Chapter 16
Impacts in Extreme Environments

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Abstract The Earth's particularly arid (hyperarid) or humid, cold or hot regions are most commonly classified as extreme physical environments. Because of their limited capacity for human settlement, anthropogenic impacts here are minimal. Being especially susceptible to external impacts, however, human presence often results in significant local alterations of landforms. In boreal areas mines operate, water reservoirs, pipelines, roads and railway lines are constructed. In extremely arid environments most human-induced geomorphological phenomena are associated with transportation, water supply, mining, military facilities and sacral activities. The arid highlands of the Himalayas, the Pamir and the Andes are populated locally even at elevations of 4000–5000 m above sea-level, and the challenging conditions created examples of extreme adaptation to and partial transformation of the physical environment. In cool high mountains traditionally terraced slopes accommodating both settlements of small extension and barley fields are established. Road cuts and rock paths represent anthropogenic landforms. Interventions of the Modern age (such as high-mountain mines, sports centres, high-mountain roads, meteorological and astronomical observatories), however, resulted in surface transformations of a new kind.

Keywords Cold environments · Antarctica · Arid environments · High mountains

16.1 Introduction

The Earth's particularly arid or humid, cold or hot regions are most commonly classified as extreme physical environments. Especially extreme cold and aridity, by which relatively large surfaces are affected, represent a great challenge to human adaptation. Due to the great differences from what is considered to be average

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or customary, such regions can be regarded as extreme terrestrial environments. Anomalies become more apparent when such extremities are combined – as cold and aridity in the most extreme and special cases (in high mountains and polar regions).

These spectacular extreme regions offer a limited capacity for human settlement, thus anthropogenic impacts here are minimal. With such extreme environments being especially susceptible to external impacts, human presence often results in significant topographic alterations of local scale. Human-induced geomorphic processes occur sporadically in isolated patches but can be of decisive nature.

16.2 Cold Environments

The *extremely cold areas* of the world are sparsely populated and today only a low number of population inhabits some of their regional centres. Most of the Inuits in the northern parts of North America live in winter settlements; the extreme residential environment in Siberia consists of small towns and village centres; whereas on Antarctica, human presence is restricted to container stations. Population density outside such centres and its impact on the environment therefore is rather low: human-like columns (inukshuks) of the Inuits set on stone heaps support the driving of caribou herds and hunting (as animals tend to recognise such figures as humans); Inuits and the samanist indigenous people of Siberia erected *stone mounds* at their sacred places, although the hunting–fishing and the semi-nomadic grazing life-styles do not cause any changes worth mentioning in the landforms. It is a principle on Antarctica that researchers carrying out fieldwork should not leave any traces in the area (also meaning that it is prohibited to set an open fire, or that temporary toilets and their content must be transported).

Despite this, boreal areas do not lack significant anthropogenic environmental impacts as such northern cold regions experience the operation of mines (e.g. on Svalbard); for the construction of water reservoirs, pipelines, roads and railway lines – similar to the building of homes – serious obstacles have to be surmounted. Among these the most relevant is the adaptation to the permafrost bedrock (Pinneker 1990). Soils of the *permafrost* regions thaw at summer only to a depth of some decimetres or metres; this active layer however becomes oversaturated, inaccessible and impractical. Such regions are accessible mostly in wintertime when *construction* is only possible with the soil section reframed warmed in situ. The local climate of settlements can impact the frozen bedrock causing its degradation. This can fundamentally alter geomorphic processes and water balance in periglacial areas, as a rather significant amount of water is originated here from the temporal permafrost thaw (Plate 16.1).

In cold regions *settlement* has the most remarkable topographic impact on the environment. Rather picturesque examples of this can be seen on Antarctica. Human presence only dates back to 50–60 years, there are no settlements in the conventional sense, and dwellings are represented by bases situated, in some cases, several

Plate 16.1 Storage basin between dykes near the buildings of the Arctowski Station on Antarctica (Nagy 2003)

100 km from each other, mainly on deglaciated surfaces. Life, for the some tens of people usually residing there, without any external help is unfeasible. Apart from oxygen, nearly everything has to be transported there – for many stations, even drinking water – whereas garbage should be taken away. The establishment of these bases has permanent geomorphological consequences from a number of points of view (Donachie 1993).

