serial # 90014

U.S. GEOLOGICAL SURVEY
BRANCH OF ATLANTIC MARINE GEOLOGY
MEMORANDUM
10 July, 1990

To: Distribution

From: Peter Popenoe

Subject: Administrative Cruise Report: Submersible DELTA, Escort Vessel R/V POWELL

1. Escort Ship: R/V POWELL
   SUBMERSIBLE DELTA

2. Cruise: NOAA-NURP Designation 90-OR-SUB-POPENOE

3. Parent Project: EEZ Inventory, 9470-30041

4. Funding Agency: All costs but travel to and from the area of the dives and shipment of equipment were paid by the NOAA-National Undersea Research Program. Costs to NOAA-NURP were estimated at $62,500. USGS costs are estimated at $3,000. Each institution or agency paid travel expenses for their participant.

5. Area of Operations: Blake Plateau 80 miles east of Charleston, South Carolina. Water depths of 500 to 1200 feet (152-366 m).

6. Cruise start and end dates, ports:
   Start July 2, 1990 from the Charleston, S.C. Port Authority Dock.

   End July 6, 1990 at Morehead City, N.C. at the Maritime Authority Dock.

7. Chief Scientist: Peter Popenoe
   Co-Chief Scientists: Frank Manheim, Vernon J. Henry

8. Cruise Data Curator: Peter Popenoe, Fisal Idris

9. Scientific Party:

Peter Popenoe	USGS
Frank T. Manheim	USGS
Vernon J. Henry	Georgia State University
John B. Wilson	Institute of Oceanographic Sciences
Paul Huddlestun	Georgia Geological Survey
Robert Woolsey	U. of Miss. Mineral Resource Inst.
Mark Evans	Emory University
Fisal Idris	Skidaway Institute
Clark Alexander	Skidaway Institute

NOAA NURP Representative:

Andrew Shepard — Science Director, Wilmington, N.C. Office

10. Ships Captain: Captain Frank
Sub Pilots: David Slater, Bob Wicklund
Sub roustabout: Jim Prescott
Mate: Grant, Cook: Sally, Engineer: Don, Deckhands: Scott, John.

11. Purpose of Cruise:

1. To establish stratigraphic age, lithology, and phosphorite content of strata by bottom sampling of outcrop areas.

2. To determine the nature of scarps. To observe and measure fracture patterns and possible scour and bioerosion features.

3. To observe and record phosphorite pavement thickness and extent and presence and thickness of manganese rinds.

4. To assess the benthic ecology of the study area, with particular emphasis on sessile epifauna.

5. To record current directions and speed with time.

6. To observe and record nepheloid layers, acoustic scattering and other organisms in the water column, and other water column parameters.

12. Navigation techniques: Positions for dives were picked from sparker profiles from the FAY 17 survey and transferred to topo-bathy maps where latitude and longitude were picked. The R/V POWELL used standard Loran-C to find the dive sites. When the submersible was on the bottom, the POWELL would calculate the submersible's position by passing directly over the sub. Several times during the dives the POWELL would pass over the sub and record its position again, and usually the end position of the dive was recorded. Traverses in the submersible were made on compass headings from a gyro compass.

13. Scientific Equipment:

The DELTA Oceanographics two-man submersible with object recovery claw, slurp sampler, external benthos camera, external and internal videocorder, internal hand-held camera with external strobe.

A gravity corer borrowed from WHOI and 25 five-foot long core barrels. This equipment was not used due to the fact that the winch borrowed from Pacific Marine Geology to operate the 200 lb gravity corer did not have the power to

lift the core bomb off the deck.

A 30 Joule Bubblepulse seismic-reflection system borrowed from the Marine Minerals Institute, University of Mississippi. This equipment failed to find the bottom due to its low power, so the system was not used.

14. Tabulated Information:

a. Days at sea: 4 1/2
b. Individual dives: 23. the positions are indicated in Figure 1.
c. Data Acquired:

Nine video tapes taken with the external camera.
Nine video tapes taken with the internal camera.
Three rolls of 36 exposure slides.

Unknown amount of pictures taken with the external Benthos camera. (these have not yet been sent to me by NOAA.

12 rock samples, of which three were calcarenites taken from the walls of tilefish holes.

38 sand samples taken with the slurp suction.

