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Lessons learnt from the disasters of Sgorigrad (Bulgaria) and Stava Valley (Italy)

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IV INTERNAT. GEOMECHANICS CONFERENCE

SECOND PLENARY SESSION – TOPIC 8

- As regards Topic 8 “Education and Qualification of Geomechanical Experts”, we think that a lot can be learnt from past mine incidents and disasters and that “lessons” from failures of geotechnical structures can convey important information to young engineers and geologists who are to be in charge of the safe construction and management of these structures.
- In particular, we think that full awareness and sense of responsibility towards the risks involved are of paramount importance in the formation of qualified experts in the fields of mining and geotechnical engineering.

- Mining activities require the use of ore washing plants for separating concentrated mineral ore from the waste rock or “gangue” which will not be used. This is usually attained by means of flotation, a process relying upon the capability of finely ground minerals to aggregate to water.
- The processed waste – or tailings – resulting from flotation is a liquid mixture of sand and silt that is disposed by conveying it through a pipe to a purposely built basin, named tailings dam. A tailings dam can grow progressively to a considerable height (up to over 70 m), therefore its proper construction and management are of paramount importance in order to guarantee its long-term stability. Unfortunately, in the construction of tailings dams there is no economic interest since no revenue can result from this waste material and many mining companies tend to spend as little as possible for these geotechnical structures to the detriment of their stability.
- The catastrophic failures of Sgorigrad and Stava can teach us an important lesson on this high-relevance topic: the safety of tailings dams.

Sgorigrad – Stava: identical disasters (I)

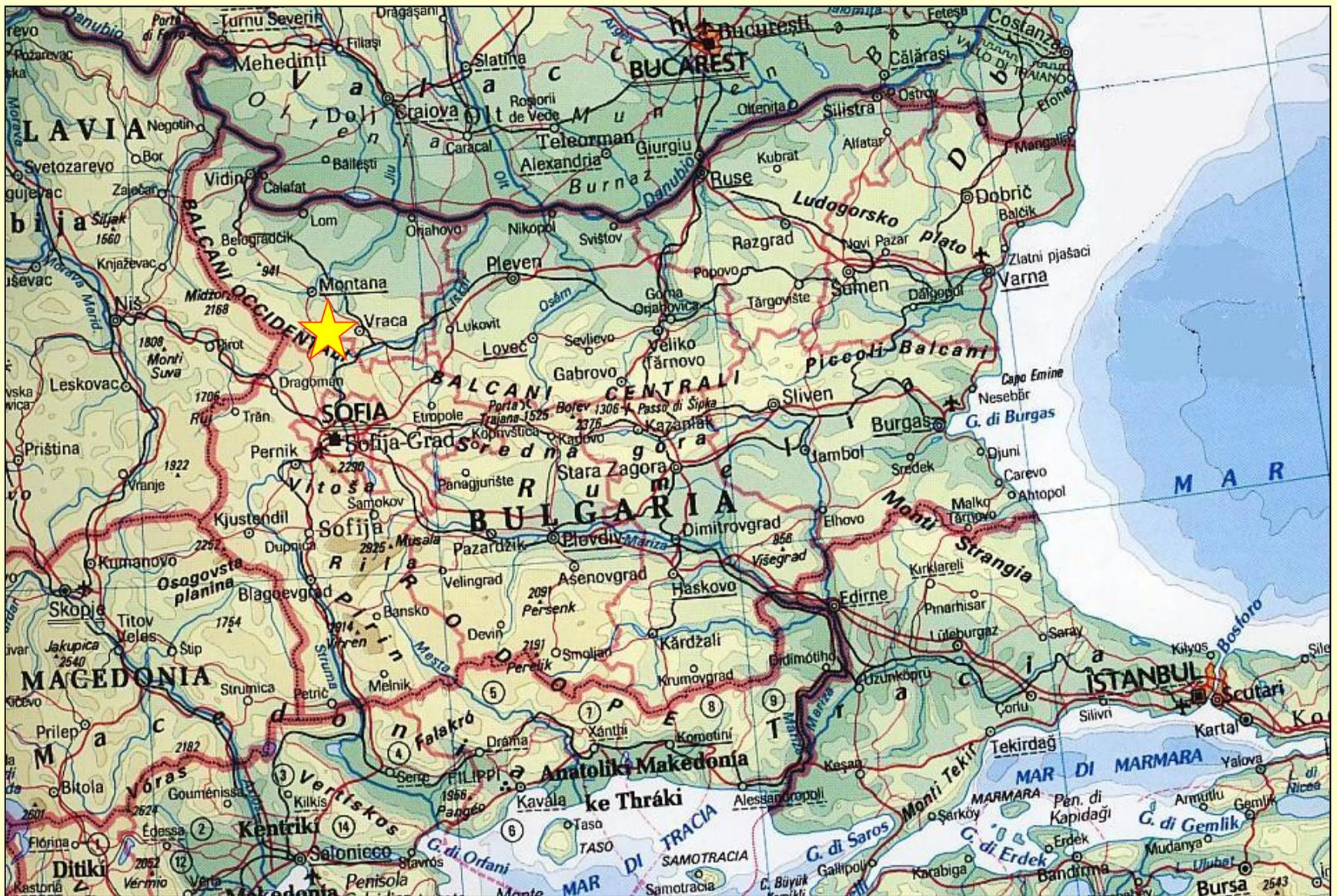
The catastrophe of Sgorigrad and Vratza, in Bulgaria, and the catastrophe of the Stava Valley in the Municipality of Tesero, in Italy, are to date among the worst disasters caused by the failure of tailings dams worldwide.

