Innovative approaches to information modeling of placer deposits

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SUMMARY

The paper is devoted to the problem of information support for geological research and works aimed at developing the mineral resources base of priority sectors of the national industry. The purpose of this publication is to present innovative approaches to information modeling of placer deposits of heavy minerals, cassiterite and rare-metal mineralization, amber. The tasks are the coverage of the methodology and methods, demonstration of modeling examples for typical objects, designation of a strategy for further research in the field of information modeling. The methodological basis of targeted information modeling is the formation analysis combined with the approaches of info-geology. Methodological and methodic development is predictive and reconstructive complex for modeling geological objects of various scales. The methodological complex of information support for research and works includes two blocks: a predictive-paleoreconstructive retrospective-static model and an integrated ecological-geological model of a local geological object (CEGM), including a digital structural-lithological (subordinate rank) model (DSLM) and other functional submodels. The examples of modelling of placers are shown. Prospects for the further development of information modeling are suggested.
Introduction

The relevance of the problem statement is determined by the need to introduce innovative effective means of information support for geological research and works (R&D) aimed at developing the mineral resources base of priority sectors of the national industry.

The practical significance of the development of this direction is illustrated by the list of examples of geological objects of interest to the leading spheres of industry and commerce: titanium-zirconium, cassiterite, rare metals, amber placers. The introduction of the proposed methods, corresponding to the level of technology, meets the priorities of the state innovation policy.

The purpose of this publication is to present innovative approaches to information modelling of placer deposits of heavy minerals, cassiterite and rare-metal mineralization, amber. The tasks are the coverage of the methodology and methods, demonstration of modelling examples for typical objects, designation of a strategy for further research in the field of information modelling.

Methodology and methods

The methodological basis of targeted information modeling is the formation analysis combined with the approaches of info-geology. Methodological and methodic development is predictive and reconstructive complex for modeling geological objects of various scales. The methodological complex of information support for R&D includes two blocks: a predictive-paleoreconstructive retrospective-static model and an integrated ecological-geological model of a local geological object (CEGM), including a digital structural-lithological (subordinate rank) model (DSLM) and other functional submodels. This complex provides a full cycle of forecasting, prospecting, geological exploration, operation and environmentally appropriated divestiture. To increase the efficiency of modeling, we introduce the method of frame organization, which has shown effectiveness on examples of other areas of the geological environment handling (Goncharov, 2011). The methods are modified for algorithms for studying placer objects. The Poltava Series of the Dnieper-Donetsk Depression (DDD) and the Ukrainian Shield (USh) was taken as the object of info-geological modeling studies. From the point of view of info-geology, in the hierarchical scheme of the frame organization of the lithosphere, the Poltava Series (as a formational and lithostratigraphic subdivision of the same name) occupies the regional level of information geoframes (IGF), referring to two geological regions - DDV and sedimentary cover of the USh. According to its geological and genetic characteristics, it can be ranked among the group of natural geological systems of the sedimentary shell, according to the degree of determinism - to the category of deterministic using abstract formulations, and according to its purpose - to the target IGF. It stands out as an IGF object of the next hierarchical rank - a promising placer-bearing horizon (“productive” for titanium-zircon placers) - the middle Novopetrovsk subsuite formation. Within the regional IGF, frames of a subordinate order can be distinguished, corresponding to structural-facies zones (or placer zones and regions). The IGF, which belong to the abstract category (group) - formational-material placer formation systems (FMPFS), are especially considered. The FMPS is a unit of targeted zoning of the placer-bearing formation, representing the combination of “placer-forming formation - intermediate reservoirs - placer” (Laviorov et al., 2014).

Another object of info-geological research is the Kharkiv Series, which occupies the regional level of the IGF and belongs to the sedimentary cover of the USh. It is distinguished as an object of the next rank - the Obukhov suite as a productive horizon of columbite - cassiterite placers. This is the upper horizon of the placer formed in coastal marine conditions. The suite is represented by glauconite-quartz sands, medium-fine-grained with medium-coarse grained low-thickness layers greenish-gray color. Often there are grayish-green siltstones with layers and lenses of clay. They occur with stratigraphic consistency on loose sediments of the Kyiv suite and disagree with the Mesozoic sediments, less often on crystalline rocks and their weathering crusts. They overlapped by deposits of the Oligocene, Neogene and Quaternary systems. Frames of a subordinate order are Paleogene shallow-water sediments and relics of the Mesozoic-Paleogene continental rock mass of aluvial-deluvial genesis, representing separate structural-facies zones.
Infogeoframes of local geological objects are built on the basis of the DSLM and the final CEGM. DSLM is a virtual volumetric digital (3D) multi-sided display of a geological object, containing its structural and qualitative characteristics. CEGM is a high-order target model, which can be compiled by several subject models of subordinate ranks, based on the structural-lithological model as a matrix one. Unlike DSLM, it displays the dynamic characteristics of the object (processes) that take place and are predicted during the operation and closure of the object.

