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GENETIC CLASSFICATION OF LAKES IN THE CZECH REPUBLIC

B. Janský, M. Šobr: *Genetic classification of lakes in the Czech Republic.* – Geografie – Sborník ČGS, 109, 2, pp. 117–128 (2004). – The paper provides genetic classification of lakes in the Czech Republic. We separate lakes to two groups - natural and anthropogenic origin. The genetic classification is based on the classification of lakes according to the way of origination of the lake basin while the geomorphologic viewpoint prevails: glacial lakes, fluvial lakes, karst lakes, lakes dammed-up by landslides, organogenous lakes and anthropogenic lakes. As the anthropogenic lakes we may regard all the water bodies which originated as a consequence of the human activity - mining of mineral resources.
KEY WORDS: glacial lakes – fluvial lakes – karst lakes – lakes dammed-up by landslide – organogenous lakes – anthropogenic lakes.

1. Introduction

In comparison to the world's lakes, the lakes in the Czech Republic are of far smaller size and volume dimensions. They are located prevailingly in the protected natural regions – national parks, protected landscape areas and natural preserves. They deserve attention especially with respect to the maintenance of ecological stability of the protected area, preservation of the characteristic habitats, ecosystems, etc. Therefore, they are extraordinarily valuable and unique natural complexes. The objective of the thesis is to outline the geographical layout of the individual types of lakes in the region of the Czech Republic with the specific focus on the anthropogenic lakes.

The renowned German limnologist of the beginning of 20th century, F. A. Forel, presented the definition of lake that is quoted in the specialised geographical or limnology literature (Forel 1901): "Standing stagnant water mass that is located in a recess in the earth's surface enclosed on its perimeter without a direct connection to sea is generally referred to as lake". Accordingly, in Forel's opinion, each standing water accumulation without a direct connection to sea irrespective of its size is lake. It implies then that also puddles as well as ponds and marshes belong to lakes. Therefore, Forel (1901) distinguishes "the lakes in more specific sense", ponds and marshes.

Lakes in more specific sense are deep in that extent that the surface ripple does not affect its bed and due to their depth shore vegetation does not reach the bed (with the exception of shallow-water areas). Lakes are then the water accumulations with the deepest areas not grown with any vegetation. This definition may be applied for the conditions of the Czech Republic especially as regards the lakes of organogenous type.

On the basis of the analysis of information of the sources of the specialised literature and with a view to the specific conditions of the Czech Republic, we have laid down our own definition of lake: Lake is a natural depression in or under the earth's surface, permanently or temporarily filled with water without a direct connection to sea. In contrast to ponds and minor water basins, lakes cannot be easily drained off. As opposed to shallow standing waters such as minor waters (poodles and pools), ponds, and organogenous and fluvial lakes, as far as deep lakes are concerned, the surface ripple does not affect their bed and the shore vegetation does not reach to the beds due to their depth. The deepest areas are not therefore grown with the water vegetation.

2. Present stage of geographical reseach of lakes

A number of geographers seated in Prague dealt with the research of lakes in our country as well as abroad. This tradition was established by the professor Václav Švambera, who performed the systematic mapping of the glacial lakes in Šumava Mts. In the thirties, the lakes in Šumava and karst areas in Slovakia were dealt with by Karel Kuchař and Josef Kunský. In the post-war period, Václav Král, Eduard Kříž and other authors dealt with research of the lakes in the High Tatras. In the years 1972-75, Bohumír Janský performed the first geomorphologic and limnology research of Mladotické Lake dammed-up by landslide.

After ninety years which have passed since the last researches of the lakes in Šumava made by Švambera, we have decided to resume them. By means of modern equipment the limnology studies of three glacial lakes Prášilské, Plešné and Laka have been drawn up within the Master's thesis by A. Zbořil (1996), T. Vránek (1999), and M. Šobr (1999).

