REPORT

IODP-PAIS Antarctic School

IODP Gulf Coast Repository, College Station, TX
10–14 June 2019

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IODP-PAIS Antarctic School participants and instructors (photo by Laurel Childress)

Summary

One of the largest uncertainties in projections of future sea level rise is how much and how fast the Antarctic ice sheet will melt. In order to reduce this uncertainty, ice sheet and climate models require better constraints from the geological record, which can be accessed through scientific ocean drilling. The International Ocean Discovery Program (IODP) embarked on a campaign to investigate Antarctica and past ice sheet variability through a series of three expeditions targeting the Ross Sea (Expedition 374, January–March 2018), the Amundsen Sea (Expedition 379, January–March 2019), and the Scotia Sea (Expedition 382, March–May 2019). Initial results from these expeditions have already provided exciting insight into Antarctica's past and forthcoming research results will provide significant contributions to our understanding of natural climate variability in the past and how increasing greenhouse gas concentrations will affect Earth's climate, Antarctica's ice sheets, and sea level rise in the coming decades. Approximately 30 scientists sailed on each expedition to conduct initial shipboard characterization of the cores and to lead the initial post-expedition research efforts. Many of these scientists have graduate students and post-doctoral researchers working on these projects, yet these early career scientists did not sail on the expedition and many have never participated on an IODP or other Antarctic campaign. Thus the primary goals of the IODP-PAIS Antarctic School were to introduce these early career scientists to Antarctic sediment cores, analytical techniques and data interpretation, and results from previous Antarctic expeditions.

The school was held at the IODP Gulf Coast Repository (GCR) on 10–14 June 2019. The school introduced 25 graduate students and post-doctoral researchers to legacy Antarctic sediment cores through lectures and hands on activities using cores and other data. Twelve instructors lectured and oversaw activities throughout the week. The school participants came from 10 IODP and/or Scientific Committee on Antarctic Research (SCAR) member countries and most received funding from either the U.S. Science Support Program (U.S. attendees) or the SCAR Past Antarctic Ice Sheet dynamics (PAIS) working group (international attendees). The participant group included 4 MSc students, 19 PhD students, and 2 post-doctoral researchers. All participants are (or will be) involved in Antarctic research using sediment cores (legacy cores, newly collected IODP cores, or cores collected via other oceanographic research campaigns). The instructor pool included one early career instructor from Europe and the new curator for the Oregon State University Marine and Geology Repository (OSU-MGR), which houses cores collected by the U.S. Antarctic Program and other ice/land-based drilling in Antarctica. The other instructors are mid-career and senior scientists from the U.S. with a variety of Antarctic experience (including scientific ocean drilling, oceanographic expeditions, and on-ice campaigns). For a different perspective, we also included an instructor who primarily works in Alaska.

The school schedule included lectures and classroom activities in the morning (Monday–Thursday), with hands on activities using Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program cores in the afternoon. The morning lectures primarily focused on introducing the participants to our current understanding of Antarctic climate evolution from the Paleogene Greenhouse through the Eocene/Oligocene transition, and into the Neogene, particularly focusing on warm intervals including the Miocene Climatic Optimum, mid-Pliocene Warm Period, and Pleistocene superinterglacials. Morning activities included how to interpret seismic

data and select drill sites for IODP coring, interpreting biostratigraphic and paleomagnetic data and then integrating those data into an age model, and describing and interpreting the depositional environments recorded in the ice-proximal records of the ANDRILL cores. Participants were divided into five groups based on their research interests for the legacy core description activities. The groups collected data for their cores in five laboratories: macroscopic core description, microscopic core description, physical properties (magnetic susceptibility and gamma ray attenuation bulk density), X-ray fluorescence core scanning, and age model development (using micropaleontologic and paleomagnetic data collected either shipboard or postcruise). Each group presented their results and interpretation on Friday afternoon at the end of the school. We also included a few other lectures during the week, including summaries from the recent IODP Antarctic expeditions and what it is like to sail on an IODP expedition.

The primary outcomes of the school included introducing 25 early career scientists to Antarctic sediment cores and Antarctic science, learning core description from experienced Antarctic scientists, networking opportunities for participants and instructors alike, the presence of the ANDRILL cores (shipped from the OSU-MGR) and establishment of a relationship between that repository and the IODP GCR, and vetting the viability of hosting similar core schools at the GCR in future years. Feedback from the participants and instructors (informally and through a survey) was overwhelmingly positive. Everyone learned a lot from the school and felt that their participation would benefit their research. The main criticism was the overly ambitious schedule, with a number of participants suggesting we add another day to the school in the future to provide participants with more time to synthesize their data and prepare the final presentation. Several also suggested including time for participants to present their own research. Two surveys noted a lack of (primarily ethnic) diversity in the instructor and participant pools. One way to potentially increase diversity at a future school is to ask for a diversity statement as part of the application. We also plan to have more time between application submission, issuing invitations, and the school itself to ensure that overseas participants have plenty of time to apply for visas. Overall, the first IODP-PAIS Antarctic School was a large success and we look forward to hosting more schools in the future.

1. Introduction and Motivation

IODP embarked on a campaign to investigate Antarctica, its ice sheets, and the Southern Ocean by coring and logging offshore shelf and deep water marine sediments. The first expedition, Ross Sea drilling with the *JOIDES Resolution* (Expedition 374), was completed in March 2018, and Amundsen Sea (Exp. 379) and Iceberg Alley (Exp. 382) sailed in early 2019. The primary scientific motivation for the new drilling expeditions is to investigate the stability of the Antarctic ice sheets under past warm environments to provide analog scenarios for ice retreat and consequent sea level rise under future climate warming. Model estimates of the sea level rise vary widely from anywhere between 30 and 130 cm global average sea level rise by 2100, with the uncertainty in large part due to unknown contribution from Antarctica (Sweet et al., 2017). For better predictions, the ice sheet and climate models need to be calibrated with geological and glaciological records demonstrating ice sheet extent and sea level rise under analogous past warm climates (DeConto and Pollard, 2016).

Antarctic sediment cores are crucial to these calibrations and it is important to ensure that the research results from these expeditions yield the data required to improve climate and ice sheet models. To help address this, we conducted a one week Antarctic School that provided an introduction to Antarctic paleoclimate research using sediment/rock cores from IODP and ANDRILL scientific drilling. The school targeted early career scientists (graduate students and post docs) conducting research on cores collected during recent Antarctic expeditions, including non-IODP work. Seeing and working on actual sediment cores provides context and understanding that is lacking when working on samples that arrive by mail. The primary goals of the IODP-PAIS Antarctic School were to train young scientists to:

- Document and interpret lithological, chemical, and physical properties of Antarctic marine sediment cores.
- Understand how interpretation of stratigraphy and depositional environments in the context of ice, climate, and source-to-sink processes can improve our understanding of past and future Antarctica.

This Antarctic school was originally conceived by the Past Antarctic Ice Sheet (PAIS) group of the Scientific Committee on Antarctic Research (SCAR), and thus was international in scope. Non-U.S. participants were funded by PAIS, and the US participants by USSSP. The school built on the experience of past successful schools at IODP, including the sediment description workshop (November 2016) and the USSSP/Magellan-Plus workshop on Antarctica's Cenozoic Ice and Climate History (May 2016). The co-chiefs from the recent IODP expeditions enthusiastically supported this effort.

