

According with the International Permafrost Association, Permafrost is defined as "soil (soil or rocks with ice inclusions and possible organic matter) remaining at a temperature lower than 0°C over at last two years". Permafrost is one of the main components of the cryosphere (the solid part of the hydrosphere) together with sea ice, snow and the glacier covering part of the Earth surface.

The presence of permafrost in a certain area is also linked, in addition to the average annual temperature, to the insulation of the mountainsides, the distribution, duration and depth of the snowy layer and the characteristics of the subsoil.

In general, three different types of permafrost distribution can be distinguished: continual, discontinuous and sporadic, depending on precipitation and the average temperature in the area. Permafrost is present on our planet in two distinct and often overlapping geographical areas: at high latitudes (polar permafrost) (Fig. 1) and at high altitudes at medium and low latitudes (alpine or mountain permafrost). In the mountainous zones, e.g. in the Italian mountain ranges, permafrost is mainly discontinuous or sporadic.

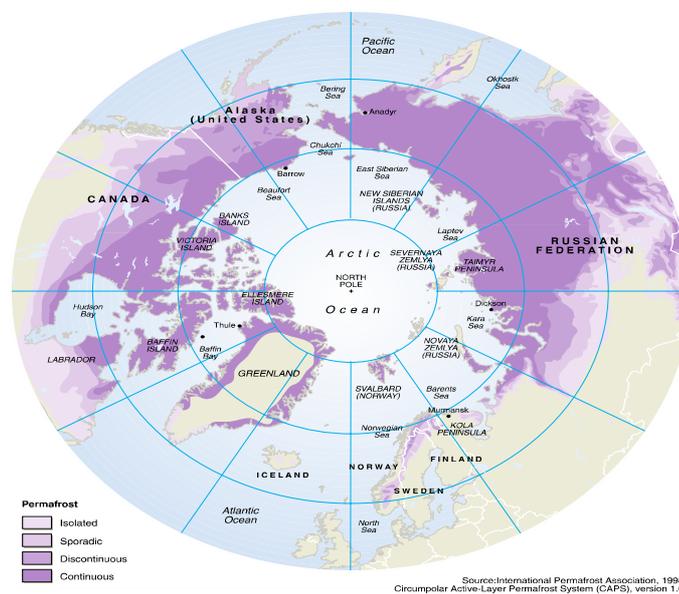


Fig. 1

The outermost layer of an area containing permafrost is subjected to cycles of annual melting and freezing and for this reason is defined as "active layer" (Fig. 2). Underneath this layer, the temperature is always below 0°C and therefore the soil is permanently frozen. Going deeper, the annual variations in temperature cancel each other out, and the maximum and minimum temperature profiles tend to connect one to the other; in other words, temperature becomes constant throughout the entire seasonal cycle. The point where the annual variation in temperature is less than 0.1°C is defined as the "Depth of Zero Annual Amplitude" (ZAA). The depth of this point can vary between 10 and 20 metres, according to the climate conditions and soil. Underneath the ZAA, the temperature of the soil gradually increases as depth increases, due to the geothermic heat originating from below. The point where the temperature of the soil reaches 0°C again is defined as the base of permafrost; this point therefore separates the perpetually frozen soil from the unfrozen soil and indicates the lower limit of permafrost.

