Table S1. BZBT1 U-Th ages and 2σ uncertainties. Shading identifies ages not used in age model development. Bold red text identifies ages that intersect lines AB or BC in Figure 5 and bold blue text identifies ages within 150 years of this line. Note that we considered U1-8 as intersecting line AB as it was used to initially construct the line; however, this age does not fully intersect the combined radiometric model lines after adding a growth rate change point at 20 mm.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | Depth | 238U | | 232Th | | 230Th / 232Th | | δ234U | | 230Th / 238U | | 230Th Age (yr) | | δ234UInitial | | 230Th Age (yr BP) | |
| Number | (mm) | (ppb) | | (ppt) | | (atomic x10-6) | | (measured) | | (activity) | | (uncorrected) | | (corrected) | | (corrected) | |
| U1-9 | 9.0 | 49.1 | ±0.1 | 514 | ±10 | 91 | ±12 | 1575.9 | ±11.3 | 0.0580 | ±0.0076 | 2477 | ±326 | 1586 | ±11 | 2298 | ±336 |
| **U1-8** | **17.0** | **46.7** | **±0.1** | **1090** | **±22** | **23** | **±1** | **1541.3** | **±14.5** | **0.0323** | **±0.0017** | **1393** | **±74** | **1546** | **±15** | **1065** | **±203** |
| U1-7 | 24.0 | 4.8 | ±0.0 | 385 | ±8 | 10 | ±1 | 1298.4 | ±11.6 | 0.0503 | ±0.0026 | 2408 | ±127 | 1303 | ±12 | 1319 | ±738 |
| **U1-6** | **33.0** | **3.8** | **±0.0** | **64** | **±2** | **33** | **±3** | **1236.5** | **±11.7** | **0.0334** | **±0.0032** | **1640** | **±159** | **1242** | **±12** | **1359** | **±222** |
| U1-5B | 41.0 | 3.6 | ±0.0 | 175 | ±15 | 83 | ±13 | 1103.2 | ±17.8 | 0.2475 | ±0.0341 | 13508 | ±1963 | 1144 | ±20 | 12779 | ±2009 |
| **U1-4** | **58.0** | **4.5** | **±0.0** | **66** | **±2** | **37** | **±3** | **1481.9** | **±8.2** | **0.0328** | **±0.0025** | **1451** | **±110** | **1487** | **±8** | **1217** | **±164** |
| **U1-3** | **75.5** | **44.1** | **±0.1** | **609** | **±12** | **49** | **±2** | **1610.7** | **±12.4** | **0.0412** | **±0.0016** | **1734** | **±67** | **1618** | **±12** | **1519** | **±128** |
| **U1-2** | **81.0** | **6.0** | **±0.0** | **235** | **±5** | **23** | **±1** | **1511.2** | **±19.0** | **0.0545** | **±0.0030** | **2387** | **±132** | **1520** | **±19** | **1876** | **±345** |
| U1-1 | 88.0 | 5.2 | ±0.0 | 672 | ±13 | 27 | ±1 | 1456.6 | ±12.6 | 0.2096 | ±0.0069 | 9642 | ±333 | 1490 | ±14 | 8067 | ±1121 |

