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CONFLICTING CHRONOLOGY OF TEKTITES

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Abstract—Tektite samples collected from two major strewn fields have been dated by using fission track (f.t.) technique. F.T. ages of both Australites and Moldavites yield conflicting chronology of tektites. U content varies from 1.7 to 3.3 ppm. It is concluded that tektite chronology needs a fresh reappraisal.

1. INTRODUCTION

Tektites are small glassy objects with distinct physical and chemical characteristics which set them apart from volcanic glasses (obsidians), meteorites and luner rocks. Various authors (Fleischer et al; 1965 and 1969; Gentner et al; 1967 and 1969; Storzer and Wagner, 1971; Durrani, 1971; Virk, 1977) have studied tektites to establish their origin and chronology. Two schools of thought have existed for a long time—the terrestrial (Barnes, 1961; Cohen, 1962) and the extra-terrestrial (Chapman and Larson, 1963; O'Keefe, 1976). Recent findings of Shaw and Wasserburg (1982) support the terrestrial hypothesis by providing indirect evidence that tektites belong to the old terrestrial continental crust.

Tektite finds are confined to certain restricted areas of the earth known as strewn fields. There are four such fields, within each of which the tektites have the same K-Ar and fission track ages. Thus the North American (Bediasites), European (Moldavites), Ivory Coast and Australasian (Australites) tektites are about 35, 14, 1.3 and 0.7 million years old respectively. These ages represent the times at which the tektites were last molten; they say little about the types of rock from which the tektites were formed, how they formed or whence they came. However, it is now possible to determine the provenance and evolution of tektites from behaviour of the Sm-Nd and Rb-Sr decay systems (Shaw and Wasserburg, 1982).

Another intriguing feature about tektites is that strewn fields are associated with impact craters (Fleischer et al; 1965). Moldavites were created by the impacting body that gave rise to Ries Crater. Bosumtwi crater is associated with Ivory Coast strewn field and the Zhamanshin crater in USSR is a candidate for Australasian field. It is interesting to note that tektite ages of the strewn fields correspond to imapctite ages of the associated craters.

Occasionally geological ages for tektites based on stratigraphy have yielded lower values as compared to K-Ar and f.t. ages. A gross inconsistency exists between the f.t. age of Australites and the age of fall indicated by stratigraphic studies (Gill: 1970). The present study reveals the conflicting chronology of Australites and Moldavites on basis of f.t. age analysis.

2. SAMPLE COLLECTION

Tektite glasses collected from two major strewn fields viz. Australasian and European (Bohemia) were purchased from Ward's Natural Science Inc; New York, USA. Samples include tektites from Western Australia, South Australia, Phillipines, Thailand and two major sites, Trebic and Milkovice in Bohemia (Czechoslovakia). Impactite (Darwin glass) samples from Western Australia were also purchased to establish their link with tektites collected from this area.

Most of the tektites are jet black in colour. Their shapes strongly suggest modelling by aerodynamic forces when they traversed through the Earth's atmosphere at great speeds, getting their anterior surface ablated in the process. Some of the australites are button-shaped or lensoid in shape (Fig. 1).

