

# The Prehistoric Salt Mines of Hallstatt

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*Perfect preservation leading to insightful simulation*



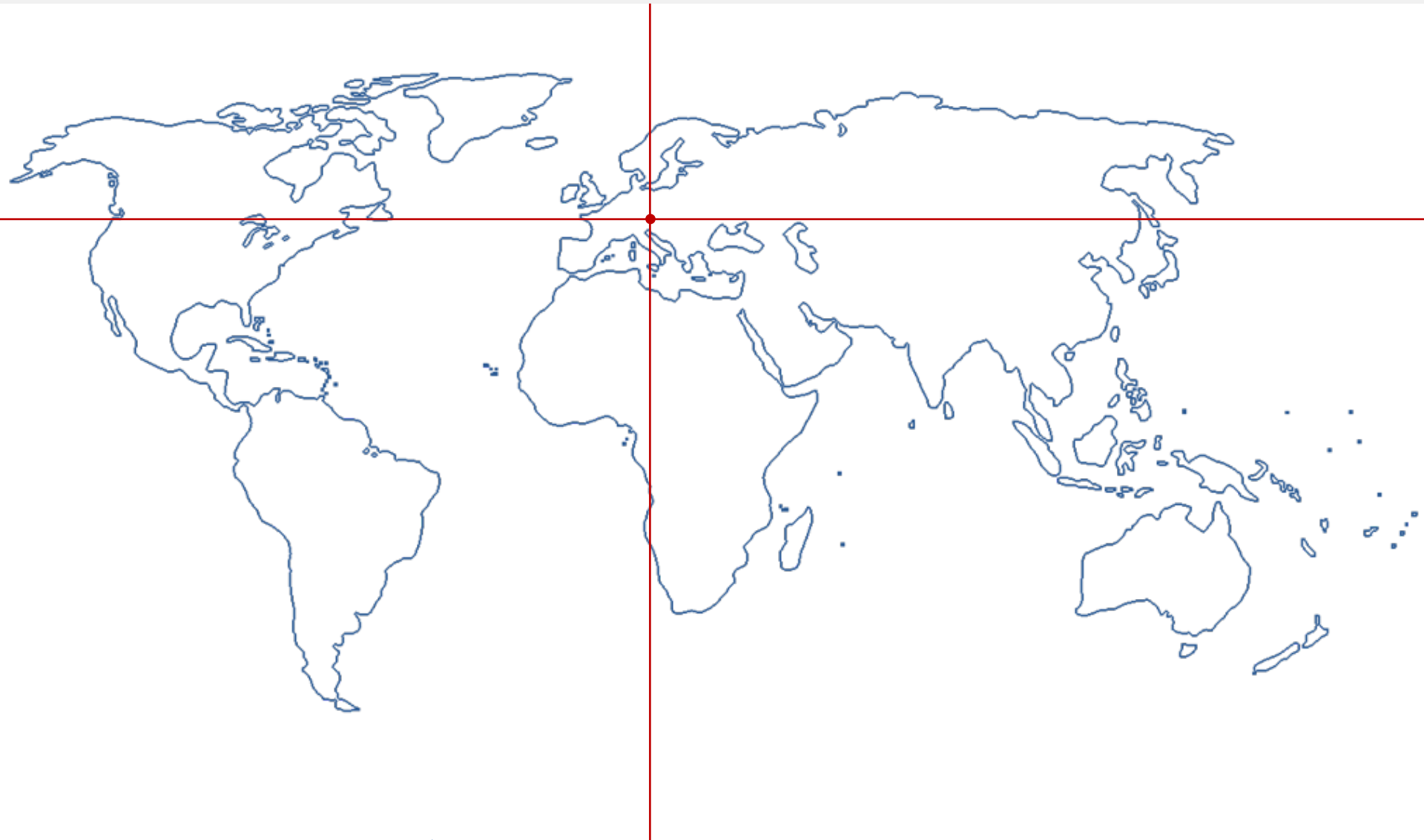
*Hans Reschreiter, NHM Wien*

*Kerstin Kowarik, NHM Wien*



*Gabriel Wurzer, TU Wien*

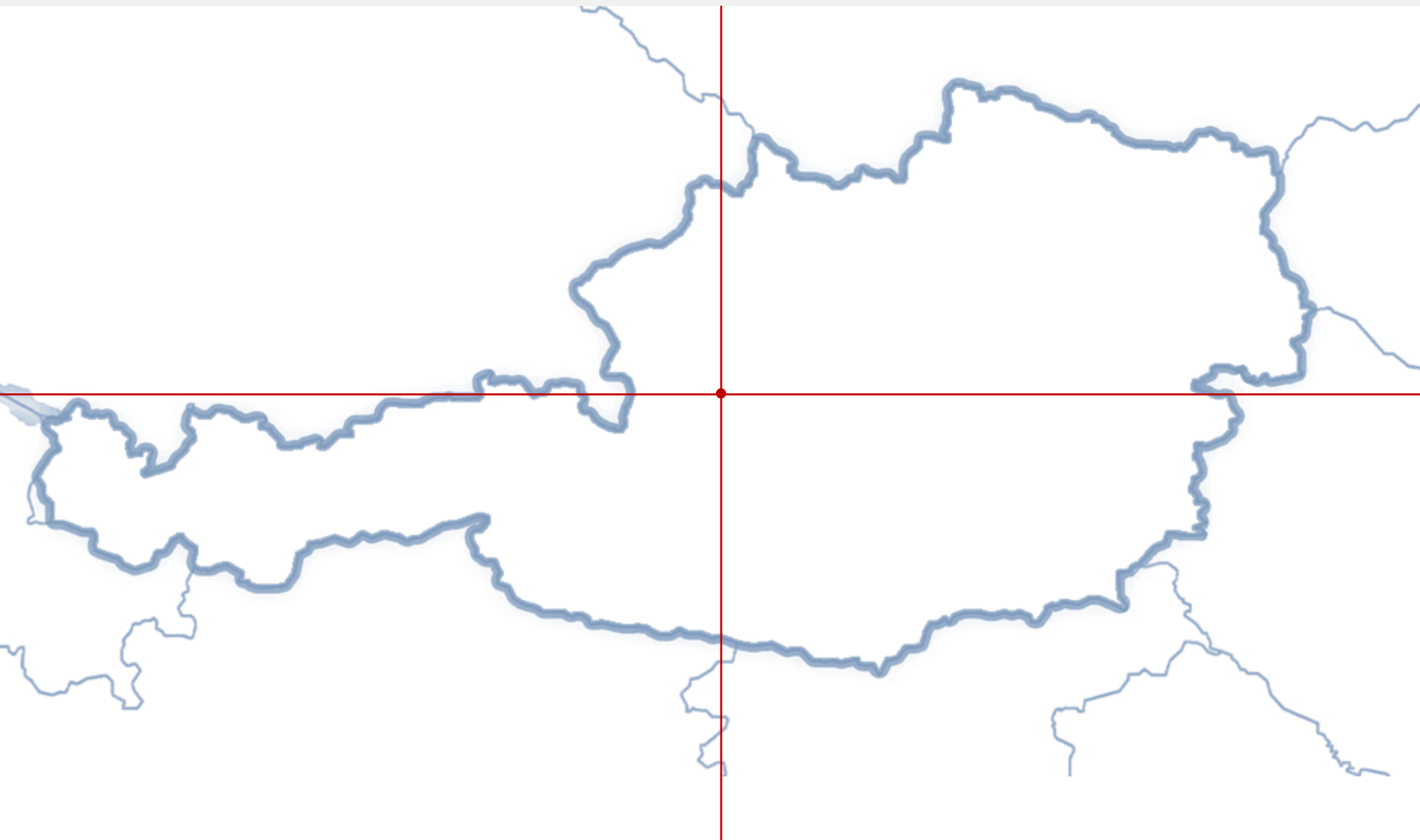
# *Hitchhiker's Guide to Hallstatt*



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High  
Valley

Hallstatt



# *Hallstatt*





# *Up the Salzberg („Salt Mountain“)*





# *High Valley*





# *High Valley*



Entry to  
Mines

Prehistoric  
Burial  
Site



# Discovery of the Prehistoric Mine

wet mining since 1311

- prehistoric waste  
a regular nuisance



1748:

