

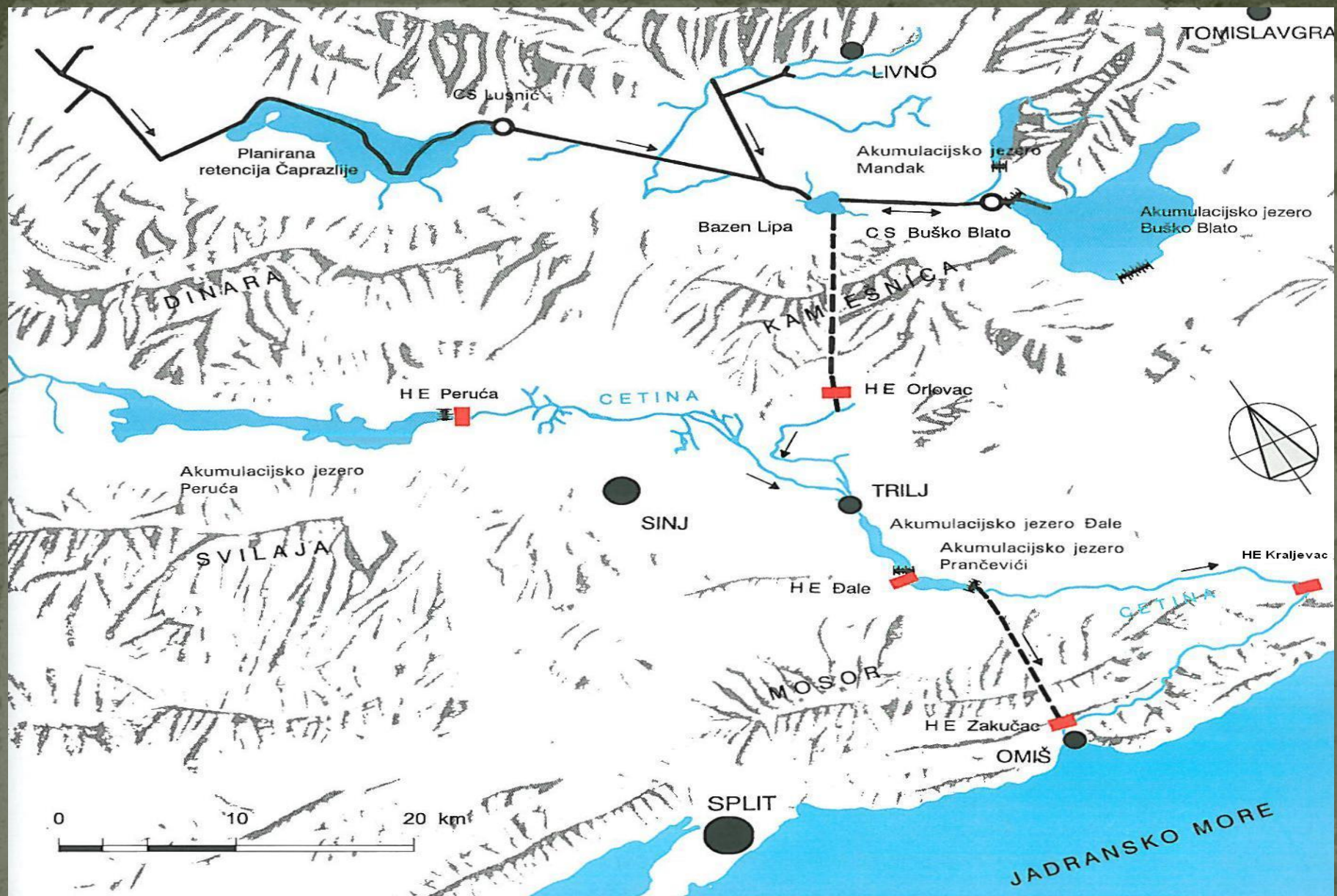


## HYDROPOWER PLANT

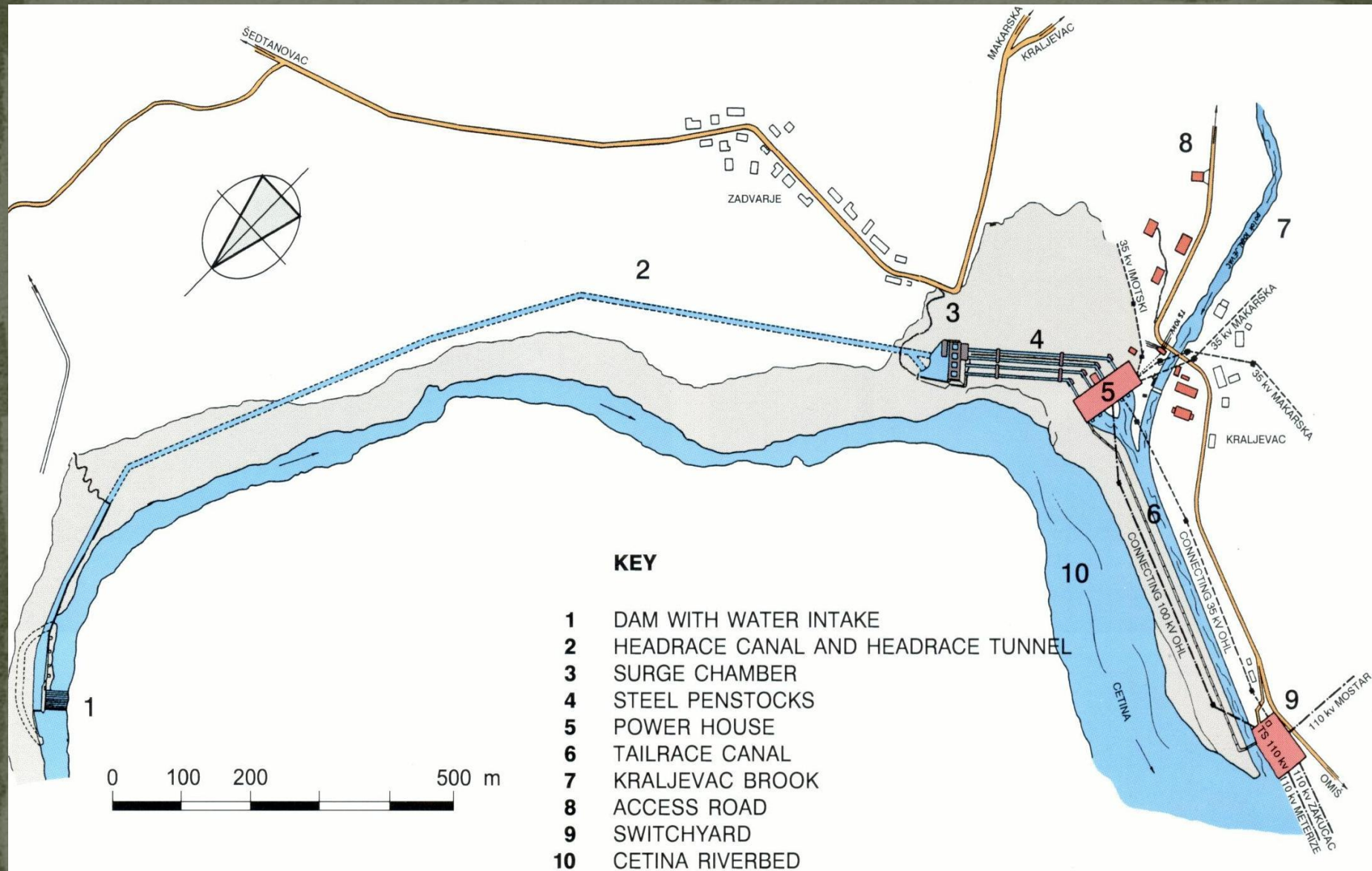
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KRALJEVAC





Kraljevac HPP is situated 21 km far from the Cetina river estuary



HPP Kraljevac layout



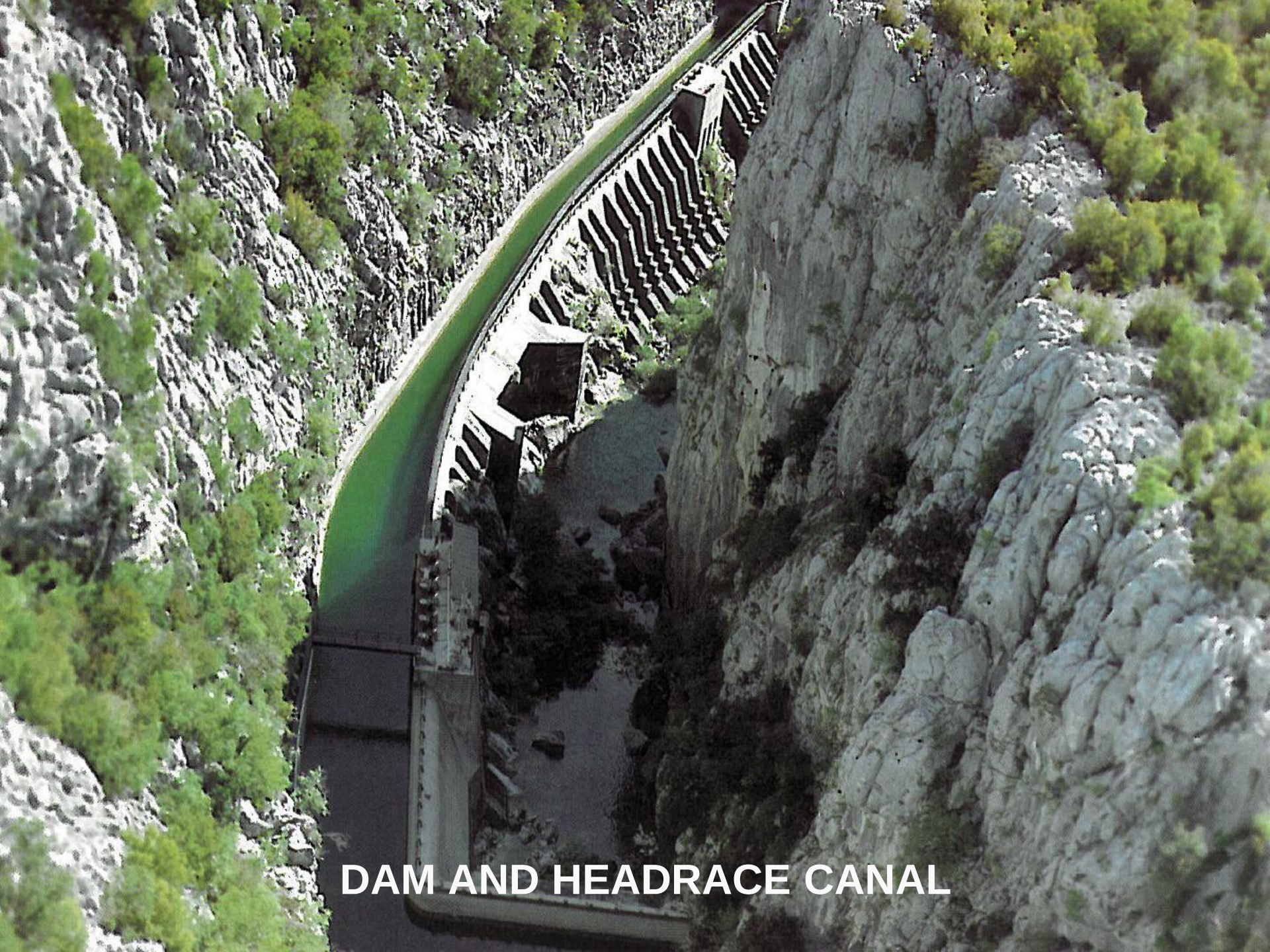
DAM

This aerial photograph captures the Gubavica Dam and Powerhouse complex, nestled within a deep, rocky gorge. The dam, a concrete structure with multiple spillways, is situated upstream of the powerhouse. The surrounding landscape is a mix of steep, light-colored limestone cliffs and dense green forest. A small village with red-roofed houses is visible on the right side of the gorge. A winding road follows the edge of the gorge, and a river flows through the center. The image is annotated with four labels: 'DAM' at the top left, 'WATERFALL GUBAVICA' below it, 'SURGE CHAMBER' further down, and 'POWERHOUSE' at the bottom left, each with a line pointing to the corresponding feature.

