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CHAPTER 14
Reclamation of Areas Affected by Open-cast Mining in the North Bohemian Brown Coal Basin, Czechoslovakia

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14.1 CHARACTERISTICS OF THE AREA

The North Bohemian basin is a significant fault enclosed to the north by the southern slopes of the mountains, to the south-east by the Czech Central Mountain Range, to the east by the river Elbe, and to the west by the strato-volcanic Doupovské hills. It is only open in the south-western direction, into the Žatec plateau. The valley character is given mainly by the significant elevation between the valley basin and the mountainous part of the Krušné Hory massif (250–900 m above sea level), whose northern slopes have a mild gradient while the eastern slopes which run towards the basin are very steep.

The dynamics of the basin relief are mild and correspond to its sedimentary origins in the Tertiary period, during which the major part of the basin was formed. The Quarternary formation of the terrain is only manifest at the foothills of the Krušné Hory Mountains (by sediments of dejection cones and slope debris) and in the south-western part of the basin where powerful layers of eolic sediments have been formed. From the geomorphological point of view, the destructive activity of the hydrographic system has only been manifest very mildly.

The area of outcrops of the coal seams is about 680 km^2, the orographic area covers about 1000 km^2, and the productive area of the basin covers 1000–1200 km^2.

14.1.1 Geological Characteristics

The geological development and formation of the basin started in the Lower Oligocene by subsidence of Saxonian tectonics on to the Neocene platform of the Czech Massif. The voluminous sedimentary area of the basin was formed especially in the Miocene by bulging out of the Krušné Hory massif, the formation of the Czech Central Mountains and the Coupovské Mountains, with the concurrent subsidence of the bottom of the basin which began filling with sediments. Following the period of sedimentation during the Miocene, a tectonic disintegration took place in the whole area, which was in turn followed by denudation.

As for the stratigraphy of rocks in the basin, there are crystalline rocks, calcareous, Tertiary rocks, i.e. of the basal series, the detrital vulcanite series, the sub-grade series of strata of sands and loam, the series of strata of brown coal seams, the series of strata of overburden rocks, with a prevalence of Miocene loams and Quarternary rocks.

Crystalline rocks in the basin mainly comprise gneisses which, in contact with the sediments of the basin, are strongly kaolinitic. The oldest developmental stage of the sedimentation is the chalk stage of the Mesozoic era, represented by sandstone, conglomerates, quartzites, argilites and marls.

The basal series of Tertiary sediments was formed in the Upper Eocene and Lower Oligocene. It is mostly formed of conglomerates, sandstones and argilites. The vulcanic detrital series was mostly formed in the upper Oligocene during increased volcanic and denudation activity. This was followed by the sedimentation of sandstone and argilite sediments, forming the direct sub-grade of the coal seam.

The most favourable conditions for the growth of vegetation existed in the period of the Upper Burdigal, Helvetium and Lower Torton eras. This was the period of formation of the series of strata of brown coal seams. The cleavage of the seams, especially in the western part of the basin, is the result of delta-shaped flows into the basin and denudation in the area of the Krušné Hory Mountain massif during the discontinuation of sedimentation of the organic substrate. The intermediate strata of coal seams are formed by clay, sandy clay and sand.

The Miocene sedimentation formed a powerful overburden in which clays and argilites are prevalent. Locally the series of strata which forms the overburden is interrupted by semi-siderite parts in the direction to the Žatec face and in the boundary areas, namely in the Duchcov–Bílina part of the basin where there are thick layers of sand and sandy clays.

Quarternary rocks cover almost the entire Tertiary fill of the basin. They are formed by substrates which differ widely in structure: ranging from clayey weathered tuffs to weathered eluvial rocks to boulders deposited at the Krušné Hory foothills, to stone seas and sandy gravels formed mainly by muscovite biotic orthogneiss.

14.1.2 Climatic Conditions

The climatic conditions of the area are characterized by low precipitation, and a relatively high atmospheric temperature.

The highest average total annual precipitation is reached in the northern part of the basin (670 mm); in the central part of the basin the average drops to 517 mm and in the south-western part to 470 mm. The average annual temperatures are extremely high in the last-mentioned area and reach an average of 8.4–8.8°C (Kadaň 8.09°C, Most 9.0°C, Ústí nad Labem 0.0°C). The average temperatures during the vegetation period reach 13–14°C. Atmospheric moisture is 72% (long-term average). The direction of the wind conforms to the relief, and therefore the wind mostly blows along the southern slopes of the Krušné Hory Mountains. In the whole basin the prevalent winds are those of the western quadrant, i.e. in Chomutov 305°, Litvínov 288°, Bílina 260°, Teplice 268°, in Ústí nad Labem 255°.

The climate of the basin is significantly influenced by the orographic situation in relation to the neighbouring orographic units, mainly the vertical topography of the terrain. With this is connected the considerable attenuation of flow, the frequent formation of a very stable boundary layer with poor conditions for dispersion, and the frequent occurrence of solar radiation. The annual number of foggy days is extremely high: in Chomutov 70, Teplice 87, Bílina 108, Litvínov 126, Ústí nad Labem 141.

The frequent occurrence of inversion prevents the dispersion of emissions from the industrial area. The relatively stable layer of cool air in this situation preserves the major part of industrial aerosols in the basin area.

14.1.3 Hydrological Conditions and Water Management

The hydrographic system of the basin is influenced by the fact that water from the whole area is diverted by the river Bílina, and partly by the river Ohře. Streams flow from the Krušné Hory Mountains and their upstream beds are sharply cut into the terrain. Water reservoirs mostly have the character and function of water-retention basins (accumulating industrial waters); pond systems are practically non-existent.

In the tenth century the Komořany Lake existed here and was the biggest basin lake in the country. It was described by the Arabian merchant Ibrahim Ibn Jakub. The Komořany lake covered an area of 60–70 km^2 and reached a depth of 40 m. It was fed by the waters of the Bílina river and several smaller tributaries and mountain streams. Archaeological surveys have shown that human settlements existed on the banks of this lake 6000 years ago and continued to exist throughout the Slavonic period. The Komořany lake was continually silted and its area and depth decreased. The last remnant of the lake, having an area of 165 ha, was drained and dried by the owners of the estate of Jezeří in 1835.

The hydrological conditions are characterized by the low efficiency of crystalline slates, permo-carboniferous localities, with the exception of the Teplice quartz porphyrite which is the bearer of the thermal and mineral waters in the Teplice area, of the Tertiary sub-grade and overburden clays and argilites, and of the Quarternary physically heavy loess and slope clays. Hydrogeologically effective rocks include calcareous sandstone: of the Tertiary, Oligocene sandstones, overburden sandstones, porcelainites and, mainly, the brown coal seam; of the Quarternary, the powerful strata of slope debris and dejection cones at the foothills of the Krušné Hory Mountains.

The groundwaters in the basin are considerably mineralized. The waters of the sub-grade strata series are mostly of the $MgNa–HCO_3$ or $Na–HCO_3$ types, their mineralization in the range 300–1400 mg/l. The waters of the coal seam strata are mainly of the $CaMg–SO_4HCO_3$ type, their mineralization in the range 900–1400 mg/l. In the Quarternary of the overburden the water is mainly of the $CaMg–SO_4HCO_3$ type, with a mineralization of approximately 1500 mg/l. The streams in the mountainous parts of the Krušné Hory have an average mineralization of 95–140 mg/l.

A very serious hydrological problem of the area is to secure the operation of the fourteen curative springs of the Teplice and Šanov line. With the development of mining their abundance has declined and seven springs have ceased to exist. In 1818 the Šanov springs had an abundance of 1262 m^3. The current unfavourable situation is being successfully resolved by the deep withdrawal of Tertiary waters, which secures not only a greater abundance and quality of the thermal springs but also the exploitation of coal in the vicinity of Teplice.

Water management in the basin is ruled by the necessity to economize the use of water for ecological, health, economic, cultural and aesthetic reasons. For water to fulfil all the required functions, it has to be available in adequate quantities and of appropriate quality. The need for potable and utility water in the basin is increasing significantly. The natural resources are very limited and there is an increasing trend to use surface waters instead of groundwaters. The surface waters are, however, highly polluted: in 1975 the river Bílina, for example, was polluted along its entire length by ammonia, heavy loadings of BOD, COD phenols and other toxic substances. The biggest polluters are the ČSSP Chemical Works in Litvínov, the towns of Litvínov, Most, Duchcov, Bílina, Teplice and Ůstí nad Labem, and the Spolek works in Ůstí nad Labem.

A supply of drinking water is increasingly being secured by the building of dams in the Krušné Hory Mountains, and utility water by the diversion of the Ohře and Elbe rivers to the Bílina catchment. However, these supplies of water are negatively affected by the considerable pollution of flows owing to the increasing level of emissions. The water is depleted by the occurrence of substances which in abnormal concentrations have unpleasant, harmful and toxic effects. In that part of the Krušné Hory Mountains where forests have been damaged by emissions, deforestation has altered the water management function of the forests; this is manifest in waterlogging, the increase of surface runoff and the reduction of precipitation infiltrated into the soil surface, the intensification of erosion processes and erosion phenomena, and an increase in the fluctuation of flow rates in water-courses.

The natural conditions in the North Bohemian brown coal basin are significantly affected by mining activities. In the preparation of the area for mining the routes of water flows are diverted and the surfaces exposed for mining are drained by wells. Annually, 30–40 million cubic metres of water are drained in the basin, and this significantly influences the groundwater regime.

14.1.4 Soil Conditions

The soil conditions in the basin are influenced not only by soil formation factors but also by anthropogenic factors: i.e. negatively by mining activity and positively by reclamation.

The texture of the soil is characterized by almost equal quantities of heavy and medium soils, with some light soils (ratio: 40:40:20). Prevalent are deep soils (75%), with 20% of soils of medium depth and 5% of shallow soils.

The dynamic development of soils in the basin is shown by the prevalence of climatogenic soils, mainly brown soils, chernozem, and rendzina. Meadow soils, allenral soils, mildly podzolized, riparian, meadow gleyic, woodland meadows, illimerized, pseudo-gleyic soils, gleisoil and peat soils are complementary.

In the area, reclamation is gradually taking place of all soils devastated by mining. This should return the soil to agriculture and forestry. Forest reclamation is carried out almost entirely by direct planting into dump substrates, which are thus influenced by soil formation factors and by reclamation culture. In this study we are almost entirely concerned with undeveloped waste-dump forest soils.

In agricultural reclamation there are two alternatives: with made-up ground (top humus profiles) or without made-up ground. In the former case the quality of the newly made-up soil is related to the quality and thickness of the humus, the character of the surface earths of the made-up ground, and the intensity of a biotechnical reclamation. The made-up ground usually has a thickness of 0.5 m, which after compaction forms a 0.4 m humus horizon. If the sub-topsoil layers of the made-up layer are excessively permeable, there results an excessive seepage of fine-grained parts, nutrients and water. In the North Bohemian brown coal basin, however, there is a prevalence on spoil banks and waste dumps of overburden loams, with a very low hydraulic conductivity; the situation therefore more often arises where the made-up layer is oversaturated with water. The pedogenetic development of these waste dump soils in such cases results in gleisation.

When a waste dump is reclaimed without the use of humus cover, by using land improvement seeding processes, the pedogenetic development of the new agricultural land is mainly affected by the nature of the waste dump earths, climatic factors and the nature of the reclamation. This type of reclamation mainly concerns clayey substrates, especially loess, loess clay and slope debris. In cases where there is an adequate calcium content conditions are good for the formation on these waste dumps of soils similar to soils formed in this region on soil-forming substrates, i.e. brown soils, brown earths and chernozem.

14.1.5. Phytogeographical Conditions and Pollution

The phytogeographical conditions of the basin are also mainly of a climatogenic nature. Reconstructed natural vegetation expresses the basic ecological potential of the landscape. The major part of the basin is thus covered by sub-xerophilous oak-hornbeam forests. On the more moist and heavy soils of the basin, formed on Tertiary loams, conglomerates and heavy slope clays, there are the hydric associations of the beech and alder woods, and on the wet alluvial stands there are the willow and poplar woods. At the Krušné Hory foothills there are acid oak woods, which in the northern direction are replaced by beech groves.

Man's activity has, however, changed the whole area: first, agricultural colonization formed a cultural steppe, and with the development of mining man turned the region into a restricted floristic area characterized by reduced forms of vegetation.

Currently the whole area is characterized by a low rate of afforestation (only 4% of the area is covered with forests); but this proportion is being increased by reclamation.