„old structure found“  
while digging shaft

Das ist ein alter Bergbau  
Lager in Christina Berg

Der Lager in Christina Berg  
ist ein alter Bergbau und aller  
ersten aufschlag bei fischer  
Bergbau in Dalberg an  
anthen anno 1710 in Christina Berg

# *Excavation since mid-19th Century*

three „epochs“:

- 1846: miners  
(Ramsauer, Engl)
- 1927: prehistorians  
(Mahr, Morton)
- 1960: archaeologists  
(NHM, Salinen AG)

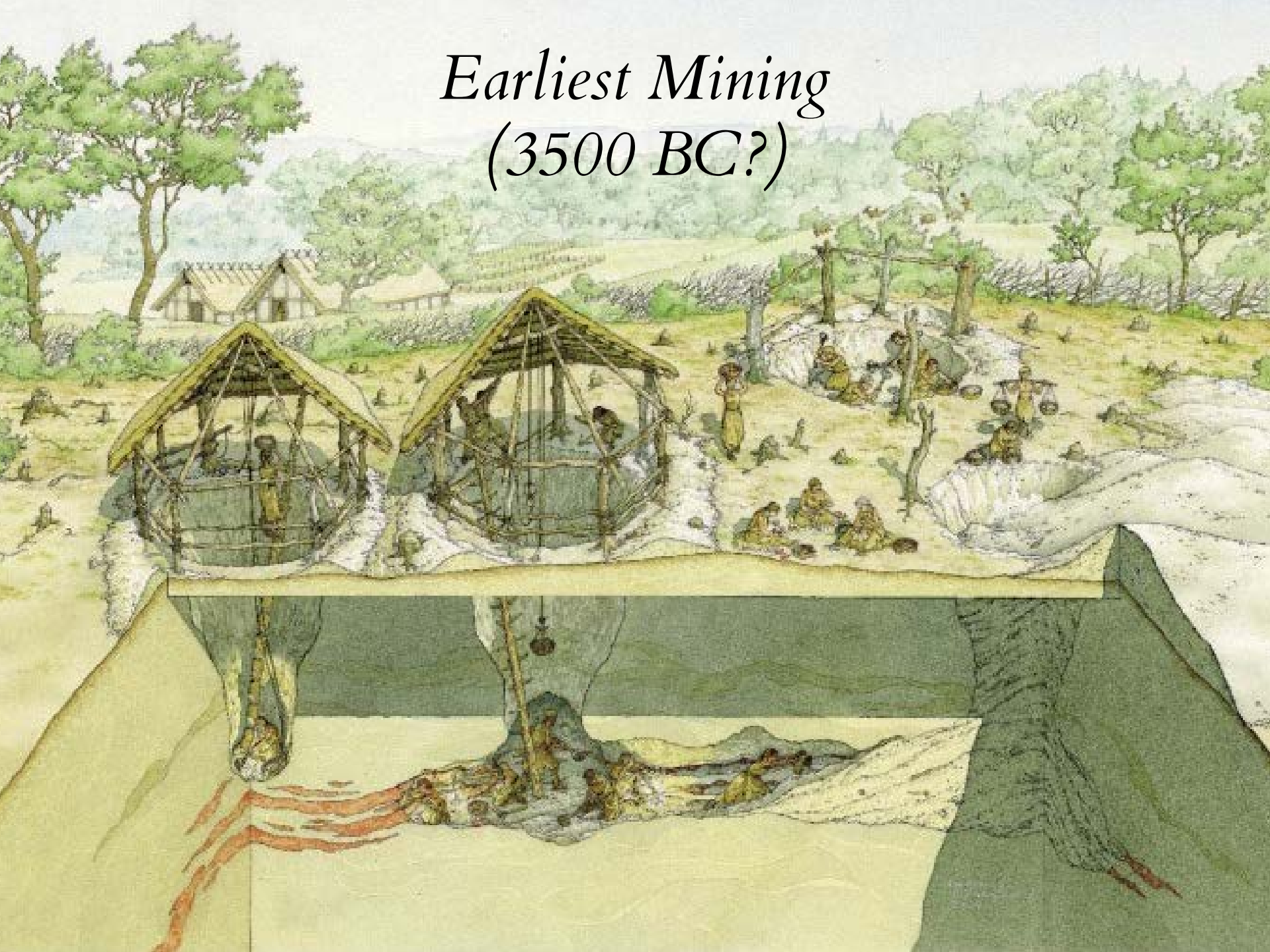


# *Salt Springs (5000 BC?)*





*Earliest Mining  
(3500 BC?)*