On 1st May 1966 the failure of the tailings dam of the Placalniza zinc and lead mine, uphill of the village of Sgorigrad, gave rise to a flowslide, which ran as far as the town of Vratza and caused the loss of over 100 lives, as well as vast material and environmental destruction.

Sgorigrad – Stava: identical disasters (II)

On 19th July 1985 the failure of two tailings dams of a fluorite mine, uphill of the hamlet of Stava, gave rise to a flowslide which ran as far as the village of Tesero and caused the loss of 268 lives, as well as vast material and environmental destruction.

The causes and shortcomings for these two catastrophic failures are illustrated and the educational activities carried out for preventing similar disasters are presented



Location of Sgorigrad, district of Vratsa, in the Western Balkans, Bulgaria (yellow star)



Location of the Stava Valley in Trento province, northern Italy (yellow star)

Sgorigrad: In order to decant and store the residual waste produced by the flotation process, in 1958 a tailings dam was constructed in a lateral valley overhanging the village of Sgorigrad. The stream running on the valley floor was dammed with an embankment and its water was pumped back upstream of the tailings basin.

In 1966 the basin attained the approximate height of 60 m.

The retaining embankment for damming the torrent, the overflow towers and segments of the pipes are still visible today, together with small amounts of decanted mud, which remained in place.

