ICE CORE DRILLING ON MT. WRANGELL, ALASKA 1982

Carl S. Benson Geophysical Institute
University of Alaska

ABSTRACT

Glacier ice in the summit caldera of Mt. Wrangell, Alaska (62°N; 144°W, 4000 m above sea level) has a mean annual temperature of about -20°C, an annual accumulation of 1 to 1.3 m water equivalent and thicknesses on the order of 500 m. In 1984 we plan to core through most of this ice using the Canadian modification of the Rufli-Rand drill. This project deals with a pilot project, done in 1982, using the PICO light weight drill which performed very well. We obtained 43.5 m of core which is being analyzed for microparticle content, total beta activity and stable isotope $0^{18}/0^{16}$ ratios. The light weight was a major asset in transporting the drill by helicopter to the summit and in moving it by sledge on the surface. The drill was well designed and the versatile way that drill rods can be used to make a tripod proved useful. It was easy for one man to raise and lower the drill to depths of 30 m. At a depth of about 40 m the time required for an individual round-trip run to retrieve core was 45 minutes. Core lengths greater than 1 m were common when using the 2 m core barrel and core quality was excellent. Safe storage and shipment of the core proved to be more of a problem than the coring itself.

INTRODUCTION

In addition to the fact that widespread drilling in ice is a relatively recent activity, we recognize that most of the ice core which has been obtained and analyzed is from the polar regions, primarily from the Antarctic and Greenland ice sheets, and the ice caps of Arctic Canada. This has provided valuable information on the properties of glacier ice itself, and historical information on paleoclimate and volcanic activity. There is an interest in examining ice core from other regions, including the equatorial parts of South America (Thompson et al., 1979) and Africa (Thompson, 1981). The present report deals with attempts to obtain ice core from the Alaska-Yukon glaciers on the northern rim of the Pacific Ocean. The first core from this region was obtained from the 5300 m level on Mt. Logan by G. Holdsworth in 1980 and is currently being analyzed. Holdsworth and the writer have selected the summit caldera of Mt. Wrangell, at the 4000 m level (Benson and Motyka, 1979) as the second site for ice core drilling in the Alaska-Yukon glacier system (Fig. 1). Ice thickness in the summit caldera of Mt. Wrangell is on the order of 500 m*; the core is intended to penetrate most of this ice in 1984 using Holdsworth's Canadian modification of the Rufli-Rand drill. The core from Mt. Wrangell will not only back up that from Mt. Logan; it

---

*Ice thickness determinations are based on radio echo sounding on the surface, by the writer with colleagues R. Motyka and the late P. MacKeith in 1976 and 1978, together with extensive airborne radio echo sounding done in collaboration with Dr. G. Clark, University of British Columbia during April, 1982.