Due to the support of the Grant Agency of Charles University, the project "Lakes in the Czech Republic" has been completed which has been intended to create an extensive study on our lakes including their genetic classification. In the years 1999 to 2002, we have worked out the analysis of number of lakes of natural origin including the water accumulations originated due to the human activity in the whole region of the Czech Republic. The work has not included the dam reservoirs and ponds. The inventory of the lakes has shown that there are almost 700 water accumulations the majority of which are of fluvial, organogenous and especially origin. Within the stage of the research, we have especially dealt in detail with fluvial lakes on the middle course of Labe in the Czech territory between Pardubice and Mělník and three deserted Labe arms have been the subject of the limnology studies (Šnajdr 2002, Klouček 2002, Chalupová 2003). All the mentioned works have been focused on the analysis of the hydrologic regime, water quality, the sediments as well as the biological revitalisation of water bodies. Apart from the fluvial lakes, we have commenced also the research of the organogenous lakes. The first study on the subject has been the work on Mechová jezírka in Jeseníky Mts. which has been completed in the thesis by Oulehle (2002). Besides the general monography conception, he especially focused on the geochemical development of the upland bogs.

The previous works have been followed by the latest extensive project supported by the Grant Agency of the Czech Republic "Atlas of Lakes in the Czech Republic". The final result should be the Atlas of Lakes in the Czech Republic which is supposed to be published in the year 2005.

Fig. 1 – The Černé Lake – glacial lake situated in the central part of the Šumava Mts. (foto M. Šobr)

3. Glacial lakes

There are six glacial lakes in the Czech Republic, situated in the central part of Šumava (Černé – Fig. 1, Čertovo, Plešné, Prášilské and Laka Lakes) and Krkonoše Mts. (Mechové Lake). The lakes in Šumava Mts. are the vestiges of the regress of glaciers of Würm age which at that time surrounded the hill-tops and hill-slopes of some of the highest peaks of the mountain range. From the research of Šumava glacial lakes it implies that all of them have the same modelling – consisting of the lake wall, lake basin, and lake brook, and are enclosed by dumped moraines of various widths which in several bends close the lake areas. The lowest moraine is regularly several hundred metres distant from the central part of the lake basin. The central moraine belt of all the lakes lies between 1000–1100 m above sea-level and the lake surface is located in the high altitudes (900–1000 m above sea-level) under the highest peaks of the mountain range (1300–1456 m above sea-level). The orientation of the cirques which are not fixed to a structure of rocks is between north and south-east. It follows that the lakes are partially hollowed by glacier (cirque lakes) and partially dammed-up by the dumped moraine. With the exception of the lake Laka, all the others are very deep (Kunský 1933). Besides the undisputed landscape and aesthetic significance, they provide for the important refuge areas for the endangered types of water flora. There is one small glacial lake in Krkonoše Mts. – Mechové Lake, situated in morain near Dolní Mísečky.

4. Fluvial lakes

The lakes of fluvial origin occur in the floodplains of a lot of rivers in the world. Their existence gives evidence of the past development of the river beds especially in the middle and lower courses. After the flow-out from the headwater mountain regions where the river courses usually deepens their beds and carries off vast amount of alluviums, they become slower in the submountain regions, they deposit the carried-off materials and frequently relay their beds or spreads out to various river arms. In the further course in the flatlands and lowlands, they often create the meanders which may be detached (oxbowed) from the current river bed in the final stage (Fig. 2). The fluvial lakes originate in this way. These may also be formed at the one-time change of the course bed, e.g. in case of the floods or by a mere overflowing of the water course in case of the high water levels occurrence and their accumulations in the depression positions (periodical pools on the flooded meadows in the natural preserve Týnecké mokřiny). The special case occurs at the origination of a through-flow lake directly in the river bed, e.g. behind the undulation, at sudden change of the structure of geological bottom or in the places of radical change of the bed slope (natural preserve Skryjská jezírka). In several cases, the river meander has been detached artificially at the straightening of the course riverbed.