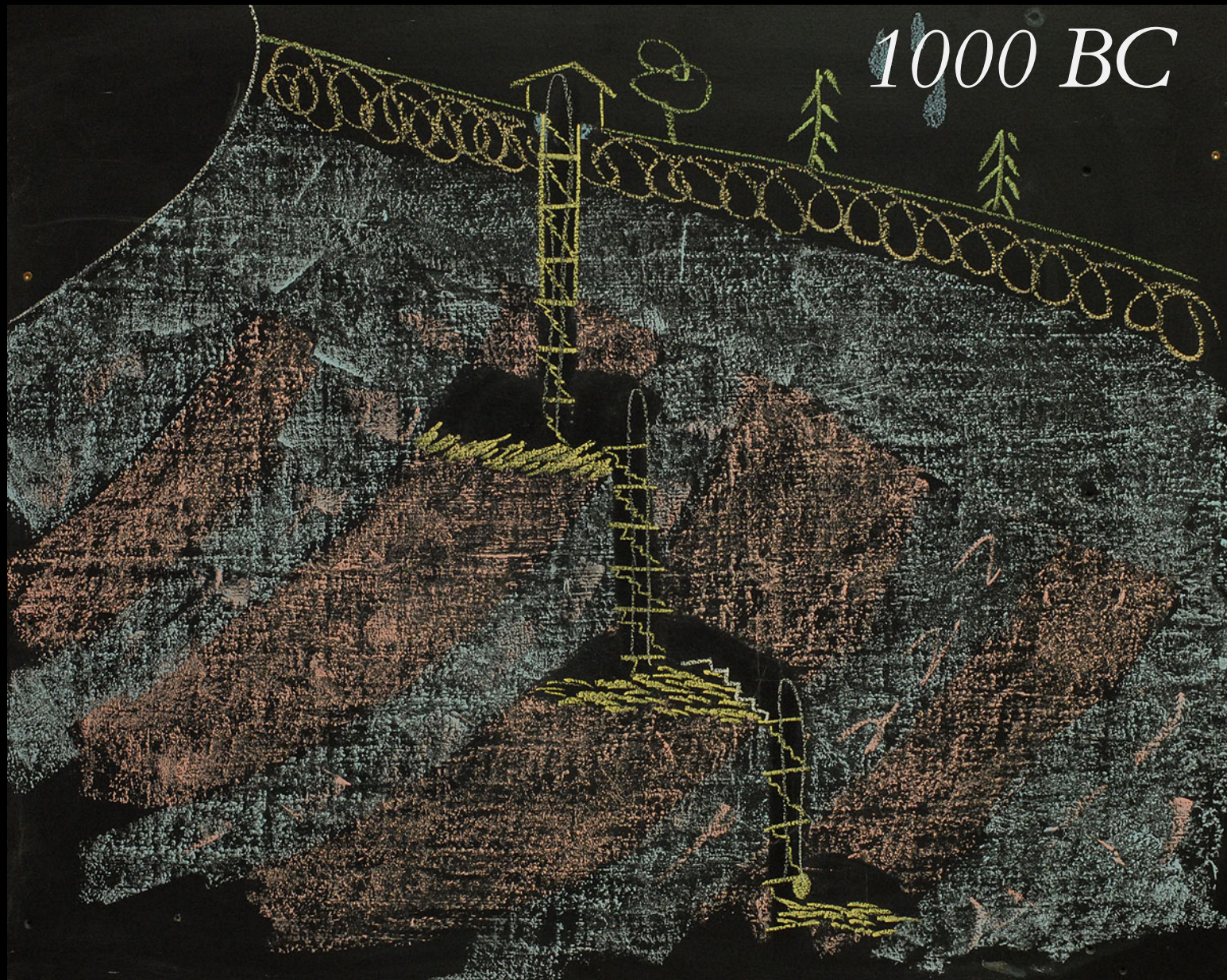


# Bronze Age Mining (1500-1000 BC)



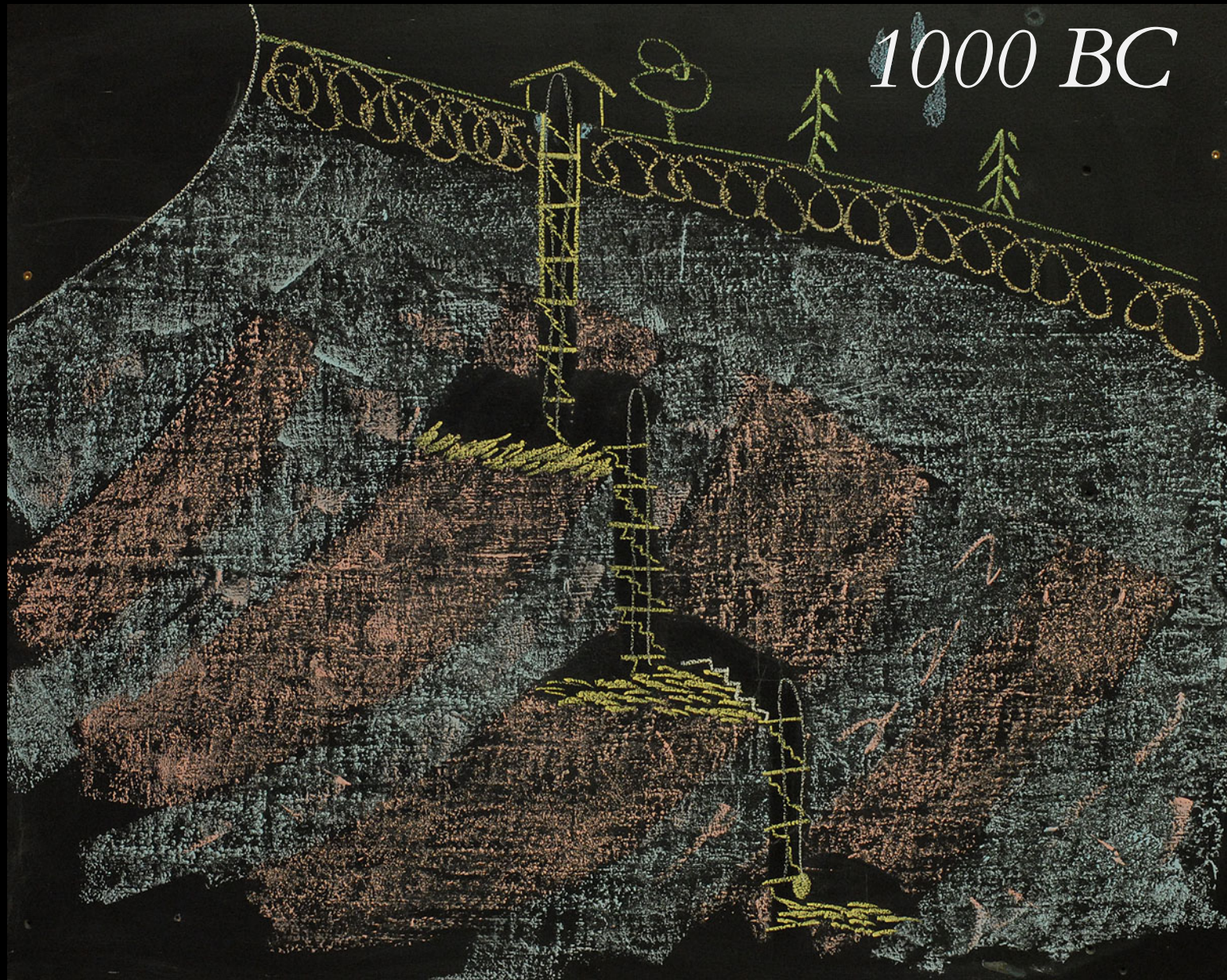


1000 BC



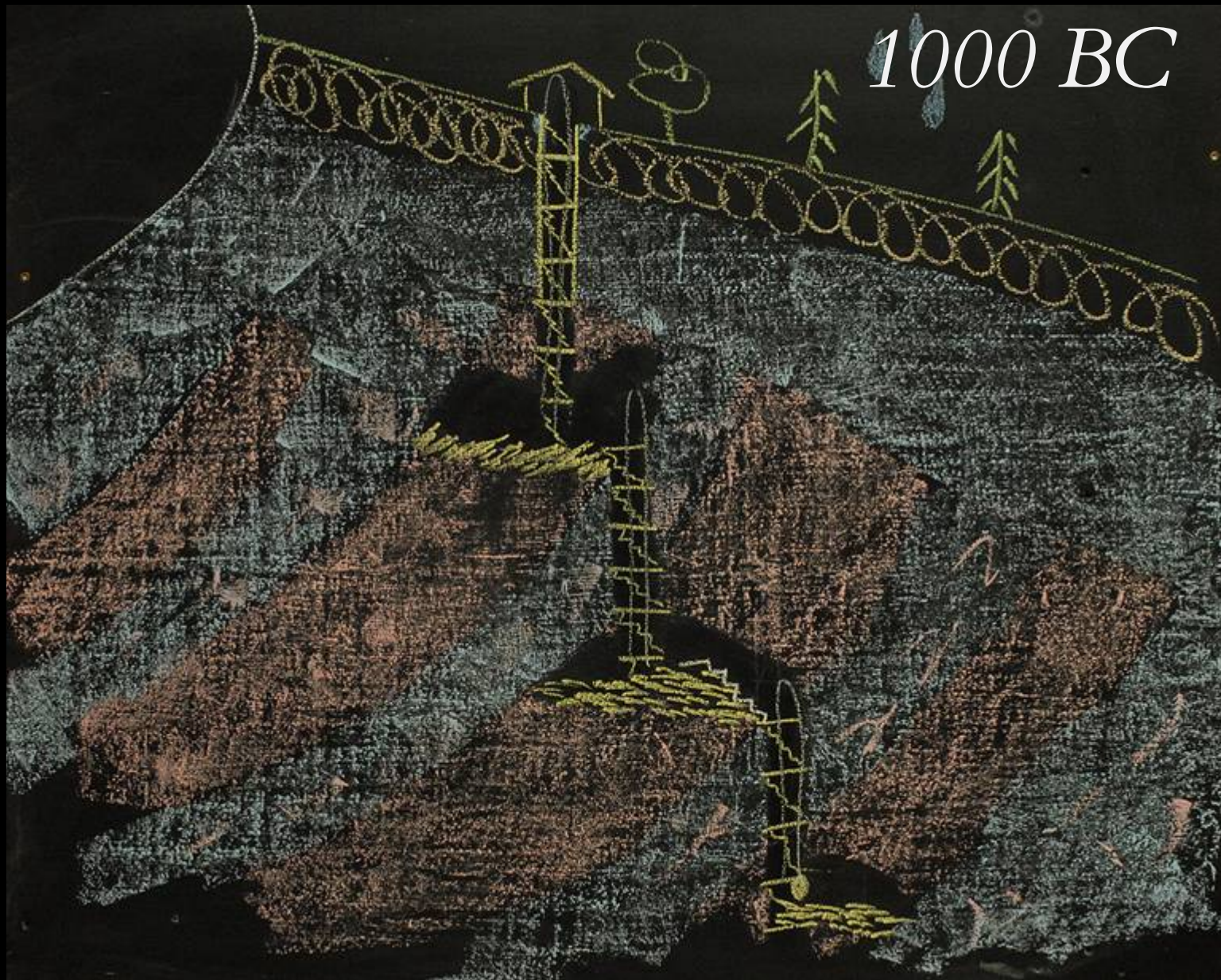


