Reframing the Australasian Tektite Source Mystery

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Abstract

NASA hall of fame researcher Dean R. Chapman successfully calibrated the Apollo lunar mission heat shield design using Australasian tektite testing, then failed to apply the requisite rotating frame transform to solve for terrestrial origin location.

Fig. 1A

All scales are unit Earth radius

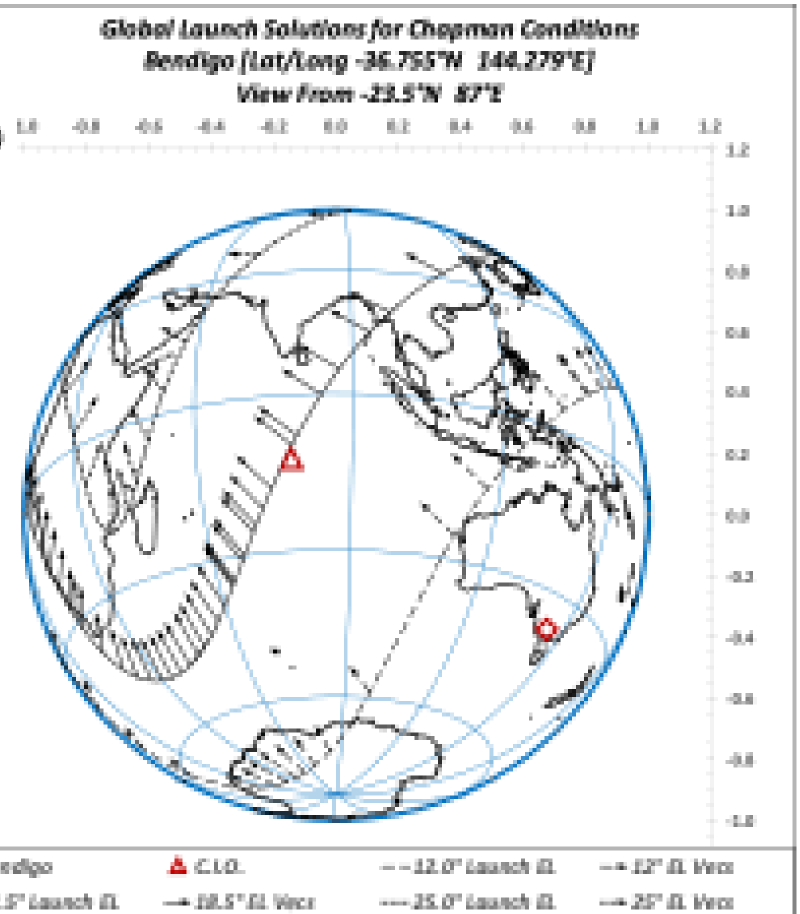
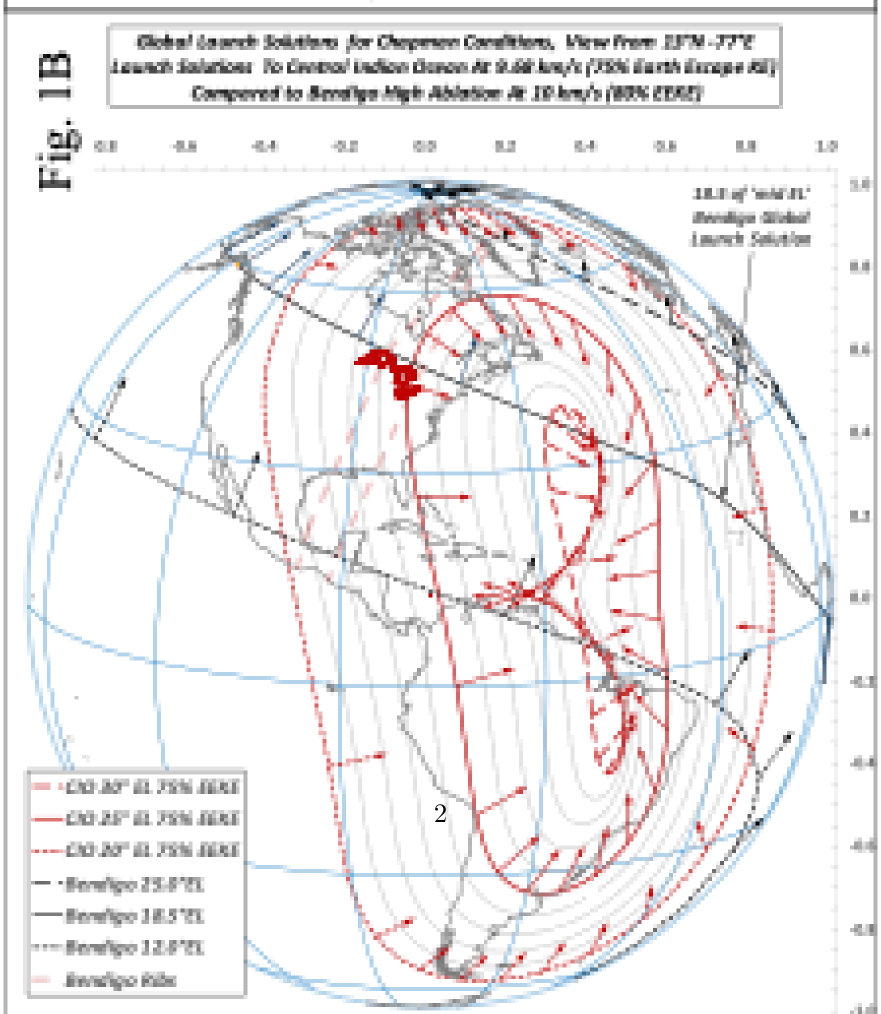


