The Introduction of Clay Placer Dredging Preparation Technology

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Abstract. A large number of placer deposits in the Trans-Baikal Territory and other regions of the Far East and Siberia feature large amounts of clay (30% and more). In such conditions, their development and preparation are complicated. The dredger performance reduced by 10-15%, and metal loss during preparation, especially small and fine-grained gold, amount to 30-50% and sometimes even more. Therefore, we face a problem of weakening the cleat between mineral grains and clay particles acting as an adhesive. Besides, we need to develop efficient technology for clay and cemented placer deposits for dredging. We developed and introduced into production a clay sand weakening technology. It was used on a dredging site in the Zabaykalye territory and resulted in a significant improvement of the dredger performance and gold output.

1. Introduction
Over the last 20-30 years, an increasing number of placer deposits featuring complex high-clay (30% and more) and cemented metal-bearing material are subjected to dredging. Their proportion amounts to 35-40% of the total reserves. Consequentially, the problem of reducing the losses of valuable components during cropping and preparation becomes especially relevant [6, 13]. These losses may sometimes amount to 50% and even 60-80% [21]. The main cause of the metal loss is the low disintegration of the clay material in the auriferous mass [9, 10]. Besides, such conditions reduce the productivity of dredgers (10-15% on average). Thus, the problem of weakening the adhesion between mineral grains and clay particles that act as an adhesive is crucial in the extraction of metal from clay and high-clay sand placers and dredger productivity improvement [1, 4, 11].

The traditional methods used to solve this problem [5, 7, 22] were based on the mechanical impact: a fluid jet was applied to the rock inside the screen. They often fail to produce the desired result because the adhesive forces between clay and mineral particles are quite significant [14, 15, 18, 19]. When dredgers work under such conditions, pellets are formed that go through the screen and the stacker and end up in the pebble pile, which leads to significant losses of valuable components [9, 12]. Besides, water with a high content of clay silts up the sluices as it passes through them, which also contributes to sending small and medium-size gold particles into the dredging waste pile [9, 10].

We see the preliminary weakening of the rock in the placer mass at the preparation stage as the most promising technology [2, 16].
2. The experience of applying dispersing agents to weaken clay rocks

Recent years saw a trend for sand weakening at the dredging preparation stage through physical and chemical treatment of the rock mass with non-toxic dispersing agents that are placed into previously-drilled holes [17, 20]. This technology has a number of big drawbacks: drilling a large number of holes in the dredging sites is associated with significant inputs of labor and time, as well as high financial costs. According to the Department of Mineral Beneficiation of the Transbaikal State University, the destruction of clay material during sand disintegration often causes the caustic wash of carbonates, hydrocarbonates, calcium, and magnesium from the clay but for the larger part, this process is based on the destruction of structural bonds and ionic exchange [7, 8]. The dispersing agent impact type is based on increasing their hydrolysis degree in water and the directional exchange of Na cations with the cations of the adhesive components of the clay, which results in the weakening of the placer rocks. We established that chloride melts (metallic salts) and sodium aluminate are the most efficient dispersing agents, and their optimum doses are 50 and 200 g/t respectively.

We had to develop a more efficient technology that would impact clay rocks based on dispersing agents. As mentioned above, traditional technology that is based on the invasion of rocks by dispersing agents through holes and the subsequent water feed is very labor-intensive and costly. Besides, mines do not always have the required drilling equipment.

3. Technological solutions for clay placer dredging preparation

We developed a technology that requires less labor inputs and funds and yet can efficiently weaken rocks. This technology is based on the physical and chemical modification of sands at the dredging preparation stage, which was applied at one of the placer deposits in Zabaikalye featuring gravel-pebble sediments with a high (up to 63%) content of silt-clay material (the Lyubov mine).

At the 80-liter dredger site, we selected a pilot and a reference area with similar geological and mining conditions and metal content. The rock mass at the area was sufficient for a month of the dredging operation. At the pilot area of about 8 thousand m², we used a previously dug out a stream diversion ditch to move the river course and planned surface layout (Figure 1). At the same time (or after the mentioned operations), we used a bulldozer to build a dam in the lower part of the area. Its parameters are as follows: height - 1.0-1.5 m; dry slope - 1:1; wet slope – 1:2; the width at the top is the same as that of the bulldozer blade. To keep the water within the flooded area, we built extra dams around the dredging site borders with the same parameters as the main dam. After that, we spread the dispersing agent evenly over the entire surface of the pilot area by hand at the dosage of 40-60 g/t of the developed rock mass. When treating large surfaces, fertilizer broadcaster machines can be used. These agricultural machines can adjust the dosage of the dispersing agent.
Figure 1. The process flow chart for clay placer dredging preparation using dispersing agents.
1 – area under preparation; 2 – bulldozer; 3 – dispersing agent broadcaster; 4 – bulldozer with ripper; 5 – water input ditch; 6 – water retaining structure; 7 – stream diversion ditch; 8 – prepared area; 9 – dredger quarry; 10 – dredger.

Then we used the tractor to rip the area to the maximum depth possible. The distance between the gages was about 1 m. After that, the waterbody was filled via the input ditches. We maintained the water level at 0.5-0.6 m for 1.5 months. Throughout this time, the dispersing agent (chloride melt) invaded the placer rock along with the water and helped weaken the bonds between the mineral particles and clay.

After dredging and sand washing in the pilot area treated with the dispersing agent, we found out that the dredger performance improved by 10%, and the metal extraction increased by 23%, even though the metal content in the pilot area was a little below the standard. The losses in pebble piles also decreased. When dredging the reference area that was not treated with the chloride melt, the dredger performance reduced to the original values.

Thus, we obtained a significant economic effect after a month of dredging the pilot area using the new rock preparation technology.

4. Conclusion
Based on the industrial tests carried out, we may give the following recommendations. The developed dredging preparation technology is simple and efficient. Dams should be built of top soils simultaneously with the stripping operations to significantly reduce the cost of work. Special equipment can be used to treat larger areas with dispersing agents faster. We recommend using heavy-duty ripper attachments with T-500 and T-800 tractors to rip the surface to the depth of 1.0-1.5 m or more. The distance between the gages, in this case, can be increased up to 1.5-2.0 m. It is necessary to maintain the water level of 0.5-0.6 m for 2-3 months depending on the placer thickness.
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