

Figure S1 X-ray diffraction results of stalagmite LH36. We collected powder samples at depth of 30, 75 and 120 mm for X-ray diffraction to verify the calcite composition. And the results show that LH36 is composed of pure calcite.

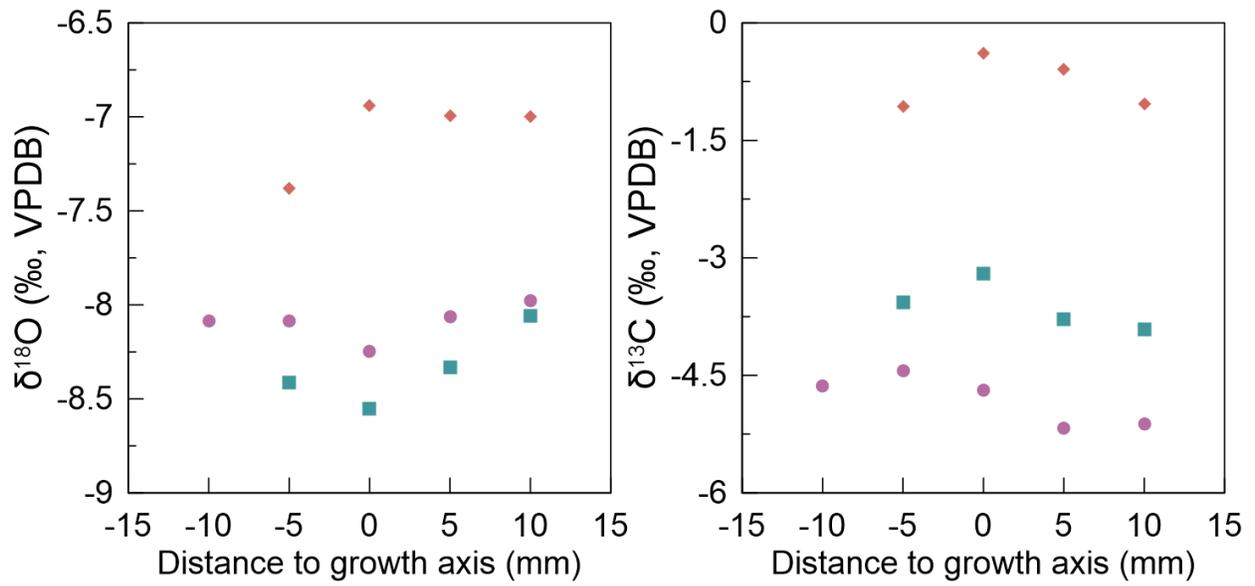


Figure S2 Hendy test results for stalagmite LH36. Samplings for Hendy test are collected at an interval of 5 mm. Purple circles indicate data at 158 mm, green rectangles indicate data at 146 mm and orange diamonds indicate data at 125 mm.