16.2.1 Station Construction

Station construction requires *landscaping*. Most bases are built along the coast, on bars or on wave-cut platforms. The building of storm-resistant containers, petrol tanks, warehouses on frozen ground is also associated with landscaping. As transportation-related expenses are extremely high, any waste generated by construction activities is frequently built in the bedrock.

16.2.2 Transportation

Polar environments are altered by transportation in most spectacular ways. Although ports are no longer constructed, there are three airports, established by the full levelling and compaction of moraine sediments in a zone of 1–2 km width, in Antarctica. Compared to the pristine Polar landscapes, the most visible features around stations are *wheel tracks* and *footprints*. In this extremely susceptible environment, vegetation grows rather slowly; thus its regeneration is also surprisingly slow. Footprints can remain on the mossy bedrock for years whereas caterpillar tracks remain visible for at least 30–40 years (Fiar and Nagy 2004). Wheeled and tracked vehicles are in widespread use at nearly all stations, and the tracks encompass coastal areas like abiding lines. This is due to the extremely *intensive mechanical weathering* on deglaciated surfaces; due to wind gusts, lag-sheet formation takes place within a period of few years and, even, intensive coastal chemical weathering can also cause crusting. On the rocky tundra, basically a ‘desert pavement’ is formed that can easily collapse under vehicles leaving traces on the surface as marked elements – even if it was passed by one vehicle once only. It is easy to imagine the degree of pressure by *tourism* concentrated on Antarctica, if a station capable to accommodate only a few persons can receive as many as 300 tourists (only for a duration of 1–2 hours) (Donachie 1993).

16.2.3 Water Supply

The water supply of stations is a rather difficult task. Meltwater has large amounts of suspended load (mainly silt), and thus requires deposition before it can be used. Moreover, its discharge is highly variable. Occasionally, supply is provided by ponds formed in the depressions of ground moraine, whereas most commonly by meltwater streams. Water running towards coastal areas is collected in *deep reservoirs* embanked by ramparts and, in many cases, underfoiled. Such lake basins can be 100 m in diameter and their considerable depths facilitate water supply during the winter. Of the rubble extracted, water-diverting dams or ramparts are constructed.

16.3 Arid Environments

In extremely arid environments, the population is concentrated mainly at oases. Most human-induced geomorphological phenomena are associated with transportation, water supply, mining, military facilities and sacral activities.

16.3.1 Transportation and Dwelling

In extremely arid regions, e.g. in the Atacama Desert of Chile, main roads follow abandoned river beds. These *wadis*, in some cases, are dry for decades, and even a concrete *road* of high quality could be constructed along the bed. Rainfall events are rather rare; the surface is predominated by the intact, distinctive landforms of previous water regimes. The desert sometimes receives waterflow, especially at intensive periods of El Niño when creeks from the Andes reach Atacama and sweep away roads.

Paved roads can, however, divert temporary branched watercourses arriving from the surrounding mountains to desert basins. Consequently, in the extremely arid basins of Iran, saline lake basins can remain without water, whereas diverted watercourses threat human settlements with flooding. In such arid basins, most of the old buildings are constructed of clay. Salt-cemented clay is an especially excellent building material. *Clay buildings* of the Incas are still seen in the Atacama Desert, and no continuous warfare and earthquakes could cause serious damage to the medieval clay fortresses Iran either. There is only one enemy they have to face: water (though early attackers were not familiar with the water cannon), and diverted watercourses easily undercut walls excellently adapted to the physical conditions.

Wheeltracks are among the most particular anthropogenic features of the microtopography of deserts. In the troughs left by tracks passing through desert pavements and lag surfaces, crusting and deflation will start again and tracks are preserved a few centimetres deeper.

16.3.2 Water Drainage

Along the edge of Altiplano near La Paz, Bolivia, infrequent rainfalls formed extremely dissected *badlands* surfaces. As there is a fast increase in the urban population, even this gullied area is cultivated. The diversion of water from abrupt, intensive downpours seemed to be an appropriate solution to start landscaping; the watercourses diverted, however, caused the saturation of sediment to a degree that vast rotational landslides have been induced – in areas already populated.

