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July 12, 1966

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Washington, D. C. 20546

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Re: Semi-Annual Report, NASA Grant NsG-541

HC $1.00
MF .50

The research conducted during the period November 1, 1965 - May 1, 1966, consisted of two basic aspects of investigations.

1. An analytical procedure has been developed by which the high molecular weight, insoluble substances in coal and kerogen and the insoluble, "polymer-like" meteorite organic matter were degraded oxidatively and the resultant products isolated and characterized. The procedure utilizes ozonolysis and alkaline hydrogen peroxide oxidation. Methyl ester derivatives of the oxidation products were prepared by means of diazomethane prior to preparative vapor phase chromatography. Individual components were subsequently subjected to mass spectrometric, infrared, and ultraviolet analysis. One of the main advantages of the procedure is its suitability for analyzing micro-quantities of samples.

Oxidation products isolated from a Pennsylvania bituminous coal have recently been identified as dimethyl phthalate, methyl esters of benzenetricarboxylic, -tetracarboxylic, and -pentacarboxylic acids, as well as 3-hydroxy adipate and 3-hydroxy pimelate. These results are in agreement with published data on coal and seem to indicate moderately condensed aromatic structures. The Devonian Bakoven shale from New York was subjected to the same degradative oxidation. Infrared, ultraviolet, and mass spectra of the resulting products show a similarity to those obtained from the coal sample. Prominent peaks in the high-mass end of the spectra were typical of methyl esters of the benzene carboxylic acid series. Outstanding peaks in the low-mass end were indicative of phenylalkyl fragments. However, yields from the ozonolysis of the Bakoven kerogen were lower than those in the bituminous coal sample, and the mass

spectra did not show the same preponderance of aromatic fragment ions. This may suggest that this kerogen is a more aliphatic-type substance than coal.

Oxidation products of the Orgueil meteorite "polymer-like" organic matter gave similar results. Dimethyl phthalate, methyl esters of benzene-tricarboxylic, -tetracarboxylic, -pentacarboxylic acids, dimethyl adipate, as well as a pyridine carboxylic acid have been identified from the Orgueil meteorite. The similarity between coal, kerogen and the Orgueil organic substances is noteworthy. However, one must study the oxidation products of abiological tars before the results can be properly interpreted. The investigations will continue along these lines.

2. Studies of the optical rotatory dispersion of soil, marine sediment, sedimentary rock and carbonaceous meteorite lipids have continued. It has been reconfirmed that both the saponifiable and non-saponifiable lipid extracts of the Orgueil meteorite show a slight levo rotation. Numerous control experiments designed to evaluate instrumental artifacts and spurious rotations have shown that the optical activity of the Orgueil lipids is not caused by instrumental artifacts or by the technique of sample preparation. It is not yet possible to ascertain that this optical activity has not been caused by terrestrial microbiological contaminations which might have invaded the meteorite. On the other hand, certain key biochemical compounds, such as free amino acids, appear to be absent in the Orgueil meteorite which would indicate the lack of serious terrestrial contamination. In addition, the C^{13}/C^{12} ratio of the optically active meteorite lipids falls in the range of ancient petroleum. Again, it is possible that certain recent terrestrial organisms may have this carbon isotope ratio. Most of the sedimentary rocks investigated showed no or border-line optical activity. This was probably due to the fact that these very dark colored lipid extracts had to be measured in very dilute solutions in order to be able to pass light through the cells. Yet, it might be considered that such samples would be more optically active if they would have been contaminated by recent terrestrial microbiological matter after they had been collected in the field. Optical activity measurements of lipids in rocks and meteorites will be continued.

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