Prevalent is the agricultural use of the soil. Sugar-beet farms cover approximately 70% of the total agricultural area. The most frequent sub-types are beet–wheat farms on heavy soils; in the Duchcov area the beet–barley farms; and in small localities in the western part of the basin the beet–rye farms. The rest of the basin is mainly given over to potato or potato and rye farms (restricted to a narrow strip at the foot of the Krušné Hory mountains) and the potato and wheat farms which are located at the foot of the Czech Central Mountain range and the Doupovské Mountains. Pastures are only found in small localities on the boundary of the basin.

As a result of the development of industry, mainly in connection with the significant increase in power production by thermal power plants which burn considerable amounts of coal with a high sulphur and ash content, emission levels have considerably increased throughout the North Bohemain brown coal basin, including the adjacent landscape areas. The harmful effects are felt by all the physical and organic components of the landscape.

From the ecological point of view there is not only the significant *direct* impact of harmful emissions on plants, but also their *indirect* impact through the soil. The emissions enter the soil by direct fallout, by precipitation, by direct sorption through the soil surface, and by way of wastes of intoxicated organs, mainly of leaves of affected plants. The direct effect of separation by vegetation, which depends on the intensity of sorption, the accumulation capacity of plants and on the amount of produced organic mass, is small to counter the impact of the said emissions. As a result the concentration of emissions throughout the basin areas is increasing in the whole soil profile. This mainly concerns sulphur compounds which appear in the form of free sulphuric acid or sulphurous acid. In some parts of the area the pH of precipitation drops to 3.5 (in some cases even less). Free acid causes the washing out of a number of substances from the soil profile, including the plant nutrients calcium, magnesium, potassium and iron. Without human interference this is an irreversible long-term process: the changes have an cumulative character and act for a long time after the emissions have ceased. There is a negative impact on agricultural cultures whose vital functions are disturbed; the intensity of phytosynthetic assimilation is reduced and yields decline.

The regional agricultural station in Ůstí nad Labem reported in 1975 that agricultural yields had significantly decreased as a result of the increased emission levels: wheat by 9–11%, oats by 12–14%, barley by 14–18%, silage maize by 25–38%, sugar-beet by 10–15%, perennial fodder by 17–32%, annual fodder by 12–14%.

14.2 BROWN COAL MINING IN THE BASIN

In 1860, 500 000 t of coal was mined in the basin, and by the time of the outbreak of the First World War production reached 18.6 million tonnes. This level was not reached again in the period between the two world wars, but the German war-needs stimulated development, which in 1943 reached 20.2 million tonnes. An upsurge of production was, however, only recorded in the post-war years, as shown in Table 14.1. Current exploitation shows a continuously rising trend, accompanied by an increasing volume of stripping of overburden rocks which has been significant especially in the second half of this century. The ratio of stripping to coal production is expected to reach 4.5 by the year 2000, owing to the increasing depths of coal seams.

The brown coal basin was originally divided into a large number of mining units by past entrepreneurial interests. There were 1639 deep mines and 186 open-cast mines. The basic aim of the private entrepreneurs was to minimize investments and to maximize profits and yields, and this was reflected in

Table 14.1 Production and stripping data

Year	Production ($\times 10^6$ t)	Stripping of overburden ($\times 10^6$ m^3)	Ratio of stripping to production (m^3/t)
1945	11.1	10.3	0.93
1950	19.8	27.4	1.38
1960	39.6	97.2	2.45
1970	55.0	106.0	1.93
1975	60.7	159.5	2.63
1980	66.7	152.2	2.28
⋮			
2000			4.50 (projected)

uncoordinated mining which disregarded the principles of good mining practice.

The current development of the basin is characterized by the intensive development of quarry exploitation which is concentrated in a small number of mines with a productive and efficient technology. Mining is advancing to greater depths in an area with increasing stripping ratios. This results not only in taking up plots, but also in intensified devastation of the natural and cultural components of the landscape, with significant growth of the volume of overburden stripping and the resulting elevated sandfills and waste dumps. It is significant for the concept of reclamation that spoil banks are established in a more or less exploited area; for complete exploitation of the area they will later be quarried, and so the reclamation of the area is only temporary. The intensive development of quarrying is made possible mainly by technology orientated to more efficient practices.

14.3 IMPACTS OF OPEN-CAST MINING

In 1980, 92% of the coal mining in the North Bohemia brown coal mining concern was of the open-cast type. This is very evident in the area (Figure 14.1). We shall therefore devote our attention solely to the impacts of such mining on the natural components of the area.

Open-cast mining technologies influence mainly the powerful profile of the *lithosphere* by transformation of the rock medium and the change in relief. They also have an impact on and contaminate the micro- and meso-climatic factors of the *atmosphere*, deform the character and regime of the *hydrosphere*, devastate and destroy the whole *pedosphere*, contaminate or liquidate the phytocenoses, zoocenoses and microcenoses, thereby significantly

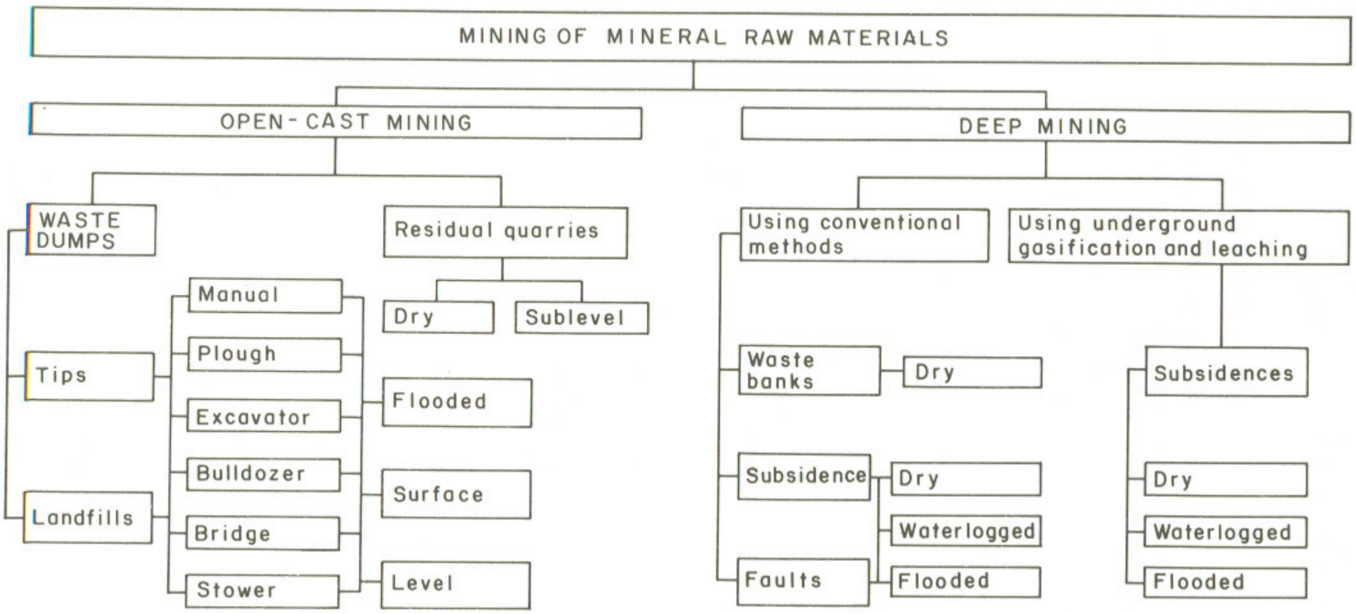


Figure 14.1 Basic forms of impacts of mining on the landscape

influencing the structure and function of the biosphere, and thus participate in the extreme transformations of ecosystems.

14.3.1 Impacts on the Lithosphere

Montane activity is still a significant exogenous geological factor; it usually creates a more explicit topography of the relief by the formation of quarries and elevated waste dumps. It is subsequently manifested by genetical and morphological processes, with significant transformations of the petrography and stratigraphy of the rock medium (Figure 14.2).

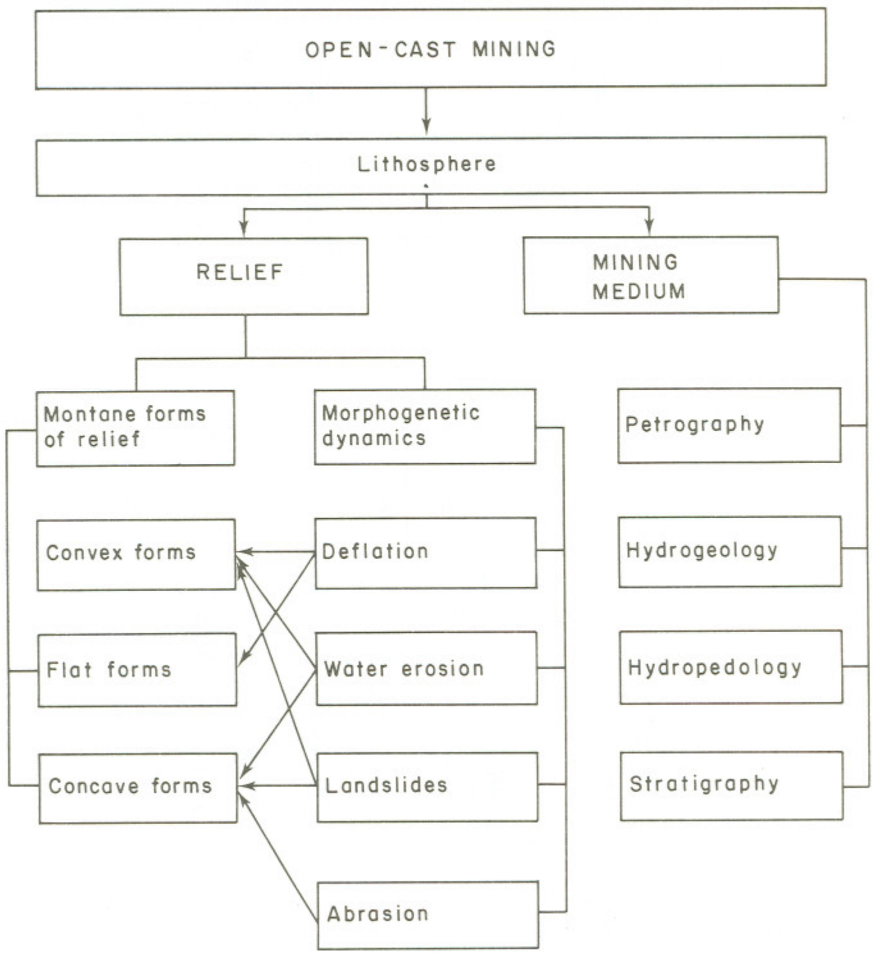


Figure 14.2 Structure of impacts of open-cast mining on the lithosphere

The convex forms of the relief are mainly due to spoil banks and waste dumps. Flat forms are due to landfills (filled or sluiced) and residual quarries. A concave relief is formed by underground landfills.

Morphogenetic processes result in the convex forms being modelled by deflation, water erosion and landslides. Flat reliefs are modelled mainly by deflation, and concave forms are transformed by landslides, mainly the solifluxion of the boundary slopes of residual quarries and by the abrasion of the banks of quarry lakes.

Open-cast mining models the relief in height, exposure and incline. Waste dumps and tips have the form of terraces, cones, plateaux, ridges and hybrid forms. In the process of overburden stripping, transport and stowing, a significant destruction occurs of the initial rock medium, as do significant petrographic, stratigraphic hydrogeological and hydropedological transformations. During the overburden stripping the devastated area is affected by mechanical, chemical, physico-chemical and mineralogical changes in the structure or rocks, which gives the area an atypical and highly specific petrographic character. The stratigraphy of the waste dump area also has a significantly anthropogenic character and does not correspond to any type of geological development. As a result of these processes the area assumes a specific *hydrogeological and hydropedological character*, with specific hydrogeological and hydropedological conditions.

The relief and the rock medium are significant ecological components of the natural environment and as such have great significance in the optimization of the reclamation of the landscape. They must therefore be considered *during* exploitation, and during the period of reclamation.

14.3.2 Impacts on the Atmosphere

Open-cast mining causes significant changes in classical climatic factors and has an impact on the quality of the air (Figure 14.3). Micro-climatic and meso-climatic changes are mainly caused by transformations of the relief, altitude, topography, its exposure and incline, colour, moisture conditions and vegetation cover. In some localities this is accompanied by thermal emissions from exothermal reactions arising during mine fires and gob fires.

