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## STATE-OF-ART AND PROMISING TRENDS IN MINING DEVELOPMENT IN RUSSIA

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The annual extraction from the Earth's bowels billions of tons of various ores, fossil fuel and building stones transforms the natural environment and results in the accumulation of huge amount of various waste on the Earth surface. This gives birth to ecological problems and the biosphere degradation. At the same time, the extraction and use of different mineral resources as the means of life support appears to be of no alternative necessity. Under these conditions, ecological safety may be raised by improving mining technologies and more rational development of mineral deposits. Introduction of resource-saving, low-waste and resource-resuming technologies acquires the utmost importance.

**Key words:** *solid mineral resources, mining waste, ecological safety, the biosphere degradation, resource-saving nature-like technologies.*

# OIL GENESIS AS A MANIFESTATION OF ECOLOGICAL FUNCTIONS IN ABIOTIC SPHERES OF THE EARTH

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The possibility of abiotic formation of oils is analyzed based on the data on composition of deep high-temperature fluids and reactivity of the mixtures of components contained in these fluids. Methane is the main carbon-containing component in such fluids and the starting material for the formation of oil hydrocarbons. Methane, in the course of deep flows' evolution and their motion towards the Earth's surface, undergoes polymerization transformations to oil hydrocarbons of various types and molecular weights. These processes occur owing to the fact that the deep fluids contain, apart from methane, the components possessing catalytic properties, necessary for similar transformations. Among such components of the fluids is, above all, elemental sulfur. Polymerization transformations of methane under the catalytic action of sulfur can lead to the formation of various (in terms of structure and molecular weight) hydrocarbons, asphalt-resinous and organosulfur components of oils. The degree of sulfur content of real oils and characteristics of their quality often agrees well with a character of sulfur effect on hydrocarbon system. In other words, the weight of oils increases with the growth in its sulfur content. Other components, which are capable of exerting the catalytic polymerization effect on hydrocarbons, are metals, "mantle labels" which are contained in high-temperature deep fluids. Participation of metals in oil genesis can also be accompanied by their introduction into composition of oil systems. Vanadium belongs to such metals, which exerts polymerization action on hydrocarbons. It is prevailing in a metallic part of oils. Due to the effect of vanadium on hydrocarbon system, heavy high-viscosity oils and bitumen become concentrators of vanadium and raw materials for its industrial extraction. Various ratios of the components in the deep fluids lead to the formation of oils of various geochemical types. Transformation of deep methane to oil components promotes reduction of its carrying out in the upper layers of the Earth and the atmosphere. Owing to such transformations, the transfer of CH<sub>4</sub> and sulfur in the top layers of Earth and the atmosphere should decrease. Taking into account a strong greenhouse effect of methane and the poisoning influence of sulfur on biological objects, involvement of these components of deep fluids in oil genesis promotes forming a favorable ecological situation on the Earth. Thus abiotic oil genesis not only ensures energy and resource demands of life activity, but also performs ecological function.

**Key words:** *composition of deep fluids, volatile components, catalytic polymerization transformations of methane, abiogenic oil genesis, ecological function.*

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## AROMATIC COMPOUNDS IN TUBEROUS PEATLANDS OF THE PERMAFROST AREA

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Qualitative and quantitative composition of phenol and polycyclic aromatic hydrocarbons was identified. Features of phenol and PAH distribution profiles in tundra tuberous peatlands were revealed. Accumulation of phenol and PAH in seasonally thawing horizons depends on vegetation decomposition level and species composition as well as on cryoturbation processes. In the permafrost horizons, the studied compounds are apparently related to the certain groups of plant residues. We found close relation between 5,6-nuclear PAH accumulation and composition of fulvic acids in the stratified peat layers. The data on PAH accumulation in conjunction with peatland paleobotanical analysis can be used to indicate vegetation using the Holocene peat formation periods. It also can be the starting point for the control content of the studied compounds to assess the changes in soils and vegetation in different types of landscapes during the local monitoring.