The sediment record of Antarctic ice stability is a high visibility research topic where IODP can make a major contribution to an area of great policy and societal importance. We want to make the most scientific gain from the recent expeditions and the existing IODP Antarctic marine sediment core collection – our aim is that the young scientists that took part in this course will be part of this exciting adventure for years to come.

The IODP Southern Ocean core collection is housed at the Gulf Coast Repository, in the same building as the *JOIDES Resolution* Science Operator (JRSO), making Texas A&M University and College Station the ideal location for this school. The lead proponents are also based here, which enabled smooth implementation of the school.

2. Participants

The Antarctic School included 25 participants and 12 instructors (**Figure 1**), with additional presentations and assistance from other JRSO employees and Texas A&M University PhD students.

Instructors

The on-site instructor group included 12 scientists ranging in career stage from early career to senior scientists (**Table 1**). Three instructors were local (Denise Kulhanek and Trevor Williams [staff scientists at the JRSO] and Gary Acton [JRSO manager of technical and analytical services]). Due to funding constraints, we were only able to invite one international instructor:

Figure 1. Group photo of the first IODP-PAIS Antarctic School attendees and instructors. The people in the front row are holding two legacy Antarctic core sections used in the school. (Photo by Katerina Petronotis.)

Katharina Hochmuth, an early career scientist with expertise in geophysical data and site surveys. The remainder of the instructors came from various institutions throughout the U.S.. Nearly all have been to Antarctica and most participated on one of the recent Antarctic/Southern Ocean expeditions (IODP Expeditions 374, 379, and 382). In addition, many have participated on oceanographic expeditions in the Southern Ocean or on terrestrial drilling or field work campaigns. We also included one scientist who works in glaciomarine settings in Alaska to provide a broader perspective, as well as the curator of the OSU-MGR, which now houses the Antarctic sediment and rock cores collected through the U.S. Antarctic Program and other campaigns including the Antarctic Geological Drilling (ANDRILL) cores. Finally, we invited a PhD student with expertise in ice-sheet modeling (Anna "Ruthie" Halberstadt, University of Massachusetts, Amherst) to give a remote lecture via Zoom to explain how climate modelers use paleoclimate records to "ground truth" models. Additional talks were given by IODP *JOIDES Resolution* Science Operator staff, including the GCR superintendent (Chad Broyles) and X-ray fluorescence (XRF) lab manager (Brian LeVay).

<u>School attendees</u>

We originally intended to invite 20 graduate student or early career scientists to participate in this school. However, after receiving a large pool of excellent applications, we were able to stretch the budgets to invite 12 U.S. scientists (all MS or PhD graduate students) and 13 international students (2 post-doctoral researchers and the remainder were graduate students) (**Table 2**). Of the 13 international students (from 10 different countries), 1 received funding from

Table 1. List of IODP-PAIS Antarctic School instructors.

Name	Affiliation	Position	Discipline
Acton, Gary	Texas A&M University	Managers of Technical and Analystical Services	Paleomagnetism, geophysics
Hochmuth, Katharina	University of Leicester	IODP Research Associate	Geophysics, paleobathymetry, sedimentology
Jaeger, John	University of Florida	Associate Professor	Sedimentology, glacial processes, stratigraphy
Krissek, Larry	Ohio State University	Professor Emeritus	Sedimentology, marine and polar geology
Kulhanek, Denise	Texas A&M University	Associate Researcher	Micropaleontology (nannofossils), (bio)stratigraphy, paleoceanography
Leckie, Mark	University of Massachusetts, Amherst	Professor	Micropaleontology (foraminiers), (bio)stratigraphy, paleoceanography
O'Connell, Suzanne	Wesleyan University	Professor	Antarctic paleoclimate
Passchier, Sandra	Montclair State University	Professor	Sedimentology, marine and polar geology
Scherer, Reed	Northern Illinois University	Professor	Micropaleontology (diatoms), (bio)stratigraphy, paleoenvironment
Stanley, Val	Oregon State University	Curator	geospatial data analysis and visualization, glacial processes
Wellner, Julia	University of Houston	Assistant Professor	Stratigraphy, sedimentology, glacial processes
Williams, Trevor	Texas A&M University	Staff Scientist	Marine geology

Table 2. List of IODP-PAIS Antarctic School participants.

Name	Affiliation	Country	Position
Christopoulou, Maria Eleni	Northern Illinois University	USA	PhD student
Clyne, Elisabeth	Penn State University	USA	PhD student
Desai, Dipa	University of Massachusetts Amherst	USA	PhD student
Douss, Nessim	National Institute of Oceanography and Applied Geophysics	Italy	PhD student
Duffy, Meghan	Louisiana State University	USA	MSc student
Duke, Grace	University of Otago	New Zealand	PhD student
Evans, Erica	Yale University	USA	PhD student
Griffin, Benji	Victoria University of Wellington	New Zealand	PhD student
Hopkins, Rebecca	University of Sheffield	UK	PhD student
Hou, Suning	Utrecht University	Netherlands	PhD student
King, Maxine	Plymouth University	UK	PhD student
Lacerra, Matthew	Princeton	USA	PhD student
Lepp, Allison	Univeristy of Virginia	USA	PhD student
Mark, Christopher	University College Dublin	Ireland	Post doc
Mastro, Joe	Northern Illinois University	USA	MSc student
Nie, Senyan	Tongji University	China	PhD student
Noh, Younho	University of Science and Technology of Korea	Korea	PhD student
Prunella, Catherine	University of South Florida	USA	MSc student
Romero, Matias	National University of Cordoba	Argentina	PhD student
Seidenstein, Julia	University of Massachusetts Amherst	USA	MSc student
Tanner, Thomas	ETH Zürich	Switzerland	PhD student
Tibbett, Emily	University of Southern California	USA	PhD student
Varela, Natalia	Virginia Tech	USA	PhD student
Wang, Rong	Second Institute of Oceanography	China	Post doc
Zurli, Luca	University of Siena	Italy	PhD student

IODP-Italy, one (from China) was self-funded as he was already scheduled to be in the U.S. to visit Ohio State University, and a third (from New Zealand) was partially funded by the Antarctic School budget, with the remainder provided by his advisor. One PhD student from a non-IODP country (Argentina) attended. We invited a post-doctoral researcher from India but she was unable to obtain a visa to enter the United States. After she informed us that she would be unable to attend, we were able to invite a PhD student from the U.K. instead. The 25 participants came from 10 different countries and 56% of the attendees were female.

3. Workshop Schedule

The IODP-PAIS Antarctic School was held at the IODP Gulf Coast Repository in College Station from 10–14 June 2019 and included 25 participants and 12 instructors (see **Participants**). Nearly all non-local participants stayed at the recommended hotel (Embassy Suites), where we had reserved a block of rooms at a set rate. Most participants arrived to College Station on Sunday afternoon; however, a few international participants arrived on Saturday so that they were rested for the icebreaker Sunday evening and the start of the workshop on Monday.

