The Art of Salt Mining in Italy

from salt springs to modern underground mines and solution mining

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Salt in antiquity

Salt is a basic commodity for everyday life (human consumption, meat and fish salting, etc.)

1- From the sea

- By evaporation: shallow, low-lying coastal lagoons (salt pans)
- Exploited as early as the Neolithic

Manilius: fish salting (*Astronomica*)
Cato, Columella et Al.: pork salting
Plinius, condensation or desiccation of liquid
Rutilius Namatianus; description of salt ponds near Volterra

2- Heating of brines

3- Mining from geological outcrops

Alessandri L. & Attema P., From Briquetage to Salterns in Protohistoric Central Italy (2021)

Heating of brines

Briquetage = Artificial boiling of the brines
Technology that used coarse thick-walled ceramic materials (briquetage) to shape the evaporation vessels and using heat produced by burning wood.

Used also (but not only)
in inland areas

Fig. 4. Chalcolithic salt moulds accumulation in Solnitsata, Provadija, Bulgaria (photos O. Weller).

http://woods-today.blogspot.com/2012/09/briquetage.html

Olivier Weller, First salt making in Europe: an overview from Neolithic times, Documenta Praehistorica XLII (2015)

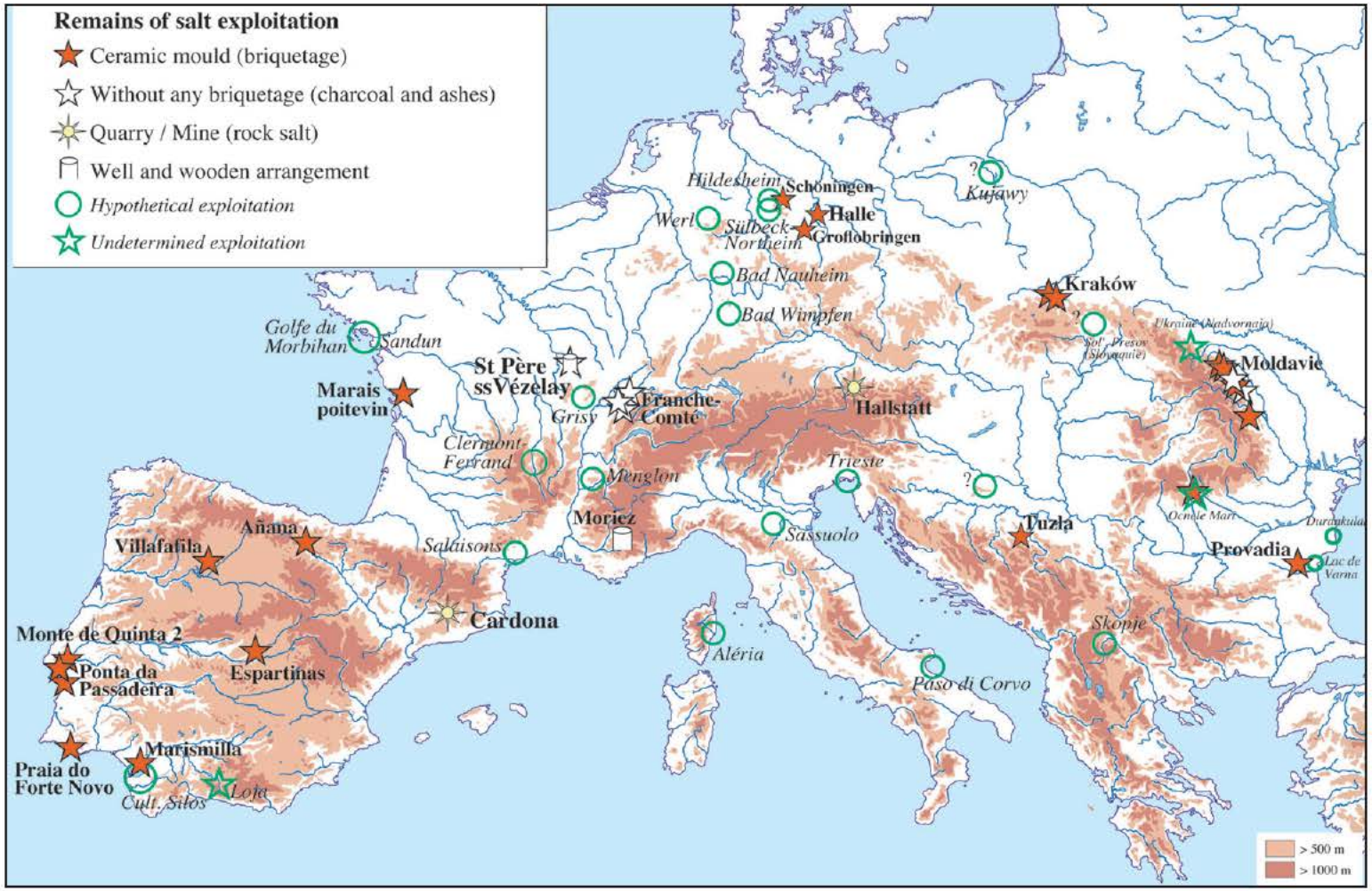


Fig. 8. An European assessment for the Neolithic and Chalcolithic periods (6000–2300 BC): the various archaeological evidences for salt production (drawing O. Weller).