Table S2. Radiocarbon ages of trapped OM extracted from BZBT1. Depth is the central point of the sample, and samples were 4-8 mm thick parallel with growth layers. The pMC is the percent modern carbon in the sample. Ages were calibrated using IntCal13 and the Calib7.10 program (Stuiver and Reimer, 1993). Shading identifies samples that did not produce enough organic material for full analysis. Bold red text identifies ages that intersect line AB in Figure 5 and bold blue text identifies ages within 150 years of this line.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | Depth  (mm) | OM Mass (mg) | 14C Age  (14C yr BP) | 2σ Calibrated Age (yr BP) | | pMC | δ13C  (‰ vs. VPDB) |
|  | Range | Median |
| OE1-8 | 5.0 | 0.000 |  |  |  |  |  |
| **OE1-3** | **20.0** | **0.065** | **990±35** | **796-963** | **908** | **88.41±0.37** | **-23.0** |
| OE1-7 | 36.0 | 0.000 |  |  |  |  |  |
| **OE1-6** | **52.0** | **0.176** | **1170±30** | **986-1179** | **1101** | **86.40±0.31** | **-21.5** |
| OE1-5 | 72.0 | 0.000 |  |  |  |  |  |
| OE1-2 | 83.0 |  |  |  |  |  | -21.9 |
| OE1-9 | 87.0 | 1.000 | 1080±25 | 933-1055 | 982 | 87.41±0.26 | -24.9 |
| **OE1-1** | **93.0** | **1.000** | **1780±30** | **1616-1812** | **1699** | **80.15±0.29** | **-24.2** |
| **OE1-4** | **93.0** | **1.000** | **1700±25** | **1548-1694** | **1600** | **80.93±0.25** | **-24.9** |

Table S3. BZBT1 CaCO3 matrix radiocarbon ages and 2σ uncertainties. Bold red text indentified ages that have a paired OM age.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Depth  (mm) | 14C Age  (14C yr BP) | pMC | δ13C  (‰ vs. VPDB) |
| RC1-10 | 0.0 | 350±50 | 95.71±0.28 | -2.6 |
| RC1-11 | 3.0 | 1180±50 | 86.37±0.25 | -8.0 |
| RC1-9 | 8.0 | 1360±40 | 84.40±0.22 | -7.1 |
| **RC1-7** | **21.0** | **1700±50** | **80.90±0.25** | **-7.8** |
| **RC1-4** | **57.0** | **2010±40** | **77.86±0.22** | **-10.6** |
| RC1-3 | 78.0 | 1820±50 | 79.62±0.23 | -10.1 |
| RC1-2 | 80.0 | 1600±50 | 81.09±0.25 | -7.0 |
| RC1-1 | 88.5 | 1780±50 | 80.10±0.27 | -8.8 |
| **RC1-0** | **93.0** | **2090±50** | **77.12±0.25** | **-5.6** |

S1. Lidar analysis of the Box Tunich region

For the lidar analysis here, the Topographic Position Index (TPI) was used to identify archaeological features (referred to as “possible” mounds and terraces) and natural features (“possible” caves and sink holes) in a 20 km2 area around Box Tunich Cave. TPI analysis produces a raster with cell values reflecting the difference between the elevations in a particular cell and the average elevation of cells within a specified search radius (Jenness, 2006; Weiss, 2001). Positive TPI values indicate that the cell is higher and steeper on average than neighboring cells, and significantly high values suggest the cell represents a high point within a specified search radius (i.e., hilltop). When considered at the local scale, features such as mounds and terraces are represented by higher TPI values (Awe et al., 2015; Ebert et al., 2016). Cells with negative TPI values are located in areas with lower elevation and may represent caves or sink holes.

Pre-processed lidar point cloud data (see Chase et al., (2014), for data processing methods) were analyzed using the LAS data set tools in ArcGIS 10.5. A digital terrain model for the study area was created from first and second lidar ground return points, with a resulting 1 m resolution. TPI analyses were performed using an open access extension for ArcGIS 9.3-10.x (Jenness, 2006). An annular search area was used to classify slope position within 1 km2 sub-sample blocks, where cells within 2 m and 10 m from the sample points were considered in TPI calculations (Ebert et al., 2016). The search neighborhood can thus identify variations of topography within each sample block, including areas with high TPI values and elevations within and between residential mound groups. This method is very similar to application of local relief modeling lidar data used to identify caves in western Belize (Moyes and Montgomery, 2016).