15. Narrative: Targets for the submersible dives were picked from the FAY 17 sparker lines and from the James Island topographic-bathemetric sheet. Generally, the targets selected were areas of rugged topography where it was believed that bedrock would be exposed and assessable for sampling. We had also planned to visit several "pinnacles" which abound in deeper water on the Blake Plateau, and have traditionally been interpreted as buildups of deep-water coral (coral mounds). The limitation on dive depth for the DELTA submersible of 1200 feet, however, prevented our visiting the pinnacle area.

Dives 1877 through 1887 were located on a series of northeast-southwest trending ridges and troughs of 20 to 30 feet (10 m) relief, and on the flanks of several erosional "mesas" along FAY line 13 (Figs. 2, 3) in water depths of 570 to 880 feet (114-268 m). Bottom in the trough areas consisted of a mixture of calcareous and phosphatic sand, with scattered phosphorite cobbles, boulders and slabs lying on its surface. As the ridges were approached phosphorite cobbles became more abundant and their size increased as the ridges were climbed. Slope angles were up to 45°. The tops of the ridges were capped by large phosphorite slabs, some exceeding 1 m in thickness, piled upon each other with bedding at different angles. In other areas the pavements were more continuous on the tops of ridges and undercut, forming a habitat for fish. These rock piles were a live-bottom with abundant attached sessile epifauna including

gorgonian corals, hydroids, sponges, anemones, and bryozoans. Spiny echinoids, sea cucumbers, gastropods, and spider crabs browsed the surface. Small fish, including many sculpin, were abundant and occasional large snowy grouper or orange roughie were seen.

On dive 1885 a flat pavement was observed (Huddlestun) with joints set at right angles. The weathered joints had a separation of a few inches to roughly one foot and some of the slabs were slightly tilted. Unfortunately, no joint orientation was taken.

Bedrock beneath the pavement in the dive area had been interpreted from seismic stratigraphy (Paul and Dillon, 1980, Popenoe, unpublished) as consisting mainly of calcareous silty clay and calcareous mudstones of Paleocene age, with occasional small erosional remnants of Eocene calcarenites. It was not known how extensive the capping layer of Miocene-age phosphorite pavements would be. We found the phosphorite pavement to be nearly ubiquitous, which prevented our sampling of bedrock in most areas. On dive 1883 a large tilefish hole was observed which penetrated strata beneath the pavement. The hole was cut into a cream-colored calcarenite or silty mudstone, which was sampled. Preliminary examination aboard ship found the calcarenite to consist of uniformly-sized small foraminiferal tests of early Tertiary age. An examination of this sample by Wiley Poag in Woods Hole identified the foraminifera Planorotalites Pseudomenardii , which pinned the age to Blow foraminiferal zone P.4, or early Paleocene, as predicted from the seismic stratigraphy. In all other areas the ubiquitous pavements prevented sampling bedrock.

Visibility was generally 50 to 80 feet on all dives and bottom currents were zero in troughs increasing to 1/2 and occasionally 1 knot, from the east or southeast, over ridges. Temperatures were 22° C at the surface decreasing to 13° C on the bottom.

Dives 1888-90 were made along FAY 17, line 15 across the flanks and top of a large erosional "mesa" where outcrop areas were anticipated (Fig. 4). Depths of dives ranged from 970 feet (296 m) at start to 820 feet (250 m) at dive end and currents were 1/2 knot from the east. Bottom temperature was 12° C. Bottom along the mesa flanks consisted typically of cobbley phosphorite with interspersed boulders. These were littered on gray carbonate sandy bottom with dark specks of glauconite and phosphorite. Slopes of 3-4° increased to 10-15° and slopes of up to 40o were encountered toward the crest of the mesa. On climbing the mesa, occasional large boulders of phosphorite were seen at regular intervals, some estimated to be 1 1/2-2 m in thickness. The coarser sediment was always correlated with an increase in slope. It was clear (Manheim) that the slope

consisted of a series of intersecting ridges that were typically concave and had their greatest slopes near the tops of the ridges where the coarsest slabs and boulders were exposed. Slopes decreased flankward with a corresponding increase in sediment. In moving upward, ridge after ridge was crossed for about 20-30% of the traverse.

