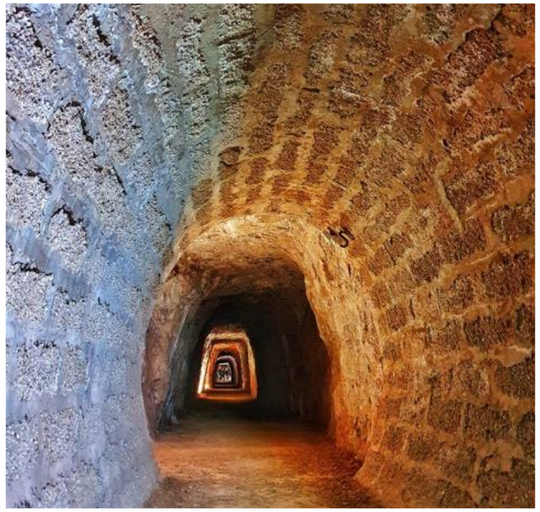
PARCO GEOMINERARIO STORICO AMBIENTALE DELLA SARDEGNA

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

"The long life of Sos Enattos: a lead and zinc mine, an industrial archaeology site, and a future underground observatory for gravitational waves"

TOPIC 13: New functions of mines (culture and entertainment, sports and recreation, scientific and research projects, healthcare and underground sanatoriums)






The Geomining Historical and Environmental Park of Sardinia

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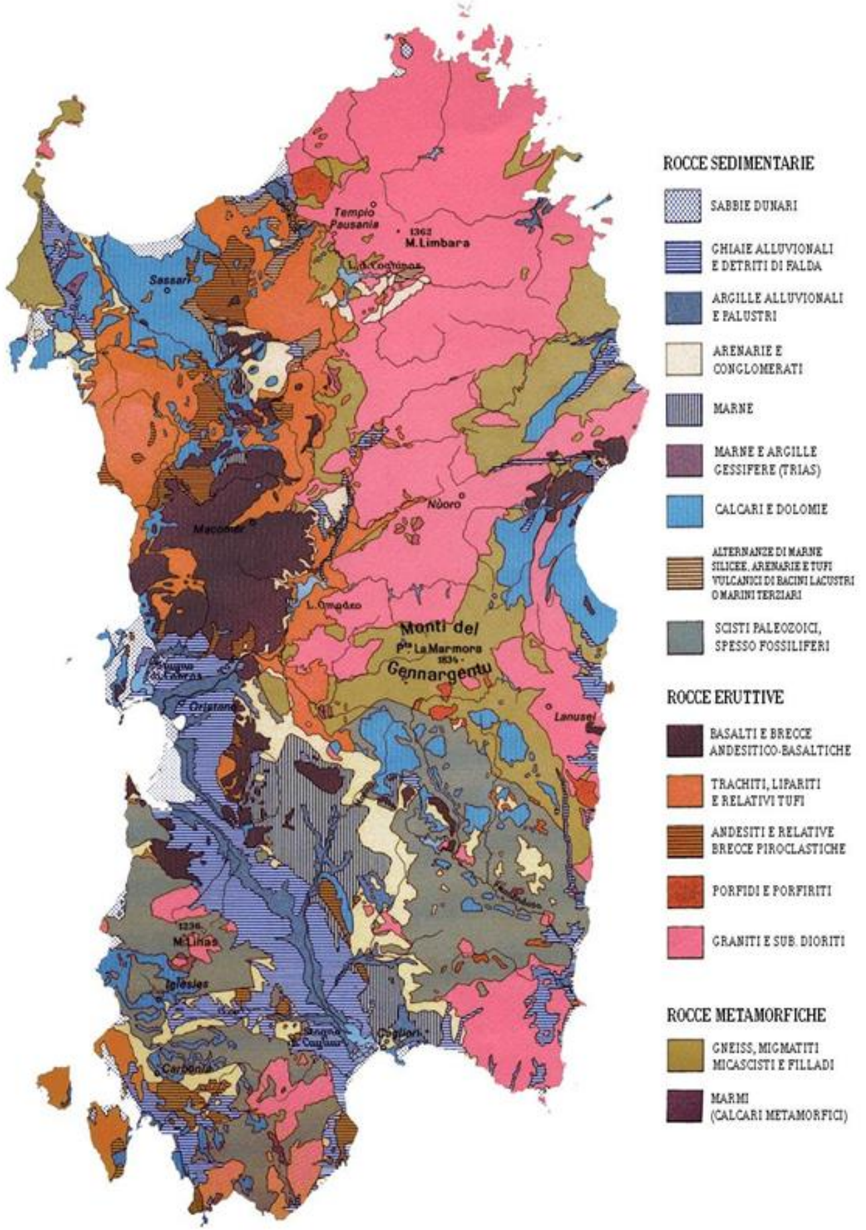
Land of miners and mines

- The long and complex geological history of Sardinia has generated exceptional concentrations of minerals which, if useful to humans, become mineral deposits.
- The oldest land in Italy: 540 million years is the age of the oldest fossiliferous outcrops, located in the sub-region of Sulcis Iglesiente in the southwest of the island;
- The greatest geodiversity among Italian regions: the outcrops of intrusive and effusive magmatic rocks, sedimentary rocks, and metamorphic rocks represent almost all geological eras starting from the Cambrian;
- The enormous number of mining concessions: there are over than 250 granted since 1850, considering only metallic minerals;
- The variety of chemical elements: dozens of chemical species, in native form or as chemical compounds, have been extracted in Sardinia. Among these we find gold (1), silver (19), lead (112), zinc (78), antimony (7), molybdenum (3), fluorine (10), barium (41), iron (27), copper (8), and talc (12);
- The know-how: for thousands of years, but especially since the Industrial Revolution, Sardinia has been at the forefront of mining technology and engineering. Innovations conceived, tested, and implemented here have later been used throughout the world.



