the piezoelectric classes respond to hydrostatic pressure as well as to compression and torsion (*8*). Among these ten classes are some interesting mineral representatives such as shortite [$Na_2Ca_2(CO_3)_3$] and pirssonite [$Na_2Ca(CO_3)_2 \cdot 2H_2O$] which could easily fall within the exploratory analyses we have made so far. It would seem that there might be many possibilities that an organic constituent is responsible for the piezoelectric property.

We believe we have presented sufficient evidence to warrant exhaustive analytical studies of otoliths and physiological experiments designed to test whether or not piezoelectricity has any significance in the function of the fish ear. It appears that such a piezoreceptor is unknown in biological systems.

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Geological Exploration in an East Coast Submarine Canyon from a Research Submersible

Abstract. *Large talus blocks litter the flat floor of Oceanographer Canyon at a depth of 1460 meters; they indicate down-axis mass transport of floor sediment at an unknown time and rate. From 1460 to 1310 meters the sidewall is covered by unconsolidated sediment lying at 35° to 40° from the horizontal. An outcrop of Pleistocene or younger sediment at 1460 meters is probably a remnant of a former fill.*

The first descent into an East Coast submarine canyon was made on 15 October 1966 in the research submersible *Alvin*, which carries two men (three by redesign in 1967), and can go to a depth of 1830 m. It has four viewing ports, a six-motion mechanical arm, an exterior tool rack and sample basket, four exterior incandescent lamps, closed-circuit television, an exterior 500-shot strobe-illustrated 35-mm camera, and varied depth-indicating, navigation, and communication systems.

Sedimentary strata ranging in age from Late Cretaceous to Recent have previously been dredged from the walls of submarine canyons off the East Coast (*1*), but dredging techniques have not revealed the depth of individual samples. Currents have been measured (*2*) and photographs have been taken at the bottom of the canyons, but little information about geologic processes or dynamic events has resulted. Numerous traverses made near and across the canyons with continuous seismic profilers (*3*) indicate that large-scale slumping is a common process on the continental slope in the area.

The dive was made in Oceanographer Canyon at 40°14.9′N, 68°06.1′W (Fig. 1). The submersible, piloted by McCamis, landed on the canyon floor at depth 1460 m, traversed west approximately 100 m to the sidewall, ascended the sidewall to a depth of 1310 m, and returned to the surface. The dive was terminated after 2⅓ hours because the anchored navigation reference buoy went adrift; the submersible could have spent more than twice as much time on the bottom.

The canyon floor where first seen, about 100 m from the western sidewall, was planar and appeared level; an inclination of much more than 1° would probably have been detectable. The unconsolidated bottom sediment (not sampled) appeared to be the dark olive-brown clay-silt-sand that blankets that general area. Virtually all the surface was disturbed by the action of burrowing organisms. Circular pits as deep as 10 cm were surrounded or flanked on one side by mounds of the removed material. The only numerous bottom-dwelling organisms seen were off-white stalks or tubes roughly 8 mm in diameter, projecting 6 to 8 cm above the sediment surface. They were not associated with the pits.

Within about 75 m of the sidewall, the canyon floor is inclined about 5° toward the wall. The inclined part of the floor appears the same as the flat part, except for the presence in the inclined area of a small area of old-appearing inactive ripple marks about 10 m from the sidewall. The profile of the ripple marks indicated a down-canyon current. No ripple marks were seen on the flat part of the floor.

Small strands of organic matter attached to the canyon floor streamed in the 10 cm/sec down-canyon water current, but no sediment was seen in motion. In both the flat and the inclined floor areas, ridges and depressions in the sediment near to and concentric with projecting talus blocks indicated a down-canyon current; they were similar in appearance and presumably in origin to wind sculpturing of a snow surface near an obstruction.

The junction of floor and sidewall was smooth and covered by sediment; the radius of curvature at the junction was 1 to 2 m. No evidence of relative motion between the floor sediment and the sidewall was seen.

Large talus blocks protruded above the sediment in both the flat and the inclined area. One block about 2 by 6 m appeared to be tabular and to be resting on the sediment surface. It had an open, sinuous, parallel-sided break that indicates fracture after emplacement on its bed of sediment. Another block of talus projected monolithically 3 m at a high angle from the floor sediment (see Fig. 2). The talus blocks were not in contact with one another at or above sediment level, and did not appear to be in contact below that level. Shapes of the tabular rocks suggested that they are sedimentary. Talus blocks as small as 15 cm also rested on the sediment. The smaller blocks were highly angular; the large ones, subrounded.

