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METHODOLOGY OF GEOLOGICAL ENVIRONMENT ESTIMATION FOR SITE SELECTION OF TOXIC WASTE DISPOSAL FACILITY

Розроблено методологію оцінки геологічного середовища (а саме глинистих формацій) для розміщення приповерхневих сховищ токсичних відходів. В основу покладено всебічне вивчення геологічного середовища, яке має виконувати три функції: ізолюючого середовища, середовища масопереносу та середовища для будівництва. Розроблено схему етапності робіт; наведено основний комплекс робіт, розроблено комплекс еколого-геологічних критеріїв для вибору й оцінки ділянок, придатних для розміщення сховищ.

The methodology of an estimation of geologic environment for site selection disposal facility of toxic waste is esteemed. In a basis the versatile learning of geologic environment is necessary, that generally executes three functions: environment of insulation, environment of transfer and environment for building. The range schema of activities, connecting to site selection disposal facility of toxic waste of geologic type, and complex of ecological and geological selection criteria for estimation of geologic objects in clay formation is designed.

Problem. Raw orientation of Ukraine industrial production determine the dangerous man-caused loading to the geological environment and result in Ukraine fall within countries with the most substantial amount of wastes formation and accumulation. Activity of the enterprises of chemical, metallurgical, mining, machine-building field of the industry, agriculture and domestic sphere have resulted to huge accumulation of toxic waste (TW) to be demand removal [3]. Taking into account absence of economic and technological conditions for processing and recycling TW, today the most acceptable decision of this problem with economic and technical point of view is direction of TW in landfill.

Analysis both investigations and references in world practice point to there is a number of instructions containing the certain complex of criteria and specifications for sites selection and estimation disposal facility. There are a number of publications that separate methodical questions take up, but complete methodological base is not created. For last years in Ukraine development of methodical base for creation of storages of different type [4-10 etc.] is begun, however this direction demands the further development.

The purpose of this publication is to illuminate methodological approaches concerning a site selection disposal facility of toxic waste in clay formations, including ranging of works, criteria of a choice of geological objects and principles of the safety analysis.

The basis of methodology of the researches connected to a problem of toxic wastes isolation to near surface disposal facility in geological formations is versatile studying the geological environment. The geological environment it is considered is submitted by the certain containing geological formation. Generally it carries out three functions: isolation environments, environments of mass transfer (potential environment of carrying out of toxic substances) and environments for construction. Thus toxic wastes together with storage constructive elements should be considered as geological and technogenical system which from the moment of arrangement in the geological environment enter relationships with natural geological bodies.

Proceeding from these representations at procedure of geological objects selection for storage site multiregularity of geological space determines necessity of methodical approaches differentiation to geologic researches on scale levels (ranges). According to this the following stages of geologic researches are defined:

1. Specialized survey of all territory of the country with the purpose of definition of regions with the geological structure favorable for isolation of toxic wastes.
2. Regional researches – studying of areas of distribution of geological formations with the purpose of allocation of favorable, potentially suitable zones for isolation of toxic wastes.
3. Zone researches – mesoscale search studying of perspective zones with the purpose of emanating favorable units of fineer rank: sites – candidates.
4. Local researches – the detailed target perspective of sites – candidates with the purpose of allocation of a site for accommodation to object of isolation of toxic wastes.

At **the first stage**, the source data for which one are materials state geological mapping scale 1:1000000, small-scale tectonic mapping on the basis of geophysical researches and other sources, the analysis of distribution and specific properties of geological formations, potentially suitable for isolation of toxic wastes and analysis of regional structural – geological conditions of areas distribution of these formations are carry out. At the given stage seismic and neotectonic (epeirogenetic, block, fault) activity of areas of potentially suitable formations distribution; the general material structure of formations; the general hydro-geological mode; geological relationships of containing formation with other spatially associated formations are estimated.

Selection of clay rocks as optimum landfill site connected to a number of specific properties as clay minerals – the basic compound clay rocks, and the clay rocks. It is capacity of clay minerals to sorption and ion exchange (allows to entrap and retard toxic substances in molecular and ionic forms); chemical inertness in the relation to acids and alkalis; plasticity and other physic-mechanical properties of clay rocks due to which they are a waterproof rocks to be able prevent to penetrate atmospheric and underground water underlaying aquifers to landfill and migration toxic substances in a liquid phase from landfill to biosphere in case of destruction of engineering barriers. With plasticity of clay rocks absence in them of faults and crushing zones is connected. Low filtration parameters predetermine practical absence of a convective stream through clay bed.

Analyzing a clay formation (as object of researches), the basic attention it is necessary to give studying of hydraulic permeability of rocks as the greatest danger is made with transferring toxic soluble substances by underground waters. In engineering geology waterproof rocks with permeability coefficient smaller 0,001 m/day are considered [2]. As the average value of clay permeability coefficient is $1\text{-}10^{-4}$ m/day, practically any clay rock may be considered waterproof. But such conductivity may be provided under conditions lithological homogeneity and the certain minimal thickness of clay rocks. Under rock lithological homogeneity understand the sustained structure, at absence sand, carbonate and others permeable, high-porous or soluble rocks.