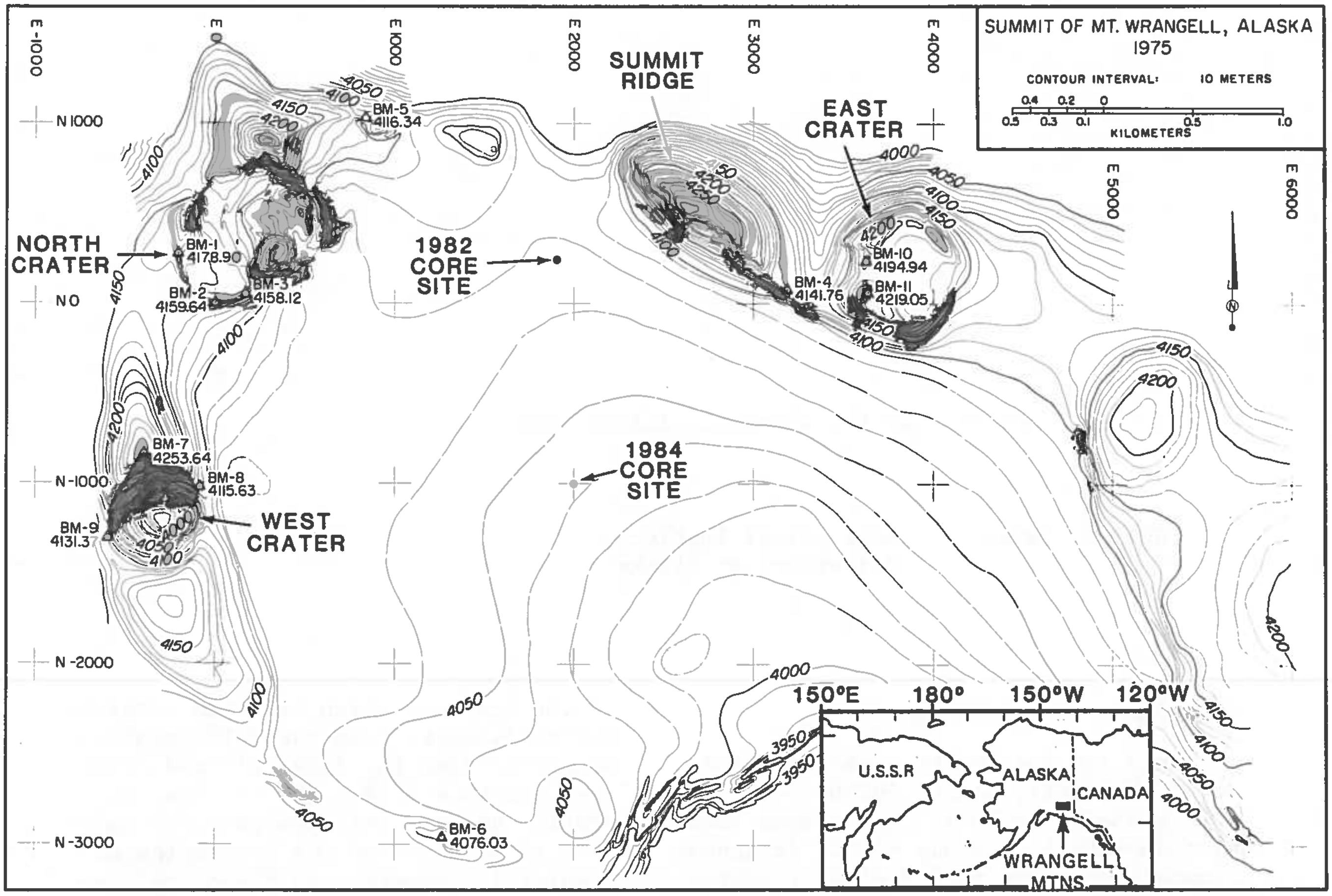

Figure 1. The summit of Mt. Wrangell based on aerial photographs taken in 1975. The broad summit has an area of about 35 km^2 above the 4000 m level. Dark areas on this map indicate snow-free areas. The North Crater has lost much of its ice cover since 1975. The 1982 core site was afflicted by sulfurous volcanic gases diffusing through the snow. The gases probably came from the fault zone lined with active fumaroles which arcs northwestward from BM-4 along the base of the summit ridge and under the snow about 300 m north of the 1982 core site. We expect that the proposed 1984 core site will be far enough from sources of volcanic gases to avoid the problems caused by gases diffusing through the snow. The aerial photography and mapping were done by North Pacific Aerial Surveys Inc. of Anchorage.

will also include more man-made contributions to air pollution, because it is from an altitude which is 1300 m lower.

In preparation for the 1984 ice coring project, a pilot project was done at the summit of Mt. Wrangell during 1982. The light weight core auger described by Koci (1984) was used; it was made available by the Polar Ice Coring Office (PICO), sponsored by the National Science Foundation, Division of Polar Programs. A total of 43.5 m of core was obtained and successfully transported to the Institute of Polar Studies (IPS), Ohio State University, Columbus, Ohio. Analysis of microparticles is being done by Drs. Ellen Mosley-Thompson and Lonnie Thompson; total beta decay is being measured by Dr. Ian Whillans, all of IPS. The core will be analyzed for δ O^{18} in the Quaternary Research Center's Laboratory at University of Washington, Seattle, Washington, by Drs. Pieter Grootes and Minze Stuiver. The results of these analyses will be interpreted together with results from pit studies and coring, to depths of up to 20 m, obtained in the 1960's and 1970's. This report deals with operational problems involved in obtaining ice core from Mt. Wrangell.