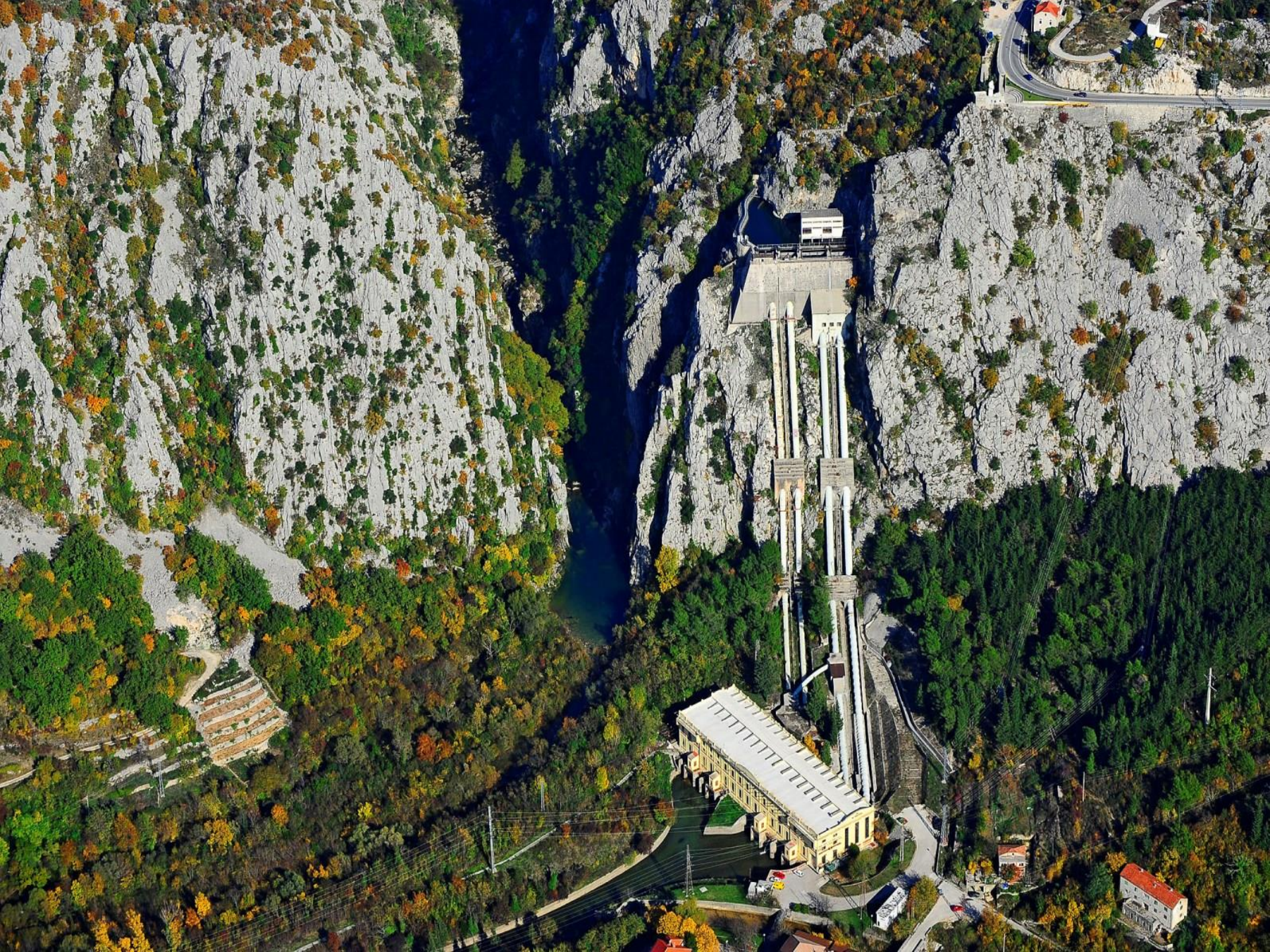
WATERFALL  
GUBAVICA

SURGE  
CHAMBER

POWERHOUSE



**DAM AND HEADRACE CANAL**

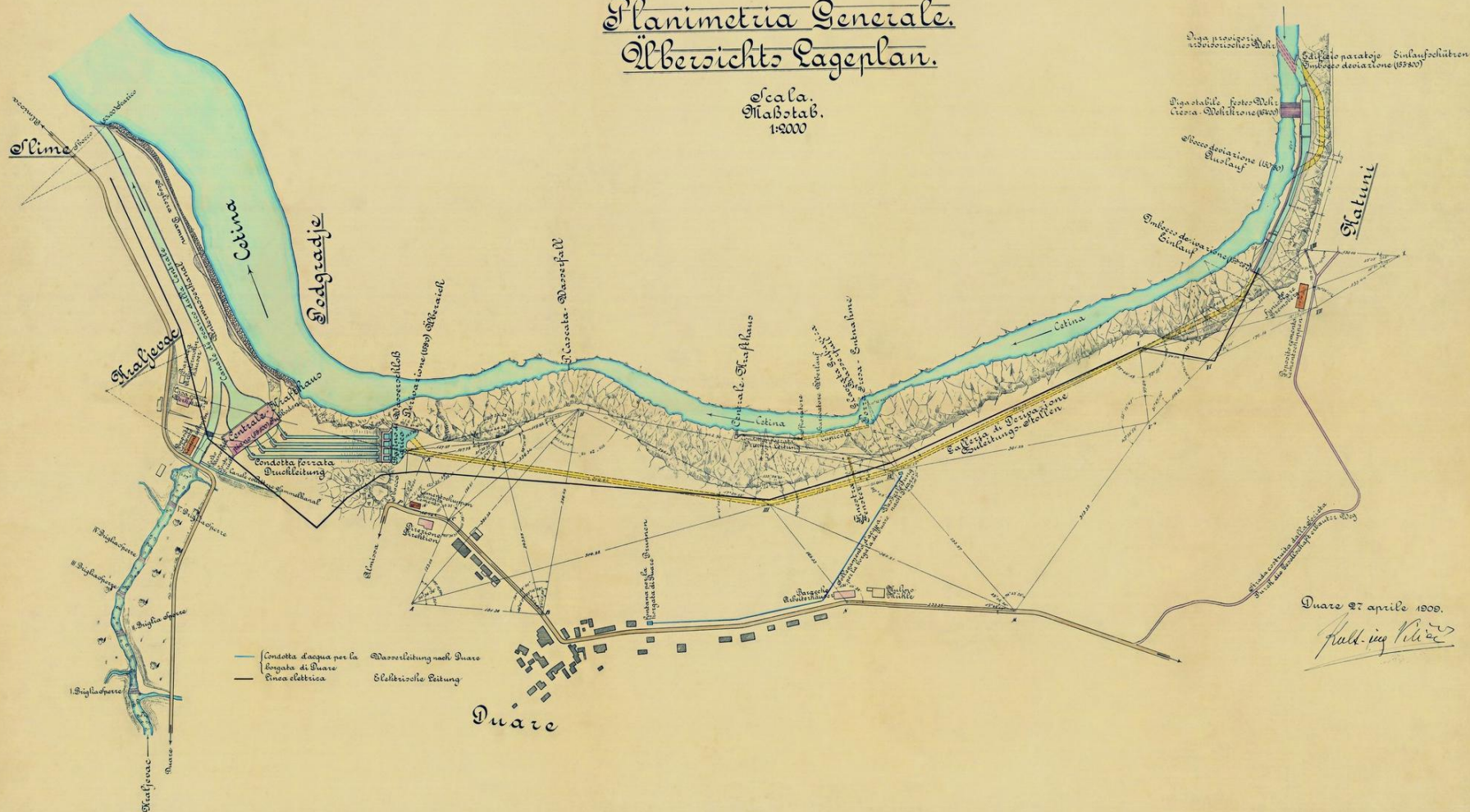


- At the end of the 19th century the first researches of the Cetina river hydro potential
- In 1897 the company Schuckert & Co elaborated the basic design for utilization of the considerable natural water head at the Gubavica waterfalls
- In 1899 Dešković & Wagner elaborated the first detailed design for the 87 m gross head and 35 m<sup>3</sup>/s discharge at the Gubavica location
- In 1902 the Belgian expert Macquet elaborated 5 alternatives of the water potential utilization downstream from the town of Trilj and he proposed an alternative similar to Zakučac HPP as the most favorable one

- In 1904 the Austrian association „Wasserwerke“ got the water utilization concession for the water potential of the concentrated head of Gubavica, based on the design by Dešković & Wagner
- In 1906 the Swiss engineer Charles de Halle elaborated a detailed design for the construction of Kraljevac HPP
- In 1907 the association „Wasserwerke“ sold the management rights to the Italian association „Sufid“. The general manager of the company „Sufid“ E. Cairo with his associates modified the design for the existing location
- In 1909 the „Sufid“ association requested a widening of the concession for the 110 m head and the 75 m<sup>3</sup> /s discharge

# Planimetria Generale. Übersichts Lageplan.

Scala.  
Maßstab.  
1:2000



The original design of Kraljevac HPP from 1909



Between 1907 and 1909 the small auxiliary hydropower plant „Centralina” with a Pelton turbine and 130 kW generator was constructed at the pedestal of the Great Gubavica waterfall



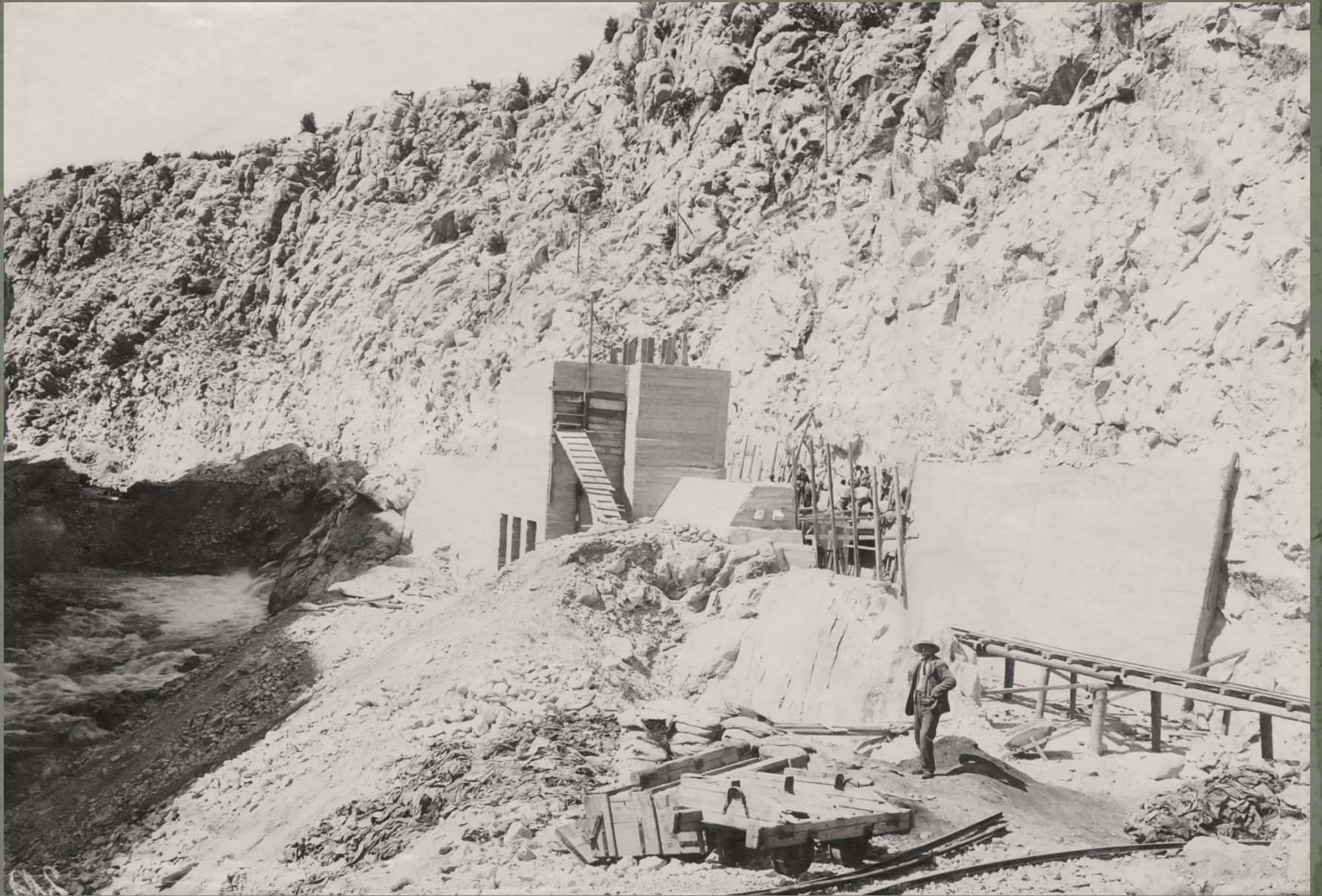
**For transportation of equipment for „Centralina“, a 250 m long cable railway surmounting the vertical height of 140 m was built**

## 1908 - 1912

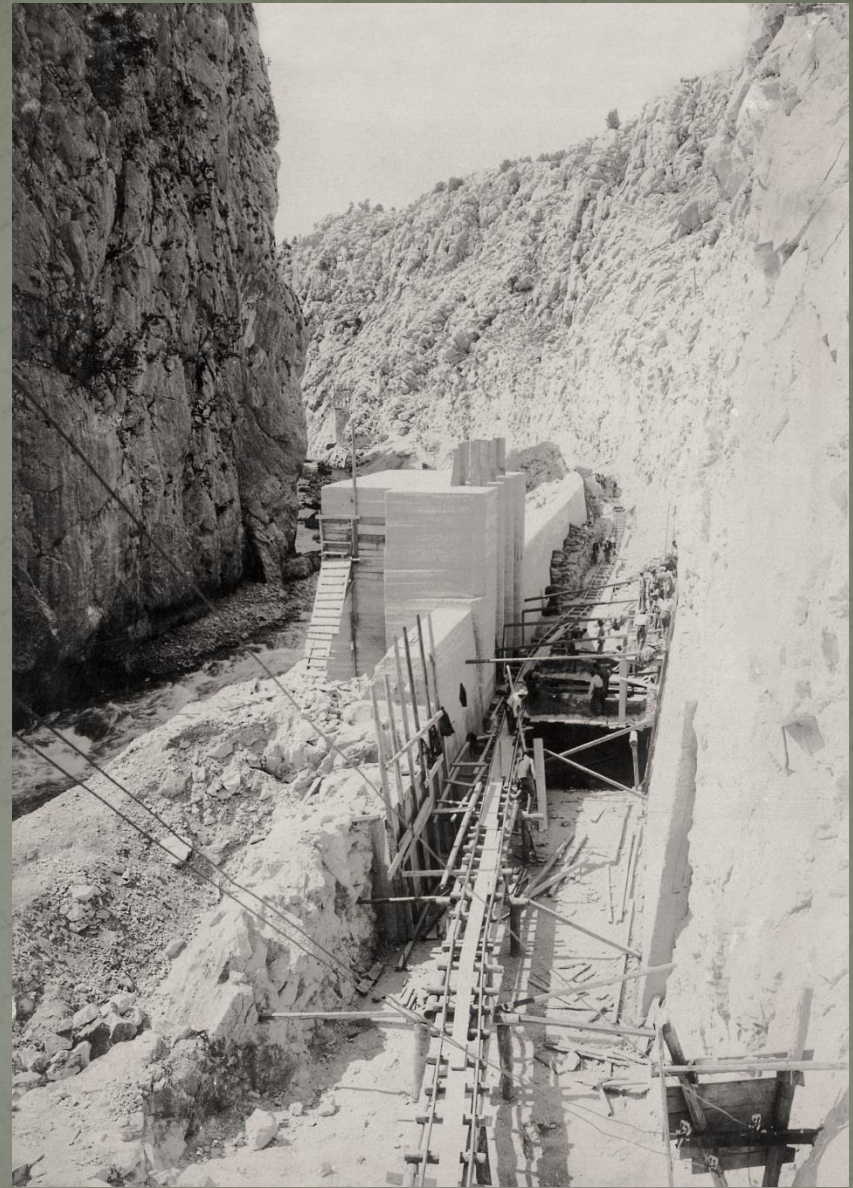
- In the Cetina river canyon, 25 m wide and 70 m high, at the bottom of Zadvarje, a dam 18 m high and 25 m long was built
- For the purpose of building the dam, a precedent provisional dam and bypass tunnel 180 m long with cross section of 48 m<sup>2</sup> which serves as a bottom outlet with five sliding gates was built
- A headrace canal to the dam 244 m long containing a bottom outlet with 6 sliding gates was built
- The headrace canal enters the intake tunnel 1265 m long and approximately 5.5 m high, conveying water into the surge chamber



Construction of the dam in 1909



Construction of the headrace canal at the dam in 1909



Construction of the headrace canal at the dam in 1909



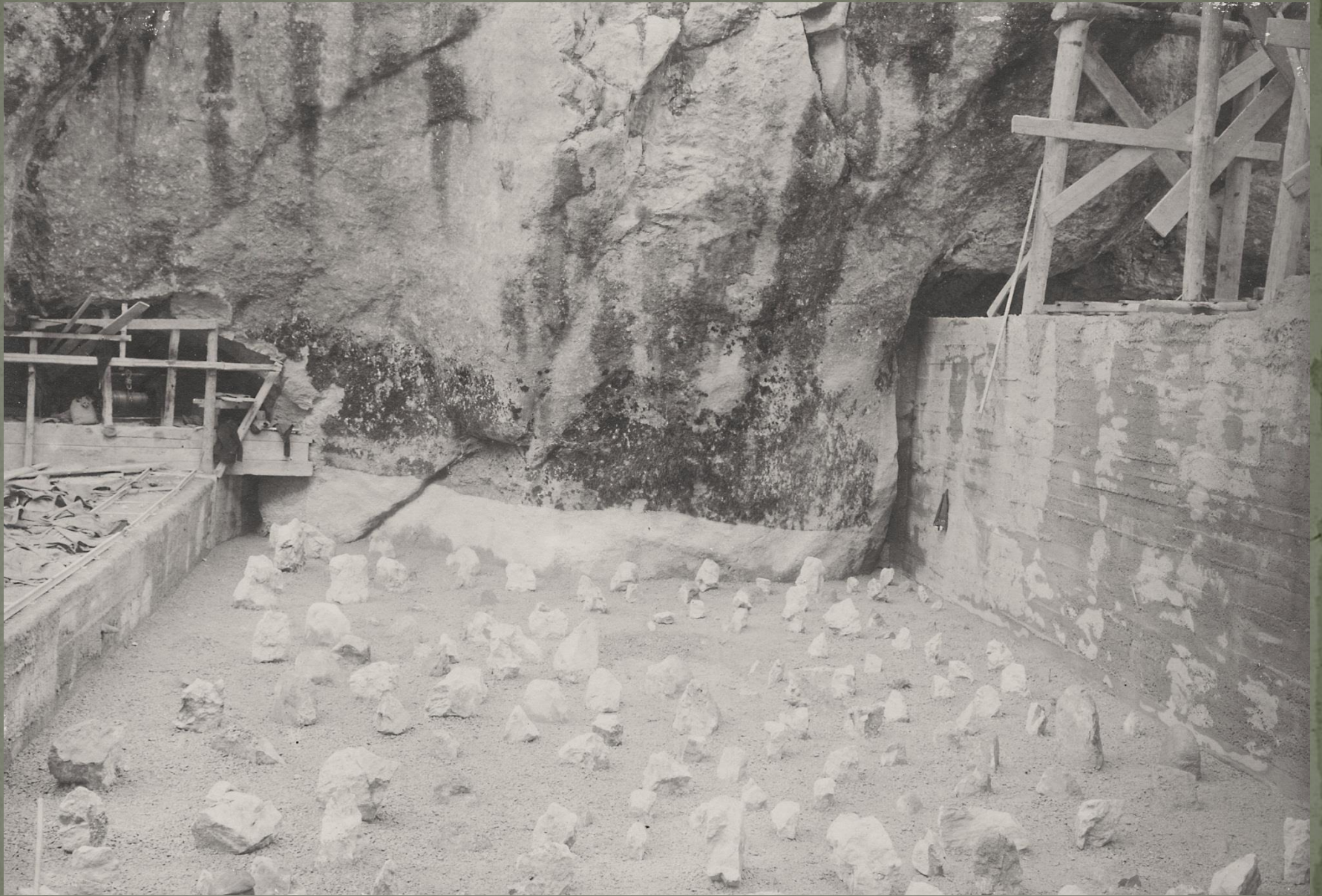
Construction of the bypass tunnel in the dam in 1909



