therefore ~2.5 cm/yr, with one standard deviation allowing values in the range 1.8 to 3.5 cm/yr. In view of the small distance between samples, the rate of spreading may not be typical for the area at 45°N when greater distances and time intervals are considered. Ocean-floor spreading is not necessarily continuous in the strict sense of the word, but may be the result of a number of small, relatively rapid movements. Such a movement may have occurred between stations 9 and 56. These spreading rates are to be compared with averaged values inferred from other considerations (*18*, *19*), and from K-Ar ages over greater distances (*17*), which give values in the order of 1 to 2 cm/yr for the Mid-Atlantic Ridge in this area, as is discussed further (*17*). Significant differences in spreading rate are likely to occur over small distances from place to place along the ridge, which, when integrated through time, will give the average rate of spreading inferred from magnetic anomaly patterns. A continuing program is planned to assess this question along with that of the chronological significance of the magnetic-anomaly patterns.

R. L. FLEISCHER
J. R. M. VIERTL, P. B. PRICE
General Electric Research and Development Center, Schenectady, New York
F. AUMENTO
Geological Survey of Canada, Ottawa, Ontario

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Excited Singlet Absorption in 1,2-Benzanthracene by the Use of Nanosecond Laser Photolysis and Spectroscopy

Abstract. *Using the technique of laser photolysis and spectroscopy, we have observed excited singlet state absorption bands in 1,2-benzanthracene at 560 and 520 nanometers. The bands decay in less than 50 nanoseconds and are replaced by the known absorption spectrum of the lowest triplet state.*

We recently observed the lowest excited singlet state of coronene in absorption, using the new technique of laser photolysis and spectroscopy (*1*). We now report observations for 1,2-benzanthracene, for which the excited singlet lifetime of 44 nsec (*2*) is almost an order of magnitude shorter than that of coronene, 300 nsec (*3*).

The technique is shown in Fig. 1. The mode of operation has been described (*1*). To obtain time-resolved spectra, a direct-vision combination of five prisms is used to form a spectrum on the photocathode of an image-converter camera (*4*). Xenon at 1 atm pressure replaces O_2 in the spark cell and gives a laser-induced spark lasting several microseconds. This provides a background source for the image-converter camera of almost constant intensity for times up to 1 μsec.

Figure 2 shows a time-resolved absorption spectrum for a poly(methylmethacrylate) plastic specimen containing a $10^{-3}M$ concentration of the aromatic hydrocarbon 1,2-benzanthracene, taken with a sweep-time of 200 nsec. The right-hand frame shows two absorption bands at 520 and 560 nm which decay in approximately 50 nsec. Concomitantly, they are replaced by three absorption bands at 430, 460, and 490 nm, which agree well in wavelength with the triplet-triplet absorption spectrum of 1,2-benzanthracene observed in separate experiments on a longer time-scale (*5*). The apparent drift of the triplet absorption to longer wavelength with time arises from nonlinearities in the electron-deflecting optics of the image tube. The left-hand frame in Fig. 2 shows the fluorescence emission, which decays at about the same rate as the new absorption bands. We attribute the new bands to absorption from the lowest excited singlet state of 1,2-benzanthracene at 25,910 cm^{-1} (*6*) to a higher

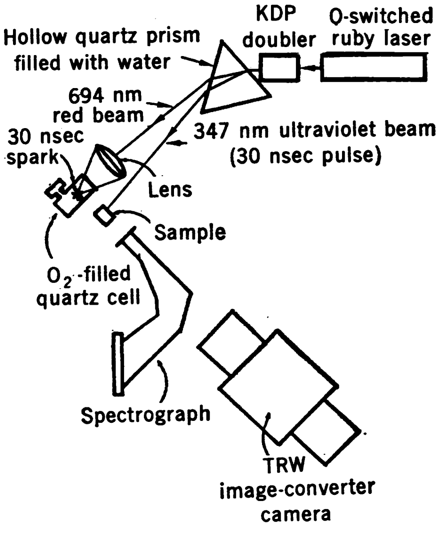

Fig. 1. Laser photolysis and spectroscopy in the nanosecond time range.

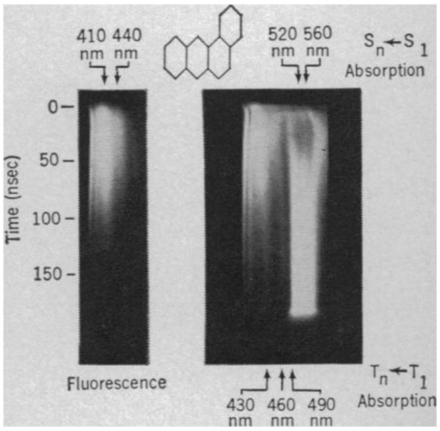

Fig. 2. Decay of fluorescence (left frame) plus decay of excited singlet absorption and build-up of triplet-triplet absorption (right frame) in 1,2-benzanthracene (structure shown at top) [25°C, poly(methylmethacrylate) plastic sample].

electronic singlet state lying at an energy of 43,800 cm^{-1} above the ground state. In addition to coronene and 1,2-benzanthracene, new absorption bands have also been observed for 1,12-benzperylene (510 and 490 nm; decay time ~100 nsec) and for 1,2:3,4-dibenzanthracene (480 nm; decay time ~50 nsec).

