TITLE: GEOCHEMISTRY OF THE CARBONATE CYCLE IN THE MARINE ENVIRONMENT

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GEOCHEMISTRY OF THE CARBONATE CYCLE IN THE MARINE ENVIRONMENT

General Statement:

This final report is relatively short because most of the results have been published and distributed.

The carbonate cycle in the marine environment is characterized by very slow reaction rates and chemical disequilibrium (Chave and Smith, in press). The cycle involves atmospheric CO_2, dissolved calcium and carbon ions and complexes, suspended mineral particles, sediments, and living organisms. Our contribution to the understanding of the slow reaction rates in this cycle has been the demonstration that organic compounds in seawater are a major factor regulating reaction rates (Chave, 1965; Chave and Suess, 1967; Suess, 1968; Suess, 1970; Chave and Suess, 1970).

U.S. Navy Relevance:

1. Sediment distribution patterns.

The slowness of the reaction rates involving carbonates in the ocean prevents simple prediction of sediment distribution patterns on the basis of chemical thermodynamics. Carbonate sediments exist on the deep sea floor where waters are undersaturated with respect to $CaCO_3$ (Smith, Dygas and Chave, 1968), yet carbonates dissolve in relatively shallow water associated with the O_2-minimum (Smith, 1970).

These observations, plus the fact that carbonate sediments occur, not only in the tropics, but at all latitudes (Chave, 1967), have led us to our present study of reaction rates on the deep sea floor, and the effects of these reactions on accoustical and other physical properties of the sediments (N00014-70-A-0016-0001; Nr 083-603; Task 3).

2. Interfaces.

Our studies of reactions of organic materials at the carbonate mineral-seawater interface suggest that similar reactions may be taking place at other--U.S. Navy relevant--interfaces, such as the air-sea interface, instrument package-sea interface, and the ship-sea interface. Work at the Navy Research Laboratory in Washington, by Garrett and others (Garrett, 1967, for instance) has shown that the same organic compounds that are absorbed to carbonate mineral grains in the ocean are absorbed to the air-sea interface, modifying the physical properties of this interface as well. The same could certainly be true of other interfaces in the ocean.

3. Scale formation.

Near-surface seawater is chemically unstable, reaching more than 700% supersaturation with respect to $CaCO_3$ (Lyakhin, 1968). Although these waters do not precipitate their excess $CaCO_3$ spontaneously, largely as a result of interactions with dissolved organic matter in sea-water (Chave and Suess, 1970), when physically disturbed, for instance by heating or by passing through a small orifice the carbonate precipitates out as scale. A thorough understanding of the organic chemistry of this precipitation inhibition could lead to the solution of problems of scale formation.

Personnel and Publications:

The two principal workers on this contract, other than the principal investigator, have received Ph.D. degrees: Erwin Suess (1968) and Stephen V. Smith (1970). A majority of the references listed below were supported by this contract and have been, or will be, distributed to the Navy distribution list.

References:

Chave, K.E. 1965. Calcium carbonate: Association with organic matter in surface seawater. Science 148, 1723-1724.

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Garrett, W.D. 1967. The organic chemical composition of the ocean surface. Deep sea Res. 14, 221-227.

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Suess, E. 1968. Calcium carbonate interaction with organic compounds. Ph.D. Thesis, Lehigh University, 183 p.

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13 ABSTRACT

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The report summarizes the authors

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