Jezero Jižní Pesteana

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Abstrakt

Jezero Jižní Pesteana vzniklo počátkem roku 2015 ukončením produktivních činností (těžba hnědého uhlí) ve stejnojmenném povrchovém dolu. Doposud je zaplaveno přes 70% původní části povrchového dolu, přičemž výška hladiny je udržována provozem části odvodňovacího systému, který sloužil povrchovému dolu tak, aby byla chráněna blízká železnice a domácnosti. Hlavními zdroji vody jsou zvodně (freatické a hlubinné) přerušené důlními pracemi a v menší míře voda přímo ze srážek nebo povrchového odtoku. V současné době není stanoven přesný účel nově vzniklého jezera, avšak v úvahu se berou různé možnosti: rekreační jezero, rybolovné jezero, zavlažovací nádrž nebo jejich kombinace.

Lake South Pesteana

Lake South Pesteana was formed, starting with 2015, with the cessation of productive activities (lignite mining) in the open pit of the same name. Until now, the remaining gap of the open pit is flooded in a proportion of over 70%, the level being maintained by keeping in operation a part of the dewatering system that served the open pit, in order to protect the nearby railway and households. The main sources of water are aquifers (phreatic and deep-water) intercepted by mining works and to a lesser extent water directly from rainfall or surface runoff. At the moment, a precise destination of the newly formed lake is not established, however being taken into account different options: recreational lake, fish lake, irrigation tank or combinations between them.

See Pesteana Süd

Der See Pesteana-Süd entstand am Anfang des Jahres 2015 dank der Einstellung der produktiven Tätigkeiten (Braunkohlegewinnung) im gleichnamigen Tagebau. Bislang ist mehr als 70 % des ursprünglichen Teiles des Tagebaus beflutet, wobei die Wasserspiegelhöhe durch den Betrieb eines Teils des Entwässerungssystems gehalten ist, der dem Tagebau so diente, damit die nahe Eisenbahn und Haushalten geschützt wurden. Die Hauptwasserquellen sind Grundwasserkörper (freatische und unterirdische), die infolge Bergbautätigkeiten durchgebrochen werden und im kleineren Maß ist das Wasser direkt aus Niederschlägen oder aus dem oberflächigen Ablauf. Gegenwärtig wird ein genauer Zweck des neu entstandenen Sees nicht festgelegt, in Betracht werden verschiedene Möglichkeiten genommen: Erholungssee, See für Angelsport, Bewässerungsbecken oder deren Kombination.

Klíčová slova: jezero, povrchový důl, hnědé uhlí, Jižní Pesteana, hydrogeologie, zvodně.
Key words: lake, open pit, lignite, South Pesteana, hydrogeology, aquifers.

1 General informations

South Pesteana open pit is located in the south-eastern extremity of Rovinari coal basin, in the Jiu river meadow, between Olari and Plopşoru localities, on the national road DN 66 Filiaşi - Tg. Jiu and the localities Urdari and Fântânele, on the county road DJ 674 Turceni - Fărcăşeşti - Rovinari.

From an administrative point of view, the open pit perimeter is part of the territory of Urdari and Plopşoru villages.

The mining perimeter, with a total area of 4.767 km^2, is delimited as follows (Fig. 1):

- east – the regularizing channel of Jiu river,
- west – Urdari village,
- north – former dump of Urdari open pit,
- south – former exterior dump of South Pesteana open pit and the Jiu river.

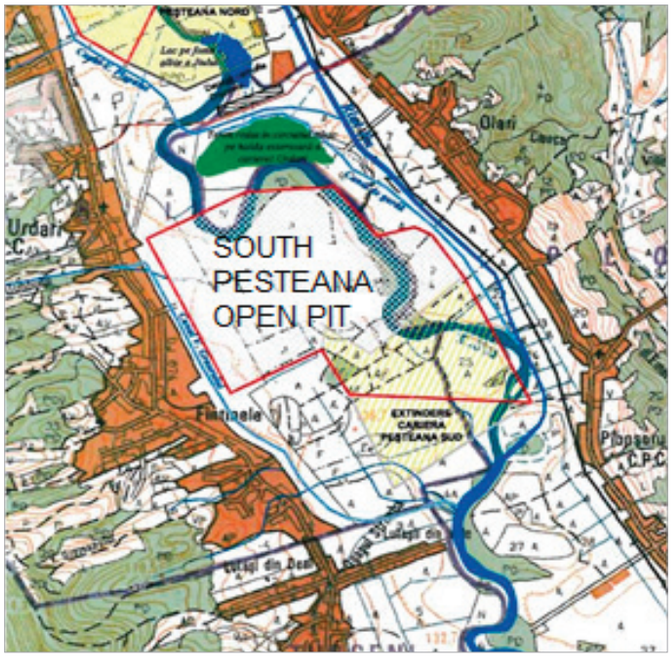

Fig. 1: South Pesteana - mining area and its surroundings.