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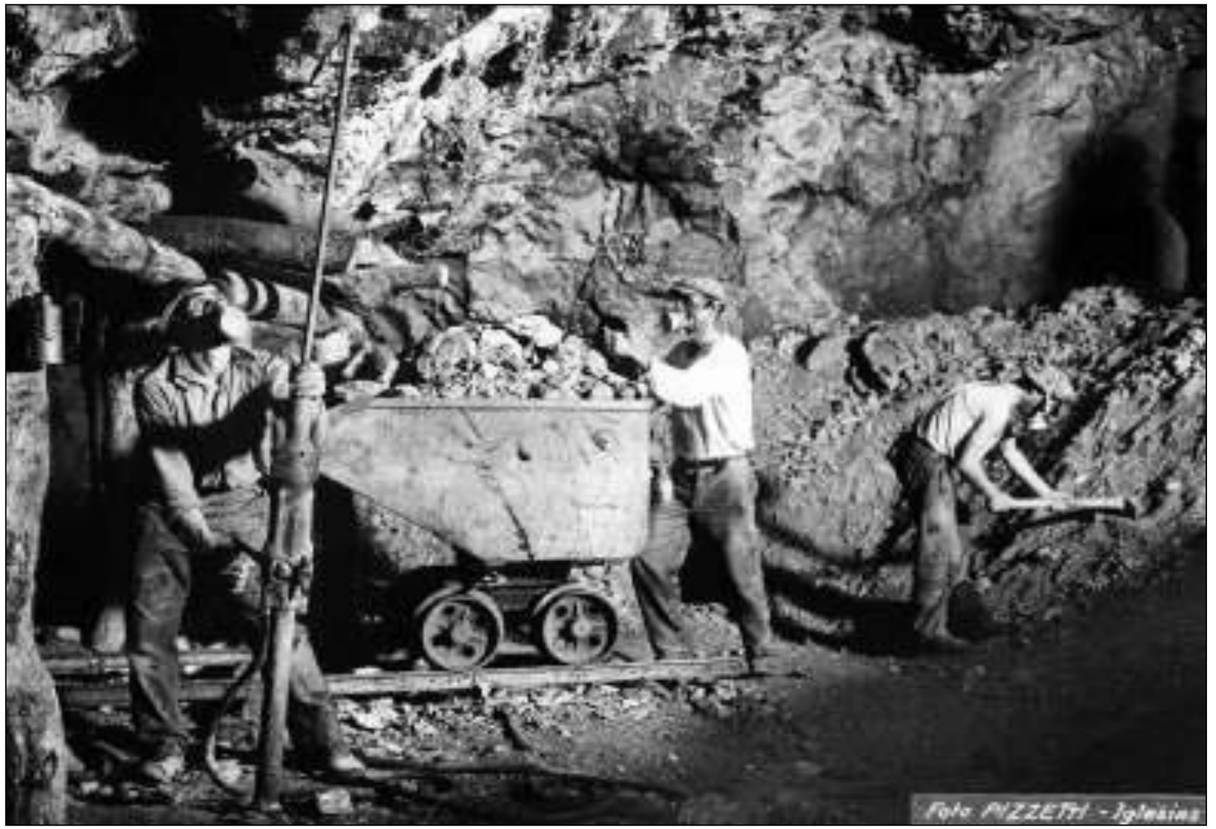
Evolution of mining activities

- It is necessary to go back to the Early Neolithic period (6000–4000 BC) to find the origins of what would become the mining epic of Sardinia, to observe its rise, its peak, its decline, its effects, and the signs of a modest revival.
- Early Neolithic: tools and ritual objects were made of stone. In this period, in Sardinia, the extraction, processing and trade of materials such as obsidian, talc, and jasper began;
- Late Neolithic and Nuragic period: metallurgy developed, and copper, silver, bronze, lead, and iron progressively replaced stone in the construction of weapons, tools, and ritual objects;
- Phoenician and Roman period: new uses were introduced, such as coin minting and the construction of imperial piping systems, which greatly boosted the extraction of lead and silver;
- From the fall of the Roman Empire to the Savoy period: mining activity continued with alternating fortunes, depending on geopolitical conditions and the “transfer of control” of Sardinia, which passed through various dominations.

