much longer period, such as the 100kyr of exposure since the penultimate glacial, and if rainfall was set to 0.1m/yr (an order less than during the Holocene pluvial and analogous to today's arid climate), equation 1 predicts D to fall to ~0.01m/kyr. Over 100kyr of aridity and 5kyr of pluvial conditions, these combined rates of dissolution would denude ~330,000m^3 of carbonate from the 500×500m plot, a volume too great to be compensated by any realistic rate of framework growth after the Holocene marine transgression (that is *D*>>*A*). This disparity prevents the reconstruction of any Type-2 terrain recognised in this study. As predicted by the CHILD model, such large volumes of carbonate removal that have developed over 100kyr time-frames take the form of Type-1 depressions. These are larger and morphologically distinct from Type-2. On the basis of this volumetric reconstruction, the model simulations of landscape evolution under pluvial conditions are deemed reliable.

For this study, the rate of precipitation is presumed to be 1m/yr. As detailed in the manuscript, this value is supported by the literature which points to substantially higher rainfall than present during the early Holocene. However, for the Northern Red Sea in particular, this value is hard to constrain as the closest robust climate reconstructions for the period are derived from the Mediterranean coast of Israel (Arz et al., 2003). To ensure the model remains valid under either reduced precipitation or increased evaporation, simulations were conducted for scenarios of lower rainfall during the pluvial. If precipitation is reduced to 0.7m/yr and 0.5m/yr, *D* decreases to 0.05 and 0.03 m/kyr, respectively. This lengthens the time required for the development of Type-2 morphology, which is recognised in the model once ~30,000m^3 of carbonate has been dissolved over a 500×500m plot. With 1m/yr of rainfall, this point is reached and Type-2 karst is evident after 2kyr of exposure. By comparison, if rainfall is set to 0.7m/yr, this point is not reached until 3kyr. With 0.5m/yr rainfall, appearance of Type-2 karst does not occur prior to 4kyr, which is the lower bound for the length of time that the studied platforms were exposed to a pluvial climate. The model hence suggests that the rate of precipitation was somewhat greater than 0.5m/yr.

An accepted uncertainty for the CHILD simulations is the unknown magnitude of tectonic uplift/subsidence in the Gulf and Red Sea during the pluvial, which would serve to alter the duration that the considered reef terraces were sub-aerially exposed. These effects were neglected in the modelling as even a tectonic event of 5m magnitude would only confer a ±500yr error to the timing of inundation. Such an error is well within acceptable limits of uncertainty induced by the sea-level reconstructions used in the study, lack of precise knowledge of rates of precipitation during the pluvial, and ambiguity in the pace of reef accretion. Within these bounds, the conclusions on the timing of Type-2 karst formation remain unchanged.