

What lies beneath the Antarctic Ice?



Adelie penguins on sea-ice



Australian Government

Geoscience Australia

National Science Week 2007: Antarctic Science

BIOLOGICAL HISTORY FROM AN ANTARCTIC SEDIMENT CORE

Background Information

An ice shelf is a thick, floating platform of ice that forms where either a glacier or ice sheet flows down to a coastline and onto the ocean surface. Ice shelves are found only in Antarctica, Greenland, and Canada. Forty-four percent of the Antarctica coastline has ice shelves attached. The Lambert Glacier drains into Prydz Bay via the Amery Ice Shelf, where the sediment core in this activity was collected. The Lambert Glacier is the largest valley glacier in the world, measuring up to 80 km in width and more than 500 km in length. As such, it drains one-fifth of the East Antarctic Ice Sheet.

The seafloor beneath the Antarctic ice shelves has been rarely sampled, because of difficulties in accessing it through the thick ice. The core from the Amery Ice Shelf referred to in the classroom exercise provides one of the few clues that we have to find out what the sub-ice shelf environment is like, how it has changed through time, and what sort of organisms live there. One of the most exciting findings of this research is that there is a thriving ecosystem in this environment, 100 km south (inland) of the modern edge of the ice shelf. Until now, ice shelves have been considered unlikely habitats for seafloor organisms. This is because light levels are extremely low in this environment (due to the overlying hundreds of metres of ice) which means that organisms that require photosynthesis can not survive. The primary producers in the open ocean consist of various types of photosynthetic algae, so in areas where these organisms can not survive, the food supply for other, larger organisms is restricted. The fact that we find a thriving community beneath the Amery Ice Shelf indicates that there is a consistent food supply to this site, with food (including photosynthetic algae which have been found in the sediment by other researchers) being brought in from open water areas via bottom currents beneath the ice shelf.

The seafloor biota have only colonised this site since the end of the last glacial period (which ended ~12,000 years ago). Before this time the ice sheet was grounded over the core site, which means that the ice was in contact with the sea floor. Once the ice sheet began to retreat as the climate warmed, the grounding line moved to the south of the site, leaving new areas of seafloor exposed. In time, the newly exposed seafloor at the core site has become colonised by marine organisms.

Useful web links:

<http://www.aad.gov.au/> Australian Antarctic Division

http://www.ga.gov.au/oceans/mc_Antrctc.jsp Geoscience Australia

<http://www.ncdc.noaa.gov/paleo/education.html> NOAA education website

PAST CHANGES IN THE ANTARCTIC ICE SHEET



Ice sheet extent 20,000 years ago

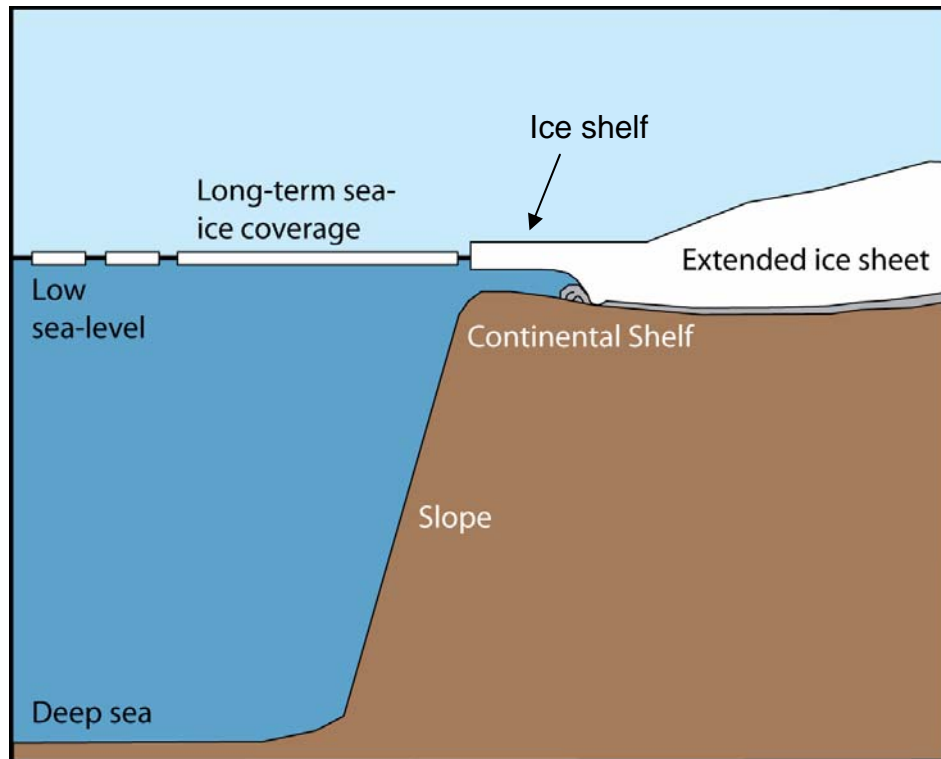


Modern ice sheet extent

The Antarctic ice sheet fluctuates in size roughly every 100,000 years due to changes in global climate. These climate cycles are referred to as glacial/interglacial cycles.

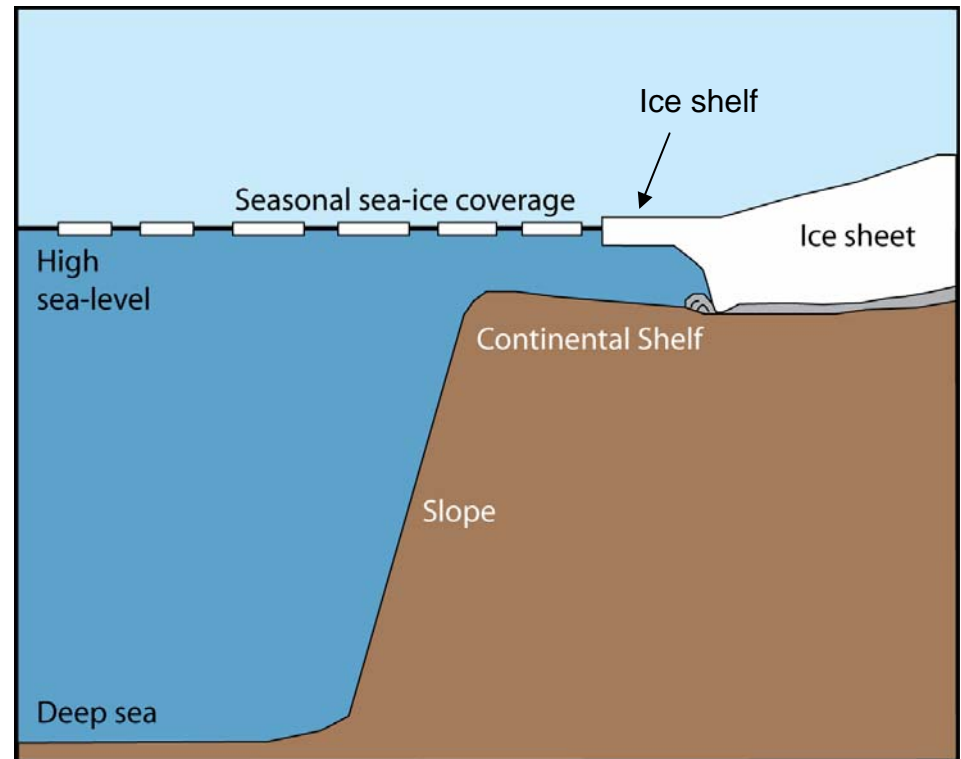
The last glacial cycle occurred about 20,000 years ago. At this time the Antarctic ice sheet was approximately double its current size. The ice sheet began retreating at about 12,000 years ago, adding to the rise in sea level at the end of this glacial period.

ICE SHEET EXTENT IN PROFILE



Glacial ice sheet extent

During glacial (cold) periods the ice sheets extend out towards the edge of the continental shelf.



