Glaciers, a resource

A water resource

Glaciers in dry temperate regions supply a source of water which is very important for the economy of local rural communities. The most systematic use of glacier water is to irrigate fields while the use for drinking purposes is often limited by the great amount of solid particles carried by water as these often have a greyish colour and a milky look. In the high Karakorum valleys, which are real high-altitude deserts, where rainfall varies from 200 to 80 nm per year, agriculture depends exclusively from melting of glacier water. To use this water are built canal systems that can be even several kilometres long: often the canals are built on unstable glacial deposits that need constant maintenance and continuous fixing to adapt them to glacier front variations. Also in the Alps, in Val d'Aosta or in the Rhone Valley, in the past existed a network of irrigation canals, called "bisse" or "ru", that employed glacier melting water.
In Polar regions, instead, populations in the far North, such as Inuits, for a long time have used icebergs as a drinking water source. As these are constituted by ice from glaciers, coming hence from the transformation of snow, icebergs are made mostly of fresh water. Even in these days are periodically presented projects to exploit these precious resources, for example towing icebergs close to the coasts of countries characterised by drinking water shortages, although the costs of these operations for the time being are still higher than the benefits.

An energy source

Hydroelectric energy production represents an important revenue for mountainous regions in many countries, including Italy. Melting glacier water guarantees a supply of great amounts of water even during summer and a great number of tanks and hydroelectric plants are supplied directly from glacier streams. Many examples can be on the Italian Alps, in northern mountainous regions such as Piedmont, Valle d'Aosta, Trentino-Alto Adige and Lombardy. On some glaciers, water is collected directly from inside the glaciers. Among the most famous, we can mention the Engabreen, in Norway, where in the water collection tunnels is installed an important glacial laboratory that allows to make observations on the inside of the glacier. Even on the Argentière Glacier, which descends on the French side of the Mount Blanc, in the Sixties were dug tunnels in the ice to harness melting glacier water but due to unforeseen variations in the direction of subglacial streams, the project didn't have the expected success and the galleries have now been closed and converted into an underground laboratory for the study of basal erosion.

Water inside the glacier

The study of glacial cave systems is very important also from an hydrogeological point of view as it allows to understand how water contained in the glacier functions and works when it constitutes a **glacial aquifer**.
Glaciar aquifers work in a very similar way to Karstic aquifers and are thus studied with the same methods. First of all there's an attempt to walk through most of accessible caves drafting a topographic survey in order to understand how the network of conduits stretches and which are the directions of the water flow. With regards to the parts which cannot be explored by humans as they are too flooded or too narrow to be walked through are studied in detail the flow rate data of glacier discharges that constitute the source of glacial cave systems. In particular, it's important to observe the balance between flow rates coming out of the system and flow rates entering (in this case, melting water or possible rainfall) and how "springs" answer to external supply. Also tracement operations of water are undertaken to support this type of research, inserting in the caves a set amount of specific tracing substances (in general fluorescent dyes) in corresponsance to sinkholes and observing how these return from springs. From the time employed by tracing substances to get out and from the level of their dilution, can be estimated the volume of water stocked inside the glacier and for how long water filtering inside the glacier remains there: in other words, can be estimated how water works and the volume of hydric reserves. This is of great importance as in many areas of the world glaciers offer **a copious source of water** both for agricultural use and, in many dry regions (such as the Karakorum for example) as well as in many Alp glaciers, for hydroeletrical purposes. Understanding the amount of water stocked in glaciers and in which ways it is

moved out of glaciers is crucially important to plan collecting operations and preventing possible risks. The presence of great quantities of stocked water in a medium that moves and continuously changes shape, infact, can represent a great danger: the breakage of the walls and gateways that sustain those that are to all effects real lakes inside glaciers can cause sudden leakage of great amounts of water provoking the so-called glacial ruptures, one of the most destructive and tremendous phenomenona faced by glaciers.