2 Site morphology

From the morphological point of view, the perimeter of the South Pesteana open pit is part of the Getic Plateau. Situated at

the junction between Jiu and Jilţ rivers, the perimeter comprises the Jiu Plain (meadow) about 2.5 km wide, with elevations ranging from +153 m to +130 m, with inclinations from west to east (to the Jiu riverbed) and from north to south (Fig. 2).

The relief is presented in the form of plain and lower terraces in the area adjacent to the Jiu river (Fig. 3).

The hills that surround the region have a pronounced platform aspect, characteristic of the Getic Plateau, with altitudes around +300 m and slopes up to 30°. The surrounding hills have heights ranging from +255 m (Aninoasei Hill) to +274 m (Cioaca Hill). They are forested and are crossed by numerous valleys that have the general flow direction from west to east.

3 Geology

The stratigraphic succession of the sedimentary deposits in the Rovinari mining basin is related to the general evolution of the Getic Depression, where formations belonging to the Cretaceous (Albian-Senonian), Paleogene, Neogene (Miocene, Pliocene) and Quaternary were highlighted (***, 2012) (Fig. 4).

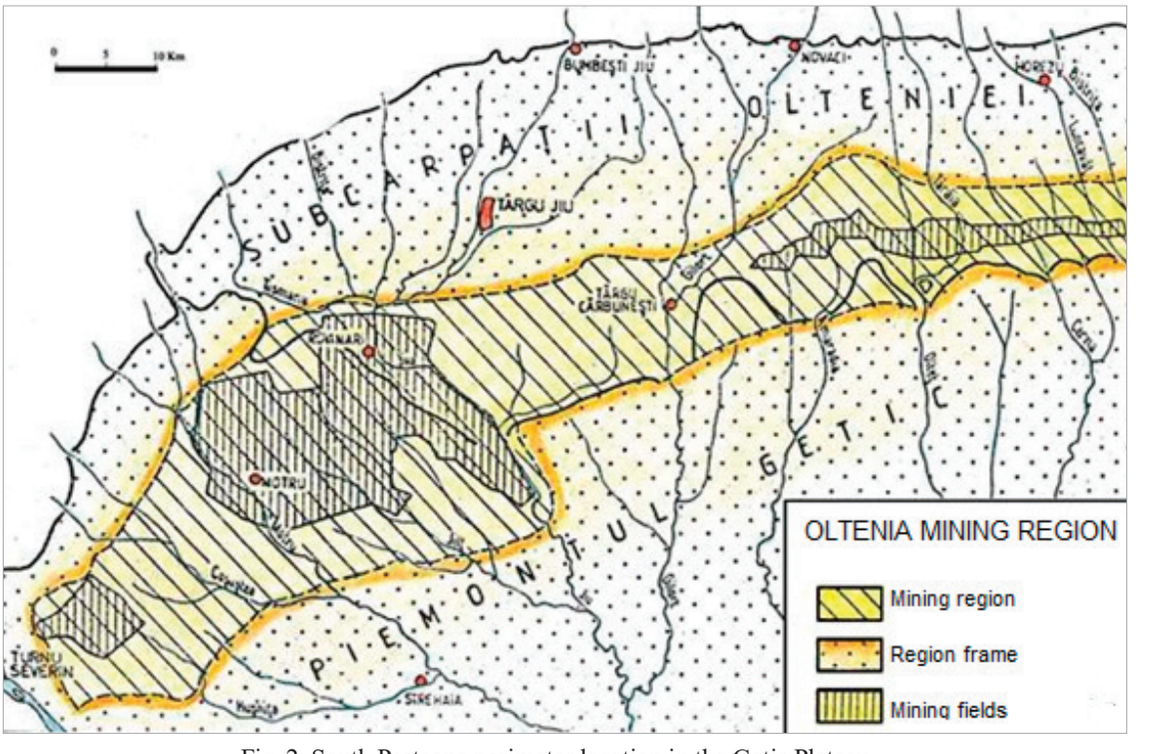

Fig. 2: South Pesteana perimeter location in the Getic Plateau.

