SEISMIC EVENTS DISCRIMINATION IN THE KUMTOR DEPOSIT AREA (KYRGYZSTAN)

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INTRODUCTION AND MAIN RESULTS

There are several deposits of solid minerals in Kyrgyzstan. Every year, seismic stations of the Institute of Seismology of National Academy of Sciences of Kyrgyz Republic (IS NAS KR) register a large number of quarry explosions in the magnitude range from 1 to 3.5. Much work is being done to identify the nature of seismic events. The difference in the wave pattern of tectonic earthquakes and explosions is shown.

The presence of active faults in the deposit area, blasting, and the movement of large volumes of soil lead to significant additional load on the earth's crust and to the implementation of some geodynamic processes that allow the crust to move to a new equilibrium state. In this regard, in recent years, the effect of induced seismicity has been observed in the deposit area, manifested in an increase in the number of earthquakes and their energy. In addition to endogenous events, exogenous phenomena are also recorded in the deposit area, such as glaciers and landslides.

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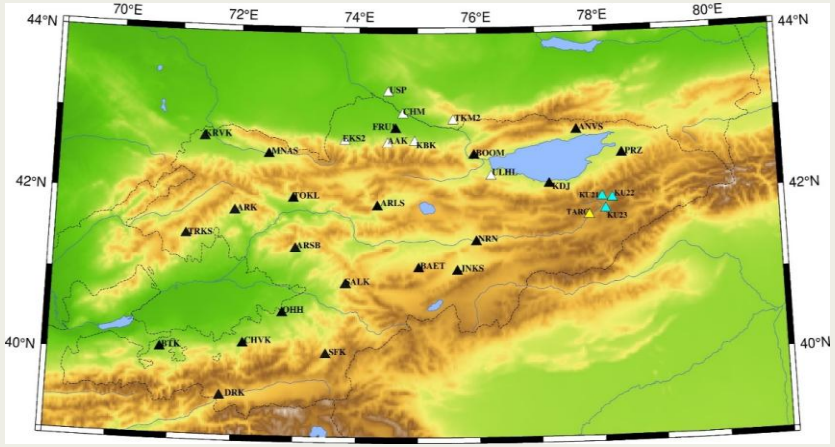
INTRODUCTION

The unique Kumtor gold deposit is located on the northwestern slope of the Ak-Shyirak ridge of the Central Tien Shan at an altitude of 5,200 m and is covered by glaciers and perennial frozen rocks up to 250–400 m thick. The gold ore deposit was discovered in 1978, and geological exploration work was carried out until 1992. This area is characterized by the presence of several large thrust fault zones extending in the north-east direction and dipping south-east at varying angles. The ore body mainly consists of Vendian metasomatites (late Proterozoic or early Paleozoic). Of particular note in this system of fault zones is the Kumtor fault with a south-east dip azimuth of the reverse-thrust type, which limits the ore zone from the north. The thickness of this fault zone reaches several hundred meters. Along this fault, Cambrian-Ordovician limestones and phyllites are thrust onto red-colored Tertiary rocks [Omurbek et al., 2024].

Since 1996, Centerra Gold Inc. the Kumtor began commercial open-pit gold mining, primarily in the Central area. Explosions in the quarry are mainly carried out using the short-delay method. There are no instrumentally recorded earthquakes with magnitude M> 5.5 on the territory of the mine and adjacent areas with a radius of 50 km.

KYRGYZ SYSTEM OF SEISMIC OBSERVATIONS AND MATERIALS USED

Photo of the Kumtor deposit.



Map of Kyrgyz system of seismic monitoring. By black triangles the KRNET (IS NAS KR) network, by white triangles KNET (RS RAS) network, by blue triangles the local network of the Kumtor mining company, and by yellow triangle the TARG (CAIAG) seismic station are indicated.

