The ClO values obtained here are consistent with the upper limit and tentative detection of our earlier summer aircraft measurements (*2*), the recent winter ground-based microwave measurement (*16*), and the mean of winter in situ resonance fluorescence measurements (*17*). Our winter balloon measurement and earlier summer aircraft measurements indicate less ClO above ~ 30 km than was measured by laser heterodyne radiometry (*18*) in autumn and, occasionally, by resonance fluorescence in summer (*17*). Simultaneous measurements with our instrument and others should show whether these differences are due to natural variability or to measurement technique.

Note added in proof: A second flight of the BMLS from the National Scientific Balloon Facility was performed on 11 and 12 May 1981, and useful ClO and O_3 measurements were obtained between approximately midnight and noon. Initial analyses show that (i) before sunrise the ClO averaged over the altitude region ~ 27 to 33 km is at least ten times below its midday value, and (ii) after sunrise the ClO at ~ 27 to 33 km increased, reaching a value by 11 a.m. (local time) which agreed with that measured on the first BMLS flight within 20 percent. These initial results from the second flight further support theoretical predictions that $ClONO_2$ is formed from ClO in the stratosphere at night. The tentative H_2O_2 feature is still under investigation.

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Dated Rock Engravings from Wonderwerk Cave, South Africa

Abstract. *Radiocarbon dates associated with engraved stones from sealed archeological deposits at Wonderwerk Cave in the northern Cape Province indicate that rock engraving in South Africa is at least 10,000 years old.*

Prehistoric rock art in South Africa is found in the form of both paintings and engravings. Rock paintings are generally found on cave and shelter walls in the coastal regions and in mountain ranges along the Great Escarpment and occasionally also as "art mobilier," such as painted stones, found in archeological deposits in southern Namibia and the southern Cape Province. Rock paintings are infrequently found in the semiarid interior plateau regions, on cave and shelter walls in the relatively rare mountainous areas such as the Kuruman Hills. Engravings on exposed rocks scattered in the veld and on glacial pavements are clearly the most prevalent form of rock art in the interior plateau regions (*1*).

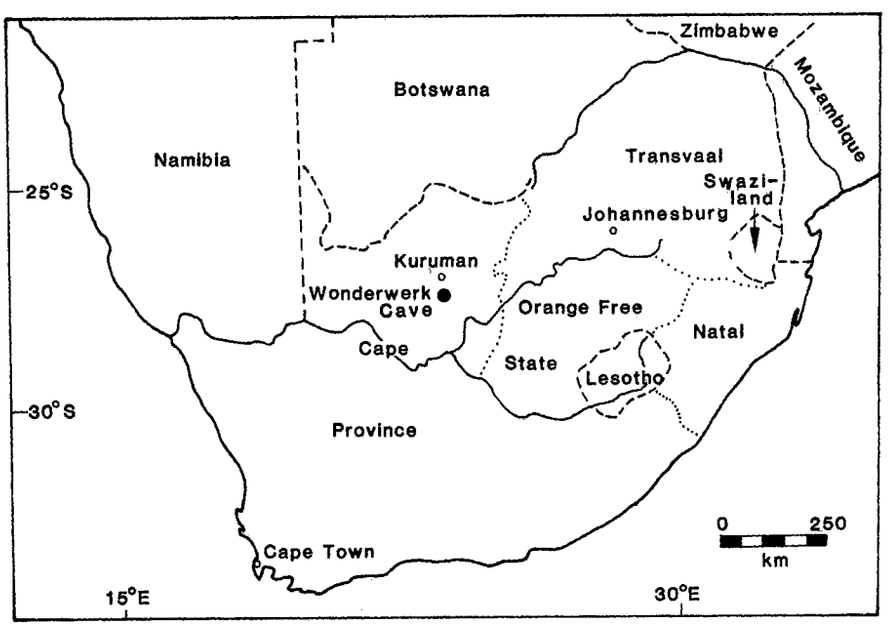

Fig. 1. Map showing the location of Wonderwerk Cave in the northern Cape Province, South Africa.

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That rock painting in Southern Africa is perhaps 26,000 years old has been recently established from radiocarbon dates associated with art mobilier from the Apollo 11 Cave in southern Namibia (*2*). Painted stones from archeological sites in the southern Cape Province have been similarly dated to periods within the last 7000 years (*3*). Rock engravings have not been found in archeological deposits in South Africa, but superpositioning and differences in patination have been used to deduce that fine "hairline" engravings are older than "pecked" engravings, while inferred geological relationships are claimed to indicate that the practice of rock engraving is at least 4000 years old (*1*).