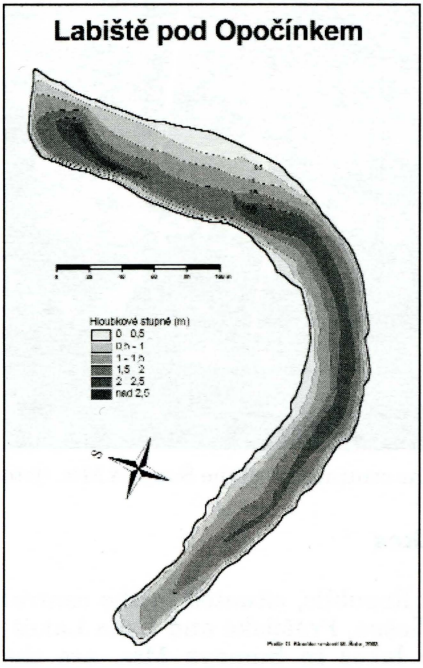

Fig. 2 – The Lake Labiště pod Opočínkem is typical fluvial lake, bathymetric map show layout depths in former river (in meters)

The fluvial lakes are the most frequent type of natural lakes in the Czech Republic and they are located especially along the courses of Labe (between Hradec Králové and Mělník – Fig. 3), Morava (between Zábřeh and Litovel and between Otrokovice and the junction with Dyje), Dyje (from Nové Mlýny to the junction with Morava), Lužnice (from Nová Ves to Nová řeka), Orlice (from Týniště to Hradec Králové) and Odra (from Košatka to Ostrava-Petřkovice). The riparian lakes often occur in the regions of special nature protection including the natural monuments as well as the national nature reserves. The most renowned are the National Nature Reserves Libický luh, Polanská niva, Křivé jezero, Ramena řeky Moravy, Vrapač, and others.

5. Karst lakes

The karst lakes originate by means of the accumulation of rainfall water or underground water in the recesses or depression positions of the karst minerals which include predominantly limestone and dolomite. Their origin

Fig. 3 – Fluvial lake Labiště pod Opočínkem (foto M. Šobr)

may be predetermined by the tectonic disturbances along which the underground water is rising and it is frequently directly fixed to the processes of karstic phenomena such as e.g. the formation of sinter terraces or travertine dams, the dissolution of carbonate rock by the aggressive rainfall or mineral waters, and others. The karst lakes may also be formed in the places where the cave profile constriction occurs or in front of the cave traps.

The karst lakes in the Czech Republic occur especially in the deepest abysses, cave areas and in exceptional cases in the beds of the water course under the spring of the karst waters. All the lakes are characterised by the specific thermic regime with a small amplitude of water temperature in the whole course and the considerable content of dissolved carbonates. With respect to the fact that the majority of them are located in the cave areas or deep terrain depressions, they serve rather for the aesthetic variation of caves and abysses than for the protection of the endangered species of animals.

The lake in Hranice Abyss has small surface size and its surface is situated 69.5 m under the edge of the rock wall. However, it is unique by its depth which amounts to 205 m according to the last measurements, due to which Hranice Abyss is the deepest abyss in the Central Europe. Unconfirmed measurement taken in the year 1960 has determined its depth even at 260 m. On the bottom of Macocha Abyss, there are two lakes of small sizes in the depth of 138.5 m. The upper lake is 11 m deep, the lower reaches the depth of up to 30 m.

6. Lakes dammed-up by landslides

The youngest natural lake in the Czech region is Mladotické (Odlezelské) jezero (Fig. 4) which is situated on the north of Plzeň, in the basin of the river

Fig. 4 – The Mladotické (Odlezelské) Lake, view from tributary part to dam – landslide (foto M. Šobr)

Střela. It originated by damming the valley of Mladotický potok by the landslide of overlaying feldspathic sandstone (arcoses) and pudding-stones on the western bottom of Potvorovský vrch. The landslide came about after the intensive rainfalls and subsequent catastrophic floods during the night from 27th to 28th May 1872. The brook valley was dammed in the length of ca 300 m. Since its origination, the intensive sedimentation of the lake proceeds. The maximum measured depth in the year 1972 was 7.7 m, the maximum depth at the last measurements taken in the year 1999 dropped to 6.7 m. Also the lake surface has diminished from 5.93 ha to 4.55 ha. Two small lakes dammed-up by landslide are probably located also in Moravia, in Vsetínské vrchy.