An outcrop of semiconsolidated, well-bedded, clayey and silty sandstone was found at the base of the sidewall. Its base was hidden by overlapping floor sediment. The part seen was about 5 m high and 20 m long; one end was out of sight in the darkness. The beds were about 30 cm thick and dipped 15°SE. No disturbance of the bedding was seen. About 800 cm^3 of this unit was sampled by a brass coring tube held by the submersible's mechanical arm. A later analysis (*4*) of Foraminifera indicated a Pleistocene or younger age. Aside from one starfish, no organisms were seen on the surface of the outcrop. On the less steep part of the outcrop lay a thin layer of unconsolidated sediment, clearly derived from the slope above.

No further outcrops were present in the 150 m of sidewall above the outcrop. Most of the sidewall was a smooth surface inclined 35° to 40° from the horizontal. In part of the area traversed, the wall had the form of spurs and intervening gullies. Both the spur-and-gully area and the smooth sidewall were blanketed with unconsolidated sediment similar in appearance to that on the canyon floor. Where sampled at a depth of 1310 m the unconsolidated sediment was at least 25 cm thick. A faunal analysis of the sediment indicates a Recent age. The unconsolidated sediment on the sidewall was at or near its maximum angle of repose, judging from one small triangular slip-scar seen on its surface, and from the fact that the sediment slid downhill out of sight when disturbed by the submersible. No organisms were seen in or on the sidewall sediment, but pits and mounds, typical of those caused by organisms, were present, though much more widely spaced than those on the canyon floor.

Several tentative conclusions about large-scale dynamic processes in the canyon can be made, even with this fragmentary evidence. The distribution of talus blocks at a distance from the sidewall and from one another seems to indicate that they became dislodged from the walls farther up the canyon and were carried down the canyon in a mass movement with the floor sediment. This process was reported by Dill (*5*) in the head of La Jolla Canyon off California. He noted that such blocks become subround and smooth, as are the larger blocks in Oceanographer Canyon.

The outcrop sampled was Pleistocene or younger in age, but results of dredging and of nearby seismic profiling (*3*) indicate that undisturbed rock at that position would be of Cretaceous age. The outcrop is probably a remnant of a former fill; Roberson (*3*) found a buried channel in the continental shelf just above the head of the canyon.

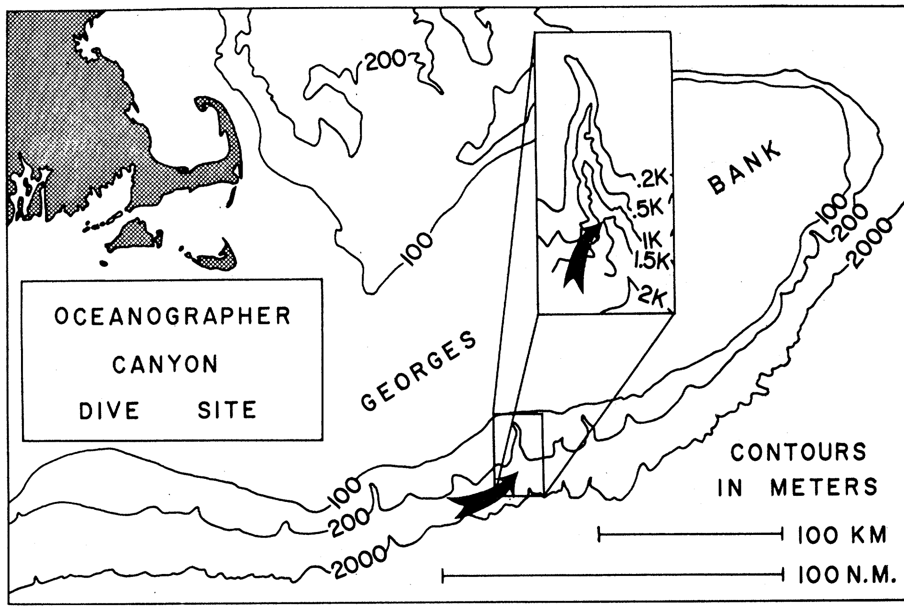

Fig. 1. Location of Oceanographer Canyon and of dive (arrows). Cape Cod, Massachusetts, at upper left. Distance markers indicate kilometers and nautical miles.

