LETTERS TO NATURE

PHYSICAL SCIENCES

Search for a Trans-Plutonian Planet

Brady and Carpenter[1], when working out an ephemeris for the 1986 apparition of Halley's Comet, found they had to include a secular term to explain the observations of previous apparitions. Kiang[2] has examined the original records of the apparitions of the comet, and his revised dates of perihelion passage considerably decrease the residuals of Brady and Carpenter's adopted orbit, which includes the secular term. From this term, Brady[3] inferred the existence and predicted the position of a trans-Plutonian planet.

During the months of June and July 1972, we conducted a search for the planet, covering an area which extended at least $3\frac{1}{2}°$ from the predicted position in every direction. Two contiguous polygons were covered, bounded by the lines of α,δ given in Table 1.

Table 1 Search Area for Trans-Plutonian Planet

	RA (1950)	DEC (1950)
	h m to h m	° ′ to ° ′
1	00 15 to 01 40	+67 00 to +74 00
2	00 45 to 01 25	+74 00 to +75 30

Two series of plates of this area were taken on the 13-inch Astrographic Refractor of the Royal Greenwich Observatory, on 'Kodak IIaO' emulsion. The field covered by each plate was about $2\frac{1}{3}$ degrees square, and we allowed $\frac{3}{4}°$ overlap between the plates because of the non-circular images formed away from the centre of the plate. The predicted motion of the planet across the plates was 0.7 mm in 24 h. One day was the minimum interval between plate pairs.

We blinked each plate pair on a blink comparator to the plate limit of the inferior plate of a pair. This in all cases was fainter than magnitude 15.5 and most went fainter than magnitude 16.0. We found no moving object brighter than the magnitude limit on any of the plate pairs.

If Brady's hypothetical planet had the albedo of Pluto and a reasonable density, it would be no fainter than 14 mag. If a trans-Plutonian planet does exist, then either it is a much less massive object and hence considerably fainter than Brady has predicted (see ref. 4), or it is not near Brady's final position.

A. P. O. Foss
J. S. Shawe-Taylor
D. P. D. Whitworth

Royal Greenwich Observatory,
Herstmonceux Castle,
Hailsham,
Sussex

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[1] Brady, J. L., and Carpenter, E., *Astron.*, **76**, 728 (1971).
[2] Kiang, T., *Mem. Roy. Astron. Soc.*, **76**, 27 (1972).
[3] Brady, J. L., *Proc. Astron. Soc. Pac.*, **84**, 314 (1972).
[4] Seidelmann, P. K., *Astron. J.*, **76**, 740 (1971).

Earth Tides and the Triggering of Eruptions from Mt Stromboli, Italy

Earth tides with stress gradients exceeding 10^{-8} bar/m (ref. 1) and with predominant periods at approximately 12 h, 24 h and 14.7 day constitute the largest short period oscillatory stress in the Earth's crust[2]. The release of secular tectonic strain accumulation in the crust by tidal triggering has been suggested[3–5], and many attempts[2,3,5–8] have been made to correlate earthquake times with records of Earth tides. All these attempts have proved unable conclusively to relate tides to the occurrence of earthquakes, although microearthquakes may prove to be an exception[9].

For volcanic eruptions the question of whether the tides provide a triggering mechanism is still unclear, although observations of pre-eruptive strain accumulation[10,11] indicate a long-term process. Because eruptions of many of the world's volcanoes are usually described in relation to the characteristics of Mt Stromboli, Italy, that volcano was selected as a test case for these ideas. Eruptions during the past 72 yr have been relatively frequent and eruption times and descriptive details of the eruptions[12–14] were consistently better than the data from other volcanoes. Of the 33 major reported eruptions, all were known to the day and 67% to the hour. 82% of the events could be definitely classified as initial or primary eruptions following quiescent periods of varying intervals from a few months to several years. The remainder of the volcanic activity was either of secondary or tertiary nature. Geochemical analysis of the erupted products[12] indicate all to be of olivine trachybasalt character.

We have derived components of the solid Earth tide as a function of time and position using a program based on a method similar to that developed by Longman[15]. These agree with the values from other independent computations[16], and a check with published tidal observations from quartz

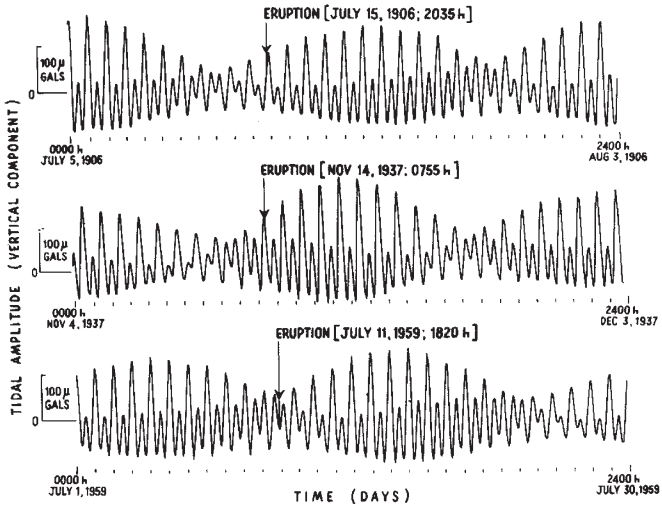

Fig. 1 Three plots of the calculated vertical tidal acceleration as a function of time before and after primary eruptions from the volcano Stromboli. Each starts 10 days before the eruption.