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RUSSIAN EXPERIENCE OF BLAST-FILL DAM ERECTION

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Elaboration of the technology of dams and embankments construction based on utilization of powerful explosions started in Russia in the 30's of the XX Century. Advantages of this technology lie in use of rock material available just at the dam site, in the construction period decrease, in the possibility to construct large structures in the remote areas where no qualified workmen are available, and, finally in the project's cost reduction.

Before the World War II several rather small dams from 5000 to 200000 cubic meters in volume were erected by blasts that used from 5 to 500 tons of the explosives. Later on this technology developed further and during the 1959-1989 several large dams have been erected by powerful explosions. They were constructed as water-retaining dams, for protection from debris flows, and as tailings' storages embankments (Table 1).

Explosions at the Alamedin and Shamsi Rivers (Northern Kyrgyzstyan) were experimental. The most unique project was the 80-m high Medeo dam constructed in 1966-1967 on the Malaya Almaatinka River (Southern Kazakhtan) to protect the Almaty city from devastating debris flows. More than 9000 tons of explosives was used in two blasts to erect a dam about 3×10^6 m^3 in volume. The first one (Figure 1) created the dam about 60 m high and the second one enlarged it up to 80 m.

Several years later after its construction the dam stopped power-

No	Location	Year of the explosion	Rock type	Total amount of the explosives (tons)	Dam height (m)	Dam width along the stream (m)	Dam volume (m^3)	Unit rate of the explosives (kg/m^3)
1	Alamedin River (Kyrgyzstan)	1959	Porphyrite	153	21	280	1.15×10^5	1.33
2	Shamsi River (Kyrgyzstan)	1960	Granite	48	19	250	**6×10^4**	0.8
3	Malaya Almaatinka River (Medeo – Kazakhstan)	1966, 1967	Granite	5923 (first blast) 3946 (second blast)	80 (60 after first blast)	560	3×10^6 (1.5×10^6 after first blast)	3.95 1st blast 2.63 2nd blast
4	Baipasa HPP on the Vakhsh River (Tajikistan)	1968	Limestone	2000	50	550	1.5×10^6	1.33
5	Ak-Su River (Dagestan)	1972	Limestone	552	85	330	2.5×10^5	2.2
6	Burlykia River (Kyrgyzstan)	1975	Granite	703	50	320	5.4×10^5	1.3
7	Alindjai River (Nakhichevan)	1982	Porphyrite	689	32	200	6.1×10^5	1.13
8	Kvaisa (Georgia)	1984	Porphyrite	437	26	250	1.1×10^5	3.97
9	Uch-Terek River (Kyrgyzstan)	1989	Sandstone and siltstone	1915	45	295	8.7×10^5	2.2

Table 1 - Main parameters of the blast-fill dams erected in the former USSR

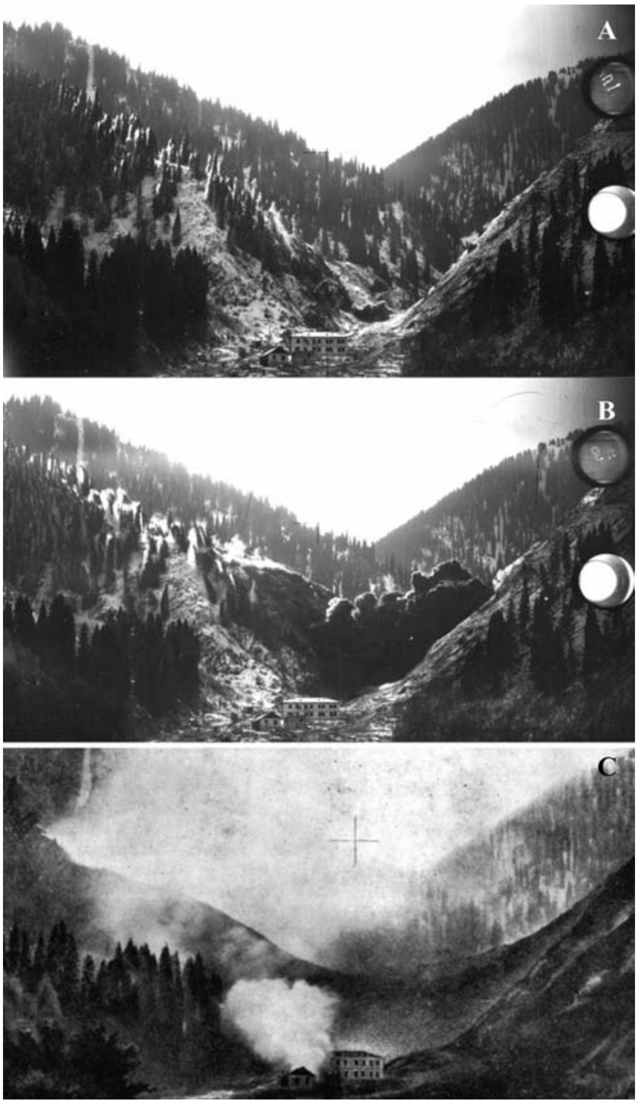

Figure 1 - The 1st explosion at the Medeo. A – First appearance of the explosive gases at the slope foot; B – Slope starts collapsing; C – The dam immediately after the explosion

ful debris flow and saved the Almaty city from the catastrophic disaster. Later on the dam was enlarged by rockfill.