Provisional dam built of 20 000 bags with sand



Construction of the dam comes to its end – 1911



Concrete construction works



Concrete construction works



The dam was built – the end of 1911

## 1908 - 1912

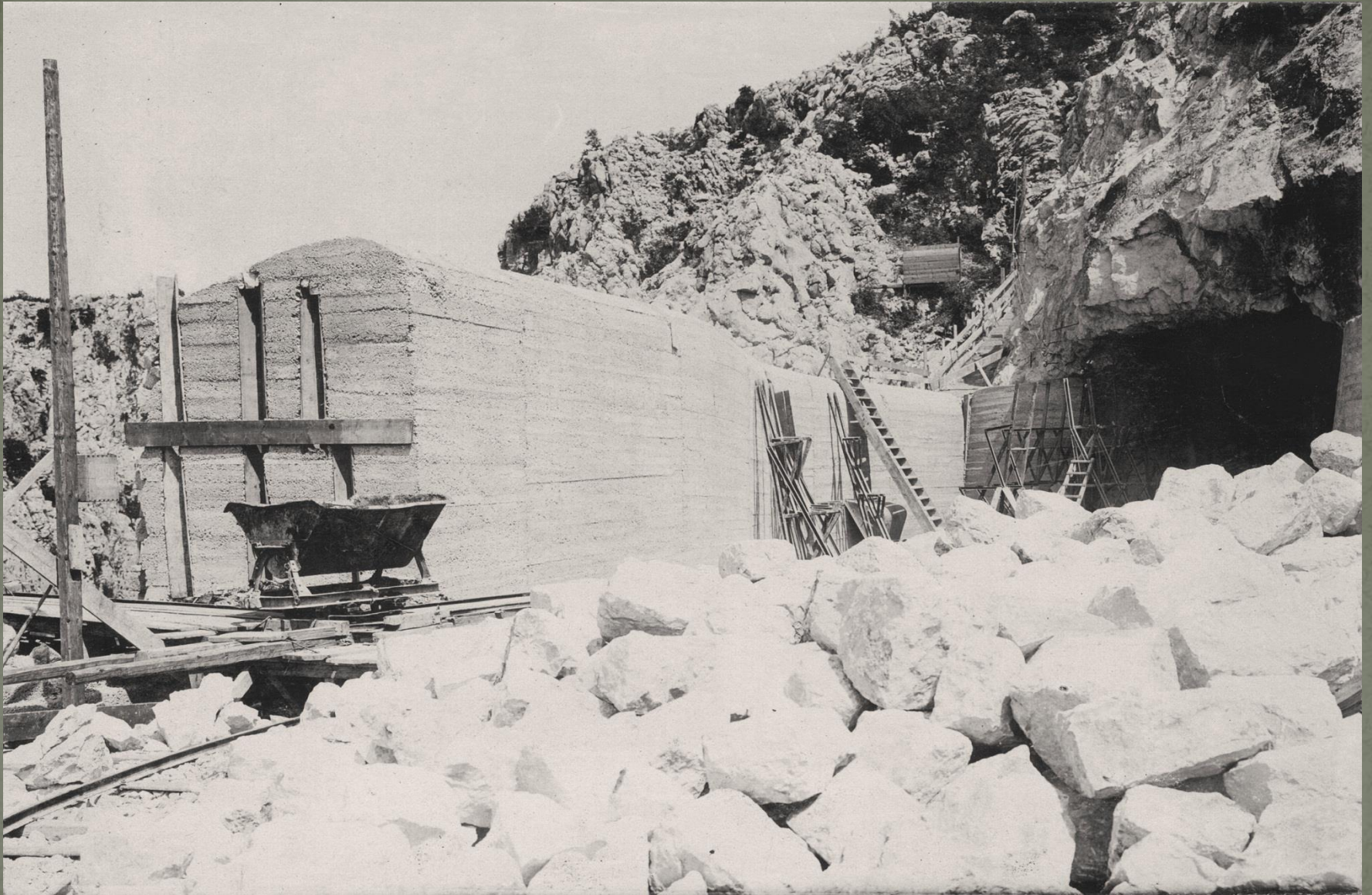
- The surge chamber was built on a cliff 100 m high, with a volume of  $4500 \text{ m}^3$  and a surface of  $1000 \text{ m}^2$  covered with water. At the downstream part of the chamber there are radial gates at the entrance to the steel penstocks
- Two steel penstocks with the diameter ranging between 2.3 to 1.8 m, 190 m long were erected
- A part of the powerhouse 44 m long, 26 m wide and 13 m high was built
- Two generating units of the Hungarian manufacturer Ganz 12.8 MW each were erected
- Upon completion of the first construction stage, this was the biggest hydropower plant in south-east Europe and one of the biggest in the whole Europe



Construction of the surge chamber spillway wall



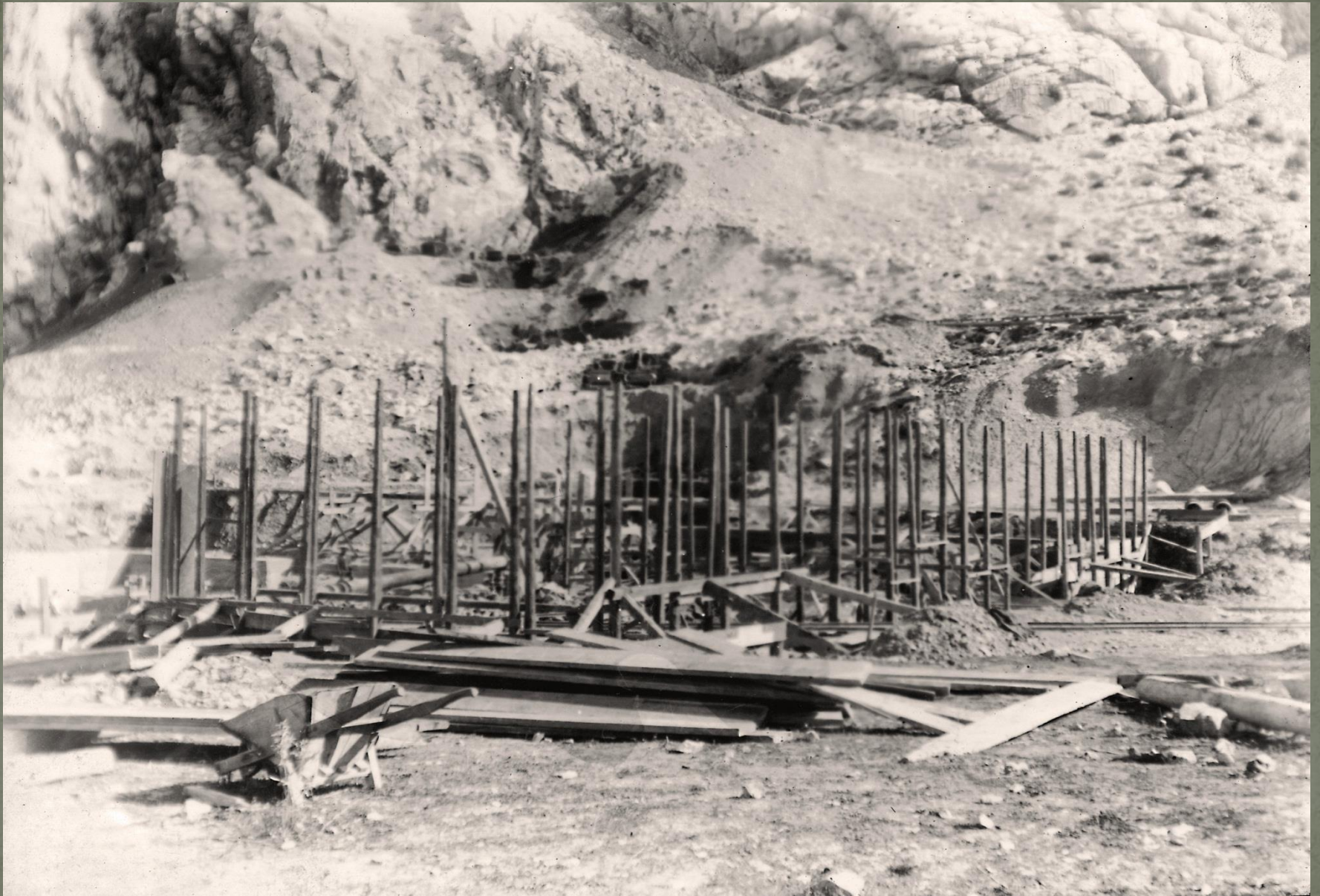
Right outlet from the tunnel to the surge chamber



Left outlet from the tunnel to the surge chamber



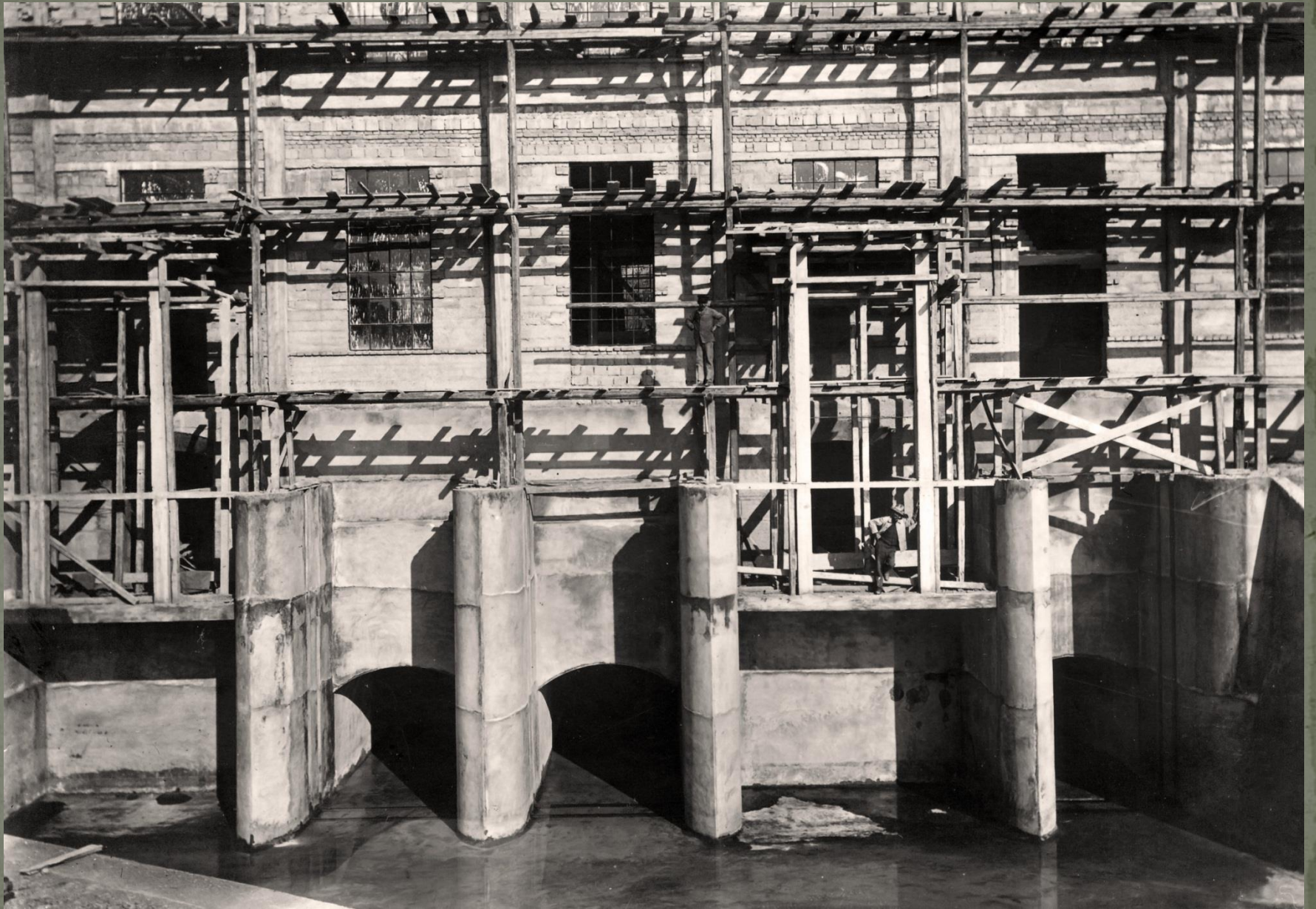
Commencement of the works on the powerhouse



Commencement of the works on the powerhouse



Works on the construction of the first two penstocks



Final construction works of the first stage



Final construction works of the first stage



Completed works of the first construction stage

- Kraljevac HPP was officially put into operation on 19 March 1912 when it was the biggest hydropower plant in south – east Europe, according to its capacity
- During the first few years the plant exclusively served for power supply of the carbide factory in Dugi Rat and the surrounding settlements
- In 1915 the „Sufid” association finally got a concession for the head of 110 m and 75 m<sup>3</sup> /s discharge, after accepting the terms of the Austrian War and Railway Ministry
- In 1924 by construction of an overhead line 15 kV Dugi Rat – Omiš, Omiš got electric power supply from the Kraljevac HPP
- By construction of a 50 kV overhead line Dugi Rat – Split, since 1 January 1927, Split got electric power from Kraljevac HPP

- In 1929 the French association „La Dalmatienne“, founded in Paris, bought the complete property of the „Sufid“ association and continued with construction works on the second stage
- During the second construction stage (1928 – 1932) the powerhouse was widened, two new penstocks and two generating units of 20.8 MW rated power each were erected
- In 1932 Kraljevac HPP was again the biggest hydropower plant in south – east Europe, not only upon its power (67.2 MW) as well as upon electric generation



