Draft white paper for additional community input

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IDP Ice Core Working Group (IDP-ICWG)

Community Recommendations for the NSF Ice Core Facility

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Summary

Ice cores have provided seminal records of past environmental change, including abrupt climate change and greenhouse gas concentrations. The National Science Foundation Ice Core Facility (ICF) has been integral to advances in our understanding of natural and anthropogenic climate change. For more than 25 years, the ICF has helped facilitate an inclusive community through access to its facilities and the ice archived within. As the original facility has reached its design age, a new facility of similar size is being planned. This document provides recommendations from the research community for consideration in the planning process in the following areas:

Archive – implement rolling racking and design dedicated storage for large diameter cores

Processing – utilize an open-floor concept for the exam freezer, develop tools for large diameter core processing, and consider a modular workspace for specific investigations

Scientific Instruments – support PI measurements useful to broad range of researchers

Database – help to coordinate database updates utilizing existing data centers to improve usability by researchers

Inclusivity – continue to promote broad access to facilities and samples from the archive

Role of NSF-ICF

The National Science Foundation Ice Core Facility (ICF, formerly NICL) has supported ice core science for over 25 years. The records of past environmental change captured in ice core archives have fundamentally impacted our understanding of Earth's climate system. For instance, the Greenland Ice Sheet Project 2 core revealed the nature of abrupt climate change events while the West Antarctic Ice Sheet Divide Core has established the benchmark carbon dioxide record for the most recent glaciation. The ICF has archived these and many other ice cores, allowing any scientists with new ideas or improved techniques access to these seminal cores. A great example of the value of archiving previous cores are the carbon dioxide and methane records from the Byrd ice core, which was originally drilled in 1968 and archived at the

ICF once it was established. The ice stored at the ICF continues to be requested and sampled regularly, enhancing the value of the cores collected over the past seven decades.

The ice stored at and the facilities maintained by the ICF are open to investigators from any discipline. The ICF has thus served as a venue for broadening the community of ice core science by allowing access across broad collaborative disciplines to these precious resources. It is expected that emerging research projects will demand the processing of ice cores with improved techniques. It is crucial to keep existing ICF capabilities and also create a research platform that will advance ice core science in the next decades. Sustained investment in the ICF is important to support a diverse community of principal investigators and to train undergraduate and graduate students and inspire them to pursue professional careers in the geosciences.

Archiving

The ICF currently houses over 22,000 meters of ice and is at ~92% storage capacity, with 7% of the ice marked for deaccession when capacity for new cores is needed. The new facility is anticipated to have the same footprint as the existing facility, and thus a similar storage volume, and will need to store new ice cores drilled during its planned ~25 year lifespan. Therefore, ICF is likely to face two different, although related, challenges for archiving.

The first challenge will be the quantity of planned “traditional” ice cores, which will have a diameter of 4 in (10 cm), and are stored in foil coated, 1 m long cardboard tubes. For example, a ~2000 m ice core is planned for Hercules Dome, Antarctica, in the next few years. Additionally, a ~1,250 m ice core has been proposed in the Allan Hills, Antarctica, as well as a new ~1500 m site in Greenland. In total, these projects could add ~5000 m of ice core within the next decade in addition to potential short cores recovered from other smaller projects.

The second challenge is the increase in large (9.5”) diameter cores from the Blue Ice Drill (BID). This drill was developed to allow large sample volumes. In blue ice areas, very old (>1 million years) ice can be found, but it is not a continuous climate record like a traditional deep ice core. Moreover, there are significant stratigraphic disturbances and samples from different depths in the cores can be of very different ages. Thus, preserving a continuous smaller cross-section of the core, as is commonly done for deep ice cores, is less appropriate. Ultimately, the larger diameter pieces are preferable for archiving to allow sampling of specific time intervals. The ICF is not currently configured for storage of this type, with the large diameter pieces typically stored in ice core boxes. Because of the weight of these boxes, they cannot be stacked to the same height as individual ice core tubes due to safety concerns.

Recommendations: Because the footprint of the new facility is not planned to increase, the best way to accommodate current and future ice cores is by increasing the efficiency of storage in the archive freezer. One method for this is using rollable racking to the maximum extent possible. The new facility should also consider a more flexible type of storage for BID or other cores types as those cores are not conducive to being stored on the traditional racks. It should be explored whether a dedicated floor area (i.e. along a wall) or on the lower shelves of rollable racks would reduce safety hazards and increase accessibility in an efficient space.

Processing

The ICF maintains a variety of measuring, sampling (saws), decontaminating, labeling, packing, and other equipment for the processing of ice cores. In this context, processing indicates accurately measuring ice dimensions and cutting the ice, but not performing scientific measurements. This equipment is primarily optimized for typical large community ice core projects with core diameters up to 5 inches. One challenge for larger core processing lines (CPLs) is that the layout of the exam freezer room. It is an L-shape with two cutouts for exit/entry to separate rooms. Core processing is most efficient when the ice can be moved through successive stations via roller tracks, minimizing the hand transport of the ice and contamination.

