HYDROGEOLOGY OF EAST SLOVAKIAN NEOGENE COAL DEPOSITS

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ABSTRACT

Groundwater conditions are considerably influencing underground coal mine planning development and operations. Hydrogeological problems are expected in East Slovakia where groundwater occur under artesian pressure and rises to high water inflows . The hydrogeological complexity is demostrated on example of the Sejkov lignite deposit .

INTRODUCTION

Due to continuous exhausting of the home raw material base and a world power crisis as well, there is an increasing interest in utilization of domestic coal resources though characterized by lower caloricity, less amount of reserves but of favourable geographic position, and rather difficult mining and hydrogeological conditions .

Several coal deposits are known in Eastern Slovakia having been subject to geological prospection and investigation but not used from industrial point of view until now. There are lignite deposits involved of Sarmatian-Pliocene age occuring in the Sub-Vihorlat Coal Basin situated on the Vihorlat-Popričný Volcanic Massif slope .
In this coal basin mentioned, the Hnojné and the Sejkov-Vyšné Nemecké deposits were in 1951-1957 most intensively explored the Sejkov deposit having been subject to experimental openings , too .
In the frame of geological survey operations carried recently out for proving oil and gas-bearing horizon occurence in the East Slovakian Lowland , possible coal-bearing areas have been there studied at the same time . From among them, the Michalovce-Ňačovce-Bežovce and the Sečovce-Malčice-Trebišov regions seem to be e.g. as very promissing ones where new lignite deposit indices to be subject to future investigation have been noticed /see Fig.1./.