Unloading of the penstocks in Makarska



Parts of the penstocks in the Makarska harbour



Parts of the penstocks on the Makarska beach



Transportation of the penstocks Makarska - Kraljevac



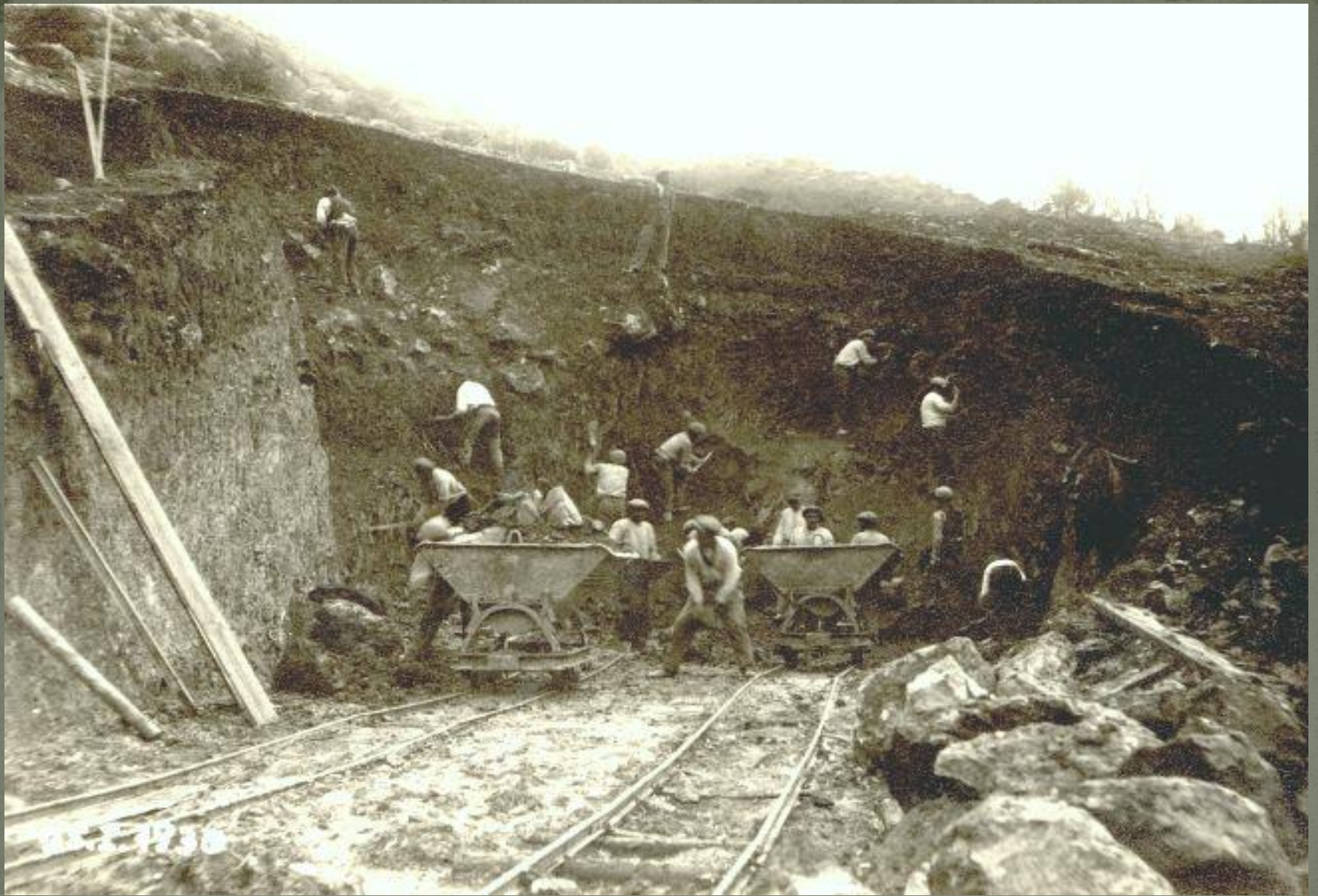
Transportation of the penstocks Makarska - Kraljevac



Transportation of the penstocks Makarska - Kraljevac



Disposal of the penstock parts in Kraljevac HPP



A great number of workers took part in construction works



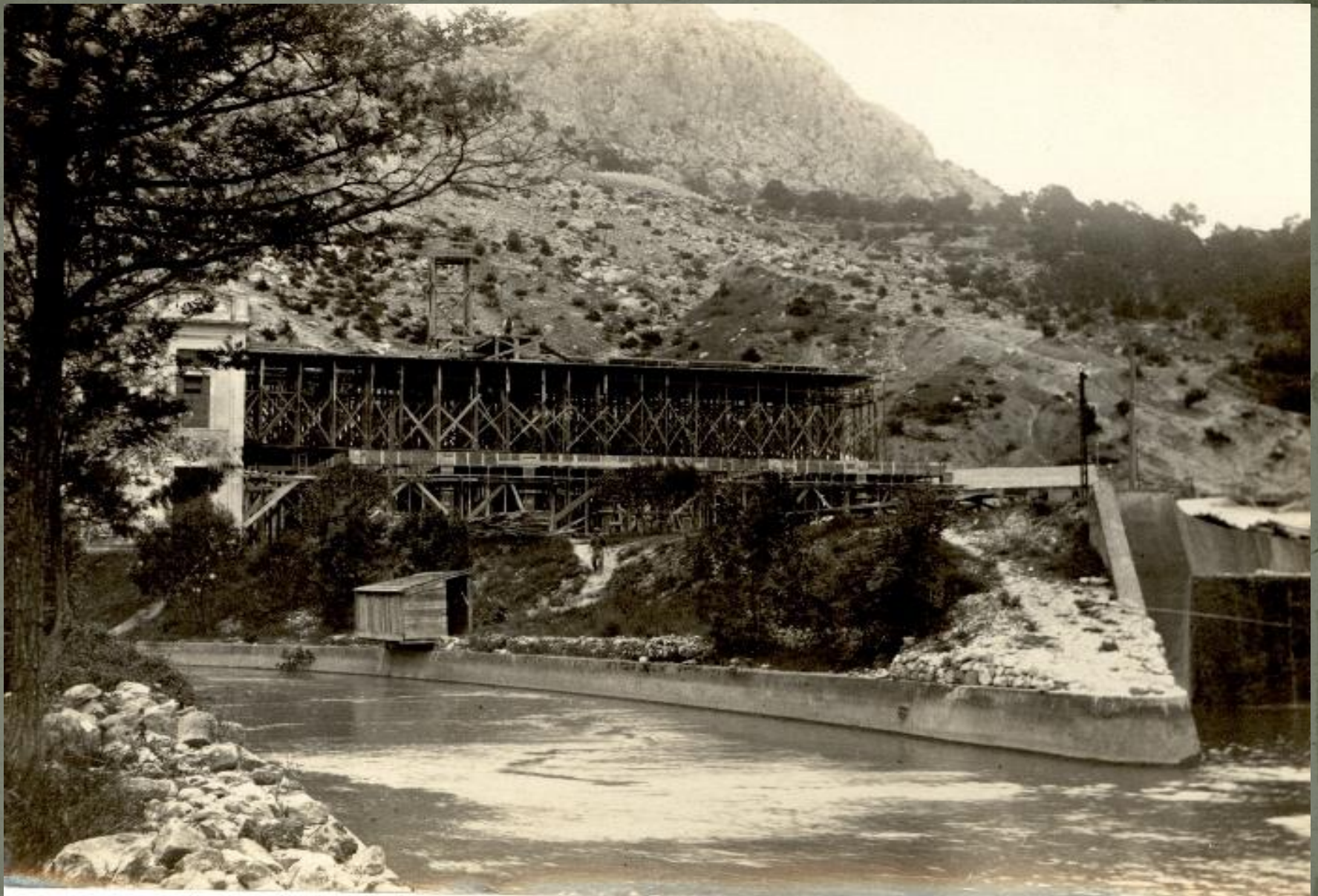
Excavation of the foundations for widening the powerhouse



Works on widening the powerhouse



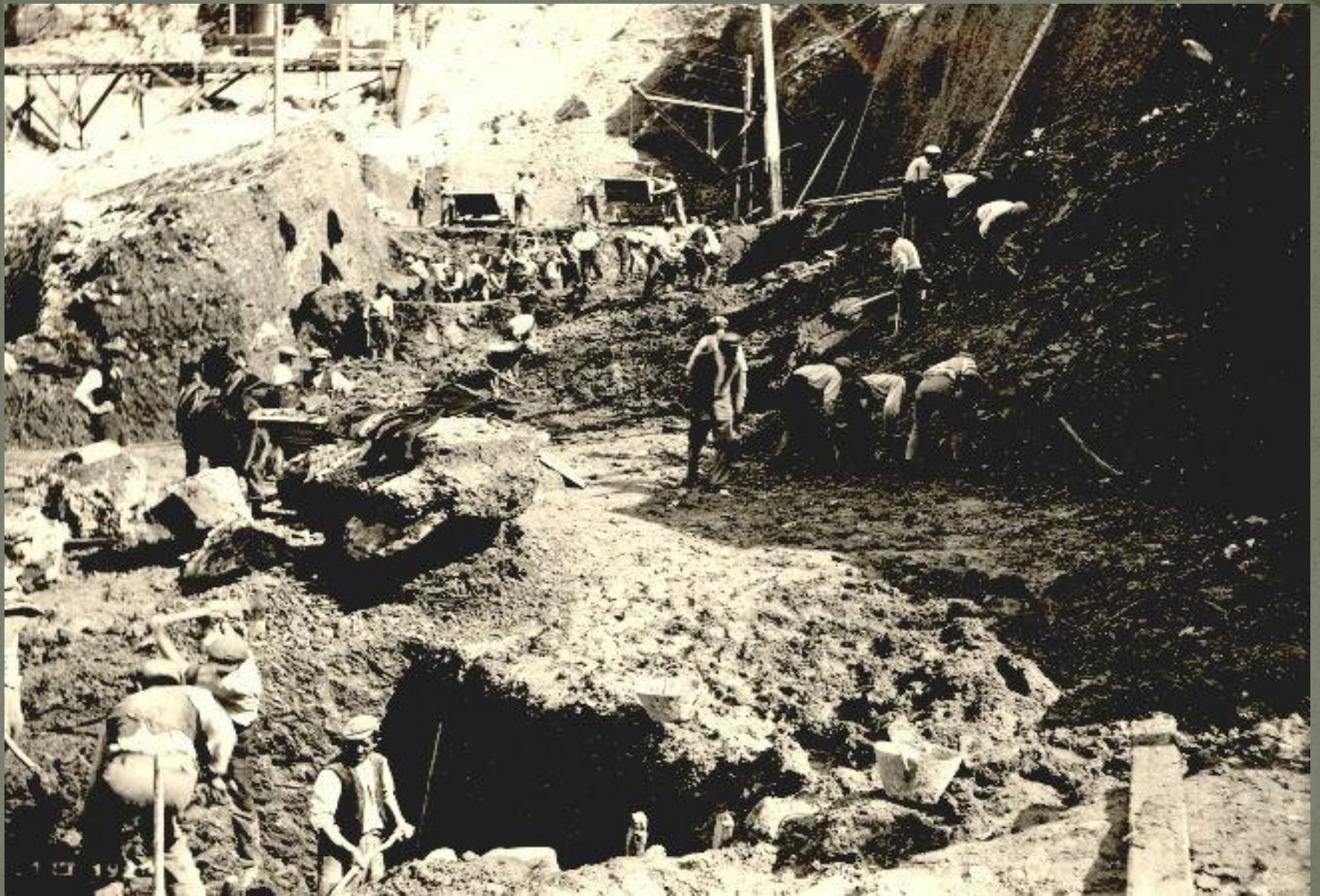
Works of widening the powerhouse are approaching its end



A view from tailrace canal on the powerhouse widening works



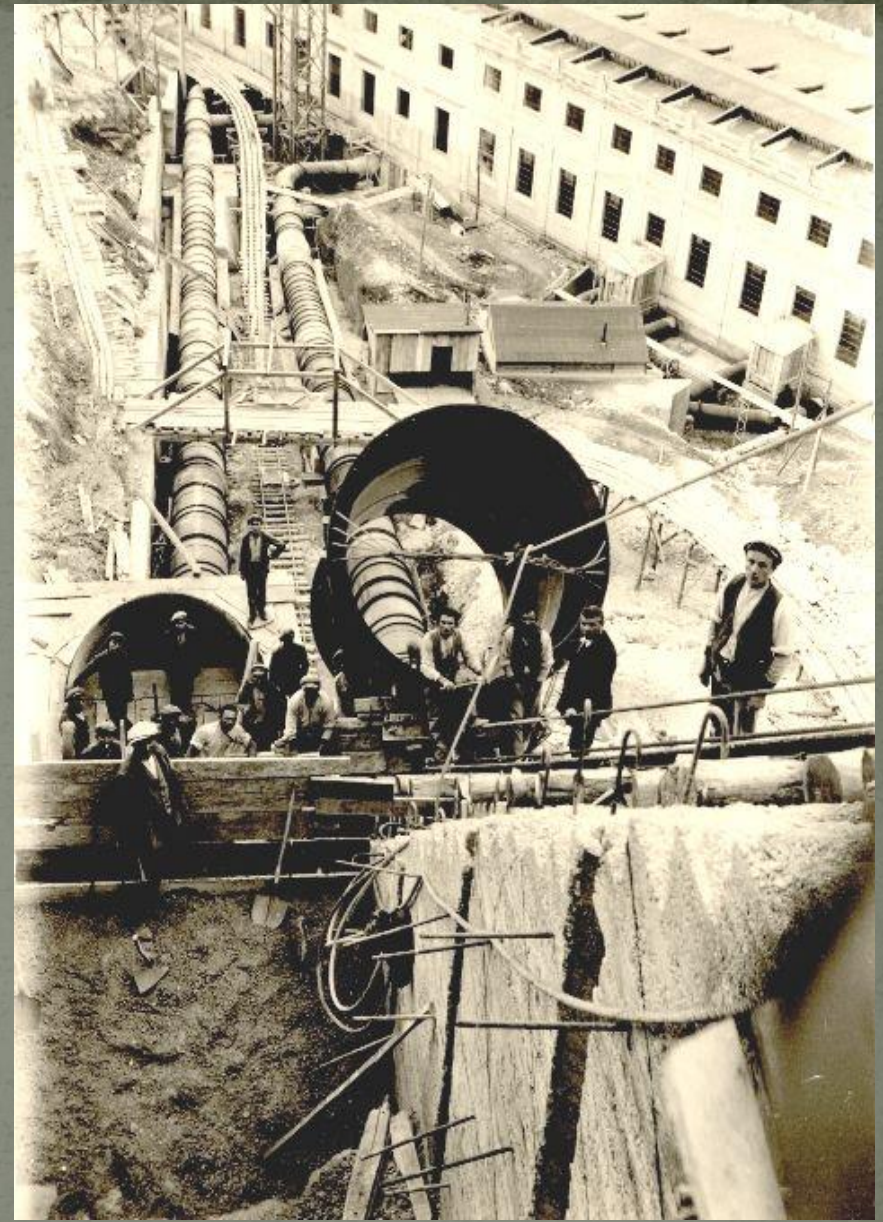
**Works on widening the powerhouse and construction of the penstocks 3 and 4**