7. Organogenous lakes

The lakes of organogenous origin originate by the retention of the rainfall or underground water in the shallow depressions under the participation of peat bogs or moor lands formation. Therefore, we draw a distinction between the bog lakes and moor lakes which have specific origin, composition as well as water quality. The bog lakes originate most frequently inside the upland bogs where the soft rainfall water accumulates and is afterwards coloured by the products of peat bogs forming. The characteristic feature is the lack of the mineral substances and low pH which is most frequently within the range of 3–5 and thus disallows for the occurrence of a lot of species of animals. Minor trophy is also caused by rather limited utilisation of organic substances which occur to a great extent in the form of humus colloids which make the water rusty red or even red-brown colouring.

Fig. 5 – The Blatenská slať, example of organogenous lakes in the Šumava Mts. (foto T. Hrdinka)

The bog lakes are generally of small dimensions and they occur almost in all our border mountain ranges. The most of them are located in the resting area of Modravská slať in the central part of Šumava (Rokytecká slať, Roklanská slať, Blatenská slať – Fig. 5, Mlynářské slatě, Novohuťské močály, and others) and they number approximately two hundred. Also the largest organogenous lake is located in Šumava which is of valley bog type and which has been formed in Chalupská slať near Borové Lady (area of 1.3 ha).

Other distinguished areas of the occurrence of the bog lakes are Jizerské Mountains (Na Čihadle, Klečové louky, Černá jezírka, Rybí loučky, and others), Krušné Mountains (Velké and Malé Jeřábí jezero, Velký močál, Novodomské rašeliniště), Bohemian Forest (Lakes near Rozvadov), Krkonoše (Úpské rašeliniště, Pančavská louka), Orlické Mountains (Jelení lázeň, Pod Pětirozcestím), Jeseníky Mountains (Mechová jezírka near Rejvíz) and Slavkovský Forest (Sirňák, Smraďoch, Kladské rašeliniště). All the lakes are located in the protected nature areas, frequently in the category of national natural reserves (Velké Jeřábí jezero, Mechová jezírka near Rejvíz, Novodomské rašeliniště). At Červené blato near Suchdol nad Lužnicí and Borkovické Blato near the village of Záluší, the artificial organogenous lakes originated in connection with the peat diggings for the economic purposes.

By contrast, the moor lakes occur in the lower altitudes on the springs of the underground water or in the areas of occurrence of the deserted river arms in the advanced stage of land-filling. Water of the moor lakes is richer in mineral substances as well as in organic nutriments, and eutrophisation (organic enrichment) develops more often. The typical examples are minor, slowly disappearing detached meanders in the vicinity of Labe and Dyje and the lakes at the springs of mineral waters in the National Nature Reserve in

Soos near Františkovy Lázně. The special examples are the bog or moor pools on some brooks which probably developed out of the original ponds (Na Kačíně and the Rašelinné jezírko Rozsíčka). In those cases, it is rather difficult to determine whether it is an organogenous, anthropogenic (pond) or fluvial lake.

8. Anthropogenic Lakes

As the anthropogenic lakes we may regard all the water bodies which originated as a consequence of the human activity. These are the water works constructed for the purpose of specific utilisation or the lakes originated as a result of mining activities. These lakes are mostly wrongly omitted, and with respect to the high quality of some of mine waters and quarry waters, they could be effectively utilised in future, e.g. for the water-resources and recreation purposes. Also their environmental significance is not negligible, since they for the most part affect its surroundings positively and often form the areas of the concentration of natural values. Considering the high variability of the anthropogenic lakes, the further classification of them is necessary.

