UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WIRELINE-ROTARY AIR CORING OF THE BANDELIER TUFF, LOS ALAMOS, NEW NEXICO

By Warren E. Teasdale and Robert R. Pemberton

Water-Resources Investigations Report 84-4176

Denver, Colorado

1984

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information, write to:

U.S. Geological Survey
Water Resources Division
Mail Stop 403, Box 25046
Denver Federal Center
Denver, Colorado 80225

For purchase, write to:

Open-File Services Section
U.S. Geological Survey
Box 25425
Denver Federal Center
Denver, Colorado 80225
(303) 236-7476;   FTS 776-7476

CONTENTS

ILLUSTRATIONS

CONVERSION TABLE

Multiply inch-pound units	By	To obtain SI units
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
cubic feet per minute (ft^3/min)	472.0	cubic centimeters per second (cm^3/s)
pound per square inch ($lb/in.^2$)	6.895	kilopascal (kPa)

WIRELINE-ROTARY AIR CORING OF THE BANDELIER TUFF, LOS ALAMOS, NEW MEXICO

By Warren E. Teasdale and Robert R. Pemberton

ABSTRACT

This paper describes experiments using wireline-rotary air-coring techniques conducted in the Bandelier Tuff using a modified standard-wireline core-barrel system. The modified equipment was used to collect uncontaminated cores of unconsolidated ash and indurated tuff at Los Alamos, New Mexico. Core recovery obtained from the 210-foot deep test hole was 92 percent.

A standard, HQ-size, triple-tube wireline core barrel (designed for the passage of liquid drilling fluids) was modified for air coring as follows: (1) Air passages were milled in the latch body part of the head assembly; (2) the inside dimension of the outer core barrel tube was machined and honed to provide greater clearance between the inner and outer barrels; (3) oversized reaming devices were added to the outer core barrel and the coring bit to allow more clearance for air and cuttings return; (4) the eight discharge ports in the coring bit were enlarged. To control airborne-dust pollution, a dust-and-cuttings discharge subassembly, designed and built by project personnel, was used.

INTRODUCTION

Present geohydrologic concerns and their attendant studies indicate a great need for obtaining geologic samples representative of in-situ conditions for laboratory analyses and other testing purposes. Greater emphasis also is placed on studies of flow through the unsaturated zone requiring in-situ field testing and well instrumentation under ambient conditions.

To minimize core contamination and optimize in-situ conditions of the cores and samples collected, drilling and coring needs to be done by dry-drilling methods whenever field conditions permit. The principal criterion necessary for use of the dry-drilling method is that the geologic formation to be drilled has to have a negligible moisture content. Under these conditions bit plugging and mud accumulation on the drill rod does not occur and the technique works very well.

The site chosen to conduct the initial air-coring experiment was located on the Los Alamos National Laboratory, Los Alamos, New Mexico. The drilled formation was the upper member of the Pleistocene Bandelier Tuff consisting of ash falls, pumice, and moderately welded to well-welded tuff.

The authors wish to thank W. D. Purtyman and the personnel of the Environmental Surveillance Group (HSE-8), Los Alamos National Laboratory, New Mexico, for their cooperation, technical and logistic support, and assistance in many ways throughout the experiment. Special recognition is also extended to Lyle D. Bohn, chief driller, and Larry L. Matson, assistant driller, for their efforts on the project.

EQUIPMENT

Air-rotary coring of the tuff was accomplished using a truck-mounted Central Mine Equipment (CME) 75 model drilling rig.[1/] A trailer-mounted, water-cooled, Quincy air compressor, rated at 600 ft^3/min and 250 lb/$in.^2$ provided the air used for the coring experiment. The hole was drilled with HQ-size wireline rod and a conventional Longyear HQ-3, triple-tube wireline core barrel that had been modified for air coring. The core bit was a modified Longyear, tungsten-carbide, stagger-tooth, pilot-type face discharge bit.

