



CLAST - TEACHER WORKSHEET

The teacher worksheet includes two parts

1. **CLAST's explanation**
2. **Keys for "Student's worksheet" questions**

1. CLAST's explanation

The App CLAST has been designed to connect clearly the evidence coming from sediments found in the Antarctic Sea and its past climate conditions. This kind of connection is basic to reconstruct the environmental history of this area and consequently to understand better how the whole Earth climate system works.

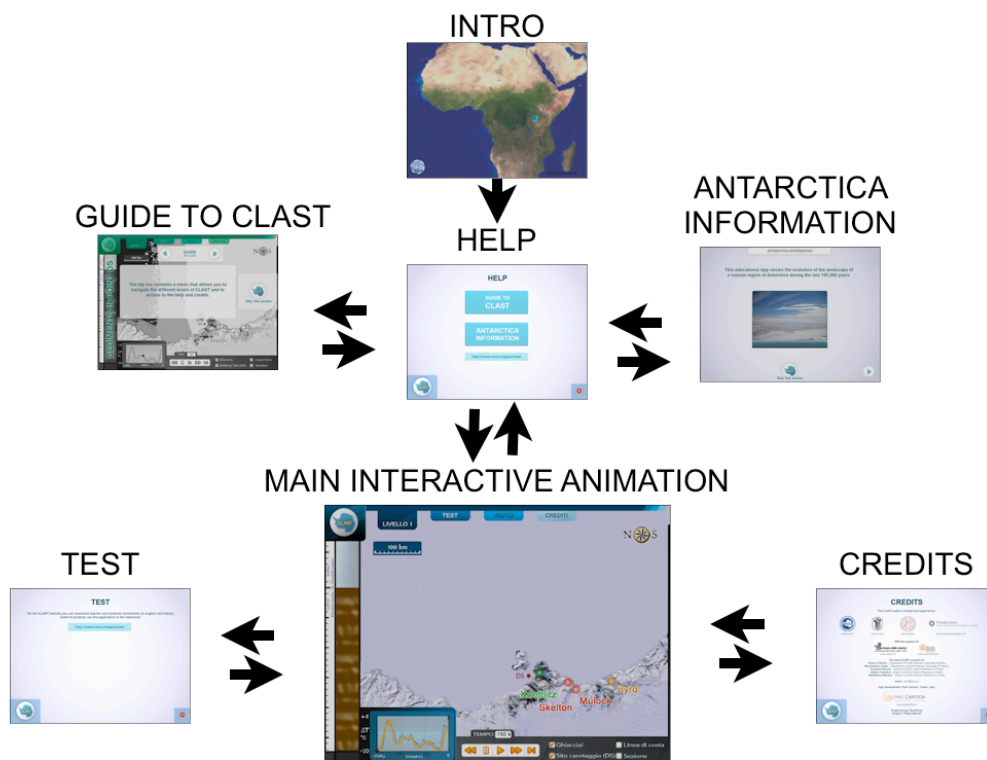
The inner "core" of the app is an interactive video-clip, which shows the evolution of some environmental scenarios during the last 150,000 years. The scenarios are linked to the estimated past temperature and the sediments cores recovered by the drilling project ANDRILL in the Ross Sea.

Other than the **interactive animation**, the app includes a HELP section with a "GUIDE to CLAST" and "Antarctica Information" .

All the references and further teaching resources are present in the website <http://www.mna.it/apps/clast/>

CLAST'S MAP

CLAST consists of some interactive sections, and some help and guide. They are connected according to the following map



PART 1. INTRODUCTION

After a flight about 16,000 km long from Italy to the South Pole we eventually arrive virtually to the Ross Sea.

PART 2. GUIDE TO CLAST

This section allow to explain the tools of the app and its controls and includes some pages describing all the elements present in the screen.

PART 3. ANTARCTICA INFORMATION

This section shows the main features of The Antarctica Continent, of the Southern Ocean, of their glaciers, and of the ice shelves.