The instrumental seismic observations in Kyrgyzstan have begun since 1927 on the base of analogue stations that essentially influenced on the network efficiency. Nowadays, Kyrgyz system of seismic monitoring contains from 2 seismic networks KRNET (Kyrgyz Republic Digital Network), operated by the Institute of Seismology of National Academy of Sciences of Kyrgyz Republic (IS NAS KR), which consists of 21 seismic stations, and KNET (Kyrgyzstan Telemetered Network), operated by Research Station of Russian Academy of Sciences (RS RAS) in Bishkek, which consists of 7 seismic stations, as well as the Taragay station (TARG) of CAIAG (Central Asian Institute of Applied Geosciences). In 2022 a local network of seismic stations, consists of 3 sites, has begun its operation on the territory of the Kumtor deposit. Almost all stations of the KRNET network (IS NAS KR) are equipped with strong motion devices. In addition to the stations of the KRNET (IS NAS KR) and KNET (RS RAS) networks, IS NAS KR regularly uses seismic stations of Central Asian countries to improve the quality of the catalog.

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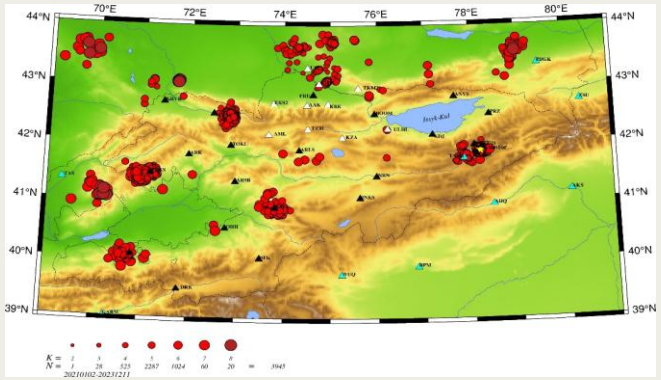
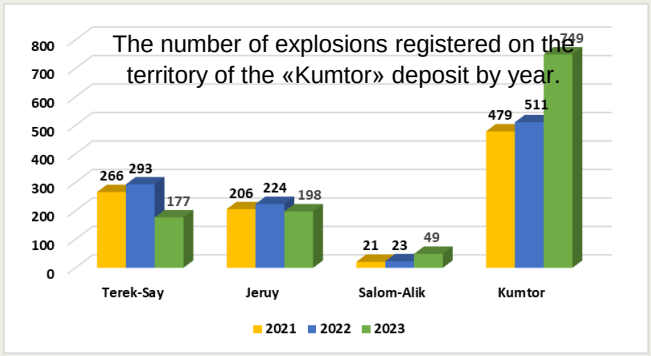
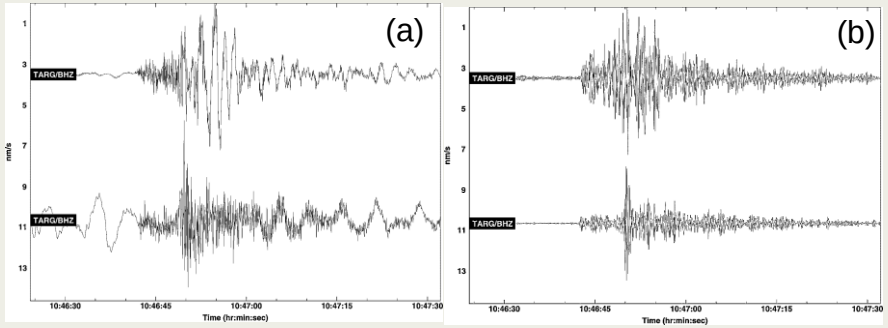
REGISTRATION OF INDUSTRIAL EXPLOSIONS IN THE TERRITORY OF KYRGYZSTAN

The activity of blasting operations during the extraction of ores and building materials in Kyrgyzstan increases year by year. The total number of processed and localized seismic events in the areas of quarries exceeds a thousand per year. Taking into account the level of seismic activity of Kyrgyzstan, epicenters of explosions and earthquakes are often close in their location. Moreover, for the correct compilation of earthquake catalogues, precise identification of the nature of the recorded events is necessary, and that is why the task of industrial explosions registration and processing is very important. Next figure demonstrates a map of the epicenters of industrial explosions produced in 2021– 2023 in the territory of Kyrgyzstan and adjacent areas. From all active deposits in the territory of Kyrgyzstan, the «Kumtor», the «Terek-Say mine», the «Bozymchak and Ishtamberdy», the «Jerui», currently, the largest number of explosions are produced at the Kumtor quarries.