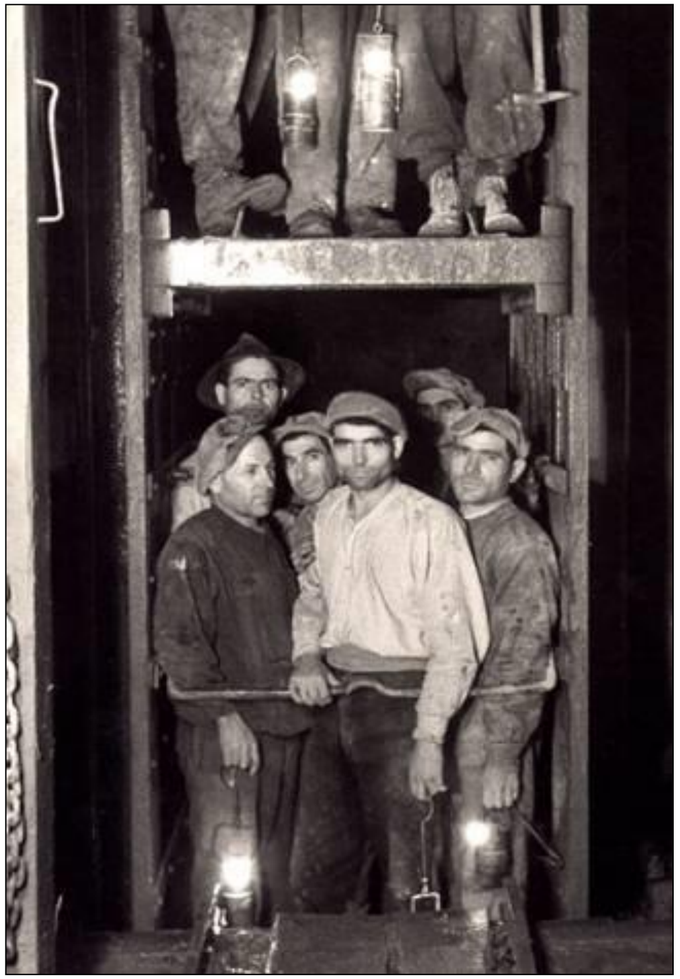


Evolution of mining activities

- Contemporary period (from 1850 to the second half of the 20th century): new technologies and new mining regulations stimulated investments, which made Sardinian mines becoming one of the most prosperous economic realities at national level. On the other side, in the same period, the first workers' struggles and some tragic strikes occurred;

- Current period: due to competition from large-scale global deposits, only a few mining concessions still remain active. Nowadays, also thanks to the "Critical Raw Material Act", a European regulation of May 2024, there is a renewed interest in raw material extraction, carried out with modern and as sustainable as possible methods;

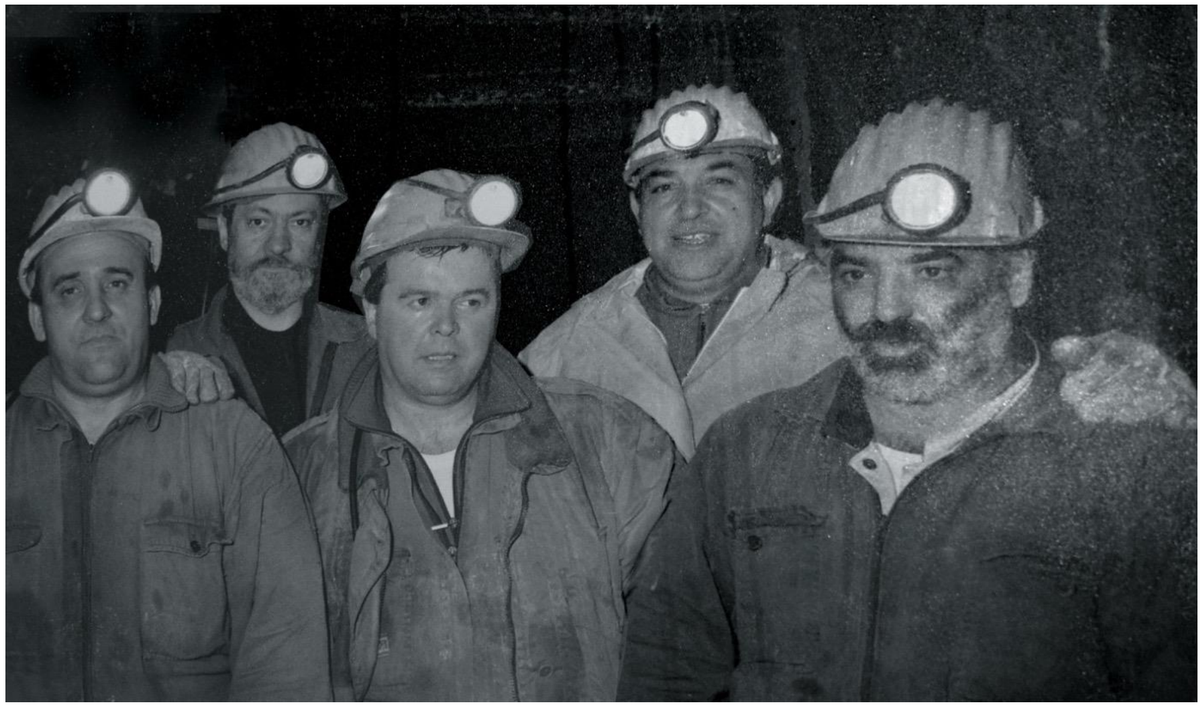
- Future: a potential large-scale revival of extractive activities will have to face market trends, mineral exploration of "new" raw materials, and the challenge of addressing the loss of know-how resulting from large-scale mine closures.