The most significant changes take place in all basic micro-climatic factors in the area of the mines and quarries and in the area of barren waste dumps with no vegetation cover. The surface of these areas is exposed to more intensive solar radiation. Ecologically significant is the considerable overheating of the ground layers of the atmosphere on slopes exposed to the south, especially in areas with dark substrates and excessive albedo values; here there is increased evaporation and reduced moisture content of the ground layers of the atmosphere.

The concave parts of the relief are susceptible to inversion situations,

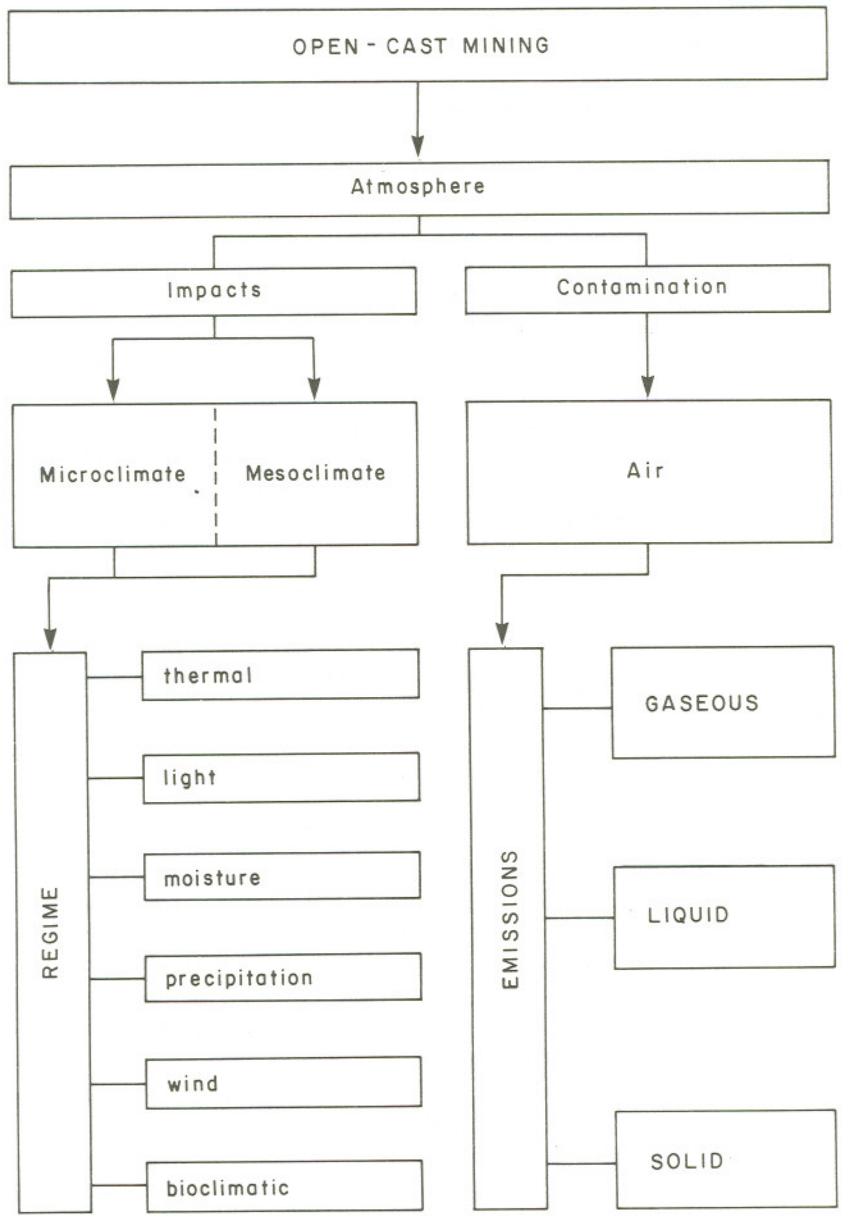


Figure 14.3 Structure of impacts of open-cast mining on the atmosphere

characterized by a relatively stable temperature stratification which is manifested by more frequent ground frosts and, in areas with a contaminated atmosphere, by considerable disturbances in the bioclimate.

The technological processes of mining usually cause contamination of the atmosphere by emissions resulting from mine fires and gob fires in quarries and waste dumps, during the liquidation of waste dumps for further mining, during coal crushing and the crushing of bituminous rocks during mining, and during blasting and transportation. Harmful gaseous substances—namely the products of the burning of the coal substance and combustion processes taking place in combustion engines—have more intensive effects than *dust* generated by the mining operation and by deflation occurring on barren waste dumps and quarries.

Brown coal basins of Tertiary origin, by virtue of their position in relation to the adjacent orographic entities, have a natural tendency to create inversion states. This situation is made worse by increasing in the depth of open-cast mines, whose slopes are made as steep as possible with the intention of minimizing overburden stripping. From this ensues the danger of a considerable concentration of biotic emissions in the area of the mine.

14.3.3 Impacts on the Hydrosphere

In the system of the natural components of the landscape in the North Bohemia brown coal basin the hydrosphere has an infrastructural character and penetrates the whole ecosphere. For practical reasons in this study we shall restrict ourselves to the groundwaters and to the surface parts of the hydrographic system.

The open-cast mining of mineral raw materials has an impact on the quantity and quality of water—usually by disturbing the regime, and by contamination. These changes may be negative and/or positive (Figure 14.4).

Open-cast mining may have the following *negative* impacts on the water regime:

(1) The mine functions as a drainage system; it uncovers the aquifers, reduces the ground water table and desiccates the whole area.
(2) There is artificial drainage of areas designed for mining, through restriction of surface inflow and the acceleration of outflow by hydrotechnical means (e.g. by deep drainage), where a system of hydrodynamic barriers is realized by a system of hydrogeological wells, mainly in those parts of the basin where, in the sub-grade, coal deposit or overburden, there are hydrogeologically efficient rocks with an artesian water regime.
(3) There may be liquidation or diversion of existing water-courses and water reservoirs. The hydrogeological effect of such action mainly consists in the reduction of infiltration owing to the impermeable lining of the beds.

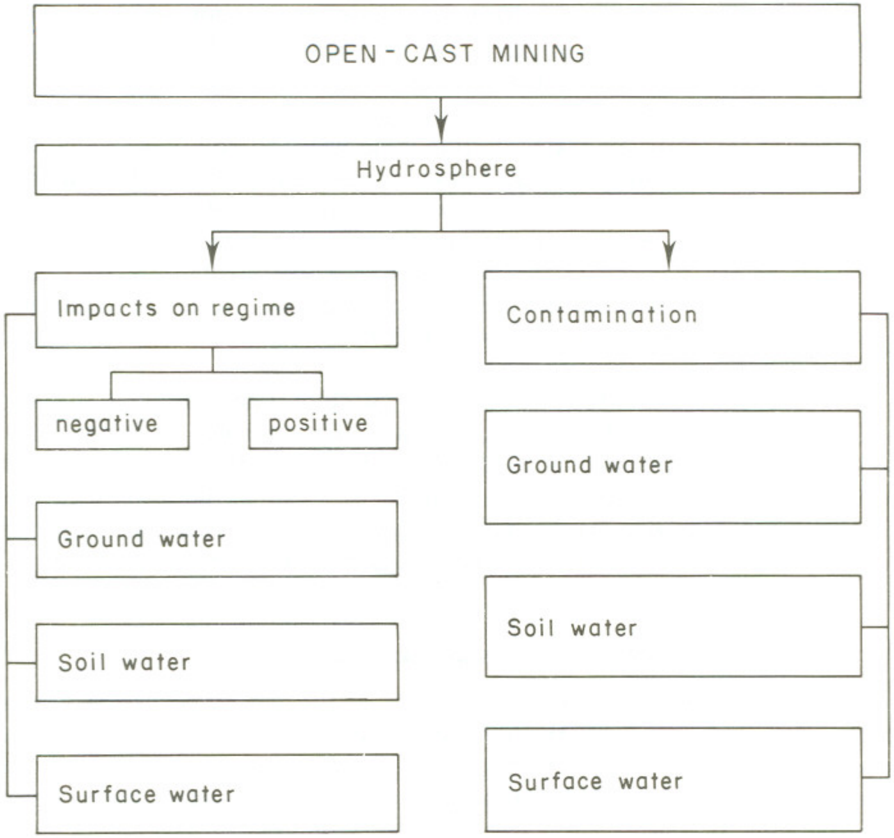


Figure 14.4 Structure of impacts of open-cast mining on the hydrosphere

(4) There may be changes in the rock medium. Significant deformations of the water regime occur in cases where the surface of the waste dumps is formed by rocks with extreme mechanical and physical properties.
(5) There may be changes in runoff conditions owing to the new relief of the exploited area.
(6) Unsuitable diversion of mine waters may cause uncontrolled waterlogging of adjacent plots.
(7) There may be an excessive rise of the groundwater table owing to uncontrolled accumulation of water in residual quarries, which is reflected in undesirable impacts on the environment (e.g. the expulsion of groundwater from the sub-grade of waste dumps).

Open-cast mining in some cases has *positive* impacts on the water regime:

(1) It increases the accumulation capacity of the exploited area (inundated residual quarries, other water reservoirs).

(2) It increases the flow rate in water-courses by the discharge of mine waters.
(3) Mine waters may be used as utility or potable water.
(4) There may be a rise of deeply sunk groundwater tables with previously low ecological effectiveness.
(5) There may be a lowering of excessively high groundwater tables, which is beneficial for agricultural and forest ecosystems.
(6) The formation of recreational water spaces may, in association with vegetation, be suitable for leisure-time activities.

From the point of view of *contamination*, the mine waters of open-cast brown coal mines in North Bohemia are usually characterized by low pH values, the most frequent cause being iron sulphides, mainly pyrite. Also contributory to the reduction of pH values is trivalent iron. The reactions are:

$$\begin{aligned} FeS_2 + 2H_2O + 5O_2 &\longrightarrow FeSO_4 + 2H_2SO_4 \\ 4FeSO_4 + O_2 + 2H_2SO_4 &\longrightarrow 2Fe_2(SO_4)_3 + 2H_2O \\ Fe_2(SO_4)_3 + 6H_2O &\longrightarrow 2Fe(OH)_3 + 3H_2SO_4 \\ FeSO_2 + 14Fe^3 + 8H_2O &\longrightarrow 15Fe^2 + 2SO_4^2 + 16H^+ \end{aligned}$$

The excessive occurrence of iron sulphides has the same negative effect on the water of the pedosphere of certain waste dumps, which in turn contributes to the long-term biotoxicity of all components of the waste dump soil-formation substrate (phytotoxic earths).

The mine waters also have a high level of hardness. Groundwater in the area of the coal seam is influenced by the oxidation of sulphides and the ensuing sulphate mineralization. In the North Bohemia brown coal basin the prevalent chemical types are CaNa—SO_4HCO_3, CaMg—SO_4.NaCa—SO_4, possibly Ca—HCO_3SO_4 or CaMg—HCO_3.

There is, too, a high content of metal ions. The released mineral acids, mainly H_2SO_4, act on silicate minerals—of which the ions of Al, Fe, Na, Zn, Cu, Pb and other metals may be released into mine waters.

Finally, the mine waters have a high concentration of dissolved substances and suspensions, but extremely low levels of organic substances.

14.3.4 Impacts on the Pedosphere

Open-cast mining will cause degradation or destruction of the soil as the basic ecological factor, the basic means of agricultural and forestry production, and as the space for recreation and for building (Figure 14.5).

Degradation of the soil is caused by excessive waterlogging or desiccation in the area. Contamination of the pedosphere is usually the result of pollution as well as of the negative impacts of the emission background on the whole mining area, where emissions are caused not only by the mines themselves but

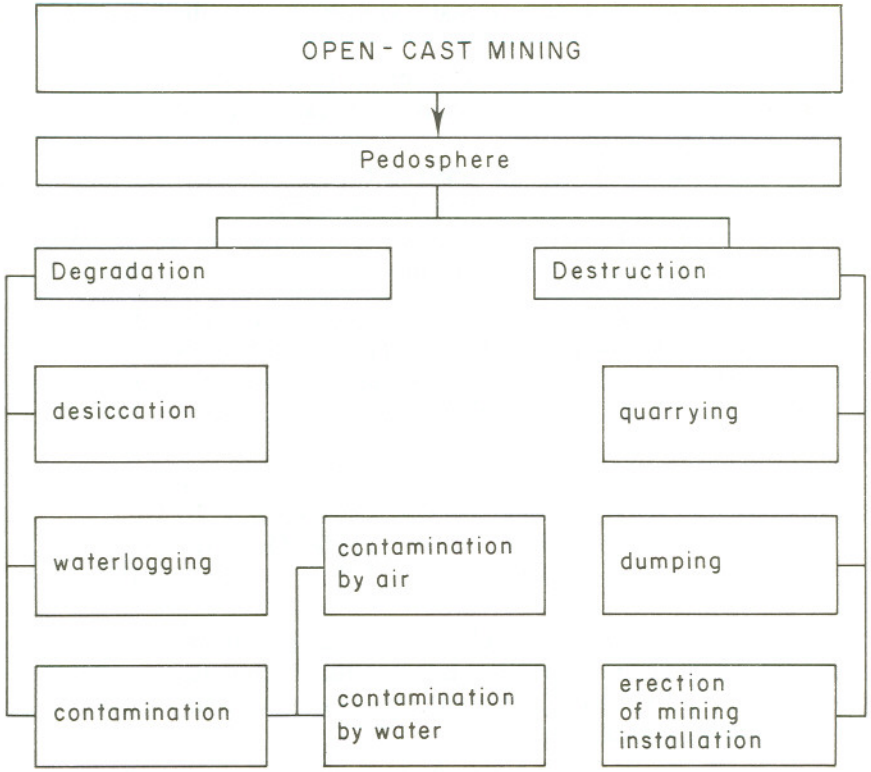


Figure 14.5 Structure of impacts of open-cast mining on the pedosphere

also by other sources (mainly by thermal power plants and other industrial furnaces).