Modern Salterns in Italy

Evaporation ponds:

- Trapani (Sicily)
- Margherita di Savoia (Puglia)

www.margheritadisavoia.com/media/images/articles/salina3.jpg

www.salineculcasi.it

Antonino Leto, *Saline di Trapani*, 1881. Palermo, Galleria di arte moderna «Empedocle Restivo»

«Industrial» production from saline springs

Agricola (*De Re Metallica*, 1556)
Biringuccio (*De la Pirotechnia*, 1540)

Forced evaporation of natural brines

- Heat of the sun
- Artificial heat

Fossa A. Vaso nel qual corse l'acqua salsa B. Romaiuolo C. Secchia attaccata a una pertica D.

ie, far sogliono il sale nero. Alcuni altri ne le medesime pentole cuocono l'a lamoia di tutte le cose salate, e massimamente de pesci, ma questo sale ha l'a dor del pesce.

Pentole A. Trepiede B. Romaiuolo profondo C.

Biringuccio 1540

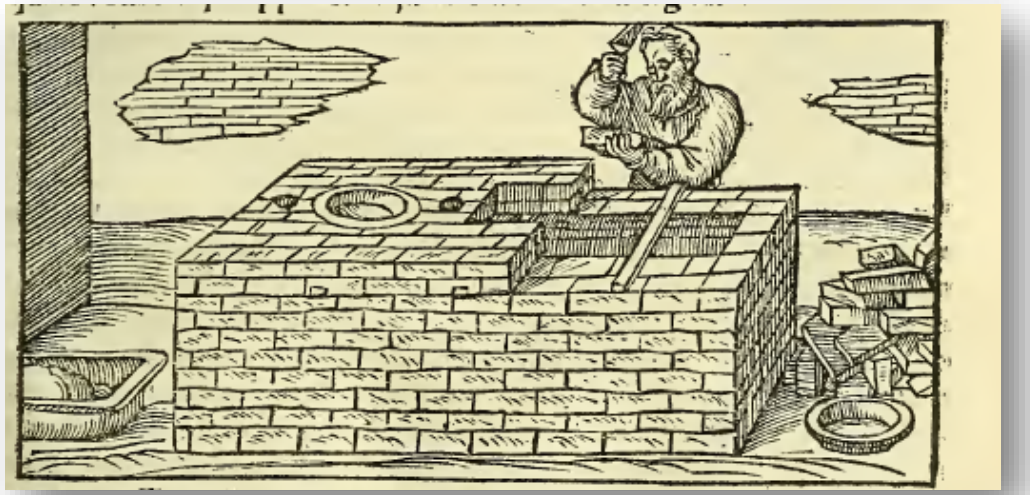
In the Middle Ages, the salt water seepages of **Volterra** were systematically exploited;
The mineral rights belonged to the Bishop

Leaf 35 R

confirmation di qito oltre agli altri luochi che vi si potrebben dire vi di
ro di quello che mi ricordo hauer veduto a Halla nel ducato Dauſtria,
doue e vn riuetto dacqua dolce qual ſol per eſſer fatto atrauerſare vn
mõte doue e miniera di ſale diuẽta, per tal modo ſalſo, che meſſa detta
acqua in certe caldere fatte di piaſtre di ferro grãdi di diametro circha
a quatro braccia, aconcie ſopra a vn forno o piu, col bollire & euapora-
re ſi riſtregne, & coſi cõ certe pale riuercie a modo di raſtelli fatte di le-
E iii

Leaf 35 V

alta abundantemẽte ſi ſerue. Queſto medeſimo interuiene in Thoſca-
na in quel di Volterra duna aqua ſalſa che ſi caua di certi pozzi, laquale
ſimilmẽte metteno in certe caldere di piõbo ſimili a quelle del vetrio-
lo, & per ebullition la fa diſecchare, delaquale cauano vn ſal biãchiſſi-
mo come neue, & in tanta quãtita, che nõ ſolo la citta di Volterra, ma
quella di Firenza, con tutto il ſuo cõtado altro ſal nõ adopera che q̃llo.

