Short communication

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Migration of mercury at different stages of the existence of the Nizhne-Koshelevskoe Novoe thermal field (Kamchatka)

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ABSTRACT. This article presents data on the behaviour of mercury in near-surface layers of the Nizhne-Koshelevskoe thermal field that appeared in 2008 and existed until 2016. The observation of the new heated area revealed two periods of the field existence. Monitoring of mercury concentrations in the soil-pyroclastic strata on the surface of the field elucidated the characteristics of mercury accumulation and migration at different stages of the existence of thermal fields.

Keywords: mercury, hydrothermal systems, Kamchatka

1. Introduction

The studies were carried out in the south of the Kamchatka Peninsula, near the Koshelevsky volcanic massif. The Quaternary volcanic massif consists of five volcanic structures (Vakin et al., 1976). Two large thermal fields are confined to the Koshelevsky volcanic massif: Nizhne-Koshelevskoe and Verkhne-Koshelevskoe. Here, the Koshelevskoe steam-hydrothermal deposit was discovered (Pozdeev and Nazhalova, 2008). In the thermal fields of the Koshelevsky volcanic massif, the composition of the discharged solutions is ammonium sulfate, while that of the condensate of the steam from deep exploration wells is bicarbonate-sulfate and sulfate-bicarbonate. All condensates have high concentrations of chlorine and ammonium ions, which may indicate its deep origin (Pozdeev and Nazhalova, 2008).

2. Materials and methods

In 2008, on the western slope of the Koshelevsky volcanic massif, near the Nizhne-Koshelevskoe thermal field (300 m to the south), there was a rare natural phenomenon, a formation of the new thermal field that was called Nizhne-Koshelevsloe Novoe (Rychagov et al., 2014). Heating of this site lasted about two years, and then cooling followed. The formation of this thermal field was associated with widespread hydrothermal processes in this area and the closely located Nizhne-Koshelevskoe thermal field (Fig. 1), which the geophysical research conducted here confirmed (Nuzhdaev and Feofilaktov, 2013). The study of mercury concentration in the strata of soil-pyroclastic deposits in the Nizhne-Koshelevskoe Novoe field allowed us to examine in detail the behaviour of mercury under near-surface conditions during the formation and decay of a thermal anomaly. For this purpose, in the 2010, 2011 and 2013 fieldwork seasons, the wells were traversed in the central and marginal parts of the field area. Each stage was characterised by the individual distribution of mercury in the section.

3. Results and discussion

The first stage was the heating of the field, which was accompanied by an intensive supply of mercury and its accumulation. This stage was characterised by high temperatures throughout the field area. In 2009, the temperature reached 90 ºC at some sites. Previously, there were no signs of hydrothermal activity in the field area. Apparently, before the formation of the field, mercury concentrations were at the background level. Based on the 2010 survey, the maximum mercury concentrations in the field area were 27.25 mg/kg, whereas the background concentrations were at the level of 0.08 mg/kg. During the disclosure of the section by the well traversed through the entire thickness of the soil-pyroclastic cover in the central part of the field, at the most heated site, high mercury concentrations were observed throughout the section as well as a sharp increase in the temperature with depth (Fig. 2).

The second stage was the decay, cooling and disappearance of the thermal field. Since 2011, there