TPI rasters were classified based on standard deviations from the elevation, reflecting the variability of elevation within each sample block (Weiss, 2001). Cells with the highest values represented other features on the ground surface that resembled archaeological structures such as agricultural terraces or mounds (Awe et al., 2015). Features identified as terraces were digitized from the TPI raster for each sub-sample block manually as line features. Features identified as mounds were exported as individual shapefiles for additional quantitative analyses within ArcGIS. Area, volume, and elevation for each shapefile were calculated using the ArcGIS 3D Analyst toolbox according to methods described in Ebert et al., 2016.

In order to produce a conservative estimate of the number of mounds in the study area, possible mounds with volumes less than 8 m3 (Ashmore, 1981) or surface areas less than 25 m2 (Yaeger, 2005) were eliminated from the sample since they are likely too small to have been residences. These smaller features identified by TPI may represent non-residential architecture including field houses, kitchens, and other ancillary structures. Alternatively, they may be the result of modern bioturbation (e.g., dirt pulled up by tree fall or bulldozed areas) or locations of lower-resolution within the lidar point cloud (Ebert, 2015; Hutson, 2015). Features identified as possible caves of karst sink holes were also exported as individual shapefiles, though no additional metrics were calculated.

The identified features of mounds, terraces, and caves were also visually verified against the color classified TPI rasters. Based on a comparison of six different lidar visualization methods, Hutson (2015) suggests that color-classified rasters provide one of the most reliable method for the identification of archaeological features. We also used several other visual techniques to eliminate modern cultural features (e.g., modern houses) and natural features (e.g., tree growth/falls) which may have been misidentified as possible mounds. This included systematic visual inspect of a hillshade model produced from lidar data for the Belize Valley, visual inspection of Landsat 8 satellite imagery captured on 16 December 2014, and producing profile views of features identified as possible mounds using the LAS extension tools in ArcGIS 10.5.

A total of 214 possible mounds were identified in the 20 km2 study region around Box Tunich Cave using TPI analyses. These mounds are concentrated to the north of the cave at lower elevations. Possible mounds may include more than one structure on a large platform or may represent individual residential structures. Pedestrian ground-truthing survey would be necessary to determine these distinctions for each identified group. A total of 14.05 linear km of possible terraces were also identified by TPI analyses, many of which flank the hillsides around residential groups.

Based on the TPI results, no archaeological features were present immediately adjacent to the entrance of Box Tunich Cave. It should be noted that the study region has been heavily impacted by modern development, however, and that it is highly likely that activities such as construction and farming have destroyed prehistoric features in the area. Over 209 possible caves and/or sinkholes, including Box Tunich Cave, were also identified using TPI analyses. These natural features are present throughout the entire region and concentrated in the southeastern portion of the study area.

S2. Concerns regarding the basal layers

Samples from 80-87 mm in depth have exceptionally high δ18O and δ13C values as well as abrupt changes in values at the boundaries bracketing the zone. These samples correspond to a single dense calcite section clearly visible to the naked eye directly above the bottommost deposits, and the abrupt value changes occur at the top and bottom petrographic boundaries of the section. These abrupt isotopic changes and clear petrographic bounds suggest growth hiatuses bracketed the deposition of this section (Railsback et al., 2003). Additionally, the high stable isotope values in the 80-87 mm section are consistent with an increased effect of kinetic fractionation from greater outgassing and prior calcite deposition. While the bottommost layers from directly below the section described above do not share exceptionally high isotopic values, they are also composed of dense calcite in contrast to the braided calcite of the upper zones.

Finally, the CaCO3 radiocarbon ages from these two dense calcite sections are also largely younger than the CaCO3 ages from the upper zone, and this is likely due to differences in the DCF of the formative water. The combined petrographic, isotopic, and radiocarbon results support a different water source or water routing for these basal layers relative to the main braided calcite upper section. This makes comparisons of isotopic and DCF data between the basal and upper zones difficult and uncertain. Thus we have interpreted the DCF corrections separately for the basal section, and we do not place as much emphasis on the basal stable isotopes in our isotopic tuning.

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