The school schedule (**Appendix 1**) included lectures, exercises. and hands-on core activities using Antarctic sediment cores from the IODP GCR and the Oregon State University Marine and Geology Repository (OSU-MGR) (**Appendix 2**). The schedule was designed to accomplish 3 main goals:

1. Familiarize participants with Antarctic geology (and oceanography) and what we currently know about how Antarctica evolved from the greenhouse climate of the early Cenozoic through to the present.
2. Introduce participants to development and implementation of IODP expeditions, including how to select drill sites using site survey data and how data are collected and interpreted during an expedition.
3. Interpret the depositional history of a set of Antarctic cores by collecting (or analyzing) a variety of data (including sedimentological, geochemical, physical properties, and micropaleontology/paleomagnetism) and then present their results and interpretations to the group, similar to how scientists on an IODP expedition would present results during a site summary meeting.

To achieve these goals, we used a variety of instructional methods, including lectures, classroom activities, and collection of descriptive and other datasets of sets of Antarctic cores.

We included several different types of lectures during the school. Some lectures were informative and used to introduce participants to our current state of knowledge for different time slices. These lectures included presentation of results from studies using Antarctic sediment cores. Specific topics included the Paleocene-Eocene Thermal Maximum (PETM), the Eocene–Oligocene, temperature glaciomarine environments of the Oligocene to Miocene, and Neogene warm periods (Miocene Climatic Optimum, mid-Pliocene Warm Period). When possible, core sections spanning these time intervals were displayed in the conference room for the participants to examine (**Figure 2**). Other lectures were used to introduce participants to classroom activities

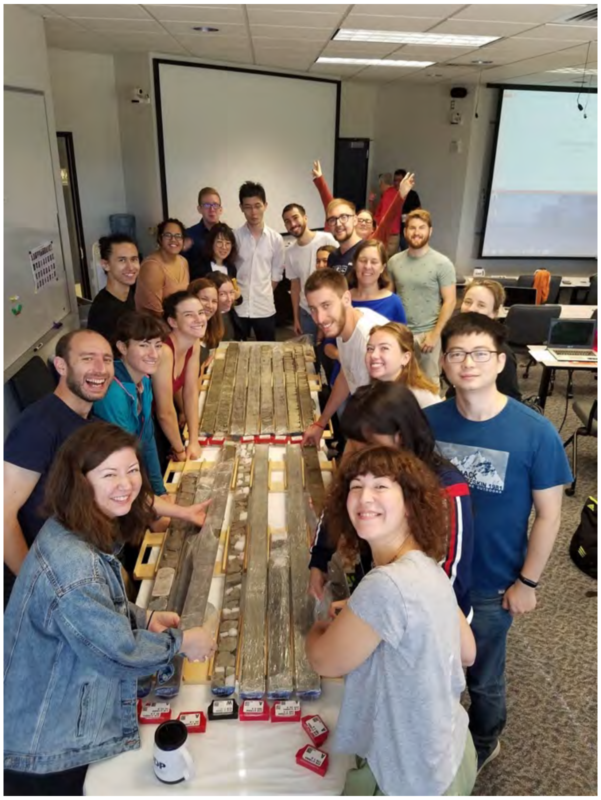

Figure 2. Antarctic School participants and instructors examine cores for IODP Expedition 318 (Wilkes Land Glacial History) following a presentation by Sandra Passchier. (Photo by Reed Scherer.)

and/or the types of data they were to collect on their sediment cores and how to interpret those data. These lectures introduced seismic and other site survey data, biostratigraphy and magnetostratigraphy to develop age models (and the unique challenges to working in the Antarctic), how to describe Antarctic marine sediment cores, and using and interpreting XRF data. These lectures prepared the students for the activities that they completed throughout the week. Finally, we also took this opportunity to introduce the participants to both the GCR and the OSU-MGR core collections, results from the three IODP expeditions (374, 379, and 382), and what it is like to sail on and IODP expedition aboard the *JOIDES Resolution*.

Each morning (Monday–Thursday) included a classroom activity following the introductory lectures. The first activity, led by John Jaeger and Katharina Hochmuth, included interpretation of seismic lines and then identifying locations to drill to address specific questions about the sedimentary basin (**Figure 3**). On Wednesday, students interpreted calcareous nannofossil and planktonic foraminifer biostratigraphic data and paleomagnetic data from a "well-behaved" low latitude site. After identifying biostratigraphic datums and paleomagnetic reversals, they generated an age model and calculated linear sedimentation rates. This activity was led by Mark Leckie, Reed Scherer, Denise Kulhanek, and Gary Acton. On Thursday, the students were divided into groups to describe sets of ANDRILL cores and interpret the sedimentary facies and make interpretations about the depositional environment (**Figure 3**). Each group then presented their results (**Figure 4**). This activity was led by ANDRILL scientist Larry Krissek.

The primary hands on activity during the school was characterization of sets of Antarctic sediment cores by collecting and analyzing five data sets: macroscopic and microscopic core descriptions, physical property data collection (gamma ray attenuation bulk density and magnetic susceptibility), XRF core scanning qualitative geochemical data, and using biostratigraphic and paleomagnetic data collected previously to develop an age model for each site. The school participants were divided into 5 groups based on their primary research interests and assigned a set of ODP/IODP core sections (**Table 3**). Each day, the participants spent ~2 hours collecting and/or analyzing data sets for their assigned cores. Groups often continued discussion of their results at the hotel in the evening (**Figure 5**). At the end of the week, each group presented their results and an interpretation based on their observations. Each member of the group had to participate in the presentation.

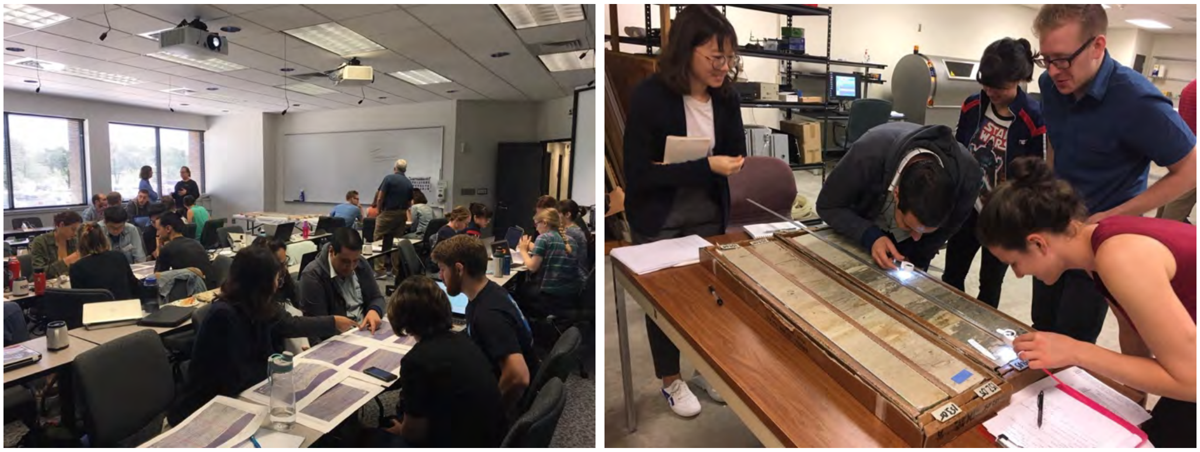

Figure 3. Left: Antarctic School participants work on a seismic interpretation activity in the conference room. Right: A group of Antarctic School participants describe ANDRILL core in the IODP GCR. (Photos by Katharina Hochmuth.)

Figure 4. Participants present their ANDRILL core interpretations to the group in the conference room. (Photo by Katharina Hochmuth.)