The top of the mesa was capped with a rubble of phosphorite cobbles and slabs interspersed with coarse sand and pea-sized phosphorite gravel. On moving across this surface (Popenoe), patches of larger slabs and boulders were randomly encountered but there was very little relief. On suctioning up the pea-sized gravel, an unbroken phosphorite pavement was found at about 1 1/2 inches depth beneath the phosphorite rubble and sand at the surface. To confirm the extent of pavement beneath the thin sand cover an attempt was made to scrape several holes with the submersible's ballast base and in all cases continuous pavement was encountered. Currents were from the east-southeast at 3/4 knot on the mesa top.

Dives 1891-93 were in deeper water (1000-1100 m) eastward along on FAY 17, line 15 (Fig. 5). On Dive 1891 (Henry) the submersible landed on a bottom characterized by large sand waves or mega-ripples moving across a flat phosphorite cobble and boulder strewn surface. The mega-ripples ranged from one to three meters in height and had a wavelength of 8 to 12 m from crest to crest. The waves were made of modern carbonate sand (sampled) whose surface on the stoss side rose at about 12° slope and was covered with lunate or linguoid ripples. The lee slope was steep with an angle of 30 to 45° and was free of ripples. The troughs were also rippled and strewn with cobbles and boulders of phosphorite. Ridges and ripples were oriented north-south transverse to the direction of the prevailing current, which during the dives was from about 112° at 3/4 knot.

Also seen on this dive were rock ridges capped with phosphorite cobbles, boulders, and large slabs. In some cases the upcurrent face of the ridge was current swept, uncovering phosphorite slabs. Dives 1892 and 1893 in the same area encountered a more flat sandy bottom strewn with phosphorite cobbles.

Dives 1894 and 1895 were made in an area just north of FAY 17, line 11, where the James Island topo-bathy map showed an area of ridges and troughs of over 10 m relief. In both dives the submersible landed on a coarse, iron-stained and highly bioturbated sand-covered bottom with possible relict ripple marks. Current was from the southwest at about 1/4 knot. On traversing the bottom in a northeast direction several ridges of 3 to 4 m relief, capped by phosphorite boulders and rubble, were crossed. Toward the end of dive 1895 (Manheim) an area of larger filled circular depressions

was crossed which were believed to be ancient filled tilefish holes. This was an area of very little phosphorite rubble or debris and the bottom was either sand or near-outcrop. The filled tilefish hole hypothesis was confirmed when a large circular depression of 7-8 m diameter and 1 1/2 m depth was found to have several inner holes about a meter across excavated by a tilefish. The hole was cut into off-white colored, layered, partly-cemented sediment which was sampled. Examination of the sample by C. Wiley Poag in Woods Hole indicated that the foraminiferal calcarenite was early Oligocene in age.

Dives 1896-99 were positioned over a depression seen on FAY 17, line 11, which appeared to have pinnacle-like buildups on both it's eastern and western flanks similar to levees associated with canyon systems (Fig. 6). These buildups at the edges of scour depressions are quite commonly seen in seismic-reflection records over the Blake Plateau and have always been attributed to coral mounds or colonies proliferating in the increased water turbulence caused by the interaction of bottom currents of the Gulf Stream and the bathymetry. The buildups were believed to be accumulations of coral skeletal debris mixed with hemipelagic material trapped in the coral framework (Stetson, Squires, and Pratt, 1962). The "pinnacles" at the edges of channels quite commonly have fish signatures over them and the "coral mounds" were believed ecologically analogous to shallow-water reefs as a biological habitat for numerous sessile benthos and benthic fish. It was the theory of John B. Wilson that deep-water coral skeletal remains could not support such structures, therefore these dives presented a primary target for our dive series.

Dive 1896 landed at a depth of 700 feet, indicating that the dive had landed in a channel, the deepest feature seen in this area of line 11. Bottom temperature was 14°C. The bottom consisted of light-colored medium-to-coarse sand that was highly bioturbated, hummocked, and mounded, and tracked with many trails. There were no sand ripples. Pectinaria tubes, caryophyllas, cidaroids, and starfish were abundant.