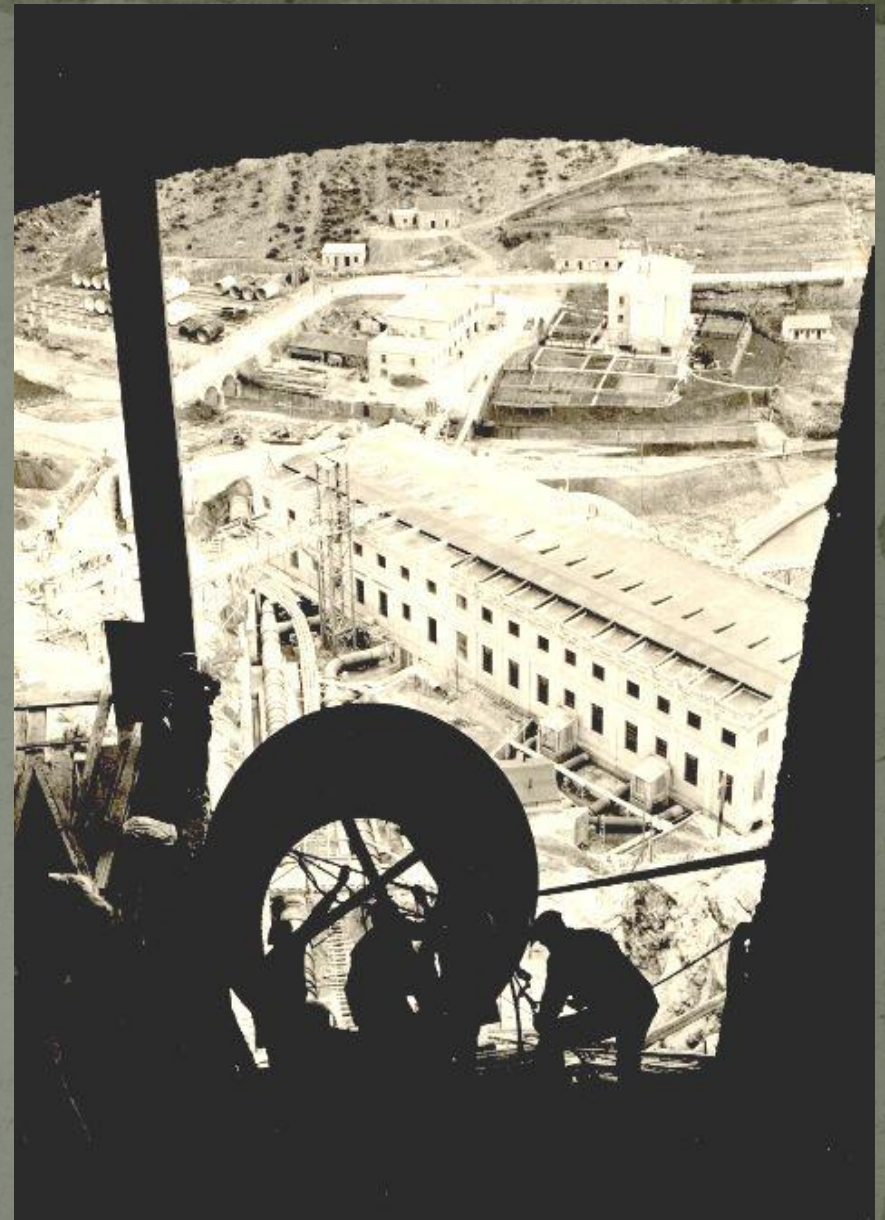
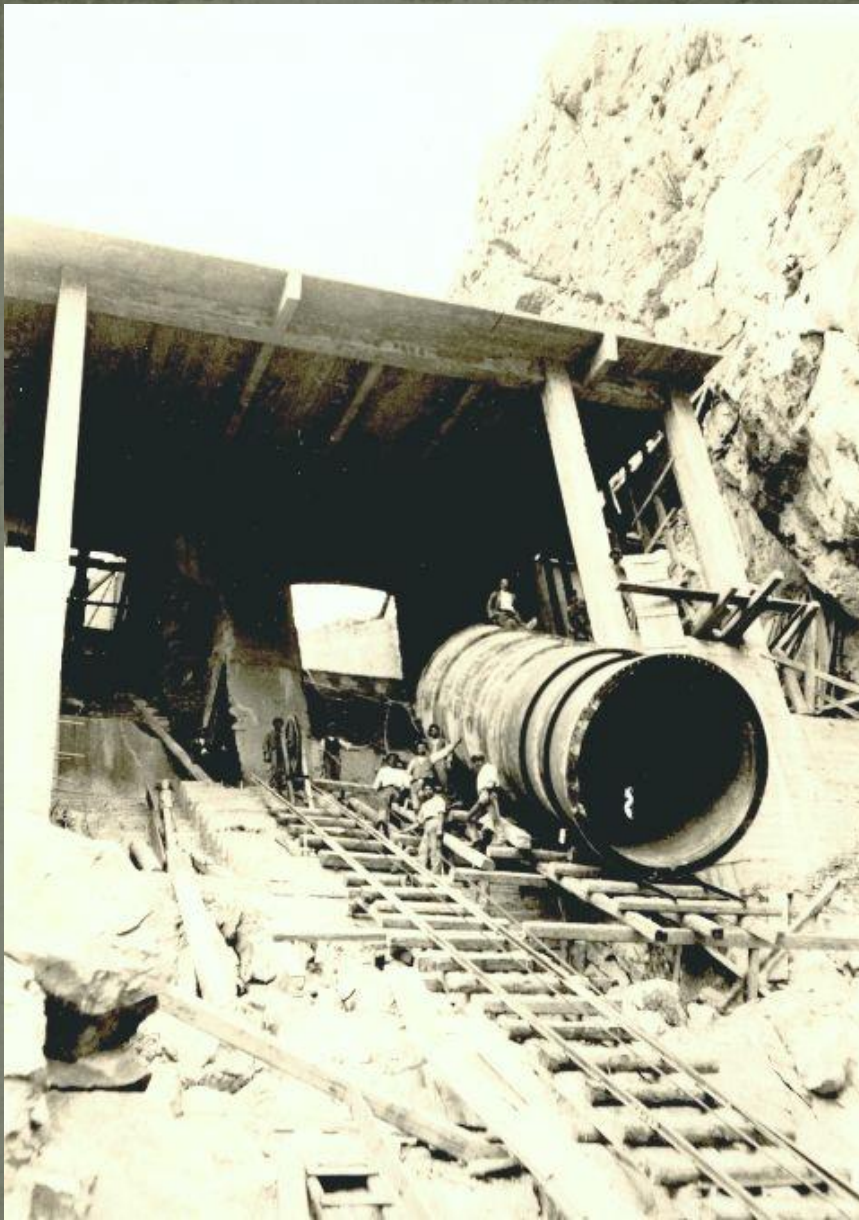
Commencement works on construction of the penstocks 3 and 4



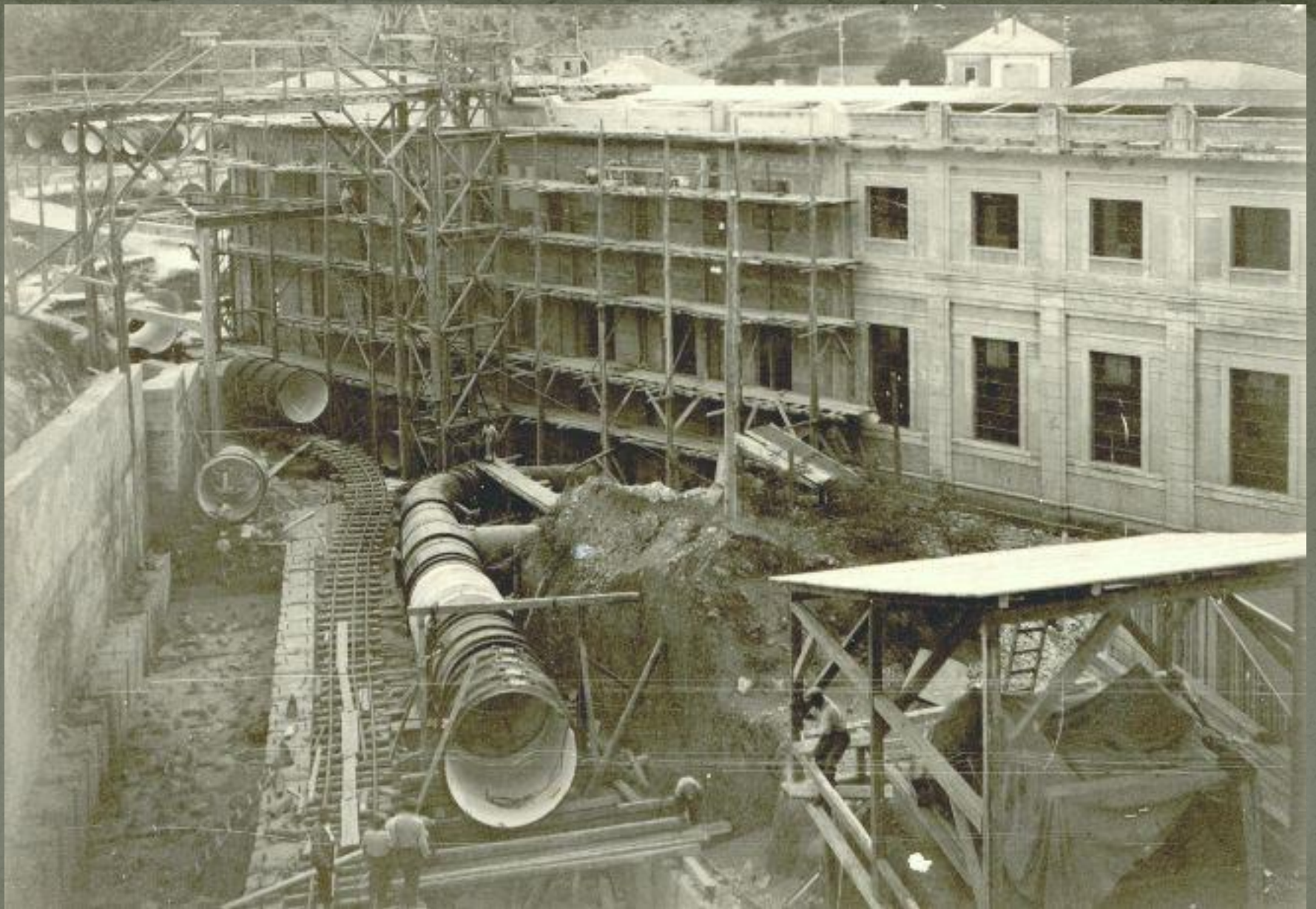
Works on construction of the penstocks 3 and 4



A cable railway for transportation of the penstock parts was constructed



Transportation of the penstock parts to the surge chamber



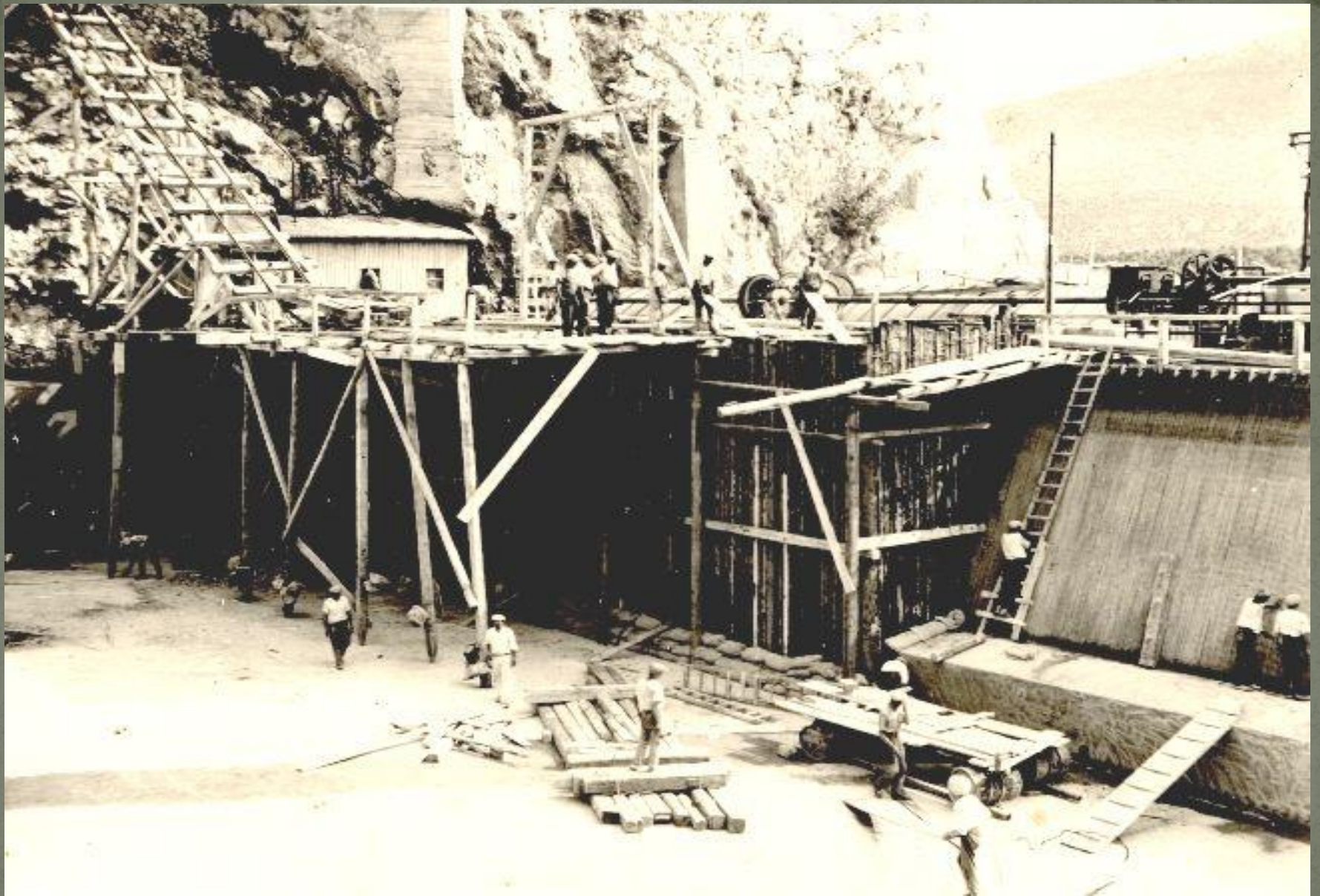
End of the works on the powerhouse and penstocks 3 and 4



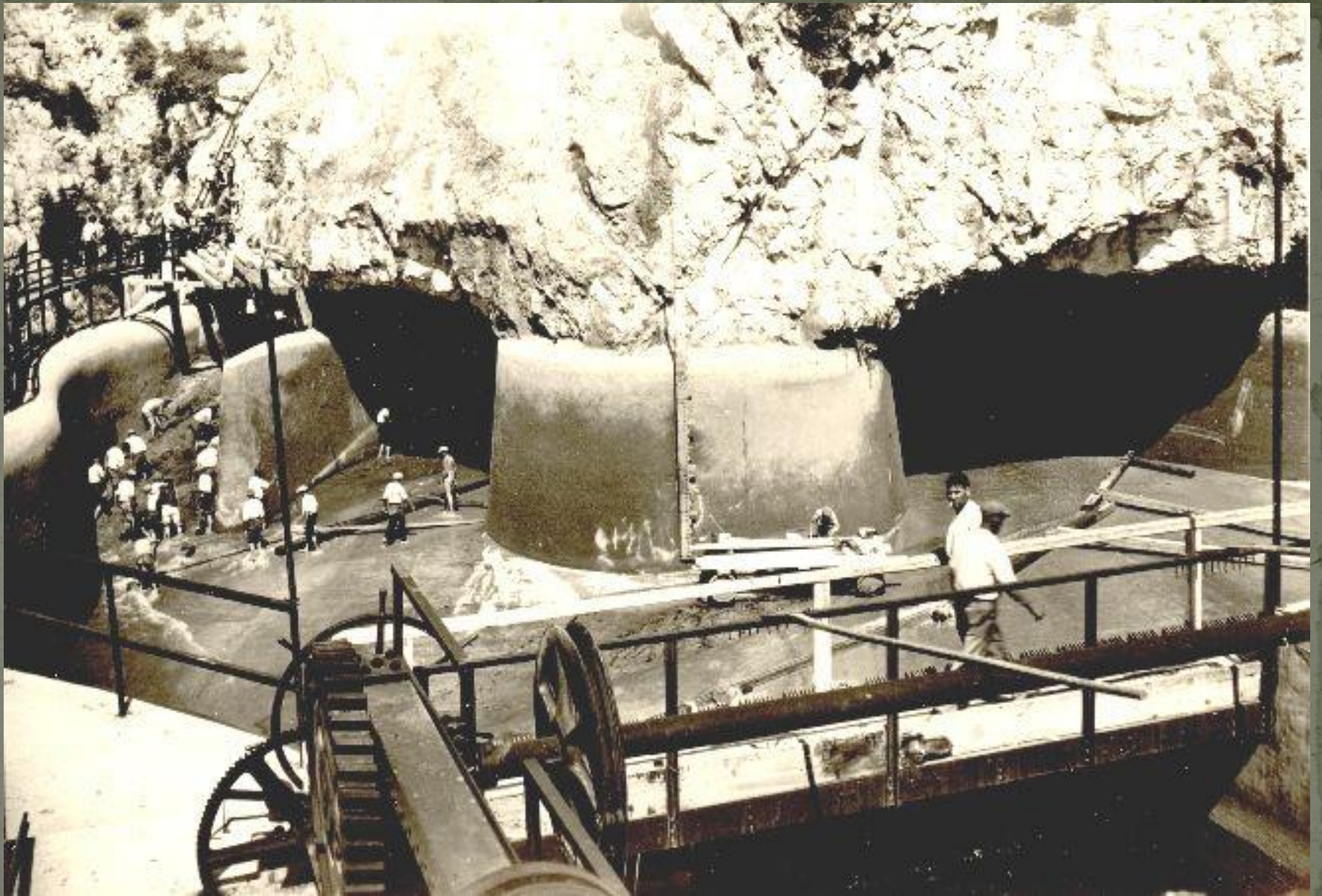
End of the construction works on the penstocks 3 and 4