Figure 5. A group of participants looks over their results from the day during happy hour in the Embassy Suites lobby. (Photo by Katharina Hochmuth.)

Table 3. IODP-PAIS Antarctic School core activity groups and core assignments.

	Group 1 - Holocene (Palmer Deep; ODP Site 1098)	Group 2 (Pleistocene, ODP Site 1096)	Group 3 (early Pleistocene, ODP Site 1101)	Group 4 (Plio/Plesitocene, IODP Site U1361)	Group 5 (Eocene to Pleistocene,ODP Site 689)
	Lizzy Clyne	Nessim Douss	Erica Evans	Marialena Christopoulou	Meghan Duffy
	Alie Lepp	Grace Duke	Benji Griffin	Dipa Desai	Becky Hopkins
	Younho Noh	Matt Lacerra	Joe Mastro	Suning Hou	Chris Mark
	Matías Romero	Seyan Nie	Catherine Prunella	Maxine King	Luca Zurli
	Rong Wang	Natalia Varela	Julia Seidenstein	Thomas Tanner	Emily Tibbett

Lab	Monday, 10 June	Tuesday, 11 June	Wednesday, 12 June	Thursday, 13 June	Friday, 14 June
Macroscopic Core Description	Group 1 - ODP 1098	Group 5 - ODP 689	Group 4 - IODP U1361	Group 3 - ODP 1101	Group 2 - ODP 1096
Microscopic Core Description	Group 2 - ODP 1096	Group 1 - ODP 1098	Group 5 - ODP 689	Group 4 - IODP U1361	Group 3 - ODP 1101
Physical Properties	Group 3 - ODP 1101	Group 2 - ODP 1096	Group 1 - ODP 1098	Group 5 - ODP 689	Group 4 - IODP U1361
XRF	Group 4 - IODP U1361	Group 3 - ODP 1101	Group 2 - ODP 1096	Group 1 - ODP 1098	Group 5 - ODP 689
Chronostratigraphy	Group 5 - ODP 689	Group 4 - IODP U1361	Group 3 - ODP 1101	Group 2 - ODP 1096	Group 1 - ODP 1098

4. Outcomes

The main highlights of the Antarctic School include:

- Introducing 25 early career scientists to IODP and actual Antarctic sediment cores.
- Learning core description from top Antarctic scientists using legacy Antarctic sediment cores.
- The presence of ANDRILL sediment cores and development of a relationship between the IODP and OSU core repositories.
- Networking opportunities for all participants.
- Establishing that the IODP GCR is a viable location for a core school.

In particular, working directly with sediment cores from Antarctica gave all of the students a new perspective of their research. None of the students had previously participated on an IODP expedition, and only a handful of students had been on an oceanographic research cruise to the Antarctic. Receiving samples in little plastic bags means that graduate students have little or no perspective of where the samples come, from how they are collected, or a context of changes found in the sediment cores themselves. The presence of the ANDRILL cores meant that students could directly point to the record of ice advance or retreat in the core. Seeing the lithological expression of these events in the stratigraphic record of the cores gave the participants a new perspective for their own research.

<u>*Participant survey*</u>
Following the Antarctic School, participants were asked to complete a 28-question survey, covering topics that included the application process, the reimbursement process, travel and

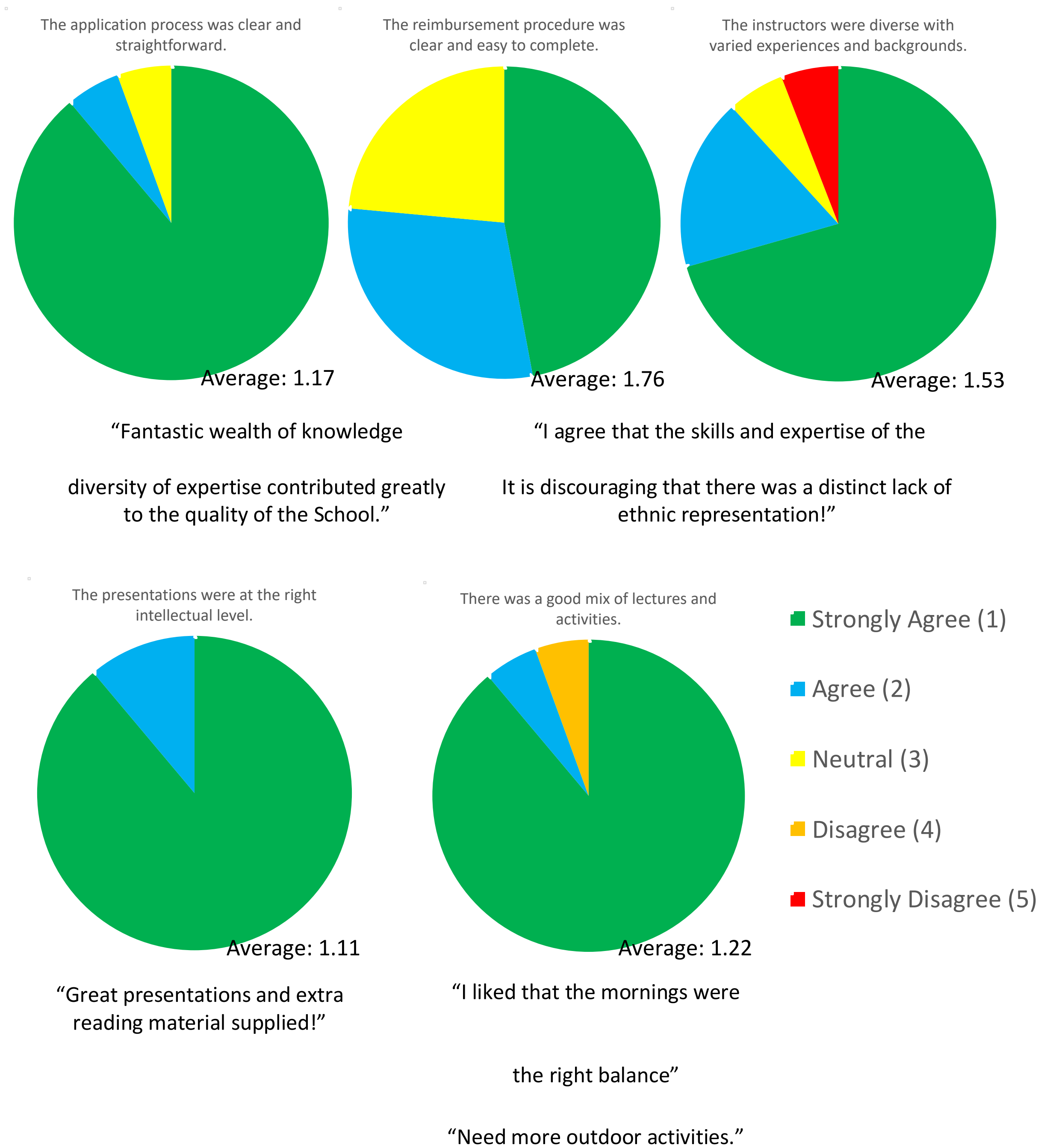

Figure 6. Responses from representative Antarctic School survey questions, with strongly agree (green) and low average values indicating very positive results. Included in boxes below the pie charts are quotes from students related to the questions.