SITE SELECTION AND LOGISTICS

The drill site (Fig. 1) was selected away from the center of the caldera where previous studies (Benson, 1968; Benson et al., 1975) have shown accumulation to be a maximum, at about 1.3 m water equivalent per year. Accumulation at the drill site was expected to be on

Figure 5. The 2 m auger barrel being prepared for another trip down the hole. The light weight of the PICO drill made it easy for one man to handle. The usefulness of the ladder as a rack for drill rods is especially apparent in this view. The base of the summit ridge is seen on the left of center.

when coring nearly half of our man power and time went into logging, wrapping and storing the core.

The time required for making a round-trip run with the auger increased with depth of the hole. By the time we exceeded 35 meters it took 45 minutes to lower the auger, drill, pull it up and extract the core.

We used the 1-m long auger barrel in the first 10 m and than changed to the 2-m long barrel. The longer auger barrel proved very useful and core lengths of 80 to 130 cm were obtained. The quality of the core was excellent!

We did not use the core dogs on the PICO drill head. As a result the core sometimes protruded about 10 cm or more from the end of the auger when it was pulled out of the hole. However by carefully removing the auger we did not break the core as it was coming out of the casing and no core was lost. The ends of the core varied from flat breaks, perpendicular to the cylinder axis, to spiral fractures. Spiral fractures complicate the core logging and the volume determinations required for calculation of density. The use of core dogs in the drill head may help in preventing spiral fractures.

The tripod, which is made from pieces of the drill rod, worked well. For the first 10 m or so it was not necessary when two people were drilling. But it proved to be very useful when only one person was drilling. The tripod blew down once and we laid it down or partially disassembled it when winds exceeded 25 knots. An aluminum ladder which was cached on the rim of the north crater from previous projects proved useful as a stand for the drill rod (Fig. 4 and 5).

During several warm days (-5°C or above) with clear skies, problems were

Figure 4. The 2 m auger barrel is shown being supported in the core hole by the support clamp on the casing, in order to protect it from direct solar radiation, while Dan prepares himself for the next drill run. The aluminum ladder, brought by helicopter from a cache on the rim of the North Crater, was very useful as a holder for drill rods.

fiberglass casing provided with the auger (Fig. 3 and 4). Most of the first 2 m of core was discarded because the upper snow layers were so weak that good core recovery was not possible. These strata were sampled in detail on the exposed pit wall; temperature was measured at 10 cm intervals as excavation proceeded; and samples were taken with 500 cm^3 steel tubes inserted horizontally. The samples were weighed, so density values could be calculated, with a triple-beam balance which was sheltered from unstable air by being used in the bottom of the pit on the first day (29 June) that it was open. After being weighed they were sealed in plastic bags for laboratory analysis of microparticles. Another set of samples was taken for stable isotope measurements. The top of the logged core was determined to be 194 cm below the snow surface of 5 July 1982. It was matched with strata which had been sampled in the pit.

The core drilling began on 5 July and ended on 17 July. However, storms made it impossible to drill during three of the twelve days and shut down operations for at least half of three other days. In addition to this direct loss of time to storms, there was a daily need to devote time to digging out from the effects of blowing snow. Of the nine days that we did drill and log core we averaged 4.6 m per day. The minimum was 2 m on 7 July when drilling was stopped by a major storm with winds from the east. The maximum was 9.1 m on 6 July. On five days we obtained 5 or more meters of core. Our rate could have been faster if we had not needed to devote so much time to survival and,

Figure 2. The 1982 core site with the puffing North Crater in background; the view is toward the west. The sun shield which served as protection for the core while it was being logged is to the left of the tripod. In front of our tent is a solar snow melter designed by Solie and Sturm; on bright sunny days it provided up to 9 liters of water.