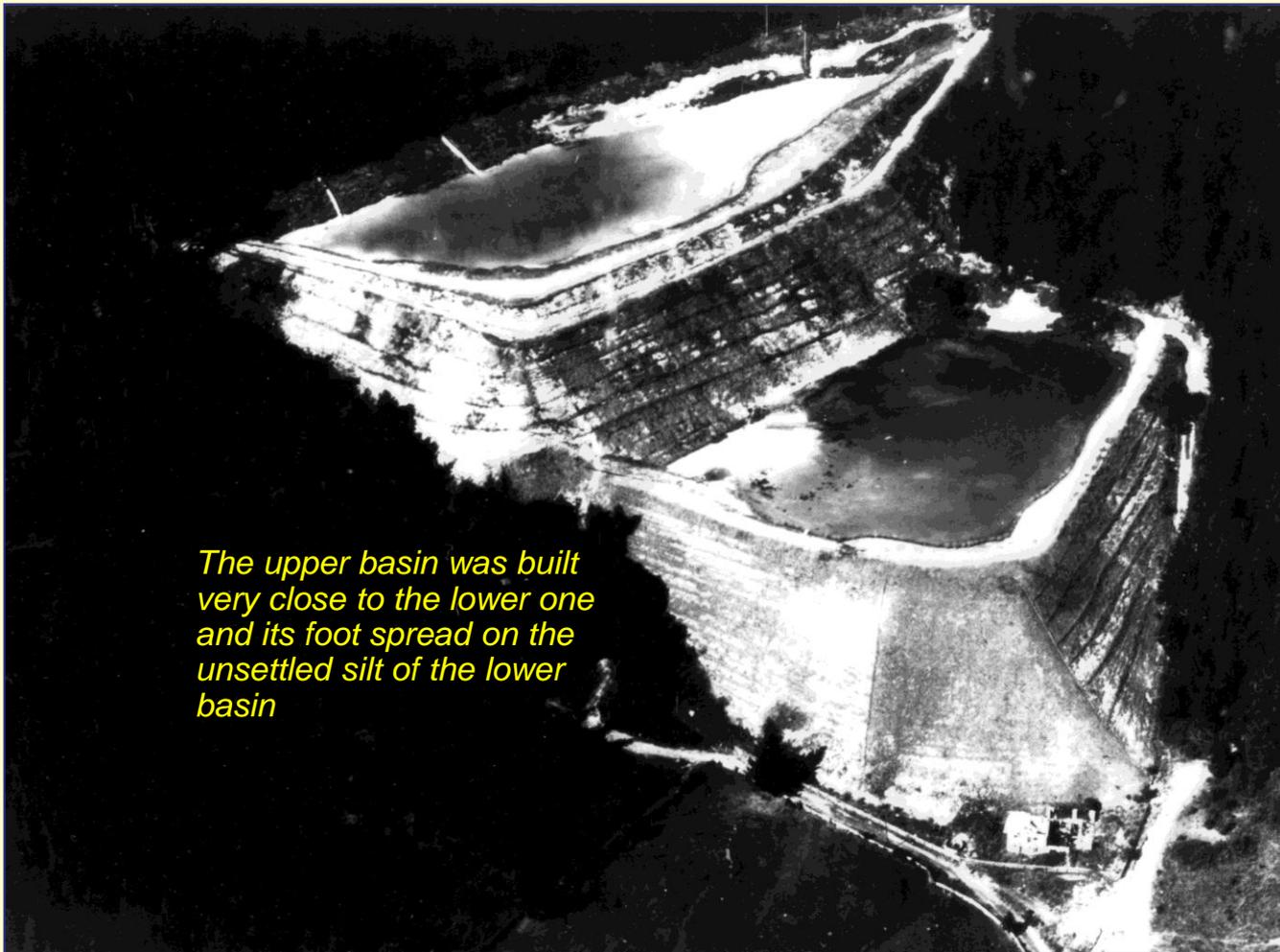


The remains of the Sgorigrad tailings dam with a fallen overflow tower.

Stava Valley: in 1961 the Prestavel mine was equipped with a flotation plant and a water-supply pipeline. A first tailings dam was also built and the residual mud resulting from processing the rock was conveyed to the tailings dam by means of a pipe.

In 1969 a dam for a second basin was started uphill of the previous one without any provision either for anchoring it to the ground or for draining. The overflow pipes were placed inside the basins and discharged outside by passing through the dams.

At the time of failure the two tailings dams were nearly 60 m high.



The upper basin was built very close to the lower one and its foot spread on the unsettled silt of the lower basin

The tailings dams of the fluorite mine in the Stava Valley in 1981

Sgorigrad: stability analyses

A year before disaster, stability analyses had been carried out on the safety of the Sgorigrad tailings dam. In June 1965 Professor Pavel Evdokimov wrote a report in which he stressed the potential danger of fissures at the foot of the basin's downstream dam and forecast the impending failure of the dam by stating, with amazing precision, that it would occur – as in fact it did – in April or May of the following year. He also urged that any further storage of tailings inside the basin should be stopped immediately. The managers in charge of the mine and of the tailings dam, however, did not take into any account whatsoever Professor Evdokimov's serious warning.

Stava: stability analyses

In 1974 the Municipality of Tesero officially required confirmation of the safety of the Stava tailings dams. The Mine District of Trento Province entrusted the concessionary company itself with stability analyses. Although these stability analyses neglected several indispensable investigations, their results nevertheless showed that the slope inclination of the upper dam was exceptionally high and stability was at danger point. However, the reply of the mining company to the Mine District and therefore to the Municipality was positive. This led to further growth of the dam although this was carried out with a lower degree of inclination.