1000 BC



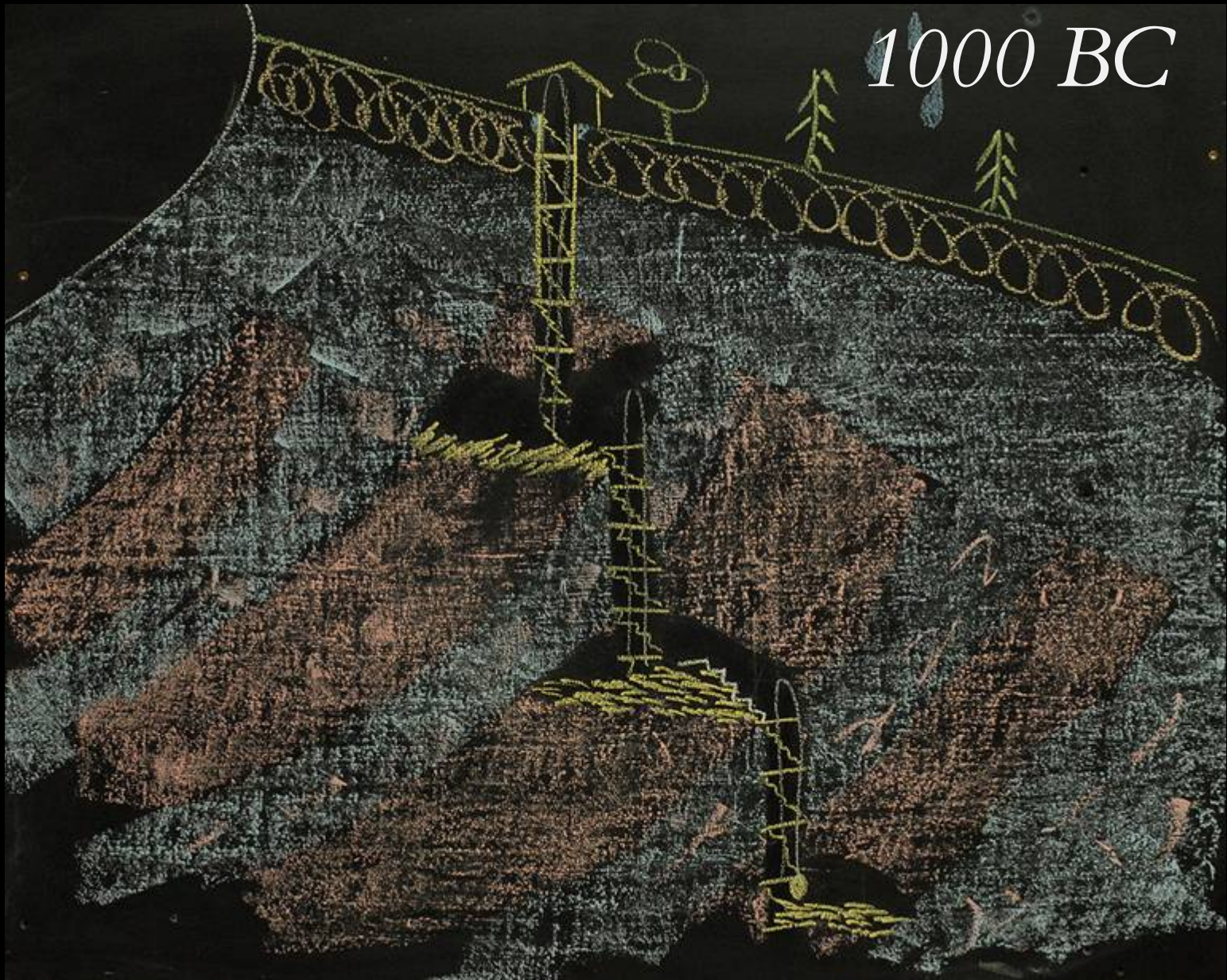


*1000 BC*



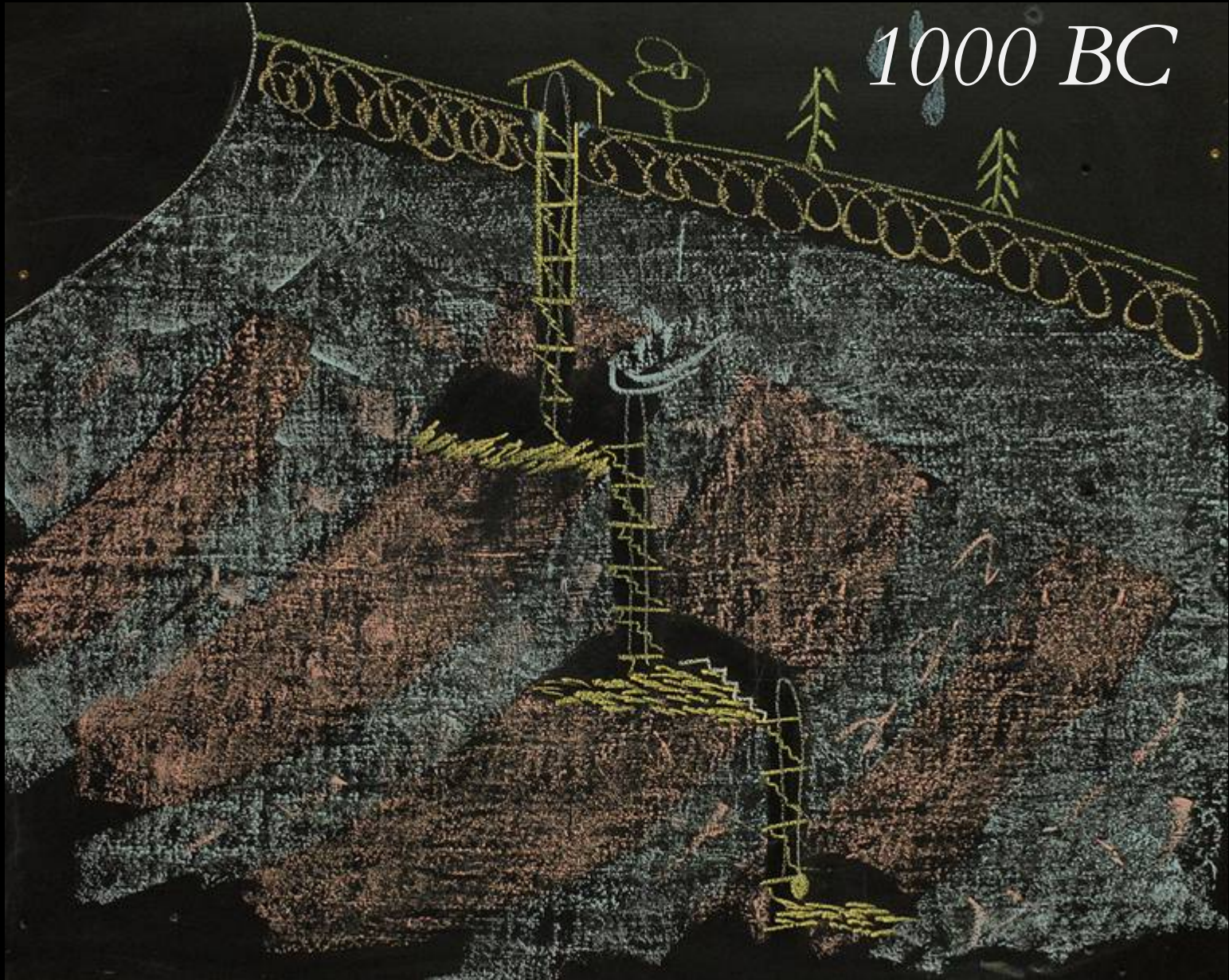


*1000 BC*



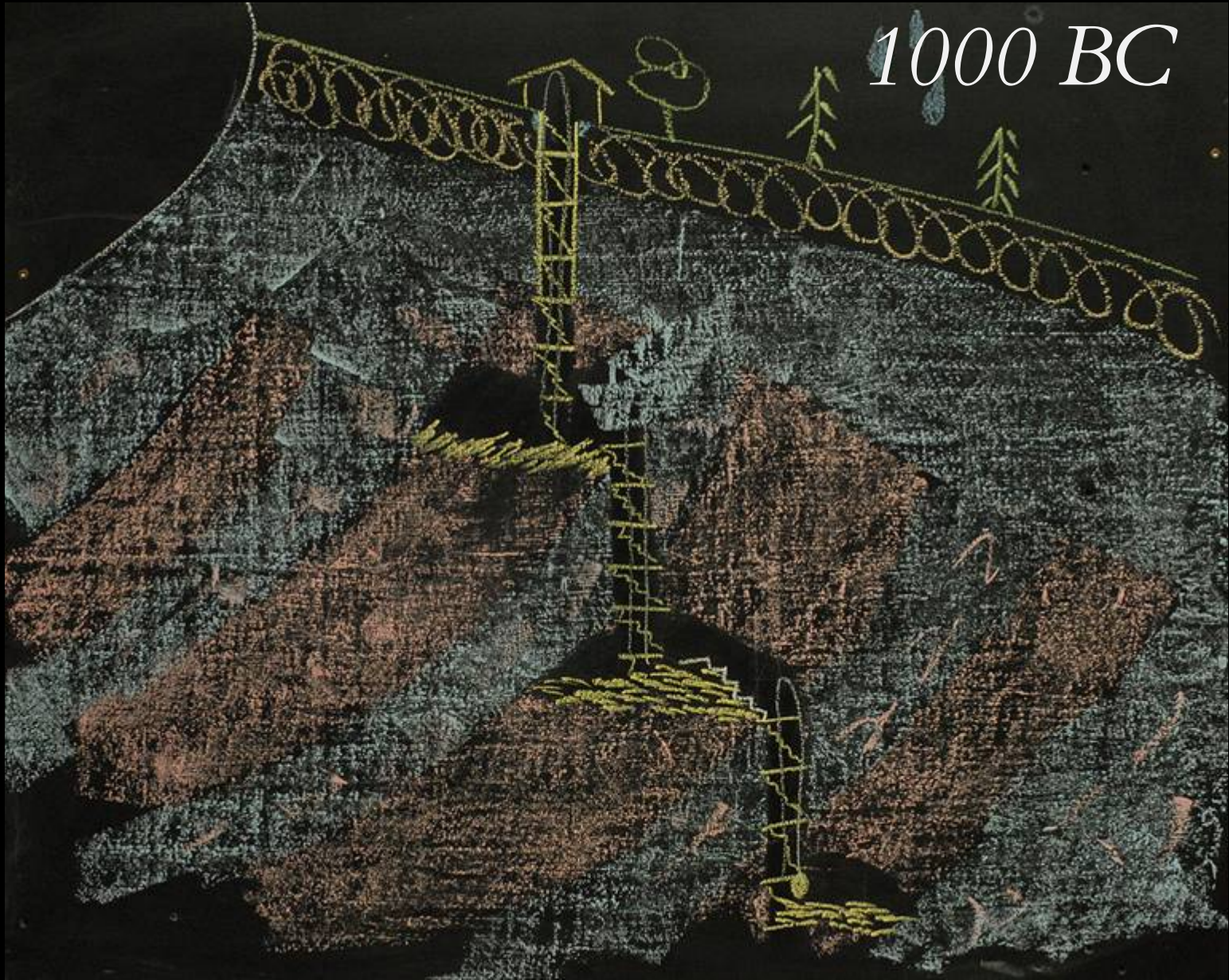