PART 4. INTERACTIVE ANIMATION

The interactive animation represents the following main aspects:

1. the temperature variations of our planet in the last 150,000 years
2. the movements of a part of the Antarctic ice cap in response to temperature variations
3. Glacial flows and their transported sediments
4. The sedimentary process in correspondence to a benchmark site named Drilling Site (symbol DS)



These four aspects are visualized dynamically in a satellite photo made on the Ross Sea, which spans in the central screen area.

1 The temperature variations

The temperature trend is plotted as difference between past and current mean temperatures.

On the graph time/temperature (shown on the bottom left) are drawn two curves. The first curve (grey line) represents the estimated mean temperature, whereas the second one (orange line) is only approximate.

A black dot shows the punctual age in the scenario. If the black dot doesn't move, it represents a static situation, while a moving black dot describes a dynamic situation. The position of the black dot can be modified clicking on the controls (forward, backward, to the next scenario, pause, start again).

2 Ice cap movements

Ice shelf observations

When the time goes by, it is possible to look at what happens in the grounded (anchored) ice shelf depending on the temperature.

In particular, we can notice progressively:

1. During a warming up phase, the ice shelf retreats from north to south and the glaciers transport their own clasts less distantly.

2. Firstly, a darker area of ice appears in the north, which represents a not grounded ice shelf made by floating ice. This darker color is a symbolic representation that helps to distinguish between grounded and floating ice shelf.

WARNING! Actually the color of both shelves as seen from satellites images is indistinguishable.

3. During a maximum of heating, the not grounded ice shelf retreats entirely and the screen shows the dark blue open sea.

4. Along the boundary between the open sea and the ice shelf we can look at many icebergs, originating from the ice shelf. The line of iceberg detachment is called "calving line".

5. During a cooling phase, the shelf moves northward. Firstly, a floating shelf appears (darker color) and then the anchored part of it develops, extending more and more up to span the whole screen. In these phases, the glaciers move their sediments to greater distances.

3 Glacial flows and their transported sediments

Glaciers flows

During the animation some trails appear differently colored. They represent the sediments that each glacier transport to the open sea each of them having the same symbolic color of the glacier.

Notice that the sediments are transported to different distance from the coast line, depending on the temperature.



4. The sedimentary process in correspondence to a benchmark site named Drilling Site (symbol DS)

The sediments column represents what kind of clasts has been deposited over time in the drilling site, in a synchronic way respect to what happens in the center of the screen. The sediments, or clasts, accumulate layer by layer and deepen more and more. The color of the sediments is linked to its origin.

During the animation, based on the state of advance or retreat of the ice shelf, the feature of sediments changes in regards to:

1. Color
2. The size of the clasts (grain size)
3. Stratification (layering): in some phases it is present, while in others it is not so clear, particularly when the shelf is more extended and grounded. During colder periods, the sediments appear more massive and not stratified. During the hot periods the stratification is evident, when the shelf is not grounded or in open sea conditions..



2. KEYS FOR "STUDENT'S WORKSHEET" QUESTIONS

The right answers are in bold and underlined

FLYING TO ANTARCTICA

After a flight from Italy to the South Pole about 16,000 km long, you eventually arrive to the Ross Sea, our research area. Look carefully at what happens during the journey and answer the following questions:

1. The flight is
 - From north to south**
 - From south to north
 - From east to west

2. The flight is
 - Along a meridian**
 - Along a parallel

3. The trip ends on the Ross Sea: where is it located with respect to Italy?
 - Along the same meridian
 - Along the opposite meridian (anti-meridian)**

4. After the trip, where is the South Pole located with respect to the Ross Sea?
 - To the right**
 - To the left
 - Upward
 - Downward

5. How much wide is the visualized area in the App?
 - **700 km x 500 km**
 - 7.000 km x 5.000 km

TIME/TEMPERATURE GRAPH

Look at the time / temperature graph and answer:

Given that «ky» means 1000 years, what is the duration of the observed period?

- 15.000 years
- 1500 years



- **150.000** years
- 150.000.000 years
-

Where is the present time located in the graph?

