Physical-Mechanical Properties of the Bottom Formations of the Hydrothermal Ore Fields on the Mid-Atlantic Ridge

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ABSTRACT

The results of the studies of physical-mechanical properties of bottom formations obtained by engineering-geological investigations of hydrothermal ore targets of the Russian Exploration Area (REA) in the axial zone of the Mid-Atlantic ridge (MAR) are presented. The hydrothermal ore targets studied are the Ashadze, Semenov, Pobeda ore clusters, the Yubileinoye and Kholmistooye ore fields and several exploration blocks in the REA outside the targets. Determinations of physical-mechanical properties of polymetallic sulphides (PMS), host rocks and bottom sediments were carried out both at onboard and stationary laboratories. The main regularities of variability of physical-mechanical properties of bottom formations and the factors determining them were presented. Also reported is the influence of hydrothermal processes on the formation of physical-mechanical properties of igneous rocks and bottom sediments.

KEY WORDS: Atlantic ocean, Mid-Atlantic ridge, the Russian Exploration Area, engineering-geological investigations, polymetallic sulphides, igneous rocks, bottom sediments, physical-mechanical properties.

INTRODUCTION

At present, Russian geological and engineering-geological studies of hydrothermal ore fields are performed in the northern near-equatorial part of the MAR (Fig. 1), within the REA of 10,000 km² (100 exploration blocks 10x10 km each, grouped in 7 clusters from A to G) [Kondratenko et al., 2017].

The targets of the study are ore objects of different scale. These are ore bodies (natural accumulations of PMS), ore fields (structurally unified local areas of seabed, featuring the groups PMS of spatially close ore bodies within one hydrothermal system) and ore clusters (ore-bearing seabed areas, containing groups PMS of ore fields and individual ore bodies).

As of 2017, as a result of many years of expeditionary exploration, 18 ore fields had been identified in the REA, 11 of them were combined into 4 ore clusters [Beltenev et al., 2013, 2015, Cherkashev et al., 2013]. Since 2012, only in the northern and central parts of the REA the Pobeda ore cluster and the ore fields Yubileinoye, Kholmistooye and the Surprise ore occurrence have been discovered.

Engineering-geological investigations are an integral part of the contractual works of the Russian Federation on the MAR. This work is concentrated mainly in the identified ore fields. It aims at a comprehensive assessment of the engineering-geological conditions of exploration and exploitation of potential PMS deposits. Considerable attention is paid to the study of physical-mechanical properties of bottom formations, which are part of the most important components of engineering-geological conditions of mining, as it determines the choice of methods for the future mining of sulfide ore deposits, technology of mining operations and the design features of mining equipment.

MAIN FEATURES OF GEOLOGICAL STRUCTURE OF THE REA

The Russian Exploration Area is located in two major structural megasegments of the Mid-Atlantic ridge, the boundary between them running along the transform fault "Fifteen-twenty" (Fig. 1). A special feature of the MAR is the presence of a clearly expressed rift valley which is confined to the axial part of the ridge. The majority of the REA ore deposits are located on the walls of the rift valley. The hydrothermal ore fields lie on the seabed surfaces at depths ranging between 1900 m (the Puy de Folles ore field) and 4100 m (the Ashadze-1 ore field).

The rocks hosting the hydrothermal sulphides of the REA are basalts and gabbro-peridotite complex. Basalts occupy most of the area of the REA. They are abundant in the axial part of the rift (bottom and walls of the rift valley) and on its flanks. They form a diversity of seamounts (rift ridges, volcanic central type, etc.).

Tholeiitic basalts are the most widespread, exposed at the bottom of the valley, in the volcanoes of central type, as well as in the axial neovolcanic uplifts. In these rocks, traces of secondary processes are nearly absent.