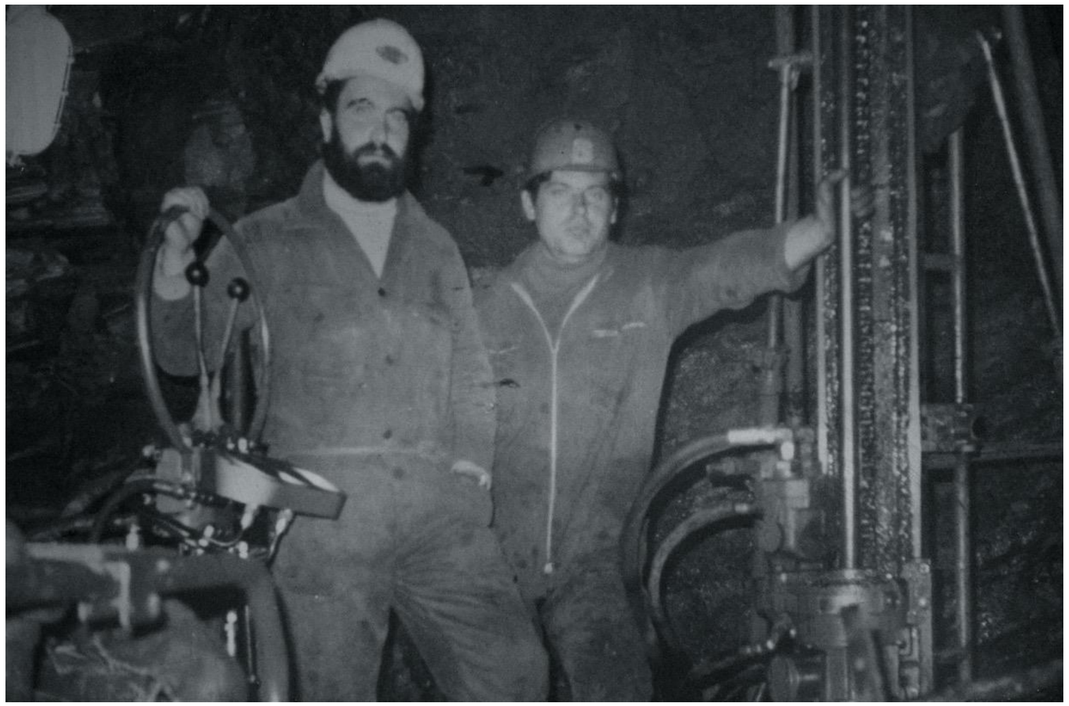


Sos Enattos lead and zinc mine – Sardinia

The cessation of industrial activities in 1997 led to strikes and protests by the workforce, who sought to save their jobs. During those years of widespread mine closures, a growing awareness emerged in Sardinia of the immense value of the island's geological and mining heritage. This awareness ultimately gave rise to the first institution of its kind in the world:

The Geomining Historical and Environmental Park of Sardinia





Miners at work underground in the Sos Enattos mine, between the 1970s and 1980s

The Geomining Historical and Environmental Park of Sardinia
The History

- It is a bottom-up reality: the initiatives, studies, and efforts that led to the establishment of the Geomining Park were in fact the work of an entire community—scholars, mining engineers, miners, and ordinary people—who became aware of the need not to lose the immense technical, scientific, documentary, industrial and archaeological heritage of the memory and of the mining engineering tradition.

- 1970s: the progressive and unstoppable decline of the mining industry led the territories most affected by its impact to develop an awareness of the urgent need to find a path of reconversion for everything it had created and represented;

- 1997s: at the General Conference in Paris, the Autonomous Region of Sardinia submitted to UNESCO the project of the Geomining Historical and Environmental Park of Sardinia, with the aim of demonstrating its potential value;

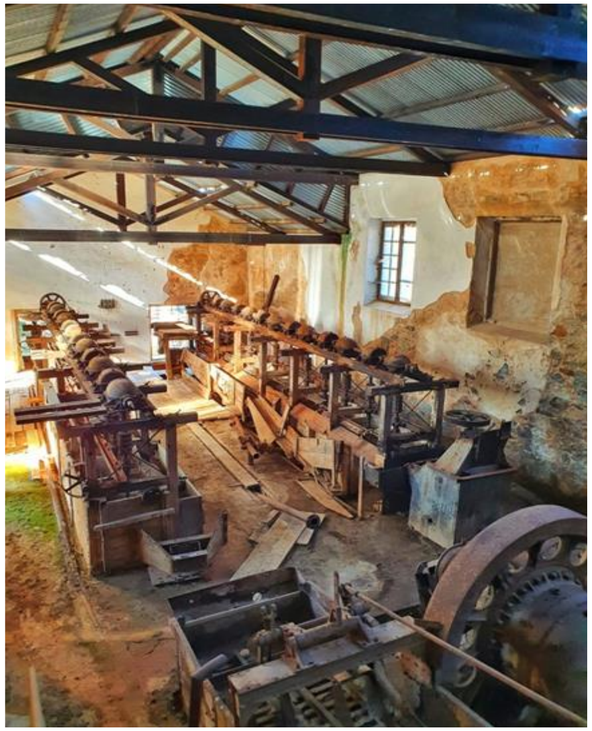
- 1997s: UNESCO stated that the proposed Geomining Historical and Environmental Park of Sardinia would be the first park of the emerging Global Network of Geosites;

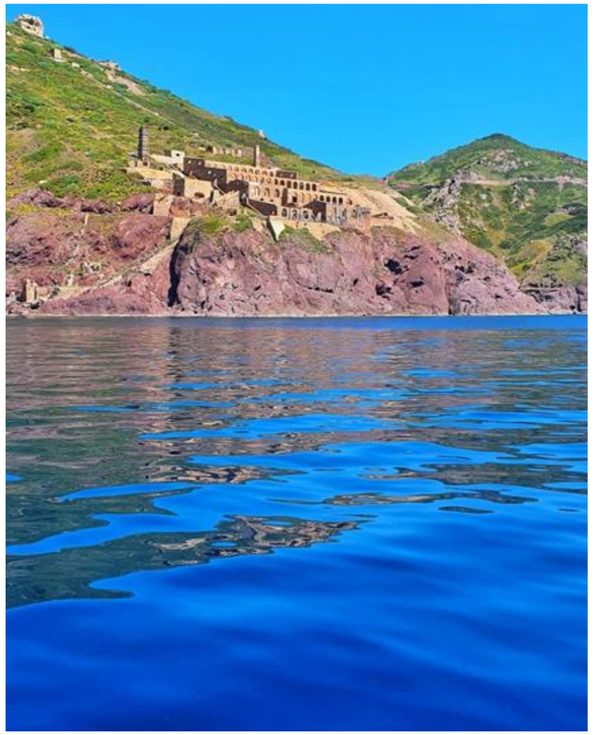
- 2001s: with the Ministerial Decree of 16 October 2001, the Geomining Historical and Environmental Park of Sardinia was officially established;

- The Park is divided into 8 areas, reflecting the most representative territories in terms of number and importance of mining sites. It spans 86 municipalities out of the island's total 377. All geosites in Sardinia fall under the Park's responsibility.