The failure of the Sgorigrad tailings dam

- Failure took place on 1st May at 11:15 hours. A 220,000 m³ flowslide, in some places over 3 m high, ran a distance exceeding 6 km.
- The mudflow destroyed most of the village of Sgorigrad, and eventually reached the town of Vratza.
- The number of casualties in Sgorigrad was rather high as most of the inhabitants were in the town centre taking part in the celebrations of Workers' Day. The corpses of the victims were then taken to Vratza's stadium but their identification was a particularly difficult task. Officially, the number of lives lost was declared as 107. Over 2,000 persons were injured, 576 families were affected, over 150 houses were destroyed together with Vratza's Zoological Garden.



The Sgorigrad area soon after the collapse of the tailings dam (May 1966)

The failure of the Stava tailings dams

- At 12:23 hours of 19th July 1985 the dam of the upper basin failed and collapsed onto the lower basin, which also failed. The flowslide composed of water, sand and silt descended downstream at a velocity of nearly 90 km/h, sweeping away whatever it met in its path as far as the main valley floor over a distance of 4.2 km.
- 268 people were killed and many houses and bridges destroyed.
- The area where the dams stood and the path of the mud flow were completely reclaimed some years after failure.



The upper Stava Valley soon after the tailings dams failure (July 1985)



The devastating effect of the flowslide on the Stava Valley (July 1985)



The mass grave for the unidentified bodies in Tesero cemetery, July 1985

Sgorigrad: causes of the failure

The failure of the Sgorigrad tailings dam occurred after days of heavy rains. The basin was in “high pond” conditions and the tailings were saturated. Since the decant towers had a low spillway capacity, the pond water level had risen dangerously and caused the submersion of the beach.

Hydrogeological investigations on the tailings dam area had not been adequate since they did not detect the presence of a water spring located inside the basin.

The dam failed suddenly and a large mass of tailings and water went down like a fast-moving wave of mud. According to eye-witnesses, the dam did not overflow. This was recorded also by aerial photographs. The ultimate cause of failure was the sudden loss of stability and the ensuing liquefaction of the tailings, that is the complete loss of shear strength of saturated soils under static loading. If it had been overtopped, erosion would have taken some time and the failure wave would not have been so vast and fast.

On the other hand, failure could have occurred due to water percolation inside the dam coming from the water spring.

Since the Sgorigrad disaster tailings dams in Bulgaria have been designed only by civil engineers specialized in dam engineering.

Stava: causes of the failure

In the case of Stava the cause of failure was due to inadequacy and shortcomings concerning the construction of the upper tailings dam which collapsed first.