In 1968 the explosion was used to construct the water-retaining dam of the Baipaza HPP on the Vakhsh River in Tadjikistan (Figure 2). The specific character of this blast was determined by the presence of the spillway and other structures constructed beforehand that had to be protected from the seismic effect of powerful explosion.

To decrease seismic effect the total amount (2000 tons) of explosives was divided into 12 charges located in the separate drifts, which were exploded one by one with the 0.5-5.5 seconds delays. Due to the high steepness of the exploded slope (60º - Figure 2-A) almost one half of the dam body was formed by the rock mass that slid after the explosion (Figure 2-B). As a result, its entire volume increased up to $1.5{\times}10^6$ m^3 and unit rate of the explosives turned out to be low – about 1.33 kg/m^3.

Since 1972 all large industrial explosions, including those designed for blast-fill dams construction have been tested on the

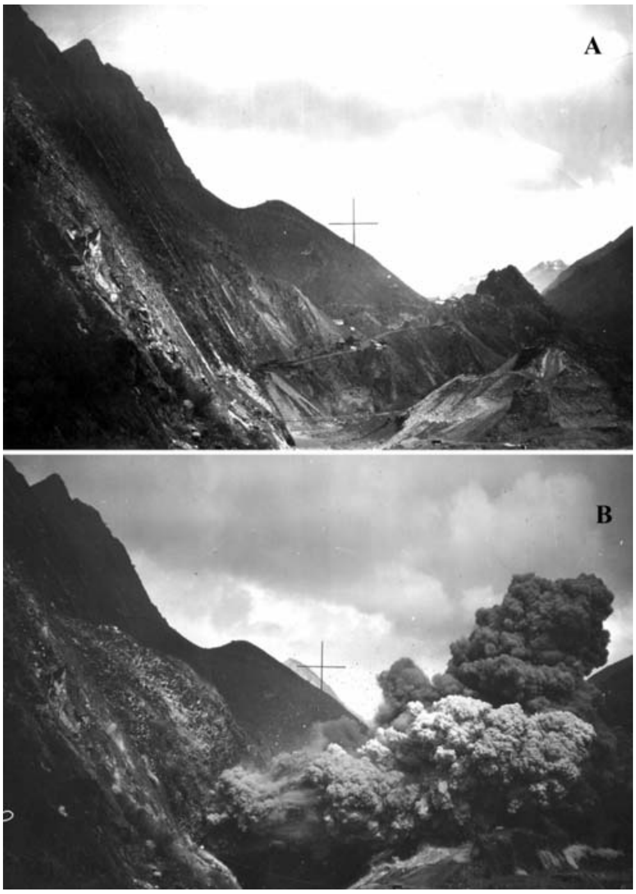

Figure 2 - The Baipasa explosion. A – The morphology and geological structure of the site; B – Sliding rock mass above the erupting explosive gases