lodging arrangements, logistical details during the school, and the content of the school. The questions were ranked on a scale of 1 (strongly agree) to 5 (strongly disagree). We received 18 responses (out of 25 school participants). Evaluations of the school were strongly positive, with the average response ranging from 1.06 to 2.31 (and only one question about the timeliness of reimbursement had an average response value greater than 1.7), indicating that the participants

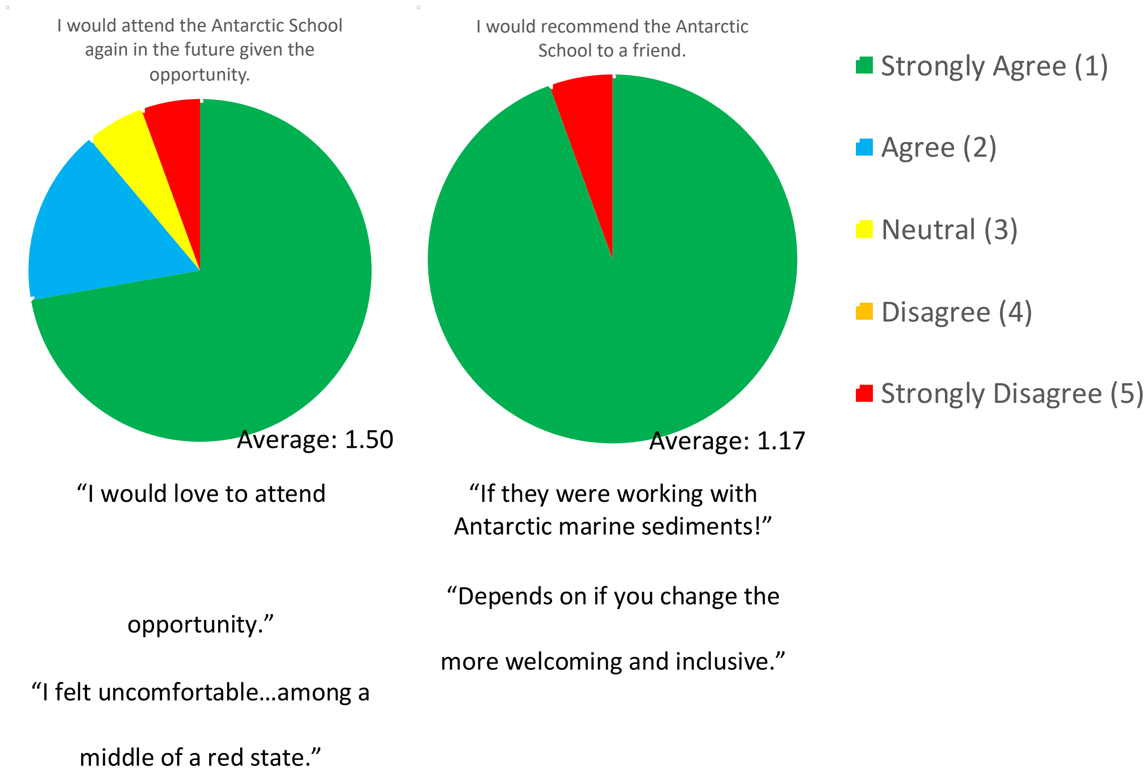

Figure 7. Responses from Antarctic School survey questions related to the participants' overall impressions, with strongly agree (green) and low average values indicating very positive results. Included in boxes below the pie charts are quotes from students rela

overall had positive to very positive views of almost all aspects of the Antarctic School. Responses to a few of the survey questions are presented below (**Figures 6 and 7**) and are representative of the responses to the broader range of questions.

Nearly all participants (16) strongly agreed that there was a good mix of lectures and activities (**Figure 6**). Student comments also provided detailed information about the perceived value of individual exercises during the school; this information will be extremely useful in planning future Antarctic schools. It is also worthwhile noting that all participants agreed or strongly agreed that the presence of the ANDRILL cores was an integral part of the school, indicating that the costs associated with shipping those cores to College Station were worthwhile. Nearly all of the participants agreed or strongly agreed that the afternoon core activities in each of the five "laboratories" were useful. A few participants were "neutral" on the usefulness of several of the laboratories and only one participant felt that the XRF core scanning exercise was not useful. A few of the participants felt that adding one day to the school would have helped, as the agenda was very full and we were often behind schedule. Alternatively, we could reduce the length or number of presentations. Two participants also noted the lack of ethnic diversity in the instructor pool and participants from the U.S. (and western countries in general) as indicated in comments (**Figure 6**). However, most of the participants appreciated the mix of instructors who participated and that they also had plenty of opportunity to interact with the instructors since all but one stayed for the entire week. Overall, out of the 18 evaluations we received, 17 would strongly recommend the school to a friend (**Figure 7**).

5. Educational Product

Another goal of the school was to compile some of the school materials into an educational product that could be easily disseminated to those who could not attend the school or that could be used in a classroom setting without the need for access to the physical cores. To facilitate this, we collected copies of all lectures (with any unpublished data removed) and activities. We are currently in the process of determining which lectures to include to supplement the activities. The educational packet will be made available through the SCAR-PAIS and *JOIDES Resolution* websites.

6. Recommendations

Overall, the Antarctic School was extremely successful and if we propose to host another school in the future, we can build on the successes but also use some of the lessons learned to improve the school.

Application process

The short timeline between final notification of funding and the start of the school (the dates of which were constrained by busy summer schedules for many of the instructors in large part due to post-expedition activities of the recent IODP Antarctic expeditions) caused some challenges for the application process and the invited participants. In particular, the application deadline was less than a month after the call for applications was posted. The original call for applications for the school was distributed via the U.S. Science Support Program (USSSP) and the SCAR-PAIS mailing list and website, which we thought would reach a large proportion of potential participants. Unfortunately, we failed to inform all of the IODP program member offices (PMOs) of the school until late within the application window, which likely resulted in fewer applications from some PMOs. We received a large number of applications such that it took several weeks to finalize invitees. This proved to be problematic for international participants who needed to acquire a visa to attend. While most ultimately received a visa, one scientist from India was denied a visa and did not have enough time to reapply and so was unable to attend. Increasing the length of time from the initial call, to the application deadline, and the start of the school will help to ensure that all invitees are able to apply for visas and plan travel well in advance.

The application process asked for a short CV, a statement of interest that included why the participant wanted to attend, how it would benefit his/her career, and a basic description of planned or in-progress Antarctic research. Additionally, students needed to include a letter of support from their advisor. The requested information did not address diversity, so we had almost no way to ensure a diverse participant group. Despite this, 14 of the 25 participants were female; however, only 2 of the 12 U.S. participants were from underrepresented (ethnic) populations. If we host another Antarctic School, we will offer the option for applicants to include a diversity statement and we will also explore other options for attracting diverse applicants.

Antarctic School Schedule

We knew from the start that the schedule was very ambitious, and so we were not surprised when we routinely ran behind each day. Despite this, we were able to complete nearly all of the scheduled lectures and activities each day. This meant that there was a little less time for lab work in the afternoons; however, most groups only needed 2 hours to complete data collection in all of the labs. Only the XRF core scanning required significantly more time (which was accomplished by having instructors and GCR staff run the last couple of core sections on the after the school participants had prepped the cores and then send the data to the participants via email). Additionally, some students indicated that more time (or more microscopes) for the microscopic core description laboratory would have been useful. Finally, all of the students would have liked more time to thoroughly synthesize their data and prepare their final presentations.