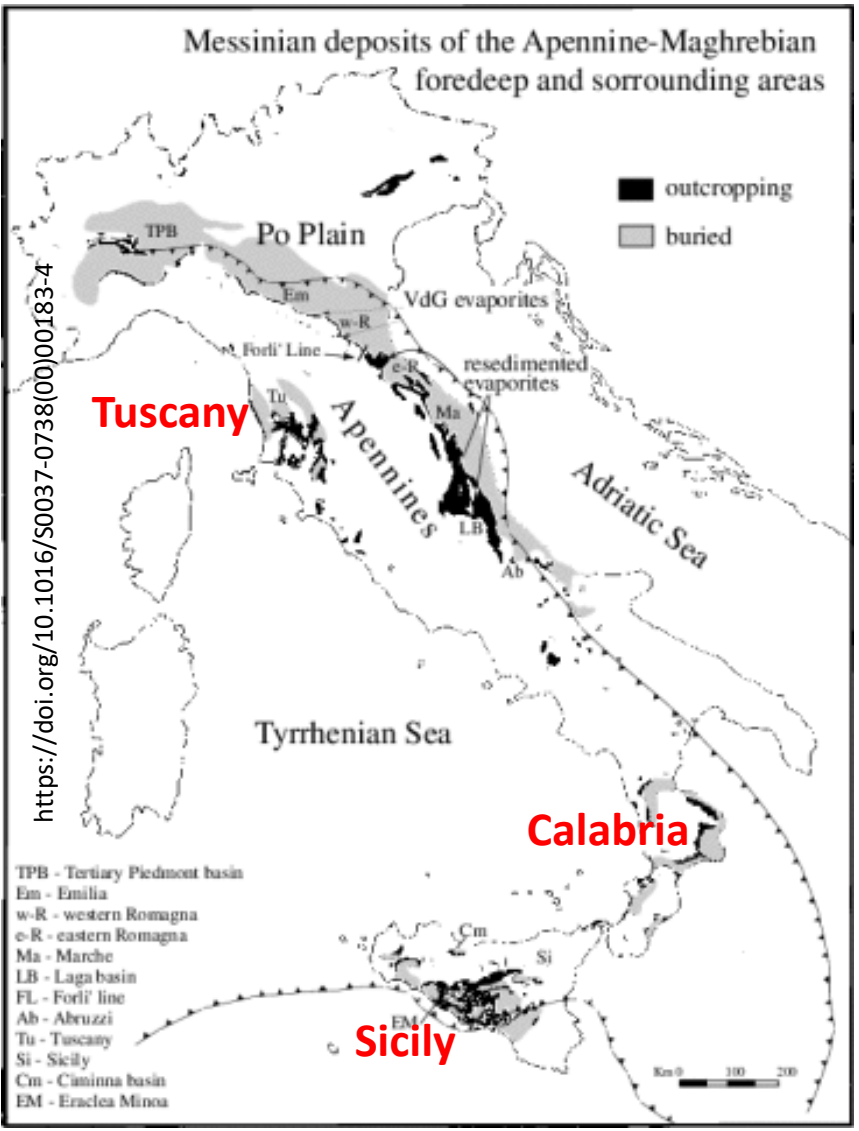


Leaf 64 R,
Heating furnace for vitriol production,
the same used for salt water evaporation

«Similarly to what happens in “Halla in the Duchy of Austria (*modern Hall in Tyrol*), even in Volterra salt is produced from salt water extracted from some wells»
(book 2 on “Common mineral salt”)

Salt & Sulphur geology in Italy

Messinian outcrops in Italy



https://doi.org/10.1016/S0037-0738(00)00183-4

Messinian stage (7.2 - 5.3 Mya) & Salinity crisis (5.96 - 5.33 Mya)

Messinian salinity crisis: the Mediterranean Sea separated from Atlantic and was subjected to cycles of partial or nearly **complete evaporation** (late Messinian)

Salt is on top of the evaporitic sequence

Marly Limestones rich in Foraminifera

Post Gypsum-Sulphur fm.

Gypsum-Sulphur Formation :

"Salts" (Na + K + Mg)

Gypsum

Evaporitic Limestones rich in **Sulphur**

Diatomaceous marl rich in organic substance

Pre Gypsum-Sulphur fm.

Marls - Clays

Strong evaporation produced huge salts deposits in the most isolated sedimentary basins

Sulphur and Halite
Sicily

Evaporitic sequence

The deposits often show a repeated sequence of minerals, indicating cyclic conditions with a mineralogy determined by solubility.

The most important minerals and the sequence in which they form include calcite, gypsum, anhydrite, halite, and lastly K and Mg salts (sylvite, carnallite, kainite); gypsum and halite dominate.