**Key words:** *phenol, polycyclic aromatic hydrocarbons, humic substances, forest-tundra, peatlands, indicators.*

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## GROUNDWATER FORMATION IN THE PALEO-BELAYA RIVER VALLEY SYSTEM IN NEOGENE IN THE SOUTHERN CIS-URALS

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The article discusses the geological and hydrogeological consequences of tectonic events that occurred in the east of the Russian Platform and the Urals at the turn of the Miocene and Pliocene. They cause intense erosion of the bottom and the formation of the Paleo-Belaya river valley system deeply incised (up to 200–300 m) at different stratigraphic Paleozoic complexes (from the Lower Carboniferous to Upper Permian). It is shown that the basis they are draining sands and gravels, lying at the base of Kinel superhorizon, is composed mainly of clay sediments. Due to the specific conditions of occurrence and the permeability and porosity of the basal aquifer, it accumulates underground drainage discharged from the gypsum, carbonate and clastic rocks that form the slopes and bottoms paleovalleys. The attention is focused on enhancing the processes of dissolution and leaching riverain paleovalley areas, which lead to the formation of surface and underground karst (karst-suffusion) forms greatly complicating the economic development of karst areas. The results of hydrogeochemical research in the Neogene regional valleys reveal the lateral geochemical zoning of groundwater, which consists in the succession of the downstream river Paleo-Belaya water: calcium bicarbonate replacing first by calcium sulfate, next sodium sulfate and sodium sulfate-chloride. The authors share their ideas on the basic processes responsible for the formation of ion-salt composition of groundwater.

**Keywords:** *Neogene valley, Paleo-Belaya River, groundwater, hydrogeochemistry, hydrogeodynamics.*

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## RHEOLOGICAL PROPERTIES OF THE CLAY SOILS

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The rheological properties of clays are considered in the article. Peculiarities of the rheological properties, namely, the creep and stress relaxation mechanisms, were experimentally studied. The results obtained are discussed from the viewpoint of structural-contact theory. Loss in strength, cohesion, above all, upon the rheological processes is typical to all clay varieties. The intensity of rheological processes depends on the quantity of clay particles in the soil, and consequently the quantity of contacts between the mineral particles, which is reducing in the row: clay – silty clay – silt. It also depends on the liquidity of clay characterized by the liquidity index (IL). The intensity of rheological properties manifestation in clays falls with the increasing water content; and they are not evident at  $IL > 0.5$ .

The intensity of rheological processes depends on soil microstructure. They are most clearly manifested in the soils, with the structure involving mainly transitional and near coagulation contacts (very stiff and stiff clay). The properties of such soils are mostly determined by the influence of an adsorption layer of hydrated films of mineral particles. The intensity of rheological processes is reduced with the increase of moisture content and thickness of the diffusive layer of hydrated films (in firm–stiff clay soil). Rheological properties are not pronounced in soft and very soft clay soils with liquidity index  $(IL) > 0.5$  and prolonged stress action results in the flowing process development. Far coagulation contacts prevail in the microstructure of these soils and their properties are mainly controlled by the diffusive layer of hydrated films.

Rheological processes may be manifested in clay soils through the creep and stress relaxation mechanisms. Realization of each of these mechanisms leads to similar results as described above. Study of rheological properties of clays may be based on the method of creep in shear tests and the method of stress relaxation in triaxial compression tests depending on the stress that soils undergo either in natural or technogenic conditions. The methodology of such studies was developed and adopted in the IEG RAS.

**Key words:** *rheological properties, creep, stress relaxation, microstructure, transition contacts, near and far coagulation contacts, adsorption layer and diffuse layer of hydrated films, liquidity index.*

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## NUMERICAL MODELING OF NATURAL HYDROGEOCHEMICAL ZONATION IN THE AREA OF BKPRU-1 MINE FIELD AT VERKHNEKAMSKOE POTASH-MAGNESIUM SALT DEPOSIT

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Flooding caused by groundwater inrush at BKPRU-1 potash mine lasted from October 2006 through the end of 2008. As a result hydraulic connection between the flooded salt mine workings at depth of 260–380 m and aquifers in the oversalt rock formation occurred within the zone of fracturing in the salt-bearing water-protection stratum. To predict the groundwater quality change caused by the following saline mine waters reflux into the oversalt aquifers, current natural vertical hydrochemical zonation was taken into account. The latter comprises natural saline waters underlain by chloride

sodium concentrated brines with a mineralization of 320 g/l. The brines were formed by natural dissolution of the covering salt layer in the top of salt-bearing formation as the result of infiltration water action. BKPRU-1 mine case study discussed in the article provides the example of 3D numerical variable-density groundwater flow model application to simulation of natural hydrogeochemical zonation formation. In particular, natural chloride sodium concentrated brines formation is studied with due account to alternation in spatial distribution of the top of underlining regional aquiclude being subject to dissolution, i.e. "covering" salt layer. The formation duration of current 3D equilibrium distribution of dissolved NaCl in groundwater has been estimated to be as long as 10000 years. The necessity of taking into account the density gradient in solving the problems related to natural brines formation and transport is found. It is shown that the rate of degradation (dissolution) of the salt water-protection stratum separating underground mines from the oversalt aquifer system due natural dissolution of the salt does not exceed 0.06 mm/year under current undisturbed hydrodynamic conditions. The estimated rate of salt discharge into surface water bodies at sites of groundwater contamination in the vicinity of mine brines storage capacities is considerably lower than that caused by the discharge of natural concentrated brines.