EQUIPMENT MODIFICATIONS

The modifications to the aforementioned equipment by drilling project personnel are described in the following sections. The modifications were made in Denver.

Core-barrel head assembly

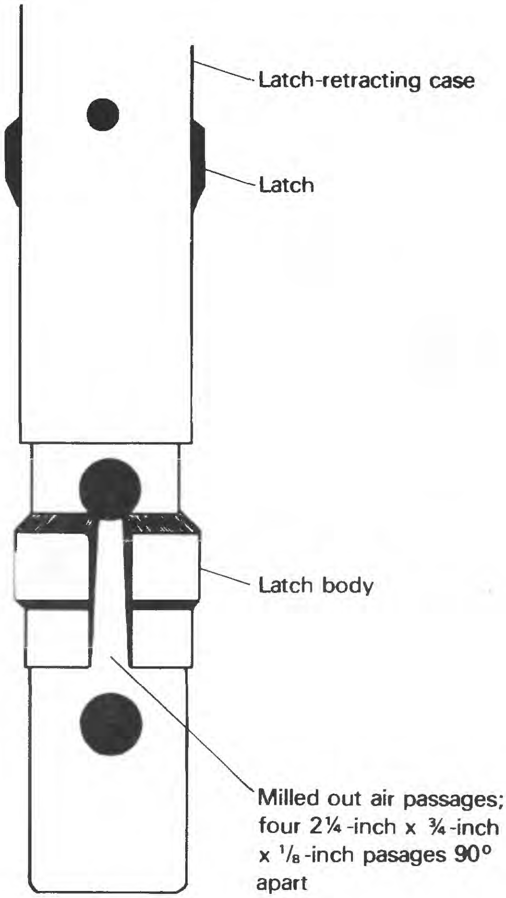
The standard, commercially available head assembly for the Longyear wireline system is designed for the passage of liquid drilling fluids such as drilling muds or polymers through the core barrel. The unrestricted circulation of these fluids through the drill string and core barrel and back to the surface through the annulus between the borehole wall and drill tools, is necessary to bring the drill cuttings up and out of the hole. If these drill cuttings were not removed, the drill tools would become locked in the hole. The same situation would occur, using air as the drilling medium instead of liquid, if circulation of the air was severely impeded or blocked. To allow a sufficient volume of air to carry the cuttings uphole, air passages were milled in the latch body part of the head assembly. Four equally spaced 3/4-in. wide by 2 1/4-in. long by 1/8-in. deep grooves were milled through the latch-body shoulder (fig. 1). This was the only modification needed in the core-barrel head assembly to adapt it from a fluid-coring mode to an air-coring mode.

Core-barrel outer tube

The annular space between the outer wall of the inner barrel and the inner wall of the outer barrel also is a limiting factor to the volume of circulating fluid (or air) that can be pumped through the core barrel. As designed and built, the Longyear HQ-3 core barrel worked very well when coring was done using a circulating liquid drilling fluid. However, the annulus beween the inner and outer tubes of the core barrel was insufficient for air coring, and modification was necessary. As designed and built, the inside dimension (I.D.) of the outer tube was about 3 1/16 in., and the outside dimension (O.D.) of the inner tube was about 2 7/8 in. To allow more clearance for the passage of air about 1/32 in. was machined, and then honed from the inside dimension of the outer barrel, which was the maximum thickness of material that could be removed without decreasing the strength of the core barrel too much. With this modification the total annulus clearance was approximately 1/4 in. or, the clearance at any point on the circumference of the inner barrel was 1/8 in.

1/Any use of trade names and trademarks in this publication is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

A.



B.

Figure 1.--A. Modified core-barrel head assembly. B. Detail of core-barrel head assembly modifications.