Figure 3. Dan Solie cleaning the 1 m auger barrel which was used to start the core, the 2 m auger was used below 10 m. A piece of core can be seen in the core logging holder. In this photo two of the insulated boxes used to store and ship the core were being used as a platform for core logging. Before core was put in the boxes they were buried or placed in the pit bottom to maintain their temperatures at -12°C and away from solar radiation. The casing in the top of the core hole can be seen in the left center, near the mittens. To the left of the tent is the snow drift that we built in our "gased out" attempt to make an igloo (see text). The base of the summit ridge with its active fumaroles is in the background.

the order of 1 m water equivalent per year. We planned to drill on the caldera side of the divide where a small amount of ice exits from the north rim of the caldera.

The light weight of the drill was a major advantage. It fit into five zipper-locked bags and was transported to the summit together with other equipment by a modified Bell 47 helicopter; the modification included replacement of the piston engine with a jet engine and installation of a larger tail rotor (the Soloy conversion). Air transport was from the Gulkana airstrip, or from Copper Center, both of which lie 75 km west of the summit of Mt. Wrangell. A staging area was established on the Chetaslina Glacier which is on the west flank, 6 km west of, and 2000 m below, the summit. Five helicopter trips, one of which carried a large sling-load, were required from the staging area to establish the summit camp. Originally we planned on having a four man team at the summit. Following nearly a month of field work on the Chetaslina Glacier, two of us (D. Solie and C. Benson) were transported by helicopter from the west flank directly to the summit caldera. The other two (M. Sturm and C. Tobin) planned to climb to the summit after completing a series of measurements on the Chetaslina Glacier. The first two people on the summit planned to establish a camp, complete a snow pit study to 3 to 4 m depth and initiate drilling from the pit floor while the climbing team ascended the west slope, doing shallow pit studies en route. The pit was to be covered with a tarp supported by a framework of timbers to prevent it from being filled by blowing snow. We have had experience with drilling from the bottom of pits in Greenland and on Mt. Wrangell and expected this plan to enable us to work in any weather. We also have had enough experience with storms on Mt. Wrangell to know that special provisions for bad weather were essential for efficient operation. Unfortunately, two problems modified our plans. First, the climbing team did not reach the summit--it had to be evacuated by helicopter from the west flank because of a dental infection. Thus, the summit operation was reduced to a two-man effort, and some of the projects originally planned had to be abandoned. The second problem arose because sulfurous volcanic gases diffused through the snow and filled the pit making it impossible to inhabit when it was covered.

Most equipment had been transported to the summit on 12 June while volcanic gases of the North Crater (Fig. 2) were being sampled by Roman Motyka (of Alaska Division of Geological and Geophysical Surveys) and Matthew Sturm. When we arrived at the summit with camp gear on 27 June, we found the helicopter sling load had touched down too close to the divide so we spent our first two days establishing a camp and sledging things to the drill site marked on Figure 1.

The pit study was begun on 29 June and completed to a depth of 2.10 m before we covered it to prevent it from being filled overnight by blowing snow. When we uncovered the pit enough to enter it on 30 June we found it full of sulfurous volcanic gases that had diffused through the snow and settled in the pit. Because of stormy weather with blowing snow it was not possible to leave the pit uncovered, and the volcanic gases made it impossible to continue excavation and sampling in the covered pit as we had originally planned to do. Therefore, we decided to leave the pit covered as a place to store the core but to abandon our plan of drilling from its bottom and to drill from the surface instead.