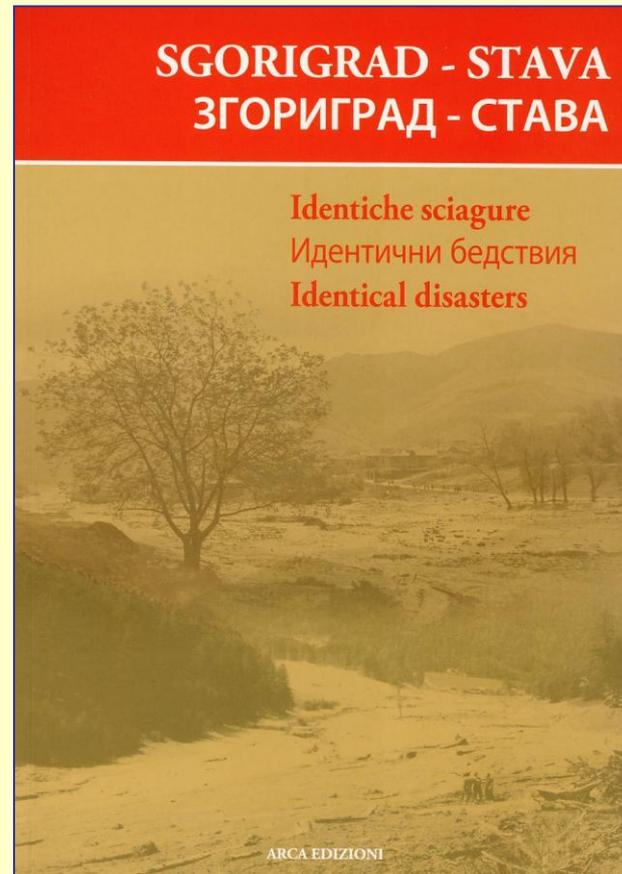
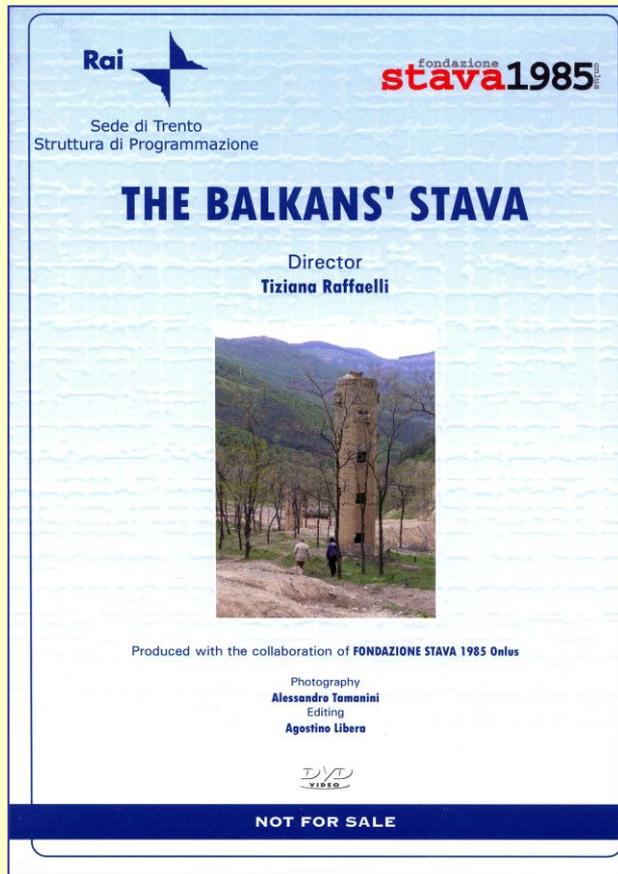
In particular, the stability conditions were never satisfactory and the silt deposited within the basin could not be properly consolidated owing to:

- i) the marshy nature of the foundation ground, which hindered the consolidation of the sediments;
- ii) the erroneous construction of the upper basin's dam, which did not allow adequate drainage at its foot;
- iii) the position of the upper basin just uphill of the lower one: as it grew in width the dam came to rest partially on the silts of the lower basin, thus worsening drainage and stability conditions.

As a consequence, there was considerable build-up of pore water pressure inside the upper basin's dam. Therefore, water fluctuations led to a high piezometric surface that eventually caused the failure of the dam and the liquefaction of the silts therein contained.

Sgorigrad – the aftermath and the educational activities

- On the 40th anniversary of the Sgorigrad catastrophe, 1st May 2006, the “Path of the Stava-Sgorigrad Brotherhood” was inaugurated on an overlooking mountain. Several explanatory panels written in Bulgarian, English and Italian provide visitors with information on the analogies between the Sgorigrad and Stava Valley catastrophes. This path seals the link of solidarity and brotherhood uniting the Sgorigrad and Tesero communities, both struck by similar disasters.
- In 2008, the Italian State Television (RAI) produced a short documentary film describing the Sgorigrad disaster entitled “The Stava of the Balkans”, which points out the analogies with the Stava Valley failure.
- On the initiative of the Municipalities of Vratza and Sgorigrad, on 1st May 2009, the anniversary of the catastrophe, a small monument in memory of the Sgorigrad Victims was unveiled outside the church of Sgorigrad. A three-language book was also published on Sgorigrad-Stava.
- Lastly, on 1st May 2010, the main square of Sgorigrad was entitled “Tesero Square”, in remembrance of the Victims of the Stava disaster, which occurred in Tesero Municipality.