**Information Modelling Examples**

At present, we have developed information models of different scales for various geological and genetic types of FMPFS, including deposits of titanium-zirconium ores, gold and cassiterite with rare-metal mineralization.

**Motronovsko-Annivske deposit of titanium-zirconium ores.** The DSLM of the deposit has been developed. To build the model, we prepared a database based on the author's principles of sections division of exploration drilling wells (1062 sections), taking into account the results of our own field studies. In accordance with this, the initial data on the structural characteristics of the ore-bearing strata, lithofacies division (according to two signs - the content of clay material and particle size distribution), as well as the distribution of ore minerals, collective concentrate and conditional ilmenite (according to the average content in the sections, partially - by layers of sections) were introduced into model.

The section of the sedimentary cover within the area of the deposits as a whole is represented by deposits of the Paleogene (Buchak, Kiev, Kharkiv formations) and Neogene (Novopetrovka suite as the upper, Miocene part of the Poltava Series, the Boyar suite and its age analogs - the upper middle Miocene - Pliocene), as well as the Quaternary systems.

According to our interpretation of the above mentioned section of the sandy strata of the "Poltava Series", its lower horizon should correspond to the Berekian stage of the Oligocene, the middle and upper - to the Novopetrovka suite of the Miocene. The lower subsuite formation of the Novopetrovka suite in this section has not been reliably established, its upper subsuite formation is conditionally assumed based on lithological features.

The deposit model includes several sub-models that reflect reservoir characteristics in relation to the development of this object. The spatial distribution of ore bodies has been established, their interrelationships with the morphology of the ore strata and its lithological features (clay content, granulometric composition of sands, etc.) have been traced; the spatial distribution of technological types of ores (content of clay material, granulometric composition of sands, content of individual useful components) has been established (Figure 1).

**The Perha placer columbite-cassiterite deposit** covers 8 isolated placer bodies, which, according to the modern geomorphological plan, are located in the basin of the lower reaches of the river Perha, within the boundaries of the right above-floodplain terrace and the floodplain part of the valley (Galetskiy et al., 2016). Placers are localized within the area of development of ore-bearing bodies (deposits, ore occurrences) of the crystalline basement with weathering crusts covering them, which, with a number of other features, makes it possible to classify them as the number of near drift placers. At the same time, in spatial terms, the mineralization of placers (constituting the sedimentary cover) is associated with that in the underlying weathering crusts, i.e. from the point of view of the ore deposits geology, both of these formationally different subdivisions can be combined into a single object, like a deposit based on the fact of the general ore-material specialization of the Perha tectonic "node".
In the section of the object, five structural-formational levels were established, the lower of which - the crystalline basement - was not involved in modeling, being taken into account in general metallogenic constructions as the primary source of placer-forming material (PSPM). Perhaps granites, rare-metal metasomatites, granite-porphyries are considered in this aspect. There are four floors included in the modelling: 1) Weathering crust, levels of sedimentary cover; 2) Mesozoic formations presumably late Jurassic-early Cretaceous age; 3) Paleogene formations; 4) Quaternary deposits.
The lithofacial types are distinguished as follows: fine-grained sands, medium-grained sands, various-grained sands (fine-, medium- and coarse-grained); gravelly sands, gravel; clay; redeposited kaolin; weathering crust kaolins.

At the initial stage of modeling, the following gradations of cassiterite contents (g / m³) are outlined: - 50, 500-100, 100-200, 200-300, 300-400, 400-500, 500-1000, 1000-1500.

Two predominant sources of PSPM drift can be considered: outshots of metalliferous weathering crusts and intermediate reservoirs, i.e. ore-bearing deposits of the underlying "lower layer" (kaolin deposits, presumably Buchak age). Figure 2.

Thus, the predictive-paleoreconstructive retrospective-static model for both objects should include paleogeographic schemes at the regional level and large-scale paleogeomorphological reconstructions for detailing placer formation events.

**Conclusion**

Prospects for the further development of information modeling of the considered direction are as follows:
- development of methodology for infogeological modeling of placer deposits within the framework of the theory of information support for R&D on handling the geological environment, taking into account the aspect of frame organization;
- implementation of systemic zonal and local forecasting of various material-genetic types of placers within the Ukrainian placer province on the basis of the developed regional schemes of basin placer formation (Subparatetis, etc.) using the methodological complex of PPRRSM;
- detailed study of titanium-zirconium, gold-bearing, cassiterite with rare-earth mineralization established by FMPFS, as well as amber within the Ukrainian placer province;
- improvement and implementation of the principles of development of CEGM for information support of the stages of exploitation and post-mining of deposits;
- development of principles of information modeling for non-traditional types - complex mining and geological conditions, with a low content of a useful component, intended for development by geotechnological methods, etc.

**References**