16.3.3 Water Supply

The water supply of arid regions encircling deserts is a basic precondition of human settlement and farming. Even some hyperarid deserts unsuitable for habitation offer opportunities for water supply. The water to be utilised is in most cases not of local origin, and through draining the vital water, characteristic man-made landforms developed even further away from settlements. An old and exquisite way of water conveyance is the construction of *underground channels*. Such canal systems carrying the spring water, poor rainwater and spring meltwater of mountain ranges along the desert margins to inland regions were built from North Africa to the Middle East since ancient times. Such conducting systems, called *qanats* in Iran and *kareezes* in the Sahara, carry water originating in the mountains and straight infiltrating into debris slopes and arid debris fans (in other words, water quickly disappearing from the surface) on hillsides and foothills. In Iran the qanat system totals several ten thousands of kilometres.

For qanats *tunnels* with a gentle slope running 5–20 m deep are dug and this involves large-scale earth removal. To dig and maintain the underground water collection and drain passages, vertical pits have to be prepared, and tunnels connect the *pits* horizontally (Cholnoky, no date; Probáld 2002). The tunnels slightly slope from the mountain ranges towards the interior of the basins, while the system is ventilated through vertical shafts, from a distance seen as a series of large mole-hills (Plate 16.2). The pits generate draught, and, therefore, the water flowing underground remains cool. The earth-piles around the pitheads are gradually elevated as all deposits extracted during the cleaning of tunnels are pulled up and piled there.

Plate 16.2 Kareez pitheads in the Moroccan section of the Sahara (Nagy 1998)

Due to the significant loss by evaporation, water storage in the arid regions may require the construction of *underground reservoirs*. Around the first ancient facilities of this kind towns were erected – using the stones extracted during reservoir construction. Under the settlement of Rasafa of Roman age in the Syrian Desert, vast cisterns of three to four storeys are found, whereas of the stones extracted, a settlement with several thousands of inhabitants was built in the middle of the desert.

16.3.4 Quarrying

Wherever large amounts of *non-ferrous metals*, *building stones* (e.g. in Egypt) or *salt deposits* are found in the desert, in spite of the extreme environment, quarrying begins. As salt, in certain regions, is a valuable and fundamental raw material, food and forage stuff, it is still extracted manually and then transported by camel caravans at the hottest part of the world, i.e. in the Danakil Desert of Ethiopia. Due to unbearable heat, however, long-term extraction on a commercial scale has failed (Middleton 2004).

16.3.5 Warfare

Warfare constructions, fortresses in arid environments were adapted to the topographic and climatic endowments. Since there was no possibility to dig moats, they were strengthened most commonly by the rebuilding and fortifying the top and edge of desert mesas, thus by the building of 'citadels' (*ksars*) or fortified villages on plateaux (in Morocco and Israel). Effective defence could be also achieved by the construction of trenches, often in summit position. The oasis of Palmyra and caravan roads in the Syrian Desert are also controlled by *fortresses*, significant in size, built on a hilltop. Around the fortress with a wall height of 15 m, a *moat* of the same depth was carved into limestone (the fortress itself was built of the limestone extracted from the moat), consequently the fortress looks like if it was erected on a rock elevated in the middle of a large crater. Due to its position at the top, nothing is seen of the moat from underneath; the pinnacle of the separate hill covered by moving debris is almost impregnable (Plate 16.3).

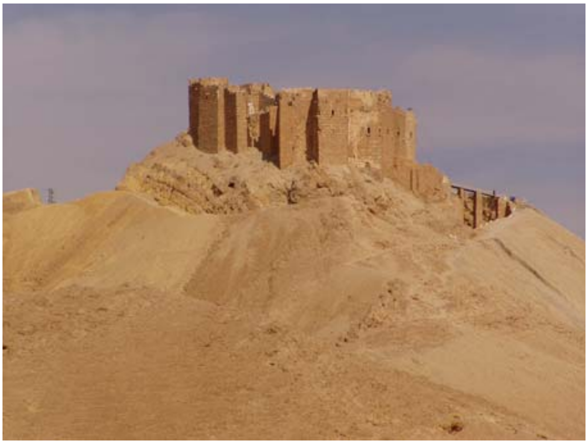

Plate 16.3 The main defence system of the fortress of Palmyra along the Silk Road, is a deep round ditch on hilltop (Nagy 2006)