End of the construction works on the penstocks 3 and 4



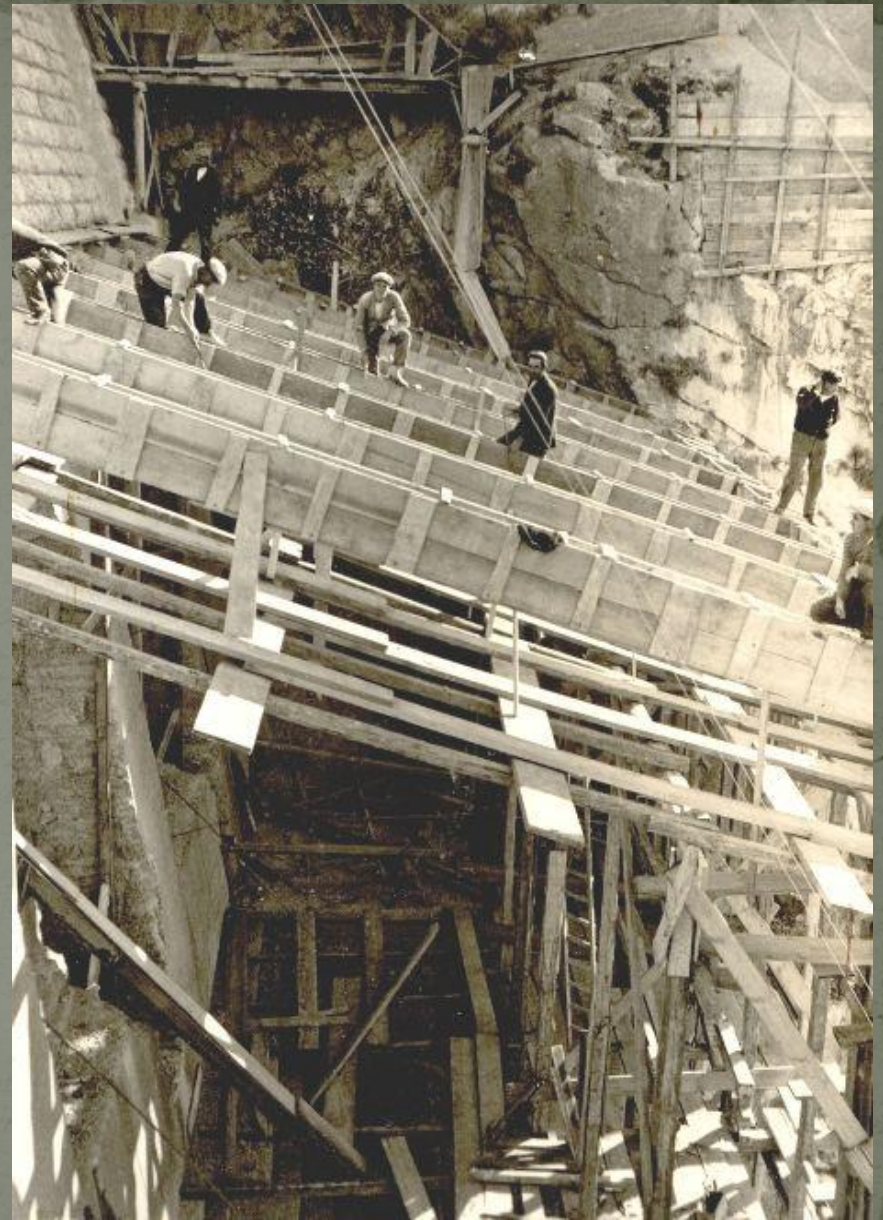
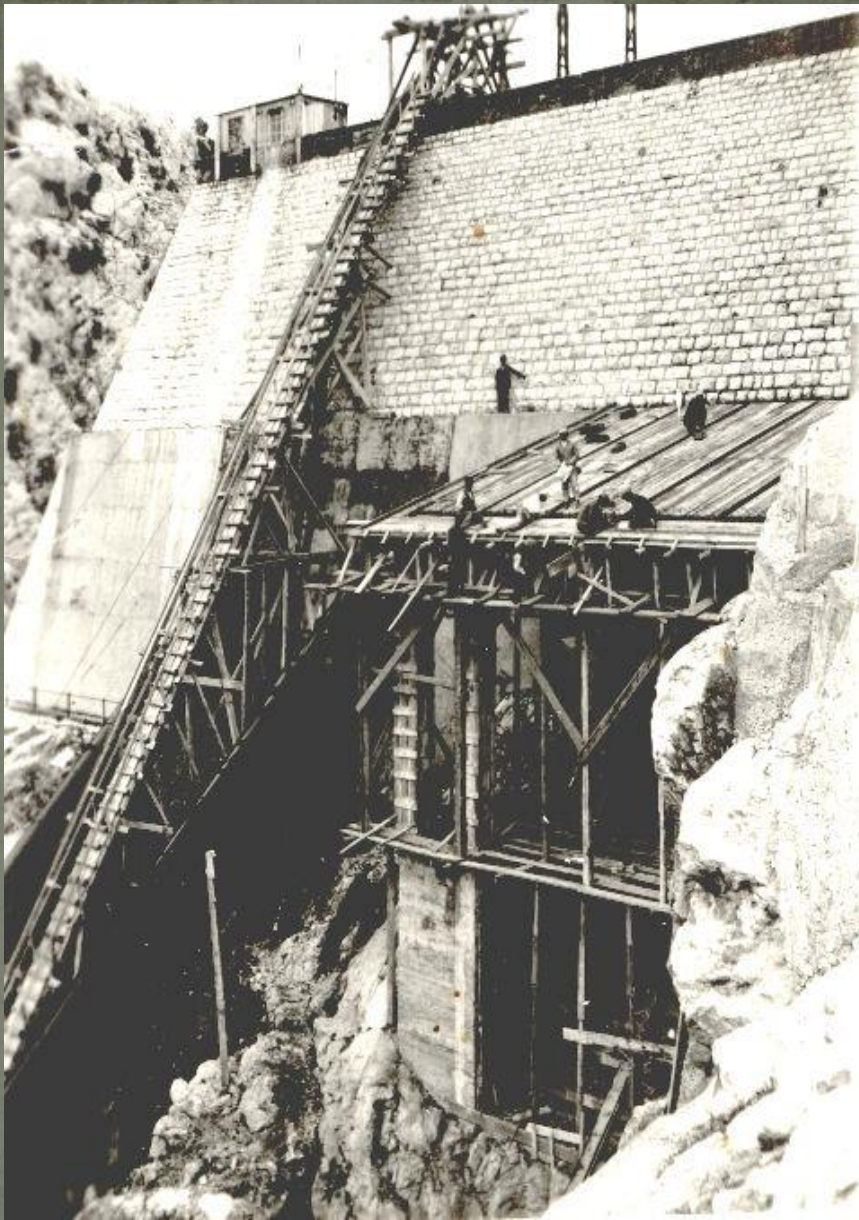
Final works in the surge chamber of the second stage



Final works in the surge chamber of the second stage



Final works in the surge chamber of the second stage



Final works in the valve chamber



Erection of the bridge crane



Arrival of the turbine parts on the site



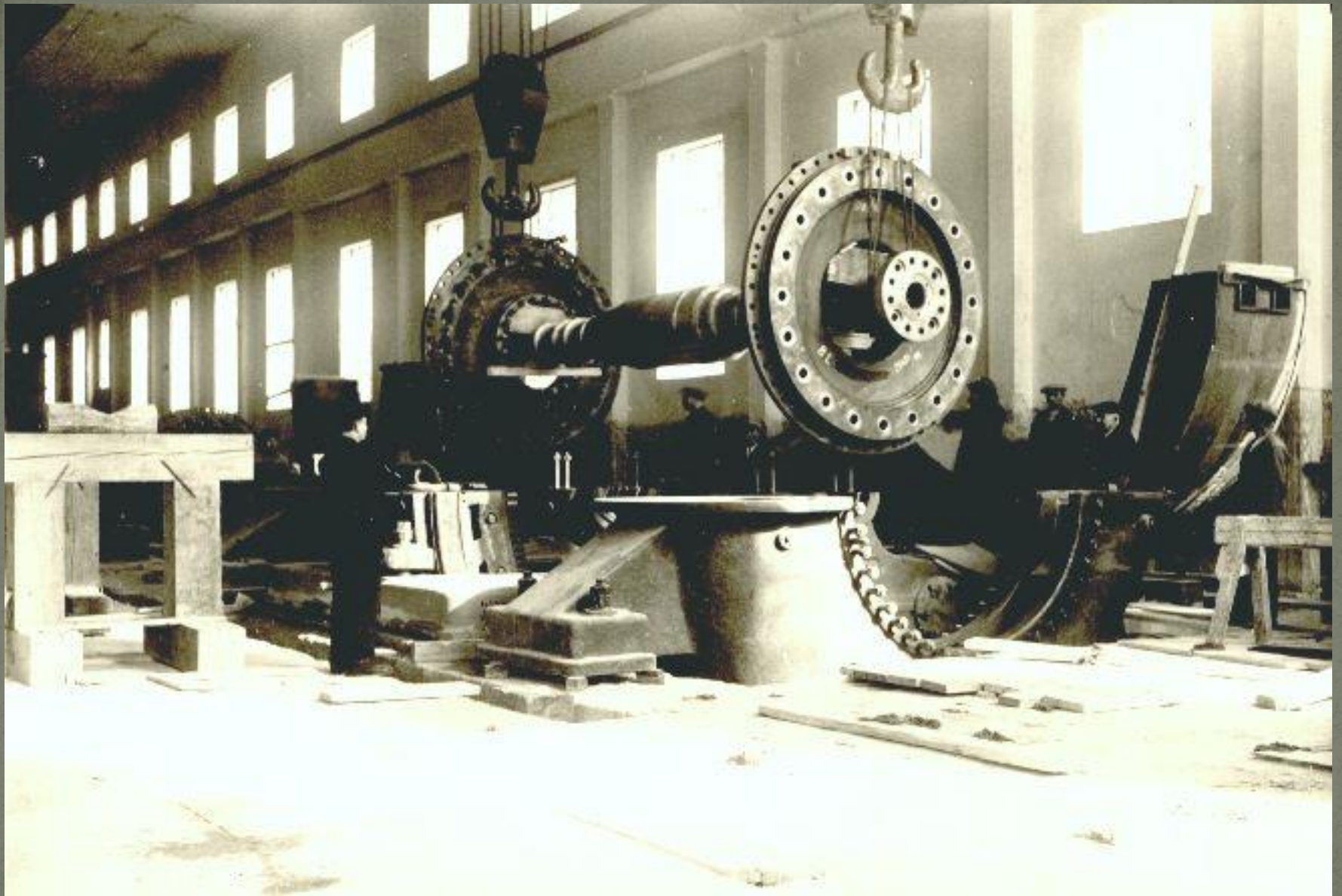
Commencement of the erection works on generating units