**Keywords:** *Verkhnekamskoe deposit, dissolution, numerical modeling, brines migration, density gradient, hydrogeochemical zonation, groundwater salinization.*

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## MATHEMATICAL MODELS FOR QUANTITATIVE ASSESSMENT OF ECOLOGICAL RISK IN GROUNDWATER USE

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The article is devoted to the development of approach to the quantitative assessment of ecological risks in the areas, where groundwater sources are used for water supply (by the example of the Kerch Peninsula). The authors have analyzed the current situation in water supply in the region, they have highlighted the main problems and have revealed the strategic role of groundwater sources. The authors have substantiated the necessity to assess ecological risks associated with the use of groundwater as a source of water supply. The process of risks estimation involved five steps: calculation of ecological indicators, harmonization of hazard degree indicators, integration of hazard degree indicators, assessment of hazard manifestation possibility and the assessment of ecological risks. The ecological situation in the contest of groundwater use was assessed according to the essential and the most common (in terms of regional features) criteria. They involve the characteristics of human living conditions, i.e., the quality and availability (scarcity) of water, the level of anthropogenic impact, and population density.

A key step in the assessment was to unify the dissimilar particular indicators using the non-linear functions, which enabled us to create a system of ecological indicators with a dimensionless scale estimates in the range from 0 to 1. The subsequent integration of ecological indicators using non-linear weighting coefficients calculated by exponential sigmoid allowed us to take into account the significance of individual components in the final risk assessment on the extent of their respective ecological hazards. The proposed method is a tool to the geoecological assessment of situation in different areas that use groundwater as a water supply source. The main advantage of this approach is its possible expansion both by increasing the number of ecological indicators in each group and by introducing new criteria for defining the particular environmental conditions taking into account the regional specifics. In addition, this methodology can be adapted to evaluate ecological situation in the territories facing other ecological problems.

**Key words:** *ecological risk, groundwater, Kerch Peninsula, model evaluation, water shortage, water quality, the level of anthropogenic impact, population density, hydrogeoecological risk, unification, integration*

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## MONITORING OF OIL PRODUCT MIGRATION IN THE LABORATORY USING ELECTRICAL RESISTIVITY TOMOGRAPHY

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The results of a laboratory experiment on the possible use of electrical resistivity tomography (ERT) for the study of oil product migration in the disperse ground are reported. The experiment was performed in a model cell representing a plastic tank dimensions 2000x700x600 mm. The cell was filled with fine, homogenous sand, which laid sloping clay layer

(angle 20°). Waste oil was used as a pollutant. In the first stage of the work, we investigated the relationship between the indicators of the electrical resistivity and the content of pollutant to the fine sand at change of humidity of 15 to 30%. It was found that the resistivity increases with the increasing the percentage of oil in the sand. This relationship is obviously not linear (a polynomial trend line was constructed in the article). This is due to the processes of water and oil distribution in the pore space of sand, which causes a change of electric current direction. The data acquisition was made through electrical resistivity tomography (ERT) method with a day measurement interval. Four models were obtained, which show the distribution of the environment resistivity every 24 hours. Measurements were carried out using the equipment SKALA-48M with Schlumberger survey array by step of 50 mm along profile. The data sheet were processed using the time-lapse inversion. The simulation showed that the redeposition of oil is reliably registered by the resistivity characteristics. In addition, we investigated the influence of anthropogenic noise generated by local objects (pipe, metal, brick), on the information obtained from ERT geoelectric models. It was shown that these objects operate as are a sort of "collectors" for petroleum products and can increase their concentration in the environment. Proceeding from the laboratory experiment results, the possibility of using ERT for localizing the areas contaminated by oil products, and conducting monitoring studies at the geo-ecological research was demonstrated.

**Key words:** *ERT, pollution, oil product, geoelectrical model, electrical resistivity, migration, cell laboratory, monitoring.*

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