16.3.6 Sacral Activities

Certain points of the arid regions are *sacral sites* of a specific significance, and exhibit human-made landforms. Vast formations drawn by rock-piles, surface ripples or just rocks turned upside down are found on the bare slopes of the Atacama

Desert (desert rocks are different in colour in their lower sides without weathering crust, desert varnish, than on their polished side exposed to direct solar radiation). These *geoglyphs* of debated origin are – in addition to the roads running across deserts – the most characteristic anthropogenic landforms of arid regions.

With no other solution available, the followers of the Persian Zoroastrian faith – respecting the basic natural elements, i.e. earth, water, fire and air – sacrifice their dead placing them in the *Towers of Silence*, exposed to birds of prey. These large, round-shaped towers, in the arid Central Basin of Iran stand on the top of separate clusters of cliffs, hills or mounds in the vicinity of settlements. *Hilltops* are, as a result, entirely built-up by artificially supported natural walls, the towers 'reach up the sky', creating the typical elevations of desert basins.

In extremely arid environments, *permanent springs* are of great significance; a spring cave in the middle of the Central Basin of Iran being one of the most important site of pilgrimage and sanctuary of Zoroastrians. In the hollows in the hillside of the limestone range, water leaks all the time (referred to by their local name being Chak-chak, i.e. 'drop-drop'), and the karstic cavern of the sacred spring is partly *incased*, and functions as a place of worship today. With terraces carved into cliffs in its surroundings, groups of buildings provide dwellings for hundreds of people.

The worship of fire also led followers to the arid and cool summits of *volcanoes*. On the hardly climbable, debris-mantled peak of the Erciyas Volcano in Central Anatolia (3916 m), large artificial hollows can be seen in the side of the tower-like dacite pinnacles: *sanctuaries* were suitable to accommodate a number of people were carved by Zoroastrians on the severe summit (Plate 16.4).

Plate 16.4 Cave hollows carved by Zoroastrians at the 3916 m high peak of the Erciyas Volcano in Turkey (Nagy 2000)

16.4 Cold and Arid Regions

Simultaneously cold and arid regions are probably the most extreme habitats on the Earth. Mainly the plateaux of mountains and isolated valleys are classified as such (as well as some inhabited areas on Antarctica,e.g. the Dry Valleys, which have not received rain for 2 million years). The arid highlands of the Himalayas, the Pamir and the Andes are populated locally even at elevations of 4000–5000 m above sea-level, and the challenging conditions created examples of extreme adaptation to the physical environment as well as its partial transformation (Plate 16.5).

Plate 16.5 The extensive monastery group of Phuktal built in a spring-cave hollow in the Himalayas of India (Nagy 2005)

16.4.1 Dwelling

Barley is grown at a height of 4000 m in the northern arid regions of the Himalayas. This is only possible by having the *slopes terraced* and collecting topsoil gathered from larger areas. Pathways and caravan roads also run on artificial terraces and benches carved into bedrock. The most particular habitable and altered sections are the dwellings of Buddhist monk communities. The Phuktal monastery group was built in a hollow of a vast *spring cave* of a vertical cliff, the craggy valley side of one of the River Indus tributaries. This bird's-nest-like monastery constructed by broadening the miniature rock terraces, elevating piled rock-walls and the widening of foothold rock benches was, for a long time, the home of the scholar of Tibet, Alexander Csoma de Kőrös. The only caravan road of the valley also crosses this cluster of buildings through tunnels and narrow passages. The surrounding slopes, hardly accessible for humans, were terraced over the centuries, and rock paths lead along the cliffs.

