antarctic Mountains. In the Ellsworth Mountains *Glossopteris* occurs in a thick section which probably represents the folded, marine, geosynclinal equivalent of the thinner, flat-lying formations that yield a similar flora in the Transantarctic Mountains. On Polarstar Peak, *Glossopteris* is found in argillite interbedded with thin coals; the formation overlies a thick conglomeratic graywacke probably deposited under glaciomarine conditions. In South America (*5*), South Africa (*6*), and Australia (*7*), *Glossopteris* also occurs closely associated with coals and glacial deposits, and the thin, flat-lying cratonic *Glossopteris*-bearing beds pass oceanward into thick, deformed, partly marine, geosynclinal sequences. *Glossopteris* has also been found under similar geologic conditions in Madagascar (*8*) and the Falkland Islands (*9*) although coal beds seem to be absent in the latter area. Such similarities between the geologic history of the Ellsworth Mountains and these other regions of the southern hemisphere were predicted by du Toit (*10*), and they are compatible with his reconstruction of Gondwanaland and its bounding geosyncline.

CAMPBELL CRADDOCK
THOMAS W. BASTIEN
ROBERT H. RUTFORD
School of Earth Sciences,
University of Minnesota, Minneapolis
JOHN J. ANDERSON
Department of Geology,
University of Texas, Austin

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Pulse Radiolysis of Dioxane Solutions

Abstract. *Liquid dioxane gives transient absorptions owing to the production of free radicals and solvated electrons when subjected to a pulse of high-energy electrons (4 million electron volts) for a duration of 2 microseconds. Solutions of benzophenone give the ketyl radical and ketyl radical ions. Solutions of anthracene give anthracene in the triplet state and the anthracene anion. The formation of these species is largely prevented when hydrochloric acid is present.*

We have observed the transient absorptions produced when a 2-microsecond pulse of 4 million-electron-volt electrons is absorbed in liquid dioxane with an apparatus previously described (*1*). With pure dioxane, a 5000-rad pulse gives two species, one with a maximum at 290 mμ (half-life 300 μsec) and another (half-life 2 μsec) which absorbs increasingly from 500 mμ to 800 mμ, the limit of observation. At 650 mμ the absorption amounts to 1 percent.

It seems likely that the former is a free-radical product of the radiolysis, and the latter absorption, like the long wavelength absorptions produced in water and alcohols (*2*, *3*), is due to solvated electrons.

With benzophenone present ($4 \times 10^{-2}M$) new absorptions (Fig. 1) are produced. That with a maximum at 545 mμ matches exactly the spectrum of the ketyl radical, $(C_6H_5)_2\dot{C}OH$, obtained by Bell and Linschitz (*4*), and their absorption coefficient gives the yield $G = 0.5$ (number of radicals per 100 electron volts). The half-life of the radical increases from 200 to 600 μsec when the pulse intensity is decreased ten times, an indication of partial removal by radical combination reactions. The small peak at 700 mμ matches the spectrum of ketyl ion $(C_6H_5)_2CO^-$ which is no doubt formed by electron attachment (*3*). It decays rapidly with a half-life of 7 μsec and has a yield of $G = 0.1$.

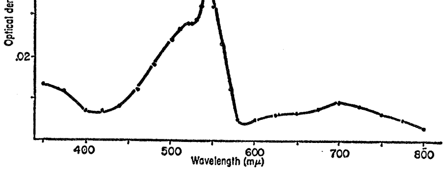

Fig. 1. Absorption spectrum of species produced immediately by a single pulse of 4 Mev electrons (5 kilorads) on 0.04*M* benzophenone in deaerated purified dioxane.

Anaerobic addition of a small amount of hydrochloric acid completely prevents the formation of these species, an effect which is paralleled in the aqueous system (*3*). In explanation of this, it was suggested that the ion is a precursor of the radical and that acid prevents ion formation since H_3O^+ captures the available electrons. This may also occur here, in which case all of the electrons, with a total $G = 0.6$, are captured by benzophenone. The alternative explanation, that the benzophenone radical is formed by the triplet states, as in the photochemical system (*4*)

$$(C_6H_5)_2CO^* + RH \rightarrow (C_6H_5)_2\dot{C}OH + R$$

(where RH is the solvent), would require quenching of the triplet state or its precursor (possibly an excited solvent molecule) by acid, which seems less likely than an electron-scavenging effect.

Similar experiments with anthracene solutions ($5 \times 10^{-3}M$) give transient spectra corresponding to the triplet state [peaks at 410 and 425 mμ (*5*)] and to the anthracene negative ion [peaks at 600 and 720 mμ (*6*)]. These species were also found in similar experiments when alcohols were used as solvents (*7*).

Acid (0.01*M*) removes the anion as expected, but it also removes 75 percent of the triplet state. This could arise again by the quenching processes mentioned above, but the alternative explanation that 75 percent of the triplet state is formed by neutralization of the anion

$$\text{Anthracene}^- + R^+ \rightarrow \text{Anthracene}^* + R$$

seems more likely.

These experiments indicate that secondary electrons produced by radiolysis of a medium of low dielectric constant such as dioxane may become solvated. Because of the greater probability of recapture of the parent ion in such media, however, the yield of solvated electrons is much smaller (not greater than $G = 0.6$) than in more polar media such as water and alcohols.

J. H. BAXENDALE
E. M. FIELDEN†
J. P. KEENE
University Chemistry Department and
Christie Hospital, Manchester, England

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† Present address: Chemistry Division, Argonne National Laboratory, 9700 Cass Avenue, Argonne, Illinois 60440.