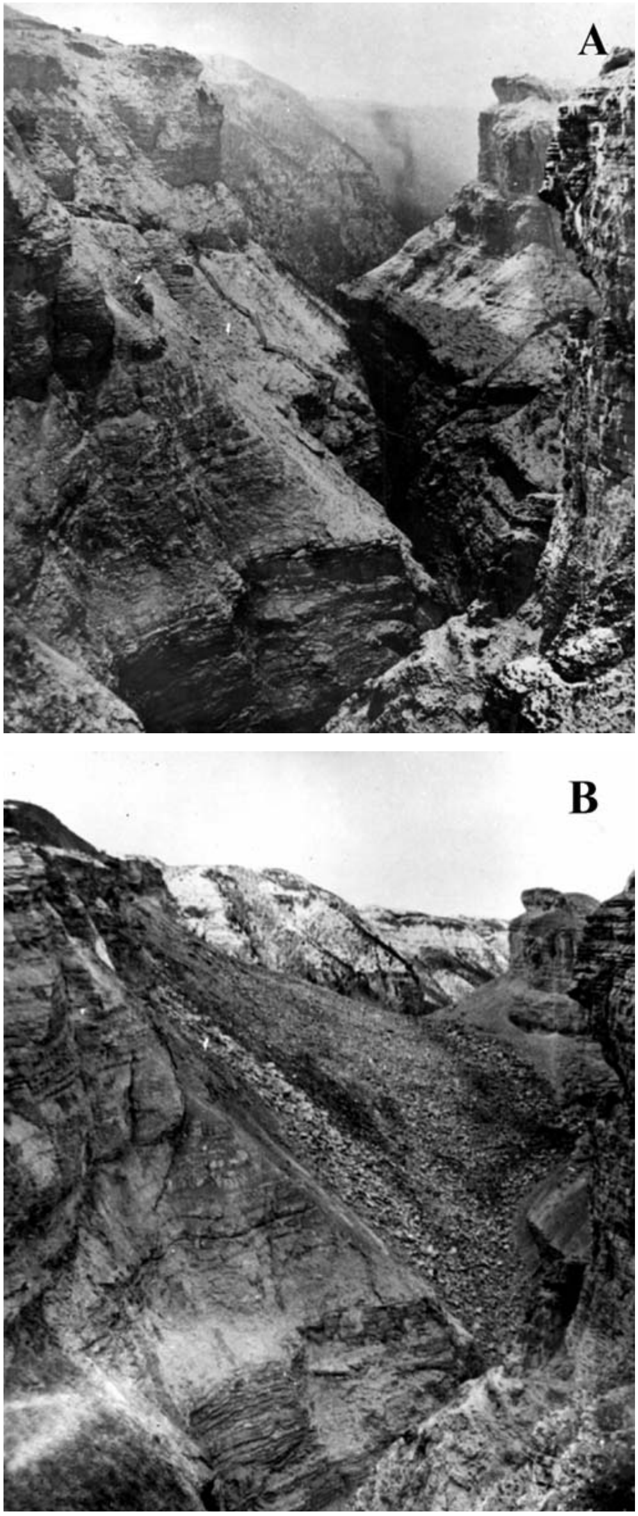

Figure 3 - The Ak-Su River valley before (A) and after (B) the explosion

special simulator developed in our institute. Experiments have been carried out in the vacuum camera that allows complying with the similarity criteria. We also performed back analysis of well-known industrial blasts. Starting from the Ak-Su explosion (Figure 3) all such projects have been tested by use of the simulator. Different variants of charges' mass and location within the blasted massive were tested in search of the optimal explosion implementation.

Special emphasis had been devoted to the Kambarata-1 HPP project in Kyrgyzstan. It includes the blast-fill dam 200 millions cubic meters in volume that should be constructed by blasting of 200-250 thousands tons of explosives. No one similar project has been proposed worldwide. Two experimental blasts have been done at the Burlykia River in 1975 (Figure 4) and at the Uch-Terek River in 1989 (Figure 5).

Their effects and simulation results have been described in the presentation together with data on modelling of the explosions designed for the Kambarata-1 and Kambarata-2 dams erection. In the Kambarata-1 case emplacement of main portion of blasted rock should be due to its sliding from the high (about 1000 m) and steep (up to 40-45º) slope. Special measures to prevent avalanche-like motion of debris along the Naryn River valley, that could result in dam crest lowering were envisaged. In the late 80th underground excavations started at the Kambarata-2 dam site where drifts for charges, spillway and headrace tunnels were constructed. Preparatory work started at the Kambarata-1 dam site too. Unfortunately these activities ceased after breakdown of the USSR.

Figure 4 - The Burlykia experimental blast-fill dam. Adit at the base of the right slope was made to investigate seismic effect of the explosion on the underground structures

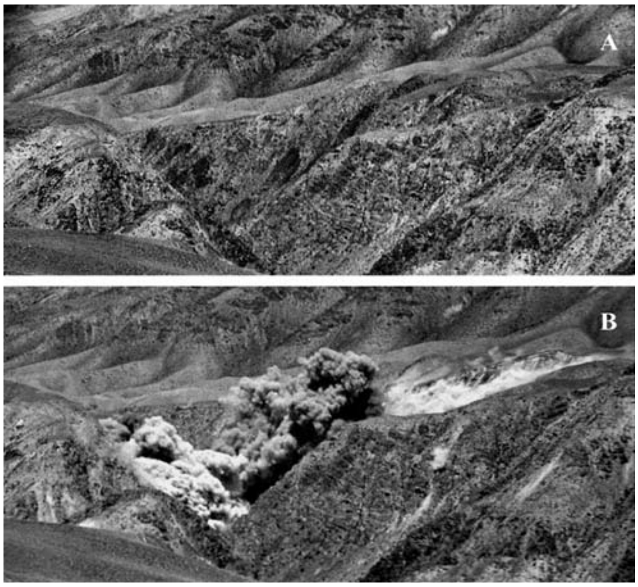

Figure 5 - The Uch-Terek experimental blast. A – Test site immediately before the explosion; B – Formation of the artificial rockslide scar at the upper part of the exploded slope