One large group is formed by ponds, the other one by the dam lakes and the last by the water bodies originated in connection with the mining activity. The former two groups have already been extensively dealt with in the specialised literature, therefore, we will focus on the lakes originated as a result of the mining of mineral resources which are one of the most numerous types of lakes in the Czech Republic.

Lakes originated in connection with the mineral resources mining are together with the fluvial lakes and ponds the most numerous types of water bodies in the Czech Republic. The lakes occur in the open pits and quarries of all kinds, at the associated waste dumps or in the subsidence basin-shaped valleys. The water bodies of various sizes originated either spontaneously or as a result of the specific, so called hydrologic reclamation. Their occurrence is naturally fixed to the presence and mining of the specific mineral resources which by their character affect, apart from the size and depth, also the parameters of the accumulated water of the surface as well as the underground origin. The parameters thus most often affected are colour and transparency of water, content of the specific minerals, pH and the resulting biological activity arising out of them. The important factor is also time which passed since the mining termination (even several hundreds of years) and the associated eutrophisation of accumulated water that is for the most part very slow and gradual and often is missing utterly. With respect to the above-mentioned, it is necessary to classify these lakes according to the type of mined mineral resources as follows: the lakes originated on the mining of sand and sand-gravel; kaolin; lignite and black coal; limestone, bluestone and greywacke; granite, diorite and whinstone; brick clay and loam and other mineral resources.

The lakes in the open sand and sand-gravel quarries belong to the most frequent type of the anthropogenic lakes in the Czech Republic. These are for the most part localised along the big as well as minor rivers in the area of Quaternary sand-gravel alluvial deposits. The lakes originated due to the mining of sand and sand-gravel are especially located along the watercourses of the river Labe (from Jaroměř to Lovosice), Morava (from Mohelnice to Hodonín), Lužnice (from Nová Ves to Veselí) and Odra (north of Ostrava). Sporadically, they occur in the basin of Jizera, Cidlina and Opava, and in other places of the Czech Republic.

The lakes originated after the mining of kaolin occur both in the traditional areas of mining and occasionally within the whole region of the Czech Republic. The highest concentration of the lakes the areas north of Cheb, west of Karlovy Vary and northern as well as southern surroundings of Horní Bříza. Sporadically, they occur in the minor quarries in the vicinity of Znojmo, Veverská Bitýška, Jedovnice in Moravský kras, Vidnava and Podbořany near Žatec. The lakes are mostly of smaller sizes than the water bodies in the coal mines and sand mines and they are not so deep.

The lakes originated after the mining of lignite and black coal, together with ponds and the lakes created due to the mining of sand-gravel, the most numerous type of the anthropogenic lakes in the Czech Republic. Their occurrence is especially fixed to the mining of lignite coal whose largest deposits are located in the lignite coal basin in the northern Bohemia. The largest number of the lakes is then localised in Sokolovská and Mostecká pánev and in the vicinity of the towns Teplice and Ústí nad Labem.

The next group of lakes may be found in the quarries in which the compact sediments of sea origin are mined, namely especially the limestone, bluestone and greywacke. Those minerals differ in their colour and the basic physical and chemical parameters, however, the quarry waters are equal as regards some of the parameters. The lakes are similar by their size, which is often of considerable dimensions, the depth, which may reach up to several tens of metres, and the colour and transparency of lake waters. The most well-known lakes fixed to the limestone mining are found in the quarries Velká and Malá Amerika near Mořina in the region of Karlštejn, and the similar lakes of smaller dimensions may be found in other places in Český kras. Another lakes occur only sporadically in the lenticles of crystalline limestones near Rabí and Hejnice and in the Neozoic limestones north of Valašské Meziříčí. The lakes in the bluestone mines are concentrated especially east of Bruntál, the singleton occurrence is also in the vicinity of Vrbno pod Pradědem and in Český kras. Another lakes are fixed to greywacke which occur only in Morava especially in the fringe areas of Oderské vrchy and Nízký Jeseník, sporadically, in Moravský kras or in the vicinity of Litovel. The water body in the compact sediments is also the lake in the quarry Rasová in claystone and sandstone near Komňa as well as the lake in the pudding stones of Cetraceous Period in the Natural Park Skalka near Žehušice.