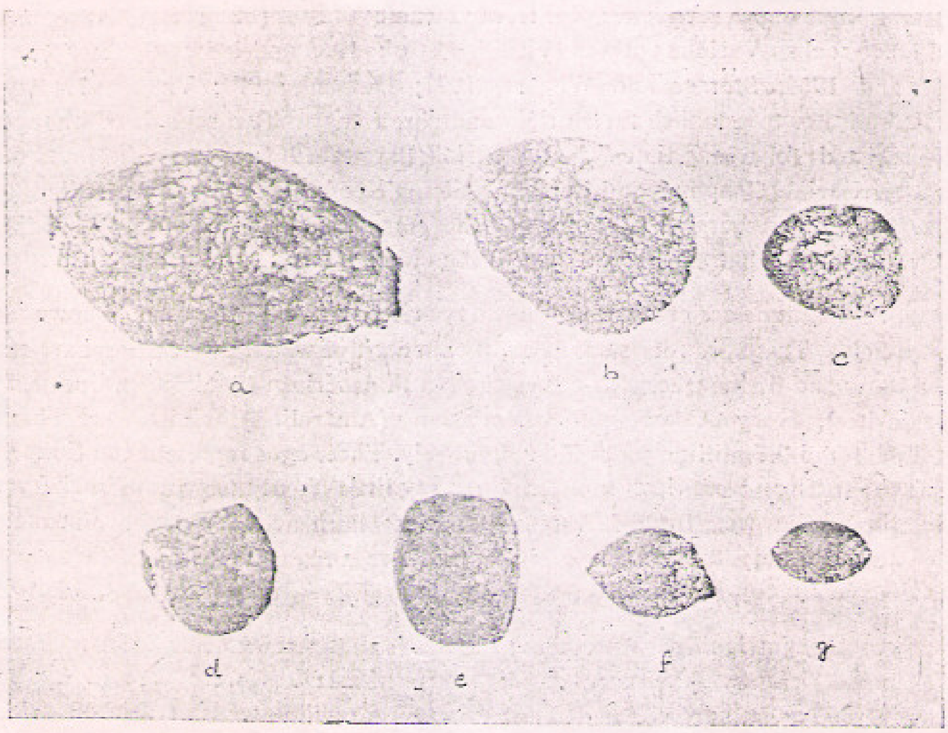

Fig. 1 : (a) Indochinite (Thailand) (b) Moldavite (Bohemia) (c) Philipinite (Philipine Island) (d) Darwin Glass (W. Australia) (e) Australite (Queensland, Australia) (f) Australite button (W. Australia) (g) Australite lens (W. Australia)

3. EXPERIMENTAL PROCEDURE

The experimental procedure is essentially the same as that previously reported (Virk, 1977). Small pieces of each tektite were irradiated with an integrated thermal neutron dose of 1.47×10^{15} n/cm^2 in IC-2 column of CIRUS Reactor, Trombay. The total *nvt* dose was determined by irradiating simultaneously and in the same reactor geometry as the tektites, a standard glass of known U concentraction (20 ppm) and calibration constant, 4.6×10^9 n/track.

Polished sections of both irradiated and unirradiated samples were etched together in 48% HF for 2 min at room temperature, 30° C. Fossil and induced fission tracks were counted under a magnification of 600 X using a binocular microscope of Olympus make.

Counting of fossil tracks in tektites is a very tedious job. Tracks were counted twice by two different observers for sake of comparison. It is observed that in addition to fossil fission tracks there are many fake tracks arising due to air bubbles, glass spherules or other impurities embedded during solidification of tektites. This problem was particularly accentuated in Darwin glass (Fig. 2).