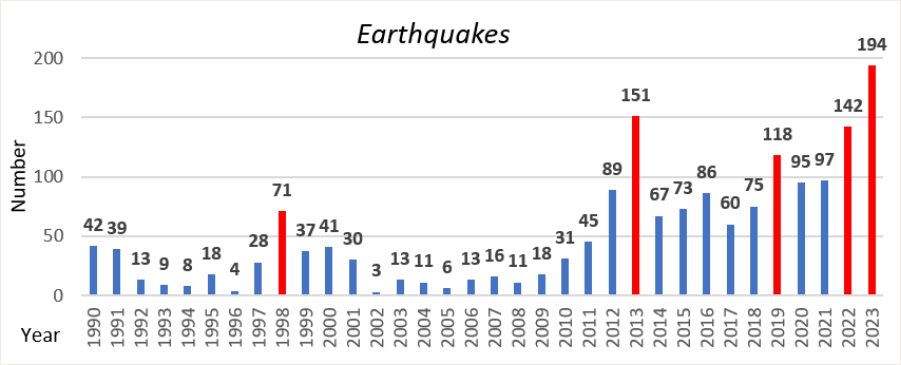


Number of registered quarry explosions by quarry produced in 2021-2023 (**N=3945**).





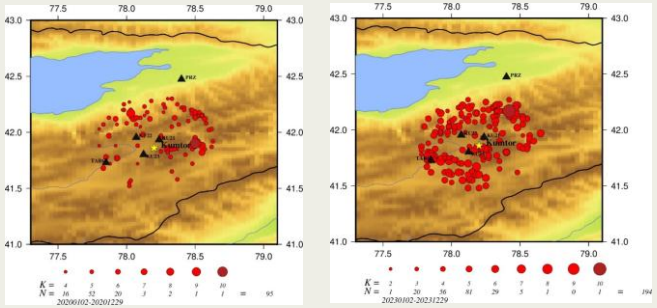
Seismic records of: (a) explosion (upper trace) and earthquake (lower trace) without filter, Z-component, TARG station; (b) explosion (upper trace) and earthquake (lower trace), 5.0 Hz filter, Z-component, TARG station.



REGISTRATION OF INDUCED EARTHQUAKES

In recent years, due to the intensification of mining activities at solid mineral deposits where regular blasting operations are carried out, dangerous geodynamic manifestations have begun to be observed [Aristova et al., 2022]. The main factors that provoke the occurrence of man-made seismicity within the area of coal quarries are the redistribution of loads on the surface of the crust due to the creation of large trenches and mine dumps, the influence of dynamic loads, such as regular powerful explosions [Aristova et al., 2022].

It is necessary to notice, that in recent years the number of registered weak earthquakes has increased sharply in the territory of the Kumtor deposit. It is highly likely that the increase in the number of earthquakes was caused by a large number of explosions in recent years, as well as by redundant masses of the geological environment in the area of the mine dumps.



Map of earthquake epicenters in the Kumtor area: (a) for 2021; (b) for 2023.