An emerging issue with core processing is the handling of the large diameter BID cores. As these cores are becoming more common, the lack of dedicated equipment for their processing has become a more immediate and apparent problem. Improvised jigs and repurposing of saws are currently used to accommodate these cores, but this takes personnel time and can result in less precise cuts.

The separate exam room is sometimes referred to as the “clean room” despite insufficient facility ventilation and air filtering to be officially classified as such and has primarily been used for physical property analysis. There is considerable interest in a “clean” room for trace element or biology sampling but maintaining such a facility is expensive and challenging because the diverse researchers using the facility have different requirements regarding cleanliness and decontamination protocols. There is also a need for a separated space for sensitive procedures, such as microtoming thin sections, even without clean requirements.

Recommendations: To the extent possible within the freezer footprint, the exam room should be configured with an open concept to allow flexibility and adaptability over time. Instead of a permanent separate room, a multipurpose modular compartment should be considered to encourage diverse needs of researchers and promote inclusive research goals. This type of compartment could be constructed when needed and not in conflict with other processing activities. The construction materials, such as the absence of metal, could also be considered. It should also be explored to what extent this modular room can be equipped with essential air filtering and conditioning to allow cleaner decontaminating and sampling for ultra clean chemical or biological samples. To this end, a portable laminar flow hood would be desirable. Investments in saws dedicated to wide diameter cores should also be made. To the extent possible, equipment for standard cores and wide-diameter cores should be “swappable” so that processing can be rapidly switched and evolve over time. It is also important to develop strict equipment decontamination protocols. All past processing should be recorded, and materials used should be cleaned to avoid cross contamination across different projects.

Scientific Measurements

A variety of baseline scientific measurements are made at the ICF due to: 1) measurements that need to be made before further cutting of the core and 2) the fact that the ICF is well suited to the needs of the research. Four primary scientific measurements have been made on recent ice core projects and are often considered standard measurements for all large ice core projects: electrical conductivity measurements (ECM), optical imaging, visual stratigraphic analysis, and thin section preparation. The first three are typically performed in succession during core processing because they all require a freshly and uniformly planed surface across the core diameter.

The ICF maintains the line scan imaging system for archiving and is usually responsible for its operation, however they cannot maintain scientific measurements for a wide spectrum of emerging ice core projects. The other scientific instruments are primarily operated and maintained by individual PIs. The data produced from each instrument is not stored or shared within the ICF database. The imaging and ECM are both using outdated hardware and software (e.g., DOS OS) and overdue for mechanical and sensor upgrades.

Recommendations: Scientific instruments, measurements, and data need to be maintained by affiliated Pis, in coordination with ICF staff, so that they can be continually improved and remain cutting edge for future use. However, better workflow integration, both mechanically and with data, would improve access to the instruments by the community.

Database and Datasharing

The ICF maintains a database of all ice cores archived. The database is publicly available (https://nicldb.unh.edu/fmi/webd/NICL_Main) and was built using FileMaker Pro software. The database contains important details of sample availability; however, the publicly available web version is difficult to navigate and has limited search functions. This makes it particularly challenging for new researchers not already familiar with the specifics of ice core sites, naming conventions, and drilling dates, to find the information needed. There is also no capability of finding data generated in the past from these cores including the depth-age relationships. Thus, the database serves as a record of the ice archive but is of limited utility to researchers.

Recommendations: Effective curation of the ice core collection includes developing and maintaining systems to share information of the collection to broad researchers. The database should be upgraded and remastered to promote ease of use for researchers. Integration of pointers to data generated at the ICF (i.e. images and ECM) would be a helpful start; including links to published data sets would also be useful and relatively simple to implement. Generating International Geo Sample Numbers (IGSN) to allow searchability through the System for Earth Sample Registration for better integration with Antarctic and Arctic and other data centers should be considered. Attaching additional information is particularly important for BID cores which have complex stratigraphy and depth-age relations and thus are more challenging for researchers to determine if the ice would be useful for their analyses. Collaboration with PIs that generate the data will be necessary.

Inclusivity

The ICF has fostered and promoted an inclusive ice core community for the past ~25 years by integrating undergraduate and graduate students into the CPL campaign and making the ice available to a wide research community. The process for obtaining US-drilled ice employs an open access policy, which is the most inclusive to diverse researchers worldwide. The facilities maintained at the ICF also contribute to a broad and inclusive community by encouraging researchers to access available research space and instruments that they cannot replicate in their own labs. This is particularly helpful for young investigators or established researchers in other communities expanding into ice core analysis.

Recommendations: The ICF should continue promoting a broad and inclusive ice-core community through open access policies for the use of space and requests for samples. Enhancement of the database to allow improved searchability and more integrated data sets will expand inclusivity. The ICF should continue to provide and maintain access to processing and limited scientific instrumentation and promote data sharing standards and sampling protocols that support and assist researchers with a wide range of past ice core science experience. Specialized facilities, such as a clean sampling space, will broaden inclusivity because they are expensive and logistically challenging to replicate at individual labs; however, this benefit must be weighed with the challenges of maintaining specialized spaces for a broad range of researchers whose needs vary.