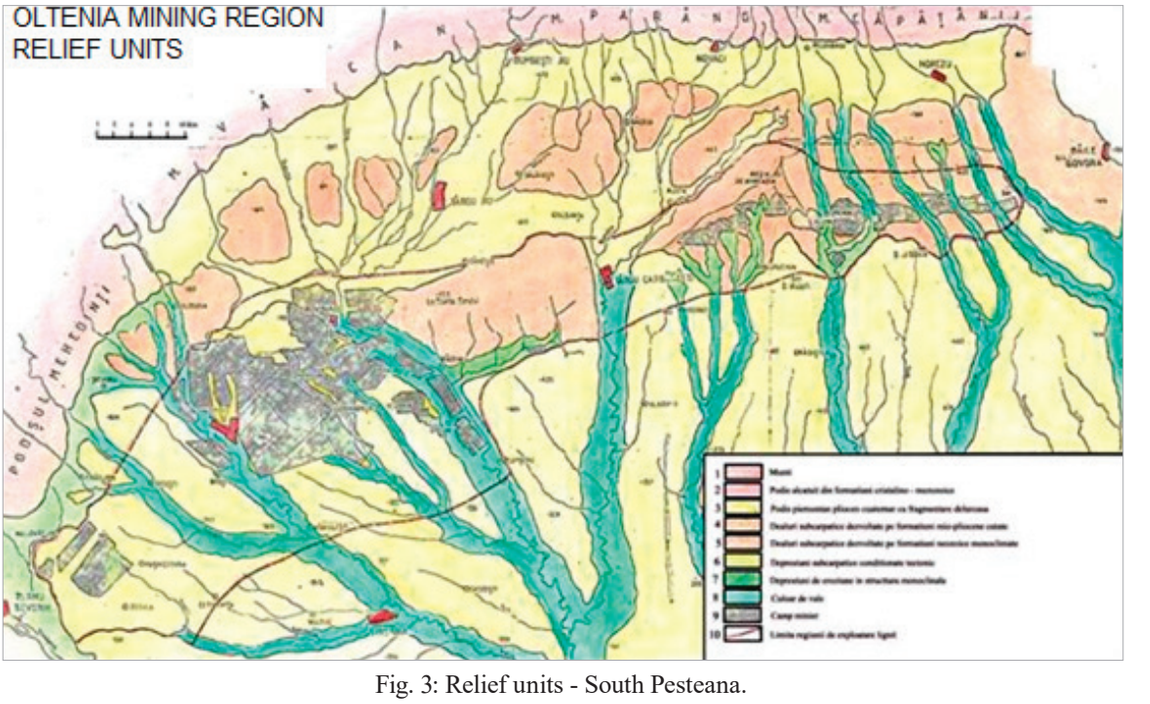

Fig. 3: Relief units - South Pesteana.

The Cretaceous is composed of a bundle of grey, fine micaceous marls, blackish clays and thin sandstones intercalations, thin conglomerates at the base, over which the grey sandstones, marls and clays have settled.

The Paleogene is represented by two horizons of the Eocene (the basal conglomeratic horizon and the marly horizon, situated above, consisting of a monotonous succession of clays and marls with intercalations of sands and sandstones), marls, sandstones and sands, with marl-limestone intercalations.

The Neogene is represented by a succession of polygene and breccia conglomerates followed by coarse sands and shale clays over which compact marls have been settled with sandy intercalations. Also, coarse deposits appear in the marl areas and the marl clays in the centre.

The Pliocene is represented by its four eras: Meotian, Pontian, Dacian and Romanian.

The coal layers that have been exploited in the South Pestean open pit are included in Dacian, which is represented by a succession of clays, sandy clays, sandy marls and sands with lignite layer intercalations, which marks the entry of the basin into the final state of its evolution. Based on the lithology, the correlation of the lignite layers and the micro-fauna, within the Dacian layer two horizons were separated:

- lower horizon, sandy, with Pachydacna,
- upper horizon, clayey, sandy, with coal.