We report here the recent discovery of engraved stones in sealed archeological deposits at Wonderwerk Cave in the northern Cape Province (Fig. 1). The radiocarbon dates associated with these engraved stones provide minimum ages for rock engraving in South Africa that extend back to 10,000 years before the present (B.P.).

Wonderwerk (27°50′45″S, 23°33′19″E) is a very large cave, apparently representing a solution cavity in stromatolitic dolomite. It runs almost 140 m into the base of a low foothill on the eastern flank of the Kuruman Hills and has a mean width of about 18 m. The maximum roof height above the modern floor ranges from about 10 m near the cave mouth to less than 3 m elsewhere. Light fails rapidly as one enters the cave, with areas inward of about 45 m being in permanent darkness. The most arresting internal feature is a large stalagmite, rising more than 5 m above the modern floor, situated 19 m from the cave entrance. A thick deposit of bat guano, suitable for fertilizer, was present in the cave in the past (*4*), and most of the area inward of about 35 m has been badly disturbed by guano diggers during the 1940's (*5*) (Fig. 2). Rock paintings in red, yellow, black, and white, depicting animals and enigmatic designs, are found on the cave walls up to about 40 m from the entrance but have been badly defaced by graffiti since the early 1900's (*5–7*).

Wonderwerk Cave has been the subject of a number of archeological investigations since the first published description (*8*). These include excavations conducted by Malan and Wells in 1943–1944 and by Malan and members of the University of California African Expedition (Southern Section) in 1948 (*5, 9, 10*) (Fig. 2). A study of existing collections and sections was begun by Butzer in 1974; eight radiocarbon dates together with some sedimentological information have been published (*1, 11*). Excavations conducted by Beaumont in 1978 showed that the cave contained a Later Stone Age sequence spanning the Holocene in the top meter of deposit (layers 1 to 4d). Below this was probable Later Stone Age material in layers 5a to 5b and Earlier Stone Age material down to layer 16 on bedrock at 3.9 m (*12*). These excavations were extended by Thackeray and Thackeray in 1979 in an effort to obtain large cultural and faunal samples, as well as additional radiocarbon dates, from the Holocene layers.

Only the Holocene stratigraphy is relevant to this report. The stratigraphy described below (Fig. 2) applies to the excavation of Thackeray and Thackeray, but it is essentially similar to that found by Beaumont (*12*). All sediments were removed by natural layer, with further arbitrary 5-cm subdivisions when the stratum thickness exceeded that value. These arbitrary subdivisions are referred to by Roman numerals (for example, 4aI, 4aII, and so forth). The stratigraphy is as follows: layer 1a, comminuted sheep and cattle dung plus surface dust; layer 1b, stone rubble, presumably from the guano diggers, in unconsolidated sheep and cattle dung; the dung in layers 1a and 1b undoubtedly results from the use of the cave as a stock shelter after 1911 (*9*);