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Rotation Technique in Electron Microscopy of Viruses

Abstract. *Some of the features revealed by the rotation technique of examining electron micrographs may be artifacts. To avoid misinterpretation, "rotated" photographs should be compared with originals. The criterion of reinforcement of structures in the "rotated" photographs is not enough, and it cannot be presumed that all the structures reinforced are actually present in the object under study. Further tests for radial symmetry in the arrangement of elements in a pattern should be made.*

Markham *et al.* (*1*) described some methods for increasing the amount of information that can be obtained from electron micrographs of virus particles. Utilizing the symmetry of the virus particle, these workers devised a rotation technique which, they suggested, could provide an increase in resolution above that which is on the original plate. The apparatus used is quite simple and consists of a circular card with a pin through its center. The periphery of the card is divided into an integral number of equal angular divisions, each corresponding to a simple fraction of one complete circle. The pin is fixed on a piece of board, and the whole card is capable of rotation around the pin. The object to be examined is enlarged photographically to a convenient size and is projected onto the card and centered as well as possible. A piece of photographic paper or a lantern slide is then attached to the card. An exposure of $1/n$ times the exposure required for the photographic material, where n is the number of subdivisions to be used, is given. The card is then rotated by one division, or $360°/n$, and another exposure given. This is continued until n exposures have been made. The paper or the plate is then developed. If n is the fundamental periodicity in the specimen, and if the centering is accurate, this periodicity will appear to be reinforced. A departure from this relationship will result in a meaningless blur. Once a reinforcement is achieved, tests may be performed to see whether it is a real one, by making successive exposures in which n is replaced by n-x or n/x, where x is an integral number. Naturally, any flaw in the object or photograph is repeated n times. Markham *et al.* (*1*) suggested that the foregoing test will serve to detect such artifacts. Although they stressed that the technique should be applied with caution, the artifacts inherent in such a technique have not been clearly pointed out and discussed.

To safeguard against a possible misinterpretation of such rotated micrographs, we describe here some of our observations.

Several authors have already used the rotation technique in studying the structure of some viruses (*1–3*). The technique has also been used in studies on the structure of other symmetrical objects (*4*). In some of these instances, only the rotated micrographs are presented, and it is not clear whether a comparison was made between the rotated and unrotated photographs and whether the photographs were found to be in agreement. In our opinion, such a comparison is necessary to eliminate the possibility of misinterpretations attributable to artifacts (*2*).

By rotating through n successive positions (where n is an integer) and superimposing all n, one may very likely detect a structure with n "lobes," even if the original has no such lobes. If so, the degree of symmetry of this structure is not a direct indication of the symmetry of a corresponding structure in the original. The criterion of reinforcement alone is not enough and it cannot be presumed that all the structures appearing reinforced are actually present in the object under study. This is illustrated by Figs. 1, 2, and 3.

An arrangement of random points, taken from MacKay (*5*), is shown in Fig. 1*A*. The same diagram is shown in Fig. 1, *B* through *F*, after rotating 2/2, 3/3, 4/4, 5/5, and 6/6, respectively. The numbers indicate the degree of rotation (that is, 2/2 is 360°/2 = 180°, 3/3 is 360°/3 = 120°, and so on) and the number of exposures made (2, 3, 4, 5, and 6 represent directly the number of exposures corresponding to

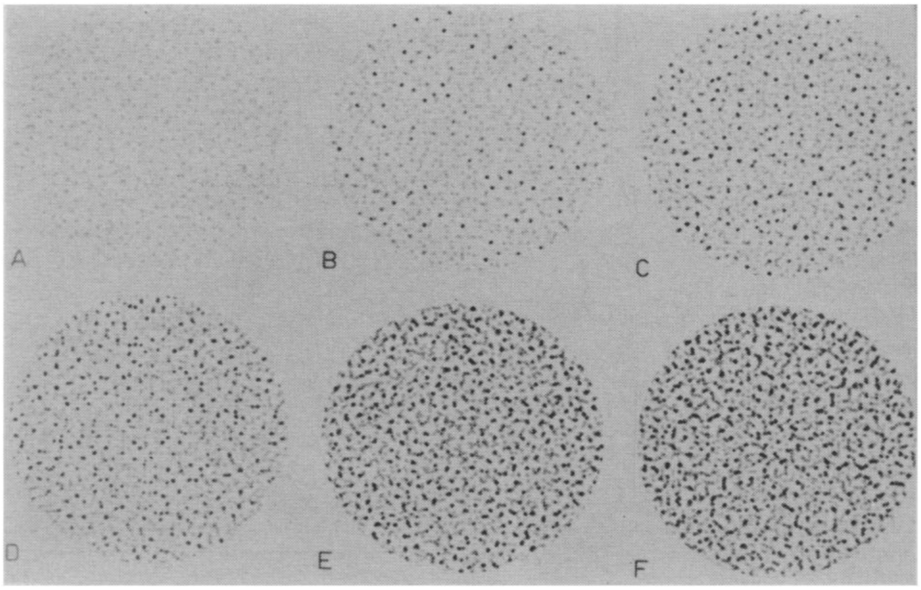

Fig. 1. (*A*) A pattern with random points (*5*). (*B* through *F*) The same pattern photographed by the rotation method after rotating 2/2, 3/3, 4/4, 5/5, and 6/6, respectively. The denominator indicates the number of divisions of rotation (or degrees—that is, $360°/n$ where n = 2, 3, 4, 5, or 6). The numerator shows the number of exposures made corresponding to the degree of rotation.