Fig. 1B



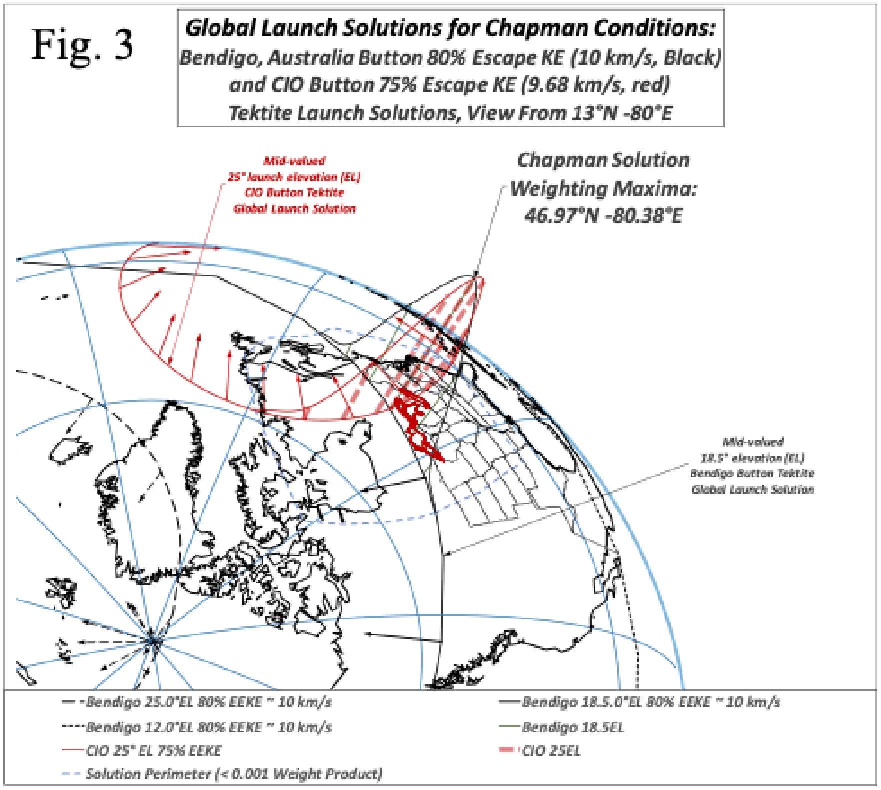

Global Launch Solutions for Chapman Conditions:
Bendigo, Australia Button 80% Escape KE (10 km/s, Black)
and CIO Button 75% Escape KE (9.68 km/s, red)
Tektite Launch Solutions, View From 13°N -80°E
Mid-valued
25° launch elevation (EL)
CIO Button Tektite
Global Launch Solution
Chapman Solution
Weighting Maxima:
46.97°N -80.38°E
Mid-valued
18.5° elevation (EL)
Bendigo Button Tektite
Global Launch Solution
Bendigo 25.0°EL 80% EEKE ~ 10 km/s
Bendigo 18.5.0°EL 80% EEKE ~ 10 km/s
Bendigo 12.0°EL 80% EEKE ~ 10 km/s
Bendigo 18.5EL
CIO 25° EL 75% EEKE
CIO 25EL
Solution Perimeter (< 0.001 Weight Product)