In the western sector of the depression, the lower horizon is composed of fine and medium sands, with clayey intercalations.

At the top of the sandy complex is the first layer of coal (the first layer with general extension in the region). Next, there is an alternation of fine grey sands with compact clays, sometimes sandy clays, between which the lignite layers II, III and IV are intercalated. Within the basin there is a gradual change of facies, of clays passing to sands, so that the whole range is composed of fine sands with coarse sands intercalations, with small gravel elements. Near the Jiu river, the first and second layers become thinner, the first lignite layers encountered in the Dacian succession being III and IV, with large non-settling areas. In these sands is located the main artesian horizon of the region. The thickness of the lower horizon is from 90 m to 150 m. The upper horizon is composed of clays, sandy clays of grey colour, marls, alternating with fine and medium sand banks, sometimes coarse and coal layers (V-VII). At the bottom is a "lumaselic" (sedimentary rock with numerous mollusc shells) horizon of general extension, which is the benchmark for the correlation of lignite layers in the region (***, 2007).

In the eastern part, the Dacian is also present through its two horizons, but layers III and IV of coal become thinner, so that the entire lower horizon appears composed of banks of fine or coarse sands, with rare clay intercalations.

In this sector, the upper horizon begins with sands with pelitic levels, in which there is the fossiliferous horizon, over which a succession of compact, greenish-gray fine clays, with intercalations of fine sands and lignite layers, in general with small thicknesses, not exploitable, the main lignite layer that has economic importance is the V layer, made up of 1 to 3 benches arranged in an interval of 5 ÷ 20 m (***, 2007).

The Romanian has frequent facies differentiations, being made up of an alternation of clays, coarse sands and small gravel with lignite layer intercalations, sometimes associated with coal clays. In this suite, with the thickness between 60 m and 80 m, the lignite layers VIII-XII are included (Fig. 5).

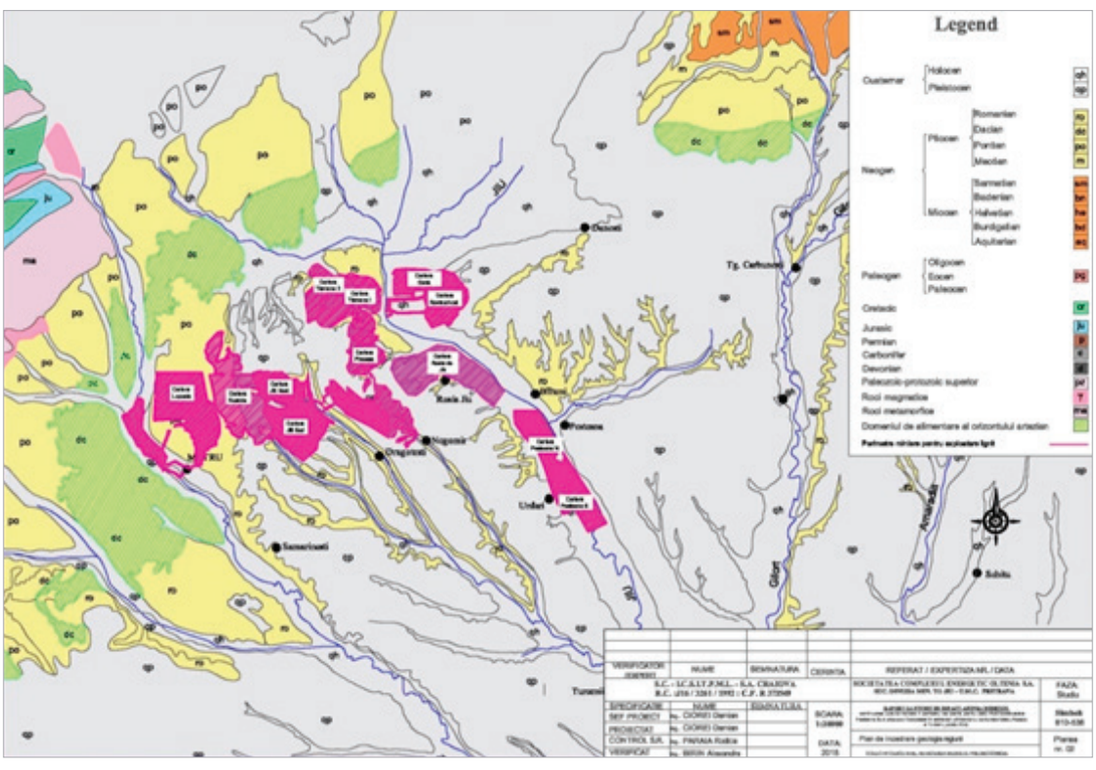

Fig. 4: Geology of the region.

