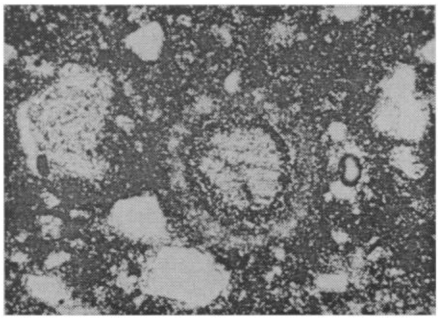

Fig. 3. Lunar chondrule (seen in plane polarized light) in an Apollo 14 sample similar to some chondrules found in primitive types of meteorites. This type of chondrule does not appear to be a rounded rock fragment or crystallized silicate droplet, but may be formed by diffusion around a rock fragment core rich in olivine in impact-generated base-surge or fall-back deposits that have cooled slowly. Length of the field of view is 0.8 mm.

rare to moderately abundant objects similar to chondrules have been found in samples 14305, 14306, and 14311. These samples are thought to be genetically different from the previously described samples from Apollo 11 and 12 mainly because they have been seriously shock metamorphosed by a large impact, probably the large impact that formed the Imbrian Basin (*8*). Although the use of the term "chondrule" for these objects causes some problems in nomenclature, this usage seems justified because of the extreme textural similarity of these objects with meteoritic chondrules. The Apollo 14 samples are the first naturally occurring materials, except for recognized meteorites, that have been observed to contain chondrules.

At least three mechanisms may exist for the formation of chondrules in large impacts: (i) impact melting, rapid cooling, and subsequent crystallization of silicate spherules (*9*) (Fig. 1); (ii) rounding of rock fragments by abrasion in base-surge deposits that result from impacts (Fig. 2); and (iii) diffusion around rock fragments and mineral grains in impact-generated base-surge and fall-back deposits that are at elevated temperatures (Fig. 3).

If these lunar chondrules have been formed by the mechanisms accompanying a large impact, then at least some, and perhaps many, meteoritic chondrules may have been formed by the same process. Thus, some fraction of the meteoritic chondrules, and hence some fraction of the chondritic meteorites, may have been formed by large impacts on the surface of medium to large sized terrestrial planetary bodies The production of chondrules and chondritic rocks may be an inescapable result of the terminal stages of accretion of silicate planetary bodies.

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8 September 1971

X-ray Structure of Racemic Glycerol 1,2-(Di-11-bromoundecanoate)-3-(-p-Toluenesulfonate)

Abstract. *The single crystal x-ray structure of racemic glycerol 1,2-(di-11-bromoundecanoate)-3-(*p*-toluenesulfonate), a sulfolipid analogous to the membrane phospholipids, reveals a folded conformation.*

In our studies on the crystal and molecular structure of model compounds for biological membrane components, *rac* glycerol 1,2-(di-11-bromoundecanoate)-3-(*p*-toluenesulfonate), hereafter referred to as compound **1**, was synthesized. Compound **1** crystallizes as triclinic needles from a 50 percent (by volume) aqueous alcohol solution. The space group is $P1$ with cell constants $a = 8.070(2)$ Å, $b = 5.463(14)$ Å, $c = 40.91(9)$ Å, $\alpha = 93.23(9)°$, $\beta = 96.21(3)°$, $\gamma = 85.18(11)°$, cell volume $= 1782$ Å^3, $Z = 2$, $d_m = 1.39$ g cm^{-3}, $d_e = 1.396$ g cm^{-3}. The crystal structure was solved by the heavy atom method and refined by full matrix least squares to $R = 0.11$ (*1*) by use of three-dimensional x-ray diffractometer data.

A folded conformation was found (see Fig. 1). The bond lengths and angles are within expected values (*2*).

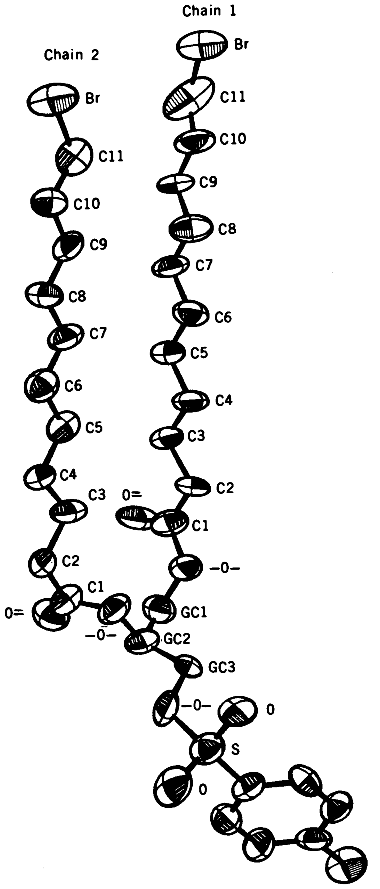

Fig. 1. The molecular structure of *rac* glycerol 1,2-(di-11-bromoundecanoate)-3-(*p*-toluenesulfonate) (**1**).

The least-squares planes (*3*) for the two fatty acid chains intersect at a dihedral angle of 79°; the hydrocarbon subcell chain packing is the orthorhombic perpendicular type (*3*). The long molecular axes (*3*) of the two hydrocarbon chains are nearly parallel showing a slight divergence of 4.5° from the glycerol region toward the terminal ends. The fatty acid chain attached to carbon-1 of glycerol is slightly helical, having a pitch of about 160 Å. The polymethylene chain twists 30° between the carboxyl group and terminal end. In contrast, the fatty acid chain attached to carbon-2 of glycerol is planar (standard deviation = 0.04 Å) and exhibits no significant deviations from its least-squares plane. The conformation angles (*4*) in the glycerol region are as follows: O(1)-C(1)→C(2)-O(2), 50.7°; O(2)-C(2)→C(3)-O(3), 76.5°; C(1)-C(2)→C(3)-O(3), − 116.9°; O(1)-C(1)→C(2)-C(3), 61.0°.