The Geomining Historical and Environmental Park of Sardinia
The History

After the closing of the industrial activities, a part of the above-ground and underground structures was preserved as part of the industrial archaeological heritage, restored and adapted for tourist and cultural purposes. The mission of the Park is to ensure the conservation, enhancement, and proper use of the technical-scientific, historical-cultural, and environmental heritage of the sites and assets included in its territory, and to contribute to the sustainable economic and social development of the areas and local communities that, over time, carried out intense mining activities and the exploitation of geological and mineral resources, and that are now facing significant changes in their economies and lifestyles.





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Sos Enattos lead and zinc mine – Sardinia

In the municipality of Lula, in the historic region of Barbagia, an intense mining activity developed thanks to the exploitation of the Sos Enattos deposit, giving a significant boost to the town's economic growth.

Knowledge of the deposit and the earliest mining activities date back to the Roman period;

The first modern mining concession for the exploitation of Sos Enattos was granted in 1863;

The extracted minerals were sphalerite and silver-bearing galena;

The mine developed underground through the excavation of shafts, galleries, and a ramp, with technologies that evolved over time, moving from ore transport by ox-drawn carts to the use of modern dumpers;

The site had a productive life of more than one hundred years, ending only in 1997; it was the last mine to be closed in the Province of Nuoro.

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Sos Enattos lead and zinc mine – Sardinia

Nowadays, the Sos Enattos mining site is in excellent condition of preservation, both externally and in its facilities and underground areas, with machinery that seems ready to resume operation at any moment, as if the industrial processes had only just been interrupted at the end of the 1990s.

Aerial view of the Sos Enattos mining site, featuring the headframe, the workshops, and the processing (washing) plant buing

Interior of the Sos Enattos processing plant (laveria), equipped with crushers, mills, spiral separators, and a flotation system.

Sos Enattos lead and zinc mine – Sardinia

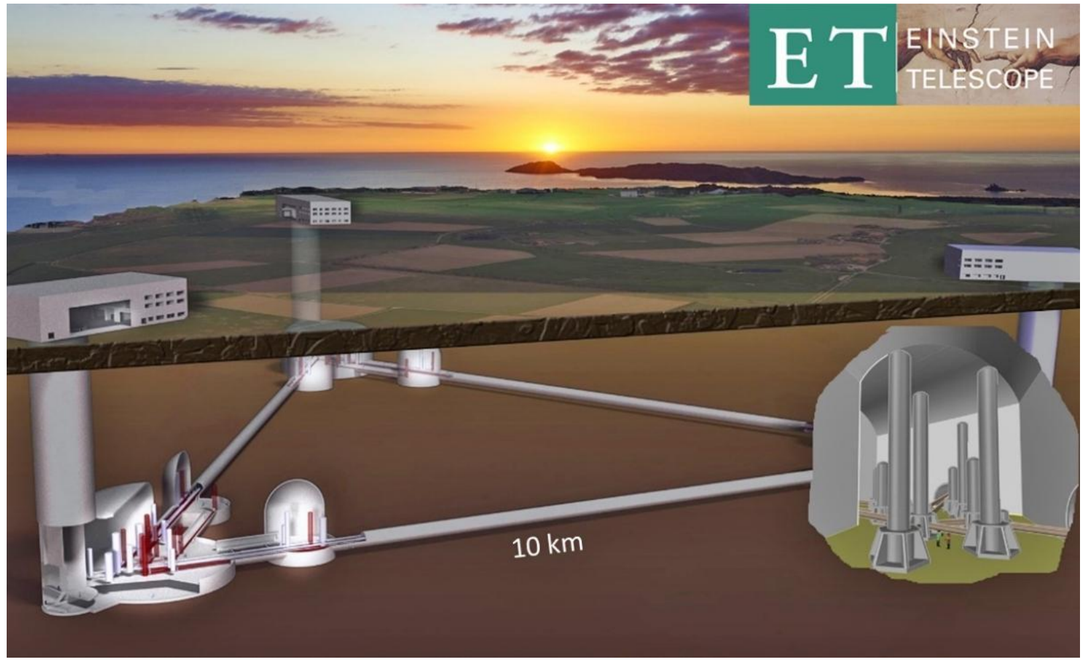
The cessation of productive mining activities, which occurred only at the end of the 1990s, meant that most of the buildings, structures, ore-processing machinery, and underground tunnels could be preserved and kept in proper working conditions, allowing them to be later adapted for tourism and cultural purposes; for this reason, the site can be considered one of the flagship attractions of the Geomining Park.

- Accessibility of mining tunnels, with the possibility of seeing the machinery used for excavation and ore removal;
- “Educational” underground: visitors can walk through both modern and older tunnels and observe differences in excavation methods and tunnel dimensions;
- Accessibility of the ore-processing plant, which remains in excellent condition and still contains the machinery used for ore beneficiation processes;
- Presence of a mining work museum, housed in one of the historic buildings.

Sos Enattos lead and zinc mine – Sardinia

The site has recently hosted some of the field-based educational activities included in the “Specialisation Course for Guides of the Geomining Historical and Environmental Park of Sardinia”, aimed at training professional guides who would later be included in the Park’s official list of guides.

Underground Gravitational Wave Observatory of Sos Enattos – Sardinia



Sardinia contains a set of unusual and seemingly unrelated characteristics that, when considered together, make possible to support Italy's candidacy to host a major research project known as the "Einstein Telescope".
In particular, the municipality of Lula has:

one of the lowest population densities in Italy, an important factor because it reduces human-made interference and environmental noise.

This is combined with the area's complex geological history, which results in extremely low seismic noise levels—an essential condition for highly sensitive scientific measurements.