16.4.2 Transportation

Road construction, however, advances slowly even in the remotest Himalayan regions. In the wake of border conflicts between India and Pakistan, military roads started to be constructed. In many cases, an annual progress of no more than 5 km is made, as roads must be carved into the walls of gorges or built on debris slopes. Completed road sections then demand permanent maintenance as unstable slopes, also jointed by explosions, constantly rip, and at times of rare rainfall events, the road is covered by thin *debris and mudflows*. (The traditional transport roads of these regions are rivers frozen in winter used by caravans or even children going to public schools.)

The so-called Pamir Road passes the Pamir Region, the marginal region of strategic importance of the Russian Empire or the former Soviet Union. This route, also accessible by motor vehicles, reaches a height above 4000 m, traverses arid and cold mountain deserts, gorges and outwash plains. Across the latter, the road passes on bulldozed gravel embankments – as effective dams against high-energy braided rivers of meltwater flow. The road opened the inland arid plateaux of the mountains (called 'pamirs') for trucks that, starting from the bank level of 4000 m, often use the arid beds of saline mountain lakes with oscillating water level. Therefore, the collapsed desert pavement formed in the vast desiccated lake bed sections preserves the *deep-cut wheel tracks* until the following flooding (i.e. for decades or centuries). There are no permanent roads in the mountain deserts of diurnal freeze–thaw alterations; patterns of wheel tracks preserved in the desert pavement are the most remarkable linear landforms of the plateaux.

To the railway line crossing the Qinghai-Tibet Plateau to Lhasa, one of the greatest challenges was the permanently frozen bedrock. In the environs of the *highest railway line of the world*, a so-called *warm permafrost* is found, i.e. soil temperature is only 1-2°C below freezing point. Railway constructions built on frozen bedrock can dislocate even following a slight warming. Therefore, frozen conditions had to be maintained here by applying a successful Chinese technology, in use since the 1980s (Brown 1984), fine-grained, insulation rock debris was spread beneath the rails, that, as a protective layer can significantly delay (or impede) the warming of subsurface layers (Permafrost warming... 2004).

16.4.3 Mining (Sulphur, Rock Salt, Ores)

On the Highlands of Bolivia (Altiplano), i.e. the cold and arid central highlands of the Andes, at similar elevations, vast salt deserts (*salars*), saline lakes and mountain hamadas are found between giant volcanoes. Open-pit *sulphur* mining takes place at extremely sparsely populated regions above 5000 m above sea level; test-drillings developed artificial geysers; on the salars, intensive *salt* mining is practiced. Locally, salt is traditionally simply scraped off from the surface and piled in heaps, but more usually ripped by axes, saline water is gathered in hollows and artificial basins.

The spatial extent of human intervention is very restricted on the salars of several thousands of square kilometres. Characteristic polygonal salt formations, however, are obliterated by the swelling and shrinking of the wetted and dried salt mass; some powdered salt can be blown away by the wind as well.

The margins of the Altiplano do not lack remarkable impacts of human intervention. The town of Potosí at 4100 m elevation with a population exceeding 150,000 inhabitants is dependent on the Cerro Rico (Mountain of Richness) rising above the town. This volcanic ruin is extremely abundant in *non-ferrous and precious ores*, still exploited – except for the use of dynamite – by long outdated technologies (Barron 2000). Despite this, typical mountain mass landforms surrounded by waste tips, with terraced slopes, dissected by mining are developed also at this elevation.

16.4.4 Science

Along the edge of Lake Titicaca plateau, extensive plug domes rise. Columnar and sheet-like lava crusts outcrop on heights dissected by erosion. The remains of the incurving lava layer of hyperfine structure run along the slopes and on the hilltops like several metres-high ridges, with narrow corridors between them. The region's Indian civilisations, Aymaras and Kechuas, claim this region to be the birthplace of their folk and culture. The crust structure of the plug domes, with minor alterations made, was used as a basic element of their calendar (Plate 16.6). Looking through the narrow corridors between the vertical lava combes only a small section of the sky can be seen. Passages are covered by horizontally laid *flagstone*s placed on *benches* carved into the combes, constraining these corridors more and letting the Sun only shine through the passages at certain time periods; moreover, the location and movements of celestial bodies were also traceable in this pipe-like 'crosshairs'.

