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CHAPTER 1

INTRODUCTION

Located near the North and South Poles are vast sheets of ice which have accumulated over thousands of years in the frigid polar latitudes. Approximately 75% of all fresh water on the surface of the earth is trapped in solid form in polar regions.

The largest sheet of ice in the Northern Hemisphere is located on Greenland, centered near 75° north latitude (Fig. 1.1). A permanent ice sheet is not located at the North Pole because no continental land mass exists above sea level.

In the Southern Hemisphere a large ice sheet covers Antarctica, which is centered on the South Pole (Fig. 1.2). There is so much ice in the Antarctic ice sheet that if it all melted, the levels of the world's oceans would rise about 55 meters.

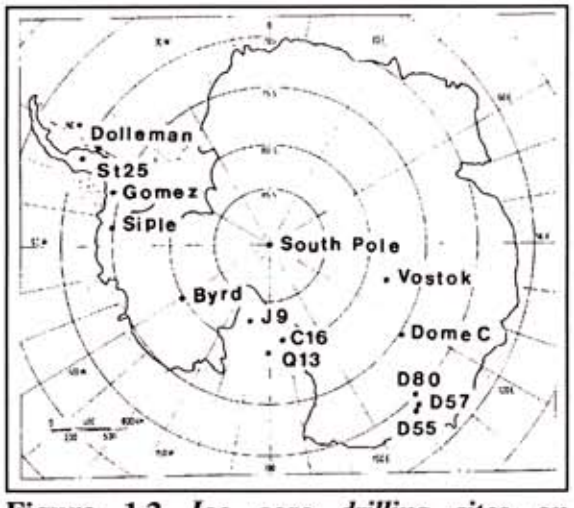

Figure 1.2 *Ice core drilling sites on Antarctica (Clausen and Langway, 1989).*

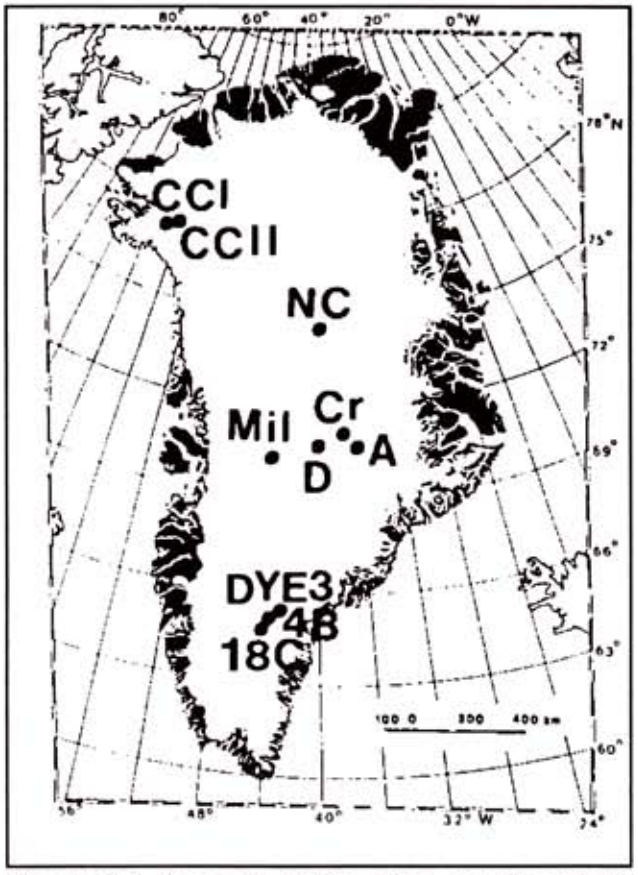

Figure 1.1 *Ice core drilling sites on Greenland (Clausen and Langway, 1989).*

The maximum altitude of the Antarctic ice sheet reaches 4000 meters above sea level near the center of the large, circular continent. This ice sheet has profound influences on the atmospheric circulation in the Southern Hemisphere and characteristics of the precipitation.

Smaller, but not unimportant alpine glaciers and ice sheets exist at high altitudes of mountainous regions all over the world. Some of these even exist in tropical regions.

CHAPTER 2

DRILLING THROUGH HISTORY

Introduction

The extraction of ice samples from deep within Greenland and Antarctic polar caps has less than a 40-year history. The first attempts were made in 1956 as part of the International Geophysical Year. Ten years later, the National Science Foundation, in association with the U.S. Army's Cold Regions Research and Engineering Laboratory (CRREL), invested in a major effort to drill completely through both the Greenland and Antarctic ice sheets.

Danish, French, and Russian teams have also drilled cores through these ice sheets, both in cooperative efforts and independent programs. Today, in 1992, two separate drilling efforts by the U.S. and European research groups are drilling cores through the deepest portion of the Greenland ice sheet. Less detail is available about the drilling procedures used by the other nations, so the U.S. efforts will be described in some detail. The equipment and procedures used by the drilling teams have also been improved for each new effort. However, the use of a modified electrodrill was found to be most successful at Camp Century, Greenland and Byrd Station, Antarctica in the 1960's. Its use will be described here.