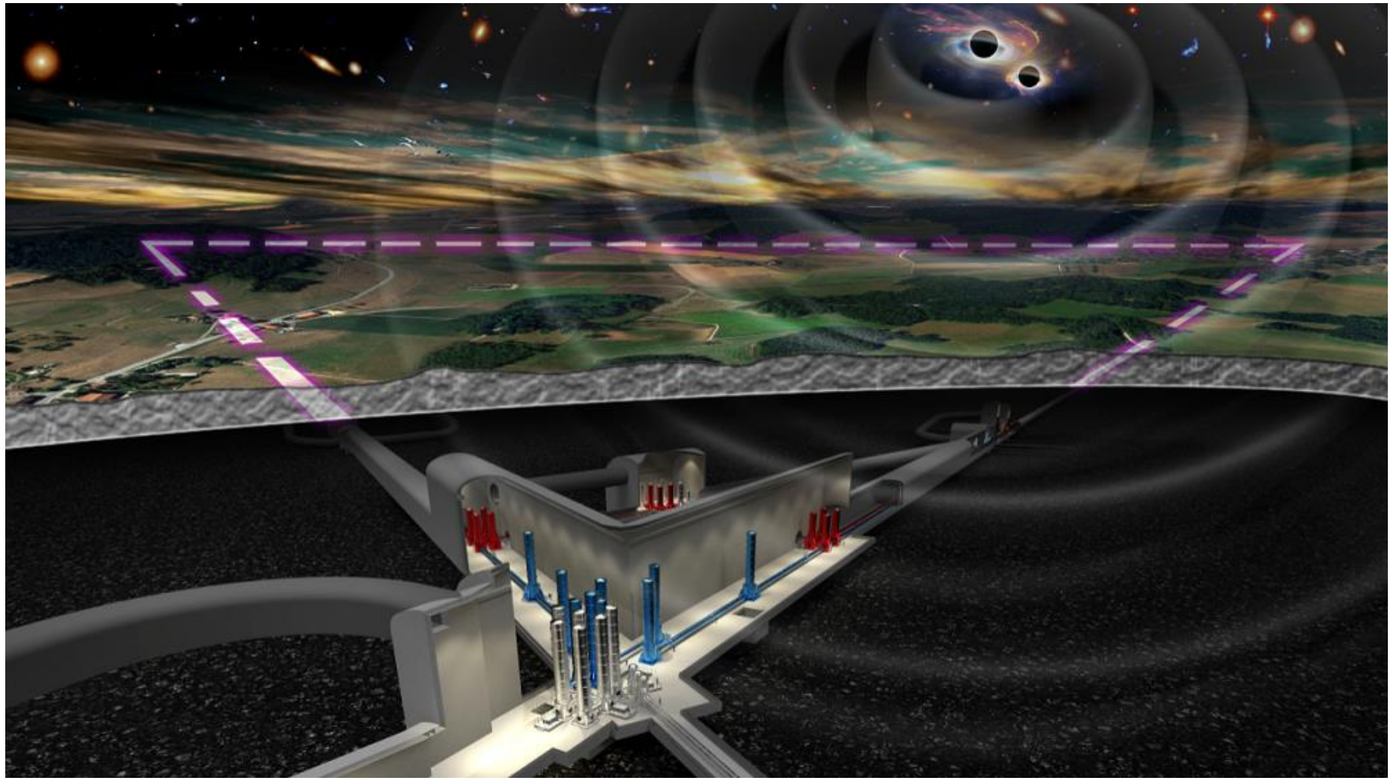
Underground Gravitational Wave Observatory of Sos Enattos – Sardinia

Another key advantage is the presence of the disused Sos Enattos mine, whose well-preserved underground tunnels provide direct access to the subsurface. These pre-existing structures offer a naturally shielded environment that is highly suitable for advanced scientific installations.

Together, these features make the site particularly appropriate for ultra-precise measurements that would be extremely difficult, if not impossible, to achieve in most other locations on Earth.

Underground Gravitational Wave Observatory of Sos Enattos – Sardinia

The project began around 2010, when the first actual underground measurements of seismic noise were carried out. In 2019, the first permanent sensors were installed by the National Institute for Nuclear Physics (INFN), in collaboration with the National Institute of Geophysics and Volcanology (INGV) and the National Institute for Astrophysics (INAF), with the aim of verifying whether the site's seismic noise characteristics were truly compatible with the Einstein Telescope (ET) project.