On traversing the bottom a small ridge of phosphorite pebbles and cobbles was crossed, with many fish. No deep-water colonial corals were observed. A second and third ridge of phosphorite boulders was crossed, the 3rd with a 25° slope approximately 20 m in height. The slope was covered with phosphorite cobbles and many attaching sponges, anemones, gorgonians, and bryozoans. These and abundant crabs and fish formed a rich bottom. The ridge was oriented east-west and the cap consisted of large up-ended slabs and boulders of phosphorite. The dive (Wilson) proceeded down a steep slab-strewn slope (appr. 25°) to a depth of 710', then climbed a phosphorite covered ridge to 662', and after a slight downward slope again entered a sand field with

occasional cobbles of phosphorite. Also crossed was a ridge of fractured and bedded phosphorite? with a slight cover of sand. The ridge had a strike of 210° and bedding dips estimated to be 45° to the east were seen. This was like no other phosphorite outcrop seen in the dive series (Popenoe observation from viewing the video-tape) and it's significance will have to be studied. It was not sampled. The levee system seen on the seismic records did not consist of coral rubble, but was comprised of a buildup of phosphorite cobbles, boulders and slabs at the margin of the channel. The origin of these buildups is currently not understood.

In order to confirm that the channel and levee system had been crossed, dive 1897 traversed due east from the end point of dive 1896 (which had traversed northwestward). This dive landed on a sand and cobble strewn bottom at a depth of 680'. On traversing eastward the dive first encountered a circular cobble-strewn hill, as though a pile of rocks had been dumped on the sea floor. We later climbed a slight rise strewn with phosphorite cobbles and boulders to 665' depth, then dropped on a cobble-covered 20-30° slope to 689'depth, confirming that we had crossed the levee system and were now in the channel seen on the seismic record. This traverse encountered hundreds of small fish associated with the "levee pinnacle".

Dive 1898 landed on a sandy bottom not different from the bottom that was observed on the two previous dives. The dive wandered around looking for the levee and the scour depression, but was unable to find it. Toward the end of the dive a tilefish hole was encountered and a sample of tan calcarenite was taken from the wall of the hole. An examination of this sample by Wiley Poag in Woods Hole indicated that the sample was early Oligocene in age, confirming the seismic-stratigraphic interpretation that the bottom material was post Paleocene and probably Oligocene or early Miocene in age (Fig. 6).

16. Tables:

Table 1: Dive, Observer, Time, Depth, and Locations

17. Figures:

Figure 1: Track chart showing locations of dives and seismic track lines along which dives were made. An expanded track chart has been filed in the USGS Data Library in Woods Hole, MA

Figure 2: Minisparker seismic-reflection record of FAY 17, line 13, showing locations of dives 1877 through 1883.