Interglacial ice sheet extent

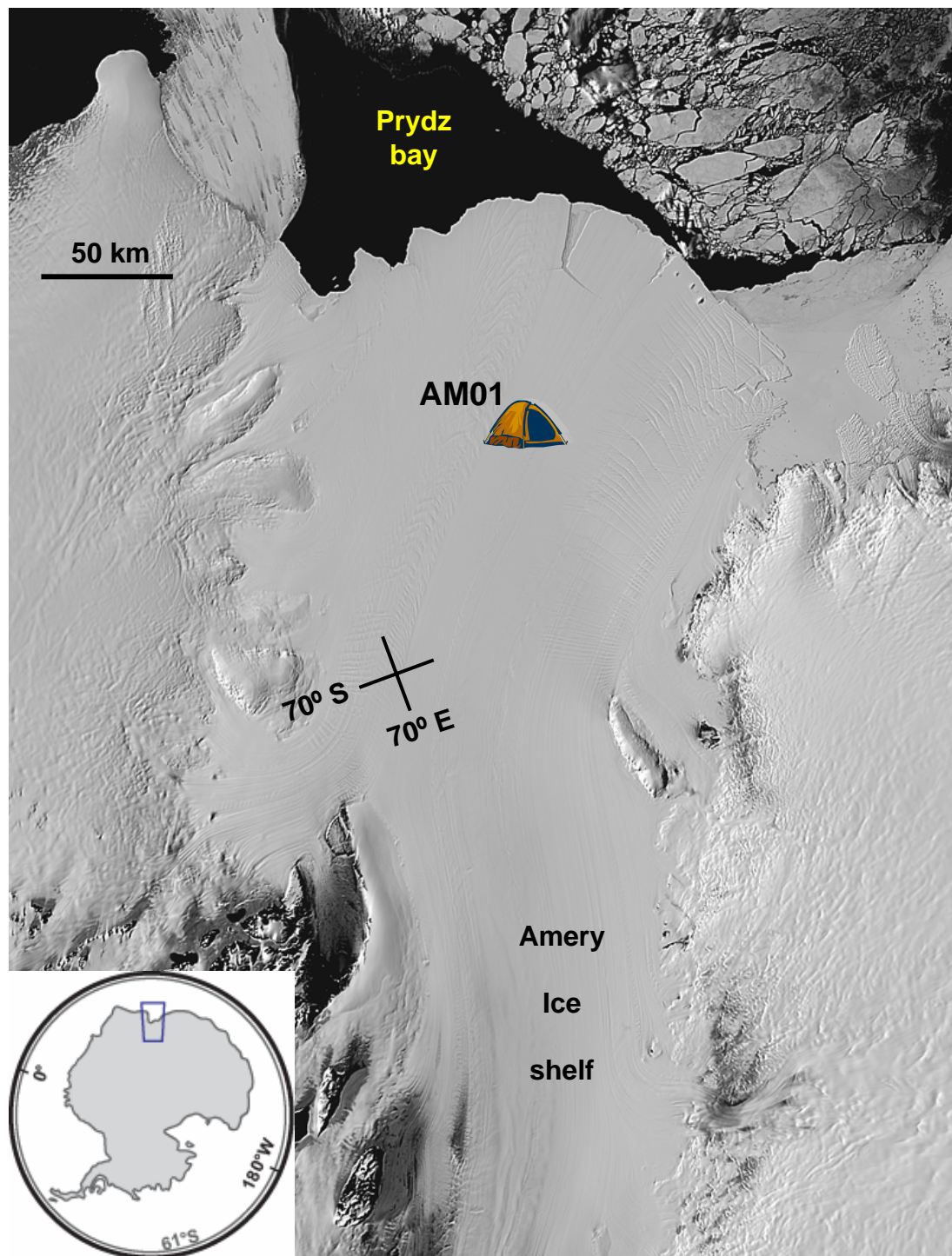
During interglacial (warm) periods the ice sheet retreats, exposing areas of the shelf covered during the glacial period.

ICE SHELF RESEARCH

During the summer of 2003 – 2004, 6 scientists and technicians spent over a month camped on the Amery Ice Shelf (see map on next slide) in eastern Antarctica. The aim of their stay was to drill through several hundreds of metres of ice beneath their feet to reach the ocean cavity below. Through this drill hole they were then able to lower instruments through the ice shelf, to study a part of the ocean which never sees the light of day. The scientists were interested in studying the composition of the ice that they drilled through, the properties of the ocean water, and the characteristics of the sediment on the seabed. They were particularly intrigued to find out whether there were any plants or animals living on the seabed and in the water, in a place which is hundreds of km away from open water.