The lakes originated in connection with the mining of granite are evenly spread in the region of the whole Středočeská pahorkatina and Českomoravská vrchovina on the places where the granite plutonic rock ascends towards the earth's surface. The highest concentration of the lakes may be found in the fringe area of Železné hory north of Hlinsko (quarry Srní, Fig. 6) in the vicinity of Skuteč, the other large concentration is the locality around Žulová in Žulovská pahorkatina in northern Moravia. The lakes fixed to diorite or granodiorite are located especially in Benešovská pahorkatina (Hříměždice and Kozárovice) and then only sporadically near Polička and Jablonné nad Orlicí. The lakes originated after the mining of whinstone sporadically occur in northern Bohemia at the well-known locality of Panská skála near Kamenický Šenov in the fringe area of České Středohoří and near Heřmanice in Frýdlantská pahorkatina. The solitary lake in whinstone may also be found in the quarry Hlavno near Sokolov. This group also includes the lake in the former teschenite (dark coarse-grained effusive rock) quarry near Žermanice in the vicinity of Havířov.

There are quite unique lakes in the Czech Republic. The lakes of this group originate after the mining of the mineral resources which affect the chemical composition of the lake water rather significantly. For example: Kamencové

Fig. 6 – The Quarry Srní – lake originated in connection with the mining of granite (foto J. Česák)

jezírko (Alum lake) near town Chomutov, Červené jezírko (Red lake) near village Hromnice, Stříbrné jezírko (Silver lake) near Fulnek ect.

9. Conclusion

Besides the lakes of natural origin, in the Czech Republic there are also a lot of standing water accumulation originated in the locations after the completion of the mining of mineral resources. With respect to small number of natural lakes, those are of concern in our country and it is necessary to give attention to them within the scientific research. Information acquired within such research may be instrumental in the considerations of their future reasonable utilisation within the scope of the environmental protection and landscape preservation, water resources management purposes, and the recreation facilities. The water accumulations originated due to the mining activities are referred to as anthropogenic lakes. We use the term "lakes" in spite of the fact that they did not originate by means of natural processes.

The genetic classification is based on the classification of lakes according to the way of origination of the lake basin while the geomorphologic viewpoint prevails: glacial lakes, fluvial lakes, karst lakes, lakes dammed-up by landslides, organogenous lakes and anthropogenic lakes. As the anthropogenic lakes we may regard all the water bodies which originated as a consequence of the human activity – mining of mineral resources (sand, sand-gravel, kaolin, coal, limestone, bluestone, greywacke, granite, diorite, whinstone, brick clay, loam and other mineral resources).

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Shrnutí

GENETICKÁ KLASIFIKACE JEZER ČESKÉ REPUBLIKY

„Jako jezero je označována stojatá stagnující vodní hmota, která se nachází v prohlubni zemského povrchu, na všech stranách uzavřené a nemající spojení s mořem." Takto široce definuje jezero významný německý limnolog F. A. Forel (1901). Podle této definice lze za jezero považovat každou vodní plochu (louže, rybníky, močály), která nemá spojení s mořem bez ohledu na její velikost. Po rozboru další limnologické literatury (Hutchinson 1957, Wetzel 2001, Kalf 2002) jsme s přihlédnutím na specifické podmínky Česka formulovali vlast-

ní definici jezera: „Jezero je přírodní či antropogenní deprese na zemském povrchu nebo pod ním, trvale nebo dočasně vyplněná vodou. Oproti rybníkům a vodním nádržím se jezera nedají jednoduchým způsobem vypustit."