- **On the Right**
- On the Left
- On the center

How many steps of heating occurred during the last 150,000 years?

- 3
- **4**
- 5

How many cooling steps occurred in the same time period?

- **3**
- 4
- 5

Look at the working area and reply using the graphic scale

The Koettlitz glacier is far from the site of drilling:

- **less of 100 km**
- more then 100 km

The Byrd glacier is approximately located at:

- 100 km
- **200 km**
- 300 km

THE ICE SHELF

Launch the animation and observe what happens to the shelf and pay attention of the time / temperature graph:

During a warming-up phase, the shelf...

- **retreats from north to south**
- retreats from south to north
- advances from north to south
- advances from south to north

Which continental situation does correspond to the following scenario?
 Select one of the following Figures A or B



Scenario of Ross Sea area (in CLAST)

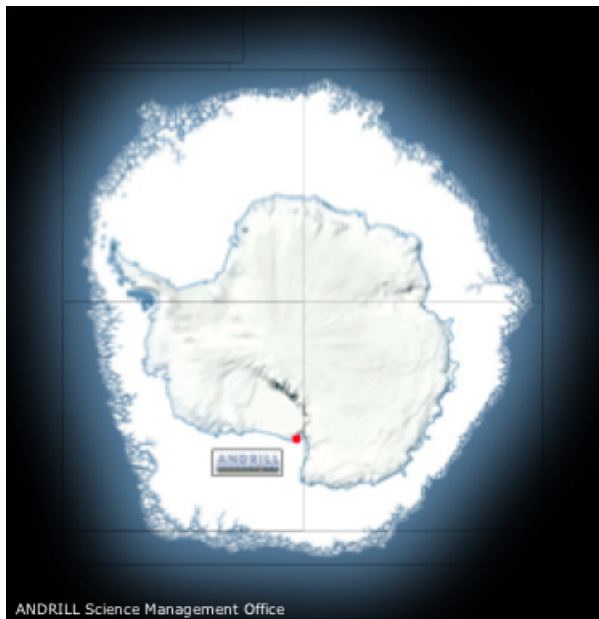


Figure A



Figure B

During a warming phase glacial flows transport their clasts

- More and more away from the coastline
- **even closer to the coastline**

When does the not anchored shelf retreat completely and then disappear?



- At the recorded maximum temperatures**
- When temperatures are very low

THE GLACIERS

Which is the closest glacier to the drilling site?

- Koettlitz**
- Skelton
- Mulock
- Byrd

Launch the animation and look at what appears in the research area.

What do the colored paths from the four glaciers represent?

- Glacial flows**
- Water rivers

What do the moving colored dots represent?

- The glacial debris rolling on ice
- The glacial debris moving with the ice**

What do the different debris colors represent?

- Debris from different rocks (kind of rocks)
- Debris from different glaciers (provenance)**

THE SEDIMENTS CORE

The sediments being at the bottom of the column are:

- The oldest ones**
- The youngest ones

Look carefully at what happens in the column of sediment during the animation, then answer:

How can you describe the sediments deposited during the cooling phases?

- well laminated (like blades), evident stratification formed by many thin layers
- more homogeneous, stratification not evident, formed by many thick layers sometimes a little bit chaotic**

How can you describe the sediments deposited during the hot phases?



- **well laminated (like blades), evident stratification formed by many thin layers**
- more homogeneous, stratification not evident, formed by many thick layers sometimes a little bit chaotic

Now look in particular at the predominant color of the sediments accumulating in the site.
Run the animation between - 150Ky and - 120 Ky

The temperature during this time

- **has been increasing**
- has been decreasing

The ice shelf during this time

- has been advancing
- **has been retreating**

The sequence of the sediments colors accumulating in the column during this time period is

- **Yellow / orange / green**
- Yellow / green / orange
- Green / yellow / orange

That means that the debris initially come mainly from glaciers that are...

- **Farther away from the drilling site**
- Closer to the drilling site

What happens at about -137 Ky?

