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ANTARCTICA DISCLOSING: THE CONTRIBUTION OF THE *MUSEO NAZIONALE DELL'ANTARTIDE* - EARTH SCIENCE SECTION OF SIENA

Abstract - The *Museo Nazionale dell'Antartide* was established in 1996 and is comprehensive of three sections characterised by different scientific aims: biology and ecology (Genova section), Earth science (Siena section) and marine geology and Antarctic exploration (Trieste section). The Museum has the aim to preserve, study, and increase the value of all scientific materials collected during the Italian research expeditions in Antarctica, and to promote the knowledge of scientific results achieved by the Italian Antarctic research community. The Earth Science section of Siena is the national repository for the geological material (rocks, fossils and meteorites) collected during the Italian Antarctic expedition since 1985, and has the aim to acquire, preserve, manage, catalogue and classify all the collection samples. Since 1996, within the frame of national and international research projects, scientific researches are carried out at the Siena section by a large variety of researchers. Antarctic samples, since 1996 Principal collection-based studies include i) the geology and petrology of metamorphic basement rocks of the Ross Orogen, ii) the mineralogy and geochemistry of Antarctic meteorites, iii) the provenance analyses of glaciomarine drill core sediments recovered in the Ross Sea, and iv) the ice-flow analogue modelling. Achieved scientific results are largely attested by the many publications on peer-reviewed international journals (H-index of 17, Web of Knowledge database source), and by the participation to national and international conferences. The Earth science section is particularly devoted to promote the polar knowledge to as wide an audience as possible, with special attention dedicated to all-level students and educators, through guided visits, lectures and didactic laboratories. The presence at the Siena section of scientists directly involved within Antarctic researches allows the visitors to be updated with some of the currently more crucial scientific arguments, as the global warming and the origin of the Solar System.

Key words - Antarctica, rocks, minerals, fossils, meteorites, outreach, scientific research.

Riassunto - *Svelando l'Antartide: il contributo del Museo Nazionale dell'Antartide, Sezione di Scienze della Terra di Siena* - Il Museo Nazionale dell'Antartide nasce nel 1996, articolato in tre sezioni con competenze scientifiche differenziate: biologia ed ecologia a Genova, scienze della terra a Siena, geologia marina e storia dell'esplorazione antartica a Trieste. Il Museo ha il compito della conservazione, dello studio e della valorizzazione dei reperti acquisiti nel corso delle spedizioni scientifiche italiane in Antartide e di ogni altra testimonianza relativa alla presenza italiana nel continente antartico. Il Museo ha inoltre il compito di promuovere la conoscenza delle attività e dei risultati scientifici ottenuti dalla comunità scientifica italiana. La sezione di Siena del Museo Nazionale dell'Antartide è la sede del deposito nazionale (petroteca) dei materiali geologici antartici (rocce, minerali, fossili, meteoriti) raccolti durante tutte le spedizioni italiane in Antartide (dal 1985 ad oggi), ed ha il compito di acquisire, conservare, gestire, catalogare e classificare i campioni della collezione. Sin dalla nascita del Museo, la sezione di Siena ha saputo

ben coniugare la conservazione e la classificazione dei reperti con la ricerca scientifica atta alla valorizzazione dei reperti stessi. I ricercatori che a vario titolo (tecnici laureati, dottorandi, borsisti post-dorato ed assegnisti di ricerca) hanno condotto le loro ricerche presso la sede di Siena hanno partecipato a progetti di ricerca nazionali ed internazionali, talvolta come coordinatori. I principali studi sviluppati presso la sezione di Siena coinvolgono: 1) la geologia e la petrologia delle rocce del basamento metamorfico dell'Orogene di Ross (Terra Vittoria settentrionale e Montagne Transantartiche centrali); 2) la mineralogia e la geochimica delle meteoriti, micrometeoriti e microtectiti antartiche; 3) l'analisi della provenienza dei sedimenti glaciomarini recuperati dalle campagne di perforazione internazionali nei bacini del mare di Ross; 4) la modellizzazione analogica dei flussi del ghiaccio. I risultati della ricerca sono documentati da numerose pubblicazioni su riviste internazionali referate (indice bibliografico H pari a 17, secondo il database Web of Knowledge) e dalla partecipazione a congressi nazionali ed internazionali (talora su invito). La sezione di Siena è inoltre particolarmente attenta alla divulgazione e diffusione della conoscenza scientifica inerente l'Antartide, attraverso visite guidate, seminari e laboratori didattici rivolti a qualsiasi tipo di pubblico, ma specialmente a studenti ed insegnanti di ogni ordine e grado (dalla scuola materna fino al dottorato di ricerca). La presenza nella sede di Siena di ricercatori direttamente coinvolti in tematiche di ricerca antartica consente alle scuole (studenti ed insegnanti) di ricevere informazioni esaustive e continuamente aggiornate su alcune delle tematiche scientifiche più attuali, quali il riscaldamento globale del nostro pianeta e l'origine del Sistema Solare.