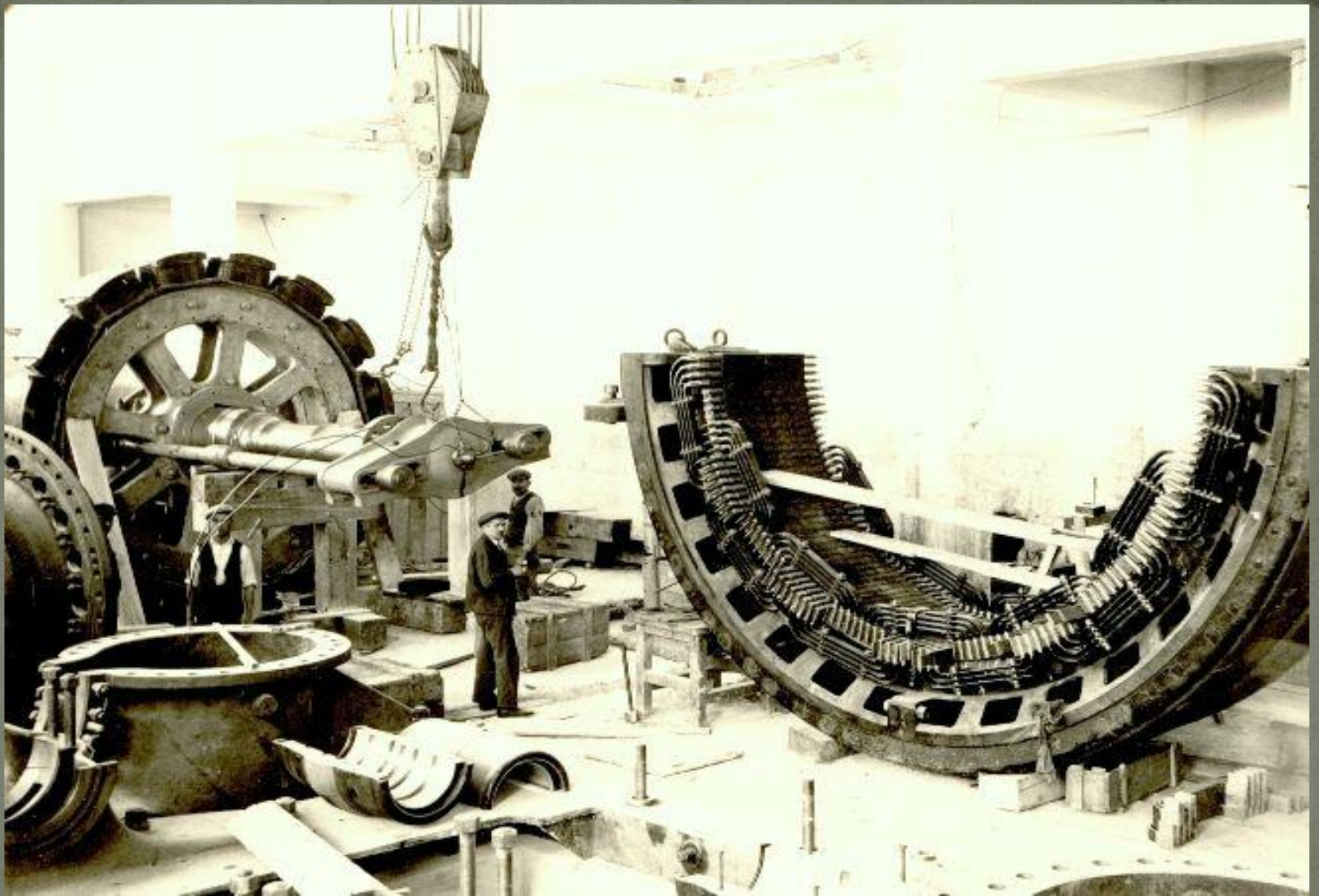
View of the powerhouse



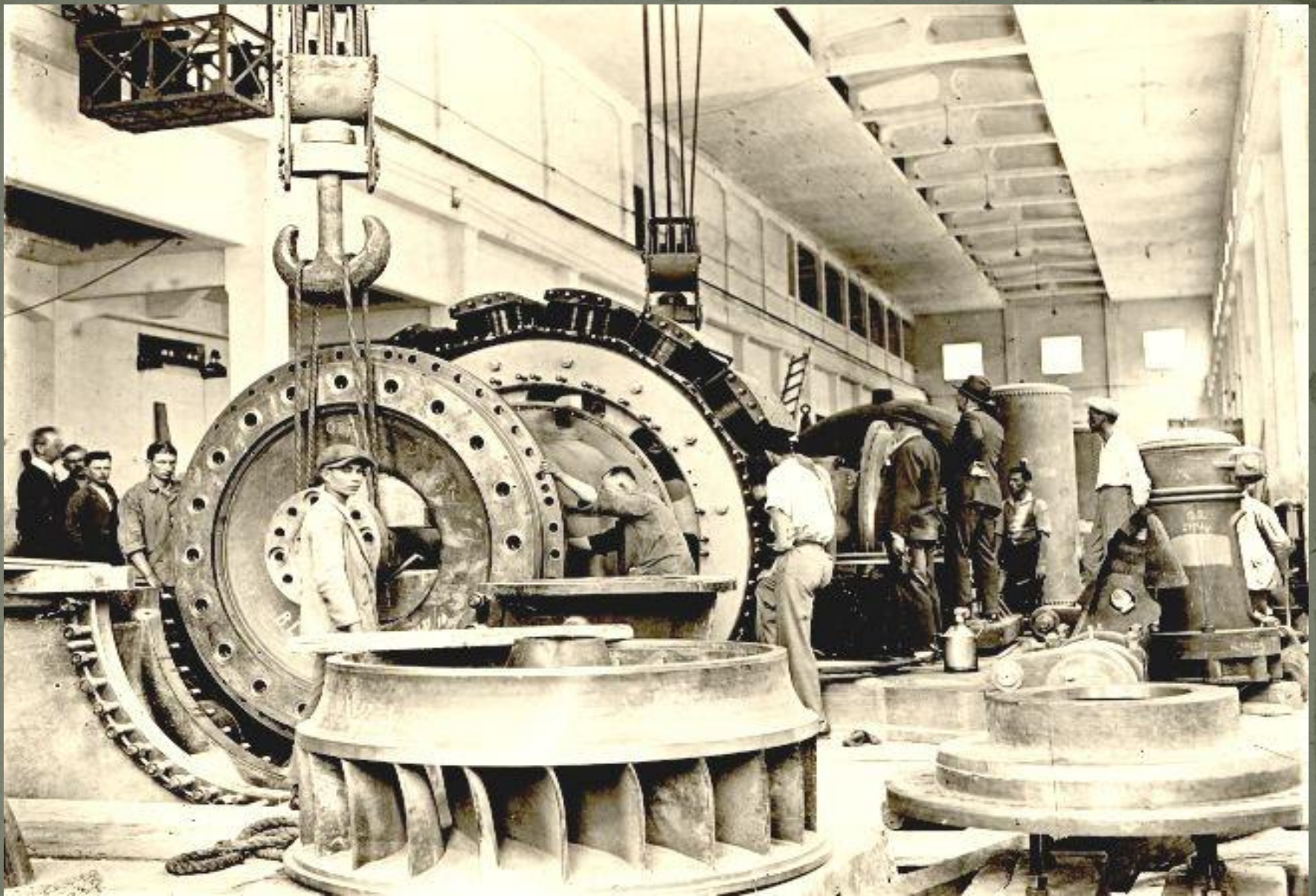
Generator rims



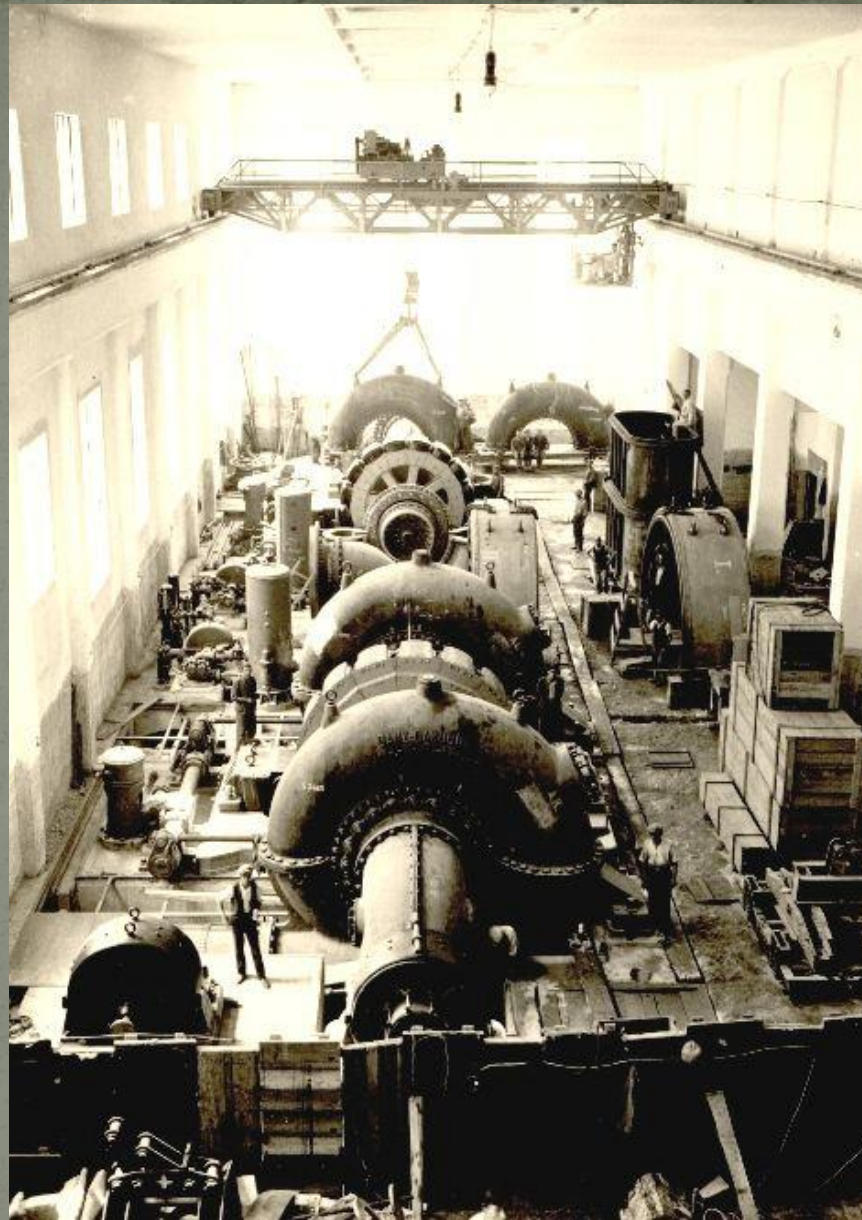
Erection of the generating unit



Rotor rim and half of the generator stator



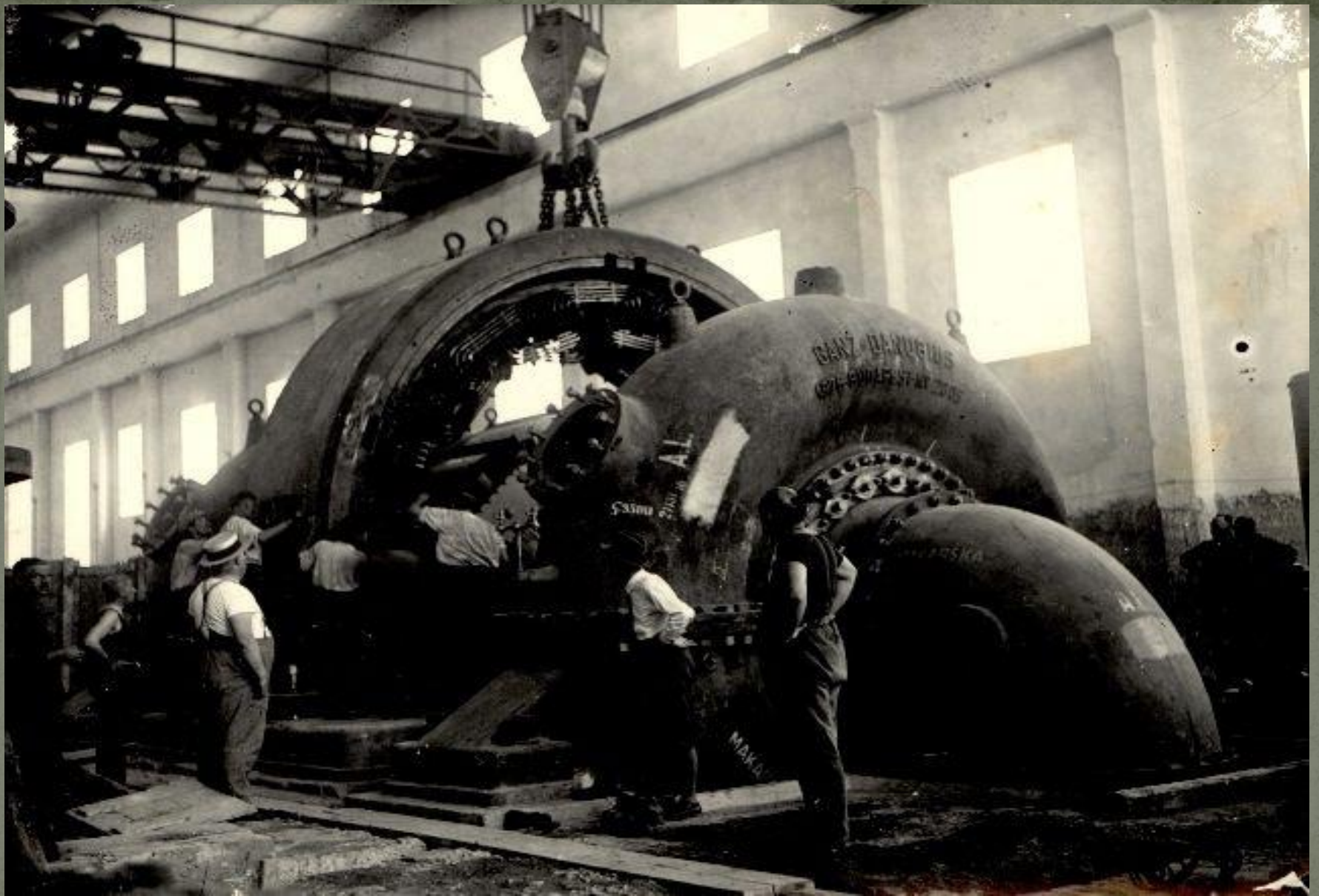
Erection of the generating unit



View of the powerhouse during the erection of the generating units



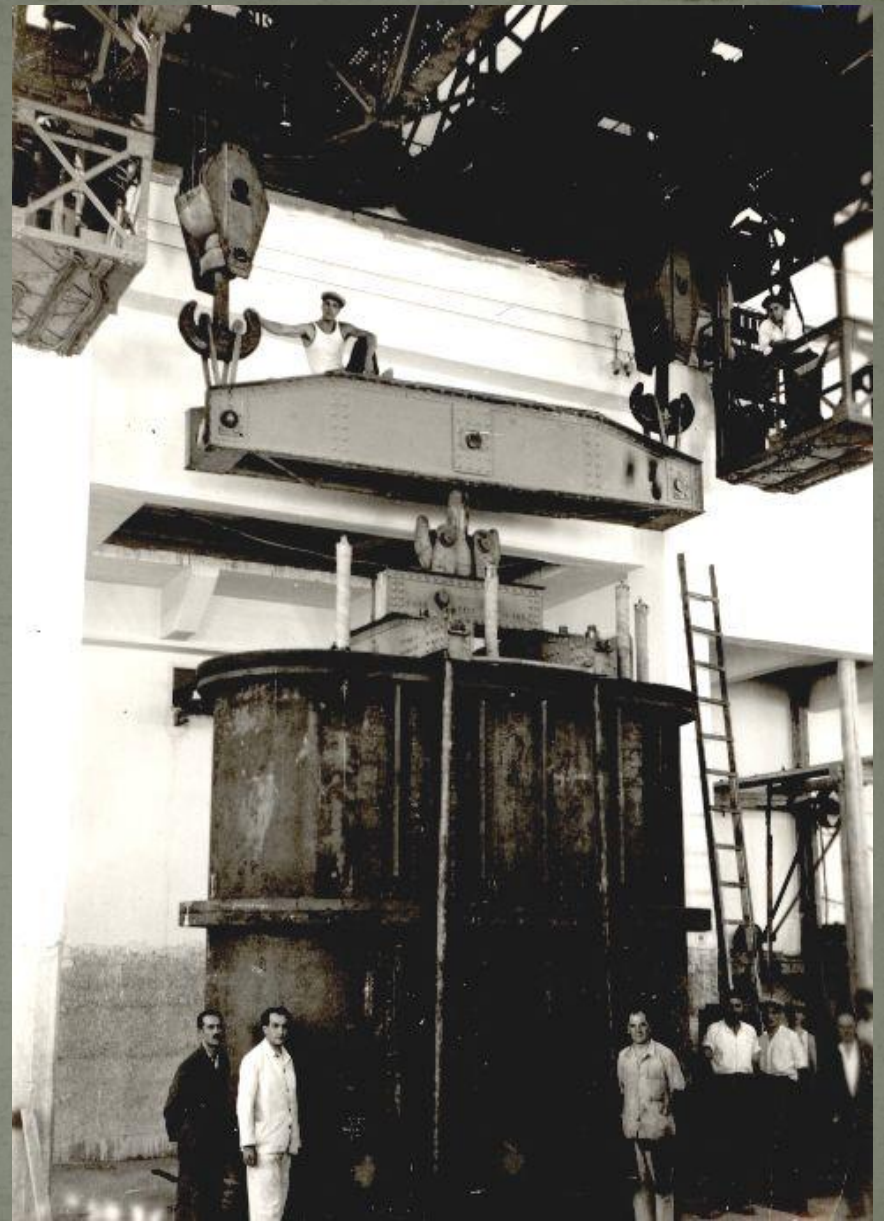
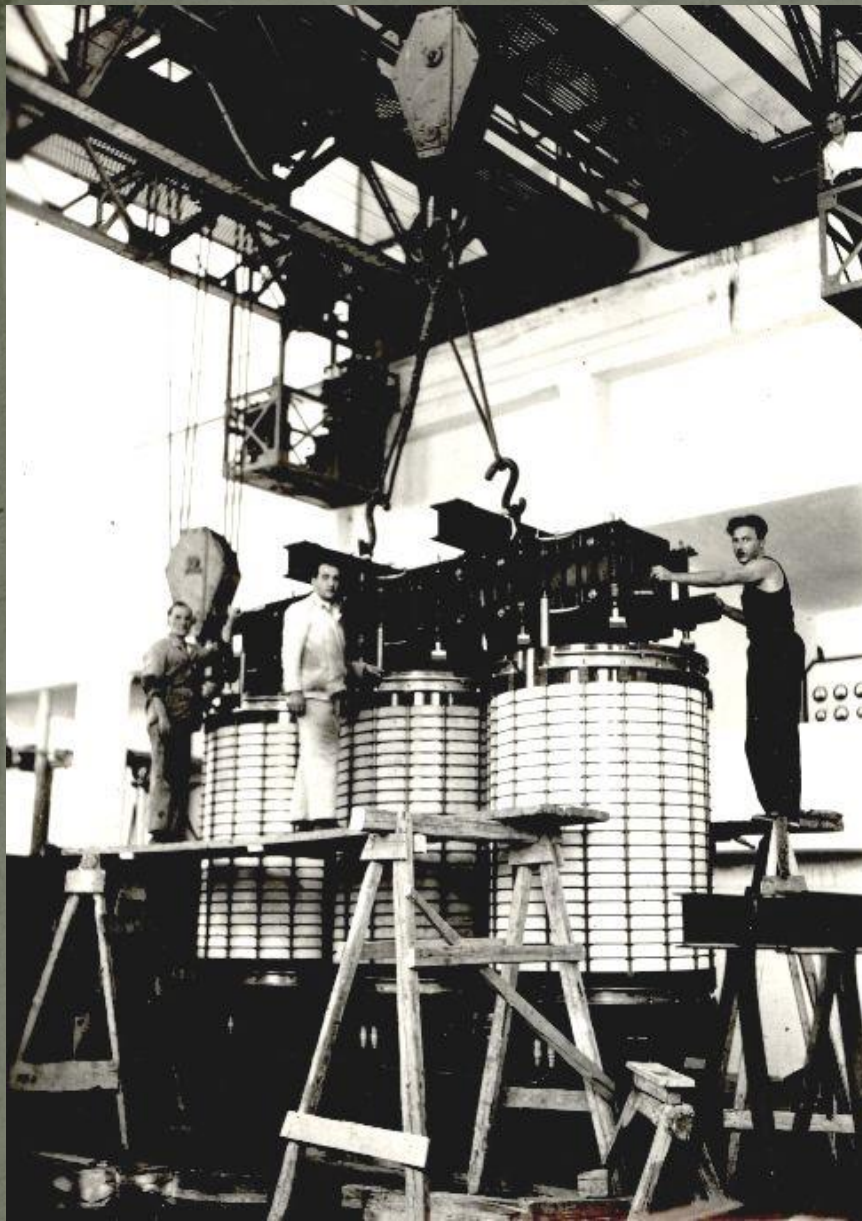
Final works on the erection of the turbine