The molecules of **1** pack in a layered structure with the bromine atoms at the tail ends and the *p*-toluenesulfonate group at the head end. The layers are packed tail to tail and head to head. Two layers packed tail to tail form a bilayer similar to that of many membrane model systems (*5*).

In similar compounds (*6*) containing ω-bromine atoms in the terminal positions, the bromine atoms pack in well-defined end group planes. In **1**, the bromine atoms do not form as clearly a defined end group plane, but rather interdigitate slightly in the chain terminus packing scheme. The head group bulk is important in determining molecular packing across the head to head packing plane.

Compound **1** is a sulfolipid having the size and shape of a saturated lecithin or cephalin; however, it lacks a zwitterionic charge in the head group. None of the phospholipid structures have yet been determined by single crystal methods. The present results have a direct bearing upon the molecular structures of the phospholipids.

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1. The *R* factor is defined as follows:

$$R = (\Sigma||F_{\text{obs}}| - |F_{\text{calc}}||)/(\Sigma|F_{\text{obs}}|)$$

where *F* is the structure factor.
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26 July 1971; revised 22 September 1971

Iron-Rich Basal Sediments from the Eastern Equatorial Pacific: Leg 16, Deep Sea Drilling Project

Abstract. *Iron-rich sediments chemically similar to those forming at present on the crest of the East Pacific Rise have been found just above basement at widely separated drill sites in the eastern equatorial Pacific, including three sites of Leg 16 of the Deep Sea Drilling Project. These sediments were probably formed when the basement was at the crest of this rise and have moved to their present location as a result of sea-floor spreading.*

The program for Leg 16 of the Deep Sea Drilling Project (DSDP) was designed around three principal objectives: (i) an examination of the tectonic and depositional history of the Panama Basin, (ii) supplementary drilling for the study of the Cenozoic depositional history of the eastern equatorial Pacific, and (iii) a search for Fe-rich sediments directly above basement similar to those found previously by drilling in the eastern equatorial Pacific. In connection with the first objective, DSDP sites 155 through 158 were drilled on shallow ridges surrounding the Panama Basin (*1*); DSDP sites 159 through 163 were drilled to supplement a north-south traverse of drill sites along 140°W which was begun on Legs 5 and 8, and to add to the network of equatorial drill sites extending across the eastern and central Pacific. The evaluation of these aspects of Leg 16 results awaits publication of the results of earlier legs.

In addition, the Leg 16 sites were designed to test the distribution of ferruginous sediments that have been reported immediately overlying basement at several sites of Legs 5 and 9 (*2*). These deposits may be analogous to the iron-rich sediments now forming on the crest of the East Pacific Rise. Similar deposits were found at sites 159 through 162 in the area between the discoveries of Legs 5 and 9 to the north and south, respectively. We present here the results of some analyses of these deposits and a preliminary discussion of their origin.

The basal sediments of sites 159 through 163 consist predominantly of clays and chalk oozes. At both site 159 and site 160 a thin basal clay unit may be present, but it is difficult to be sure since an undisturbed contact between basalt and the overlying sediments was not recovered. The lowermost core from each of these sites consists of slurried carbonate, clay, and basalt chips, whereas the deepest sediment preserved in a reasonably undisturbed state is a nannofossil chalk ooze. At site 161 the basal sediment is a locally calcareous indurated

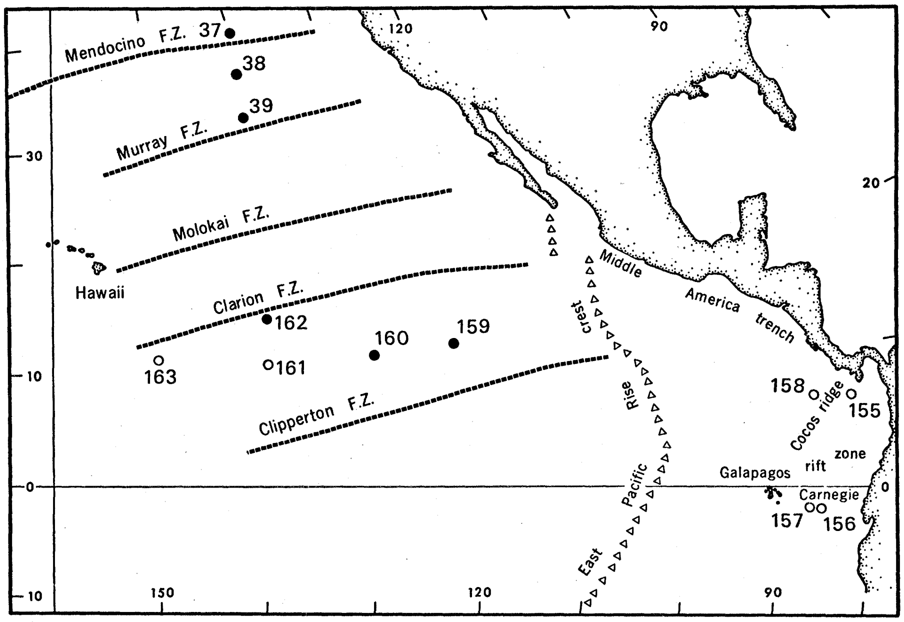

Fig. 1. Location of Leg 16 drill sites of the DSDP in the eastern equatorial Pacific (sites 155 through 163). Solid circles are sites at which sediments enriched in Fe and trace metals were recovered immediately above basement. Also shown are sites 37 through 39 of Leg 5 at which similar deposits were encountered; *F.Z.*, fracture zone.