16.5 High Mountains

Cool high mountains with diverse topography are, without any doubt, the most extreme sites for human settlement. There has to be an explanation for the presence of humans in such environments: this can be financial, a cause of power or politics as well as research interests. Certain ethnic groups, e.g. in Tibet, in the Himalayas or in the Andes could well adapt to the high-mountain living conditions and extended their dwellings to a height of 4500 m. At this level, traditionally terraced slopes accommodating settlements of small extension and barley fields are established (in the Himalayas), as well as road cuts allowing the passage of mule and yak caravans and rock paths represent human-made landforms. Interventions of the Modern age resulted in surface transformations of a new kind. High-mountain *mines* were opened (even above 5000 m elevation in Bolivia), *sports centres* were established (the world's highest ski-resort for all-year use can be found at an elevation of

Plate 16.6 Astronomical observation device formed of plug-dome crusts at Lake Titicaca (Nagy 2004)

5600 m above sea-level in Cordillera Real of Bolivia), high-mountain *roads* were constructed (crossing a pass at 5800 m in the Himalayas in India). Border conflicts and *military actions* do not avoid high mountains either: at the border regions of India, Pakistan and China, or Chile–Argentina and Bolivia bases, military roads and airports were built. Locations of the Himalayas above 6000 m, in glacial environments were also the sites for combats; Argentina and Chile maintain military bases on the ice-sheet of the Patagonian Icefield.

16.5.1 Transportation

High-mountain road construction faces challenges mainly due to *rockfalls*, *avalanches* and *frost action*. In such an environment, perfect tracks can never be found; thus these roads have to be effectively shielded from mass movement processes. In any other case the road becomes unsuitable for use. The construction of *avalanche retaining walls*, paved roads is rather expensive; thus, according to, e.g. French plans, Transfăgărăşan Road of Romania built in the 1970s can only be used in the summer and autumn months. Moreover, its section crossing a *tunnel* under the main ridge is so drenched during wintertime, hard and enduring water–ice mass is formed in it (Nagy 2008).

Road constructions can make hillside slopes unstable leading to accidents, e.g. in the late 1980s in Northern Italy where a serpentine road passing in one of the valleys of Disgrazia Hill – at its most switchbacked section – caved in with the hillside during a rockfall (Plate 16.7). A number of vehicles got stuck in the upper dead end of the valley. The vehicles remained there for years, until a new road was constructed and they could be used by anyone who carried fuel to fill their tanks.

Plate 16.7 High-mountain roads are often cut into cliff walls as in this valley of Western Tibet at 4000 m elevation (Nagy 2001)

An inundation following a downpour in the restored valley floor destroyed the broad road of marl crossing the cleaned bottom of the High Lapushnik in the Retezat Mountains of Romania. Cars marooned were taken into pieces and carried down in rucksacks, except for the bodyworks. Evidences of destructive floodings, explicitly anthropogenic in origin, are also known in mountain valleys. Although dams are now not built in the Carpathians (remains of an old dam was also destroyed by the above-mentioned flooding in the Retezat Mountains), artificially inundating steep valley sections was a frequently used method of *timber rafting*. Valleys were impounded by wooden dams, fallen trees were pulled to the valley floor and piled partly in the impounded lake, partly along the lower sections; then by opening the floodgates, timber floated down to the foothills. This method was obviously associated with extremely intensive erosion, abrasion, and valley floor degradation.

16.5.2 (*Opencast*) *Mining*

Although not being an extreme environment, the vast sulphur mine in the Kelemen (Calimani) Mountains is the largest opencast mine in the area. Exploitation began at the top of the Eastern Carpathians at 1900 m elevation. In the Calimani Negoi a 20-levelled mine, 400 m deep with a diameter exceeding 1 km has been formed (Plate 16.8). A near U-turn took place in the 1970s, in addition to what a major amount of waste material was piled in a height of 1500–1700 m. Waste material covers some of the main ridge and impounds valleys (Romania... 2004).