Italy, «modern» mining in XIX Century

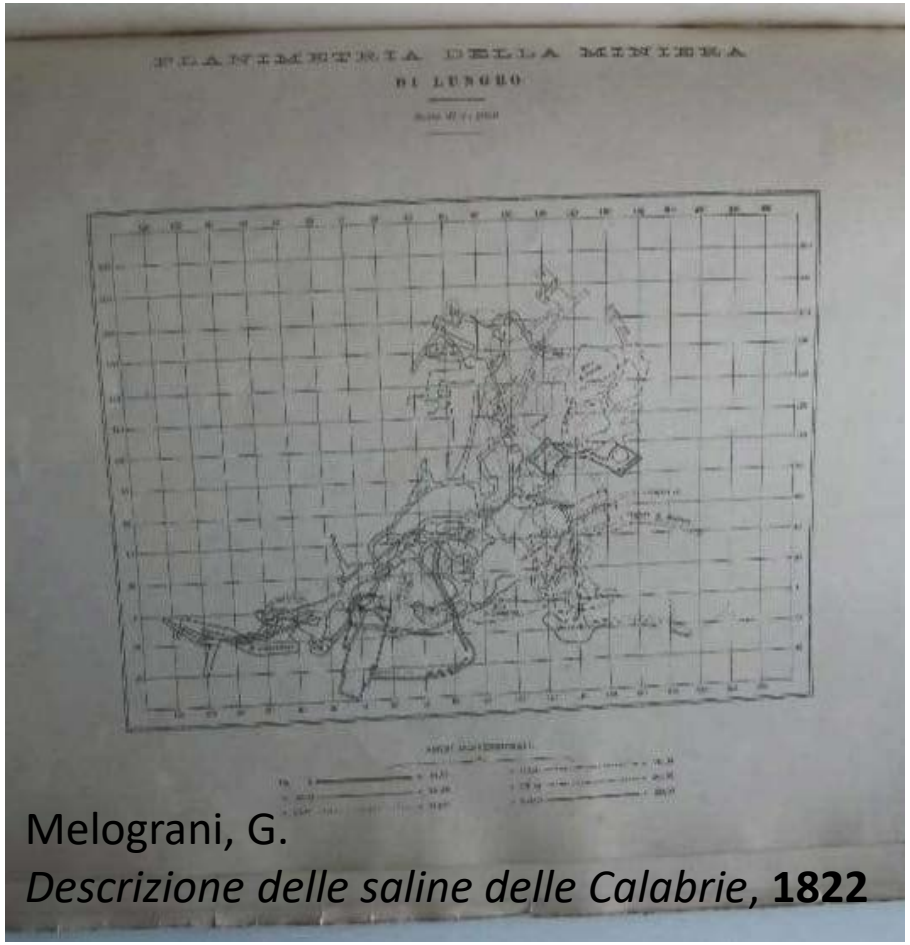
The case of Lungro-Altomonte salt mine

(Calabria, Southern Italy)

Underground mining active since the Middle Ages or earlier

Basic (pre-technological) mining methods and design until its final abandonment (1978)

Pesatura del sale



Melograni, G.
Descrizione delle saline delle Calabrie, **1822**

- The salt mass was mined in large and irregular rooms (& pillars), forming 3 to 4 superimposed levels
- **Manual hoisting and haulage**
- Only in 1800's a vertical shaft (80 m) was constructed for ventilation and equipped with a steam drawworks
- **Access to underground works only via inclined tunnels, by 1200 steps cut in the salt mass**


UNA MINIERA MILLENARIA: IL SALGEMMA DI LUNGRO 1191

(neg. rag. G. Barillari, Lungro)

Dove oggi ferve l'opera di sfruttamento già gli antichi s'erano dedicati con i loro mezzi primitivi a tentativi di estrazione. Plinio già nominava i «cristalli balbini», e avanzi di antichi utensili, forse del 1° sec. dell'êra cristiana, furono trovati presso l'ingresso a testimonianza di quegli antichissimi saggi industriali.

https://it.wikipedia.org/wiki/Salina_di_Lungro

FRANCESCO SENISE
Salinari della miniera di Lungro
(Salt miners at Lungro)

Solution mining in Tuscany

In modern times, salt production was – and still is – associated with the 19th century development of a chemical industry for the production of sodium carbonate (or soda, Na2CO3), sodium bicarbonate NaHCO3 and other chemical by-products (in an early stage with the Leblanc process and later with the Solvay-Mond one)

In 1913 the Solvay brothers chose **Rosignano**, along the Tuscan coast, as the most suitable place to build a soda plant.

