

cant role in the ultimate distribution of the sediment once it is placed in suspension by shoaling and breaking waves.

Superimposed on the framework of the larger, more stable forms of the system are the smaller ephemeral crescentic features distributed along the lower part of the curve (Fig. 3). Beach cusps of orders 1-3 are surely linked directly with shallow-water wave deformation and associated inshore current cells that are in turn linked with currents of the larger rhythmic features of order 4. This fact suggests a

direct relation between rate-of-change and order, with the smaller features (orders 1-4) responding to seasonal and short-term variations in the state of the sea, and the larger features (orders 5 and 6) responding to the less variable controls, such as wave climate and sea level. [The transitional part of the curve (Fig. 3) appears to be between orders 4 and 5, with increased scatter in the lower orders defining the most dynamic elements of the system.]

In summary: Crescentic coastal landforms, such as the Carolina capes, represent only one order of shoreline form

in an uninterrupted hierarchical grouping of coastal features. The central questions regarding the origin of these features are: (i) Do the features reflect and are they controlled by interacting processes, including both planetary currents and shoaling and breaking waves? (ii) Are these interacting processes continuous in nature?

ROBERT DOLAN

Department of Geography, University of Virginia, Charlottesville

JOHN C. FERM

Department of Geology, Louisiana State University, Baton Rouge

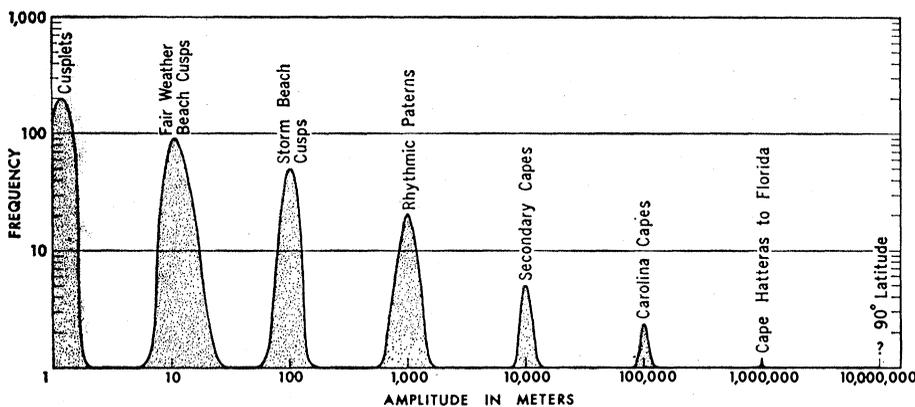


Fig. 2. Frequency and amplitude of crescentic forms observed along the middle of the Atlantic coast.

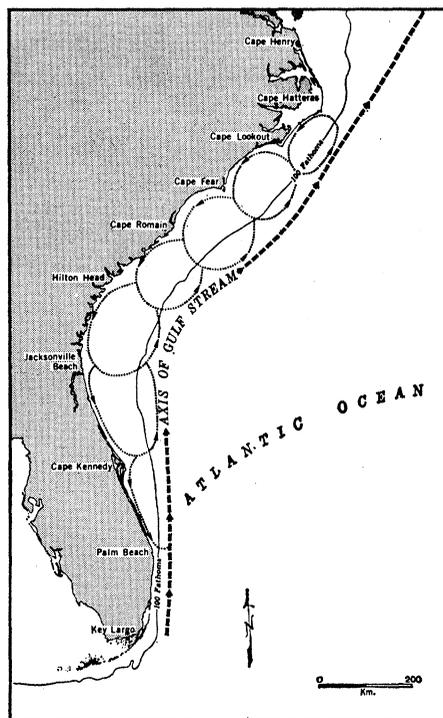
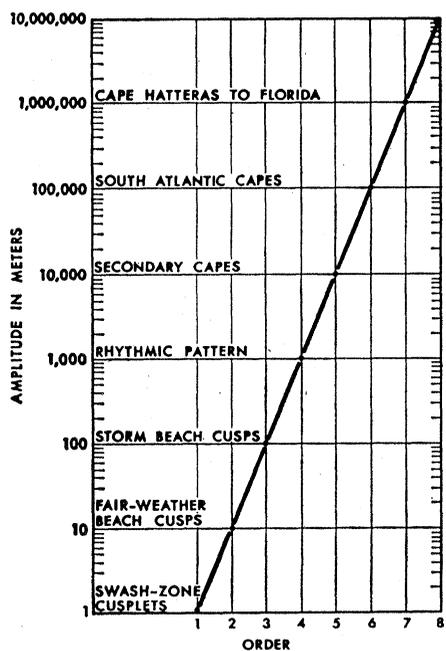