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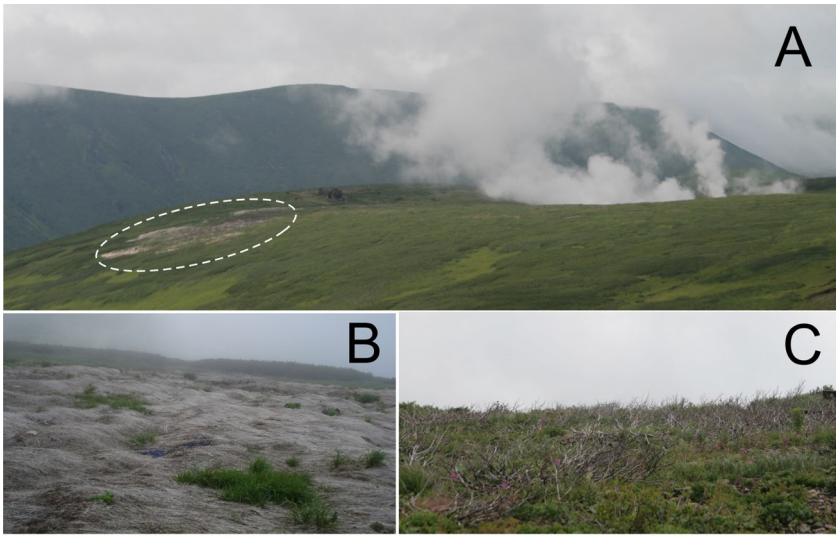

Fig.1. Nizhne-Koshelevskoe Novoe thermal field: A – general view (marked by a dotted line); B – grass burnout in the field area; C – bush burnout in the field area.

was a gradual decrease in the temperature and reduction of the area of the thermal field (measured by isolines of 15 ºC and 20 ºC) and, at the same time, some increase in the area of the mercury anomaly, with a decrease in its intensity. In the section of the central part of the field, there was a decrease in mercury concentrations in the lower layers and an increase in its concentrations in the upper near-surface layers. In other words, there could be the redistribution of mercury that previously entered and accumulated in the section as well as its migration to the upper layers (Fig. 2).

4. Conclusions

This study allowed us to observe the behaviour of mercury in the entire cycle of the existence of the thermal field: from the appearance to complete decay. During the heating of the thermal field, mercury entered the near-surface layers and accumulated in the section of the soil-pyroclastic strata at the sites of the maximum heating. As the thermal field cooled, the mercury accumulated in the section redistributed: decreased in the lower layers and concentrated in the upper layers of the soil-pyroclastic section. Also, mercury migrated throughout the field area. At the early stages of the existence of the thermal field, mercury concentrations increased at the sites associated with the most heated zones. With the cooling of the thermal field, the area of the anomaly increased, and its intensity decreased. Furthermore, a change (increase) in mercury concentration was observed in the section of the soil-pyroclastic cover outside the thermal field, as it cooled. In other words, mercury accumulated at the early stages of the existence of the field could migrate intensively as the field cooled, spreading beyond the thermal field.

Conflict of interest

The authors declare no conflict of interest.

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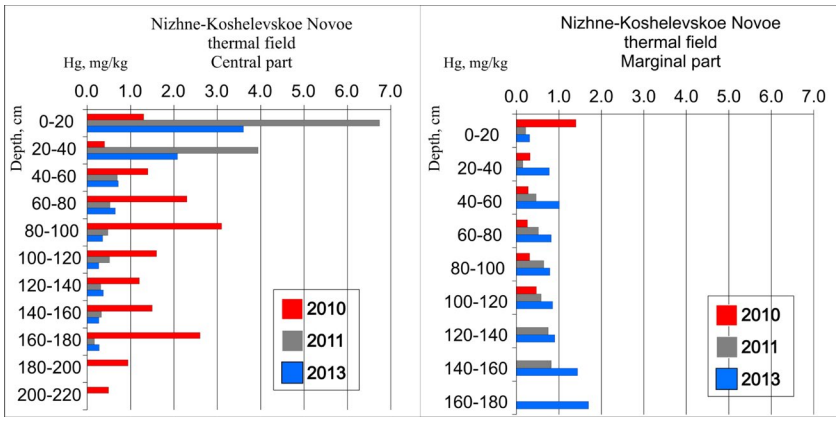

Fig.2. Diagrams showing the distribution of mercury concentrations in the sections of soil-pyroclastic cover in the central and marginal parts of the Nizhne-Koshelevskoe Novoe field (2010 to 2013).

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