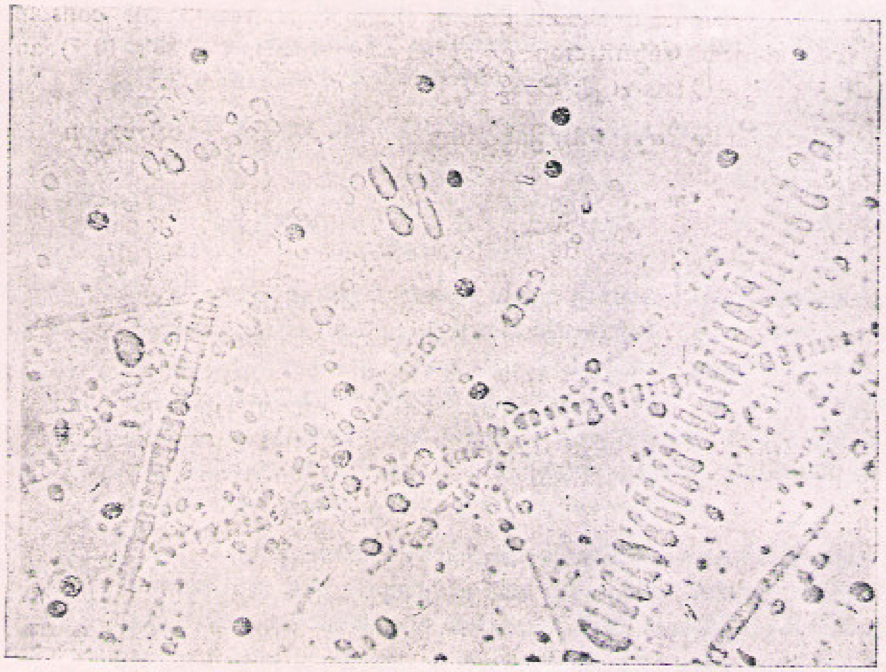

Fig. 2 : Fossil fission tracks in Darwin glass. Black dots clearly differentiate fossil tracks from surface features.

Track size measurements were carried out by recording major axes of elliptical tracks, both fossil and induced, using a projection microscope at a magnification of 1000 X. The mean values of track diameters were calculated. It is observed that in almost all tektites the fossil track diameters are reduced in size in comparison to induced fission tracks due to annealing of radiation damage.

4. RESULTS AND DICUSSION

The fission track ages can be calculated by using age equation (Price and Walker 1963)

$$T = \frac{1}{\lambda_d} \ln \left(1 + \frac{\rho_s \sigma F I \lambda_d}{\rho_i \lambda_f} \right). \tag{1}$$

where the symbols have their usual meanings. For tektite ages, considered to be much younger compared with geological ages of rocks, eqn. (1) reduces to

$$T = \frac{\rho_s}{\rho_i} \frac{\sigma I}{\lambda_f} F \tag{2}$$

$$= 6.01 \times 10^{-8} \frac{\rho_s}{\rho_i} F. \tag{3}$$

where ρ_s and ρ_i refer to fossil and induced fission track densities respectively and F is the fluence or the nvt dose of thermal neutrons. The constant of eqn. (3) is obtained by substitution of $\sigma(582 \times 10^{-24}\ cm^2)$, I (7.26×10^{-3}) and λ_f $(7.03 \times 10^{-17}\ yr^{-1}$, Roberts et al; 1968).

F.T. ages are corrected for annealing by using track size correction (Mark et al; 1981)

$$T = 6.01 \times 10^{-8} \frac{\rho_s}{\rho_i} F \frac{d_i}{d_s} \tag{4}$$

where d_i and d_s denote mean projected track diameters for induced and spontaneous fission (fossil) tracks respectively. Eqn. (4) gives satisfactory results in case of low track fading but fails where intense heating is involved. The maximum track reduction is observed in case of Indochinites and minimum in case of Moldavites. Corrected f.t. ages alongwith counting statistical errors (1σ) are summarized in Table 1. Uranium content calculated on basis of induced fission track density (Virk, 1981) is also recorded.

Tektites studied belong to two major strewn fields; Australites, Indochinites, Phillipinites and Impactites are genetically related to Australasian field and Moldavites belong to the European field located in Bohemia (Czechoslovakia). According to hypothesis of strewn fields, all tektites collected from the same field must give the same geochronological age in addition to similarity in physical and chemical properties. Our f. t. age results do not corroborate this hypothesis.