Fig. 3 (left). Relation of average amplitude to cuspsate order. Fig. 4 (right). Eddy currents that may generate along the western margin of the Gulf Stream (after C. Abbe). Crescentic coastline forms may reflect steady-state configuration. The controls are: resistance of the materials exposed along the coast, intensity of the littoral processes, and stability of the land-sea interface. Thus the well-developed capes, such as Hatteras, Lookout, Fear, Romain, and Kennedy, occur in sandy regions having narrow continental shelves.

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Carbon Tetrachloride: Plastic Properties

Abstract. *The shear strength of solid carbon tetrachloride was measured from 187° to 247°K. A 25-percent discontinuity was observed at the solid-solid transition, at about 225°K. This transition exhibited a distinct hysteresis. The shear strength of both the high- and low-temperature forms increased very rapidly as the temperature was lowered. There was no evidence of a rhombohedral high-temperature phase.*

Carbon tetrachloride exhibits an interesting variety of polymorphic transformations in the solid state. The liquid freezes at 250.5°K to form a face-centered-cubic plastic crystal characterized by a low strength and high ductility. Plastic crystals are also typified by several other features such as globular molecules, a low entropy of fusion, and a high degree of molecu-

lar disorientation. Carbon tetrachloride exhibits these qualitative features. In addition, at low temperatures it undergoes a typical solid-solid transition to a less symmetric, nonplastic structure having more conventional properties. In carbon tetrachloride, this occurs as an isothermal transformation to a monoclinic form at 225.5°K (1).

X-ray and optical studies have revealed that the properties of carbon tetrachloride are more complex than formerly recognized. The solid obtained when the monoclinic form is heated is not the original face-centered-cubic phase, but rather it is a new rhombohedral structure. The transitions are shown in Fig. 1 where arrows indicate the directions in which the reactions can occur. The reactions proceed rapidly, with the exception of the spontaneous transformation of the face-centered-cubic phase to the rhombohedral phase which requires several hours (2). At high pressure, at least two additional polymorphic forms have been detected, and it has been demonstrated that the phase diagrams of carbon tetrachloride and carbon tetrabromide are consistent with the principle of corresponding states (3, 4).

I now report on the mechanical properties of the atmospheric-pressure forms of carbon tetrachloride. The mechanical properties of several organic plastic crystals were investigated by Michils using an extrusion process (5). Although Michils did not investigate carbon tetrachloride, he did examine the isomorphous carbon tetrabromide and concluded that changes in mechanical properties afforded a means for detecting the existence of polymorphic forms and he noted that a linear relation usually existed between the extrusion pressure and temperature. Michils did not examine the temperature dependence of the strength in sufficient detail to determine whether it changes discontinuously at the solid-solid phase transitions so that the strength of the low-temperature, nonplastic polymorph increased more rapidly as the temperature was lowered. My experiments were made to determine whether the recently discovered rhombohedral high-temperature form of carbon tetrachloride could be iden-

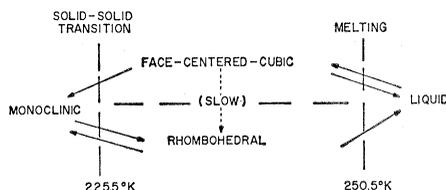


Fig. 1. Phase transformations occurring in carbon tetrachloride at atmospheric pressure [after Rudman and Post (2)].

tified through variations in shear strength, as implied by Michils' investigations, and to compare the plastic properties of this material with those of several other soft solids.

The shear strength of polycrystalline carbon tetrachloride was measured with an inverted-extrusion technique over the temperature range from 187° to 247°K. The apparatus and technique have been described in connection with similar measurements on solid argon and krypton, and silver chloride (6, 7). The pressure required to extrude the sample material through a die in the end of a hollow piston is measured at several constant temperatures. The observed extrusion pressures are used to calculate the shear strength according to the slip-line theory of Hill on the basis of the reduction in cross-sectional area of the sample (8).