The film “The Balkans’ Stava” is an accurate account of the Sgorigrad disaster based on the testimony of survivors. The book “Sgorigrad-Stava” points out the analogies between two very similar failures.



“Path of the Stava-Sgorigrad brotherhood”
sign on the mountain slope overlooking
Sgorigrad



Information hut along the “Stava-Sgorigrad Brotherhood Path”





The new “Tesero Square” near
the church of Sgorigrad



Stava – the aftermath and the educational activities

- In February 2002 the Stava 1985 Foundation (a non-profit organization) was officially established by the relatives of the Victims of the Stava Valley disaster with the patronage of the Municipality of Tesero in order to make sure that the deaths of 268 innocent people had not happened in vain.
- The duty of the Foundation is to keep alive the historical memory of the Stava Valley and other similar disasters and strengthen the culture of prevention, correct territorial management and safety in order to avoid other man-induced disasters of this kind.
- In 2003 the Documentation Centre of the Stava 1985 Foundation was inaugurated in Stava. It offers various information displays to explain the origin, causes and responsibilities for the July 1985 catastrophe.
- In 2007 a nature trail and educational footpath was inaugurated. Explanatory panels have been erected along its course to provide visitors with information on the Stava disaster. Eventually the path leads to the entrance of the mine tunnel where fluorite-rich rock was extracted and to the site where the tailings dams stood.



The Documentation Center of the “Stava 1985 Foundation” inaugurated in 2003



The “Remembrance Footpath” is a nature trail and educational footpath winding through the woods of the Stava Valley. Its explanatory panels set along its course provide visitors with information on the Stava mine disaster.

Other activities of the Foundation

- Publication of books, pamphlets and folders and production of short films to keep alive the memory of Stava, Sgorigrad and other similar disasters.
- Twinning ceremonies with delegates from other places where similar disasters have occurred.
- Travelling exhibition directed to university students explaining the causes and responsibilities of the Stava tailings dams failure.
- Patronage of a 2nd level University Master's course for qualifying young engineers in the proper construction and management of large geotechnical structures and making them aware of the risks involved.
- Seminars for engineers and geologists and conferences for both young students and the general public.