The current-caused scour marks near the talus blocks, the ripples near the sidewall, and the failure of sediment that is moving down the sidewall to fill the inclined part of the canyon floor or to cover the outcrop, all indicate current of sufficient velocity to move sediment. A time interval appreciably longer than a tidal period, however, would be needed for all the area of the canyon floor to become covered by pits and mounds. Assuming that the current would be strong enough to remove or leave its traces on the pits and mounds, it must be intermittent and must occur much less often than once per tidal period. The alternate and less likely explanation is that currents form the scour marks, remove the material descending the sidewall, and cause the ripple marks, without destroying the pits and mounds. The

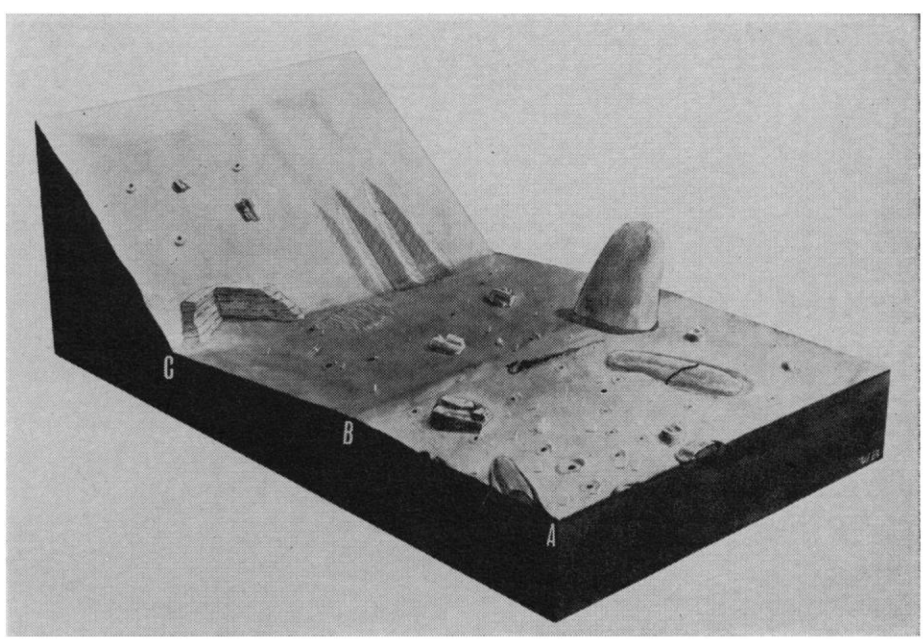

Fig. 2. Composite diagrammatic view of area observed. Canyon floor at 1460 m is flat at *A*, inclined 5° from *B* to *C*. In front of the large upstanding rock, a fish stirs the bottom sediment with his fins. Junction with sidewall at *C* has overlap of canyon-floor sediment about 1 m high, and at the place seen is occupied by large remnant of a former valley fill. Sidewall continues at uniform angle of 35° to 40° to horizontal from 1460 to 1310 m. Spur-and-groove topography on sidewall is highly diagrammatic; time did not allow close examination.

ripple marks and the inclination of the floor near the sidewall lead one to speculate that a current of higher velocity than elsewhere on the canyon floor flows intermittently at the right (west) side of the canyon.

In summary, the fragmentary evidence can be taken to indicate mass transport down the canyon axis, a previous episode of canyon filling followed by partial erosion of the fill, and perhaps intermittent flow of strong water currents on the canyon floor.

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6. The *Alvin* is funded by the Office of Naval Research and operated by the Woods Hole Oceanographic Institution. The dive was made possible by the cooperation and ability of the entire *Alvin* group, and by the financial support of the *Alvin* project by ONR. It was under the surface control of W. O. Rainnie, chief pilot of the *Alvin* group. We thank J. C. Hathaway for assistance in preparing for and conducting the operation. Publication authorized by the director, U.S. Geological Survey. Contribution No. 1921 of the Woods Hole Oceanographic Institution.