The pervasiveness of the gases diffusing through the snow was illustrated in several other ways. Once the coring was underway we could smell the fumes coming out of the core hole. Suprisingly, gases diffusing through the snow also cancelled our plans for building emergency shelters. Because of the potential for severe storms at the summit we planned to make snow caves and igloos to live in. To make such a "home" we built a large drift by piling snow near our tent and equipment cache (Fig. 2 and 3) but, when we dug into it to make an igloo we found volcanic gases filled any excavated volume within the snow. Thus, we were obliged to live on the surface in a tent as well as doing the drilling and core logging on the surface. This meant that we could not weigh the core pieces as they were logged because the triple-beam balance needed complete protection from wind. Wind and blowing snow closed down our entire coring operation when winds exceeded 25 knots.

CORE DRILLING

The core hole was located 5 m from the test wall of the pit. The top meter of the core hole was cased with the caused by the strong solar radiation. It was necessary to shade the core to prevent it from warming while it was being logged and cut on the snow surface (Fig. 2). Most troublesome was the partial melting of cuttings on the drill barrel and cutting head when they absorbed solar radiation. Since the temperature in the core hole was about -20°C, any droplets or wet snow quickly froze and interfered with the drill's cutting action. We dealt with the problem by removing the core as quickly as possible and immediately putting the drill barrel back into the hole. The tripod made this operation possible because the drill barrel could be supported in the hole, as shown in Figure 4, while preparations were made for the next drill run. The black plastic material used to make the spiral flights on the outside of the barrel was an especially efficient absorber of solar radiation. If white rather than black is available for the drill flights it may help prevent melting on the drill barrel when it is unavoidably exposed to direct solar radiation.

Two acute problems arose. The first was when a drill bit broke while drilling at the 9 meter depth. The break occurred where the mounting screw holds the bit onto the drill head. The hole for the mounting screw was counter sunk so deep that the amount of metal holding the screw head was about 1 mm thick (see Koci, 1984, Fig. 3). The broken drill bit was recovered from the hole by drilling very carefully and pulling the drill up slowly during the next drill run. The second problem occurred when the drill got stuck 40 m below the surface. Efforts to break it loose by twisting were unsuccessful. It was freed by jerking repeatedly in the vertical direction. More than an hour was spent extricating the drill. During our efforts to free the drill, the threaded junctions became very tightly joined, and wrenches had to be used with extension bars to unscrew each junction.

We experimented with a two-speed (300 and 1200 rpm) electric power drill which had been modified for use with the SIPRE auger. Power was supplied by a portable generator which was also used to run an electric chain saw in the pit work. The drill worked smoothly, but even though we used the slow speed it was so fast that we could not easily tell when the core barrel was full and we were apprehensive about getting the drill stuck. The drill also had a faulty switch that prevented more extensive use of it. However, because the time spent drilling was so much less than the time raising and lowering the drill pipe, especially at depths greater than 20 meters, and because the logistics of using the generator were complex we probably would choose to go without the electric power in order to reduce weight and space of the field experiment for a pilot study. However, if extensive coring was to be done, i.e., multiple holes in a region with adequate transportation, it would be worthwhile to devote time to developing the electric drill.

STORAGE AND TRANSPORT OF THE CORE

Our goal was to keep the core at temperatures below -10°C from the time it was removed from the coring auger until it was safely in cold storage at the Institute for Polar Studies in Columbus, Ohio. Although mean annual temperature is -20°C at the summit of Mt. Wrangell and the snow surface temperature rarely reaches 0°C, it was necessary to protect the core from direct solar radiation and, in one case, from surface air temperatures of near 0°C which were experienced during a storm on 7 July.

When the core was removed from the auger it was placed on a holding platform with its top indicated. It was measured, cut and logged piece-by-piece with notes made on grain size, core quality, ice lenses and glands - and, in rare cases, visible sediment was observed and noted. The core was then inserted into polyethylene sleeves and a card describing each core was enclosed before the sleeve was stapled shut. The wrapped core was stored in "Thermosafe" insulated containers* (Fig. 3) which were kept buried or stored in the pit at temperatures below -12°C. Dry ice (solid CO_2) purchased in Fairbanks, trucked