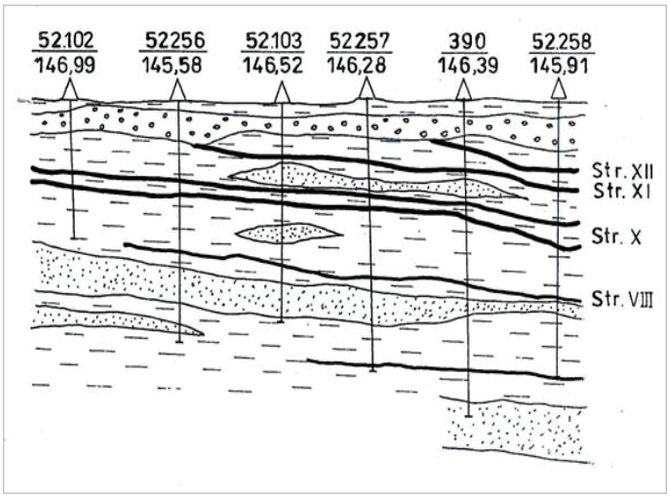

Fig. 5: Geological boreholes - The lignite layers VIII-XII and sterile intercalations.

3.1 Structural and tectonic elements

The structure of the Pesteana lignite deposit has begun to be deciphered since the preliminary exploration phase, when the major Negomir-Pesteana anticline fold was revealed, being located in its central southern area.

The northern flank of this anticline has large falls and is tectonized. The southern flank of the anticline, where the exploitation perimeter of the South Pesteana open pit has the characteristics of a monocline with small inclinations oriented to the south-east (5 ÷ 6°) and has some local undulations (***,2012).

The elevation and division of the northern flank of the Negomir-Pesteana anticline fold resulted in erosion removal of the upper layers of lignite including the X layer, which appears only in the north of the North Pesteana perimeter on a restricted surface (X inferior layer), making the exploitation of the Vth layer possible (***,2012).

Based on the natural factors, the lignite deposit in the South Pesteana perimeter was classified in the second grade of geological complexity.

4 Hydrological and hydrogeological conditions

The hydrographic network in the area is represented by the Jiu river and its tributaries, consisting of streams that form on the valleys (Nyari, 2017), namely:

- from the right side: Săscuia Valley, Graurului Valley, Urdari Valley, Orezeanului Valley,
- from the left side: Cocorenilor Valley, Oprii Valley and Mare (Big) Valley.

The banks of the Jiu River, as well as the rivers of the tributary valleys, on their lower course, are regularized. The mine was opened and continued to develop in the area where the bed of Jiu river existed before its regularization.

The aquifers horizons identified by the hydrogeological exploration works within the South Pesteana perimeter have been classified, depending on the conditions of the deposit, in:

- free-level (groundwater or phreatic) aquifers;
- under pressure aquifers with ascending or artesian levels (Fig. 6).

4.1 Phreatic aquifer horizon

Phreatic aquifer horizon is located in the quaternary alluvial deposits from the meadow and terraces of the Jiu river, as well as in the alluvial cones of the streams in the area. The thickness of the alluvium in the perimeter varies between 3.75 and 19 meters. This aquifer horizon has as sources of alimentation both atmospheric precipitation and surface water.

The hydrostatic level of the phreatic layers is located between +134.8 m and +128.83 m. The hydrostatic levels with higher elevations, between 143.14 m and 150.25 m, from the south-west of the South Pesteana perimeter indicate cantonal groundwater in the upper terraces of the Jiu or its tributaries. Due to the capacity and the important dynamic resources, with the possibility of rapid regeneration of the reserves, the groundwater aquifer horizon creates special difficulties in the exploitation of the lignite.