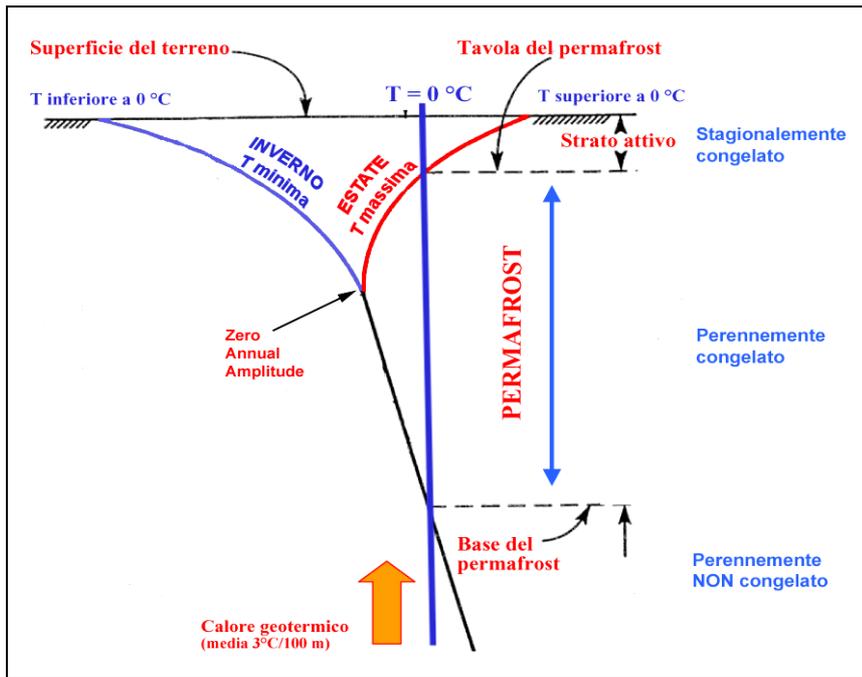


Fig. 2.

In high latitude areas, such as parts of Siberia and Alaska, permafrost can have thickness ranging from a few decimetres to more than 1500 metres. In Alpine areas, the distribution of permafrost is discontinuous and sporadic, and the maximum thickness can exceed 100 metres. In these areas, permafrost is relatively common at altitudes above 2000-2300 metres, but can reach lower altitudes according to the exposure of the mountainsides and to other local conditions.

Often, especially at our latitudes, permafrost is difficult to identify, however its presence is almost always indicated by clear morphological evidence that characterises the periglacial environment at high latitudes and altitudes. For example, taking into consideration the alpine environment, a valid permafrost indicator is the presence of rock glaciers which are created following the deformation of continually frozen debris deposits (Fig. 3).



Fig. 3. Rock glacier (Photos by Seppi)

At polar latitudes, the landscapes characterised by the presence of permafrost have different surface forms among which, for example, polygonal soils (Fig. 4), tundra vegetation or, more specifically, surface ponds (Fig. 5) or pingo (Fig. 6).

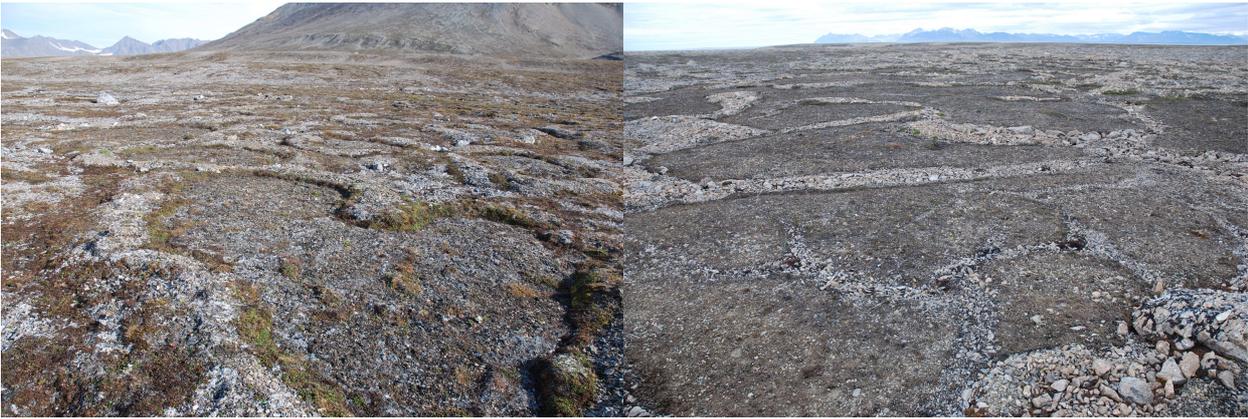


Fig. 4.



Fig. 5.



Similar to the other components of Earth cryosphere, even permafrost is subjected to significant changes due to global warming; the consequences are felt at different temporal scales. At an annual scale, the an increase in average temperatures can provoke an increase in the thickness of the active layer and the melting of the outermost layers and ice lenses. At a

decade and century level, disturbances in the permafrost deep thermal profile occur. At a century and millennium level, the total thickness of permafrost can reduce until complete disappearance. Obviously this causes many problems for the anthropic structures present on permanently frozen soil, which can be heavily effected by these variations. In particular, they can have different types of problems:

- lifting of the soil surfaces linked to the freezing of the active layer, with the consequent lifting, deformation and instability of structures (rotation, shifting, tilting etc.) that cannot return to the initial positions;
- subsistence linked to the melting of ice in the soil;
- landslides, mainly collapses or debris flows, due to the disappearance of the ice binding actions in the outermost layers of the soil.



*Thawing permafrost can render railroad tracks useless, as seen in this photo from the northern Tibetan Plateau taken in the early 1960s. Credit: Tingjun Zhang*