At **the second stage** the general goal estimation of region and allocation of favorable zones is carried out on the basis of

materials state geological mapping scale 1:500000 – 1:200000, search geological and geophysical survey by method MHZ scale 1:500000 (to depths 50-200 m), small-scale maps of neotectonic zoning, specialized tectonic, geomorphological, lithological and facial, hydro-geological maps and other materials on such major factors:

- feature of region structure and character of geodynamic processes (seismicity, neotectonic movements etc.);
- characteristic of containing formation: substantial composition, lithological and facial uniformity, general thickness etc;
- hydro-geological conditions.

At **the third stage,** the source data for which one are materials state geological mapping scale 1:200000 – 1:100000 and the other mesoscale specialized maps, carry out mesoscale prediction within perspective zones of perspective geological formations distribution with the purpose of favorable sites allocation for the further complex studying. Tasks of a stage are:

- goal structural, lithological, geomorphological, geochemical, hydro-geological and other researches (including construction of multivariate lithological-geochemical models) the allocated perspective zones;
- allocation within zones of perspective sites for the further complex studying on the basis of the developed criteria.

Development of a complex of lithological-geochemical models is the basic means goal characterization geological objects. It is carried out at different stages in various scales that are predetermined by tasks of a stage. Scale of models is: formation-zone-site (area). Detail of development of models consistently grows according to scale of researches.

The purpose of development of complex multivariate lithological-geochemical model is creation of adequate imaging of a geological structure and substantial composition, and also engineering – geological characteristics and other determining properties (consideration of formation conditions) the selected geological body.

In a basis of this technique the standard principles formation and facial analysis, added by a number of methods of system modeling with use of the structural – system approach lay.

The task of the system approach consists in an assignment of the structural organization researched formation (or its certain element, mountain massive etc.), substance composition, genesis, dynamic development and interaction with other systems. Researched formation represents natural real (instead of conceptual) system. As we examine the intended object from two positions, that is its real condition (quasi-closed systems) and processes of formation and development (open and quasi-open systems), in lithological-geochemical models are allocated two parts: static and dynamic (in the determined measure they image two principles of knowledge – systemness and historicism in their interrelation).

The static model (actual state to object) includes studying the structural organization of object, which in turn includes external and internal aspects.

The external structure of object is originally determined by character sedimentation basin caused, first of all, by type of containing tectonic structure.

The establishment of internal structure and substantial composition is, as a matter of fact, uniform process, which contains definitions rock, lithofacial, geochemical, facial and lithostratigrafical structure.

In common the rock structure formation as lithological body as a whole (its certain part) is determined by a stream of a source material, which is brought to open system (sedimentation basin) from source areas (exofund) and other sources of supply of substance (endofund, thalassofund etc.). The mineral composition clastic, partially – chemogenic part of rocks gives the precise enough data on sources. Authigenous minerals testify about geochemical facies of sedimentation stages, diagenesis and catagenesis. The lithostratigrafical structure is determined on the basis of correlation, analysis and partition of formation sections.

The dynamic model images two major stages in formation progressing: accumulation of sediment (in view of previous stage of material transportation) and its transformation into rock. The model is created on the basis of synthesis of the data on structure and structural organization of formation, taking into account processes of generation, becoming and its functioning as systems.

Lithological uniformity of formation or its parts substantially predetermines uniformity and relative stability of engineering – geological and hydro-geological properties of these geological bodies. Engineering – geological characteristics determine two basic conditions: stability (integrity) of storage and isolating properties of geological environment.

The complex of criteria of selection and estimation of sites for near surface disposal facility of toxic wastes is developed. This complex contains three groups: ecological-geological (safety), sociopolitical and technical and economic [*4*]. The ecological-geological group includes the following criteria: **structural, geomorphologic, neotectonic, lithological, hydro-geological, climatic, hydrological, ecological load and protectability of the geological environment, geological perspectivity.**

The sociopolitical group of criteria includes a number of factors influencing to a site selection: population density, arrangement of settlements, industrial – urban agglomerations and other objects economic, social, ecological and historical meaning, perspectives of land use and development industrial or housing building etc., and also psychological readiness the population to perception of the future objects of toxic wastes isolation.

The technical and economic group takes into account cost and technological complexity of construction and, in the future, operation of storage.

At **the fourth stage** including realization of the specialized works complex, detailed goal studying sites – candidates and allocation within them of areas for toxic wastes disposal facility is carried out. At the given stage according to conditions of the geological body selection by results of previous stage and the given type of storage (in view of constructive and technical characteristics last) the estimation of safety is carried out.