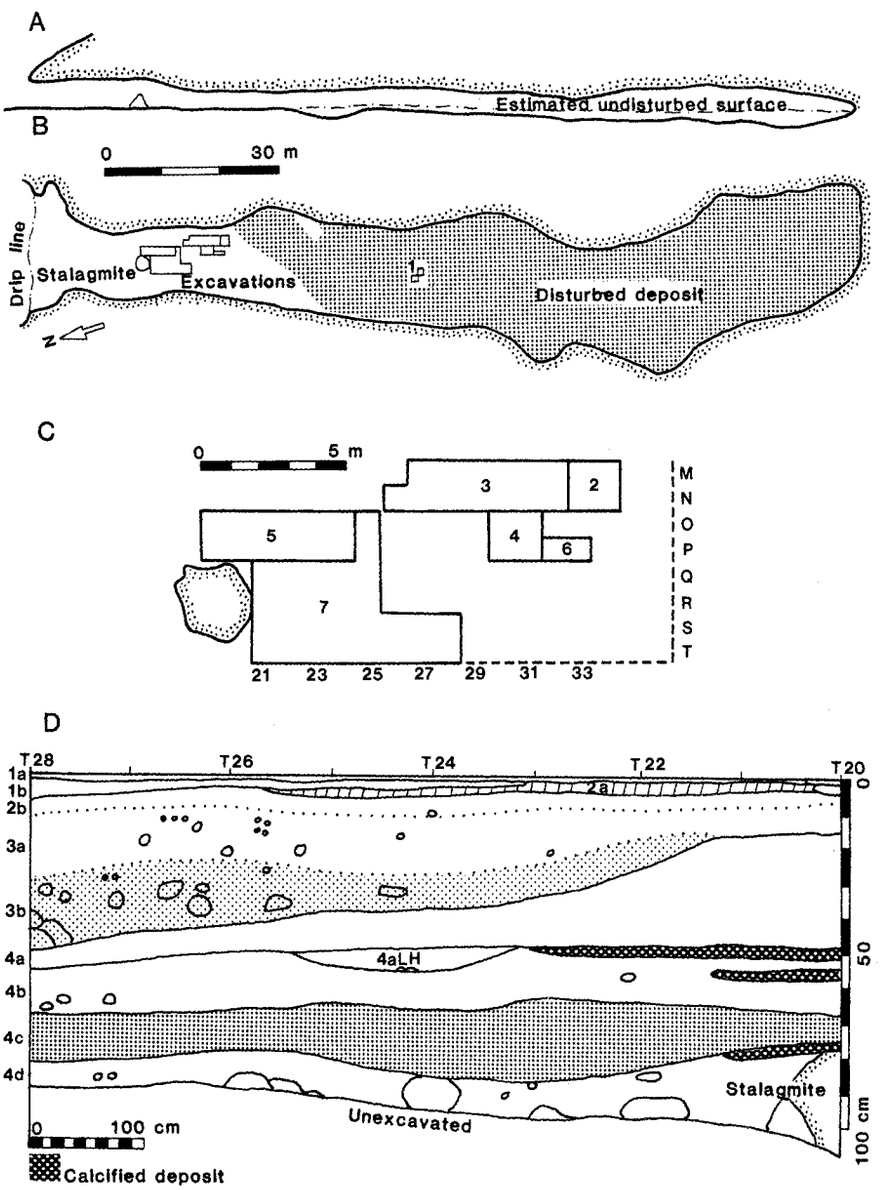


Fig. 2. Wonderwerk Cave. (A) Profile. (B) Plan, showing the excavated and disturbed areas. (C) Enlargement of the excavated areas and grid system: *1* and *2*, Malan and Wells (1943); *3*, Malan (1944), *4*, Malan and the University of California African Expedition (Southern Section) (1948); *5* and *6*, Beaumont (1978); and *7*, Thackeray and Thackeray (1979). (D) Section along line *T* of the excavation of Thackeray and Thackeray.

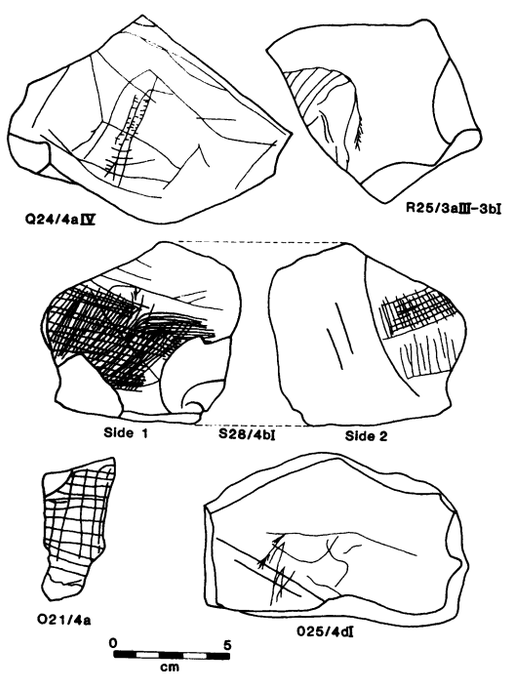
layer 2a, daga floor, probably laid down by N. J. Bosman, who lived in the cave between 1909 and 1911 (*6*); layer 2b, dung and twigs in soft dark brown sand; layer 3a, soft dark brown sand; layer 3b, guano and minor roof spall in soft dark brown sand, not well represented in the area of Beaumont's excavation; layer 4a, red-brown sand; layer 4aLH, a localized layer covering only a few square meters at the base of layer 4a, containing an unusually high concentration of artifacts, fauna, and charcoal; layer 4b, red-brown sand, slightly darker than that of layer 4a, overlain by a thin calcified crust; layer 4c, a series of compacted travertine sheets with interbedded beige sand; and layer 4d, red-brown to orange sands with ash lenses and large slabs, including roof spall.