Table 1. Fission Track Ages for Tektites

Sample	Location	Track density ρ_s	Track density ρ_i	F.T. age m.y.	Track size d_i/d_s	Corrected age m.y.	U Conc. ppm
Australite	S. Australia	345 (36)	47624 (517)	0.64±0.11	1.31	0.83±0.11*	2.49
—do—	Queensland (Australia)	466 (82)	54976 (859)	0.75±0.09	1.26	0.95±0.09	2.88
—do—	W. Australia	105 (37)	35328 (552)	0.26±0.04	1.20	0.32±0.04	1.85
Impactite	W. Australia	135 (15)	48458 (458)	0.24±0.06	1.37	0.34±0.06	2.54
Indochinite	Thailand	78 (18)	59968 (656)	0.11±0.03	1.88	0.22±0.03	3.14
Phillipinite	Phillipine Island	385 (51)	46976 (367)	0.72±0.11	1.14	0.82±0.11	2.46
Moldavite	Trebic (Bohemia)	408 (86)	32896 (514)	1.10±0.13	1.21	1.33±0.13	1.72
—do—	Milkovice (Bohemia)	7072 (526)	55785 (747)	11.20±0.64	1.08	12.14±0.64	2.93

Total thermal neutron dose F=1.47 x 10^{15} (nvt)
Brackets show the number of tracks counted.
*Statistical counting error, 1σ.

However, f.t. ages of tektites from S. Australia and Queensland show some agreement and agree with K/Ar ages of Australites (Durrani, 1971).

There is strong evidence in favour of conflicting chronology of tektites from both the strewn fields. Australites from W. Australia yield a f.t. age of 0.32±0.04 m.y. after accounting for annealing of fossil tracks due to accidental heating in natural or man made fires. This discrepancy of age is much more significant in case of Moldavites from Trebic, Bohemia. However, Milkovice sample yields f.t. age which is in good agreement with K/Ar age determined for this field (Durrani, 1971). The possibilty of "Vagabond" tektites (Faul and Wagner, 1972) contributing to this conflict is not ruled out.

It is significant to remark that f.t. ages of Australite and Impactite (Darwin glass) of W. Australia show perfect agreement which confirms the hypothesis that tektites and impactites of a strewn field are chronologically related. It is a well established fact that each strewn field is associated with some crater which is a source of these impactites.

It may be concluded that tektite problem is still fascinating. Future research on tektites lies in resolving the conflicting age problem, plus of course, the problem of their origin.

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REFERENCES

Barnes V.E. (1961) Tektites. *Sci. Amer.* 205, 58.

Chapman D.R. and Larson H.K. (1963) On the lunar origin of tektites. *J. Geophys. Res.* 68, 4305.

Cohen A.J. (1962) Asteroid impact hypothesis of tektite origin. *Proc. 3rd Int. Space Sci. Symp; (Washington)*. North Holland.

Durrani S.A. (1971) Origin and age of tektites. *Phys. Earth Planet. Interiors* 4, 251-260.

Faul H. and Wagner G.A. (1972) Vagabond tektites. *Earth Planet Sci. Letters* 14, 357-359.

Fleischer R.L; Price P.B. and Walker R.M. (1965) On the simultaneous origin of tektites and other natural glasses. *Geochim. Cosmochim. Acta* 29, 161-166.

Fleischer R.L; Price P.B.; Viertal J.R.M. and Woods R.T. (1969) Ages of Darwin glass, Macedon glass and Far Eastern tektites. *Geochim Cosmochim. Acta* 33, 1071-1074.

Gentner W; Kleinmann B. and Wagner G.A. (1967) New K-Ar and fission track ages of impact glasses and tektites. *Earth Planet. Sci. Letters* 2, 83.

Gentner W; Storzer D. and Wagner G.A. (1969) New fission track ages of tektites and related glasses. *Geochim. Cosmochim. Acta* 33, 1075.

Gill E.D. (1970) Age of Australite fall. *J. Geophys. Res.* 75, 996-1002.

Mark T.D; Vartanian R; Purtscheller F. and Pahl M. (1981) Fission track annealing and application to the dating of Austrian sphene. *Acta Physica Austriaca* 53, 45-59.

O'Keefe J.A. (1976) Tektites and their origin. Elsevier.

Roberts J.H; Gold R. and Armani R. J. (1968) Spontaneous fission decay constant of U-238. *Phys. Rev.* 174, 1482-1484.