In the measurements on carbon tetrachloride, a small but significant variation of extrusion rate with pressure required a slight modification in experimental technique. The rate of piston advance was measured at several constant pressures at some fixed tempera-

ture (Fig. 2A). A straight line was fitted to the data in the range above about 2.54×10^{-3} cm/sec, and the intercept on the pressure axis was taken as the extrusion pressure. Data obtained at lower rates of piston advance were not reproducible and were disregarded because they were not necessarily indicative of any true extrusion of the sample. Piston advance at these very low rates is largely attributable to compaction of the sample through the elimination of voids and cracks, and to stress relaxation and annealing of the sample material.

Data from 15 samples of reagent-grade carbon tetrachloride are shown in Fig. 2B. Although the extrusion pressures were measured with three different die sizes, the calculated shear strength showed no systematic variation with die size, an indication of the validity of the slip-line theory. The data fit on smooth curve segments above and below the temperature of the solid-solid transition, and a marked hysteresis effect was observed in the vicinity of this transition.

There are two essential features of the hysteresis: (i) an abrupt discontinuity in shear strength of 25 percent was observed on both warming and cooling, and (ii) the path depended only on the direction in which the temperature was being varied and was independent of which of the two phase transformations was occurring. Thus, a sample which had been cooled through the transition, then warmed above the transition, and subsequently cooled

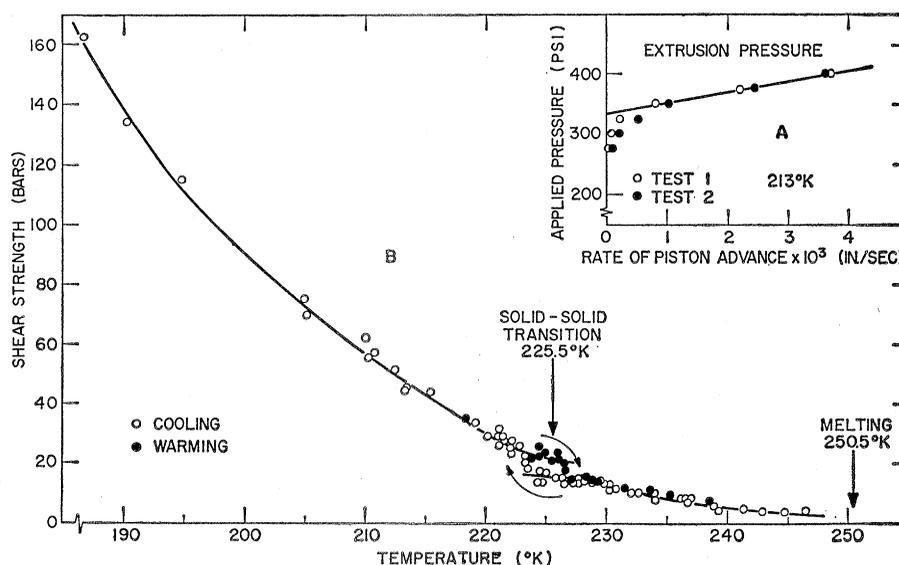


Fig. 2. (A) Applied hydraulic pressure plotted against the rate of piston advance for two successive tests at 213°K. (B) Computed shear strength plotted against temperature. Open circles, during cooling; solid circles, during warming sequence.

through the transition again followed the lower branch of the hysteresis loop during both cooling operations. This is significant because the first cooling through the transition presumably involved the transition from face-centered-cubic to monoclinic crystal structure, whereas the second cooling involved the transition from rhombohedral monoclinic form (2) (Fig. 1). Hence, the existence of the hysteresis loop is not associated with the dual nature of the structure of the high-temperature form.

The actual causes of the hysteresis are difficult to determine. The temperature of the steel sample holder was normally held constant (within 0.1°K during a given measurement) as determined by thermocouples attached to its outer surface. I made a separate test in which the temperature of the die was compared with that of the exterior of the sample holder. Under static conditions the temperature difference was $\approx 0.1^\circ\text{K}$. However, during extrusion, the die temperature increased by $\sim 1^\circ\text{K}$, the rise becoming greater as the extrusion rate was increased. The thermal energy released was quickly dissipated when the extrusion was stopped; the effect on the temperature of the outside of the sample holder was negligible. The extent to which the temperature of the sample was affected is difficult to estimate. The extrapolation to zero rate of piston advance used to determine the extrusion pressure should have minimized the effect. The observed width of the hysteresis loop, $\sim 3^\circ\text{K}$, can probably not be attributed to systematic errors in the measurement of the sample temperature.