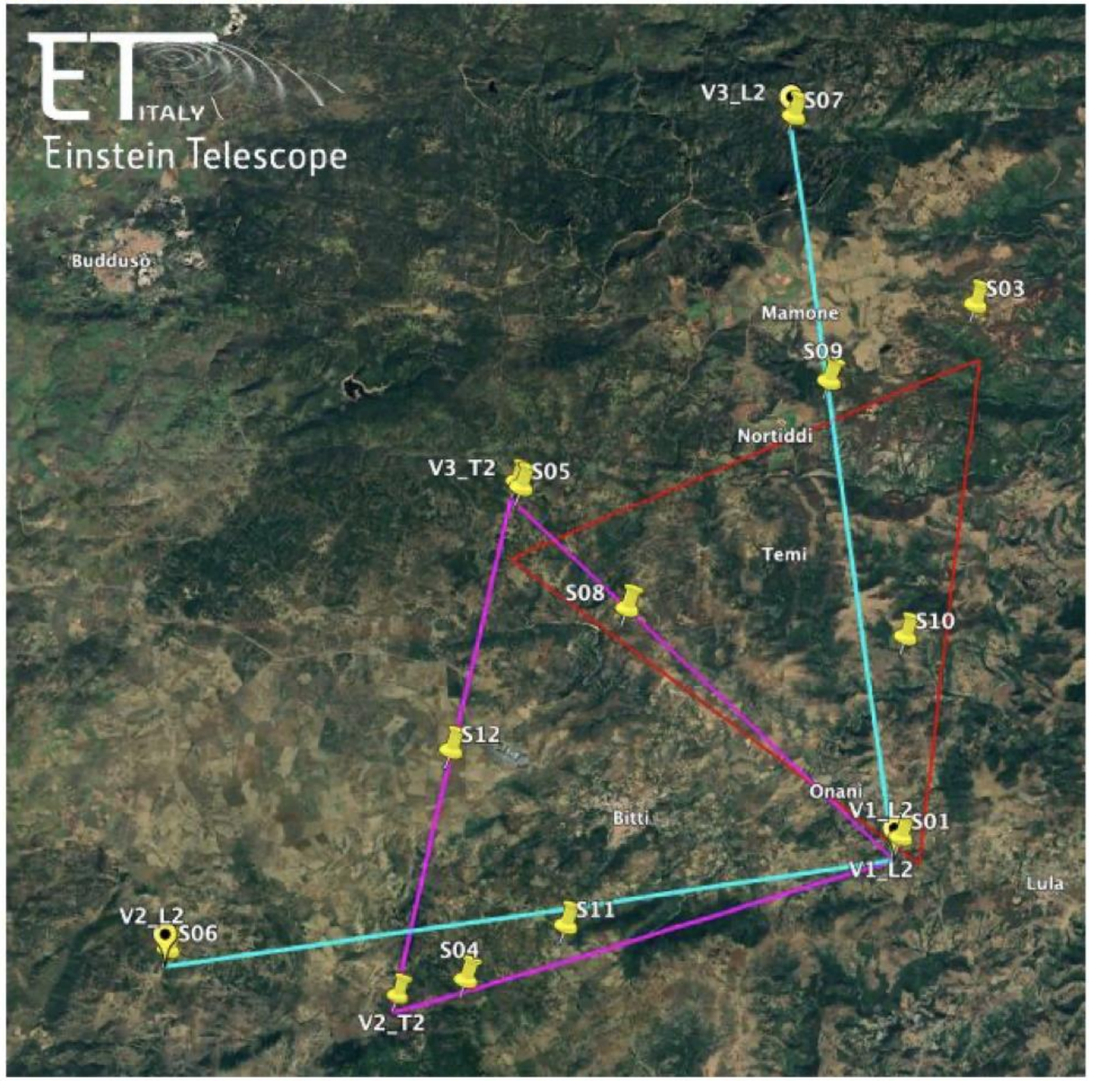


Underground Gravitational Wave Observatory of Sos Enattos – Sardinia

The underground development of the Einstein Telescope (ET) foresees the excavation of more than 30 kilometres of tunnels at a depth between 100 and 300 metres. These underground cavities would host the third-generation laser interferometer and all the instrumentation required for the detection of gravitational waves, as well as for the processing of the collected data.

ET is designed to achieve a significantly improved sensitivity compared to current instruments, increasing the size of the interferometer from the 3 km arm length of the “Virgo” detector to 10 km, and implementing a range of new technologies. These include a cryogenic system to cool some of the main optics down to 10–20 K, new quantum technologies to reduce light fluctuations, and a series of infrastructural and active noise-mitigation measures to reduce environmental disturbances.