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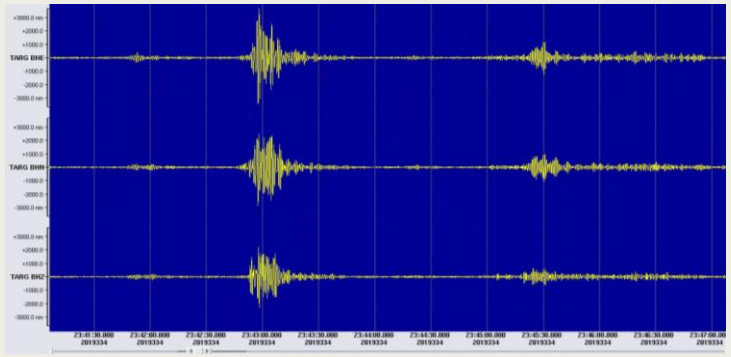
REGISTRATION OF EXOGENOUS PHENOMENA NEAR THE KUMTOR DEPOSIT

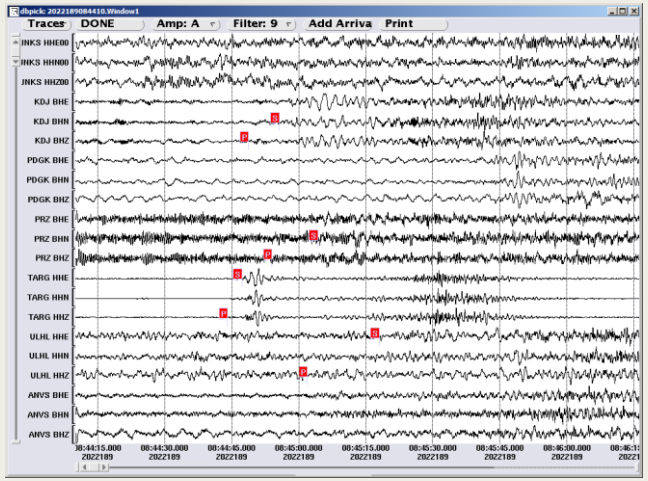
In addition to endogenous events, exogenous phenomena are also recorded in the deposit area. On December 1, 2019, at 05:43 of local time (November 30 23:43 GMT), a large landslide occurred in the Kumtor deposit area (Figure 16). The volume of the landslide was 12 million 825 thousand cubic meters - 450 meters in length, 570 in width and 50 in height.

The landslide was recorded by a large number of seismic stations in Kyrgyzstan at epicentral distances from ~36 km (TARG) to ~530 km (ARK). The landslide waveforms have weak arrival of P-wave, and long surface waves dominate.

One more exogenous phenomenon had occurred on July 8, 2022, when a part of the glacier collapsed in the Dzhukku gorge (in the Jeti-Oguz district of the Issyk-Kul region) - on the pass connecting the Issyk-Kul basin with the high-mountain Ara-Bel syrts. According to the Ministry of Emergency Situations of the Kyrgyz Republic (MES KR), the volume of the collapsed ice mass exceeded 2 million cubic meters. Experts noted that the collapse of the glacier in Juuku was influenced by two factors - climate change and mining operations in the area. This event had been processed in the IS NAS KR, and corresponding parameters had been received: July 8, 2022, t_0=08-45-11.9, lat =41.9492°, lon =77.862°, h=0, mpv=2.1, K_R=5.5.



Seismic record of the landslide November 30, 2019, t_0=23-42-39. TARG station. Filter 1.25 Hz.



Waveforms of the glacier avalanche (08.07.2022).

CONCLUSION

The features of the wave pattern of quarry explosions and earthquakes were studied.

The presence of active faults in the territory of the Kumtor deposit, blasting operations, and the movement of large volumes of soil lead to significant additional load on the crust and to some geodynamic processes implementation that allow the crust to move to a new equilibrium state. In this regard, in recent years, the effect of induced seismicity has been observed in the territory of the deposit, manifested in an increase in the number of earthquakes and their energy.

In addition to endogenous events, exogenous phenomena are also recorded in the area of deposits, for example, a landslide with a volume of 12 million 825 thousand m^3 in the Kumtor area, a part of glacier avalanche in the area of the Dzhukku gorge. The landslide and glacier avalanche were recorded by several regional seismic stations, and the dynamic and kinematic parameters of its recording were studied. The factors that caused the landslide are most likely due to anthropogenic activity and climate change.

All these events indicate the necessity of seismic monitoring in the areas with intensive anthropogenic activity and appropriate analysis.