**RASSEGNA DEI CONTRIBUTI SCIENTIFICI
SUL DISASTRO DELLA VAL DI STAVA
(PROVINCIA DI TRENTO), 19 LUGLIO 1985**

***A REVIEW OF SCIENTIFIC CONTRIBUTIONS
ON THE STAVA VALLEY DISASTER
(EASTERN ITALIAN ALPS), 19th JULY 1985***

a cura di/edited by Giovanni Tosatti



Consiglio Nazionale delle Ricerche



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STAVA 1985

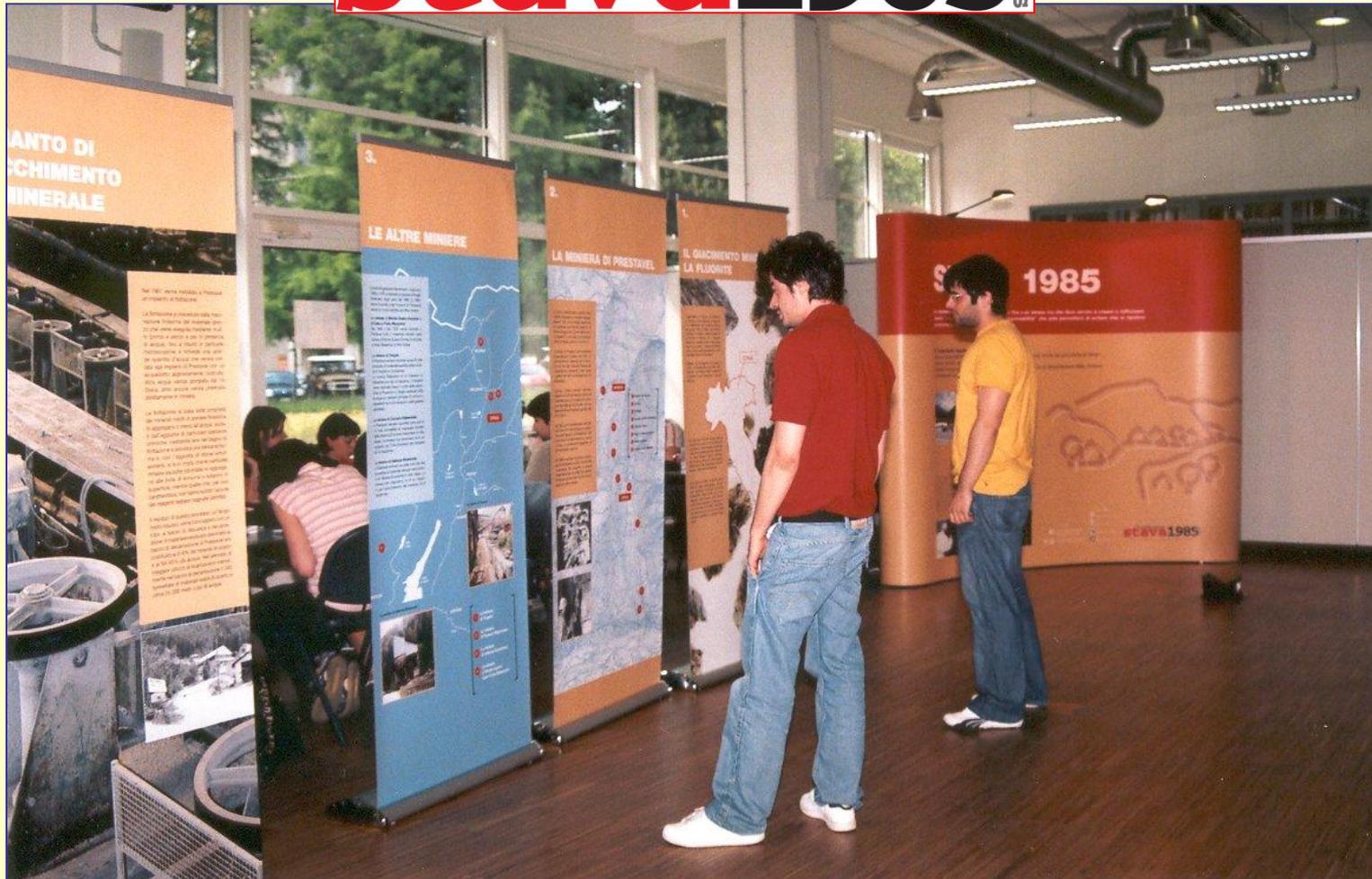
una documentazione

fondazione
stava1985

con l'Alto Patronato del Presidente della Repubblica

curcu
Genovese

A review of international scientific contributions on the Stava Valley disaster, and “Stava 1985”, a detailed reconstruction of the event, both published in 2003.



The panels of the travelling exhibition on the Stava disaster, set up in a university campus



A seminar for engineers and geologists held at the Documentation Center of the Stava 1985 Foundation

- The 2nd level University Master's course "SIGEO" is based on a European Union Directive concerning the management of waste from mining activities, which was approved on March 15th 2006 by the European Parliament and the Council of Europe.
- This project grew out of the observation that incidents similar to the Sgorigrad and Stava disasters still occur at the practically constant rhythm of two per year, on average. Both active tailings dams and abandoned ones are at risk.
- It has been organized to disseminate knowledge and awareness among young engineers and geologists about the risks involved in the construction and management of geotechnical structures.

Final remarks

After the positive conclusion of the 2nd level University Master's course at Trento University, which was patronised and partially funded by our Foundation, we express the wish that European universities and research Institutions will organize post-graduate courses for young graduates and technicians from mining societies and public administrations who are to be in charge of the safety of geotechnical structures and, in particular, of active and abandoned tailings dams in Europe and elsewhere in the world.

The international scientific community must know that now the European Union can grant funds to consortia of universities or research institutions for the qualification of engineering staff in the safe and proper construction and management of tailings dams and similar geotechnical structures.

... And this is an opportunity that should not be missed!

More information at: www.stava1985.it

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Under the patronage of the
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End of presentation

Thank you!