Photo: S Donoghue



Photos: M. Craven



Photo: M. Craven

Set up for the hot water drill

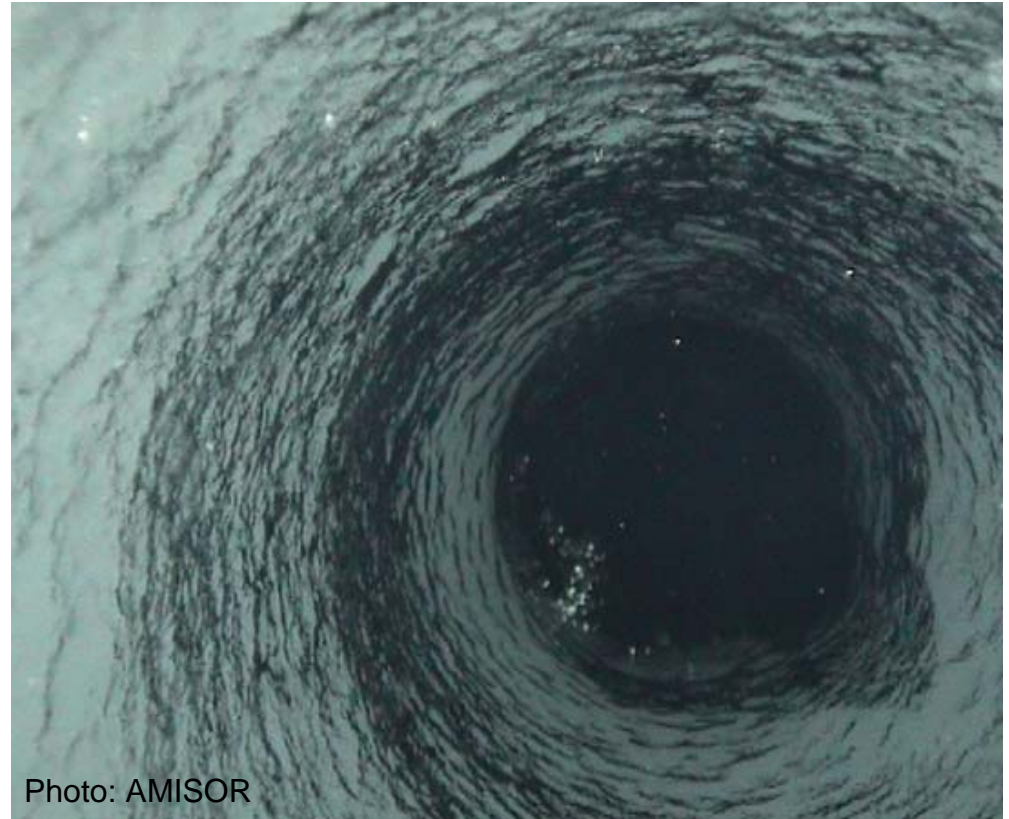
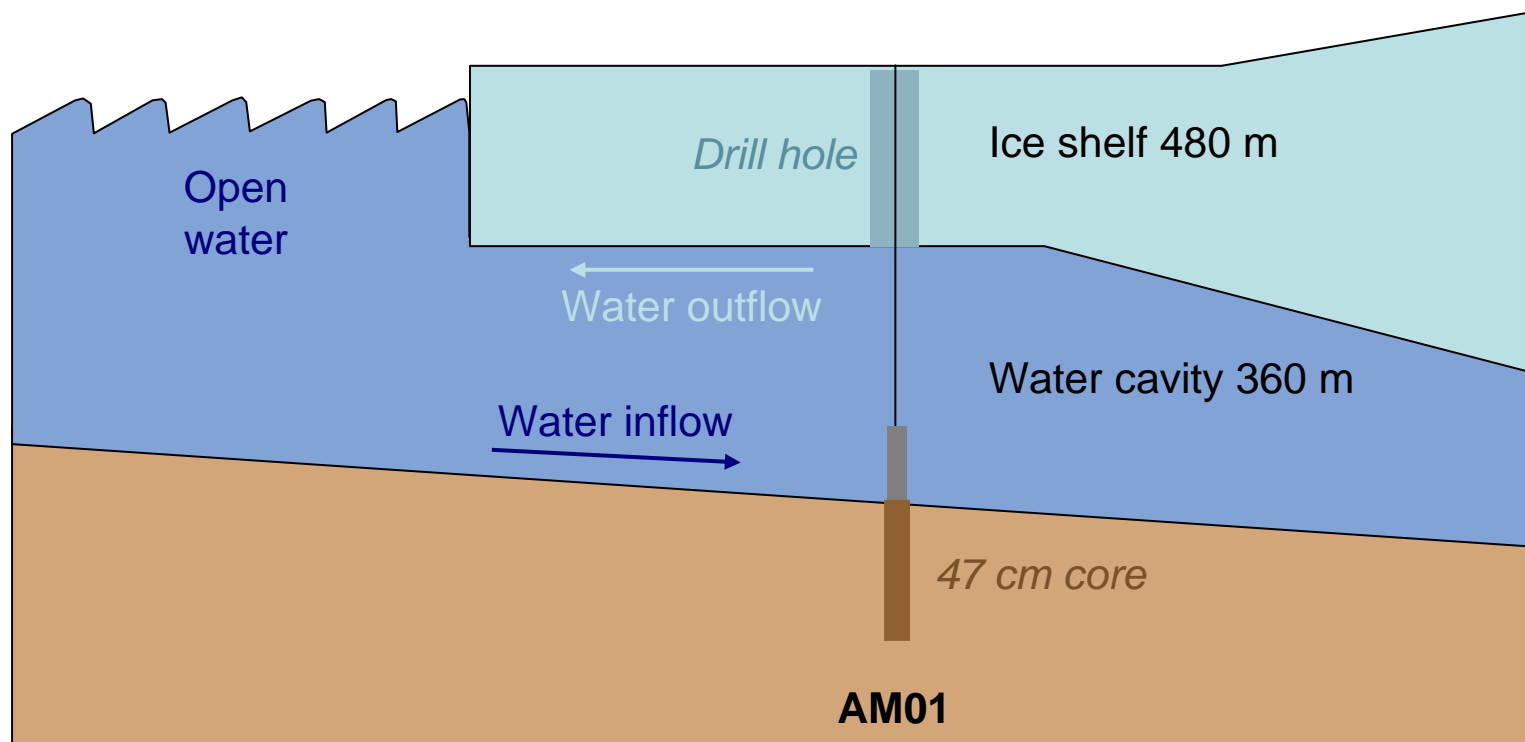