---

*The boxes were purchased from Polyfoam Packers Corp., 6415 N. California Ave., Chicago, Illinois 60645. We used Thermosafe Utility Insulated Container, Model No. 305, insulation wall thickness 2-1/2 inches (6.4 cm), capacity 5 ft^3 (0.14 m^3), with internal dimensions of 23 × 14 × 23 inches (58.4 × 35.6 × 58.4 cm). The seamless, molded containers are made of expanded polystyrene (0.19 K factor); the exterior surface is protected by a tough laminated fiberboard case. Nylon webbing provided closure and carrying straps.

to Glennallen, and brought to the summit by helicopter was packed with the core in each of the three boxes; they were transported from the summit to the staging area on the Chetaslina Glacier in a single sling load. As soon as everything was off the summit, the core was flown 75 km to Copper Center. It was then taken 30 km by truck to a freezer in Park's Grocery in Glennallen and stored by courtesy of the owner Park Krine. After two days it went by pickup truck across 400 km of "rural" Alaska to Fairbanks where it arrived in excellent condition even though the dry ice had evaporated en route. In Fairbanks the core was stored for 6 days in the freezer of Aurora Meat and Seafood, by courtesy of Mr. Josef Schruf. When the complex shipping arrangements were completed, the three core boxes were repacked with dry ice and sent by commercial air freight for nearly 6000 km, across five time zones, from Fairbanks, Alaska to Columbus, Ohio. Potential delays were feared at several points along the route, but Murphy's Law was apparently suspended until the three boxes of core arrived, in excellent condition, at Columbus with dry ice remaining in each box. In Columbus, Dr. E. Mosley-Thompson felt that the core could have survive another day's dalay enroute without its temperature exceeding -10°C.

In summary the PICO light weight drill worked very well. Safe storage and shipment of the core proved to be more of a problem than the coring itself.

ACKNOWLEDGEMENTS

This project was supported by a grant (Natural Hazard 7-81) from the Alaska Council on Science and Technology. It is part of a study supported by the National Science Foundation Grant EAR77-15166. The drill was provided by the National Science Foundation, Division of Polar Programs and the Polar Ice Coring Office of the University of Nebraska. Logistical support in the field was also provided by the Division of Geological and Geophysical Surveys of the Alaskan Department of Natural Resources, through a cooperative project on sampling volcanic gases with Roman Motyka, and by the U.S. National Park Service as arranged by Park Superintendent Charles Budge. Thanks are also expressed for long-term assistance provided by Ashby's Copper Center Lodge. It is a special pleasure to acknowledge and express thanks for the excellent support provided in the field by Dan Solie, Matthew Sturm and Carl Tobin. Without them this study could not have been done. Co-workers in analysis of the core are E. Mosely-Thompson, L. Thompson and I. Whillans of the Institute of Polar Studies at Ohio State University and P. Grootes and M. Stuiver of the Quaternary Research Center at University of Washington.

REFERENCES

Benson, C.S. (1968) Glaciological studies on Mt. Wrangell, Alaska, 1961. Arctic, 21(3): 127-152.

Benson, C.S., D.K. Bingham and G.B. Wharton (1975) Glaciological and volcanological studies at the summit of Mt. Wrangell, Alaska. Proceedings XV General Assembly, IUGG, Moscow, August 1971, IAHS-AISH Publication No. 104, p. 95-98.

Benson, C.S. and R.J. Motyka (1979) Glacier-volcano interactions on Mt. Wrangell, Alaska. In Annual Report 1977-78, Geophysical Institute, University of Alaska, p. 1-25.

Koci, B. (1984) A lightweight hand coring auger. CRREL Special Report 84-34.

Thompson, L., S. Hastenrath and B. Arnao (1979) Climatic ice core records from the tropical Quelccaya Ice Cap. Science, 203: 1240-1243.

Thompson, L.G. (1981) Ice core studies from Mt. Kenya, Africa and their relationship to other tropical ice core studies. In Sea Level Ice and Climatic Change (Proceedings of the Canberra Symposium, December 1979), 17th General Assembly of IUGG, IAHS Publication No. 131, p. 55-62.