The analysis of safety, that is procedure of a complex estimation of influence capacity of toxic wastes isolation object on biosphere, is carried out on the basis of estimation of toxic substances output in biosphere in case of destruction engineering barriers. The estimation contains calculations determining time and quantitative parameters of toxic substances output in biosphere with definition of possible influence on environment and man. The mentioned calculations are carried out on the basis of kinetic models of toxic substances migration [1] from technogenic-geological system of storage to different elements of biosphere, taking into account factors of migration and retardation of substances releasing in cases of disturbance technogenic-geological system of storage (both evolutionary, and catastrophic). Examples of such cases are below given:

- destruction of the container with the wastes, caused by corrosion owing to water penetration, in result degradation a roof or walls of storage;
- erosion of the top part of storage in result earth crust epeirogenic raising;

- exfiltration of underground waters in addition disturbance of engineering barriers part (in particular containers or packagings) as a result of groundwater level raising;
- change of groundwater regime as a result of construction of new water intake near storage;
- destruction of integrity of storage as a result fault dislocations;
- destruction of walls and internal engineering barriers (filling, insulating layer, etc.);
- destruction of integrity of storage roof and part of engineering barriers (including containers) as a result of fall of the flying device (the plane, helicopter, etc.);
- destruction of a part of engineering barriers as a result of the unauthorized drilling activities with the purpose of exploration activities or underground waters.

It is necessary to note, that the part of the analysis of safety is the analysis of performance. This operation examines variation of factors of natural environment connected to construction of storage. Mainly it concerns change of groundwater regime. Mathematical calculations of these changes are carried out; results are used for calculations of cases of the analysis of safety.

The forecast of migration of toxic substances from storage and the analysis of safety of a whole isolation system require using of model or different variations the system behavior (on the basis of the reliable initial data received for the selected site with the necessary detail).

Conclusion. The stated principles of a geological substantiation of a site selection for near surface disposal facility of toxic wastes are the important part of methodology and strategy of creation of storages. In article generalization of methodology existing development is made; guidelines of the further methodology development of an estimation of the geological environment are given; stages of geological researches are allocated and ecological-geological criteria of a site selection for near surface disposal facility of toxic wastes in clay formations are developed. In territory of Ukraine geological conditions for the further researches within geological regions such as northern part of Black Sea Coast Depression, Volyno-Podolsk part Volyno-Podolsk plate, Steppe Crimea and Northwest Donbass are favorable.

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ГЕОФІЗИКА

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ПРОБЛЕМИ ГЕОФІЗИКИ ТА ФЛЮЇДОДИНАМІКИ БЛОКОВО-ІЄРАРХІЧНОЇ СТРУКТУРИ ЛІТОСФЕРИ

Розглянуто методологічні принципи геофізичної діагностики геодинаміки блоково-ієрархічної структури літосфери. Наголошено, що основним об'єктом геофізичної діагностики мають бути структурні рівні мезо- й мікрорівня та їх динамічний флюїдний режим. Розсіювання енергії в літосфері супроводжується руйнуванням однієї щільної упаковки блоків та формуванням нової щільної упаковки блоків.

The methodological principles of geophysical diagnostics of block-hierarchical lithospheric structure geodynamics are under consideration. It is emphasised that the basic matter of geophysical diagnostics ought to be meso- and micro-levels of the structure and their dynamic fluid mode (regime). The energy dispersion in the lithosphere is accompanied by destruction of one dense blocks' packing and formation of a new dense packing of blocks.

Вступ. За минуле сторіччя геофізика пройшла знаний шлях розвитку від перших експериментів до потужної інформаційної індустрії дослідження Землі. Очевидна всезростаюча роль геофізики у вирішенні глобальних проблем виживання людства. Це вимагає, насамперед, необхідності корінного підвищення ефективності й надійності прогнозу природних і техногенних катастроф і екологічного стану довкілля та, відповідно, нових методологічних і теоретичних підходів до розробки інтерпретаційних геофізичних технологій результатів спостережень.

Основною вимогою до таких технологій має бути забезпечення можливостей дослідження механізму геодинамічних процесів, що спричиняють катастрофічні явища. При такому підході основною метою геофізичних досліджень має стати діагностика геодинамічного стану літосфери активними методами геофізичної томографії, які аналогічні методам медичної й технічної томографії [17–19].

Застосування методів активної геофізичної томографії для моніторингу геодинамічних процесів у літосфері може забезпечити своєчасне запобігання тяжких наслідків від катастроф на небезпечних для проживання людей територіях подібно до того, як медична томографія рятує життя людей завдяки своєчасній і об'єктивній діагностиці хвороби. Про можливі масштаби стихійного лиха, за відсутності необхідних засобів попередження, всьому звіту нагадали інтенсивний землетрус і цунамі, які відбулися 26 грудня 2004 року в Південно-Східній Азії та охопили близько 10-ти країн на гігантській території – від Малайзії до Африки та спричинили не лише матеріальні збитки, але найбільші за всю історію людські жертви – більше 226 тис. осіб.

Мета роботи. У статті розглядається новий методологічний підхід до діагностики геофізичних і геодинамі-