Three reason for this choice:

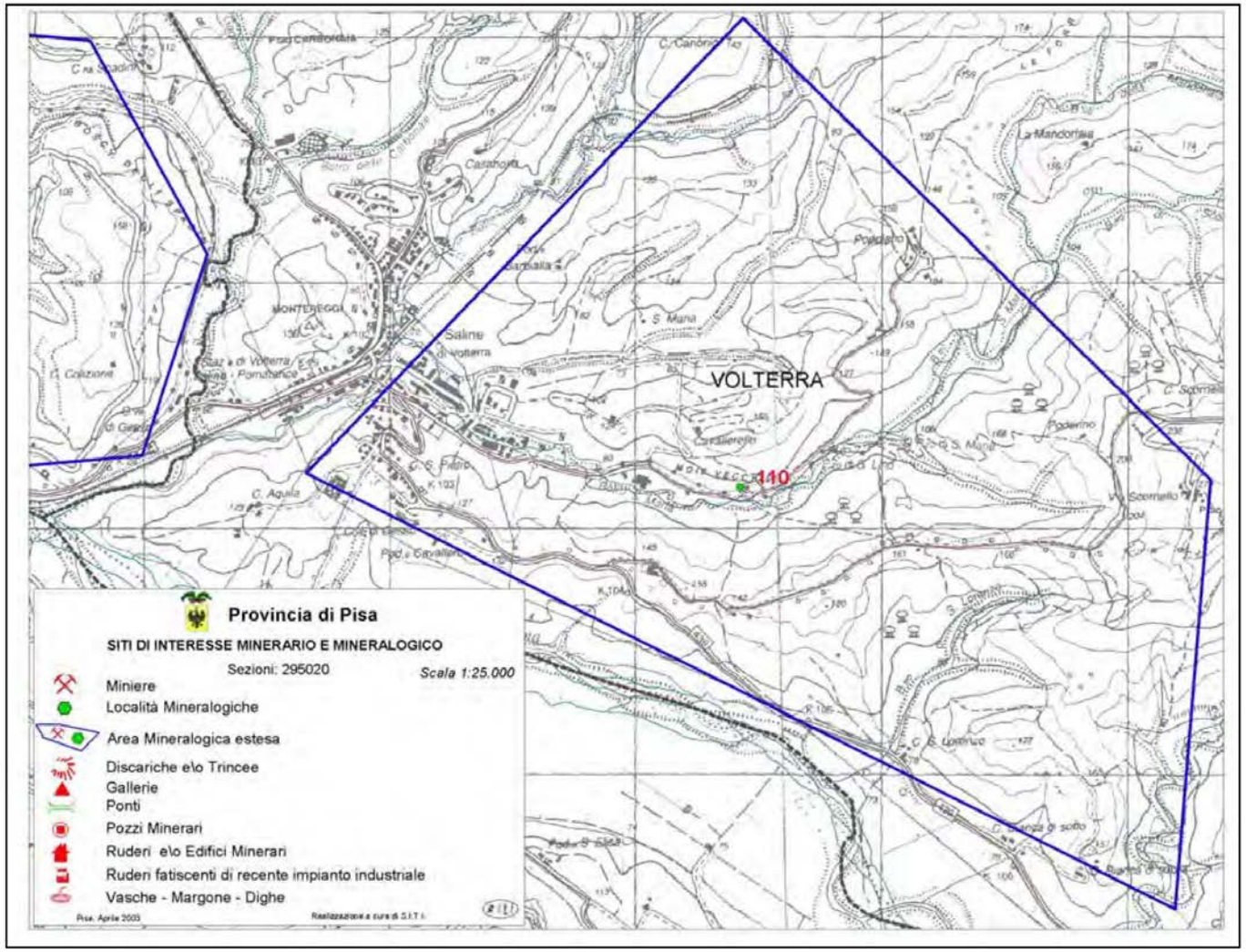
- the **railroad** heading to the port of Leghorn (Livorno)
- the nearby **limestone** quarries
- the nearby **salt** water of Volterra.

Concerns:

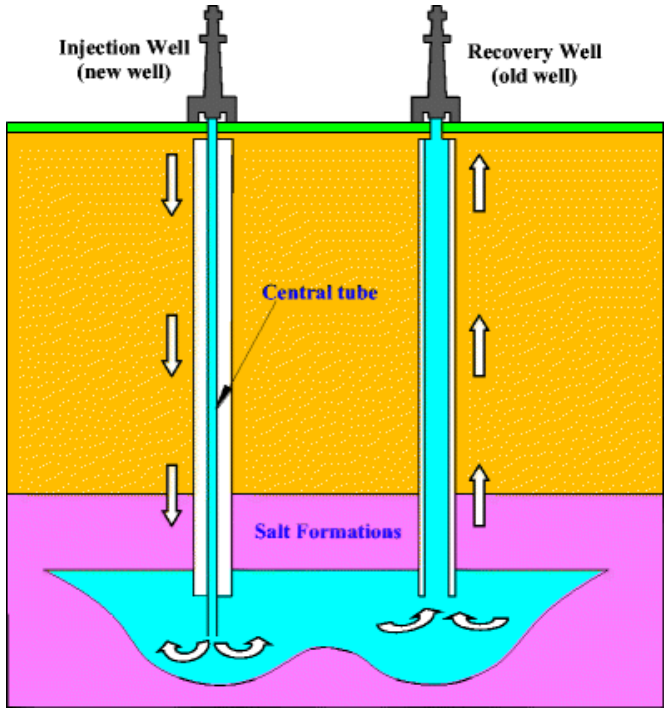
Industrial facilities + «white beaches» one of the most polluted area of the Mediterranean

Solution mining in Tuscany

Saline di Volterra (antiche "moie"). Salt production is still active here, and since the early 1900s the process is carried out with modern solution mining technologies



Today, brine production is more and more striving to comply with severe environmental regulations and landscape protection policies.



Controlled sinkhole collapse, Saline di Volterra

Solution mining in Calabria

In the last decades of the 20th century, solution mining started also in Southern Italy, at Belvedere Spinello (Timpa del Salto mine, Calabria), which has a production history similar to the one of Volterra.
Unfortunately, a sinkhole (50 x 120 m) and a landslide developed here on 25 April 1984, causing a large flood of brine to the surface (about 100,000 m^3)

https://www.ilcirotano.it/2013/07/16/fuoruscita-di-salgemma-da-miniera-belvedere-appelli-inascoltati/

- The brine invaded the irrigation canals and polluted 150 ha of olive and citrus groves.
- A month before the event, macroscopic cracks and fissures appeared on the ground, which were not related to the underground voids induced in the mine**.**
- Gradual interruption of the mining activity and of the nearby salt refining plant.
- Both sites ended the production in 2009.

Injection and production wells
400 to 600 m depth (> 200 m salt mass)

Salt mining in Sicily

Salt and Sulphur in Sicily are mined since immemorial times

The excavation of salt was granted to everyone for their own use:

in Sicily there was no salt monopoly, contrary to the rest of the Kingdom

Jervis G., *end 1880's* (vol. 3): shallow underground salt mines (-20 m) were already known:

- **Racalmuto** mine (explosives-black powder, very hard massive salt)
- **Petralia Soprana** mine (likely the first large underground mine)
- Cammarata *Salina*
- Mussomeli *Salina*
- Antinori *Salina*
- *Etc…* (> 50 leases)

Halite (NaCl)