The large variation of the flow parameters (q, k), attests a high heterogeneity of the granulometry of the alluvial deposits, which sometimes has high permeability, with q = 325 ÷ 350 m^3/day/m and k = 4 ÷ 96 m/day, and sometimes lower, with q = l0 ÷ 32 m^3/day/m and k = 3.8 ÷ 4 m/day (***, 2012). The groundwater aquifer partially feeds some lower pressure aquifers, which it comes in direct contact with.

4.2 The aquifer horizon from the roof of the XII layer

The sands from the roof of the XII layer have a restricted spread, with sporadic occurrences in the southern part of the South Pesteana perimeter, with thicknesses of 2 ÷ 15 m. The XII layer is eroded in the northern area of the perimeter, and to the south it comes in direct contact with the groundwater aquifer horizon on the path of the old Jiu river bed. It was little researched due to the reduced extension, it having the hydrostatic level at 128.74 m, the specific flow q = 14.3m^3/day/m and k = 0.63 m/day (***, 2012).

4.3 The aquifer horizon in the interval of layers X-XII

The aquifer horizon is eroded on large surfaces within the perimeter. The sands in which this horizon is confined have a discontinuous development, in the form of lenses with a thickness of 2.5 ÷ 6.5 m, with rare thickening of 10 to 12 m in the North of the perimeter and with frequent tapering in the centre and south of the perimeter.

It emerges (outcrops) to the south of Cocoreni village in the east and Toporăşti village in the west, coming in direct contact with the alluvial formations of the Jiu Plain, which favours the alimentation of the aquifer horizon from this interval directly from the groundwater horizon.

The waterproof screen from the roof of the X coal layer is of 2 ÷ 4 m in the west, sometimes falling to 1 m, and in the bed of the XII layer it varies between 3 ÷ 4 m in the north-east and 1 ÷ 4 m in the southwest of the perimeter.

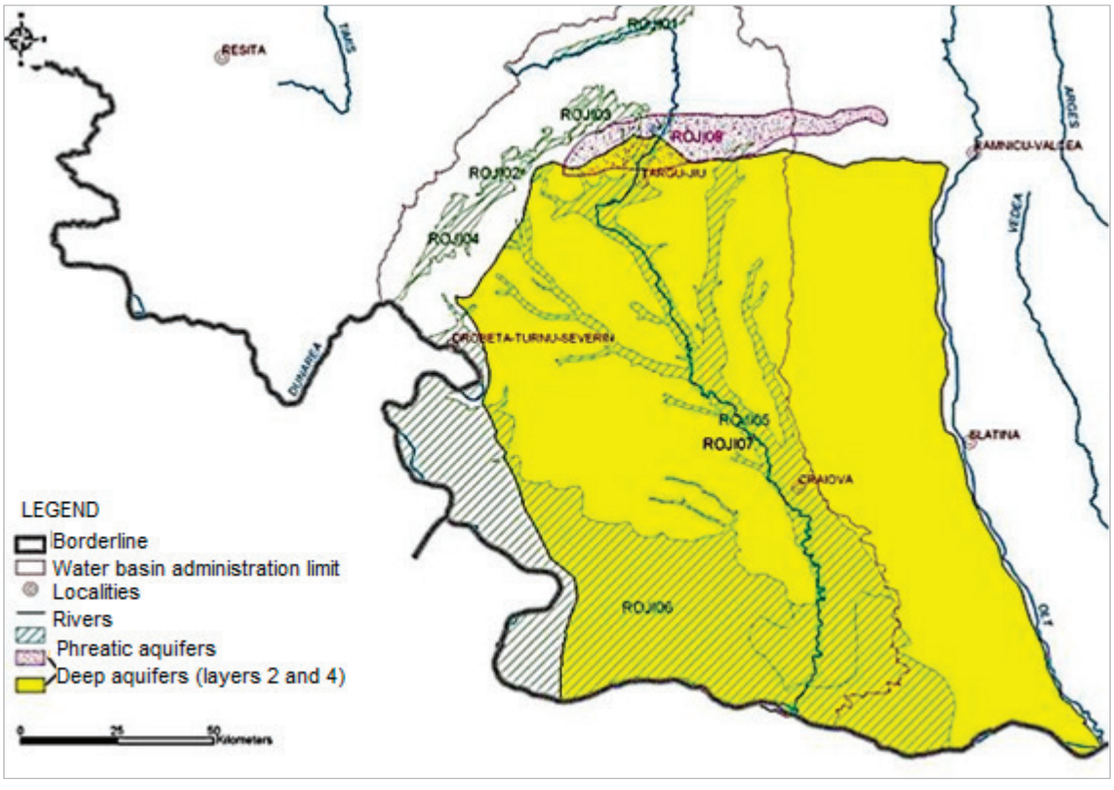

Fig. 6: The groundwater bodies in the area (***, 2012).