Destruction of the pedosphere eventually occurs inevitably in the whole area of the mine, and gradually in the whole mining space, including waste dumps and areas used for the deployment of mining equipment. Selective stripping of the topsoil (humus profile), which is the most valuable component of the soil, and especially its use for reclamation, may minimize the lasting damage.

14.3.5 Impacts on the Biosphere

Open-cast mining affects the organic components of nature *indirectly* by the degradation and destruction of the environment of organisms, of the ecotope which is formed by the rock medium, relief, atmosphere, hydrosphere,

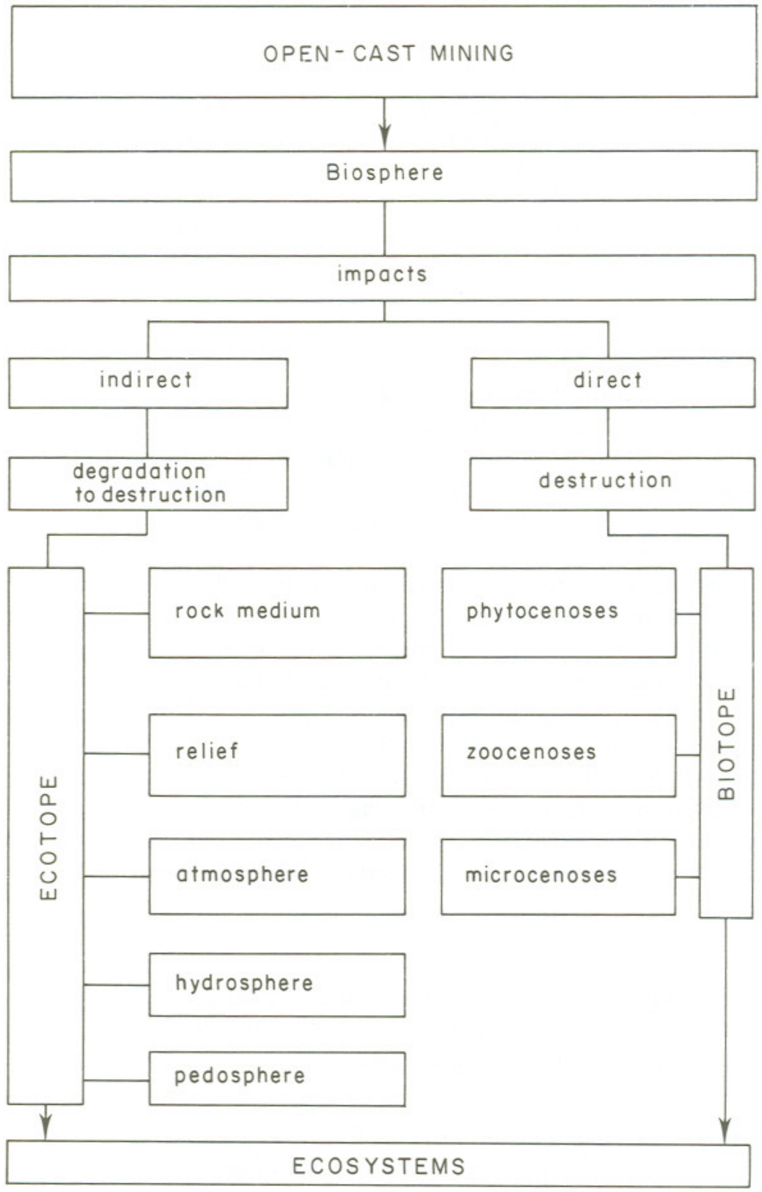


Figure 14.6 Structure of impacts of open-cast mining on the biosphere

Table 14.2 How the mining concern used the available land in 1980

Land use	Area (ha)
Productive mining	15 582
Under reclamation	3 454
Not under reclamation	1 048
Total	20 084

pedosphere, and *directly* by the destruction of phytocenoses, zoocenoces and microcenoses of the biotope (Figure 14.6).

Direct destruction of the biosphere—namely agricultural and forest cultures and green zones, including microcenoses, concentrated within the pedosphere—occurs throughout the whole mining area and in the area covered with waste dumps.

The combined impacts of direct and indirect deterioration caused by open-cast mining is a profound interference in the entire structure and function of ecosystems. In less intensive cases structural and functional changes take place only inside the ecosystems. Ecological transformations do, however, occur in the entire mining area even outside the respective ecosystems. This in turn affects the natural landscape of the area and the socio-economic sphere of the environment, i.e. the human ecosphere.

Quantification of the impact of mining in the area under consideration is evident from the following data, which show the areas of active mining carried out by units of the North Bohemia brown coal mining concern:

Year	1945	1950	1960	1970	1980
ha	5300	6380	11 600	13 620	15 580

In 1980 the mining concern used the available land in the manner shown in Table 14.2. Of the total area not included in the process, 878.37 ha was reserved for various types of construction.

14.4 RECLAMATION AND REHABILITATION OF AREAS DEVASTATED BY MINING

Legislative theory and practice in the Czechslovak Socialist Republic uses the term 'reclamation' for restoration of the ecological and utility values of areas devastated by the exploitation of mineral raw materials.

To comply with the relevant laws, reclamation of areas devastated by mining in the area under consideration is fully secured by the North Bohemia brown coal mining concern. In practice it is divided into two spheres:

(1) the technical stage of reclamation is realized by the mining activities of the individual mines;
(2) the biotechnical stage of reclamation is secured by a system of special reclamation units.

14.4.1 Technical Stage of Reclamation

This stage covers the measures taken before and during mining with the aim of creating optimal conditions for the later biotechnical stage of reclamation. The measures are therefore purposeful and cover, for example, the location of waste dumps in the landscape, the removal of overburden rocks and the construction of waste banks. The possibilities are influenced by the geological conditions, by the system of exploitation of the mineral raw materials, by the physical and technical parameters of the mining area, and by the planned future use of the area.

14.4.1.1 Concept of Brown Coal Mining

The choice of the most suitable mining system is influenced mainly by the coal deposited in the coal seams, the availability of efficient equipment and technology, the demand for brown coal, the physical and technical state of the mining area, and demands made by the principles of technical reclamation—including requirements for the use of the landscape following the discontinuation of mining.

Evaluating this situation with regard to current and future technical possibilities, we may assume that practically the whole seam is exploitable using open-cast methods. The practical orientation of mining corresponds to this situation. New mines are constructed and old mines reconstructed into technological units which are equipped with rail-track excavators, conveyor belts and stowers.

The current state of the basin is characterized by the large number of operating mines whose planned orientation is only being implemented in the second half of this century. The mining is significantly affected by the extremely complex physical and technical structure of the area—especially the intensity and density of settlements and production units—which makes it necessary to operate in constricted spaces.

Modern principles of technical reclamation were introduced at the design stage of mines opened in the 1960s. In other cases they are being introduced with greater difficulty in mines that have been in operation for a long time.

14.4.1.2 Siting of Waste Dumps in the Landscape

The siting of waste dumps significantly influences not only their reclamation, but also the physical and technical arrangement of the whole area. In the North Bohemia brown coal basin the principle is adopted of using landfills whenever possible, rather than the establishment of waste dumps and tips. The implementation of this principle in practice is influenced by the specific situation of the basin, which ensues from the multitude of operating mines that have not respected the principle. Also, mining to ever-greater depths necessitates increasing the handling area of the mines, increasing the removal of overburden rocks, and building a large number of high tips outside the actual mining area. The situation is further complicated by the construction of the whole exploited area, which has an extraordinarily high density of settlements, a technical infrastructure, and which is also used for intensive industrial production and for agricultural activities. Under these circumstances the principles of waste dump management are observed only with the greatest of difficulty.

For example, in the project design of one of the waste dumps of the V. I. Lenin mine in Komořany, three alternatives were considered: the Všehrdy waste dump, the Havraňská waste dump and enlargement of the Velebudín waste dump. The criteria applied were the following:

(1) the coefficient of use of the area of the waste dump;
(2) the total taking up of agricultural land;
(3) losses in agricultural production in terms of yields and gross value in Czechoslovak crowns per annum;
(4) the extent of topsoil stripping in terms of volume and cost.

Data provided in Table 14.3 show that the most suitable alternative was enlargement of the Velebudice waste dump, and this was done. This dump has an almost square foundation, the smallest ratio of slope yardage deposit, a high utilization of area and the lowest losses in agricultural soil. Compared with the alternative of the Havraňská waste dump, 919 ha of highly fertile agricultural plots will be saved, with an annual yield of 2,400 t of wheat or 29 000 t of sugar-beet.

14.4.1.3 Selective Removal of Overburden Rocks

In cases where the overburden varies in quality (i.e. where it is composed of rocks whose suitability for reclamation purposes differs), the selective removal of rocks is one of the basic preconditions for the reclamation of waste dumps. The length of the reclamation cycle, the intensity of the reclamation process and its final effect mainly depend on the mineralogical and petrographical composition of the overburden rocks which in the process of removal

Table 14.3 Data considered in choosing the site of a waste dump at the V. I. Lenin mine in Komořany

Criteria	Všehrdy	Havraňská	Velebudice
Total area (ha)	1 622	1 988	1 380
Content of dump area ($\times 10^6$ m^3)	912 260	850 790	819 000
Coefficient of usage of dump area (m^3/m^2)	56.2	42.8	59.3
Area of agricultural land covered by dumps (ha)	1 479	1 889	970
Loss of agricultural production:			
wheat (t/year)	3 697	4 723	2 425
sugar-beet (t/year)	44 370	56 670	29 100
Loss of agricultural production (crowns per year)	8 874 000	11 334 000	5 920 000
Topsoil stripping ($\times 10^6$ m^3)	5 179	6 611	3 397
Cost of topsoil stripping ($\times 10^6$ crowns)	119 727	152 824	78 532

have been placed on the surface of the waste dump. The properties of the rocks on the surface of the dump affect not only the course of pedogenetic changes, but also the course of the deformation processes on the dumps, a new hydrogeological and hydropedological regime of dumps and subsequent changes in other ecological factors.

In the North Bohemia brown coal basin the overburden rocks and earths were classified in 1959 with regard to their suitability for reclamation, as part of the first Master Plan for Basin Reclamation. This classification was carried out as part of a complementary evaluation of the results of a geological survey and of complex analyses of samples of rocks taken from all rock formations uncovered at that time at the faces of brown coal quarries.

All overburden rocks were divided into five categories:

1st category: rocks and earths very suitable as soil formation substrates for agricultural reclamation

2nd category: rocks and earths for soil formation substrates for agricultural reclamation

3rd category: rocks and earths suitable for forest reclamation

4th category: rocks and earths suitable for land improvement and for green zones

5th category: rocks and earths not suited to reclamation.

Substrates of the first category in the North Bohemia brown coal basin include top humus profiles with proper or degraded chernozem, loess which has a

5–25% content of $CaCO_3$ and a mild alkaline reaction. They have very favourable physical, chemical and mineralogical properties, and are highly suitable for the formation by reclamation of good agricultural soils.

Overburden rocks included in the second category comprise, in the top humus profiles, brown earths and brown soils, and in the lower layers, loess and slope clays. In the North Bohemia brown coal basin the overwhelming majority of overburden rocks are Miocene loam sediments whose properties are significantly influenced by the proportion of koalinite, illite and montmorillonite. They may be further divided into three groups: loams in the vicinity of coal seams which often contain a considerable amount of coal, grey loams and yellow and brown loams.

