

# ORIGIN AND AGE OF TEKTITES

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## ABSTRACT

Tektites from Australia, Thailand and Czechoslovakia have been dated by fission track method. Australites and Thailandites seem to be genetically related but Moldavites belong to a different age group. Various hypotheses on the origin of tektites are discussed. Moon appears to be most plausible extraterrestrial source of these exotic glass pieces.

## INTRODUCTION

**T**TEKTITES (from Greek word *tektos*—molten) are usually small, glassy objects, jet black in colour, and found in certain restricted areas of the world called 'strewn fields'. These are four such fields generally recognised. They consist of: (1) Moldavites, found in the valley of the river Moldau, in Western Czechoslovakia. (2) Australites, discovered in Australia and Indo-China, collectively called the "Australasian strewn field". (3) Ivory coast tektites in western Africa, and still very rare. (4) North American tektites called bediasites from Texas and Georgia.

What makes these chips of 'glass' so interesting from a scientific point of view? First, of course, is their distribution in only restricted fields and second, their peculiar composition. They have distinct physical and chemical characteristics which set them apart from both volcanic glasses (obsidians) and glasses produced on the earth by the impact of meteorites (impactites). Most tektites have shapes which strongly suggest modelling by aerodynamic forces when they traversed the Earth's atmosphere at great speeds, getting their anterior surface ablated in the process. Australites studied by the author show these special characteristics and are generally button-shaped or lensoid in shape.

## ORIGIN OF TEKTITES

The most controversial aspects of tektites are the theories of their origin. Two schools of thought have existed for a long time—the terrestrial and the extra-terrestrial. Any theory that seeks to establish their origin must account for the following crucial features:

(1) existence of restricted strewn fields; (2) aerodynamic shaping; (3) similarity of tektites from one strewn field to another; (4) total absence of water content, and (5) dissimilarity of tektites with local rocks.

The theories most worthy of consideration are those proposing the formation of tektites by the impact of meteorites or comets, either on the surface of earth or the moon. L. J. Spencer<sup>1</sup> was

the first to propose that tektites resulted from colossal meteorite impacts on the earth, the splashed material coming down in a fine spray. There are several objections to this hypothesis: (1) the strewn fields are too large for tektites to achieve the requisite high velocities without complete destruction; (2) if tektites have resulted from fused local rocks, they should reflect their composition whereas they often do not; (3) there should be an impact crater corresponding to each strewn field.

Terrestrialists have given two answers to these objections: The first is that of A. J. Cohen<sup>2</sup> of the University of Pittsburgh who has argued that Ries crater in south of Germany and the Lake Bosumtwi crater in Ghana are responsible respectively for the Moldavites and the Ivory Coast tektites. H. Urey<sup>3</sup> has put forward the ingenious hypothesis of cometary impacts. Comets being so nebulous, consisting largely of heated gases and vapours, no concrete craters need be made.

The extraterrestrialists have advanced the following arguments in support of their hypothesis: (i) Verbeek<sup>4</sup> had first proposed the moon as the source of tektites, he imagined them as ejecta from the lunar volcanoes. (ii) H. H. Nininger<sup>5</sup> first put forward meteoritic impacts on the moon as the causative agency. (iii) Recently D. Chapman<sup>6</sup> has pinpointed not only the crater on the moon (*viz.*, Tycho) which is responsible for the Australasian tektites but also the crater ray (Rosse ray) along which the ejected lunar material initially travelled.

The mystery of origin of tektites is as yet unsolved. On balance, however, the lunar hypothesis appears to be more plausible, as it explains more observed facts. That the moon is the most plausible of extraterrestrial sources is borne out by the following facts: (i) the greater probability with which any material ejected from it would find its way to the earth, (ii) absence of cosmic ray induced tracks in tektites, (iii) aerodynamic shaping and ablation on entry into earth's atmosphere, and the most important of all, (iv) resemblance in chemical composition of tektites with lunar rocks.

## AGE OF TEKTITES

A number of methods have been used to determine the age of tektites, the most reliable being perhaps the K-Ar and the fission track analysis methods. These two methods have usually yielded age broadly similar to each other.

Since its introduction by Price and Walker<sup>7</sup> the fission track method has proved to be suitable for glasses. Applied to tektites, the method yielded ages quite similar to the K-Ar ages<sup>8-10</sup>.

Bombay, with a thermal neutron dose of  $10^{15}$  (nvt). The irradiated samples were etched as for fossil tracks and the number of induced fission tracks due to induced fission of  $U^{235}$  was counted using a  $5 \times 5$  graticule in the microscope eyepiece.

The fission track ages of tektites were calculated by using the following age formula<sup>11</sup>:

$$T = 6.57 \times 10^8 \log_e \left( 1 + 9.25 \times 10^{-18} \times \frac{\rho_s}{\rho_i} \times \psi \right)$$

The f.t. ages are summarized in Table I.