1000 BC



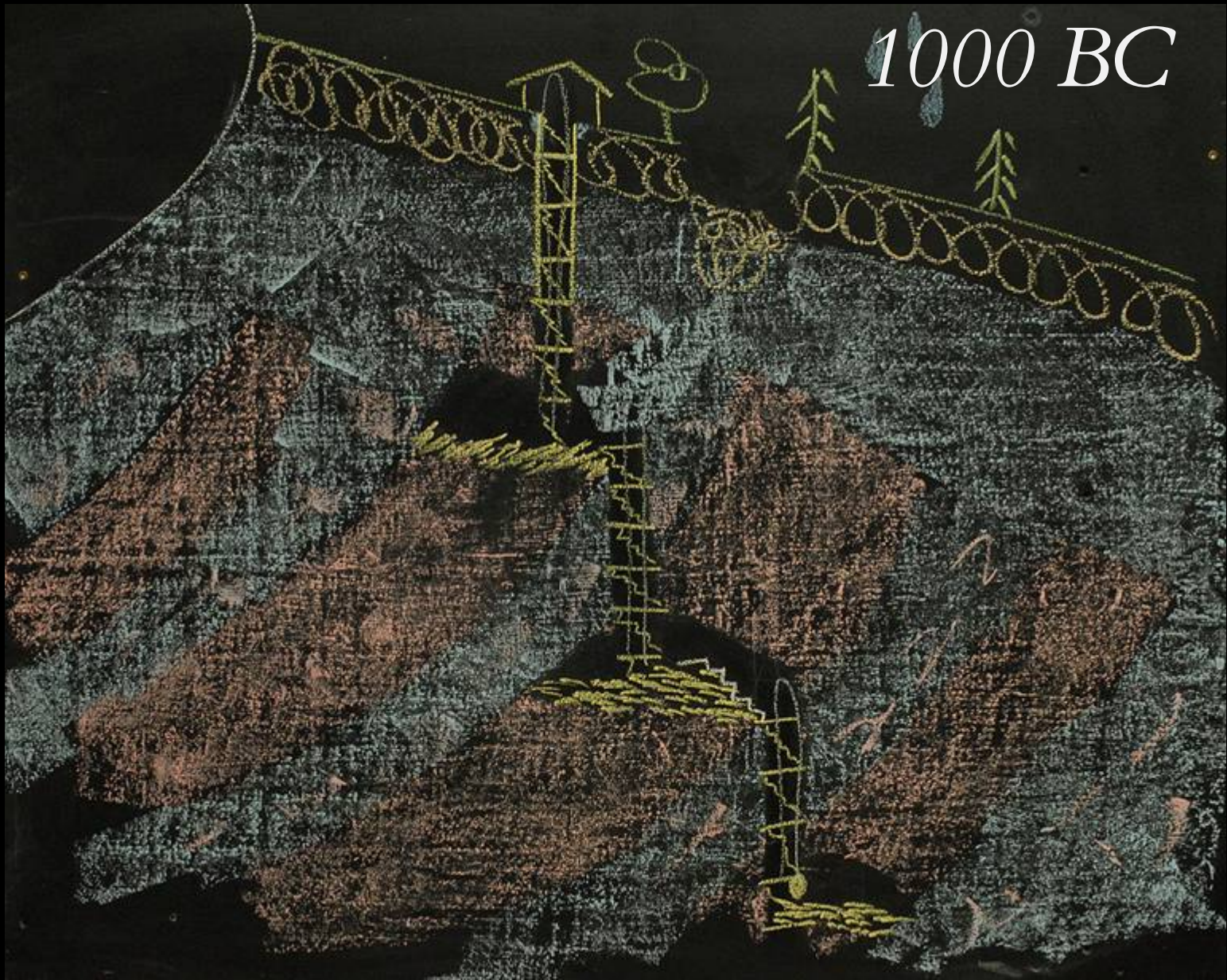


*1000 BC*



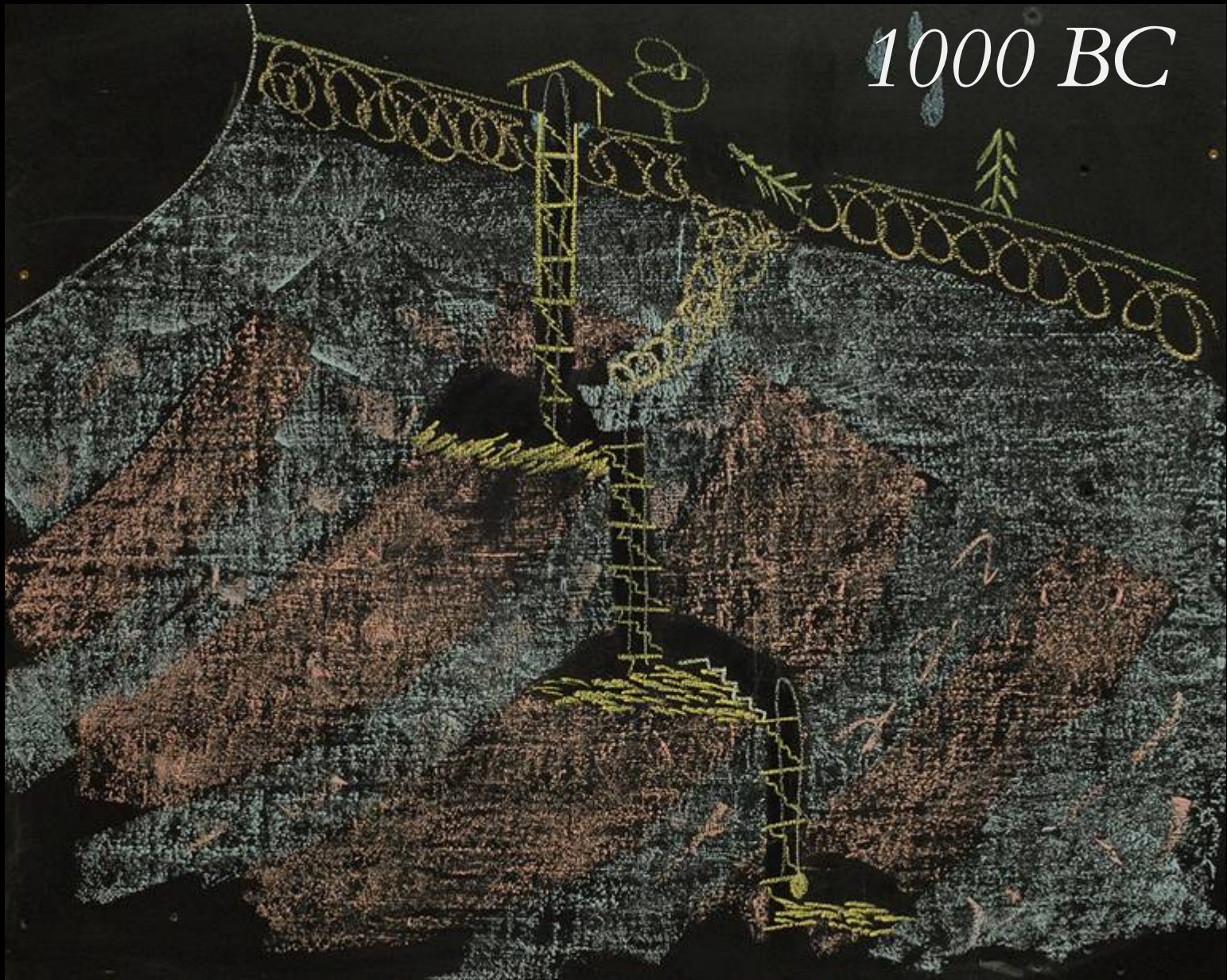


1000 BC



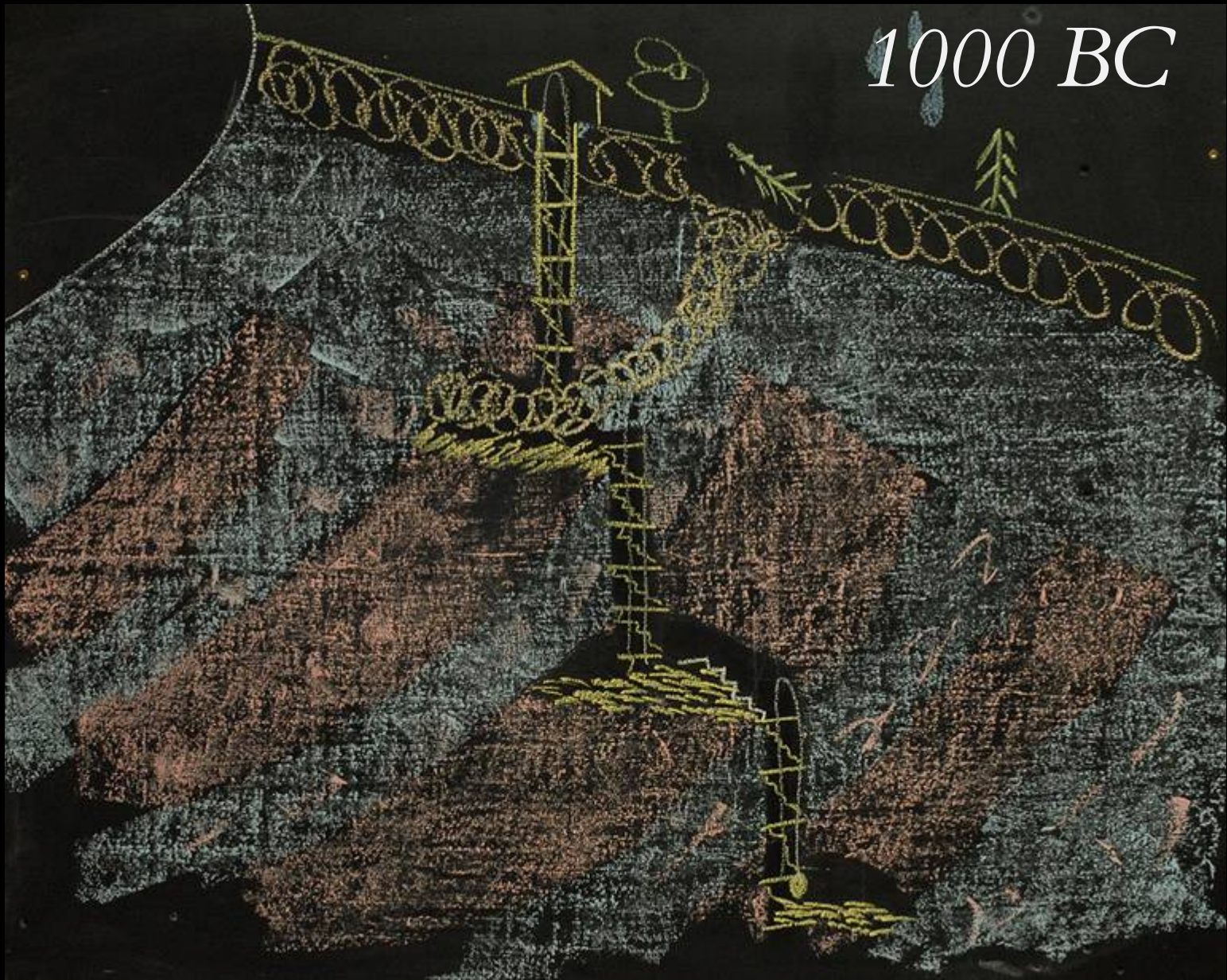


1000 BC