The outer core barrel also was modified to allow more space between the borehole wall and the outside of the core-barrel assembly for the cuttings-laden return air to travel (uphole). This required a special reaming device--consisting of six carbide-tipped auger bits welded to the upper perimeter of the HQ-3 outer core barrel (fig. 2). These bits measured 5/16-in. by 5/16-in. by 2 3/4-in. long. They were spaced equidistant around the circumference of the outer barrel, about 1 3/4 in. down from the top (or box end), and welded in place with the carbide inserts pointing in a clockwise direction toward the bit end of the core barrel. Several bit-spacing configurations were tested; these spacings provided best hole reaming.

Core bit

The core bit also required modification to allow a large enough volume of air to pass through the eight discharge ports to remove the drill cuttings. The original designed and built ports were elongate-spheroidal shaped, measuring about 1/8-in. wide and 1/4-in. long. These were all redrilled to 1/4-in.- diameter holes. Another problem with the original bit was that it did not have sufficient clearance with the borehole wall for adequate cuttings removal. The same finger-type auger bits as those welded to the core barrel were used. Eight bits were welded around the circumference of the core bit; each one was welded immediately adjacent to one of the eight air-circulation ports (fig. 3). The carbide tip of each bit was placed flush with the outer step-discharge face of the core bit, with the carbide tips facing in a clockwise direction.

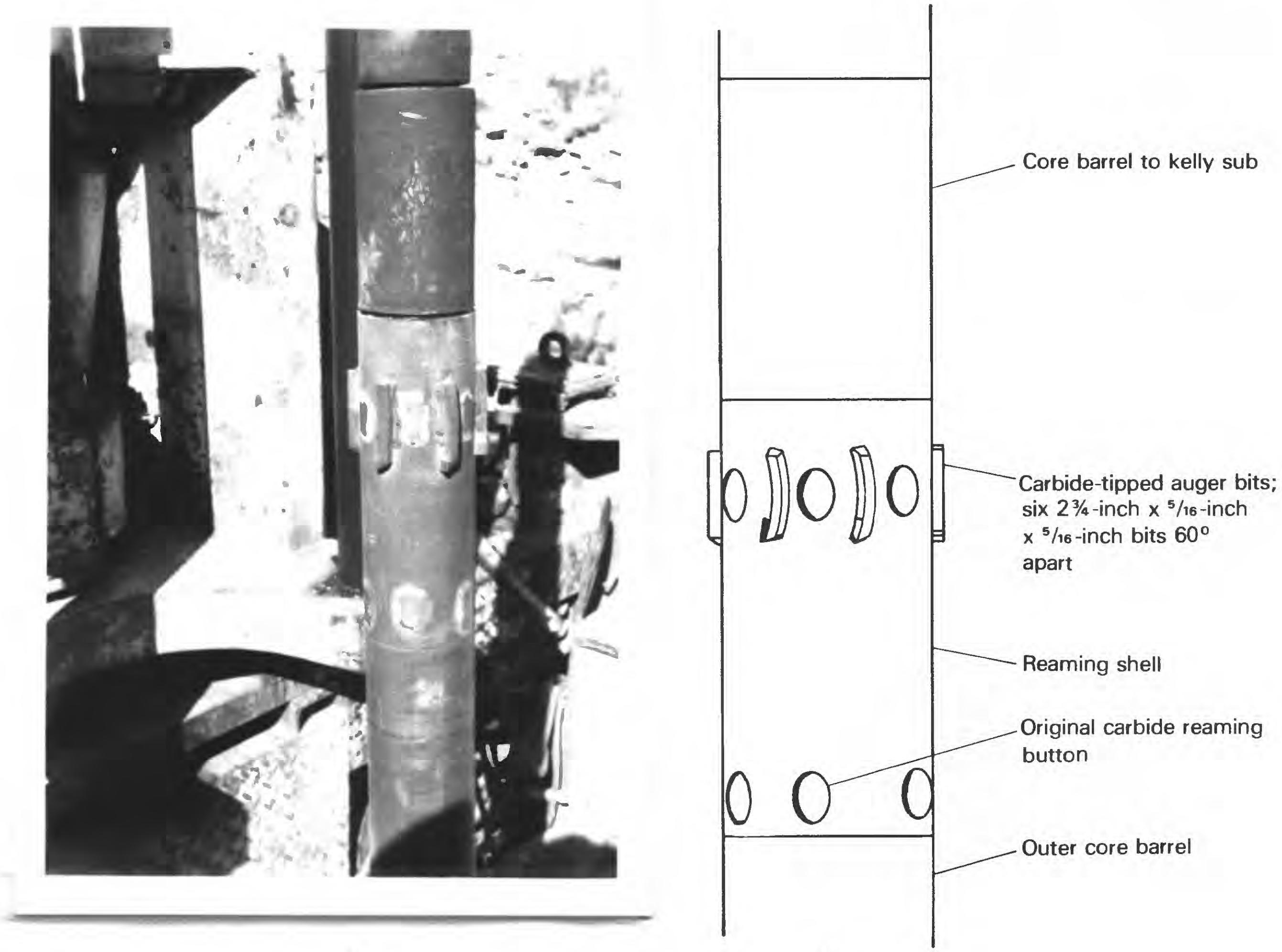
The standard Longyear bit, prior to modification, cut about one 3 3/4-in.-diameter hole, whereas the modified unit cut about one 4 1/2-in.-diameter hole. This extra 3/4 in. of clearance (compared to the conventional bit-size hole) allowed a sufficient volume of air returning uphole to remove the drill cuttings.