In the North Bohemia brown coal basin the third and fourth categories of overburden rocks include grey KMI and IKM loams whose scaled aggregates strongly resist the weathering process, contain a large amount of available nutrients (with the exception of phosphorus and nitrogen), have a neutral reaction, favourable sorption capacity with a high saturation of the sorption complex, and are favourable from the physical point of view. In the aggregate state they are also good for the formation of agricultural soils with gleisation tendency. Much better results on these loams have been achieved by forestry reclamation, during which the scaled aggregates do not disintegrate so quickly.

In areas with a prevalence of kaolinite it is best to plant green zones or forests. Substrates of the third category therefore include MIK, KI and IK loams and gravel sands. Compared with the grey KMI and IKM loams, they show a smaller resistance of flaky aggregates, they are susceptible to peptization, they have a lower sorption capacity and usually a lower content of organic substances. Their reactions are neutral. Their suitability for forest reclamation decreases with the increasing content of kaolinite.

Overburden rocks should be placed on the waste dump in natural stratigraphic sequence, and the surface should be formed of the pedogenetically most valuable earths. In this respect the situation in the North Bohemia brown coal basin is very complicated: there is a very low proportion of Quarternary result of the coherent structure with no aggregation of the loam particles. They also include Tertiary and Quarternary gravels and gravel sands which, at the foothills of the Krušné Hory Mountains, pass into layers of boulders and sandy gravels.

Rocks classified into the fourth and fifth categories for reclamation include sands, clays, loams and sands with a coal admixture, slack coal and oxyhumolites. This is a group characterized by a great differentiation in quality.

Overburden rocks should be placed on the waste dump in natural stratigraphic sequence, and the surface should be formed of the pedogenetically most valuable earths. In this respect the situation in the North Bohemia brown coal basin is very complicated: there is a very low proportion of Quarternary

rocks, which are unevenly distributed, and there are phytotoxically acting Tertiary rocks of the coal seam strata series. Another difficulty is the development of the basin-orientated large-scale mining.

Regardless of these factors the selective stripping and removal of rocks should be orientated to:

(1) the use of all earth from the top humus profiles;
(2) the use of loess, loess clays and slope debris;
(3) preservation of the greatest amount possible of overburden rocks and earth which can be used for land improvement (such as oxyhumolites, montmorillitic loams and peats);
(4) differentiation of the Tertiary overburden loams (of which the grey loams with a higher content of illite and montmorillitite characterized by flakiness usually have better pedogenetic properties than yellow loams and brown loams, which have a high content of kaolinite, are more weathered and have a coherent structure);
(5) preventing the placing on top of the dump of Tertiary rocks of the coal seam strata series when they contain a coal admixture with a high content of iron sulphides, oxyhumolites, possibly sandy rocks with an extremely high content of SiO_2, and minimal mineralogical ability to release plant nutrients.

14.4.1.4 Construction of Waste Dumps

The geographical and climatic conditions of the basin allow for intensive agricultural use of the landscape. In the Czechoslovak Socialist Republic the demands on the supply of food are increasing at a time when the area of agricultural land is constantly decreasing. In the North Bohemia industrial and highly urbanized conurbation, the quality of agricultural land as well as the quality of the environment have greatly deteriorated. The destruction of the water regime is part of this deterioration. The complex negative impacts of industrial activities on the landscape in the basin are the main cause of the degradation of this area as the natural base for settlement and for recreation.

In the open landscape the prevalent role will be taken by agricultural reclamation, in the area surrounding settlements recreation will be given priority, and in the area of industrial centres priority will be given to clearance and rehabilitation. To these trends must be subordinated any views on the anthropogeomorphological formation of the exploited parts of the landscape, and on the basic geometry of the waste dumps. However, the basic aim of the technical stage of reclamation of dumps is the attainment of a desirable, stable, geometry in relation to the chosen method of reclamation.

In the North Bohemia brown coal basin, with its prevalence of brown coal seams and therefore loam rocks on waste dumps, deflation and water erosion have but little effect, but solifluxion and landslides are a danger. The requirement is that the body of the dump should be in a steady state not only during construction but also during reclamation and subsequent use. Since space is limited, there is a tendency towards the building of large numbers of high landfills, and their general gradients are mostly within the range of 1:7 to 1:12, which corresponds to a slope gradient of 8°08′ to 4°46′, i.e. a gradient suitable for agriculture. This approach leads to very satisfactory stability and makes it possible to realize a good number of reclamation projects for agriculture.

14.4.2 Biotechnical Stage of Reclamation

The biotechnical part of the reclamation cycle is mainly concerned with the organization and management of reclamation—and the optimization of methods in relation to an integrated development of the whole region.

14.4.2.1 Organization of Reclamation Projects in the Basin

All reclamation projects in the basin are planned, managed and financed by a special unit of the general management of the North Bohemia Brown Coal Mining Concern in Most, which secures their preparation and realization through functionally subordinate working units (Figure 14.7) on a commercial basis.

The reclamation units of the individual enterprises of the concern secure the preparation, realization and implementation of all reclamation projects within their own unit in compliance with the Master Plan of Reclamation Projects.

The basin concern project unit Báňské projekty, k.ú.o. Teplice, has its own specialized reclamation unit which, for the general management of the concern, secures the processing and specification of the Master Plan and for the individual enterprises of the concern secures all project documentation of all reclamation projects. Reclamation specialists are involved at the project design stage.

The realization of the biotechnical stage of the reclamation is carried out by Báňské stavby, k.p. Most, which is a unit of the North Bohemia Brown Coal Mining Concern. Drilling and reclamation unit O4 in Odek provides such work for all concern enterprises in the basin. The reclamation department of this unit has personnel, organization, technical equipment and funds for all types of biotechnical reclamation projects.

14.4.2.2 Reclamation Methods

Reclamation of individual devastated areas must be implemented with regard to the character and trend of development of the whole area, as already

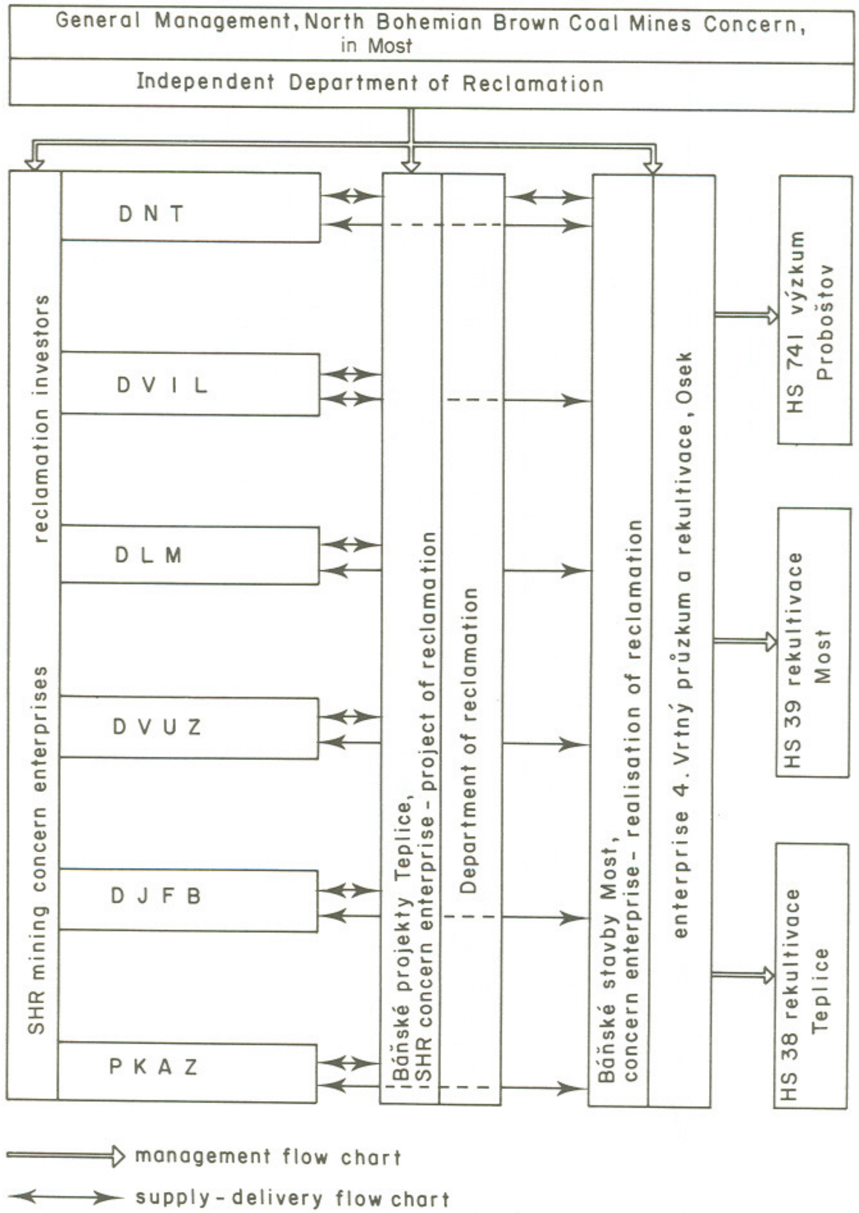
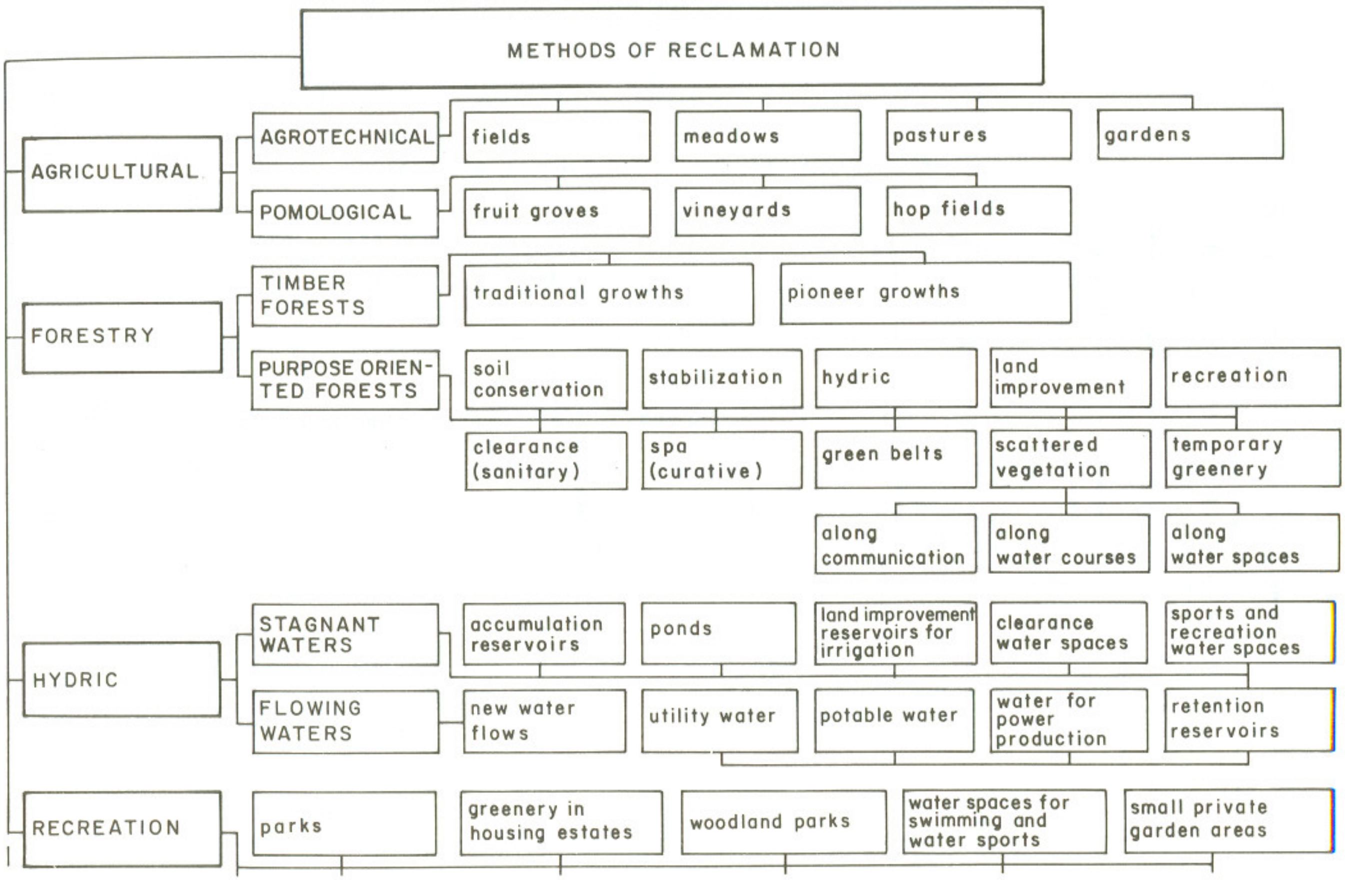