Plate 16.8 A sulphur mine hollow 400 m in depth in the caldera of the Kelemen Mountains (Nagy 2006)

16.5.3 *Sport* (*Ski Tourism*)

High mountains are the sites of mountain sport activities becoming more and more popular. The soil mechanical, surface degradation and mass movement consequences by the construction and maintenance of *ski tracks* are well known by the examples from the Alpine countries (the use of snow cannons and snow compaction by caterpillars cause *soil compaction*, and the reduced water drainage can be the cause for lateral landslides), in addition to what snowboarding off ski tracks is a typical human trigger of avalanches. Mountain shelters, helicopter platforms require *landscaping*, whereas tourists are mainly responsible for treading, which can be surprisingly severe in particularly susceptible areas visited by a large number of tourists. Debris slopes 3 km in length at the northern ice-free side of the Aconcagua, the highest summit of South America (6962 m), are ideal ski tracks: hundreds of people tread there day by day in January and February, moving a significant amount of rock, also slowly moving upward on the extremely tread serpentine road. The camps, sometimes comprising hundreds of tents on the moraine surface of the base, alter the high-mountain environment with their windbreak rock-walls (Plate 16.9).

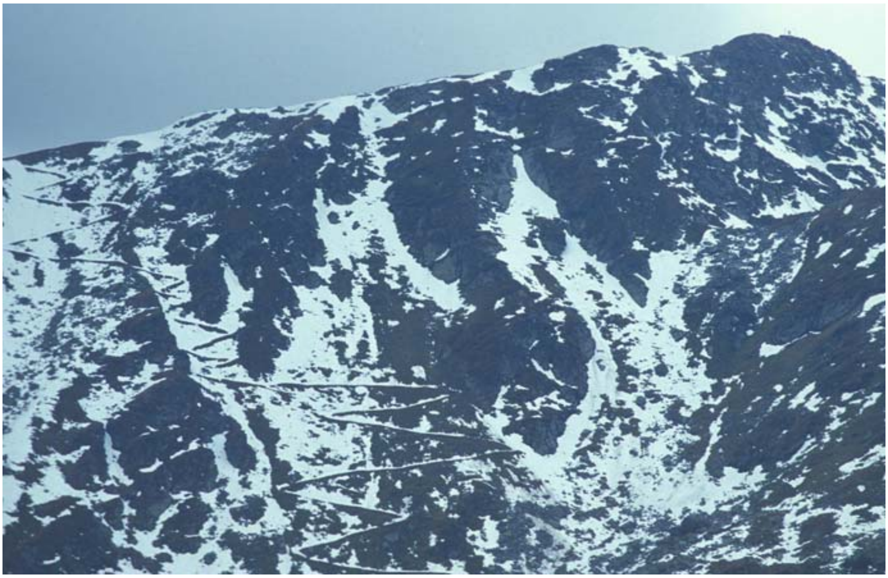

Plate 16.9 Tourist path in an avalanche channel in the Rodnei Mountains (Nagy 2002)

16.5.4 Science (Astronomy, Meteorology)

High mountains are also the sites of scientific research. Meteorological and astronomical *observatories* (sometimes both) can be characteristic objects in extreme environments. Their construction and operation are usually associated with the transformation of the top region. In many cases, there is a cableway leading to the summit; helicopter platforms are built; the top-level is terraced or levelled. Often, the process of construction itself has the greatest impact of transformation on the landscape (by, e.g. access road construction). In other cases, the evolution of the environment is changed by the houses built.

In the case of the Carpathians, a range of examples can be seen. The observatory at the High Tatras' Lomnitz Peak is a station with typical transformation of summit also supplied by a cable way. The station at the highest peak of the Bucegi Plateau (Omul Peak) stands on a broad summit, can only be accessed on foot and is surrounded by remains of buildings and high piles of construction rubble. The meteorological station in the Rarau Mountains of the Eastern Carpathians is built near a wet spring bog, modifying runoff and water flow direction. On one of the peaks of the Cerna Hora in the Maramureş Mountains, i.e. on Pop Ivan, a four-storey high giant observatory was erected. On the summit, only accessible on foot, the observatory was built by Poland prior to World War II. Pieces of the giant copper dome weighting tonnes were carried up by horses. It could not be put into operation when the war broke out, and became a well-defendable military post, later left to decay. It is surrounded by trenches and machine-gun nests deepened into the ridges.

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