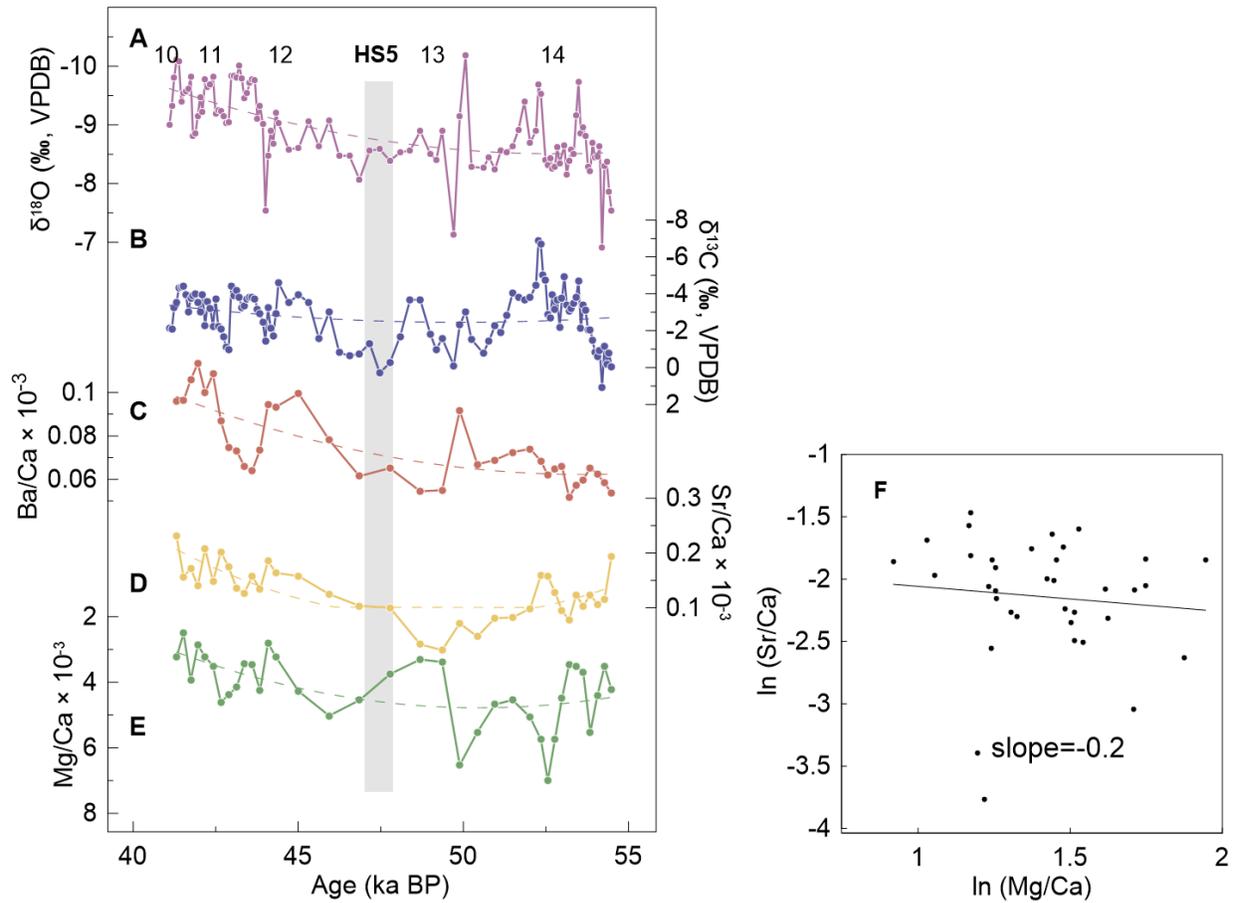


Figure S3 Multi-proxy records (left panel, A-E) and the PCP test results (right panel, F) for stalagmite LH36. From top to bottom are (A) LH36 $\delta^{18}\text{O}$, (B) LH36 $\delta^{13}\text{C}$, (C) Ba/Ca, (D) Sr/Ca and (E) Mg/Ca records. Grey shaded bars indicate HS5 event, and numbers indicate DO10 to 14 events. The slope for $\ln(\text{Mg}/\text{Ca})$ vs. $\ln(\text{Sr}/\text{Ca})$ is -0.2 in the right panel. This PCP test is derived according to Sinclair et al. (2012).

Table S1 $^{230}\text{Th}/\text{U}$ dating results for stalagmite LH36 from Lianhua Cave

| Sample ID | ^{238}U (ppb) | ^{232}Th (ppt) | $\delta^{234}\text{U}$ (measured) | $^{230}\text{Th}/^{238}\text{U}$ (activity) | $^{230}\text{Th}/^{232}\text{Th}$ atomic ($\times 10^{-3}$) | Age (ka) (uncorrected) | Age (ka) (corrected) | Age (ka BP) (relative to 1950 AD) | $\delta^{234}\text{U}$ (initial) |
|-----------|---------------------------|----------------------------|--------------------------------------|--|--|---------------------------|-------------------------|--------------------------------------|-------------------------------------|
| LH36-33 | 233.4 \pm 0.3 | 281.0 \pm 6.0 | 1922 \pm 3 | 0.822 \pm 0.002 | 11.258 \pm 0.240 | 34.73 \pm 0.10 | 34.72 \pm 0.10 | 34.64 \pm 0.10 | 2120 \pm 3 |
| LH36-37 | 161.9 \pm 0.1 | 2600.0 \pm 20.0 | 1571 \pm 2 | 0.839 \pm 0.002 | 0.861 \pm 0.008 | 41.20 \pm 0.10 | 41.10 \pm 0.10 | 41.08 \pm 0.14 | 1765 \pm 3 |
| LH36-51 | 97.5 \pm 0.1 | 2088.5 \pm 6.8 | 1474 \pm 3 | 0.825 \pm 0.003 | 0.635 \pm 0.003 | 42.41 \pm 0.20 | 42.20 \pm 0.23 | 42.13 \pm 0.23 | 1660 \pm 3 |
| LH36-80 | 95.6 \pm 0.1 | 8014.6 \pm 30.1 | 1630 \pm 3 | 0.928 \pm 0.006 | 0.183 \pm 0.001 | 45.30 \pm 0.36 | 44.52 \pm 0.53 | 44.44 \pm 0.53 | 1849 \pm 4 |
| LH36-95 | 102.6 \pm 0.1 | 11506.8 \pm 53.9 | 1196 \pm 3 | 0.842 \pm 0.006 | 0.124 \pm 0.001 | 50.31 \pm 0.46 | 49.06 \pm 0.78 | 48.99 \pm 0.78 | 1373 \pm 5 |
| LH36-113 | 156.9 \pm 0.2 | 8096.9 \pm 27.0 | 2478 \pm 4 | 1.400 \pm 0.007 | 0.447 \pm 0.003 | 52.66 \pm 0.31 | 52.31 \pm 0.36 | 52.23 \pm 0.36 | 2873 \pm 6 |
| LH36-127 | 140.9 \pm 0.2 | 11597.0 \pm 59.6 | 1500 \pm 3 | 1.021 \pm 0.007 | 0.205 \pm 0.002 | 54.11 \pm 0.46 | 53.31 \pm 0.60 | 53.24 \pm 0.60 | 1743 \pm 5 |
| LH36-147 | 256.9 \pm 0.3 | 10714.7 \pm 42.4 | 991 \pm 3 | 0.899 \pm 0.005 | 0.356 \pm 0.002 | 61.97 \pm 0.44 | 61.46 \pm 0.51 | 61.39 \pm 0.51 | 1179 \pm 4 |