Figure 14.7 The management structure for reclamation projects


METHODS OF RECLAMATION
AGRICULTURAL
AGROTECHNICAL
fields
meadows
pastures
gardens
POMOLOGICAL
fruit groves
vineyards
hop fields
FORESTRY
TIMBER FORESTS
traditional growths
pioneer growths
PURPOSE ORIENTED FORESTS
soil conservation
stabilization
hydric
land improvement
recreation
clearance (sanitary)
spa (curative)
green belts
scattered vegetation
temporary greenery
along communication
along water courses
along water spaces
HYDRIC
STAGNANT WATERS
accumulation reservoirs
ponds
land improvement reservoirs for irrigation
clearance water spaces
sports and recreation water spaces
FLOWING WATERS
new water flows
utility water
potable water
water for power production
retention reservoirs
RECREATION
parks
greenery in housing estates
woodland parks
water spaces for swimming and water sports
small private garden areas

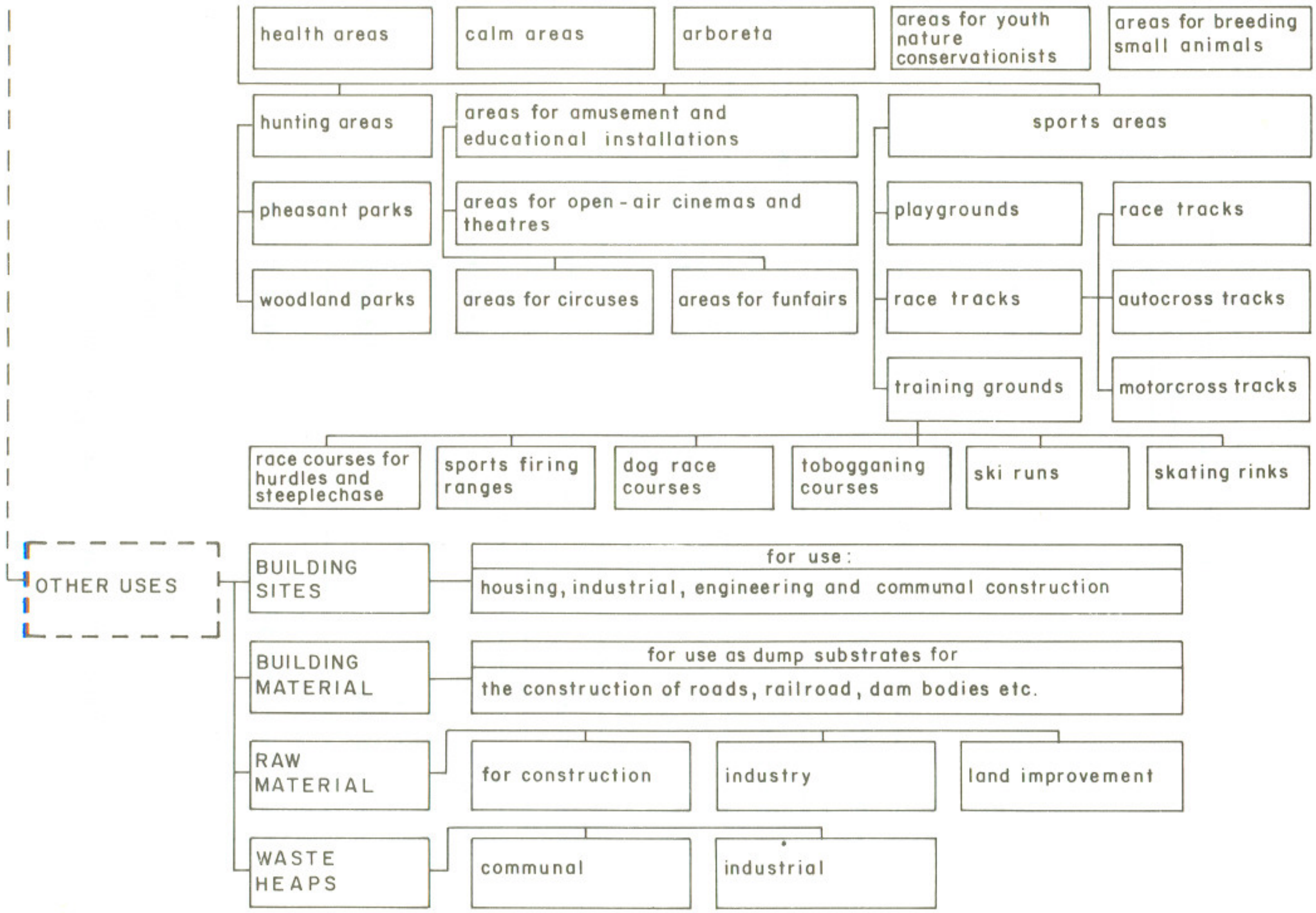


Figure 14.8 General types of reclamation

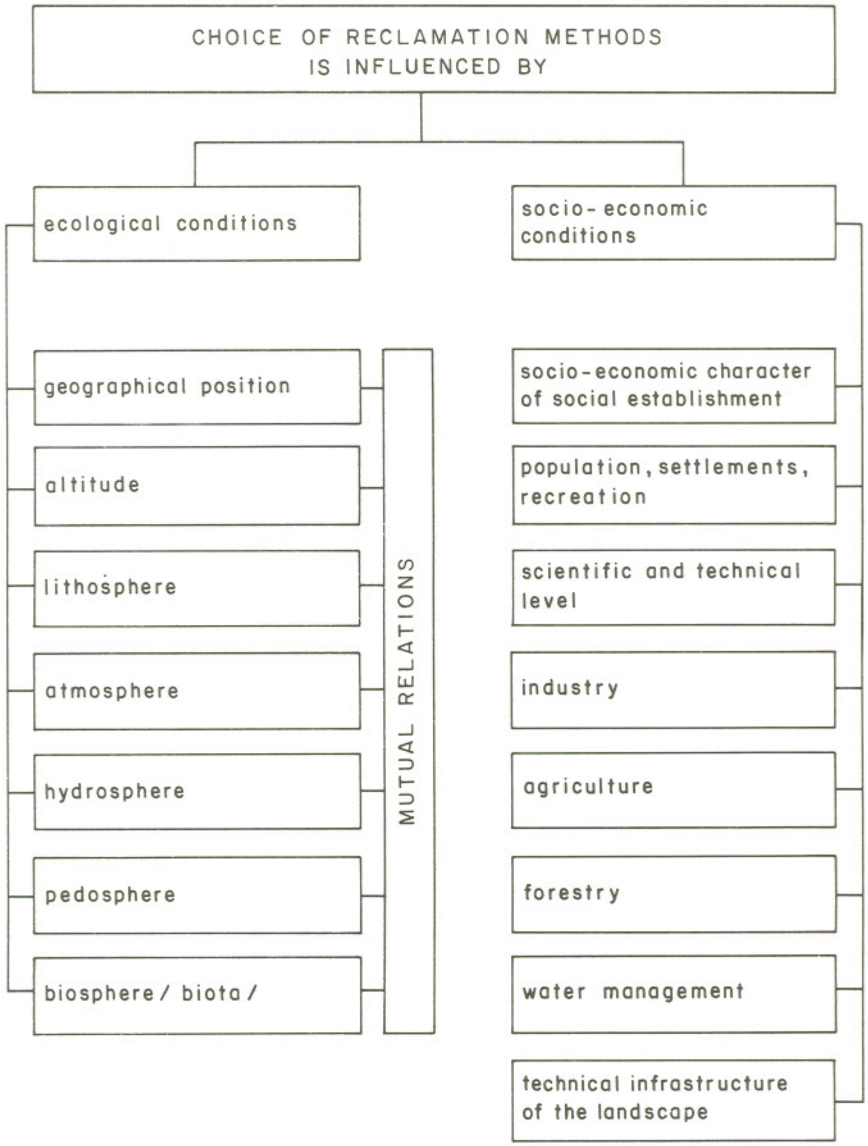


Figure 14.9 Factors affecting the choice of reclamation

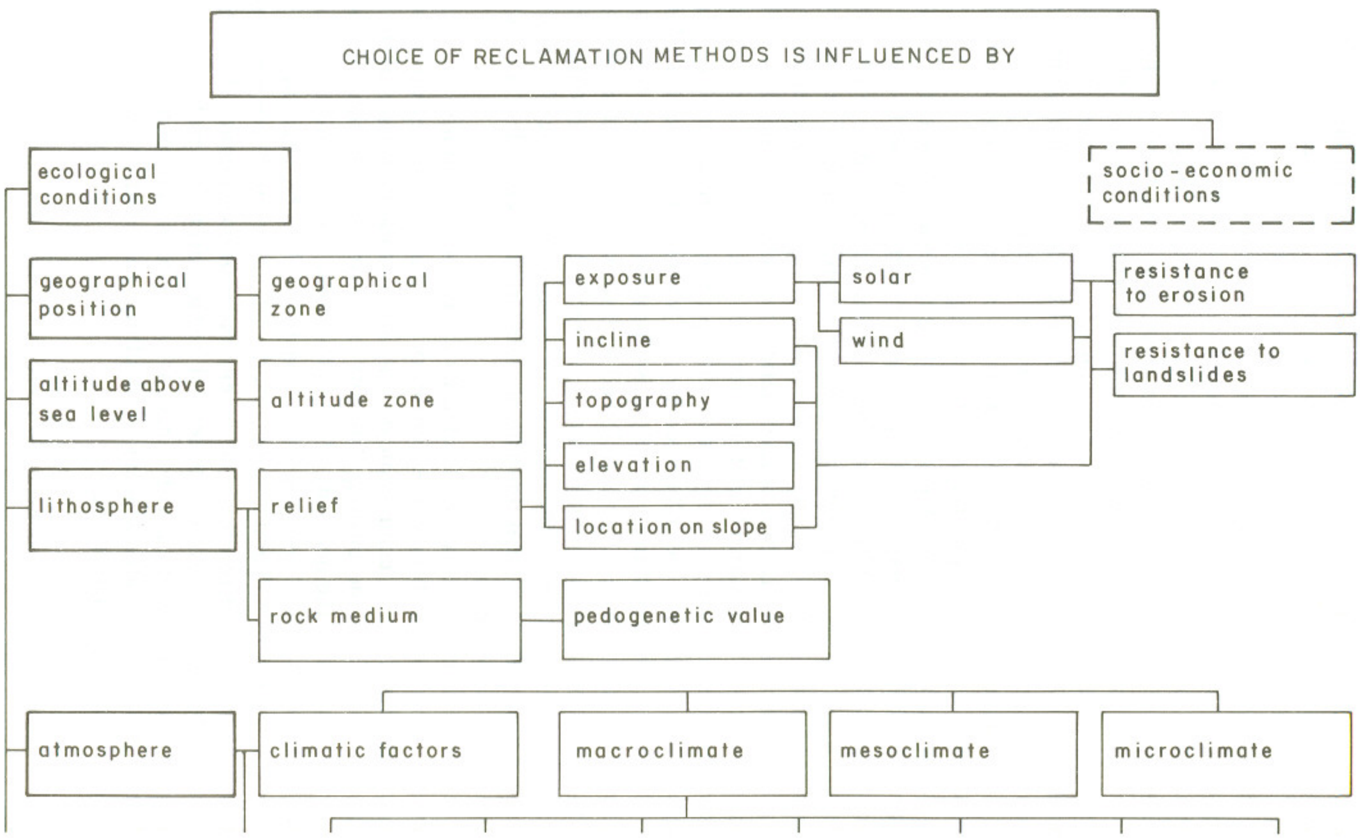
discussed. A new landscape with proportionate representation of agricultural soils, forests, woodland parks, parks and water areas meets not only the ecological but also the socio-economic interests of society.

Assessed from the ecological point of view, the reclamation principles applied in the basin must together lead to a state of inner ecological balance. From the socio-economic point of view, projects are orientated mainly at establishing a suitable environment and at increasing food production. In ecological terms reclamation mainly includes trees and hydric plants which are highly effective from the environmental point of view. Agricultural reclamation—i.e. agro-technical and pomological—is significant for its ecological and economic effectiveness (Figure 14.8).