Based on these experiences and other comments provided in the evaluations, adding one extra day to the school would be very beneficial. This would allow students to work on their presentations the night before and then be ready to being presentations early on the 6th day of the school. This change would also allow us to include a discussion and activity on science communication, as well as more discussion of diversity and inclusion in STEM disciplines. This would also allow us to include more breaks during the week and potentially even include an afternoon field trip to visit local outcrops. If adding a 6th day to the schedule is not feasible, we would look at reducing the number of lectures so that the participants have more time to analyze and synthesize the data they collect on their assigned cores. We would also want to make sure that there was enough time left at the end of the last day for a proper "round-up" of activities, which was quite brief due to our packed schedule.

References

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Sweet, W.V., Kopp, R.E, Weaver, C.P., J Obeysekera, J., et al., 2017. Global and regional sea level rise scenarios for the United States. *NOAA Technical Report* NOS CO-OPS 083.

Appendix 1
IODP-PAIS Antarctic School Schedule
10–14 June 2019

Sunday, 9 June (Icebreaker)

18:30	Arrive Blackwater Draw
18:45	Welcome and opening remarks (Kulhanek & Williams)
19:15	Dinner
22:30	Event concludes

Monday, 10 June

8:30	Welcome, safety briefing, introductions
8:45	Lecture 1 – Introduction/overview of Antarctica today & Holocene records (Wellner)
9:45	Coffee Break
10:00	Lecture 2 – Overview of seismic data and other site survey data (Hochmuth & Jaeger)
11:00	Activity - Site selection using seismic data & other site survey data
12:00	Lunch
12:45	Highlights from recent IODP Antarctic expeditions (Wellner, Williams)
13:45	Introduction to cores and core laboratories (Kulhanek & Williams)
14:15	Lab work
17:15	Reassemble for daily round-up
17:45	Return to hotel

Tuesday, 11 June

8:30	Lecture 1 – PETM (O'Connell) & Eocene–Oligocene (Passchier)
9:30	Group photo
9:45	Coffee Break
10:00	Lecture 2 – Temperate glaciomarine environments in the Oligocene/Miocene (Jaeger)
11:00	Activity – Site selection activity (continued from Monday)
12:00	Lunch
12:45	Introduction to IODP and the Gulf Coast Repository (Kulhanek & Broyles) Highlights from IODP Expedition 374 (Kulhanek)
13:15	Core description (Jaeger, Krissek, O'Connell, Passchier, Stanley, Wellner)
14:15	Lab work
17:15	Reassemble for daily round-up
17:45	Return to hotel

Wednesday, 12 June

8:30	Lecture 1 – Introduction to Chronostratigraphy (Acton, Kulhanek, Leckie, Scherer)
9:30	Activity – age model development

10:30	Coffee Break
11:30	Lecture/Discussion: Unique challenges to developing age models for the polar regions
12:15	Lunch
13:15	Part 1: Introduction to the Oregon State University Marine and Geology Repository; Part 2: Persistent identifiers for physical samples (Stanley)
13:45	Highlights from IODP Expedition 374 to the Ross Sea (Kulhanek)
13:15	Physical properties and downhole measurements (Hochmuth & Williams)
14:15	Lab work
17:15	Reassemble for daily round-up
17:45	Return to hotel

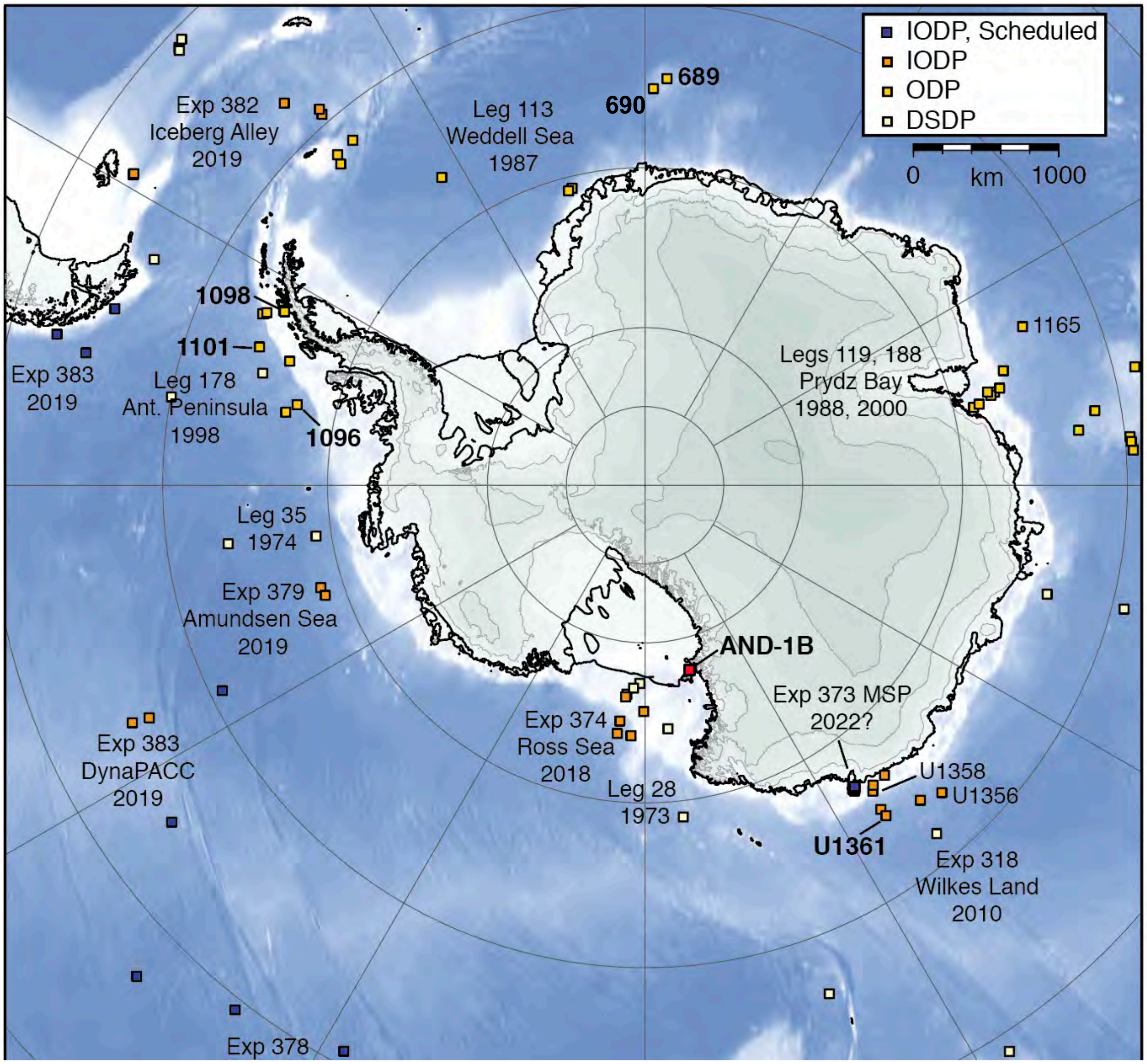
Thursday, 13 June

8:30	Lecture 1 - Sedimentary processes during Neogene warm periods (Miocene Climate Optimum/mid-Pliocene) (Passchier)
9:30	Activity – Interpreting depositional environments: case study from ANDRILL
10:30	Coffee Break
12:00	Lunch
12:45	Introduction to IODP Mission Specific Platform (MSP) expeditions (Hochmuth)
13:15	Introduction to XRF core scanning (LeVay & O'Connell)
14:15	Lab work
17:15	Reassemble for daily round-up
17:45	Return to hotel