* $\delta^{234}\text{U} = ([^{234}\text{U}/^{238}\text{U}]_{\text{activity}} - 1) \times 1000$.

** $\delta^{234}\text{U}_{\text{initial}}$ was calculated based on ^{230}Th age (T), i.e. $\delta^{234}\text{U}_{\text{initial}} = \delta^{234}\text{U}_{\text{measured}} \times e^{\lambda_{234}T}$. U decay constants: $\lambda_{238} = 1.55125 \times 10^{-10} \text{ yr}^{-1}$ (Jaffey et al., 1971) and $\lambda_{234} = 2.82206 \times 10^{-6} \text{ yr}^{-1}$ (Cheng et al., 2013).

Th decay constant: $\lambda_{230} = 9.1705 \times 10^{-6} \text{ yr}^{-1}$ (Cheng et al., 2013).

*** Corrected ^{230}Th ages assume the initial $^{230}\text{Th}/^{232}\text{Th}$ atomic ratio of $(4.4 \pm 2.2) \times 10^{-6}$. Those are the values for a material at secular equilibrium, with the bulk earth $^{232}\text{Th}/^{238}\text{U}$ value of 3.8. Errors are 2σ analytical errors. All ages are corrected to 'present' which is defined as the year 1950 AD.

Table S2 Pearson correlation coefficients for LH36 proxies ($p < 0.01$). For trace metal ratios, $n=36$; for trace metal ratios and stable isotopes, $n=36$; for stable isotopes, $n=107$.

| | $\delta^{18}\text{O}$ | $\delta^{13}\text{C}$ | Mg/Ca | Sr/Ca | Ba/Ca |
|-----------------------|-----------------------|-----------------------|-------|-------|-------|
| $\delta^{18}\text{O}$ | | 0.59 | 0.32 | -0.35 | -0.54 |
| $\delta^{13}\text{C}$ | 0.59 | | 0 | -0.07 | -0.23 |
| Mg/Ca | 0.32 | 0 | | -0.18 | -0.25 |
| Sr/Ca | -0.35 | -0.07 | -0.18 | | 0.53 |
| Ba/Ca | -0.54 | -0.23 | -0.25 | 0.53 | |

References

- Cheng, H., Edwards, R.L., Shen, C., Polyak, V.J., Asmerom, Y., Woodhead, J., Hellstrom, J., Wang, Y., Kong, X., Spötl, C., 2013. Improvements in ^{230}Th dating, ^{230}Th and ^{234}U half-life values, and U-Th isotopic measurements by multicollector inductively coupled plasma mass spectrometry. *Earth Planet. Sci. Lett.* 371, 82-91.
- Jaffey, A.H., Flynn, K.F., Glendenin, L.E., Bentley, W.C., Essling, A.M., 1971. Precision measurement of half-lives and specific activities of ^{235}U and ^{238}U . *Phys. Rev. C* 4, 1889-1906.
- Sinclair, D.J., Banner, J. L., Taylor, F.W., Partin, J., Jenson, J., Mylroie, J., Goddard, E. Magnesium and strontium systematics in tropical speleothems from the Western Pacific. *Chem. Geol.* 2012. 294–295, 1–17.