Parole chiave - Antartide, rocce, minerali, fossili, meteoriti, divulgazione, ricerca scientifica.

INTRODUCING THE ITALIAN *MUSEO NAZIONALE DELL'ANTARTIDE*

After ten years of Antarctic research activity, in 1996 Italy established the Italian *Museo Nazionale dell'Antartide* with the aim to preserve, study, and increase the value of all scientific materials collected during the Italian research expeditions in Antarctica, and to promote the knowledge of scientific results achieved by the Italian Antarctic research community.

The Museum is organised as an inter-university centre involving Genova, Siena and Trieste athenaea. Each of the three sections is characterised by different scientific aims: biology and ecology at Genova, Earth sciences at Siena, and marine geology and Antarctic exploration at Trieste sections, respectively. To promote pub-

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lic understanding of the Antarctic continent, all centres hold permanent exhibition arranged through multimedia systems, including images, movies, computer animations and workstations for virtual trips to Antarctica. Temporary and travelling exhibitions are also organised, the latest being realised as a contribution to the International Polar Year 2007-2008, with the aim to attract the interest of the public, media and students on the role of the Polar Regions for our planet.

Within the frame of an agreement with the Italian National Antarctic Programme and the Ministry of Education, University and Research, a polar summer school for teachers has been established. The school aims at teaching polar science topics and giving tools and techniques to be included in science curricula. Participation to an Antarctic research expedition is offered to the teacher, winner of a contest on an original laboratory activity on polar science.

THE EARTH SCIENCE SECTION AT THE UNIVERSITY OF SIENA

The Earth science section of the *Museo Nazionale dell'Antartide* (Fig. 1a) consists of three parts: the exhibi-

tion, the documentation centre and the research and sorting centre.

The exhibition is organised to cover all the aspects and disciplines of the Antarctic sciences, with Earth and planetary science materials (rocks, minerals, fossils and meteorites) playing a dominant role (Fig. 1b, c, d). Interactive exhibits include computer animations which: i) illustrate the main features of Polar Regions, by comparing Arctic and Antarctic areas; ii) give general information on climate, climate change and, more specifically, on the key role of Antarctica in the present-day global warming scenario; and iii) reproduce the tectonic evolution of the southern hemisphere since the last 600 millions of years (i.e., Gondwana supercontinent). Moreover, a recent acquisition allows to virtually explore Antarctica by means of a six LCD-full HD monitor system powered by Google Earth and Street View.

The documentation centre holds the Italian largest collection of Antarctic national and international scientific literature, including about 5000 documents (books, audio-visual material, maps, etc.) and 80 periodical publications. Main subjects are geology, planetary sciences, exploration history, biology, glaciology,



Fig. 1 - a) The Earth science section entry of the *Museo Nazionale dell'Antartide*, Siena University; b) panoramic view of the exhibition; c) meteorite exhibition. d) antarctic geology room: rock samples and Earth supercontinent evolution through geological time.

climatology, oceanography, atmospheric sciences and ecology; fiction and children books are also present. The established exchange relationships with the Antarctic organizations of other countries allow the Museum to collect scientific programmes, activity reports and other «non-circulation» literature otherwise hardly to be found. Furthermore, Antarctic aerial photographs (printed and digitalised) and satellite images are available. All the documents are catalogued, inserted in a database and can be freely consulted at the Museum by general public, all-level students and educators.