Friday, 14 June

8:30	Lecture – Distribution of foraminifers and diatoms around Antarctic (Leckie & Scherer)
9:30	Integrating ice sheet modeling and paleo datasets (remote lecture from PhD Student Ruthie Halberstadt, University of Massachusetts, Amherst)
10:30	Coffee break
10:45	Lab work
12:15	Lunch (optional presentation: Sailing on an IODP expedition [Kulhanek])
13:00	Lab work (continued) and finalize presentations
15:00	Coffee break
15:15	Group Presentations
17:00	Final discussion
17:15	Return to hotel

Appendix 2
Cores used during the IODP-PAIS Antarctic School



Map of Antarctica showing location of cores used during the IODP-PAIS Antarctic School. Green squares = cores used for afternoon core description. Orange squares = cores paired with lectures. Yellow square = ANDRILL cores.

<u>**Cores used for afternoon description exercise**</u>

Palmer Deep (Leg 178)

- Core 1098C-5H, Sections 1-6,CC
- Glacial to Holocene transition (sub-ice shelf deposit grading into diatom ooze

Wilkes Land Continental Rise (Expedition 318)

- Core U1361A-6H, Sections 1-7, CC
- Glacial/interglacial facies with diatom-bearing layers and coarse sand- to gravel-size clasts interpreted as ice-rafted debris

Dronning Maud Land (Leg 113)

- Hole 689B, Sections:
  - 1H-2 (Pleistocene)
  - 4H-2, 5 (middle-late Miocene)
  - 6H-4, 7H-4 (early Miocene)
  - 11H-4 (Oligocene)
  - 13H-6, 7, CC; 14H-1 (Eocene/Oligocene transition)
  - 20H-2 (Eocene
- Uphole transition from carbonate to biosiliceous sediment

Antarctic Peninsula Sediment Drifts (Leg 178)

- Core 1101A-12H, Sections 1-7
- Core 1096A-2H, Sections 1-7, CC
- Alternating silty clay and foraminifer-bearing clay with a few pebbles (Pleistocene)

<u>Cores paired with lectures</u>

- PETM (O'Connell)
  - 690B-19H-1, 2, 3
- Neogene warm intervals (Passchier)
  - U1361A-1H
  - U1356A-17R-1, 19R-1, 24R-2, 30R-2, 51R-1
  - U1358B-3R-1, 3, 4R-1
  - 1165B-589, 59X

ANDRILL cores (AND-1B)

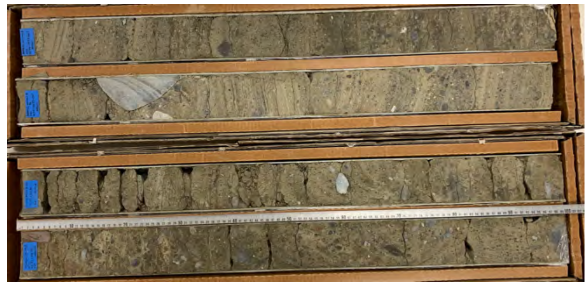
(tick marks on stratigraphic column depth scale are every 5 m)

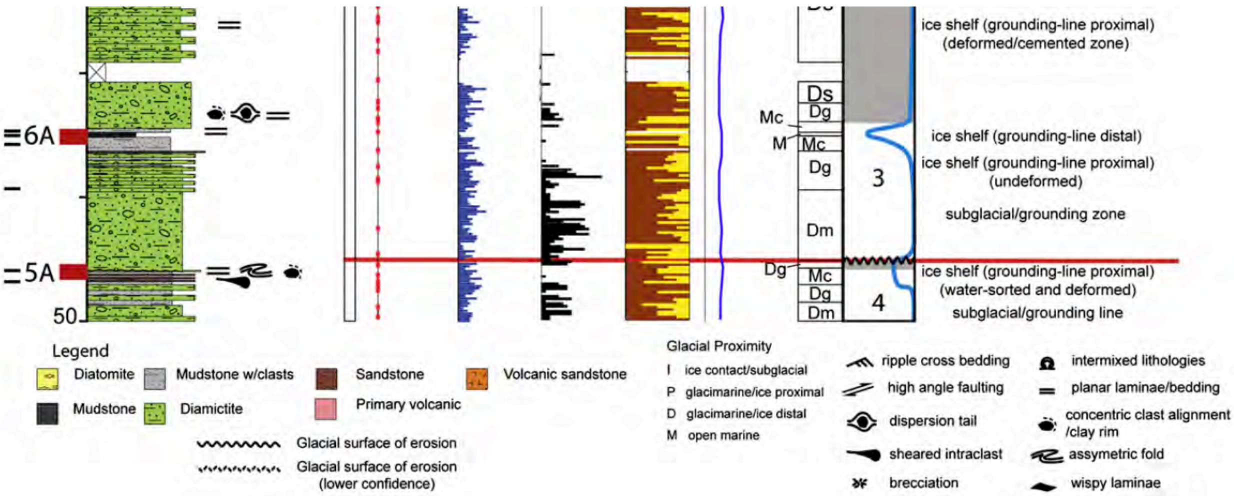
Motif 1 (a)

Boxes 28 and 29, 45.73 – 49.93 m

glacial advance and erosion surfaces,

McKay et al. / Quaternary Science Reviews 34 (2012) 93-112



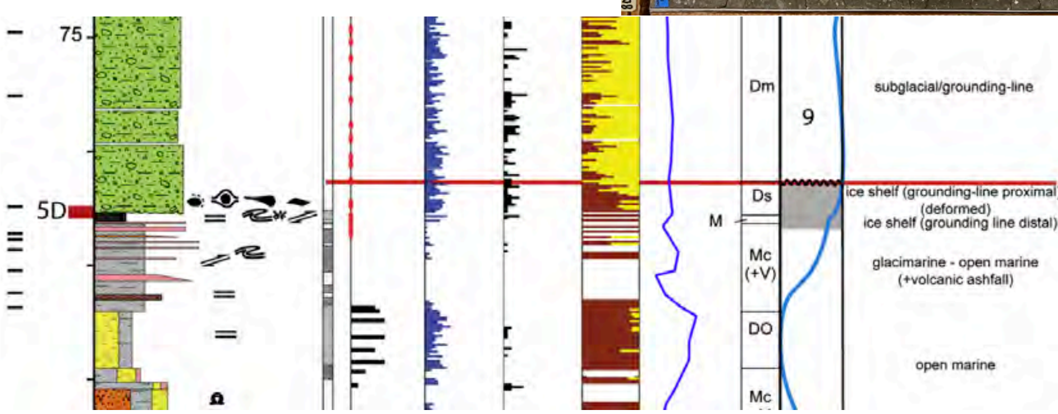


Motif 1 (b):