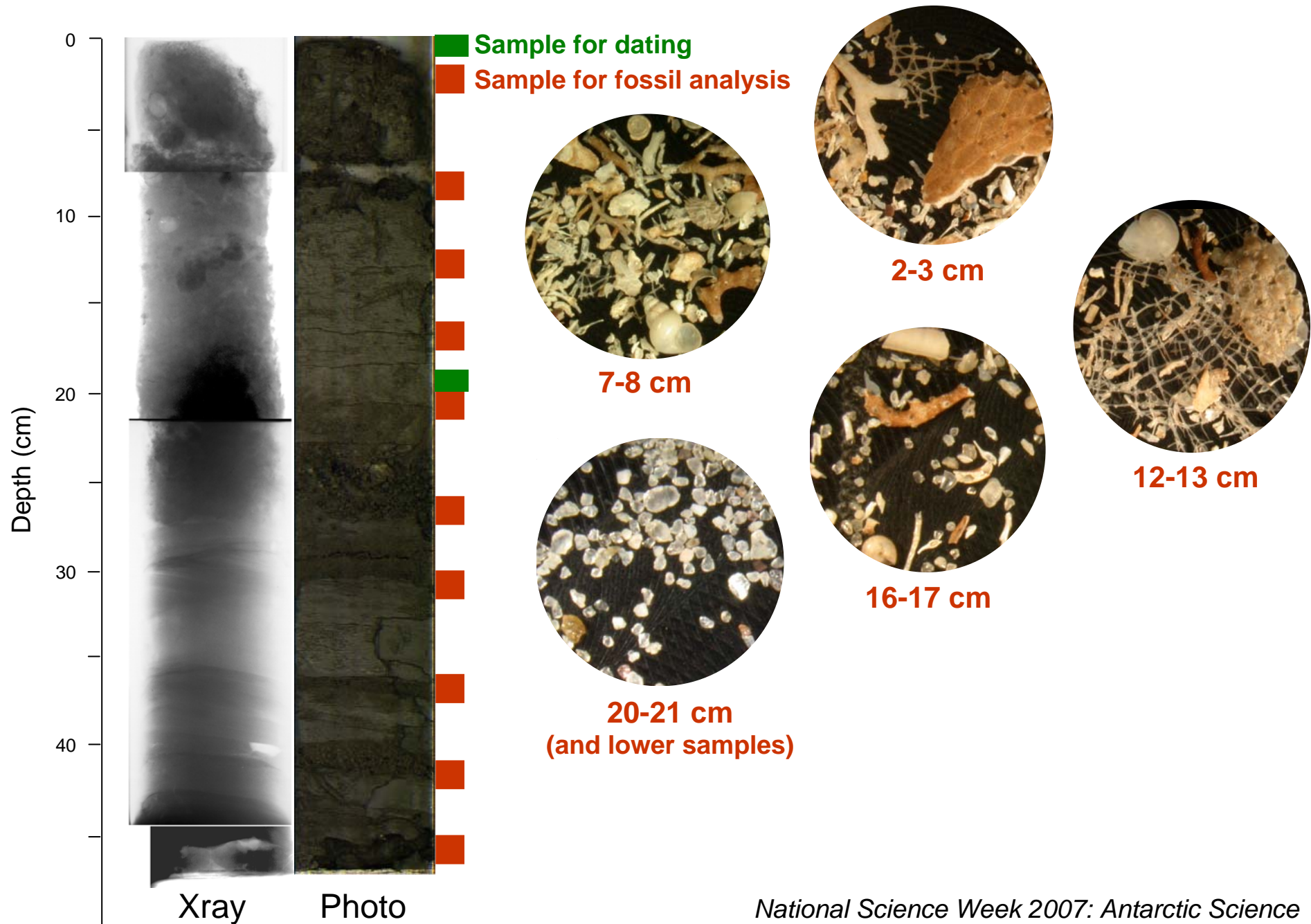
Photo: AMISOR

The drill hole through the ice

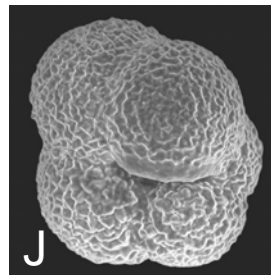
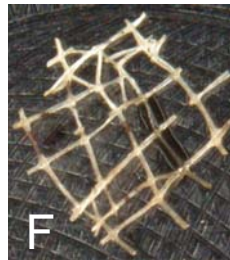
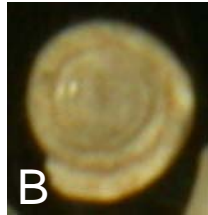
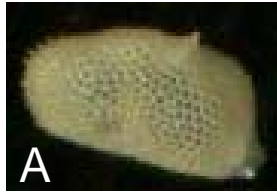
- A hot water drill was used to drill 480 m through solid ice
- Scientific instruments were then lowered through this hole
- A sediment corer was lowered to the seabed to collect a plug of sediment 47 cm long



Results from AM01 sediment core



Organisms found in the core



KEY

- A = Ostracod
- B = Benthic foraminifera
- C = Echinoderm spine
- D = Brachiopod
- E = Gastropod
- F = Sponge
- G = Bryozoan
- H = Polychaete tube worm
- I = Pteropod
- J = Planktonic foraminifera
- K = Radiolarian
- L = Other / unknown (not shown)

Down-core data

	Sample depth (cm)	2.5	7.5	12.5	16.5	20.5	27.5	30.5	36.5	41.5	45.5
	Organisms (number of individuals / gram of sediment)										
Mobile feeders	A: Ostracod	440	857	820	1113	73	0	0	0	0	0
	B: Benthic foraminifera	920	928	994	1139	109	0	0	0	0	0
	C: Echinoderm	38	96	23	14	0	0	0	0	0	0
	D: Brachiopod	86	115	87	97	0	0	0	0	0	0
	E: Gastropod	0	19	12	23	0	0	0	0	0	0
Total											
Filter feeders	F: Sponge	1734	653	740	180	18	4	0	0	0	0
	G: Bryozoan	5460	2950	2542	1759	0	0	0	0	0	0
Total											
Inf fauna	H: Polychaete tube worm	2021	1625	1363	835	0	0	0	0	0	0
Floating / swimming	I: Pteropod	57	102	64	120	0	0	0	0	0	0
	J: Planktonic foraminifera	67	96	260	309	73	0	0	0	0	2
	K: Radiolarian	19	6	12	5	0	0	0	0	0	0
	L: Other / unknown	77	211	115	245	23	0	0	0	0	0

WORKSHEET

1. Calculate the rate at which the sediment has accumulated (in cm / 1000 years and no. years / cm) in the upper part of the core based on the age and depth information in the table below.

Depth in core	Age (found by radiocarbon ^{14}C dating)
surface	present
18.5 cm	9606 yr BP

2. At what time does more than one organism first occur in the sediment core? (based on the the sedimentation rate calculated for the upper part of the core)
3. Which organism(s) are most abundant at this time?
4. How does the timing of ice sheet retreat at 12,000 years ago compare to the time when organisms first appear in the core record? What does this tell you about the sequence of events, and the way in which organisms have become established at this site?
5. Draw a line graph which shows how the abundance of each organism (individuals / gram) changes with depth in the core. Note when each organism has its maximum abundance in the core.

Extension work:

In this core, mobile and filter feeders are found in the core at different times. This provides clues about changes in food supply which are linked to changes in the environment. Mobile feeders are able to graze for their food in the surrounding sediment while filter feeders are generally attached to the seafloor and rely on food material which they can capture as it flows past. A reliable current flow bringing in food is therefore crucial for these organisms, whereas mobile feeders are able to forage a larger area so are more able to withstand a lower food supply.