The research and sorting centre acts as the national repository for the geological materials collected since 1985 during the Italian Antarctic expeditions, and has the aim to acquire, preserve, manage, catalogue and classify all the samples. The sorting centre houses:

- over 21000 Antarctic terrestrial geological samples (rocks, minerals and fossils);
- about 20700 petrographic thin sections of terrestrial rock samples;
- about 1150 meteorites, micrometeorites and microtektites, of which 770 collected in Antarctica (the fourth largest Antarctic collection in the world);
- 1160 petrographic thin sections of meteorites.

All the samples are accurately labelled, boxed and arranged in shelves, sometimes mobile. In order to catalogue and classify the rock samples, thin sections are prepared and petrographically analysed by means of a polarised-light microscopy, and, for meteorite samples, by using electron microprobe or scanning-electron microscope as well to detect the mineral compositions. Specific databases for both terrestrial and extra-terrestrial rock samples are constantly updated and the metadata can be accessed and queried by general public on our web site (<http://www.mna.it>). Rock samples or thin sections from the collection can be loaned to authorised researchers, subject to the National Antarctic Scientific Committee approval. Meteorite samples have also been distributed to some of the most important scientific institutions or museums (NASA, Smithsonian Institute, Field Museum of Chicago, and Natural History Museum, among other) for either exhibition or research purposes.

The Earth science section also supports a PhD school on polar sciences, established in 1998 by the Department of Earth Sciences of the University of Siena. The goal of this PhD school is to educate young researchers who face the thematic of global environmental change on the basis of data and observations from the Polar Regions, through an interdisciplinary preparation and a systemic approach. The education includes interdisciplinary and specific courses and seminars. Research activities generally include the participation

to at least one scientific expedition in the Arctic or Antarctic region.

THE RESEARCH ACTIVITIES

As stated by the purposes of the *Museo Nazionale dell'Antartide*, the research activities of the Earth science section aim to study and increase the value of the collected Antarctic terrestrial and extra-terrestrial geological samples. Indeed, researches are vital to better understand the collections and, therefore, to optimise the use of samples both as exhibit and educational resource.

Since 1996, research activities have been carried out by a large variety of researchers (i.e., curators, PhD students, post-doctoral research fellows) based at the Earth science section of Siena, and within the frame of both national and international research projects, some as principal investigators as well.

Major collection-based researches include:

- geology and petrology of metamorphic basement rocks of the Ross Orogen (northern Victoria Land and central Transantarctic Mountains), with special regard to high/ultrahigh pressure (eclogites) and high temperature-low pressure metamorphism (Fig. 2a, b, c);
- mineralogy and geochemistry of meteorites and micrometeorites to explore the origin of the Solar System and study the flux of extraterrestrial matter accreting to Earth (Fig. 2d, e);
- geochemistry of microtektites (microscopic impact glass particles) discovered on the tops of northern Victoria Land Transantarctic Mountains;
- provenance studies of glacial marine drill-core sediments recovered in the Ross Sea (CIROS, CRP and ANDRILL international projects), to contribute to paleogeographic and paleoclimatic reconstructions (Fig. 2f, g, h);
- ice-flow modelling using three-dimensional laboratory physical experiments, with particular attention to the mechanisms responsible for the origin of meteorite concentrations in blue ice areas of the Antarctic plateau (Fig. 2i, l).

Achieved scientific results are well documented by the many publications on peer-reviewed international journals and book chapters, and by the participation to national and international conferences with both oral presentations (some invited) and posters. Within about 130 publications produced at the Earth science section since 1998, 111 are certified by the Web of Knowledge, one of the most used scientific citation database, and the research quality is attested by a H-index of 17 (Fig. 3).