AIRBORNE-DUST AND CUTTINGS DISCHARGE SUBASSEMBLY

A dust-and-cuttings discharge subassembly was designed and built by drilling project personnel (fig. 4) to minimize airborne dust-contamination during air coring. The unit was constructed from a 10-ft. length of PW size flush-joint casing (5-in. I.D., 5 1/2-in. O.D.); a machined packing-gland subassembly; and a discharge-line hose-connection nipple.

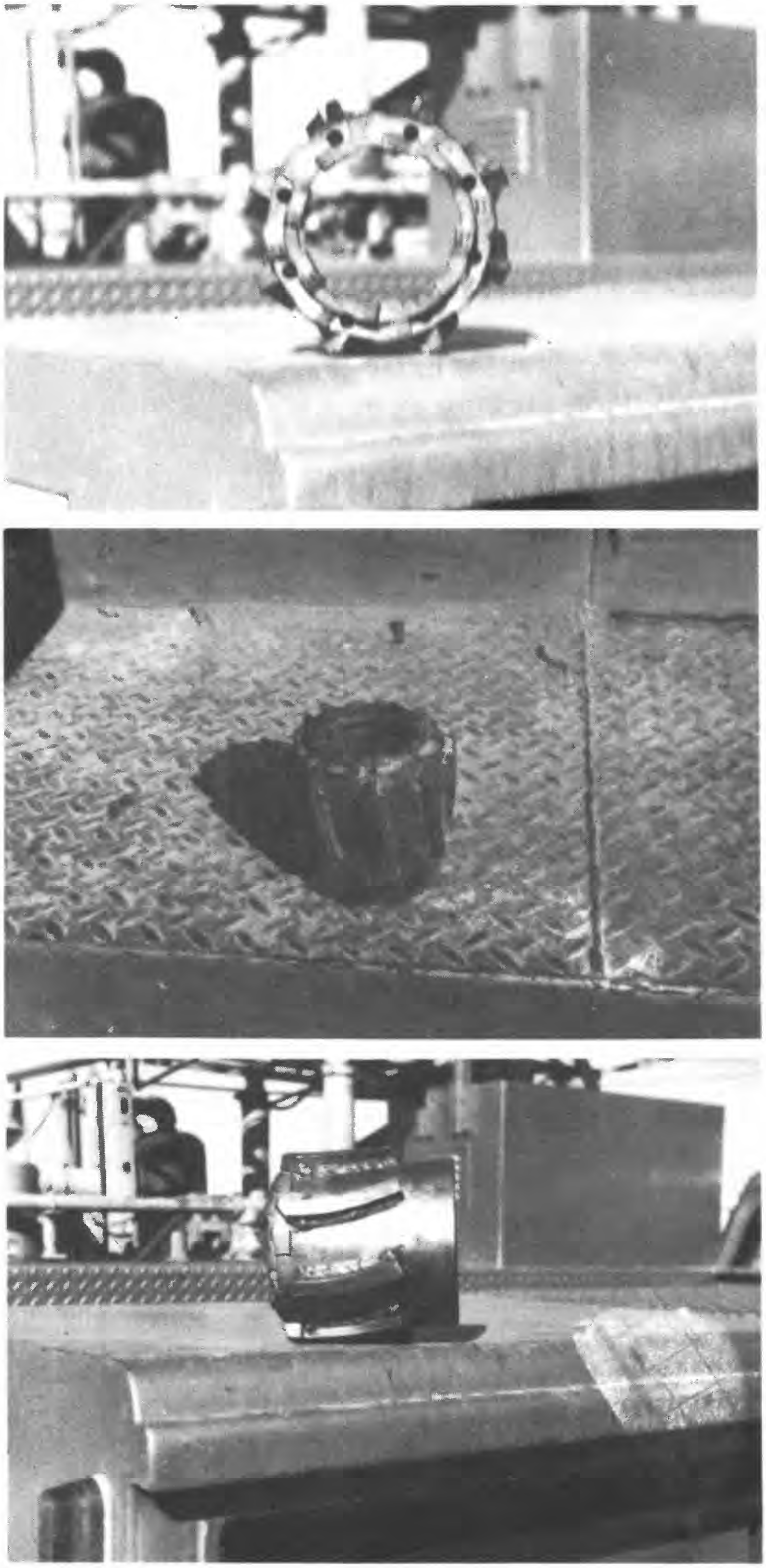
The packing-gland subassembly was made at a local machine shop. Its overall length was 15 1/2 in. from the bottom of the PW-threaded pin end to the top of the milled packing-gland end. Two rubber ring-shaped elements were seated in the upper-milled part of the subassembly; these elements were held in place by a threaded, 2-in. long compression nipple with locking nut. When the rubber elements become worn with use and leakage occurs the compression nipple can be manually tightened and an effective dust seal between the rotating drill rods and the packing gland can be re-established.

The hose-connection nipple was fabricated from a 2-in. by 6-in. standard pipe nipple. One end of the nipple was angle-ground and then flush welded to the PW casing about 5 in. down from the box end forming a 30° Y configuration. A discharge-hose connection then was attached to the nipple.



A B

Figure 2.--A. Modified core-barrel and outer tube. B. Detail of core-barrel outer-tube modification.



A. End view of core bit showing the enlarged discharge ports and the stagger-tooth bit configuration

B. Oblique view of core bit showing overall modifications and finger-type auger bits

C. Side view of core bit showing placement of finger-type auger bits

Figure 3.--Modified core bit.