TASK:

1. Using the first table provided, calculate the abundance of all the mobile feeders and the filter feeders. Draw a column graph which shows the changes in the abundance of these two groups of organisms through the core (depth vs individuals / gram of sediment).
2. At what depths do these two types of organisms peak in their abundance? Which type peaks earliest in the core?
3. What do these trends tell you about the way in which these organisms have become established in this environment? What environmental processes may be related to this pattern?

Acknowledgements

The AMISOR Project owes its success to the willing input of many team members over several seasons development and operation of the drill: Russell Brand, Nic Jones, Adam Drinkell & Seane Hall (mechanics); Alan Elcheikh, Dave Rasch & Jaret Matthews (electronic engineers); Ruth Baldwin (chef); and Shavawn Donoghue, Mark Hemer, Joel Pedro, Doug Thost, Adam Treverrow & Mike Craven (glaciologists). Without teamwork, cooperation, and persistence, cores like this could never be obtained from such difficult to access environments.

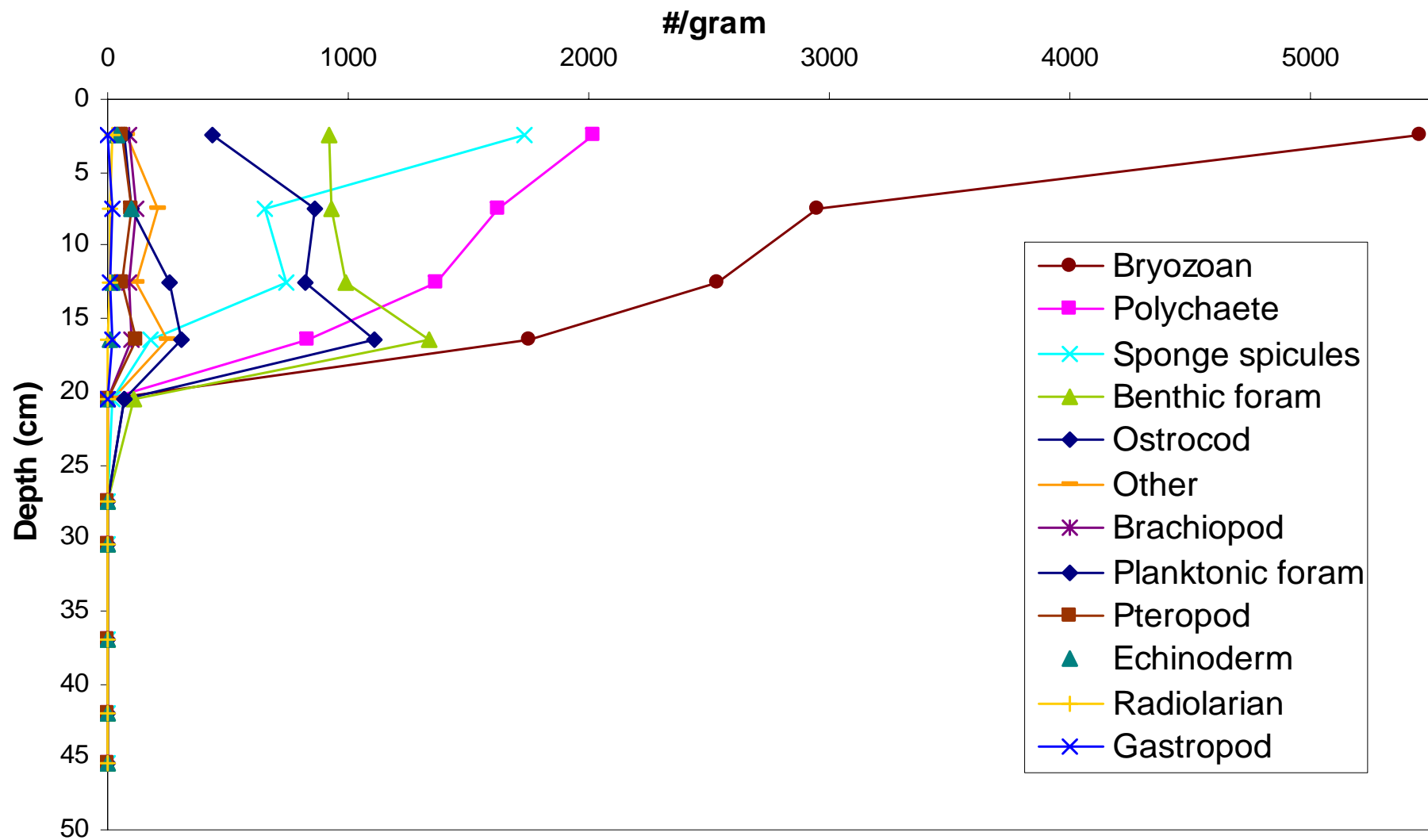
This exercise has been put together based on research by Alix Post and Phil O'Brien at Geoscience Australia, and is distributed with permission of the Chief Executive Officer at Geoscience Australia.