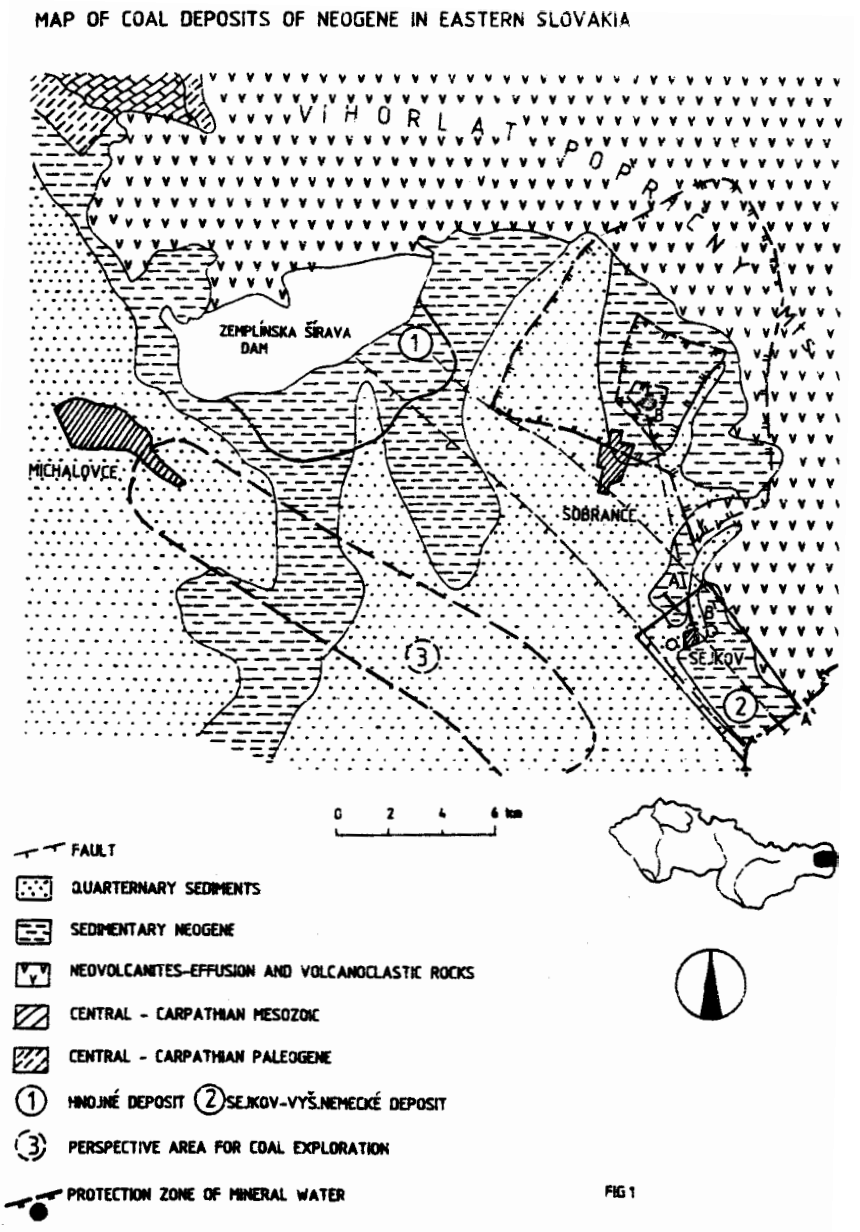


FIG 1

GEOLOGICAL AND HYDROGEOLOGICAL FEATURES OF COAL DEPOSITS

The Hnojné deposit lies in the Sub-Vinorlat and Zálužice hills east of Michalovce City and is of the following stratigraphic development. In the lowermost part of the subject basin there are Mesozoic. Central Carpathian Paleogene and marine Tortonian rocks deposited Mesozoic being present in Middle Triassic to Cretaceous evolutions. Central Carpathian Paleogene forming the remaining part of Neogene Basement is represented by a variegated Eocene formation consisting of conglomerates, sandstones and shales from among which sandstones predominate.
The coal-bearing formation is to a considerable extent underlain by marine sediments referred to Tortonian and consisting of sandstones , conglomerates and salt-bearing beds as well .
In the area where coal seams are developed , Neogene sedimentation begins with a 200 m thick Lower Sarmatian formation of clay and marly clay to marl composition characterized by variable sandy admixture and compact sandstone intercalactions with calcareous cement as well.
Overlying this, there is an agglomerate-tuffaceous group deposited being formed by lava flows of ampnibole-pyroxene andesite nature where volcanic rocks predominate. The lower group represented chiefly by fine sandy and marly clays of grey to dark grey colours comprising several coal seams of mineable thickness has been gradually developed from this volcanic group mentioned. The lower coal group is overlain by a 30 to 40 m thick interjacent tuffaceous group consisting predominantly of pumiceous tuffites of garnet nature. Overlying this, coal group comprising the main seam formation is developed.It is created by clay , less tuffaceous clay and marly horizon.
In addition to the main seam mentioned , there are 10 to 15 smaller ones of unmineable width and some negligible gravel layers composed of Paleogene pebble material are here present, too .The coal group is overlain by variegated clay beds with frequent gravel layers.
The coal deposit in question is charakterized by relatively simple tectonic pattern. Due to fault system of NW-SE strike. gradual field downthrow/ of dip and fault nature/took there place the deepest downthrown block being of SW direction .
Cross fault tectonics represented by a conspicuous fault has been there noticed, too . Tectonic events are synchronous in time with the upper coal group orgination .

The Hnojné deposit covers an area exceeding 30 km^2. It is the main seam which is there considered as the most important one and may be in the seam complex well correlated. It is developed throught the whole deposit its thickness varying between 2,5 and 5,0 m. The subject deposit is tectonically limited and restricted by the underlying rock configuration gradually dying out southwards in the sedimentary complex.

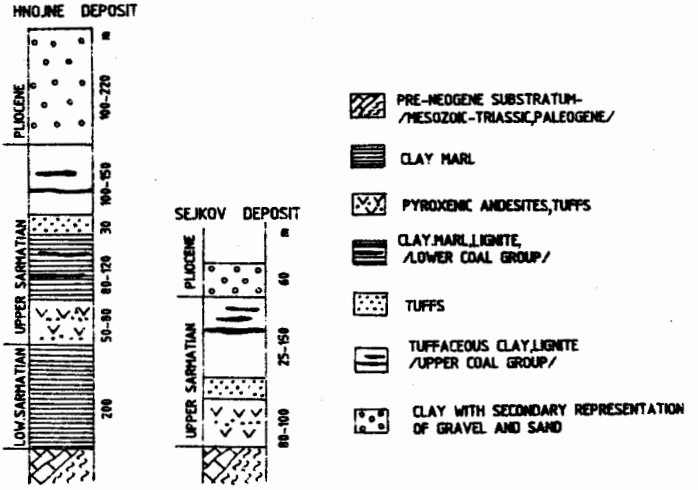
Though of mineable thickness, coal seams underlying the main seam are of lenticular evolution, that is why are considered as questionable from exploitation point of view .
In the underlying Paleogene and Mesozoic formations and in the agglomerate-tuffaceous group as well, artesian waters frequently of piezometric level are present.
In the NW part of deposit , water eruptions took place the well