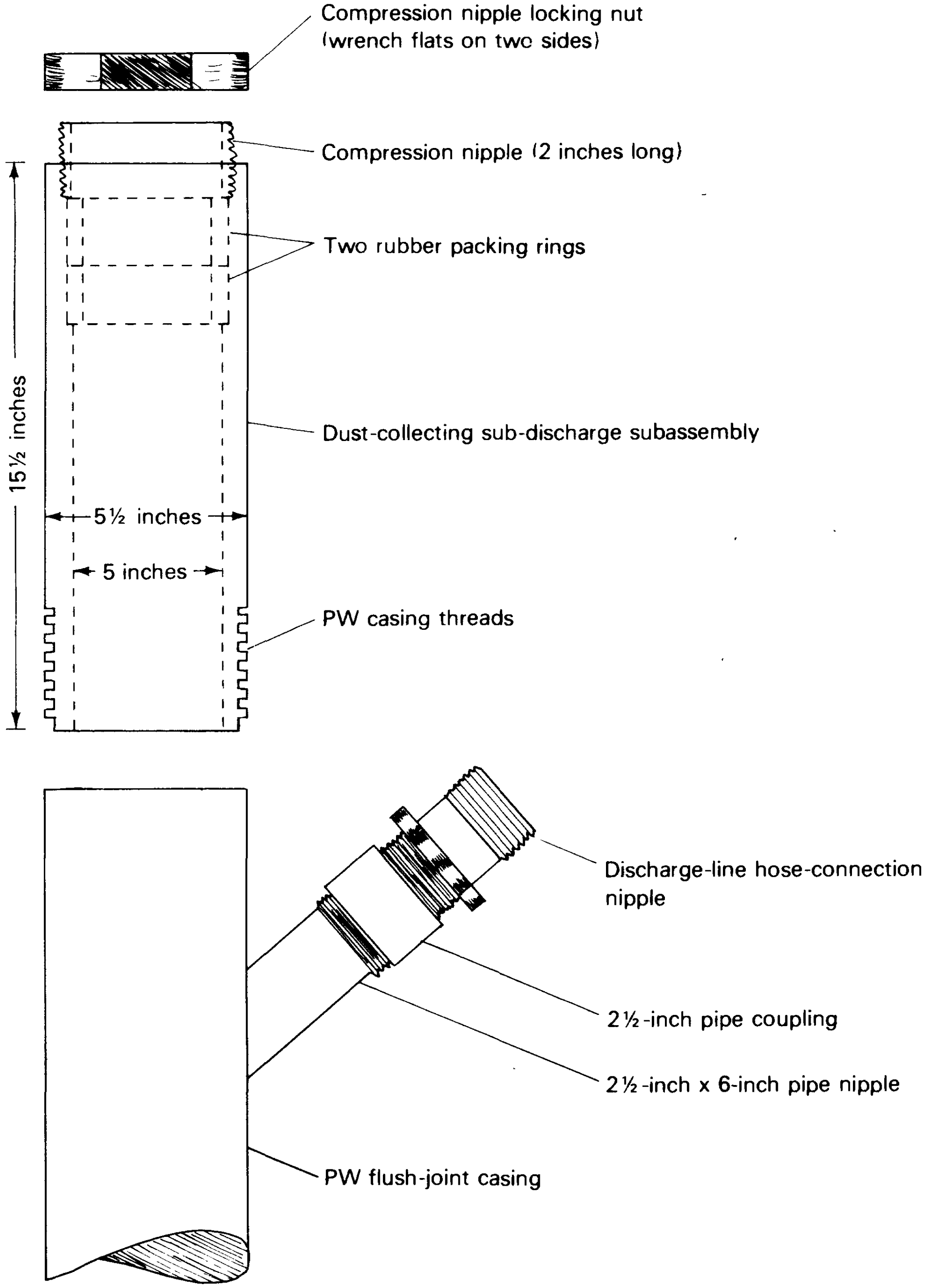


Figure 4.--Dust-and-cuttings discharge subassembly.

AIR-CORING TECHNIQUES

A 6 3/4-in.-diameter hole was drilled, using a tricone rotary bit to a depth of about 10 ft. The PW casing, modified as a dust-and-cuttings discharge subassembly, was set in the hole, then cemented in from the surface to a depth of several feet. After inserting the core barrel inside the PW surface casing, the packing-gland subassembly was installed over the HQ-wireline rod and screwed to the top of the casing. A liquid detergent was used as a lubricant for the rubber rings in the packing-gland subassembly, to allow the drill rod to turn freely inside the subassembly, after the compression nipple had been tightened sufficiently against the rubber rings to form a dust seal.

To increase the core recovery of friable or unconsolidated materials a basket-type core retainer and ring assembly were used with a conventional spring-type core lifter. They were placed in the wireline inner-barrel lifter shoe above the regular spring-type core lifter.