Final works on the erection of the stator half



Completed erection works on the generating unit



Erection of the generator transformer 42 MVA



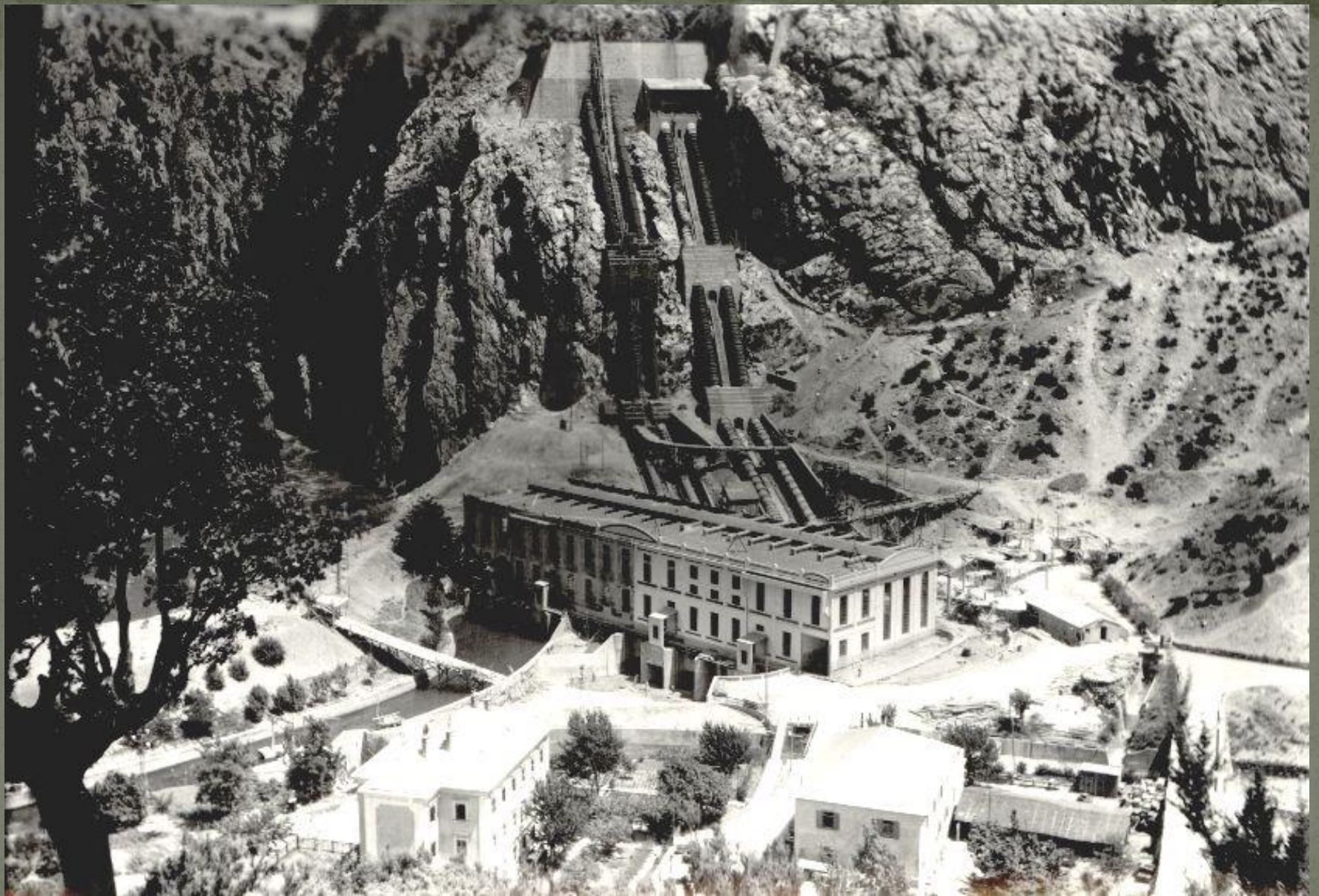
Generating unit auxiliary equipment – Pelton turbine



Works in the tailrace canal



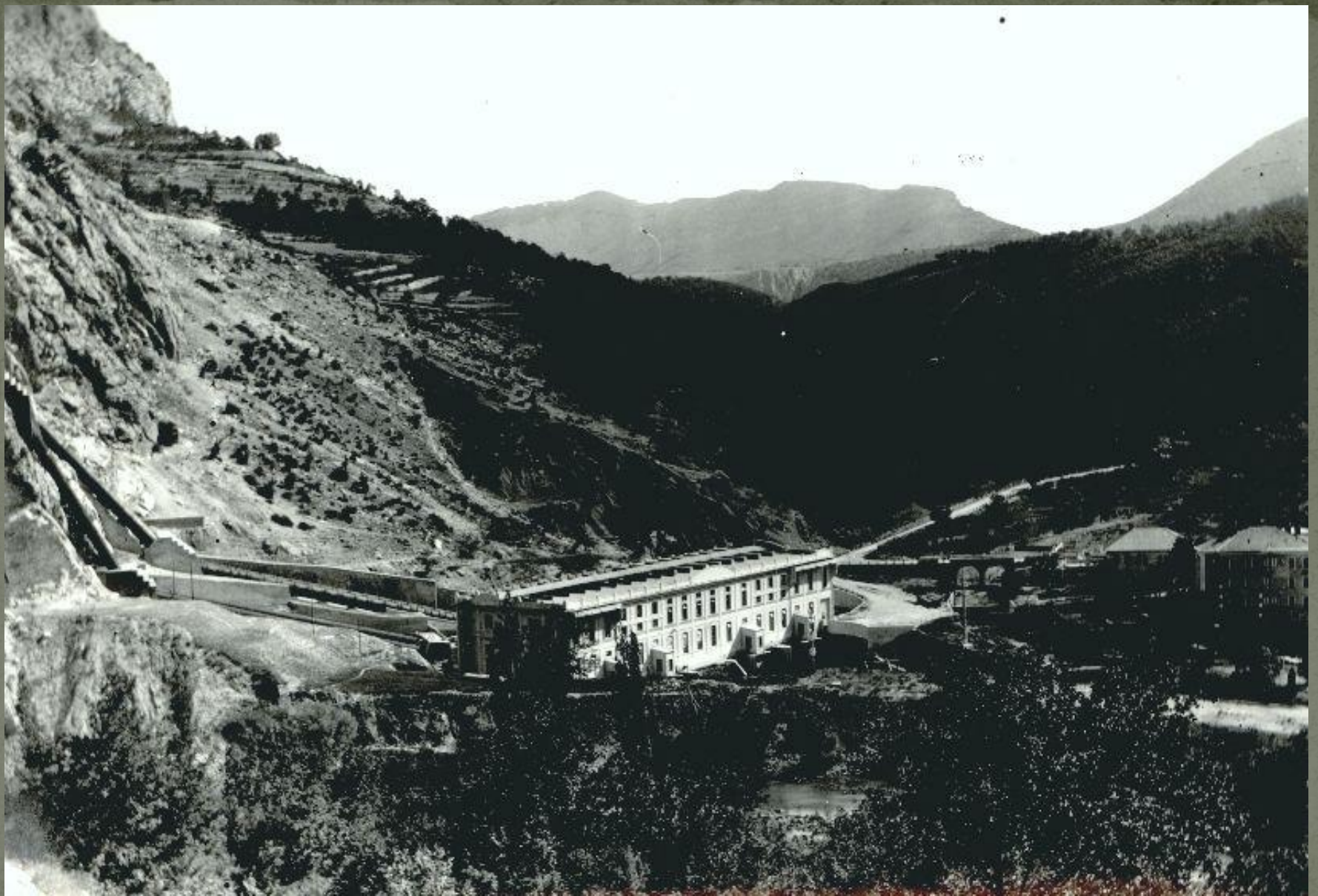
Works in the tailrace canal



End of the works and demobilization of the site in 1932



Final works on the second stage (1928 – 1932)



Final works on the second stage (1928 – 1932)

- In July 1943 the conductors of the double overhead line 50 kV Kraljevac – Dugi Rat were dismantled so preventing the electric power supply from Kraljevac to Omiš, Dugi Rat and Split
- In September 1943 the vital parts of the turbine governor on all the four generators were dismantled by the liberation army, the transformer oil was released and the equipment of cranes was disabled
- After that the hydropower plant was again under German occupation
- In the middle of 1944 the power plant was bombed by the Anglo-American army, when the roof and a part of the plants were damaged



Bombarding of the powerhouse in 1944



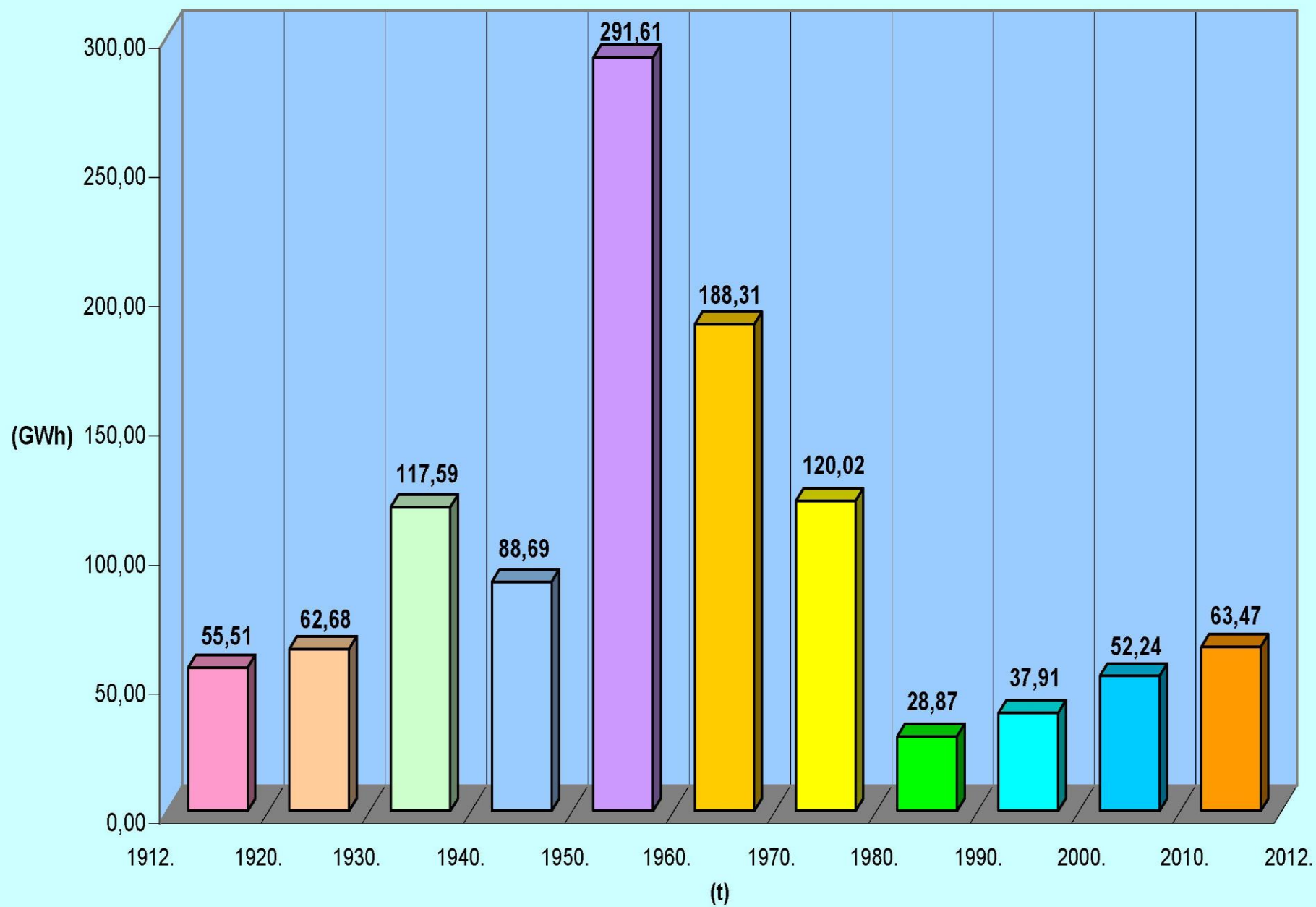
**Bombarding of the powerhouse in 1944**



Bombarding of the powerhouse in 1944

- In October 1944 the German army detonated explosive in the power plant but did not succeed to destroy it
- Two months after the liberation on 24 December 1944 Split again got electric supply from the hydropower plant Kraljevac – one generator enabled for operation
- During 1946 the workers enabled the remaining generating units for operation
- The record power generation of the Kraljevac HPP was achieved in the period between 1948 until the completion of the first stage of the Zakučac hydropower plant in 1961 and ranged from 182 000 000 kWh in 1948 to 471 560 000 kWh achieved in 1961

Mean annual production of Kraljevac HPP



- In the period between 1961 until the completion of the second stage of the Zakučac hydropower plant the mean annual generation amounted approximately 150 000 000 kWh
- By the construction of the second stage of the Zakučac HPP, the Kraljevac HPP lost its significance and its mean annual generation was significantly reduced and amounted only 28 870 000 kWh
- In 1990, by erection of the biological minimum residual flow generating unit (4.8 MW) at the position of generating unit 4 from 1912 the mean annual generation increased to approximately 37 910 000 kWh
- Since 2000 a step by step renovation and replacement of the equipment of the Kraljevac HPP in a part of the powerhouse started, which led to increase of the mean annual generation up to approximately 60 000 000 kWh

## Signifikant works since 2000

- 2001/2002, renovation and replacement of the control, indication, protection, measurement and regulation equipment of the generating units A and B
- 2003 – replacement of the generator electric protection
- 2004 – arrangement of the generator to transformer connections of the generating units A and B
- 2006 – reinsulation of the rotor poles and overhaul of the generator B
- 2011 – replacement of the complete uninterrupted DC power supply 220 V
- 2011/2012 – reinsulation of the rotor poles and overhaul of the generating unit C (biological minimum residual flow)
- Replacement of the auxiliary low voltage 400/230 V power supply is taking place

## Kraljevac HPP at present

Installed capacity: 46.4 MW

- Generating unit A (1932) 20.8 MW
- Generating unit B (1932) 20.8 MW
- Generating unit C (1990) 4.8 MW

The role of the Kraljevac HPP in the electric power system at present:

- Continuous utilization of the Cetina river biological minimum residual flow of 8 m<sup>3</sup> /s
- Utilization of the tributary waters and the Prančevići dam spillway waters

- Spare of the system in case of failure of the upstream hydropower plants
- Control services of the switchgears 110 kV, 35 kV and 10 kV which are the property of the HEP – OPS d.o.o - and HEP – ODS d.o.o.
- Services for the drinking water supply as uninterrupted presence of water in the surge chamber, from where the complete Makarska coast area is supplied with drinking water



Kraljevac HPP dam



Kraljevac HPP surge chamber



Interior of the powerhouse



Kraljevac HPP



Kraljevac HPP



## HYDROPOWER PLANT KRALJEVAC

Thank you for your attention !

Made by: Igor Šodan