The effect of any rise in temperature caused by the extrusion is a lowering of the apparent transition temperature. This is countered by the effect of extrusion pressure on the phase transition. The applied pressure of ~ 100 bars should raise the apparent transition temperature about 2°K (3) if it is assumed that the phase boundaries of monoclinic face-centered-cubic and monoclinic rhombohedral forms are nearly coincident. Thermal measurements by several investigators indicate that this assumption is valid within $\sim 0.3^\circ\text{K}$ (9). There is also a possibility that the crystallographic transformations are displaced by the shear stresses experienced by the sample. The observed hysteresis is thus the result of several competing effects, their magnitudes being difficult to estimate.

In the measurements made in the temperature range above the transition temperature, the shaded (warming) points presumably indicate the shear strength of the rhombohedral form while the open (cooling) circles represent the face-centered-cubic phase. No difference in shear strength was observed within the experimental uncertainty ~ 5 percent). This result has two possible interpretations: (i) the shear strength of the rhombohedral and face-centered-cubic phases are not readily distinguishable on this basis, or (ii) observations were not made on both phases.

The plastic properties of the two high-temperature forms are expected to be similar because of their similar symmetries. Symmetry considerations also suggest that the strength of both of these structures should be markedly different from that of the monoclinic form. Because this difference was found to be only 25 percent, it is quite possible that between the rhombohedral and face-centered-cubic forms of carbon tetrachloride there is a difference which is below the sensitivity of this extrusion technique. It is also conceivable that the stress and strain associated with the extrusion process alters the relative stability of the two forms so that measurements were not actually made on both forms. Although the latter possibility seems unlikely, it cannot be ruled out on the basis of these measurements. However, neither the measurements in the high-temperature range nor the hysteresis effect provides evidence confirming the dual structure of carbon tetrachloride at high temperatures.

The temperature dependence of the shear strength of both the high- and low-temperature forms of carbon tetrachloride exhibits a gradual curvature rather than the linear dependence reported by Michils for several organic solids. If the data are approximated by a linear function on either side of the transition, a discontinuity in slope is observed at the transition temperature as expected from Michils' measurements. However, my data can also be approximated by a smooth curve with little or no discontinuity in slope, provided that the hysteresis loop is ignored. This suggests that the mechanical properties of the high-temperature plastic phase or phases are not qualitatively different from those of the low-temperature phase and that the discontinuity in slope reported by Michils

may have been an artifact of his experimental procedure which involved only a few measurements made at relatively large temperature increments.

The mechanical properties of carbon tetrachloride can best be compared with those of other soft solids by our considering each material at equivalent values of reduced temperature, that is, T/T_m where T_m is the melting point of the material. When this is done, it is found that the shear strength of carbon tetrachloride near $T/T_m = 1$ is comparable to that of argon and krypton (6), but an order of magnitude smaller than that of silver chloride (7). However, the shear strength of carbon tetrachloride increases much more rapidly as the temperature is lowered than that of these other materials. This is apparently a reflection of the greater molecular complexity of carbon tetrachloride and its lower molecular symmetry.

LAIRD C. TOWLE
Naval Research Laboratory,
Washington, D.C.

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6-Methylpurine- H^3 : Intracellular Localization in Pea Root Tip Cells

Abstract. 6-Methylpurine- H^3 , a potent inhibitor, was detected by autoradiography in the nucleoli of pea root tip cells. Most of the radioactivity was in the nucleoli of growing cells in the meristematic region. Treatment of the labeled cells with ribonuclease indicates that 6-methylpurine- H^3 is incorporated into nucleolar RNA which then moves from the nucleolus to the cytoplasm.

Several reports show that 6-methylpurine is a potent inhibitor of cell growth (1) and possibly of viral multiplication (2). In *Pelargonium* pith-cell cultures (1) and in pea roots (3), growth