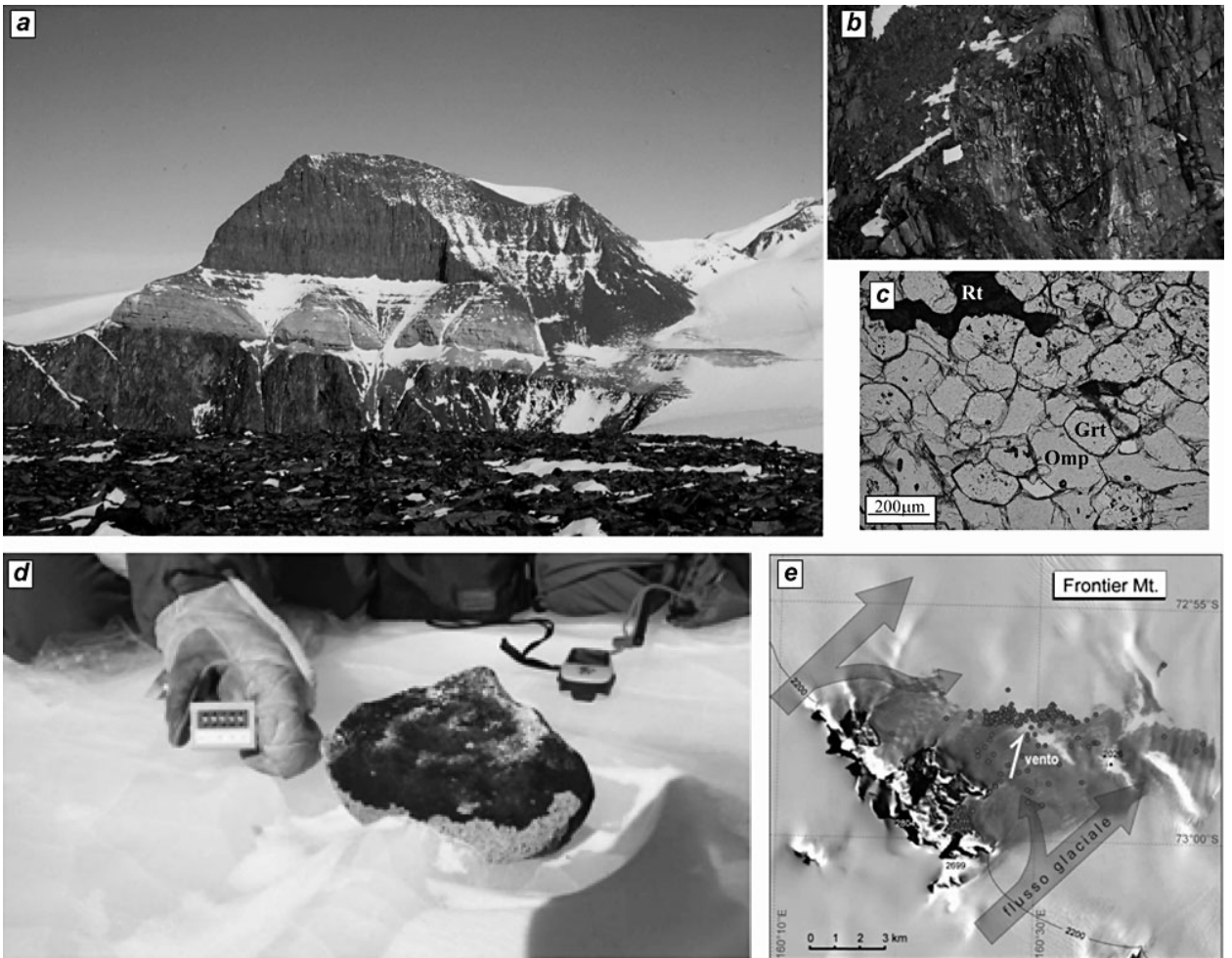


Fig. 2 - a) Transantarctic Mountains view, showing Ross Orogen basement rocks overlapped by Beacon sandstones and Ferrar dolerites (Mozzumi Range, northern Victoria Land); b) eclogite lense cropping out at Lanterman Range (northern Victoria Land); c) photomicrograph of eclogite (plane-polarised light); d) meteorite finding on the Antarctic plateau (Frontier Mountain); e) frontier mountain map, showing the blue ice area of meteorite concentration.

EDUCATION AND OUTREACH ACTIVITY

A primary goal of the museum is to contribute to education and outreach by promoting the polar knowledge to general public, school-groups and educators through lectures, guided visits and didactic laboratories. Visitors are provided with a wealth information about Antarctica, including general features concerning exploration history, environment, climate conditions, endemic terrestrial and marine life, other than the most important scientific results achieved by the Italian Antarctic research community. Moreover, we also outline some of the steps that researchers need to take before travelling to Antarctica and answer the most commonly asked questions about living and working in the Antarctic scientific stations.