TABLE I  
Fission track ages of tektites  
Total thermal neutron dose  $\psi = 1.33 \times 10^{15}$

Tektite sample	No. of Tracks		F.T. age (m.y.)	K-Ar age (m.y.)
	Fossil $\rho_s$	Induced $\rho_i$		
Australites	104	12800	$0.65 \pm 0.06$	
	114	13888	$0.66 \pm 0.06$	$0.72 \pm 0.04$
	152	19392	$0.63 \pm 0.05$	
		Mean	$0.65 \pm 0.06$	
Thailandites	332	36928	$0.72 \pm 0.04$	$0.72 \pm 0.10$
	113	12928	$0.70 \pm 0.06$	
	226	28160	$0.64 \pm 0.04$	
		Mean	$0.69 \pm 0.05$	
Moldavites	4624	25664	$14.40 \pm 0.20$	$14.60 \pm 0.70$
	4880	28416	$13.67 \pm 0.21$	
	6400	32640	$15.67 \pm 0.20$	
		Mean	$14.58 \pm 0.20$	

## EXPERIMENTAL PROCEDURE

Tektite samples collected from western Australia, Thailand and Bohemia (Czechoslovakia) were purchased from Ward's Natural Science Inc., New York, for fission track analysis. The samples which were jet black in colour became transparent and bottle green on polishing. The highly polished sections of the tektite glasses were etched in 48% hydrofluoric acid at room temperature for 2-5 minutes, depending on the  $SiO_2$ -content of the samples. The etched samples were scanned under Carl Zeiss Microscope, for fossil fission tracks due to spontaneous fission of  $U^{238}$ . It was found that fossil track density is minimum in Australian tektites and maximum in Bohemian samples. The fossil tracks are circular or elliptical etch pits clearly distinguishable from numerous surface dislocations.

The samples were heated in a muffle furnace at  $500^\circ C$  for one hour to anneal out all the fossil tracks. After annealing, the samples were irradiated in CIRUS Reactor of BARC, Trombay,

## DISCUSSION OF RESULTS

(1) The f.t. ages of Australian tektites and Thailand tektites show very good agreement confirming the fact that they are genetically related. Therefore, Australasian strewn field is very vast extending from Western Australia to Indo-China.

(2) Moldavites (Tektites of Bohemia) belong to a different generation with mean f.t. age of  $14.58 \pm 0.20$  m.y.

(3) In general, our f.t. age results agree with those determined by other authors<sup>8-10</sup>.

(4) The mean etch pit diameter of core samples is more than that of flange samples due to intense thermal annealing at the flanges during ablation.

(5) No evidence is found in favour of a second tektite fall in Australia as reported by Fleischer *et al.*<sup>12</sup>.

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## PERMEABILITY THROUGH AN ANIMAL MEMBRANE

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### ABSTRACT

Transport of various non-electrolytes, namely, water, acetamide, urea, glucose and sucrose has been studied through a urinary bladder of goat. It has been found that the flow through the membrane is neither diffusive nor viscous but flow through certain number of capillaries of membrane is diffusive and viscous through the rest.

### INTRODUCTION

TRANSPORT across natural membranes is a complex phenomenon<sup>1,2</sup>. Since the pore size in such membranes is comparable to the molecular size and channels have undefined geometry and complex surface characteristics, experimental studies are difficult. Earlier studies on transport processes, in both artificial<sup>3</sup> membranes (analogous to the natural membranes<sup>4,5</sup>) and in natural membranes<sup>6</sup>, have revealed some useful information. From these studies on permeability of membranes, it can be assessed<sup>7</sup>—(i) whether the movement occurs through the bulk of the membrane or through specific limited region of membrane, (ii) whether it is brought about by the action of the specific membrane components which are of use in explaining structural relationship of the membrane with permeating species.

With these objectives, an experiment on membrane transport is described in the present communication, using the urinary bladder of a goat in presence of water, urea, acetamide, glucose and sucrose.

### EXPERIMENTAL

The urinary bladder of goat was equilibrated with urea solution and fixed in rubber gaskets<sup>8</sup>. The flow volume was measured by noting the rate of advancement of liquid meniscus in a

capillary of radius 0.024 cm. The solutions were preheated to the temperature ( $25^\circ \pm 0.01^\circ \text{C}$ ) of the experimental cell. The diffusion coefficients were calculated from the viscosity data of solutions as suggested earlier<sup>9</sup>.

### RESULTS AND DISCUSSION

Transport equation for the flow of matter in presence of pressure difference alone through a membrane reduces to<sup>10</sup>

$$J_v = L \Delta P \quad (1)$$

where  $J_v$  is the volume flow of matter,  $\Delta P$  is the pressure difference across the membrane and  $L$  is the permeability coefficient.

For viscous flow the equation can be written as

$$J_v = \frac{n\pi r^4}{8\eta l} \Delta P \quad (2)$$

where  $n$ ,  $r$ ,  $\eta$  and  $l$  represent number of capillaries, radius of the capillaries in the membrane, viscosity of solution and length of the capillaries in the membrane respectively. Comparison of Eqs. (1) and (2) gives the following relationship.

$$L = \frac{n\pi r^4}{8\eta l} \quad (3)$$

The values of  $L$  have been calculated from the slope of a plot between  $J_v$  and  $\Delta P$  and are recorded in Table I. Although it is expected that  $L$  should decrease by increasing the molecular weight of the solutes, yet this has not been found to be valid in the present case. It is obvious from Eq. (3) that

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