The optimization of reclamation methods in the basin is based on a set of ecological and socio-economic conditions (Figure 14.9).

In the ecological factors (Figure 14.10) it is necessary to take into consideration the basic fact that the whole area of the basin is, with regard to its geographical position, altitude and the surrounding orographic entities, a very fertile area, advanced geonomically and as regards forestry. The very warm and semi-arid character of the climate makes it necessary to economize with moisture. In the localization of reclamation projects it is basically possible to implement all agricultural and forestry methods, whose ecological and economic effectiveness is magnified by the planned formation of new hydric conditions which may be influenced by new water management methods of reclamation. The limitations usually arise from inclinations and the topography of the area, which in turn are linked with resistance to water erosion and the extent to which mechanization may be applied. The topical nature of this problem is brought out by the necessity of establishing large numbers of waste dumps made up of a great amount of overburden rock with a considerable content of slope debris.

Ecological motivations are affected by many socio-economic factors, such as demographic conditions, the density of population, the density of settlement, the level of the technogenic deterioration of the landscape of the basin as a biotope, and the ensuing intensity of environmental control and the societal aspects of the necessity of providing food and recreational spaces for the population. The landscape of the basin used to be characterized by a dense network of small and medium-sized settlements, but these are currently being dispersed as a result of the development of coal mining. The housing stock is being concentrated in several towns, around which reclamation projects are implemented with a primarily aesthetic and recreational effect (trees, bushes and water spaces). Agricultural reclamation is given priority mainly in the open landscape.


CHOICE OF RECLAMATION METHODS IS INFLUENCED BY
ecological conditions
socio-economic conditions
geographical position
geographical zone
exposure
solar
resistance to erosion
incline
wind
resistance to landslides
altitude above sea level
altitude zone
topography
elevation
lithosphere
relief
location on slope
rock medium
pedogenetic value
atmosphere
climatic factors
macroclimate
mesoclimate
microclimate

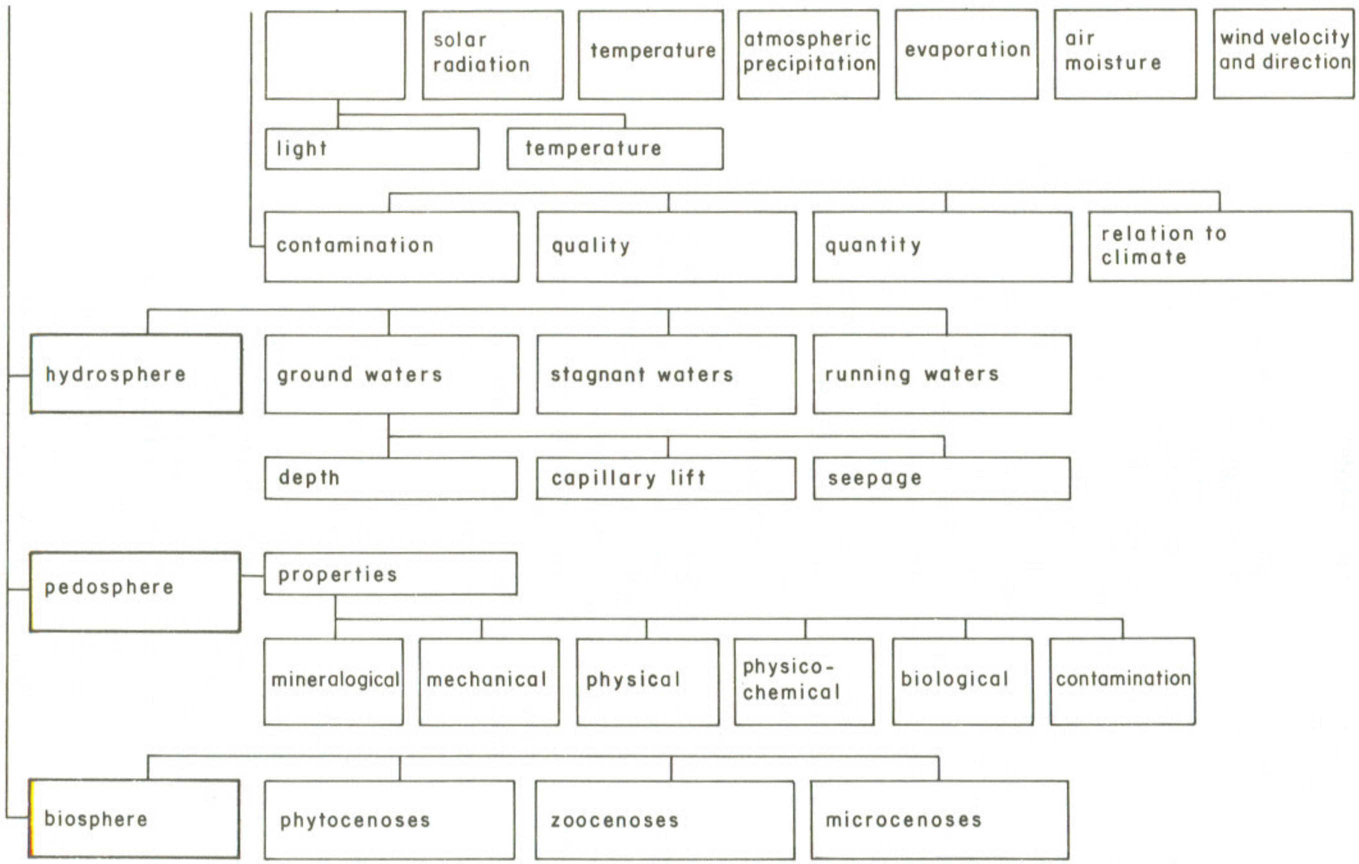


Figure 14.10 Detailed analysis of the ecological factors affecting the choice of reclamation

14.4.2.3 Regional and Technical Methods of Implementing the Reclamation Concept

So far each of man's activities in nature has to a certain extent been marked by one-sidedness, influenced by limited and subjective views. As civilization expands, the amount and intensity of human activities on the landscape increases. Reclamation of the landscape must be solved by applying a system-integrated approach which incorporates all natural and economic activities in the landscape. These demands are best met by a system of regional planning which most effectively leads to optimization of the development of the landscape and to the socially effective integration of all ecological and socio-economic activities; this is therefore the most effective long-term method. Regional planning in the Czechoslovak Socialist Republic benefits from being part of the state planning system.

The regional planning for the North Bohemia brown coal basin considers mainly the future functional use of the whole territory of the basin by all branches of production—mainly brown coal mining, industrial production, power production, agriculture and forestry. It also deals with the development of the population: employment, the settlement structure, the development of the tertiary sector, transport and water management. Next to safeguarding an acceptable measure of emission levels, the regional plan considers reclamation as being the basic factor of clearance and rehabilitation.

The initial Master Plan was processed in the years 1958–59 and projected the reclamation of the whole basin for the period 1960–80. It was modified several times and became the basic strategic directive for implementation of the individual reclamation projects by the enterprises of the concern.

In the period 1961–78 the Master Plan was modified seven times. The objective nature of the initial plan is brought out by the fact that throughout the whole period the initial distribution of reclamation projects was preserved, i.e.

agricultural	46.4–50.9%
forest	52.5–41.4%
water management	1.1–7.7%

The larger proportion of agricultural reclamation projects shows the immense pressure that has been brought to bear to offset the loss of agricultural plots by mining, and the growth of water spaces is the result of efforts made to create an area for short-term recreation in the basin itself.

The subsequent stage of the Master Plan was for the period 1981–90. The basic problem was the rapid take-up of plots for mining, with the limited possibilities for including devastated areas in reclamation projects. Table 14.4 shows how the plan was expected to work out. The new reclamation cycle in the time period comprises all devastated areas which no longer serve mining.

Table 14.4 Planned development of the land in the basin

Year	Take-up of agricultural land for mining (ha)	Newly-launched reclamation projects (ha)	Planned completion of reclamation projects (ha)
1981	389	406	255
1982	413	375	259
1983	472	277	325
1984	469	281	296
1985	391	124	435
1986–90	1556	1339	1208
1981–90	3691	2804	2779

In the period 1981–90 reclamation projects operated by the North Bohemia Brown Coal Mining Concern will cover a total area of about 2800 ha, made up as shown in Table 14.5. The Master Plan assumed that the reclamation cycle will be completed as shown in the last column of Table 14.4. These projects will cover the areas shown in Table 14.6.

The orientation of reclamation to intensive land use, namely to agriculture, and the increase in the selective stripping of topsoil and loess, are the reasons for the increasing cost trends, which are evident from Table 14.7.

Table 14.5 Reclamation projects in the period 1981–90

	(ha)	(%)
Agricultural land	1771	63.4
Forest land	644	23.0
Parks	87	3.1
Water spaces	152	5.4
Miscellaneous	143	5.1

Table 14.6 Completion of reclamation projects in the period 1981–90

	(ha)	(%)
Agricultural land	898	32.3
Forest and parks	1622	58.4
Water spaces	191	6.9
Miscellaneous	68	2.4
Totals	2779	1 00.0

Table 14.7 Cost trends for reclamation (in thousands of Crowns)

Year	Topsoil and loess	Reclamation	Totals
1981	94 768	122 264	217 032
1982	95 505	103 327	195 831
1983	72 217	88 458	160 675
1984	85 135	157 303	242 438
1985	69 918	166 910	236 828
1986–90	337 429	897 009	1 234 438
1981–90	751 970	1 535 273	2 287 243

14.4.2.4 Technology of Reclamation Projects

In the implementation of agricultural, forestry, water management and recreational reclamation projects certain technologies are being applied, which include:

(1) *technical methods*—levelling, the bringing in of fertile and potentially fertile make-up earths, a system of land improvement measures, the building of road communications, hydrotechnical and hydro-amelioration work, technical stabilization of slopes;
(2) *biotechnical methods*—erosion control measures, and a system of agricultural, forestry and grove and park reclamation (the methods have developed from extensive to intensive projects).

In the first years extensive methods of reclamation were used. The whole set of measures was usually based on the necessity to subordinate the project to the unfavourable and atypical site of the devastated plots. The aim of the reclamation was to plant vegetation on the devastated site—using mainly pioneer and ecologically adaptable plants with a low economic effect. This in practical terms meant the least earthwork. Agricultural reclamation was restricted to planting without the use of make-up ground and without basic land improvement, without intensification of hydro-amelioration measures, mostly by the direct cultivation of the waste dump.

The establishment of suitable prerequisites for reclamation during the technical (mining) stage, and growing demands on the quality of the reclamation, led to intensification of the technology. Greater emphasis was placed on the stage of improving the ecological factors of waste dump sites in compliance with the set target. The improved system of waste dump construction was followed up by a more intensive earth-work plan, the bringing in of fertile soils for land improvement, and water-course training. Measures were taken to improve the mineralogical and hydropedological structure of the surface layers of the dumps. All sites were made accessible.

Forests are planted on waste dumps with gradients not exceeding 1:5 or 1:6, which makes mechanization possible. Such trees will increasingly be exploited for timber. Forest cultures are fertilized and intensive care is devoted to the site before it is handed over to its users.

In agricultural reclamation projects higher demands are placed on area, compactness and regularity of the shape of the plots, and on the possibility of using mechanized tillage. In the preparatory stage increasing attention is devoted to securing the pedogenetic quality of the surface layers of waste dump rocks, namely their mineralogical and hydropedological properties. The number of agricultural reclamation projects is increasing on made-up ground. The make-up consists of the top humus profile, clayey rocks of the Quaternary, and various rocks which are used for land improvement (such as bentonites, tuffitic loams, marl, peats, oxyhumolites). Greater attention is being devoted to the intensity of plant nutrition: mineral organic carbonic fertilizers manufactured by the V. I. Lenin mines in Komořany from waste sludges from brown coal treatment plants have been used successfully. Almost every year the mines selectively strip and remove greater quantities of humus earths, significantly contributing to the intensification of the soil-forming process. Hydro-amelioration is becoming a frequent method in agricultural reclamation projects, including not only drainage but also irrigation. The original 2–3 year cultivation process has been extended to 8–12 years, and agricultural reclamation is now increasingly subordinated to the final target of attaining an anthropogenic soil profile with the highest potential fertility.

Technologically demanding and costly reclamations of areas designated for recreational use were only launched in the second half of the reclamation period. Woodland parks are being equipped with facilities for intensive use by the population, mainly by means of a dense system of communications. The building of recreational water reservoirs with a controlled water regime is very demanding. These reservoirs are usually set in woodland parks or parks which are planted around them. The planting of parks is very demanding because it usually requires terrain levelling and other treatment of the relief of a considerable part of the waste dump, with considerable quantities of fertile make-up soil, a wide variety of seeds and seedlings of trees and bushes. The concept is that of a combination of free grassy areas with solitaires and groups of trees and bushes resembling the English park. The areas usually have a dense network of paths, and recreational facilities corresponding to the possibilities of the park.