More detail on the equipment and procedures used in drilling through the Greenland ice sheet may be found in Ueda and Garfield (1968) and through the Antarctic ice sheet in Ueda and Garfield (1969). The complete report on Greenland core drilling by Ueda and Garfield (1968) is included as an appendix to this monograph.

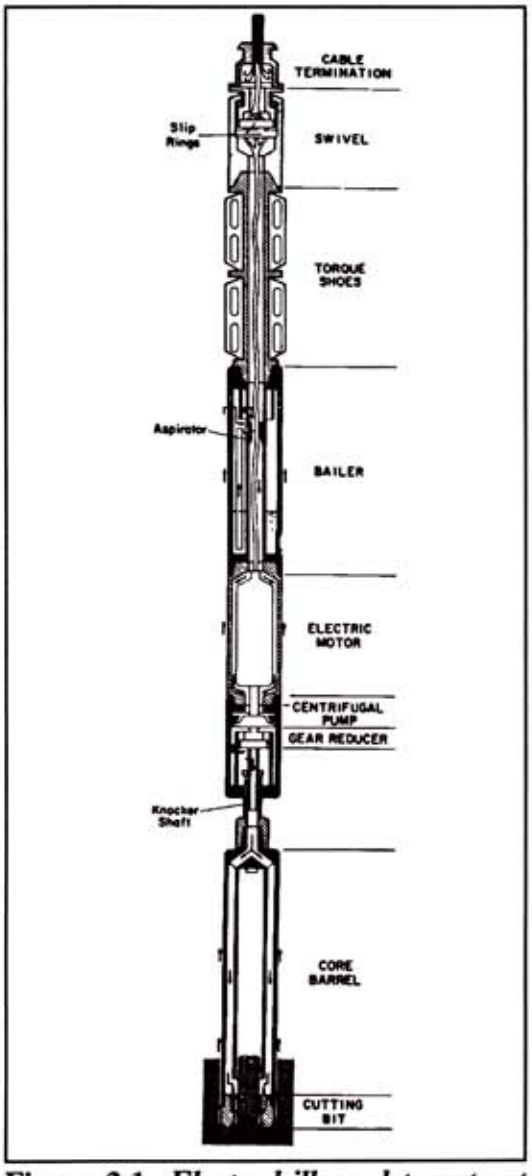

Figure 2.1 ***Electrodrill used to extract ice cores at Camp Century, Greenland and Byrd Station, Antarctica (Ueda and Garfield, 1968).***

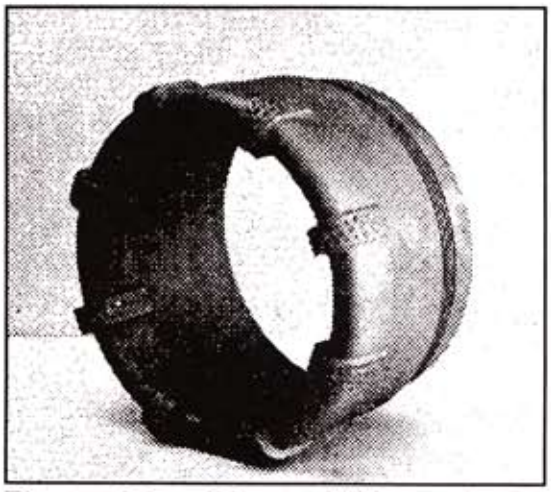

Figure 2.2 *Diamond bit used with Electrodrill to extract cores (Ueda and Garfield, 1968).*

Equipment

Drilling was accomplished in Greenland and Antarctica with a cable-suspended, electromechanical, rotary coring Electrodrill shown in Fig. 2.1. The 80-foot-long drill was lowered up and down in the drill hole by a large cable, which also provided the electrical power to the drill. The drill cut a 4-1/4-inch- diameter core from the ice. Fig. 2.2 shows a diamond-studded bit used on the end of the drill to cut the cores. Twenty-foot sections of corings were drilled and removed by raising the entire assembly between advances. The cuttings produced by the bit were melted and cycled through the drill to aid in cooling the electric motor by a bailing assembly, which circulated ethylene glycol.

Fig. 2.3 shows an example of an ice core removed by such a drilling operation. The layering in the ice can be seen visually in the alternating dark and light bands. Such banding is due to seasonal melting and the presence of particulates. Cores are carefully handled to avoid contamination and kept at sub-zero tempertures to prevent melting. These cores removed from great depths must be allowed to stabilize for several months before movement to the laboratory. The release of pressure upon surfacing causes the ice to fracture as bubbles of compressed gases expand. When the cores finally reach the laboratory, to reduce contamination, only a small inner portion is removed for chemical analysis.

Figure 2.3 *Example of a core extracted from the Greenland ice sheet (Oeschger, 1967).*

Drilling cores a mile or more in depth can take several years, and sizeable teams of scientists and technicians are required to work closely together under adverse conditions. Fig. 2.4 shows a trench constructed at Camp Century, Greenland to protect the workers from the extreme cold and wind on the surface. Even out of the wind and cold, the conditions still are not pleasant. Temperatures must be maintained below