The time-resolution of the technique is at present limited to about 10 nsec by the decay time of the ruby laser pulse used for excitation. However, the image-converter camera presently has a time-resolution of 40 psec (*7*), while laser pulses as short as a few picoseconds have been reported by use of the phenomenon of mode-locking (*8*). We therefore believe that observations by laser photolysis and spectroscopy can eventually be extended to the picosecond time range (*9*).

J. R. NOVAK
M. W. WINDSOR
Chemical Sciences Department,
TRW Systems, One Space Park,
Redondo Beach, California 90278

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Cavitation during Impact of Liquid Water on Water: Geochemical Implications

Cavitation and sonochemical processes have been suggested as widespread natural phenomena of any streaming or wavy body of water, in particular, of the ocean (*1*). Sonolysis in air-saturated water would result in nitrogen fixation (*2*). In view of the enormous amounts of wave energy in the ocean, this fixation may be an additional, important pathway in the nitrogen cycle (*1*). In the primordial methane-saturated ammonical ocean (*3*), sonolysis may lead to formation of many organic compounds, as has been demonstrated in the laboratory (*4*). The formation of complex organic molecules, including amino acids (*4*), by this mechanism is facilitated by the fast removal of the products of the high-temperature reactions into the nonreactive solvent which remains at ambient temperatures (*1, 5*).

The problem of whether cavitation takes place when water impinges on water is the subject of this report. This occurs as a common natural phenomenon, for example, in waterfalls, fast streaming rivers, and particularly in stormy seas. For measurable chemical changes to occur in a sonolyzed system, a limited volume of liquid must be exposed for a considerable amount of time; and therefore, continuous recirculation of the liquid is required for rather long periods. Chemical changes detectable under these conditions may occur anywhere along the recirculating cycle, including in the pumping device, where rapid flow over solid surfaces is most likely to induce cavitation (*1, 6*). For this reason, sonoluminescence was used as a criterion for the occurrence of cavitation in the region of impact of water on water. Preliminary experiments have shown intensive sonoluminescence in our experimental setup in the presence of bromine. This luminescence, however, was very long-lived ($t_{1/2}$ > 3 seconds) and could have originated from cavitation anywhere within the circulating system (total recirculation time 6 to 10 seconds). Therefore, the sonoluminescence used as criterion of cavitation in the region of impact was that of sodium at 589 nm, resulting from the excitation of sodium chloride

Table 1. Sonoluminescence of sodium in water-on-water impact region.

Volatile component	Nozzle	Overall scintillation rate (pulse/sec)	Peak channel No.	Scintillation rate in peak channel (pulse/sec)
Argon	Wide, short	5200	31	200
Argon	Wide, long	<30		
Argon	Narrow, short	7000	30	235
Oxygen	Narrow, short	3400	24	140
Oxygen + methanol *	Narrow, short	<30		

* 6 × $10^{-2}M$ methanol.

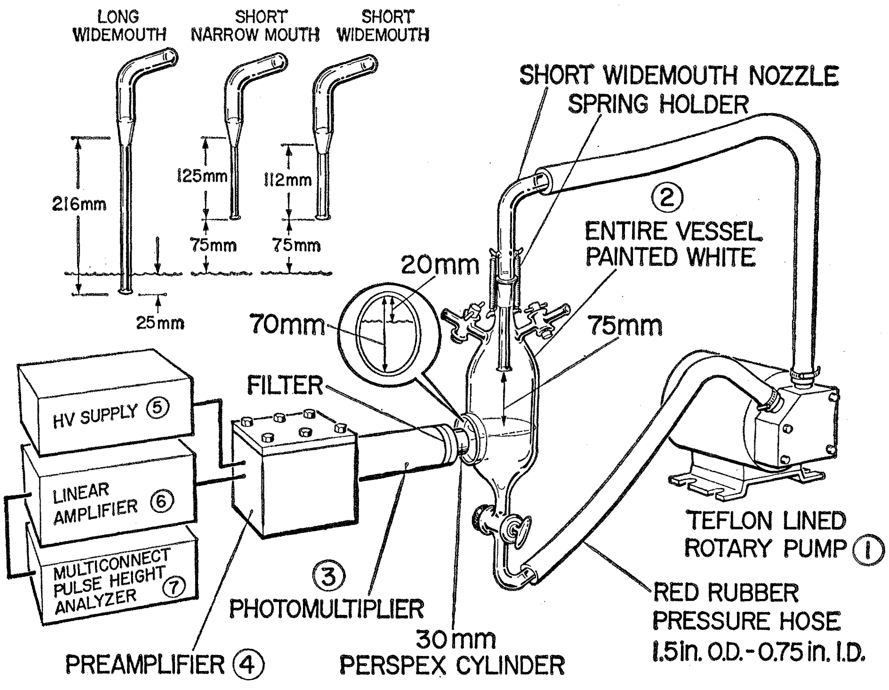

Fig. 1. *1*, Cole Palmer Flexiliner, Teflon-lined rotary pump model T-30, ½-hp motor; *2*, mixing vessel; *3*, EMI 2-inch end window 9558 QS 20 phototube with a Corning cutoff glass filter No. 368—cutoff at 570 nm. Optical coupling through a plexiglass light pipe with Cargille immersion oil; *4*, Nuclear-Chicago preamplifier model 31-14; *5*, Nuclear-Chicago high-voltage power supply model 8200; *6*, Nuclear-Chicago linear amplifier model 30-19; *7*, TMC multichannel pulse height analyzer model 404 C.