Figure 3: Minisparker seismic-reflection record of FAY 17,

APPENDICES

TABLE 1: DIVE, OBSERVER, TIME, DEPTH, AND LOCATION, CRUISE 90-0R-SUB-POPENOE

Latitude	Longitude	Dive no.	Observer	Date	Time	Depth	Samples Rock	Sediment
32°36.25'N	78°26.18'W	Dive 1877	Manheim	7/2/90	1157	565	1	0
32°36.69'N	78°23.96'W	Dive 1878		7/2/90	1327	590		
32o36.72'N	78°23.07'W	1878	Popenoe	7/2/90	1349		1	0
32°36.67'N	78°23.79'W	1878		7/2/90	1358			
32o36.61'N	78°24.01'W	Dive 1879	Henry	7/2/90	1440	595	1	3
32°36.71'N	78°23.97'W	1879		7/2/90	1449	580		
32°36.65'N	78°23.96'W	1879		7/2/90	1502			
32°36.58'N	78°23.91'W	1879		7/2/90	1517			
32°36.53'N	78°24.20'W	Dive 1880	Wilson	7/2/90	1556	570	1	1
32°36.57'N	78°24.03'W	1880		7/2/90		580		
32°36.57'N	78°23.89'W	1880		7/2/90		600		
32°36.56'N	78°24.30'W	Dive 1881	Woolsey	7/2/90	1727	570	1	2
32°36.61'N	78°24.16'W	1881		7/2/90	1739	570		
32°36.53'N	78°24.20'W	1881		7/2/90				
32°36.51'N	78°24.36'W	Dive 1882	Evans	7/2/90	1840	570	1	0
32°36.66'N	78°24.31'W	1882		7/2/90	1901	568		
32°36.66'N	78°24.30'W	1882		7/2/90		580		
32°34.96'N	78°24.01'W	Dive 1883	Popenoe	7/3/90	0828	670	0	1
32°35.06'N	78°24.70'W	1883E		7/3/90	0952			
32°34.90'N	78°25.40'W	Dive 1884	Alexander	7/3/90	1020	650	1	1
32°31.04'N	78°20.37'W	Dive 1885	Huddlestun	7/3/90	1410	880	1	2
32°31.05'N	78°20.43'W	1885		7/3/90	1420			
32°31.06'N	78°20.53'W	Dive 1886	Manheim	7/3/90	1541	870	1	1
32°31.30'N	78°19.70'W	1886		7/3/90	1741	875		
32°30.59;N	78°20.25'W	Dive 1887	Henry	7/3/90	1823	760	0	2
32°30.23'N	78°19.98'W	1887		7/3/90				
32°30.24'N	78°20.04'W	1887		7/3/90	1944	750		
32°22.26'N	78°31.74'W	Dive 1888	Wilson	7/4/90	0815	1000	0	1
32°22.29'N	78°31.71'W	1888		7/4/90	0840	1010		
32°22.30'N	78°31.63'W	1888		7/4/90	0846	1020		
32°22.40'N	78°31.51'W	1888		7/4/90	0856	1018		
32°22.65'N	78°31.05'W	1888		7/4/90	0929	940		
32°22.67'N	78°31.10'W	1888E		7/4/90	1003	940		
32°22.63'N	78°31.15'W	Dive 1889	Manheim	7/4/90	1035	970	1	1
32°22.62'N	78°31.26'W	1889		7/4/90	1048	970		
32°22.68'N	78°31.17'W	1889		7/4/90	1102	940		
32°22.89'N	78°30.71'W	1889		7/4/90	1132	910		
32°22.90'N	78°30.68'W	1889		7/4/90	1133			
32°23.35'N	78°30.06'W	1889E		7/4/90	1255	830		
32°23.35'N	78°30.62'W	Dive 1890	Popenoe	7/4/90	1327	870	0	1
32°22.98'N	78°31.13'W	1890		7/4/90	1417			
32°22.96'N	78°31.20'W	1890E		7/4/90	1425			
32°17.60'N	78°26.20'W	Dive 1891	Henry	7/4/90	1637	1070	0	2
32°17.46'N	78°26.24'W	1891		7/4/90	1700	1090		
32°17.43'N	78°26.28'W	1891		7/4/90	1711	1090		
32°17.41'N	78°26.67'W	1891		7/4/90	1731	1100		
32°17.42'N	78°26.71'W	1891		7/4/90	1740	1110		
32°17.37'N	78°26.81'W	1891E		7/4/90	1849	1120		
32°17.40'N	78°27.00'W	Dive 1892	Woolsey	7/4/90	1900	1140	0	2
32°17.27'N	78°26.96'W	1892		7/4/90	1926	1110		
32°17.28'N	78°26.94'W	1892E		7/4/90	1938			
32°17.30'N	78°27.00'W	Dive 1893	Evans	7/4/90	2027	1125	0	2
32°44.55'N	78°09.14'W	Dive 1894	Huddlestun	7/5/90	0922	590	1	2
32°44.62'N	78°09.21'W	1894		7/5/90	0933	600		
32°44.65'N	78°09.24'W	1894E		7.5/90	1016			
32°44.51'N	78°09.11'W	Dive 1895	Manheim	7/5/90	1042		1	2
32°44.47'N	78°09.17'W	1895		7/5/90	1049	595		
32°40.97'N	78°09.54'W	Dive 1896	Wilson	7/5/90	1352	700	1	2
32°41.17'N	78°09.60'W	1896		7/5/90	1423	690		
32°41.33'N	78°09.79'W	1896		7/5/90	1445	662		
32°41.32'N	78°09.81'W	1896R		7/5/90	1440	662		
32°41.35'N	78°09.77'W	Dive 1897	Popenoe	7/5/90	1536	680	0	0
32°41.34'N	78°09.77'W	1897		7/5/90	1548	650		
32°41.35'N	78°09.82'W	Dive 1898	Henry	7/5/90	1646	688	0	1
32°41.36'N	78°09.82'W	1898		7/5/90	1654			
32°41.34'N	78°10.02'W	Dive 1899	Idris	7/5/90	1741	685	0	0

DELTA SUBMERSIBLE DIVES, James Island S.C. Quadrangle, July 2–6, 1990