ARCHAEOLOGY

Fission Track Dating of a Mesolithic Knife

We wish to direct the attention of archaeologists to the fission track dating method[1], which can be of great use in dating many objects of archaeological interest. This method has given correct dates over a time span extending from 20 years[2] to more than 10^9 years[3], and shows special promise for archaeology and prehistory because of its use in dating a variety of glasses, both natural[4,5] and man-made[2,6].

In brief, the method depends on the fact that most materials contain small quantities of uranium, which undergoes spontaneous fission, thereby creating damage tracks which are easily revealed by chemical etching. For samples less than about 10^9 years old the age is proportional to the density of tracks, ρ_s, and also to the uranium content, which is found by neutron irradiation of the sample, which causes further fissions the density, ρ_i, of which is proportional to the uranium content[7]. The age in years is given by $A = 6{\cdot}12 \times 10^{-8}\, \varphi(\rho_s/\rho_i)$, where φ is the integrated neutron flux per cm^2. Fig. 1 shows an example of etched fission tracks in glass. Dating of objects 20–100 years old is only possible for materials of unusually high uranium content[2]. However, by an example we shall now show that dates of a few thousand years are accessible for materials of archaeological interest and normal uranium contents.

Fig. 2 shows an obsidian mesolithic knife blade from excavations carried out at Gamble's Cave II, Elmenteita, in 1927 by Dr. Leakey and his expedition. The knife blade was originally struck from an obsidian core in Mesolithic times. At some later date it was accidentally heated to a high enough temperature, thus resulting in the wilted shape which can be seen in Fig. 2. Since such a form of heating is known to remove pre-existing tracks[4,8], those now present must have formed since the knife was burnt in the fire. Hence, if enough tracks are present, the time at which the heating occurred can be determined.

For dating, a 0·1-g piece (less than 2 per cent of the total weight of the knife) was cut from the butt end of the knife, one surface given an optical polish, etched for 15 sec in hydrogen fluoride, surveyed for tracks, and then surveyed a further 36 times, following re-etching to expose a series of fresh surfaces in succession. In this manner 17 tracks were found on 5·6 cm^2 surface. Fig. 1 shows tracks found after this same piece was exposed to thermal neutrons. The track count of about 64,000/cm^2 indicates a uranium content of about 6 parts per million, a normal concentration for acid igneous glasses[4,5,9,10]. The computed age of the burning of this specimen is 3,700 (± 900) years before the present.

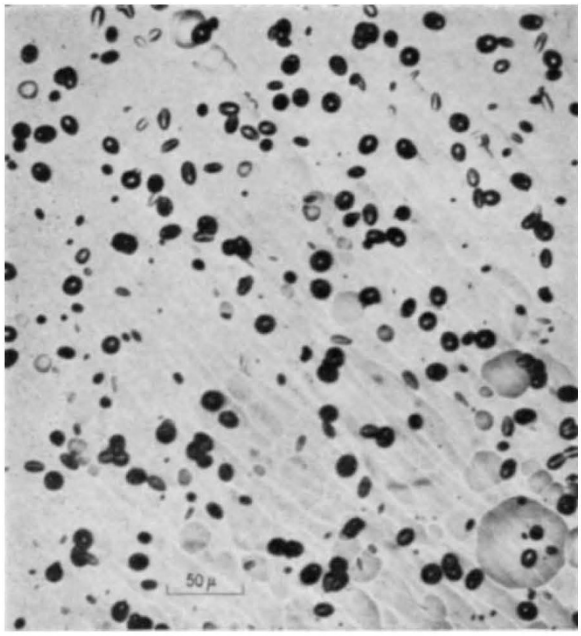

Fig. 1. Fission track etch pits in an irradiated piece of glass from a mesolithic knife. The neutron dose $1{\cdot}3 \times 10^{15}$ n.v.t.

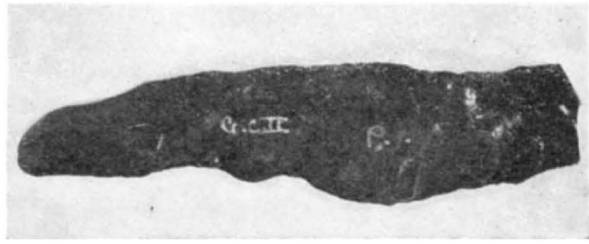

Fig. 2. The burnt obsidian blade from Gamble's Cave II, Elmenteita. The blade was re-softened by heating about 4,000 years ago. The length is 7·3 cm

This dating strongly suggests that the burning of the specimen occurred during Neolithic occupation of Gamble's Cave II. Overlying the Elmenteita culture level (to which this blade belongs culturally) was a brief Neolithic occupation with a large number of hearths. The twisted nature of the blade, as has already been stated, clearly indicates that it had been partially melted and burnt, and it was originally assumed that this burning had occurred in a Mesolithic hearth. It seems more likely that the burning of the blade was due to the intense heat of an overlying Neolithic hearth, since the date obtained compares very closely with a carbon-14 date obtained for charcoal from a Neolithic cremation at Njoro River Rock Shelter.

The rather considerable error of nearly 25 per cent is a simple result of the number of tracks counted (17). Since a survey of 1 cm^2 of surface required about 2 h, a count of 90 tracks would require about 60 h and would reduce the standard deviation error to 400 years.

By way of summary we can point out three types of situations in which fission track dating could be of use in archaeology:

(1) *Man-made glass.* Either recent material (more than 20 years old) to which uranium has been deliberately added as a colorant[2], or somewhat older glass (more than about 2,000 years old) having enough natural uranium as part of the raw materials[6].

(2) *Natural glass (or crystals) the time of formation of which is known to correspond to an activity of man.* An example of this situation would be the dating of volcanic glass laid down during the lifetime of some pre-man, as is found in the Olduvai Gorge[11].

(3) *Natural glass known to have been re-heated by some agent at a time that is of interest.* The present example of the knife illustrates this possibility.

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[1] Price, P. B., and Walker, R. M., *J. Geophys. Res.*, **68**, 4847 (1963).
[2] Brill, R. H., Fleischer, R. L., Price, P. B., and Walker, R. M., *J. Glass Studies*, **6**, 151 (1964).
[3] Fleischer, R. L., and Price, P. B., *Geochim. Cosmochim. Acta*, **28**, 1705 (1964).
[4] Fleischer, R. L., and Price, P. B., *J. Geophys. Res.*, **69**, 331 (1964).
[5] Fleischer, R. L., and Price, P. B., *Geochim. Cosmochim. Acta*, **28**, 841 (1964).
[6] Fleischer, R. L., and Price, P. B., *Science*, **144**, 841 (1964).
[7] Price, P. B., and Walker, R. M., *App. Phys. Letters*, **2**, 23 (1963).
[8] Fleischer, R. L., and Price, P. B., *J. Appl. Phys.*, **34**, 2903 (1963).
[9] Adams, J. A. S., *Geochim. Cosmochim. Acta*, **8**, 74 (1955).
[10] Adams, J. A. S., Osmond, J. K., and Rogers, J. J. W., *Phys. and Chem. of the Earth*, **3**, 298 (1959).
[11] Fleischer, R. L., Price, P. B., Walker, R. M., and Leakey, L. S. B., *Science* (in the press).