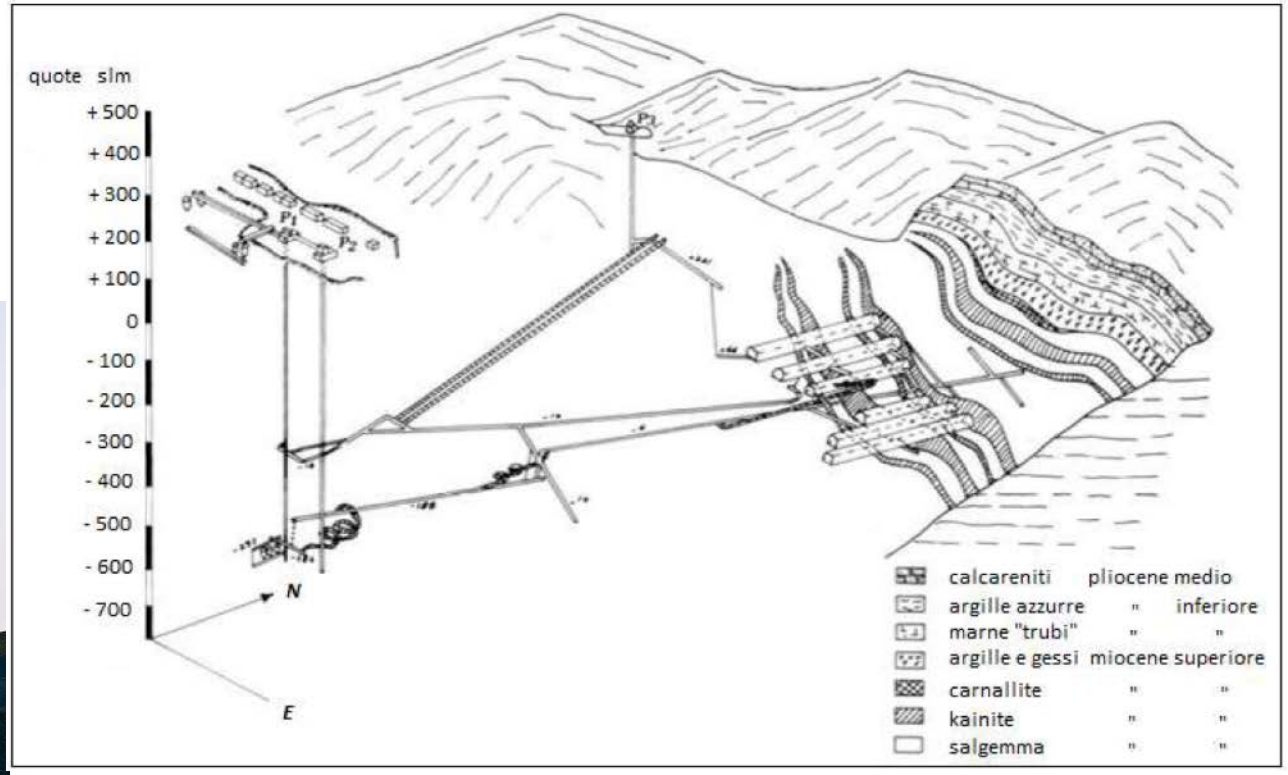
Kainite

$KMg(SO_4)Cl{\cdot}3H_2O$

Valorization of potash deposits (Kainite + Sylvite)

Since the early 1900 many underground mines of massive salt deposits were intensely exploited until a few decades ago

- **Salt production is completely mechanized**
- Room-and-pillars mining technology
- **Significant reserves of Kainite (K + Mg)**
  (±) exploited in recent decades



Potash mines (now inactive):
Pasquasia (-850 m shaft)
S. Cataldo-Bosco Palo
S. Caterina, etc.

Underground salt mining in Sicily

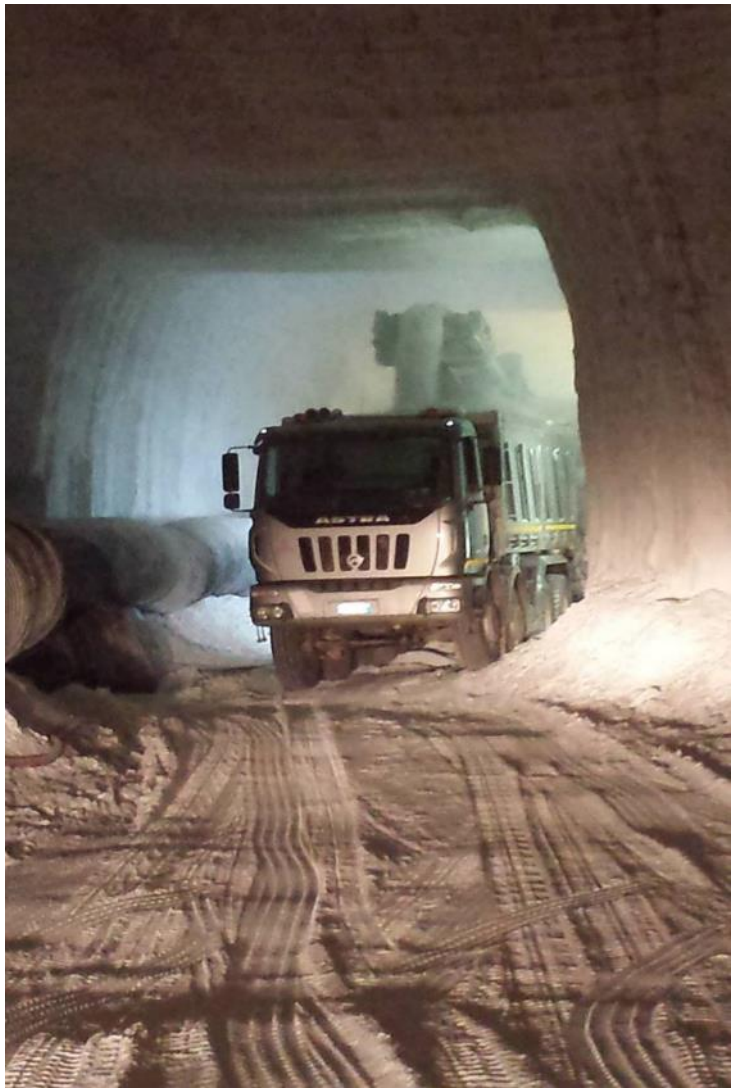
Petralia Soprana salt mine
tunneling > 40 km