Fig. 3

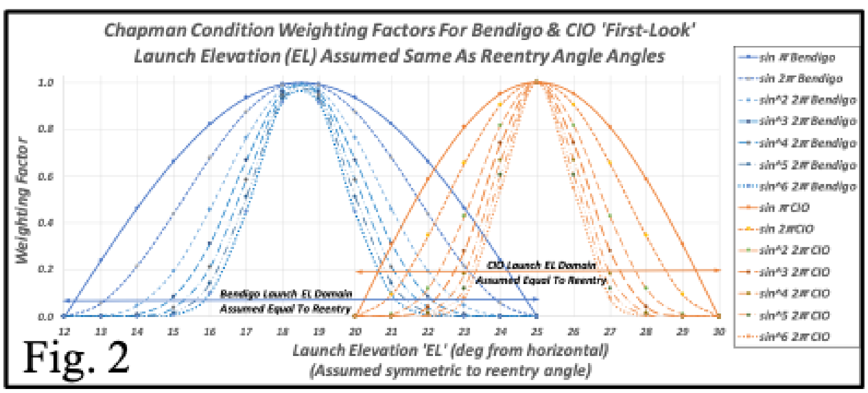

Chapman Condition Weighting Factors For Bendigo & CIO 'First-Look'
Launch Elevation (EL) Assumed Same As Reentry Angle Angles
Weighting Factor
Bendigo Launch EL Domain
Assumed Equal To Reentry
CIO Launch EL Domain
Assumed Equal To Reentry
Launch Elevation 'EL' (deg from horizontal)
(Assumed symmetric to reentry angle)

Fig. 2

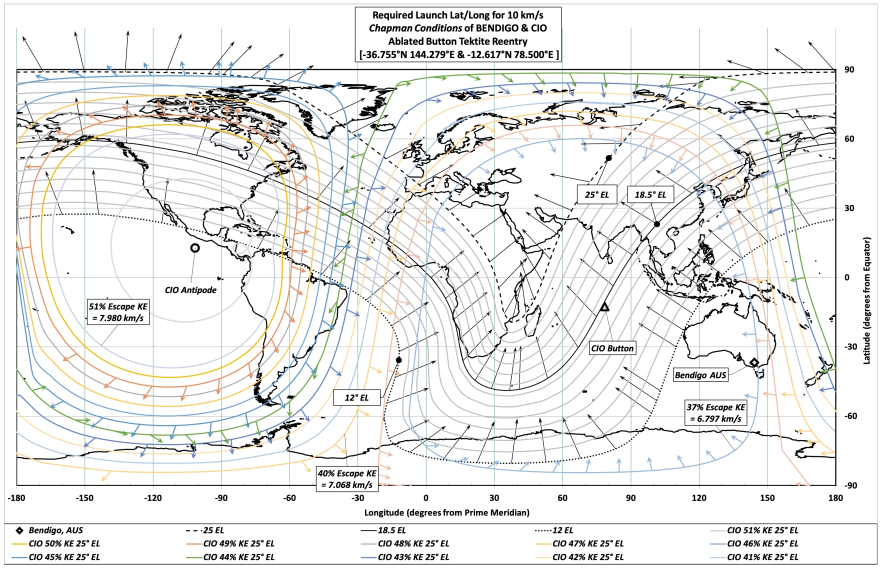
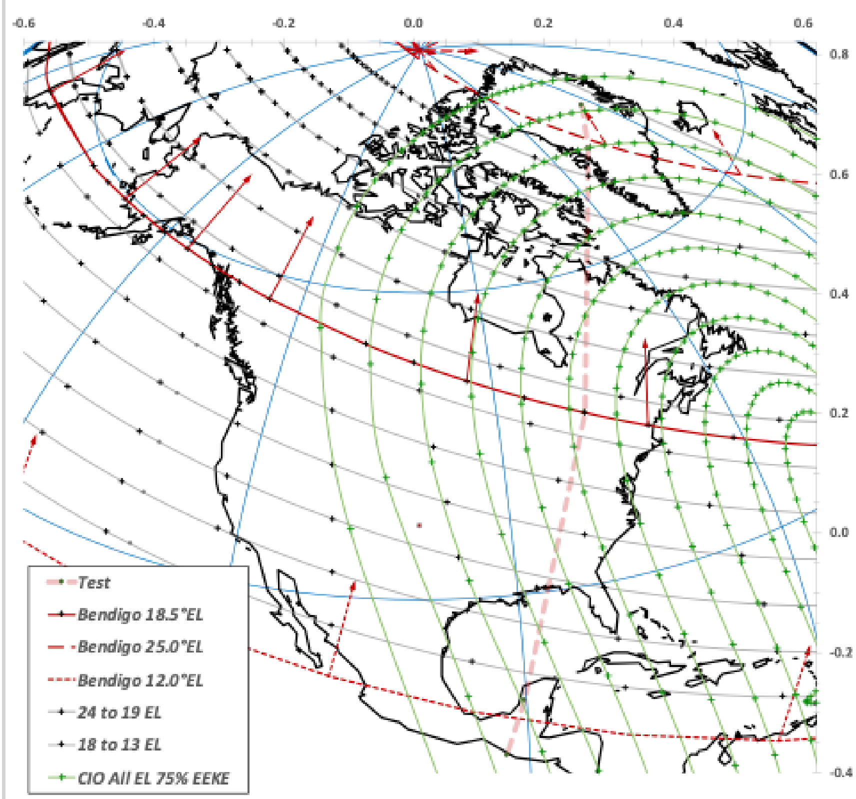