14.5 PRACTICAL RESULTS OF RECLAMATION

Reclamation projects have been implemented in the basin for three decades now. The initial stage, 1950–60, was marked by the search for suitable

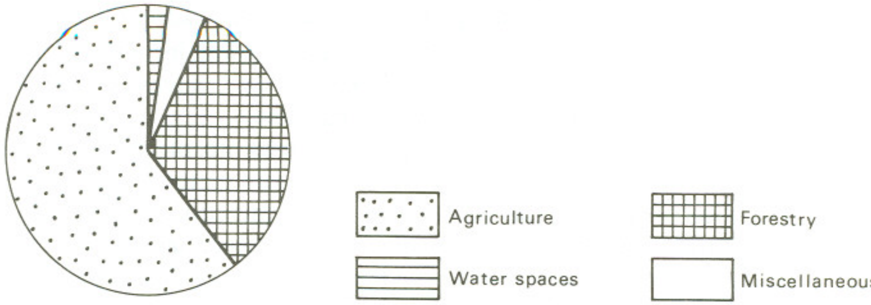
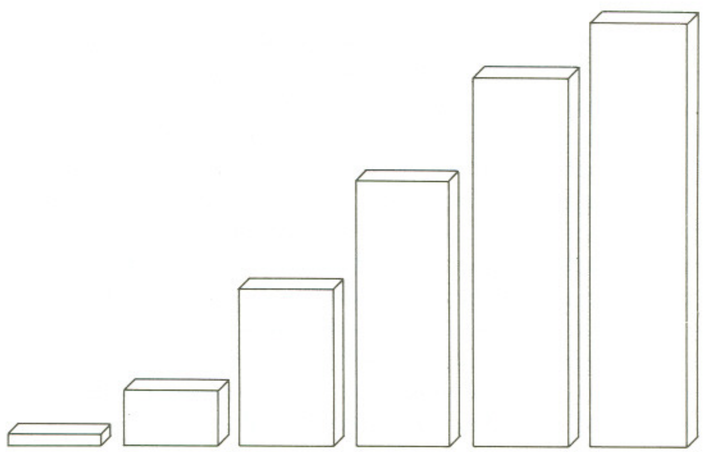


Figure 14.11 Completed reclamation projects handed over to users by the SHD Concern up to 1 January 1981

technologies in the field of forestry and agricultural reclamation, the organization of reclamation projects in the basin, and methodical specification of the whole system of reclamation ranging from the compilation of legal regulations and prescriptions to practical implementation. The first Master Plan of Recultivation was launched in 1960; this introduced the concept of regional and landscape reclamation, and the concept of regional reclamation became the long-term strategic basis for practical strategy.

Figures 14.11–14.16 summarize the 30 years' development and the current status of reclamation in the basin.



in ha	173	567	1643	2640	3888	4139.47
year	1955	1960	1965	1970	1975	1980

Figure 14.12 Development of reclamation projects by the SHD Concern

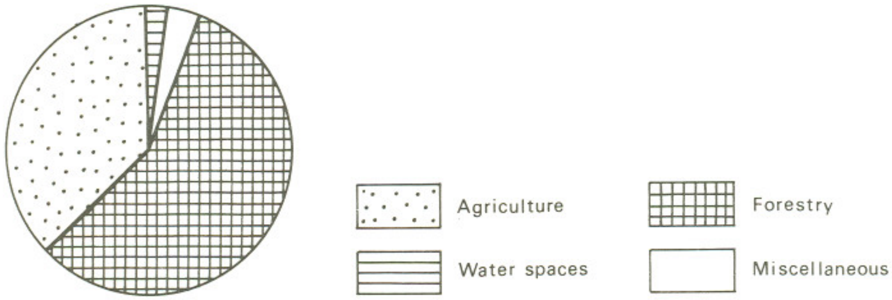
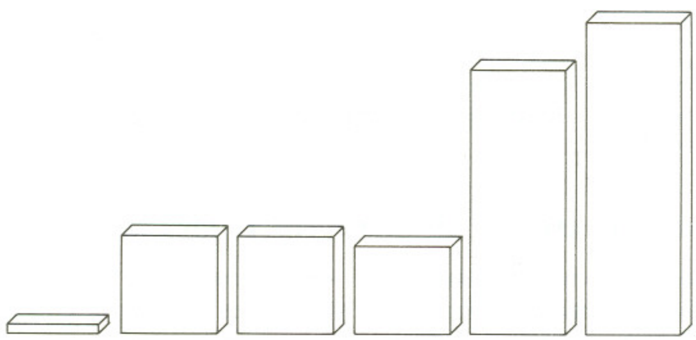


Figure 14.13 Current reclamation projects by the SHD Concern up to 1 January 1981



in 10^6 m^3	0.02	0.48	0.50	0.41	1.32	1.54
year	1956	1960	1965	1970	1975	1980

Figure 14.14 Development of volume of selective removal of topsoil by the SHD Concern

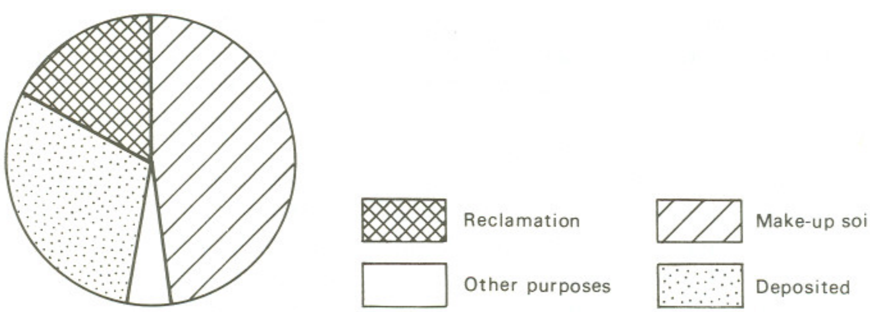
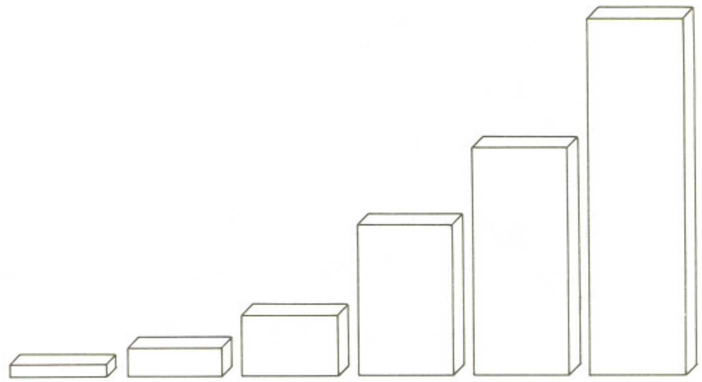


Figure 14.15 Survey of the use of topsoil selectively removed by the SHD Concern, 1956–80



in 10^6 crowns	5.0	11.7	25.0	74.7	112.4	175.0
year	1955	1960	1965	1970	1975	1980

Figure 14.16 Development of financial volumes of reclamation by the SHD Concern

14.6 DYNAMIC BALANCE OF THE LANDSCAPE IN THE BASIN

Before settlement the landscape was characterized by an abundance of riparian woodlands, water surfaces, swamps and water-courses. Medieval colonization changed the area by drying out the swamps and water spaces and by felling the forests into an area with a significant prevalence of agricultural cultures. This state culminated in the mid-nineteenth century when the opening of mines began on a large scale.

Hand in hand with the development of open-cast mining the mining industry in the area intensified, and as a result the following period saw an increase in industrialization and urbanization, with the accompanying process of denaturation. Only since 1950 has there been planned management of the devastated areas. Table 14.8 shows that after exploitation of the basin the area will again be used for agricultural purposes. Compared with the mainly agricultural use which preceded the period of mining, there will be a higher proportion of forests, woodland and parks (especially in the environs of cities), and water spaces, for recreational purposes.

The data in Table 14.8 for the years 1960 and 1980 show that the greatest losses to mining were inflicted on agricultural soils (5.6%); of this, arable soils lost 4.3%. Other areas, which include mining facilities, increased over this period by 4.1%. These data favourably reflect the reclamation work done in this period, as without it the loss of agricultural soil would have been 7.5%. The area under forest is being preserved only thanks to reclamation work; otherwise it would have recorded a loss of 0.9%.

Table 14.8 Dynamic balance of the area of the North Bohemia brown coal basin landscape[a]

Year[b]	Total area (ha)	Arable land	Hop fields	Vine-yards	Gardens	Fruit growers	Meadows	Pastures	Agricultural soil	Forest soil	Ponds	Other water surfaces	Built-up areas	Other areas[c]
1850	105 539 (100%)								83 376 (79%)	10 554 (10%)	2 111 (2%)	4 222 (4%)	4 222 (4%)	1 055 (1%)
1960	105 539 (100%)	61 411 (58.2%)	1 166 (1.1%)	– –	2 087 (2.0%)	953 (0.9%)	3 220 (3.0%)	3 816 (3.6%)	72 653 (68.8%)	4 785 (4.6%)	152 (0.1%)	2 035 (1.9%)	2 288 (2.2%)	23 626 (22.4%)
1980	105 539 (100%)	56 918 (53.9%)	1 268 (1.2%)	46 (0.05%)	1 787 (1.7%)	1 027 (1.0%)	2 440 (2.3%)	3 127 (3.0%)	66 613 (63.2%)	4 812 (4.5%)	139 (0.1%)	3 452 (3.3%)	2 539 (2.4%)	27 984 (26.5%)
2050	105 539 (100%)							(60%)	63 323 (24%)	25 329 (2%)	2 111 (8%)	8 443 (5%)	5 277 (1%)	1 055

[a]The inventory of cultures was made only in those cadastral areas in which the consequences of brown coal mining have, are or will be felt.
[b]Figures for the years 1850 and 2050 are qualified estimates; figures for 1960 and 1980 correspond accurately to the records of real estate property kept by the relevant respective units of geodesy and cartography.
[c]The category of 'mining' is classified into 'other areas'.

14.7 PROPOSALS AND RECOMMENDATIONS

14.7.1 Criteria

A set of criteria that could be applied in studying and assessing changes in the structure, dynamics and functions of land use in the area, and the impacts of these changes on quantifiable factors of the environment, were set out in detail in Figures 14.2–14.6 and Table 14.3.

14.7.2 Suggestions for Research

Ecological considerations should be introduced more systematically into technical development and technology. Research should cover this very important area, particularly with regard to simultaneous optimization of:

(1) the development of the mine;
(2) the siting of waste dumps in the landscape;
(3) the shaping of waste dumps;
(4) the technology of removal of sub-grade rocks in relation to the principles of selective stripping, transport and deposition of fertile, potentially fertile and valuable overburden rocks and earths.

There should be an integrated and systems approach to research on the socio-ecological optimization of the reclamation of the area, taking into account all ecological, socio-economic and political considerations.

Since the work considered would cover a large area (of the order of 1000 km^2) it would not be possible to use traditional methods. It would be useful to organize remote geological prospecting.

The results of this suggested research should effectively contribute to the controlled creation of good environmental conditions during the period of mining, which is important for the stabilization of the population and labour in the area. This would in turn be positively projected into the creation of conditions suitable for the optimization of reclamation in the basin.

14.7.3 Suggestions for Minimizing Negative Environmental Impacts and Optimizing Reclamation

There should be continuing research on measures to eliminate excessive dust and gaseous industrial emissions from power plants and chemical industries.

During the project design stage, and then during actual mining, there should be means to implement systematically all necessary measures for technical (mining) reclamation, namely:

(1) the selective stripping and removal of fertile, potentially fertile and valuable overburden rocks and earths;

(2) the planned construction of waste dumps observing the set future use of the area.

The above measures, again, are necessary to create good conditions for the effective realization of all the biotechnical stages of reclamation.

The concept of reclamation should be optimized so as to be integrated with all other socio-economic activities in the area of the North Bohemia brown coal basin. To achieve this it will be necessary to:

(1) speedily complete and approve plans for brown coal exploitation, with a time horizon for breaking out the coal;
(2) determine the regional prognosis for the basin, in terms of the final reconstruction and use of the whole area for mining, industrial production, agriculture, forestry, and water management, and the infrastructure, dwellings, sports and recreation spaces.