A special attention is reserved to all-level students, from kindergarten to PhD level. Polar sciences and, more generally, Polar Regions are arguments rarely treated within the average school curricula, despite the attractive appeal both the Arctic and especially Antarctica can exert on the human imagination, being so remote, extreme and inaccessible. It is therefore really important to promote polar knowledge to the students and let them get closer to scientific disciplines otherwise difficult to learn at school. To do that, a primary goal of the Earth science section is to establish permanent relationships with educators from all-level schools; science educators are mainly involved, but also subjects as English, literature, history and geography can be carried on, thanks to the multidisciplinary nature of the museum and to the extensive collection held at the documentation centre.

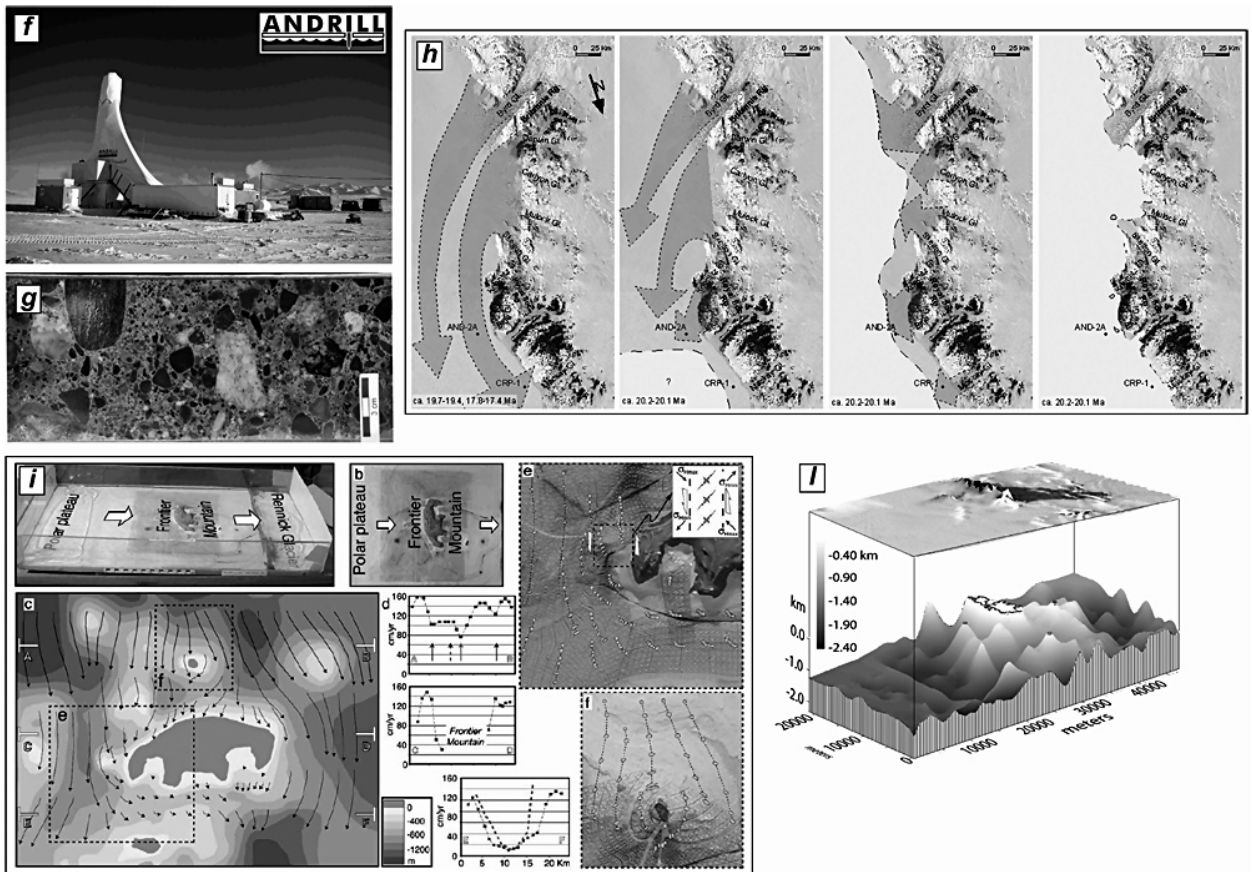


Fig. 2 continued - f) drill site of Southern McMurdo Sound - ANDRILL project (AND-2A core); g) AND-2A core section, consisting of diamicite with a very high percentage of clast content; h) Early Miocene paleogeographic scenarios inferred from clast provenance analysis of the AND-2A core; i) analogue modelling of Frontier Mountain meteorite trap. Ice analogue (PDMS silicone putty) flowing on a wood model of Frontier Mountain area bedrock allows to understand relationship between rock obstacle and ice flow on surface (blue ice areas in nature) and to reconstruct velocity pattern; l) 3D model of Frontier Mountain area obtained from radar survey.