Fig. 4 *Global Launch Solutions for Chapman Conditions, View From 40°N -110°E To Reach Bendigo Australia [Lat/Long -36.755°N 144.279°E] 10 km/s @ 12°, 18.5° & 25° EL*



REFRAMING THE AUSTRALASIAN TEKTITE SOURCE MYSTERY. T.H.S. HARRIS, GE Astro Space Division, Lockheed Martin, Boeing Helicopter, retired (THSHarris1@icloud.com)

Introduction: The Australasian tektite (AAT) source region remains paradoxically unlocated, with tens of billions of tons of melt strewn across ¼ to 1/3 of Earth's surface from a geologically very young event at 789 ka. NASA hall of fame researcher Dean Chapman's reentry condition data [1-3] for the ablated 'button' form of these objects is commonly disregarded in geosciences, while his aerothermodynamics work is still used in modern spacecraft design. In the early 1960s of Chapman's work, the required Suborbital Analysis (SA) 'back-solve' method was only available within the classified sector for ballistic missile defense.

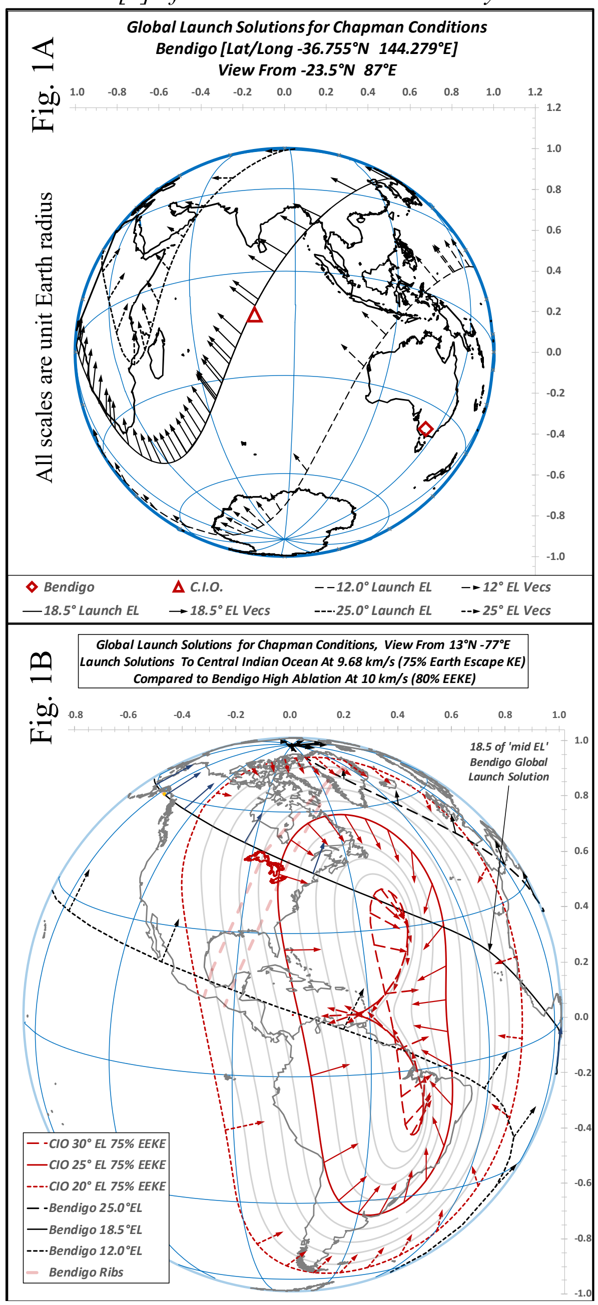
Later, another ablated button tektite was found in the Central Indian Ocean (CIO) and detailed in Glass, Chapman, Prasad (1996) [4], providing vastly different global launch solution family features due to its different fall location and the lower reentry speed of that specimen vs. the Bendigo ablated button tektite.