The specific flow capacity has values of 1.27 ÷ 5.55 m^3/day/m, with an increasing tendency towards the northwest and southeast to 10 ÷ 36.8 m^3/day/m (***, 2012).

The granulometric composition, which varies from clay sands to fine-medium sands, determines large variations of the values of the filtration coefficient (0.1 ÷ 4.8 m/day).

The other aquifer horizons located below layer X have no influence on the surface mining operations.

The dewatering of the groundwater horizon was made through three dewatering rings, and for the aquifer horizon between the X-XII lignite layers, large diameter drainage drills were placed, located on the contour and inside the perimeter to reduce the water flow from the aquifer horizons located in the roof of layer X. The volumes of water discharged were between 10 and 13 million m^3 water/year.

5 Climatic conditions

Located in the south-west of the territory, in the area of the Getic Piedmont hills and sheltered orographically from the north and west of the Carpathian Mountains, it is appreciated that the area where the South Pesteana open pit is located benefits from a more moderate continental climate (***, ANM, 2019).

The average annual temperature ranges from 9.2 to 10.1° C with lower values in January: 2.5° C and higher in summer, in July: 20-21° C.

The absolute thermal extremes ranged from 37-39° C to -30, -31° C.

Cold nights like winter days have a lower frequency: 16-20 cases, and frost days, due to the local relief reach 110-120 cases.

The atmospheric precipitations are relatively rich, with average annual quantities between 746 - 906 l/m2 but with years in which they can exceed 1180 - 1330 l/m2, or they can fall to 430 - 580 l/m2. The maximum amounts of precipitation in 24 hours can exceed - sometimes appreciably - the average monthly quantities.

The snow layer lasts on average 46 - 57 days annually, and its average decay thickness can reach 14 - 72 cm.

The wind is influenced by the character of the general circulation and especially by the shelter and the general orientation of the major forms of relief. In this context, predominant winds from the north-east, north and south-west directions at Tg. Jiu and west, east and south-west at the Apa Neagra. The monthly, seasonal and annual frequency of calm is appreciable (57-80 %). Due to the orographic shelter, the blizzard phenomenon is almost non-existent in this area (about 0.1 to 0.2 days/year). The glazed frost, also a meteorological phenomenon specific to the cold period of the year, presents an average annual frequency of only 0.4 to 1.2 days.

6 Geotechnical problems

After the cessation of the activity, the abandoned mining works do not endanger human settlements, the nearest village being located at a distance of 900 m.

During the period following the cessation of activity, it is necessary to model the upper levels of the open pit and the dump, in order to be played into the economic circuit and to protect the surrounding areas (Apostu and Faur, 2019).

After the cessation of the mining activity and after the full filling of the remaining gap with water, naturally, in time, the watercourses in the area will be restored, at quotas that have no connection with the situation existing before.

As after the cessation of the dewatering works the rehabilitation works were not executed, the uncontrolled flooding of the remaining gap began (Apostu and Lazar, 2018). Almost 5 years after the cessation of the exploitation works, the remaining gap of the South Pesteana open pit is flooded by natural means (infiltration from the aquifer and precipitation formations) in a proportion of about 70%.

The water level of the lake is maintained by operating a pump station and by pouring water into the Jiu river through a drainage channel. These measures are needed to protect households in the area of influence from flooding and/or landslides.

During the flooding process, no negative geotechnical phenomena (subsidence, landslides, discharges, etc.) were observed of the final slopes or of the slopes of the inner dump of the remaining gap.

It should be noted that the mining equipment was withdrawn from the open pit and placed on the surface, being used for spare parts.

7 Reclamation

The coal mining exploitation activity in the South Pesteana open pit ceased according to the Order regarding the approval of the Technical Instructions for the closure of mines (***, 1998) and the Law no. 85 (***, 2003), chapter VII- „Mines closure“, namely that the exploitation became economically unprofitable.