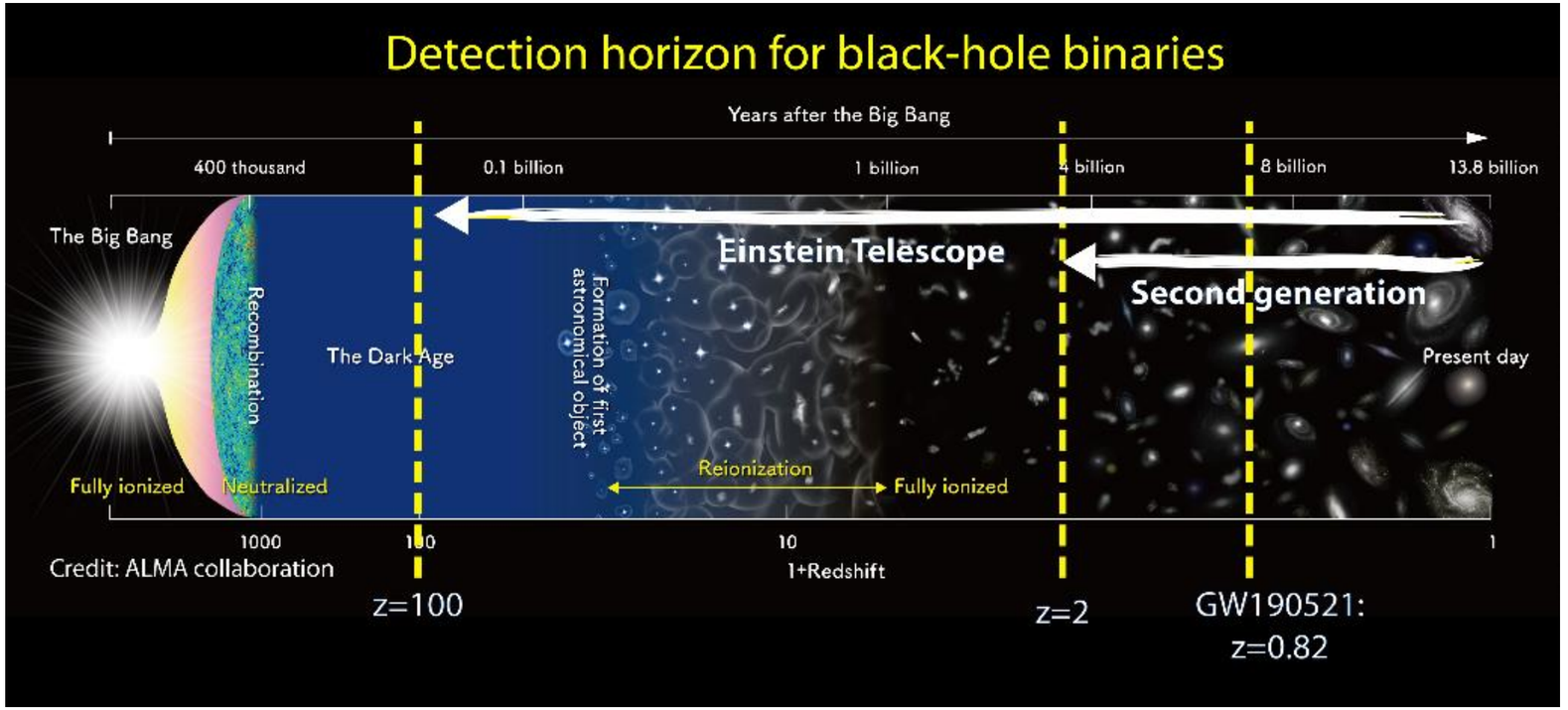
Sos Enattos



Underground Gravitational Wave Observatory of Sos Enattos – Sardinia

For the first time, the Einstein Telescope (ET) will make possible to explore the Universe through gravitational waves across its entire cosmic history, up to the cosmological dark ages, shedding light on open questions in fundamental physics and cosmology.

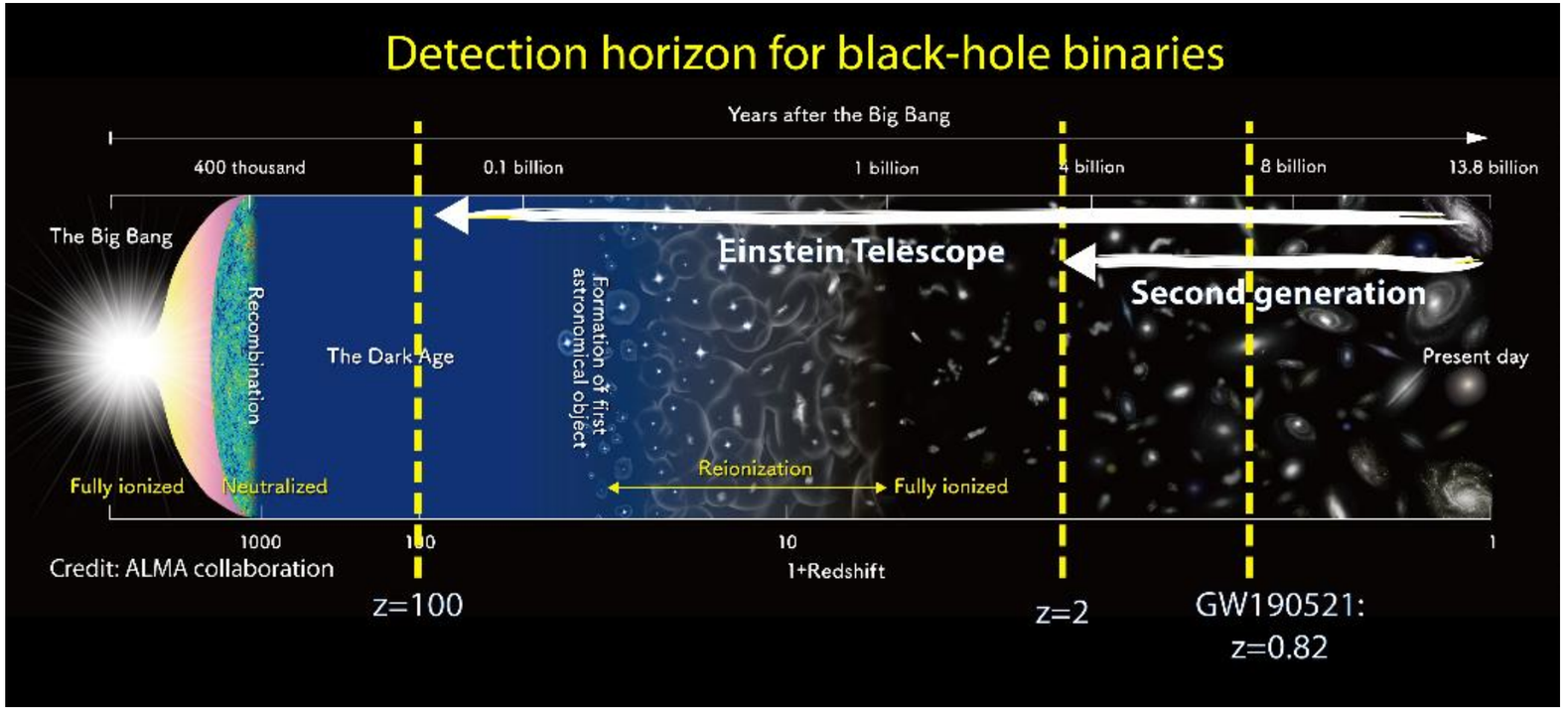
It will investigate physics near black hole horizons—from tests of general relativity to quantum gravity—and contribute to understanding the nature of dark matter (such as primordial black holes, axion clouds, and dark matter accumulating around compact objects), as well as the nature of dark energy and possible modifications of general relativity on cosmological scales.



Underground Gravitational Wave Observatory of Sos Enattos – Sardinia

By exploiting ET's sensitivity and frequency range, it will be possible to access the full population of stellar-mass and intermediate-mass black holes across the entire history of the Universe, helping to clarify their origin (stellar versus primordial), evolution, and population statistics.

ET will also observe the inspiral phase of neutron star binaries and the onset of tidal effects with a high signal-to-noise ratio, providing an unprecedented view of neutron star internal structure and probing the fundamental properties of matter in a completely unexplored regime (ultra-high-density QCD and possible exotic states of matter).



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If the project, possible thanks to the presence of the former mine and which is promoted by the Italian State together with the Netherlands, and supported by the Region of Sardinia, will be successful, Sos Enattos will enter a third phase of its existence, adapting to the times and becoming one of the major international scientific hub, once again contributing to the economic development of the territory.

Thank you for your attention

MINISTERO DELL'AMBIENTE E DELLA SICUREZZA ENERGETI

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