Discussion: During the 1960s lunar mandate, NASA poured resources into the Apollo program, including development for a heat shield to survive 'free return' all the way from the Moon, with no rocket deceleration before reentry. Heat shield hero Dr. Dean R. Chapman successfully co-developed aerothermodynamics for the free-molecular-to-collisional transition regime at the top of Earth's atmospheric column using AAT tests to calibrate his model. Material testing of natural tektite glass at hypervelocity reentry conditions, analytic and numeric modeling were all combined for detailed calibration. Successful reentry of all Apollo missions proved Chapman's triple-verified model, which is still used today for that purpose. The Apollo lunar mission reentry conditions remain the most extreme of any manned space flight in history.

Chapman's results were finely tuned using anterior-face ring waves and other AAT features that are sensitive to slight variation in the hypervelocity flow conditions, which often reached 10 km/s or more, i.e. 80% or more of Earth escape KE (EEKE). Unfortunately, Dr. Chapman *never applied the requisite rotating frame transform* to resolve possible (or impossible) terrestrial source regions of the now-estimated 30 to 60 billion tons of AAT melt, preventing *any* valid solution.

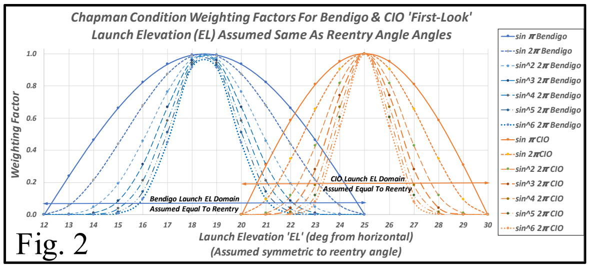
*Technique***.** A simplified two-body suborbital model is used, outlined in reference [5]. Chapman's test-derived reentry flight path angle relative to horizontal is applied as launch elevation (EL) via suborbital symmetry for this initial look. Lower-order terms and atmospheric effects are ignored, being far less significant than the high reentry speeds resolved by Chapman. The Bendigo button tektite launch solutions sweep circumglobally and nearly pole-to-pole, with lower and upper limits 12° and 25° launch EL at the southern and northern limits respectively. They are shown in Figure 1A and 1B. The CIO button Chapman condition elevation is 20° to 30°. CIO button launch solutions occupy longitude-limited domains. The 75% EEKE CIO solutions are depicted in Figure 1B, with 1° EL increments in light grey. Crossings indicate possible AAT source regions.

Figure 1. Global launch solutions for Chapman conditions [3] of ablated button tektite reentry.



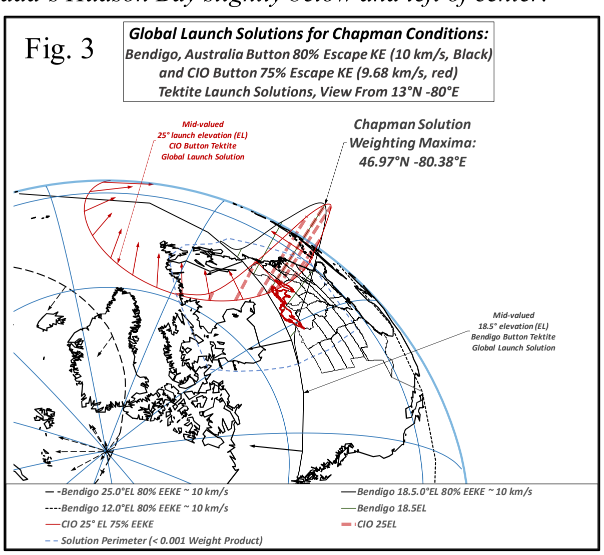
Weighting Profiles are utilized for visualization, derived from basic harmonic functions to either concentrate or spread the weighting, shown in Figure 2. The narrow weighting profiles provide sharp central peak and attenuated marginal launch EL angles for best geographic resolution of possible AAT source regions.