For any queries of more information, please contact:
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ANSWER SHEET

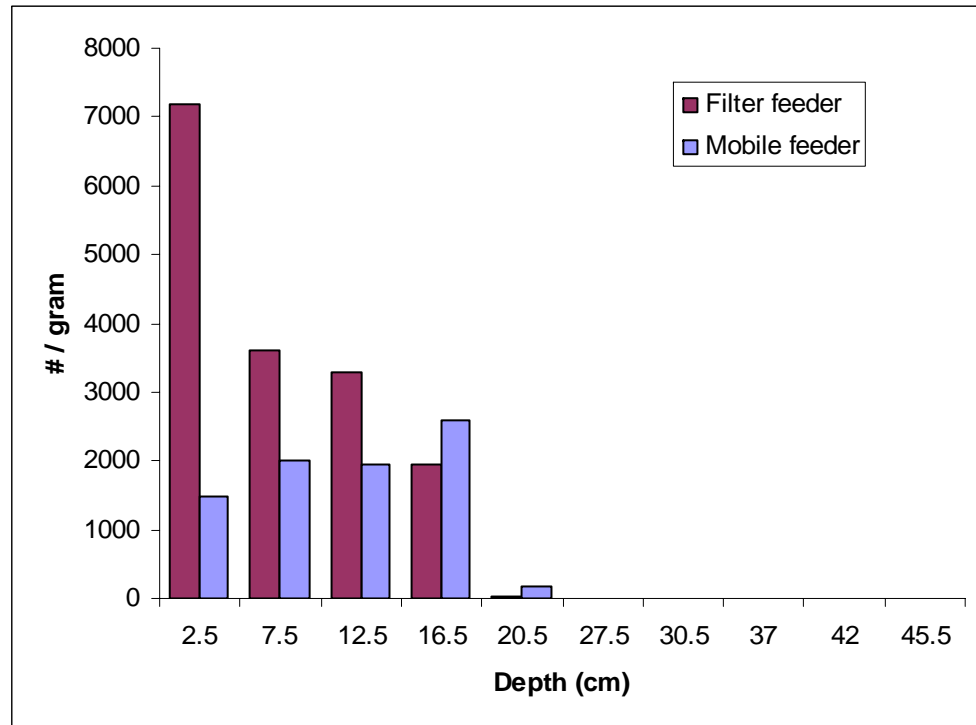
1. 1.93 cm / 1000 years
2. The first group of organisms occur at 20.5 cm in the core. Using the sedimentation calculated above this equates to a time of 10,622 years before present (yrs B.P.).
3. Organism C (benthic foraminifera)
4. From slide 1, ice sheet retreat occurred at ~12,000 yrs B.P. Organisms colonise this area beneath the ice sheet within ~1400 years of the retreat. This means that it takes 1400 years for the ice to retreat enough for the seabed to be ice-free at the core site, and for organisms to migrate to this site from areas further north on the continental shelf (see slide 2 to demonstrate new areas of seabed which appear as the ice sheet retreats).
5. Max abundances:
 - 2.5 cm organisms polychaete tube worm, sponge, radiolarian
 - 7.5 cm organisms echinoderm, brachiopod
 - 16.5 cm organisms ostracod, benthic foraminifera, bryozoan, pteropod,
planktonic foraminifera, gastropod, other / unknown

See graph over page -



ANSWER SHEET – Extension work

1.



2. Mobile feeders peak at 16.5 cm, and filter feeders at 2.5 cm. Mobile feeders peak earliest in the core.
3. Mobile feeders dominate during the early recolonisation of this site, with filter feeders only becoming dominant relatively recently (as indicated by their peak abundance at 2.5 cm). The recent success of the filter feeders implies that conditions have become more suitable for their survival. This may reflect an increased food supply since the initial retreat of the ice sheet, either due to increased current flow beneath the ice shelf, or greater productivity in the open waters where the food is being produced.