yield having been 2000 l/min. In the lower coal group and interjacent tuffaceous group there are lower amounts of water in storage of standing level close to surface.
Variegated beds and Quarternary sediments are hydraulically connected with surface waters and are of confined nature, too .
Because of intricate mining and hydrogeological conditions supposed resulting from the so-called Zemplínska Šírava dam partly covering nowadays the coal seam area . the Hnojné deposit is not considered to be extracted in the next time .

The Sejkov-Vyšné Nemecké deposit lies in the Popričný Range foot-hills situated at the Czechoslovak-Soviet boundary and will be soon subject to detailed investigation/see Fig.1 /.
For stratigraphic division of the Hnojné and Sejkov-Vyšné Nemecké coal deposit sediments see Fig.2 .

FIG.2

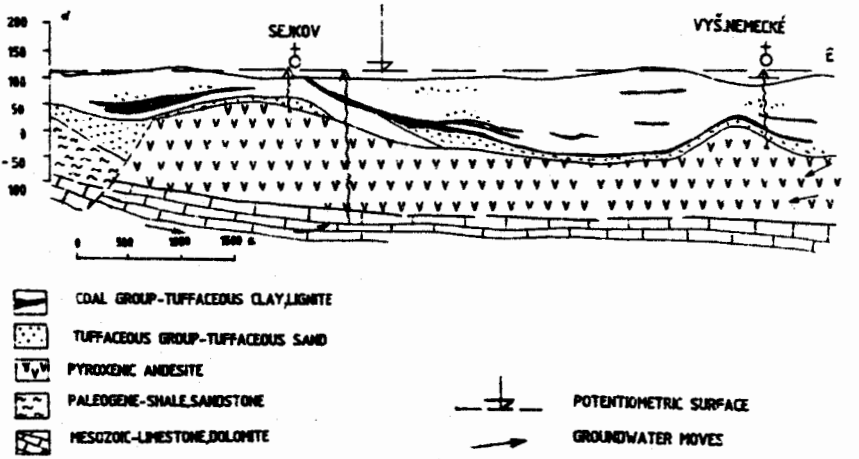
STRATIGRAPHIC AND LITHOLOGIC CONTROL OF LIGNITE DEPOSIT



In the deeper-seated parts it is underlain by Mesozoic forming there an immersed ridge- the so called Humenné-Užhorod Horst the continuation of which in the Hnojné deposit area has been noticed.
From lithological point of view, Mesozoic consists chiefly of limestones, dolomites and breccias of Triassic age.
On both of two sides of the horst, calcareous sandstones and shales of Central Carpathian Flysh evolution have been by geological survey works encounterd.
The volcano-sedimentary coal-bearing complex reaching more than 100 m in width is deposited on this basement mentioned. In its basal part sandy-tuffaceous clayey formations predominate while upwards an increasing amount of volcanogene components has been observed. Overlying those. tuffaceous-clayey beds with coal seams involved are emplaced. Five coal seams are developed

In the subject area the thickness of them being the lower coal seam consisting of lignite material with clay and tuffite together.
Tectonic evolution is considered to be relatively quiet nature. Two normal faults, however, throwing down the coal seam some 60 m have been there noticed, for geologic cross-section of deposit see Fig.3

FIG.3 SCHEMATIC GEOLOGICAL CROSS-SECTION OF THE SEJKOV LIGNITE DEPOSIT A-A`



The direct roof of coal seams is mostly composed of clayey sediments, clays and sandy /tuffaceous/clays /20 to 60m thick/ of very low permeability forming sufficient protection against water inflows. It is in the nothern and norteastern parts of deposits only that there is a lower-grade protection where water-saturated sand and sandy gravel layers occur but they are mostly of isolated nature not interconnected one with the other. Some more permeable layers may be hydraulically connected with surface streams. When performing experimental opening by underground workings, the hydrogeological observations made proved a maximum inflow of 150 to 200 l/min. coming from the roof. From mining point of view, the underlying aquifers are considered as the most important ones. They are predominantly formed by volcanic rocks/tuffites, conglomerates and andesites/ with favourable conditions for groundwater flowing and accumulation as well. There is artesian water with piezometric level involved. When encountered by drilling, water flows from wells have been in many cases observed. Water present in these aquifers is mostly in direct contact with the seam and shows considerably high pressure related to the coal seam depth. In case of the Sejkov II. Shaft, breakdown of the inclined shaft bottom has been close to the face observed resulting from high water pressure of a standing inflow of 300 l/min.