The presence at the Museum of scientists directly involved within research activities in Antarctica allows both students and educators to receive updated and exhaustive information concerning some of the currently more crucial and fascinating scientific arguments, as the global warming scenarios, the origin of the Solar System, and the geological evolution of our planet.

Among the other, climate change seminars and laboratories are currently highly requested due to the present-day global warming concern. In this scenario, Polar Regions are important for their contemporary significance in the context of global environmental change, and Antarctic sedimentary core researches (Fig. 2f, g, h) are a fundamental key both to unravel the Earth's past climate (which has changed continually throughout geological time because of natural causes) and to understand what might happen in the future due to the human interaction.

CONCLUSIONS

The wonder and appeal surrounding the Antarctic continent is well known. Long time before the age of Great Navigation, the presence of a *Terra Australis Incognita* in the southern hemisphere was already supposed by Aristotle in the fourth century B.C., and since then the myth of Antarctica has grown in the collective imagination. Being the last Earth's region to be explored only 100 years ago, Antarctica is the last frontier which experienced the human presence and it is still the most unknown continent for the general public, and sometimes for students as well.

During the last decade, consistently with other foreign countries provided with an Antarctic Research Programme (i.e., United States, United Kingdom, Germany, etc.), the Earth science section of the *Museo Nazionale dell'Antartide* has been devoting to introduce Antarctica and the Antarctic research activities

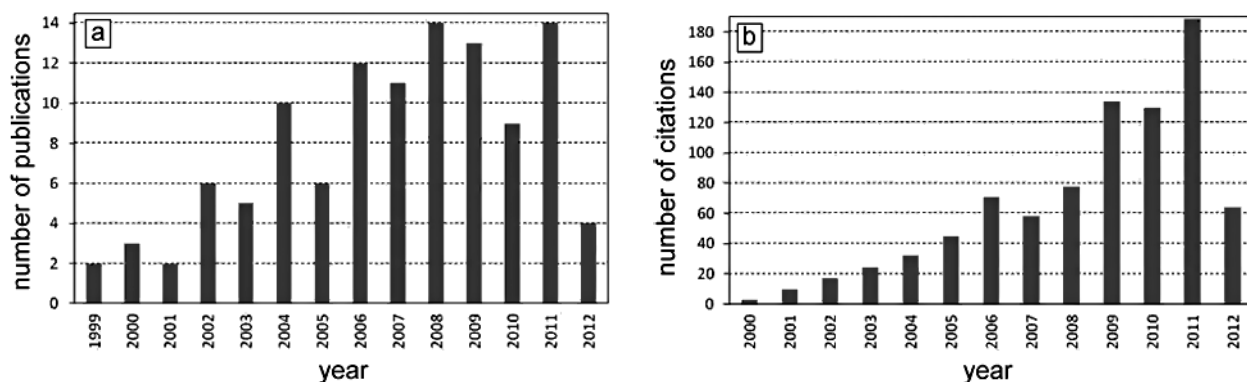


Fig. 3 - Research quality parameters of the Earth science section of the *Museo Nazionale dell'Antartide*: a) number of publications *per* year; b) number of citations *per* year (data from Web of Knowledge; note that only impact-factor ranked journals are used as source).

promoted by our nation to as wide an audience as possible, with a special care dedicated to all-level students, from the youngest schoolchild upwards. One of the primary goals has been to fill the scientific gap concerning Antarctica, and to make not only this continent but also scientific researches and scientists closer to the general public. With the achieved increasing

importance of Polar Regions in the context of our planet (i.e., as resources, key roles in the changing climate), the Museum has today the exceptional responsibility to promote the polar knowledge and to improve the understanding of how the preservation of Arctic and Antarctic areas is fundamental for the Earth's future.

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