https://italkali.com/

Underground salt mining in Sicily

Racalmuto salt mine

tunneling > 60 km



Underground salt mining in Sicily

Realmonte salt mine
tunneling > 70 km

https://italkali.com/

https://italkali.com/

Realmonte salt mine

Realmonte salt mine cathedral

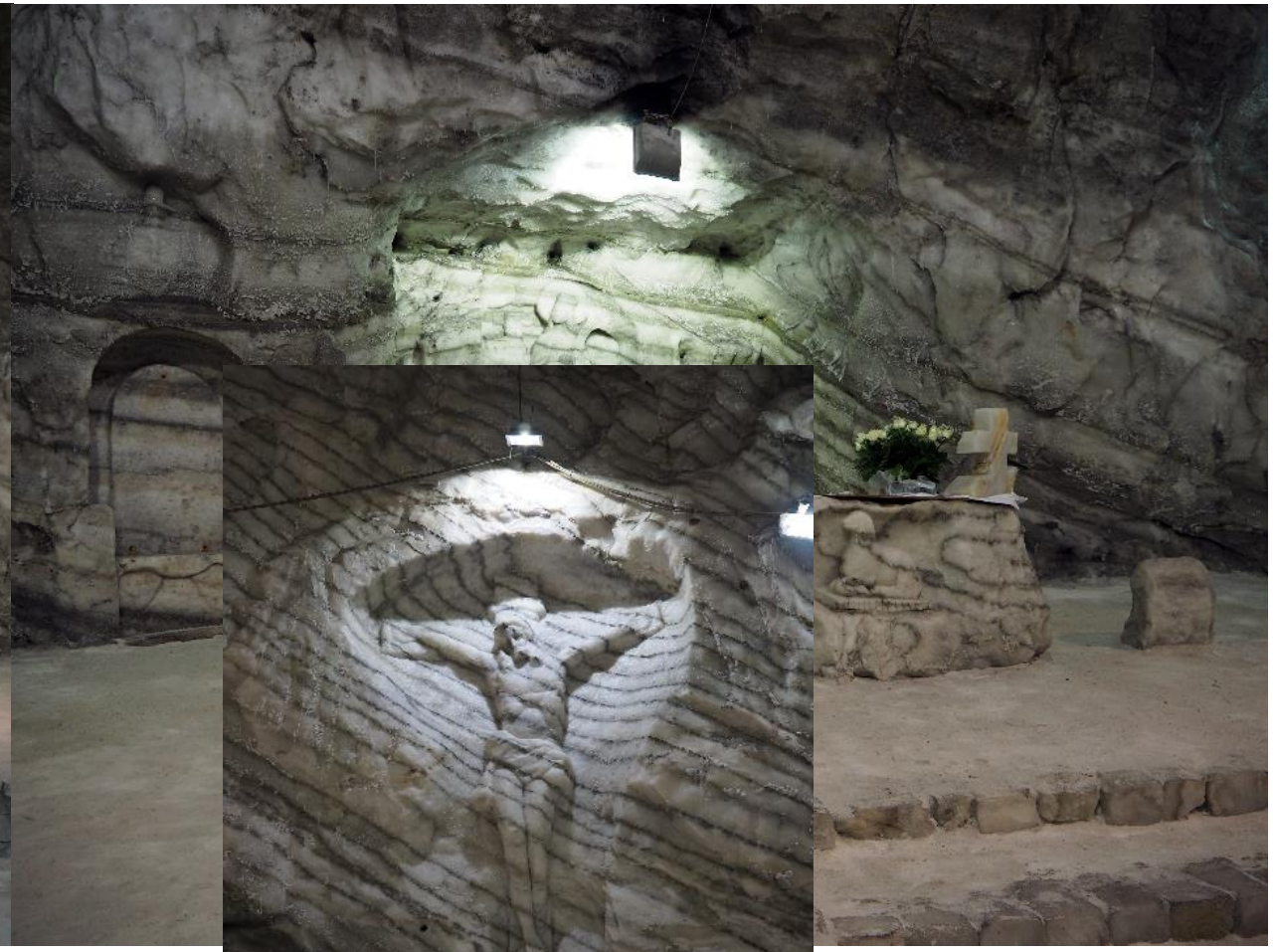


Photo: Paolo Macini

60 m length, 16 m wide, 7 m height
Can host up to 800 persons

Conclusions

The paper outlines the historical development of the Italian salt production sites and the evolution of mining technologies used in different geological contexts.

Social issues:

- Workforce
- Child Labour
- Salt Monopoly
- Employment Vs. Migration
- Salary conditions, Safety, Trade union struggles, etc.

Present production (from food-grade to industrial-grade) :

- Solution mining: 1 site in Tuscany (**Saline di Volterra**)
- Underground mines: 3 sites in Sicily (**Realmonte, Racalmuto** and **Petralia Soprana**).

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