coming from the underlying tuffites flooding an area covering 100 m in the inclined shaft /.
Underlying these aquifers mentioned. Mesozoic rocks /limestones and carbonatic breccias / are in depths reaching more than 200 m situated. The waters involved may be interconnected with the volcanic rock aquifers. In pumping tests performed , the well yield was varying between 0,1 and 0,4 l/s in case of a 1 to 40 m drawdown, water flows from wells and saturation by carbon dioxide have been somewhere observed while after encountering the aquifer , in some wells eruptions took place. It is Humenné Range which is considered as the infiltration area of these horst waters , while a certain amount of those is derived from neovolcanites of the western part of the Vihorlat Range .Under favourable lithological-tectonic conditions , waters may migrate from Mesozoic into Neogene formations. The drainage function supposed of Mesozoic rocks underlying the volcanic ones is proved by considerably high water-bearing capacity of the subject horst related to the extent of Mesozoic outcrops in the Humenné Range /few springs, low run-off values/.
Hydrogeological data coming from positive hydrogeological wells are presented in the following table:

Table 1.Hydrogeological Data from Exploration Wells in the Sejkov-Vyšné Nemecké Deposit Area

Well No	Depth /m/	Proved interval /m/	Rocks	Yield l/s	Draw-down /m/	Stan.level below.surface/m/
VH-1	192,0	15-100	andesite	2,38	9,0	0,7-1.6
H-4	281,1	244-298	dolomite	0,3	65,0	5,6
H-5	82,0	65,5-82	andesite	0,6	1,8	1,35
H-6	88,0	76-88	andesite	0,41	2,8	0,7
H-7	288,0	255-289	dolomite	0,9	1,0	w.flow
H-9	96,6	83-96	andesite	7,4	8,0	fr.well 1,6
H-11	115,0	101-115	andesite	0,5	1,0	w.flow
H-12	136,0	129-136	andesite	4,7	2,0	w.flow

On the basis of the results and evaluation of some hydrodynamic tests carried out , the following basic hydraulic parameters of aquifers could have been stated :

	Coefficient of Transmissivity T	Coefficient of Permeability k_f
Tuffaceous clay , tuffite	$1,5.10^{-5}$ m^2/s	$4.0.10^{-7}$ m/s
Tuffaceous breccia. andesite	$3,0.10^{-4}$ m^2/s	$2.0.10^{-5}$ m/s
Limestone,dolomite /Mesozoic/	$1,5,10^{-4}$ m^2/s	
Sandstone,shale /Paleogene/	$4,0.10^{-5}$ m^2/s	

Groundwaters in volcanic complexes are of medium-grade salinity /0,3 to 0,4 g/l/ and of bicarbonate-calcium type their temperature varying between 16° and 18° C. Mesozoic waters are high salinity ones /2,4-4,6 g/l/ of complex chemical type /bicarbonate-natrium-calcium/ their temperature reaching 20°C or even more .

Table 2. Basic Hydrochemical Parameters

Well	Salinity g/l	S_1	A_2	S_2	A_1	Rocks
H-5	0,41	15,68	70,75	13.57	-	andesite
U-49	0,33	-	76,23	23,72	-	andesite
H-4	2,65	30,77	56,68	-	12,55	dolomite
H-7	4,61	13,01	34,06	-	52,91	dolomite

$S_1S_2A_1A_2$ Palmer's characteristics

DEWATERING AND DEPRESSURISATION FOR MINE DEVELOPMENT - DISCUSSION

From the above mentioned it follows that hydrogeological conditions ruling in the Sejkov deposit but in the other ones , too situated in the subject area seem to be highly unfavourable from mining point of view and possible exploitation will inevitably depend on the stage of dewatering performed . It is necessary to point out that exploitation without dewatering of deposits is there not possible at all. From dewatering point of view, the following questions concerning

- -dynamic groundwater resources in case of deep depressions formed due dewatering
- -time factor of pre-dewatering, and
- -dewatering influence on the Sobrance mineral waters

cannot be answered at the present time .