A spindle-rotational speed of about 60 to 80 revolutions per minute was used throughout the entire coring operation. At this speed, rod chatter and excessive core breakage were minimized. Settings of compressor volume and pressure were adjusted depending on hardness and integrity of the formation encountered downhole. For example, when the tuff being cored became very hard, the compressor was adjusted to provide its maximum output of 600 ft^3/min of air. When softer material was cored the compressor volume was decreased to provide about 250 to 300 ft^3/min of air, to prevent core erosion or blowing the core away. The pressure of the air leaving the bit ports had to be carefully controlled to maximize the core recovery. Coring softer and more unconsolidated material requires less bit-emitted air pressure. Pressures used in this coring experiment ranged from about 25 to 75 lb/in.^{2} and averaged about 50 lb/in.^{2}. By carefully monitoring the compressor air-output volume and the air pressure passing through the coring-bit ports, about 92 percent core recovery of the tuff was obtained from 160 ft of selected zones within the 210-ft deep test hole. One particular zone in the test hole, from about 55 to 105 ft, consisted of very fine unconsolidated ash. One part of this interval was cored, with good recovery, using a bit pressure of 25 to 28 lb/in.^{2} and a relatively fast downward-penetration rate. No further attempt to core this section was made, and the hole was deepened to 105 ft into harder material. Continuous coring was then resumed from this depth to the total depth of 210 ft. Air coring beyond this depth was not possible, because the compressor had reached its output limit and the cuttings could no longer be removed from the hole. The tuff penetrated at the bottom of the hole was extremely permeable; consequently, most of the air was lost into the formation.

SUMMARY AND CONCLUSIONS

Use of the wireline-rotary air-coring technique and equipment proved to be an effective method for obtaining excellent recovery of uncontaminated cores of the Bandelier Tuff. However, this method of coring is restrictive in use, because its success is very dependent on moisture content of the materials to be cored. If the material to be air cored feels damp to the touch or will pack when squeezed between the fingers and does not immediately fall apart when released, the moisture content probably is too great for air coring as this material will plug the bit and accumulate on the drill rods, making dry coring impossible.

Wireline-coring tools that are designed for circulating liquid drilling media require extensive modification if they are used for air coring of rock or sediments. These modifications include: reaming of the outer core barrel to provide greater clearance between the inner and outer barrel; milling out of air passages in the latch body part of the inner-barrel head assembly; addition of oversized reaming devices to the outer core barrel and to the coring bit; enlarging the air-discharge ports on the coring bit. A basket-type core retainer and ring assembly is used in the inner barrel to increase the percentage of core recovery of unconsolidated sediments. This assembly is installed above the spring-type hard-rock core lifter. Downhole air volumes and air pressures provided by the compressor need to be controlled to optimize quality and quantity of core recovery. Too much air pressure erodes hard-core material; too much air pressure also disintegrates and blows away softer rock or sediments. During this coring experiment, optimal core recovery was obtained by using downhole air pressures ranging from about 25 to 75 $lb/in.^2$ depending on the degree of induration of the tuff. The volume of compressor air output also was variably controlled through a range of from 250 to 600 ft^3/min. Airborne-dust pollution was controlled through the use of a dust-and-cuttings discharge subassembly specifically designed and constructed by project personnel for that purpose. The development of specialized drilling equipment and techniques was vital to the success of these studies of the Bandelier Tuff.

REFERENCES

Acker, W. L., III, 1974, Basic procedures for soil sampling and core drilling: Scranton, Pa., Acker Drill Co., Inc., 264 p.

Campbell, M. D., and Lehr, J. H., 1973, Water well technology: New York, McGraw Hill, 681 p.

Morrison, R. D., 1983, Ground water monitoring technology, procedures, equipment, and applications: Prairie Du Sac, Wis., Timco Mfg., Inc., 111 p.