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Adenosine 3′,5′-Cyclic Phosphate: Stimulation of Steroidogenesis in Sonically Disrupted Adrenal Mitochondria

Abstract. *Adenosine 3′5′-cyclic phosphate stimulated the conversion of added cholesterol to pregnenolone in "coupled" rat adrenal mitochondria provided with succinate, and in "leaky" mitochondria fortified with reduced nicotinamide adenine dinucleotide phosphate. Adenine nucleotides other than adenosine 3′,5′-cyclic phosphate did not duplicate these actions. The cyclic nucleotide was also effective in supernatants from sonically disrupted mitochondria. The minimum effective concentration was 50 micromoles per liter or less. The results suggest that adenosine 3′,5′-cyclic phosphate stimulates corticosteroidogenesis by activating the mitochondrial enzymes which are rate-limiting in the utilization of cholesterol.*

On the pathway to corticosteroids in the adrenal cortex the initial conversions of cholesterol are carried out by mitochondrial steroid hydroxylases which require reduced nicotinamide adenine dinucleotide phosphate (NADPH) and molecular oxygen (*1*). Formation of pregnenolone from cholesterol involves as intermediates 20α-hydroxycholesterol and 20α,22-dihydroxycholesterol (*2*). Side-chain cleavage of the latter steroid completes this early sequence. Several experimental observations (*3*) are consistent with the concept that one or both of these hydroxylation steps is rate-limiting in corticosteroidogenesis and may be activated acutely by adrenocorticotropin (ACTH). Mechanisms proposed for this action of ACTH include enhanced passage of cholesterol or pregnenolone through the adrenal mitochondrial membranes, activation or induction of certain catalytic proteins in the adrenal cortex, and increased provision of cytoplasmic NADPH to adrenal steroid hydroxylase systems (*4*). Adenosine 3′,-5′-cyclic phosphate (3′,5′-AMP), which is formed in the adrenal cortex in response to ACTH, has been implicated as a possible intermediate in the action of this hormone (*5*). This cyclic nucleotide stimulates certain steroid transformations in surviving adrenal tissue (*6*), adrenal homogenates (*7*), and isolated adrenal mitochondria (*8*). Our experiments reveal that relatively low concentrations of 3′,5′-AMP activate the conversion of cholesterol to pregnenolone in sonically treated suspensions of rat adrenal mitochondria as well as in intact mitochondria in various functional states (*8*).

Adrenal glands were obtained from male Sprague-Dawley rats (6 weeks old) that were lightly anesthetized with sodium pentobarbital (Nembutal). We prepared the mitochondria by a method (*8*) which involved repeated washing in a medium composed of 0.25*M* sucrose and 0.8 m*M* tris-HCl at *p*H 7.1. This procedure resulted in cholesterol-depleted mitochondria which contained about 3 μg of free cholesterol per milligram of mitochondrial protein. When these mitochondria were incubated at 37°C in buffer composed of 24 m*M* $NaHCO_3$ (*p*H 7.5) and 130 m*M* KCl, they swelled rapidly and required exogenous NADPH to support the utilization of added cholesterol-4-^{14}C ("leaky" mitochondria). In contrast, adrenal mitochondria did not swell at 37°C in a medium containing 20 m*M* tris-HCl (*p*H 7.4) and 70 m*M* sucrose, they were dependent upon exogenous substrates of the citric acid cycle to generate NADPH intramitochondrially, and they gave other evidence of being tightly "coupled," including ADP acceptor control ratios greater than 3. For sonic disruption, we suspended washed mitochondria in distilled water at 0°C and treated them for varying periods at 20 kc/sec with a Branson Sonifier, model S-75, equipped with a microtip. The sonically treated suspension was then centrifuged in a Sorvall SM-24 rotor at 0°C and 15,000 rev/min for 15 minutes. This procedure removed from suspensions similar to those subjected to sonic disruption essentially all structures recognizable under the electron microscope as mitochondria. However, mitochondrial membrane fragments undoubtedly remained. The supernatant was incubated in the tris-sucrose medium. In all experiments, the *p*H of 3′,5′-AMP was adjusted to that of the incubation medium at 37°C. After incubation, the media were extracted with methylene chloride. Steroid products were analyzed by thin-layer chromatography on silica gel GF in an isooctane,*tert*-butanol solvent system (5 : 1). Once-repeated development of the chromatograms in this system afforded good separation of pregnenolone from progesterone as well as from the large amount of radioactive cholesterol remaining. Other solvent systems used for identification included benzene, hexane, and ethyl acetate (4 : 15 : 8); methylene chloride and methanol (94 : 6); benzene and ethyl acetate (3 : 1); hexane and ethyl acetate (1 : 1); and systems A, D, H, and L of Lisboa (*9*). Radioactivity in the separated steroids was measured with a Packard radiochromatogram scanner equipped with a disc integrator. The overall efficiency of counting was about 10 percent (that is, 1 μc was equivalent to approximately 2.2×10^5 count/min). The reproducibility and accuracy of quantitation were established by mea-