Figure 2. Weighting factor for Bendigo and CIO ablated button tektite specimens – see text for description.



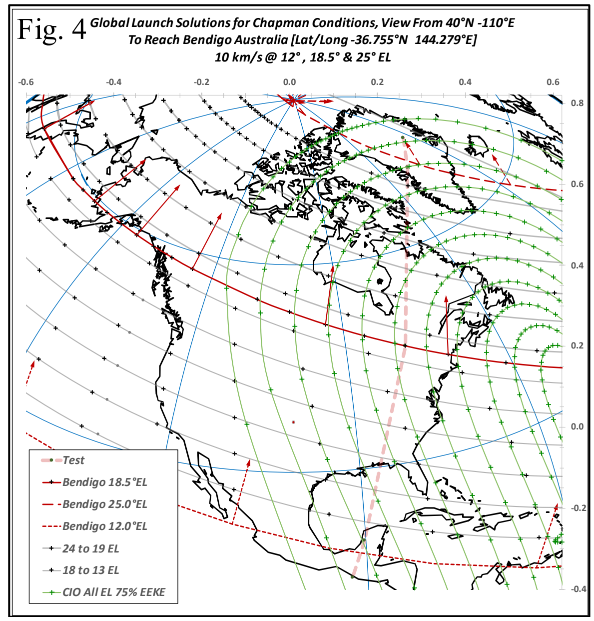
A centrally-focused weighting is in keeping with the confidence of Chapman et al. [1-3] that his mid-value solutions were very close to ablated button AAT reentry conditions (i.e. at least 10 km/s and around 18 or 19° from horizontal for the Bendigo button). The products of weighting profiles for both specimens are displayed in Figure 3 as columns along the two mid-value launch elevation solution curves, 18.5° EL for Bendigo and 25° EL for the CIO ablated Australasian button tektites. 75% escape KE is depicted for the CIO button.

Figure 3. Weighted intersection of button tektite launch solutions for Chapman's test-derived and triple-verified reentry conditions, converging at ~47°N 80°W. The view is from roughly over the North Pole, with Canada's Hudson Bay slightly below and left of center.



The dashed blue perimeter line in Figure 3 represents the threshold where the weighting product of the two button tektites decreases below 0.001. For 1° incremental EL solution curves of each button tektite, a grid of intersection points is produced as shown in Figure 4. The weighting product is then calculated for each contour crossing point, defining the 0.001 threshold perimeter and unit maxima. Green: CIO, grey: Bendigo.

Figure 4. Intersection grid of ablated tektite global launch solutions of 1° incremental launch elevation.



Sequentially lower-speed entry conditions down to 70% escape KE applied to the CIO button tektite also produce mid-valued 25° launch EL curves that intersect the Bendigo 18.5° launch EL curve in the same region around the N. American Great Lakes.

Summary: A suite of Suborbital Analysis (SA) software tools coded in commonly available and widely supported MS Excel spreadsheet software uses a simplified two-body model from a 1971 U.S. Air Force Academy textbook [5]. Macro code automation to assess global launch solutions for NASA researcher Dean R. Chapman's ablated button tektite reentry conditions, or 'Chapman conditions', indicate possible and impossible regions of terrestrial origin for the Australasian tektites. Chapman omitted the requisite rotating frame transformation to account for Earth's rotation during extended tektite loft. His heat transfer derivation, however, is still used in contemporary spacecraft heat shield design. The N. American Great Lakes region is the indicated source. SA tools and associated documentation to confirm or refute these back-solved Chapman condition launch solutions are available as share-ware.

References: [1] Chapman (1962) *NASA TR R-134*. [2] Chapman et al. (1963) *NASA TN D-1556.* [3] Chapman et al. (1964) *Gochimica et Cosmochimica Acta* Vol. 28 p. 841-880. [4] Glass, Chapman, Prasad (1996) *M & PS 31*, 365-369 [5] R.R. Bate, D.D. Mueller, J.E. White (1971) *Fundamentals of Astrodynamics,* Dover Publications.