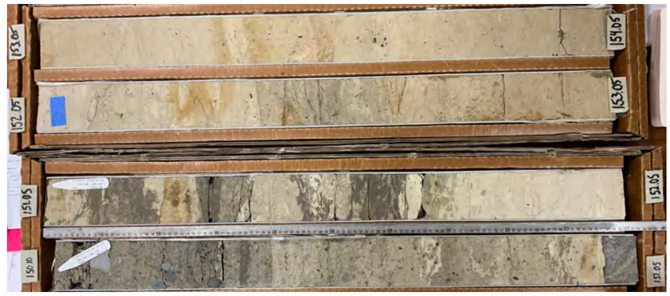
Boxes 46 and 47, 80.89 – 84.97 m

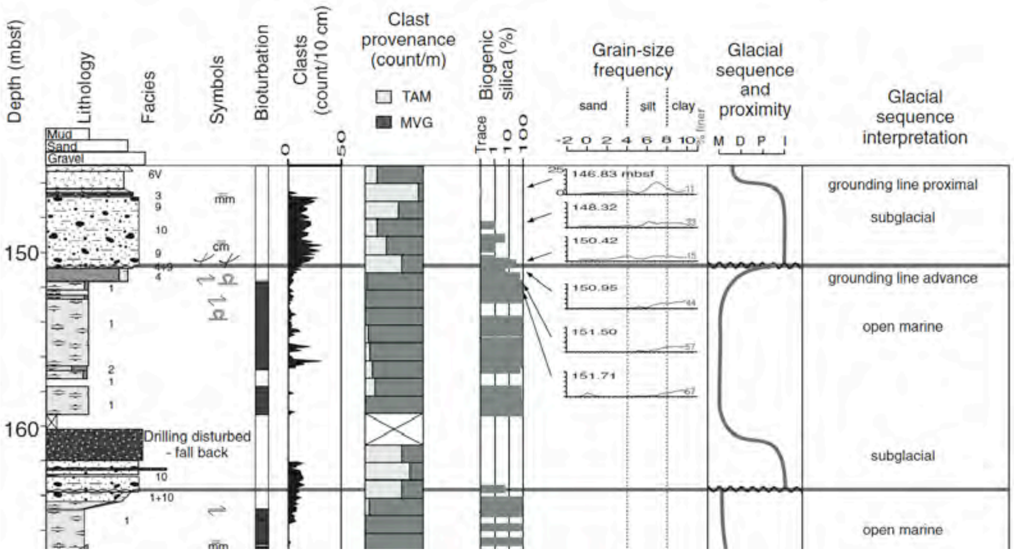
glacial advance and erosion surfaces

McKay et al. / Quaternary Science Reviews 34 (2012) 93-112

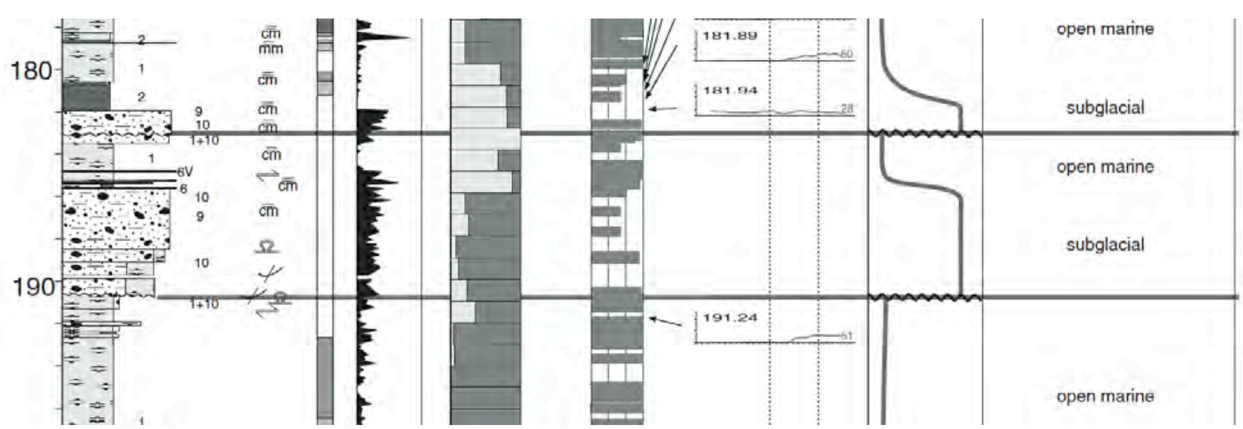


Motif 2 (a):
Boxes 80 and 81, 150.10 – 154.05m
1 glacial advance and erosion surface
McKay et al., GSA Bulletin; November/December 2009; v. 121; no. 11/12; p. 1537–1561

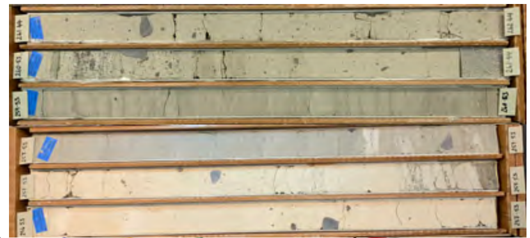


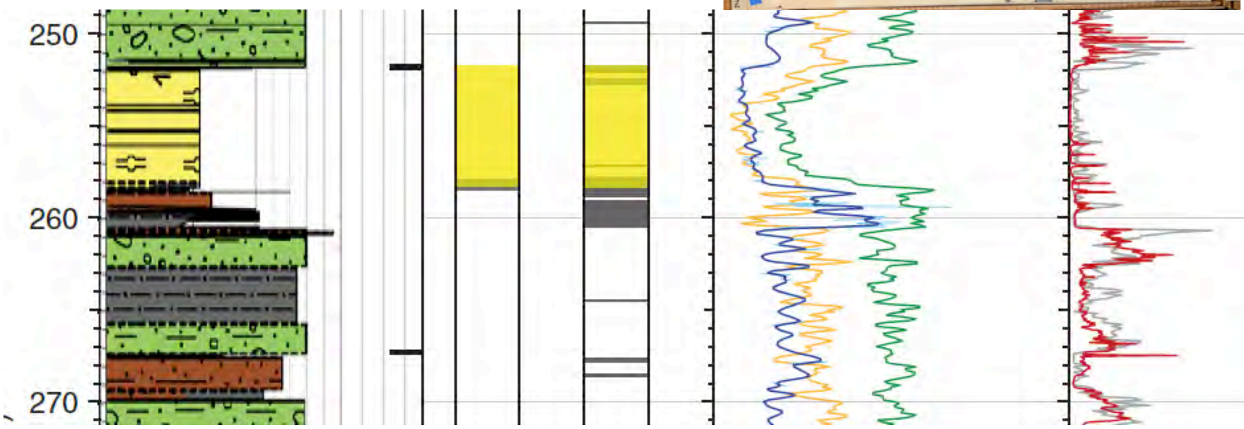


Motif 2: (b)
Boxes 94 and 95, 180.48 – 184.47 m
1 glacial erosion surfaces, 1 glacial retreat
McKay et al., GSA Bulletin; November/December 2009; v. 121; no. 11/12; p. 1537–1561



Motif 2 (c):
Boxes 130 and 131, 256.5 – 262.4 m
glacial retreat sequence
Williams et al., Geosphere; February 2012; v. 8; no. 1; p. 127–140





Motif 3 (a):
Boxes 361 and 362, 1046 - 1054 m
2x glacial erosion surfaces, 2x glacial retreat
McKay et al., GSA Bulletin; November/December 2009; v. 121; no. 11/12; p. 1537–1561