- The drilling site is located on the floating shelf and fine-grain stratification becomes evident
- The drilling site is located on the anchored shelf and fine-grain stratification becomes evident
- **The drilling site is located on the floating shelf and sediments appear more homogeneous**
- The drilling site is located on the anchored shelf and sediments appear homogeneous

What happens at about -131 Ky?

- The drilling site is located in correspondance to the floating shelf
- The drilling site is located in correspondance to the anchored shelf
- **The drilling site is located offshore**

Notice that sometimes icebergs can pass over the drilling site. Pebbles of different size can be dropped out them(dropstones). Consequently, at the drilling site there is deposition of:

- only large clasts
- **large clasts and fine sediments**
- fine sediments

When the shelf is totally retreated, is it possible that sediments coming from photosynthetic organisms can accumulate at the drilling site?

- **Yes, because the sunlight filters and makes photosynthesis possible**
- No, because the sunlight never penetrates the water
- Yes, because photosynthesis is independent of the presence of shelf
- No, because photosynthesis doesn't occur in the sea

Look at the following scenario



You can say that:

- At the drilling site **there is** / there is not a **floating** / anchored shelf
- It represents a **warming** / cooling stage with **retreat** / advance of the shelf
- The grounding line is located **southward** / northward of the site
- The stratification in the column of sediment is **evident** / not evident

Look at the following scenario



what kind of sediments have been depositing at the drilling site?

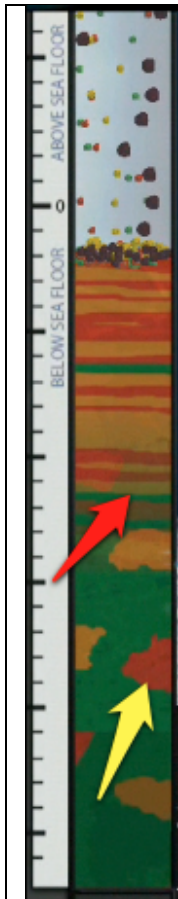
- **Homogeneous sediments, coming mainly from Koettlitz and Mulock glaciers**
- Fine laminated sediments from the Mulock Glacier
- Homogeneous sediments coming just from the glacier Koettlitz
- Sediments of mainly marine origin

Having just this information, can you deduce that the shelf is advancing?

- Yes, because the site is located on the anchored drilling shelf
- No, because I have not enough information**
- Yes, because the glacial flows are strong
- No, because it is retreating

In regards to the position of the drilling site, the grounding line is placed:

- Northward**
- Southward
- At the site of drilling
- It is impossible to have this information



Look at the figure representing the sediments core and choose the correct alternative in each of the following sentences:

- The yellow arrow indicates a large clast that probably **is detached from an iceberg** / is settled offshore
- The red arrow indicates the transition between two different modes of sedimentation: from open sea to floating shelf / **from floating shelf to open sea**
- Regarding the time, the shelf at drilling site moved from a retreat to an advance stage/ **from an advance to a retreat stage**
- In regard to the temperature variation along all the core portion, we can say that it has been **increasing** / decreasing
- I can make prediction/ **I can't make prediction** about what will happen in the core hereafter because I have sufficient / **insufficient** data.

Read the following summary and correct any mistakes. The wrong terms are only 6 and they are nouns or adjectives, NOT verbs.

When a core is recovered from the seafloor, it is possible to see sediments of **different** /same origin and size. They can have been deposited in different ways. The sediments deposited at deeper depths are **older** /more recent. When we find sediments of glacial origin, we may argue that they originated from glaciers and therefore have been deposited during a **cold** /warm/ period. In particular, we find sediments from glaciers **farther from**/closer to the drilling site during the coldest stages, whereas the nearby/distant glaciers abandon more sediment during less cold stages. When the shelf is completely retreated and at the site of drilling there is **open sea** /floating sheet condition, fine sediments are deposited, which are rich in organic matter (in particular photosynthetic microalgae). Among the fine sediments it is possible sometimes to find very large clasts, coming from **icebergs** /glaciers that pass over the site of drilling.