Vedle jezer přírodního původu se v Česku vykytují rovněž četné stojaté vodní akumulace v prostorách po těžbě nerostných surovin. Vzhledem k malému počtu přírodních jezer mají pro naši zemi význam a je třeba jim věnovat pozornost v rámci badatelského výzkumu. Jeho poznatky mohou napomoci úvahám o jejich racionálním budoucím využití, ať už v rámci záměrů ochrany přírody a krajiny, k vodohospodářským účelům či rekreačnímu využití. Vodní akumulace vzniklé těžební činností člověka označujeme jako jezera antropogenní. Název "jezera" přitom užíváme i přes to, že nevznikla přírodními procesy. Mnohá z nich však přírodní jezera vlastnostmi svých vod připomínají. Zvláště ta antropogenní jezera, která vznikla po dávné těžební činnosti, vytvářejí často cenné přírodní ekosystémy, jež je třeba zachovat pro budoucí generace.

Jezera ledovcového původu nalezneme na Šumavě. Jedná se o pět jezer (Černé, Čertovo, Plešné, Prášilské a Laka), která leží v karech hrazených morénami Würmských ledovců. Kromě jezera Laka, jehož hráz byla uměle zvýšena, se vyznačují velkou hloubkou. V Krkonoších nalezneme malé ledovcové jezírko ležící v moréně pod Kotelními jamami, které se nazývá Mechové.

Fluviální jezera se nacházejí na dolním a středním toku našich řek. Jsou svědectvím dřívějšího vývoje říční sítě. Mnoho těchto „mrtvých ramen" bylo odděleno uměle při rekultivacích vodních toků. Vyskytují se zejména podél toků Labe, Moravy, Dyje, Lužnice, Orlice a Odry.

Krasová jezera vznikají akumulací srážkové či podzemní vody v dutinách či depresích krasových hornin, jsou tedy vázána na vápencové případně dolomitové oblasti. Drobná krasová jezírka se vyskytují prakticky v každé české krasové oblasti. Většími krasovými vodními plochami jsou jezera na dnech propastí (Macocha, Hranická propast).

Nejmladším českým jezerem je Mladotické (Odlezelské) jezero, vzniklé zahrazením údolí Mladotického potoka v roce 1872. Menší sesuvem hrazená jezera se nacházejí také ve Vsetínských vrších.

Jezera organogenního původu vznikají nadržením srážkové či podzemní vody v mělkých depresích za spoluúčasti procesů rašelinní či tvorby slatin. Rašelinná jezera jsou obecně malých rozměrů a vyskytují se téměř ve všech našich pohraničních pohořích. Nejvíce se jich nachází v chráněném území Modravské slatě v centrální části Šumavy.

Antropogenní jezera lze rozdělit na tři základní skupiny. Rybníky, vodní nádrže a vodní plochy vzniklé v souvislosti s těžební činností člověka. Jak plyne z naší upravené definice pro česká jezera, zajímají nás antropogenní jezera vzniklá po těžbě nerostných surovin. Dělíme je podle druhu nerostné suroviny, po jejíž těžbě jsou pozůstatkem. Jsou to: 1. Písek a štěrkopísek, 2. kaolin, 3. hnědé a černé uhlí, 4. vápenec, břidlice a droby, 5. žula, diorit a čedič, 6. cihlářská hlína, jíl a 7. jiné nerostné suroviny.

Obr. 1 – Černé jezero – ledovcové jezero ležící v centrální části Šumavy (foto M. Šobr)
Obr. 2 – Jezero Labiště pod Opočínkem je typické fluviální jezero, bathymetrická mapa ukazuje rozložení hloubek v bývalé řece (v metrech)
Obr. 3 – Fluviální jezero Labiště pod Opočínkem (foto M. Šobr)
Obr. 4 – Mladotické (Odlezelské) jezero, pohled z oblasti přítoku ke hrázi – sesuvu (foto M. Šobr)
Obr. 5 – Blatenská slať, příklad organogenních jezer na Šumavě (foto T. Hrdinka)
Obr. 6 – Lom Srní – jezero vzniklé jako pozůstatek po těžbě žuly (foto J. Česák)

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