Table 1. Radiocarbon dates from the excavations of Beaumont (B) and Thackeray and Thackeray (T) of Wonderwerk Cave.

Number	Years (B.P.)	Association	Excavation
Pta-2779	1,210 ± 50	2b	T
Pta-2542	1,890 ± 50	3 top (= T, 3a top)	B
Pta-2543	2,910 ± 60	3 base (= T, 3a base)	B
Pta-2785	3,990 ± 60	3a/3b interface (engraving)	T
Pta-2541	4,240 ± 60	4a top	B
Pta-2797	4,890 ± 70	4a base	T
Pta-2544	5,180 ± 70	4b	B
Pta-2545	5,970 ± 70	4c	B
Pta-2798	7,430 ± 60	4c top	T
Pta-2546	9,130 ± 90	4d	B
Pta-2786	10,200 ± 90	4d top (engraving)	T
Pta-2790	10,000 ± 70	4d base	T

Table 2. List of unequivocal engraved stones from Wonderwerk Cave

Square/layer	Description and dating
Q24/4aIV	Dolomite, broken, enigmatic "ladder" design with lines; dated to about 4890 ± 70 years B.P. (Pta-2797)
R25/3aIII-3bI	Dolomite, broken, hindquarters of zebra; dated to 3990 ± 60 years B.P. (Pta-2785)
S28/4bI	Dolomite, broken, similar grid pattern on both sides; dated to about 5180 ± 70 years B.P. (Pta-2544)
O21/4a	Hematite, broken, grid pattern; dated to about 4240 ± 60 years B.P. (Pta-2541)
O25/4dI	Dolomite, unfinished mammal, head not drawn; dated to 10,200 ± 90 years B.P. (Pta-2786)



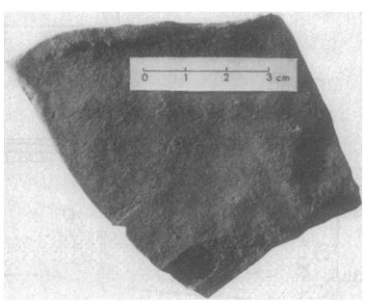


Fig. 3 (left). Drawings of the unequivocal engravings from Wonderwerk Cave. Fig. 4 (right). Photograph of engraving R25/3aIII-3bI, showing the hindquarters of a zebra.

The cultural material from layers 1 to 4c belongs to the Wilton Complex but differs from the material of the Wilton Industry known in the southern and eastern Cape Province, whereas that from layer 4d belongs to the Oakhurst Complex (*13, 14*). The faunal assemblages from layers 1 to 4d are predominantly represented by grazing fauna, including zebra, wildebeest, or hartebeest. *Equus capensis*, the extinct giant horse, is present in layer 4d, whereas *Megalotragus* sp., an extinct alcelaphine, is last recorded in layer 4c (*15*).

Holocene radiocarbon dates from the excavations of Beaumont and Thackeray and Thackeray (Table 1) were obtained from charcoal nodule samples. Two dates are associated with rock engravings: Pta-2785 with R25/3aIII-3bI and Pta-2786 with O25/4dI (see Fig. 2, c and d, for an explanation of the squares and layers). The division between layers 3a and 3b was indistinct in square R25, and the engraving in question is considered to be located in a boundary zone between these two layers. Its stratigraphic position and that of the associated radiocarbon date are referred to as 3aIII-3bI (interface between the base of 3a and the top of 3b). The other rock engravings are dated by extrapolation from radiocarbon dates obtained elsewhere in the same stratum.

The engravings are referred to by the square and layer from which they were recovered. All the engravings, except the grid design on hematite (O21/4a) which was excavated by Beaumont, were recovered from the excavation of Thackeray and Thackeray. Five unequivocal engraved stones were found (Table 2 and Fig. 3). A photograph of one example is presented in Fig. 4. In addition, six probable engravings depicting incised line designs were found in layers 3aI, 3aIII, 3bI, 4bI, and 4cI (two), respectively. These are less certain examples of rock art since there is a possibility that the lines could be utilization scars (*13*).