In case of not succeeding in lowering the piezometric level of the underlying aquifer /below the output level/, extremely unfavourable mining conditions including danger of continuous inrushes as well as possible face and support deformations could have been there expected .

By analogy from similar Czechoslovak deposits /e.g. the Dubnany Seam situated in the South Moravian Lignite District/ , dewatering can be made by combining surface dewatering wells with underground workings . Surface wells would serve as predewatering ones by means of drilling filters and the process would be terminated by underground working drainage .

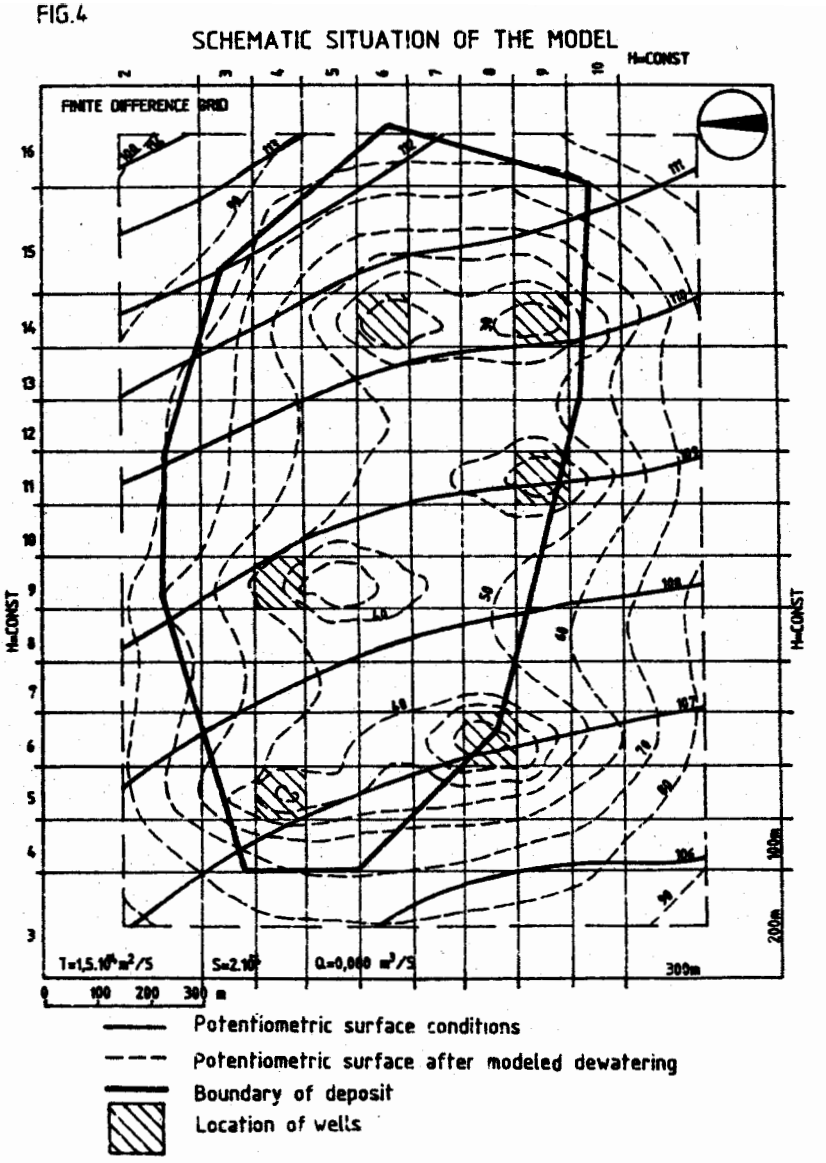
In the course of previous investigations , no attention has been paid to gas hydrogeological survey. In fact, in some wells encountering Mesozoic rocks , mineral waters enriched in carbon dioxide /about 2000 mg/l/ have been there noticed. Some lower enrichment ,however, of similar nature in the underlying volcanic complex /andesites,tuffs/, e.g. in borehole U-49 /about 400 mg/l / has been also found .
Thus, it is necessary to know, whether there is a two-phase system /i.e. water+gas/ or a one-phase one/gas-saturated waters/ involved in rocks underlying the subject deposit. Groundwaters occuring in the immediate base , however, are generally supposed to be of monophase system to be changed into a biphase one due to dewatering influence, i.e. water pressure lowering , and an increased gas saturation pressure will be there observed at the same time.
Gas occurence in groundwaters points to well permeable tectonics and may be considered as the result of post-volcanic activity.

