

URANIUM SERIES DATES FROM MASS MOVEMENT CAVES ON THE ISLE OF PORTLAND, DORSET, UK.

by

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ABSTRACT

Dating of speleothems from exposed fissures on the Isle of Portland show that fissuring on the east side of the Isle had started before 54 ka in Marine Isotope Stage (MIS) 3 with speleothem growth also occurring in MIS 2.

The peninsula known as the “Isle” of Portland is capped by upper Jurassic Portland Stone – a marine limestone famed as a building stone after being used by Sir Christopher Wren in the rebuilding of London following the great fire of 1666. Many fissures containing bones were discovered during the 19th century (Gray, 1861) but the landscape has been very heavily altered by quarrying. The beds dip very gently to the south and are a fragment of the southern limb of the Weymouth anticline.

Since the 1960s a series of abandoned dissolutional caves have been explored on the island (O'Connor and Graham 1996) consisting mainly of low phreatic tunnels from which much clastic material has been excavated to facilitate exploration. The phreatic tunnels were found to intersect fissures which have the characteristics of mass movement caves (Cooper, 1983, Cooper, *et al.* 1996) and examples have now been found all over the island (Ford and Hooper, 1964; Churcher, *et al.* 1970; Graham 1981).

The fissures contain flowstone deposits, the presence of which on the side of slipped blocks was used by Cooper, *et al.* (1995) to show the fissures were a result of toppling failure. The cliffs on the west coast are described as probably the finest British examples of toppling failure (Cooper, 2007). Flowstone deposits often cement clasts ranging from sand to boulder size to the cliff face at varying heights above the cliff foot showing that calcite coated cliff faces of today were once the landward side of fissures (Cooper, 2007). The intersection of the dissolutional caves by the fissures would have resulted in the draining and abandonment of the phreatic passages however O'Connor and Graham (1996) hypothesised that the caves were drained earlier than this by valley incision to the east and west of the present day Portland area. Some of the areas caves show the development of nick points and floor trenches indicating there was a vadose phase in their history (Graham and Ryder, 1983).

Following recent work dating speleothems deposits in the mass movement caves of the North York Moors (Murphy and Lundberg, 2008) an attempt was made to date the flowstone deposits from such caves in Portland and thus constrain the timing of the abandonment of the dissolutional caves.

Samples were taken from abandoned quarry walls on the east side of the isle at NGR SY 690 699 which had been fissures before the removal of material by quarrying activity. Two samples were sent for uranium series disequilibrium dating by inductively coupled plasma mass spectrometry at Bristol University. The samples were dated using protocols detailed in Hoffmann *et al* (2007). The pieces yielded dates of 23.1 and 54.3 ka (Table1).

Sample Code	Age (ka)	^{238}U conc (ng/g)	^{232}Th conc (ng/g)	$^{230}\text{Th}/^{238}\text{U}$	$^{234}\text{U}/^{238}\text{U}$	$^{230}\text{Th}/^{232}\text{Th}$	Initial $^{234}\text{U}/^{236}\text{U}$
IO P5	23.1±5.9	414.3±15.7	170.1±6.3	0.292±0.001	1.074±0.002	2.17±0.01	1.088±0.006
IO P6	54.3±0.3	1927.6±9.6	1.59±0.01	0.412±0.001	1.048±0.002	1526.1±9.4	1.056±0.002

Table 1. All errors are 2σ . A correction for detrital Thorium of $^{232}\text{Th}/^{238}\text{U} = 1.25 \pm 0.625$ has been adopted. Ratios are activity ratios.

The results show that fissuring on the east side of the Isle of Portland had started before 54 ka in Marine Isotope Stage (MIS) 3 with speleothem growth also occurring in MIS 2, the Devensian glaciation of Northern England. The dissolutional cave passages were drained and abandoned by the middle of the late Pleistocene. Kents Cavern, 75 km west of Portland, at approximately the same latitude has been the subject of extensive speleothem dating studies (Lundberg and McFarlane, 2007). During MIS 2 and 3 it was characterised by clastic sediment deposition rather than speleothem growth though a single date of 47 ± 3 ka showed some growth was occurring in the system during MIS 3.

Speleothem deposits do occur in the dissolutional caves on Portland. Dating of such deposits will be a major step forward in understanding the chronology of cave development in this speleologically intriguing area.

REFERENCES

- CHURCHER, R.A., BUTLER, B. and BARTLETT, P.D. 1970. A further report on the caves of the Isle of Portland. *Transactions of the Cave Research Group of Great Britain*. **12**, 4. 291-298.
- COOPER, R.G. 2007. Blacknor Cliffs, Isle of Portland, Dorset. In Cooper, R.G. *Mass Movements in Great Britain*. Geological Conservation Review series 33. Peterborough. Joint Nature Conservation Committee. 249-251.
- COOPER, R.G. 1983. Fissures in the interior of the Isle of Portland. *Newsletter of the William Pengelly Cave Studies Trust* **42**, 1-3.
- COOPER, R.G., GRAHAM, N. and READ, M. 1995. Solutional Cave Passages intersected by Mass Movement Rifts in the Isle of Portland, Dorset. *Studies in Speleology* **10**, 29-35.
- FORD, T.D. and HOOPER, M.J. 1964. The caves of the Isle of Portland. *Cave Science* **10**, 30. 171-180
- GRAHAM, N. 1981. The caves of the Isle of Portland. *Journal of the Wessex Cave Club*. **16**, 144-148.
- GRAHAM, N. and RYDER, P.F. 1983. Sandy Hole, isle of Portland. *Cave Science* **10**, 3. 171-180
- GRAY, W. 1861. On the geology of the Isle of Portland. *Proceedings of the Geologists Association*. **1**, 128-147.
- HOFFMANN, D.L., PRYTULAK, J., RICHARDS, D.A., ELLIOTT, T.R., COATH, C.D., SMART, P.L. and SCHOLZ, D. 2007. Procedures for accurate U and Th isotope measurements by high precision MC-ICPMS. *International Journal of Mass Spectrometry*. **264**, 97-109.

- LUNDBERG, J. and McFARLANE, D.A. 2007. Pleistocene depositional history in a periglacial terrane: A 500 ky record from Kents Cavern, Devon, United Kingdom. *Geosphere*. **3**. 199-219.
- MURPHY, P.J. and LUNDBERG, J. 2008. Uranium series dates from the Windypits of the North York Moors: implications for late Quaternary ice cover and the timing of speleogenesis. *Earth Surface Processes and Landforms* **34**. 305-313. DOI: 10.1002/esp.1752
- O'CONNER, M. and GRAHAM, N. 1996. *The Caves of the Isle of Portland*. Wessex Cave Club Occasional Publications Series 3 No. 3. 1996. ISBN 0950043346.

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