The remaining gap resulting at the moment of cessation of exploitation activity is located in the southern part of the perimeter and the decision regarding its rehabilitation and reuse took into account the flooding and the formation of a lake that may take on different functions in the future. The geometrical elements of the lake, as well as an aspect regarding the concept of land rehabilitation affected by the South Pesteana open pit are presented in the Tab. 1 and Fig. 9.

Fig. 7: South Pesteana pit lake with the discharge channel, old equipment and pumps station.

Fig. 8: South Pesteana open pit flooded about 70% (Google Earth).

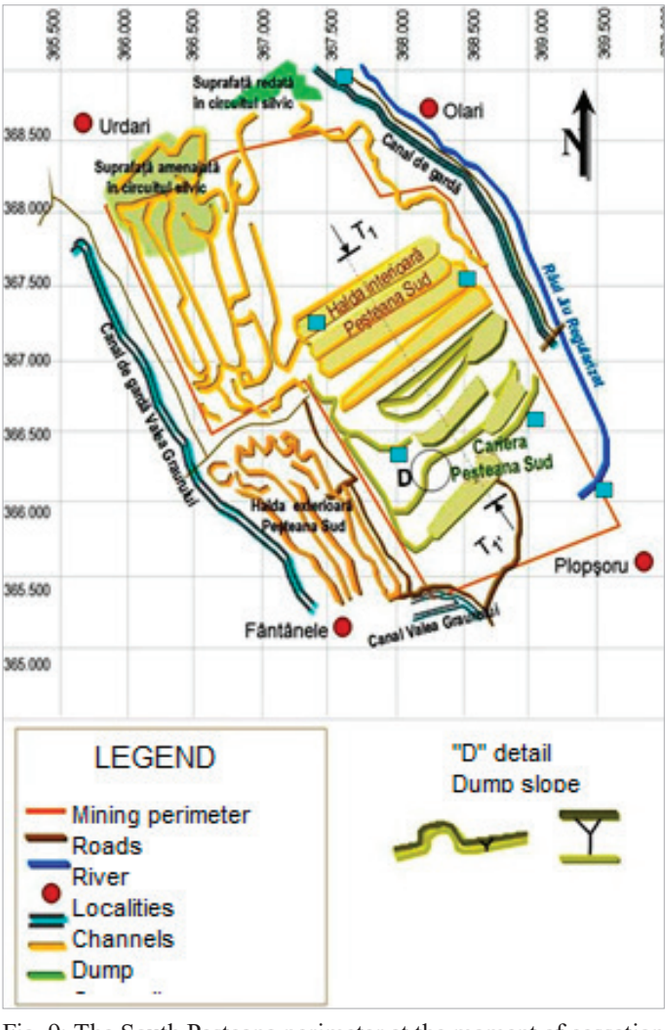

Fig. 9: The South Pesteana perimeter at the moment of cessation of exploitation activity.

It is considered that the level of the water inside the remaining gap will be controlled during the period of transporting the machinery, from the mine on the upper step, with the help of the pump stations, at the minimum elevation of the upper platform of the step I (+108 m). In the conditions in which the drainage of the aquifer horizons is done gravitationally, it is necessary the permanent operation of the pump stations.

The protection of the deposit, respectively of the lignite layers located above the water level and remaining under the influence of the natural factors (air, water, wind) will be realized with impermeable material (clays), after the definitive slopes have been arranged, in order to prevent the ignition of coal.

No special works were necessary for the interior waste dump to ensure its stability, but special attention was paid to the following measures to prevent landslides:

- twinning of the dump slopes with the final slopes of the open pit;
- elimination of water accumulations on the surface of the dump and on the berms;
- execution of drains on the base of the open pit.

The total area of the licensed perimeter is 628.31 ha; area occupied until 30. June 2015 is 480.20ha; surface not affected by mining works is 148.11 ha and the total area to be integrated

Tab. 1: Basic characteristics of lake South Pesteana.

Surface level of the lake	125.0 m asl
Surface area of the lake	154.3 ha
Average length	1 455 m
Average width	1 060 m
Max. depth of the lake	45.0 m

in the economic circuit is 202 ha (the surface proposed for agricultural purposes (inner dump) is 76.0 ha; the surface proposed for forest plantations is 126.0 ha; the area occupied by the enclosure is 65 ha) (***, 2015).

Acknowledgments

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