For better demonstration of possible dewatering of the underlying aquifers /groundwater inflow yields/, groundwater flow simulation for water level change forecasting has been performed. The groundwater flow simulation has been carried out by two dimmensional finite difference analogy using digital computer . The subject model has been simulated for steady state flow /by I.Mucha,1985,Dept.of Hydrogeology,Comenius University, Bratislava /.
For basic data /boundary conditions , hydraulic parameters , groudwater levels /see Fig. 4./. The total inflow into the deposit has been first stated by equivalent well method/0,08 m^3/s/. The water take-off facilities /wells/ individual nodes following the deposit course and dip to the south have located in such a way so that the drawdown requested could have been achieved.

On the basis of the results obtained by simulation it may be said that dewatering even under such difficult conditions will be virtually possible but it will have to be convenient to mining plans and the hydrogeological conditions given. The maximum groundwater inflows from the underlying aquifers are expected to be 0,080 to 0,100 m^3/s.

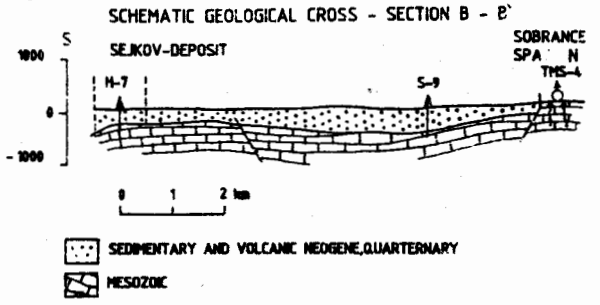
A futher problem to be taken into account is the question of possible influence of dewatering and exploitation on the Sobrance Spa mineral waters being some 8 km far from the deposit only /see Fig.1.and 5./ There are mineral waters of chloride-carbonate and calcium-sodium-sulphate nature of an increased fluoride content/total salinity 10,52 g/l ,890 mg/l CO_2 and 49 mg/l H_2S saturation/.
From genetic point of view, these waters are related to Carpathian and Mesozoic sediments ,where groundwaters originally coming from volcanic rocks are responsible for Carpathian evaporite dissolving and are then accumulated in Mesozoic rocks referred to the Humenné-Užhorod Horst. After being enriched in carbon dioxide derived from marginal faults, these waters are penetrating through volcanic rocks and Quarternary sediments and are outflowing at the surface/Mlynárčik ,1985/.

FIG.4



In order to establish a protection zone around the Sobrance Spa , detailed hydrogeological survey has been there in 1985 carried out.

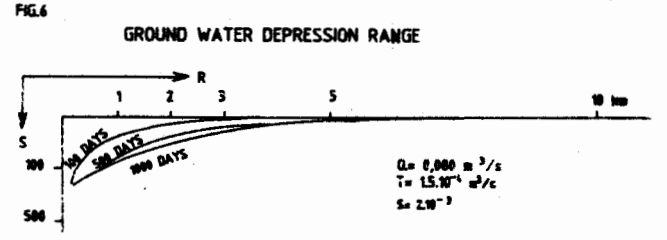
FIG.5



This third-stage zone necessary for protecting the infiltration area and that of mineral water formation is situated in the close vicinity of the subject deposit. Just dewatering of the underlying rocks will greatly influence groundwaters od deeper circulation and due to water pumping , extensive depressions reaching the protection zone are there expected to be formed .

For better demonstration of possible dewatering influence on mineral waters , groundwater depression ranges in various time intervals have been according to Theis calculated/see Fig.6/.

FIG.6



From the results obtained it follows that when dewatering , depression levels will reach the protection zone of Sobrance Spa and for this reason increased attention will have this question to be paid to.
That is why a group of observation wells is there supposed to be established for indicating possible changes during dewatering , on the basis of which protective measures necessary will be immediately taken .

References

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