The engravings are entirely on dolomite, apart from the hematite specimen (O21/4a), and all but one (O25/4dI) are clearly broken. There appear to be no changes in content and technique during the 8000 years engravings occur at Wonderwerk Cave: all are fine incisions presumably produced by means of a hard pointed stone, and similar enigmatic line designs, grid patterns, or animal representations occur throughout the sequence. It seems likely that the slightly thicker incised lines in the hematite example reflect the relative softness of this raw material. It is not possible to asso-

ciate the engravings with a particular cultural tradition because they are associated with both the Wilton and the Oakhurst complexes represented in the Holocene sequence at Wonderwerk Cave. That rock painting can similarly not be associated with a particular tradition has also been demonstrated by the observation that paintings are found not only in association with the Wilton Complex dating to the Holocene but also in association with different and older material dating to the Upper Pleistocene (*1*, *2*). When larger samples of dated rock art become available, it may be possible to make stylistic distinctions between cultural traditions.

Rock art in South Africa has been variously interpreted as either representational art (*16*) or as expressions of ritual and symbolism (*17*, *18*). There is good reason to assume that the artists responsible for both paintings and engravings shared at least some common beliefs. Quantitative analyses of rock art drawn from relatively large samples indicate that the eland is the predominant animal represented in both paintings (*17*) and engravings (*19*). Therianthropes (animal-headed figures) are similarly found in both media, although they are rare in engravings (*20*). Attention has been drawn to the possibility that some paintings in the Drakensberg region may represent an expression of trance experience and beliefs associated with rituals similar to those known among modern !Kung Bushmen (*18*). Recent studies on human subjects show that grid systems and parallel lines of the kind represented in most of the Wonderwerk engravings are often typical of hallucinatory experience (*21*). However, grids and line systems are often used for figure infilling and portion emphasis in engravings, or even to depict the ground surface (*20*). As all except one of the Wonderwerk engravings are broken, it is not possible to establish whether the grid and line depictions are examples of representational art or are best interpreted in terms of concepts associated with trance experiences.

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6-Methoxybenzoxazolinone: A Plant Derivative That Stimulates Reproduction in *Microtus montanus*

Abstract. *A plant-derived cyclic carbamate, 6-methoxybenzoxazolinone, that stimulates reproductive activity in* Microtus montanus *has been isolated. This nonestrogenic compound may be a naturally occurring environmental cue affecting reproductive cycles in many mammals.*

More than 40 years ago, Rowan (*1*) noted that endocrine systems regulating mammalian reproduction respond to an environmental stimulus, the photoperiod. In 1946, Bodenheimer made the observation that major outbreaks of voles in Palestine could not be correlated with prevailing environmental factors such as climate, photoperiod, volume of food resources, or population density, acting either alone or in combination. From his studies, Bodenheimer suggested that vole outbreaks were associated with the action of an unknown factor in the food supply (*2*). Negus *et al.* (*3*) also observed a correlation between reproductive activity in the montane meadow vole, *Microtus montanus*, and the onset of growth of the plant food resource. Subsequent field and laboratory experiments confirmed the existence of a plant factor that increases fertility and triggers reproductive activity in *M. montanus* (*4*, *5*).

Microtus montanus typically inhabits the mesic montane meadows of western North America. The onset and termination of the growing season in these environments may vary by 1 month or more from year to year. Thus the vegetative food resources are highly uncertain for a short-lived herbivore. Accordingly, if an environmental cue were available to *Microtus* that accurately predicted food resources in the near future, optimal timing of reproductive effort could be attained with the attendant benefits to fitness (*6*). Our studies of responses by *Microtus montanus* to green plant material in the diet have led us to the identification of a naturally occurring compound that functions as a reproductive trigger in this species.

Winter wheat was used for extraction because previous studies indicated that an acetone-ether wheat extract was effective in stimulating reproduction in *Microtus montanus* (*4*, *5*). The wheat was grown under standard greenhouse conditions to a height of 10 cm, harvested, and homogenized with an equal weight of acetone. The mass was suction-filtered, and the filtrate, including several acetone washes, was freed from acetone at room temperature by means of an aspirator. The remaining heteroge-

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