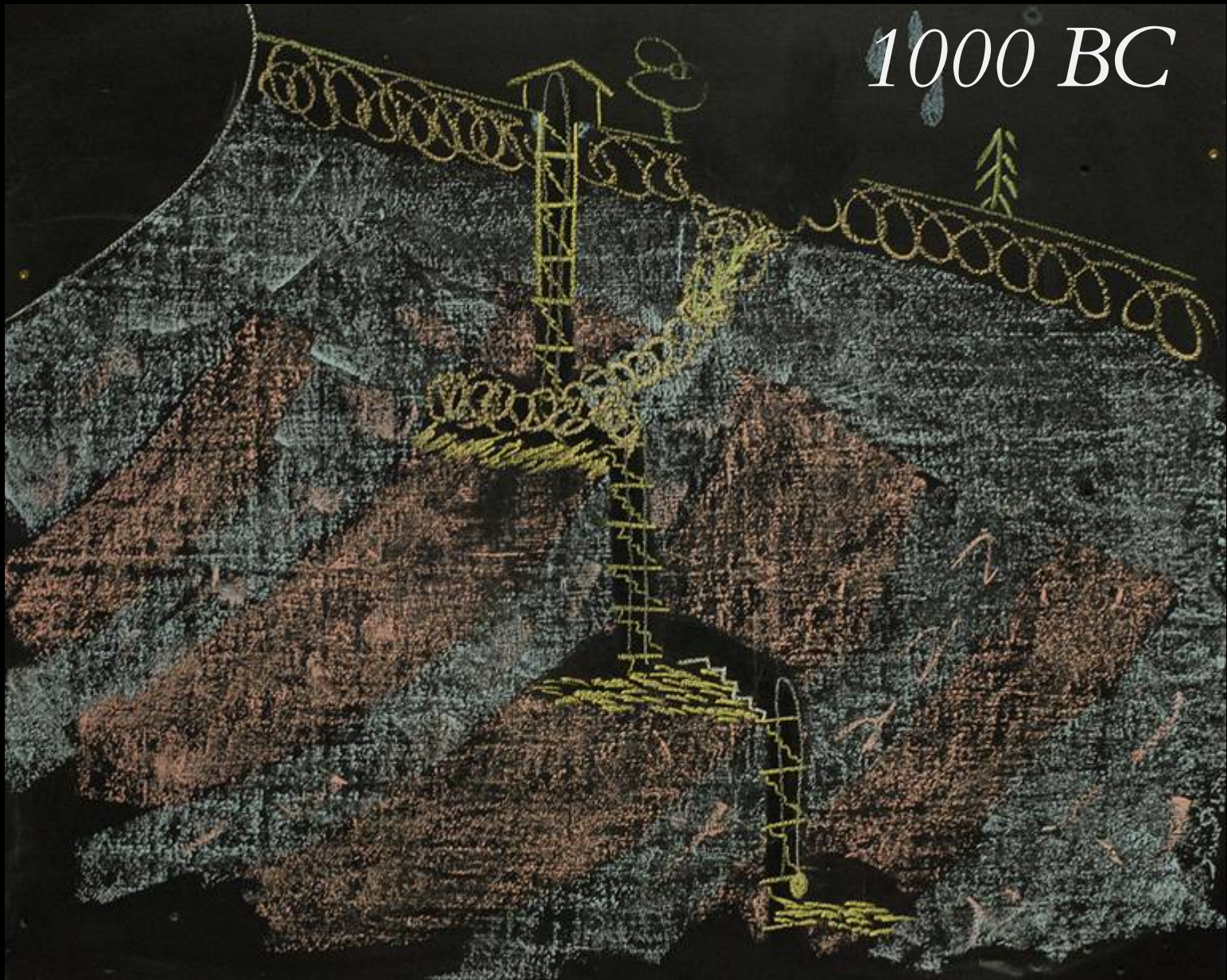


*1000 BC*



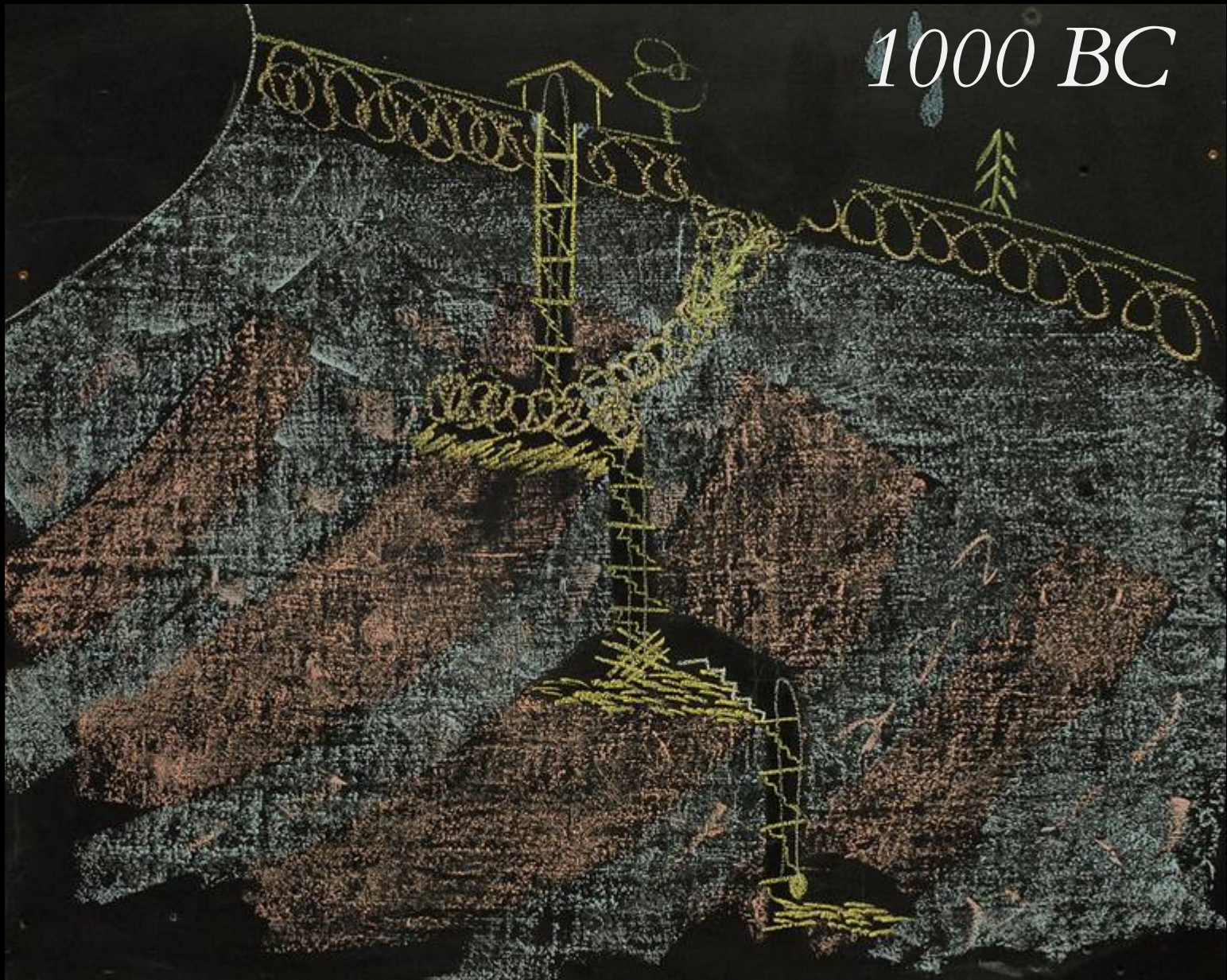


1000 BC



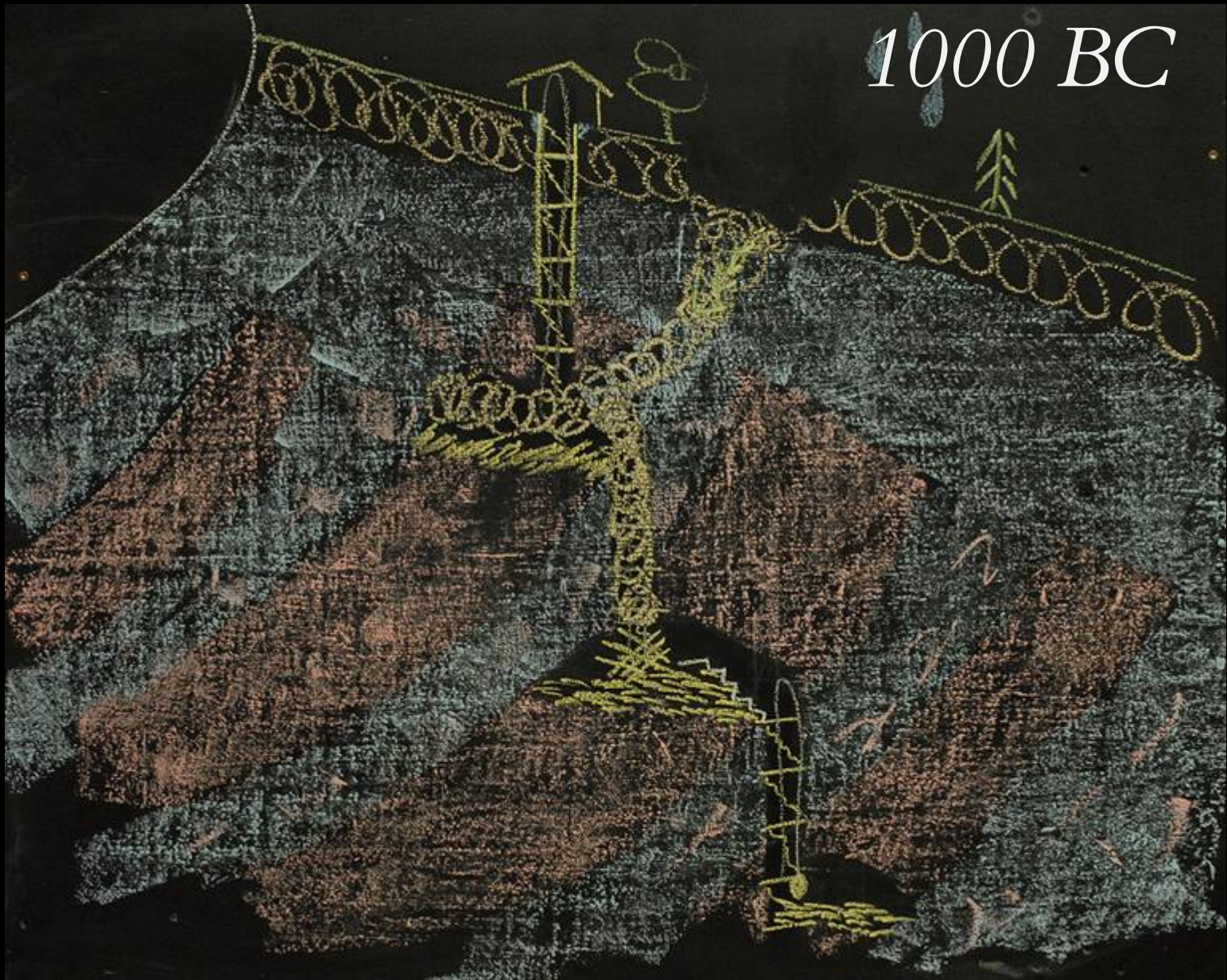


1000 BC





*1000 BC*



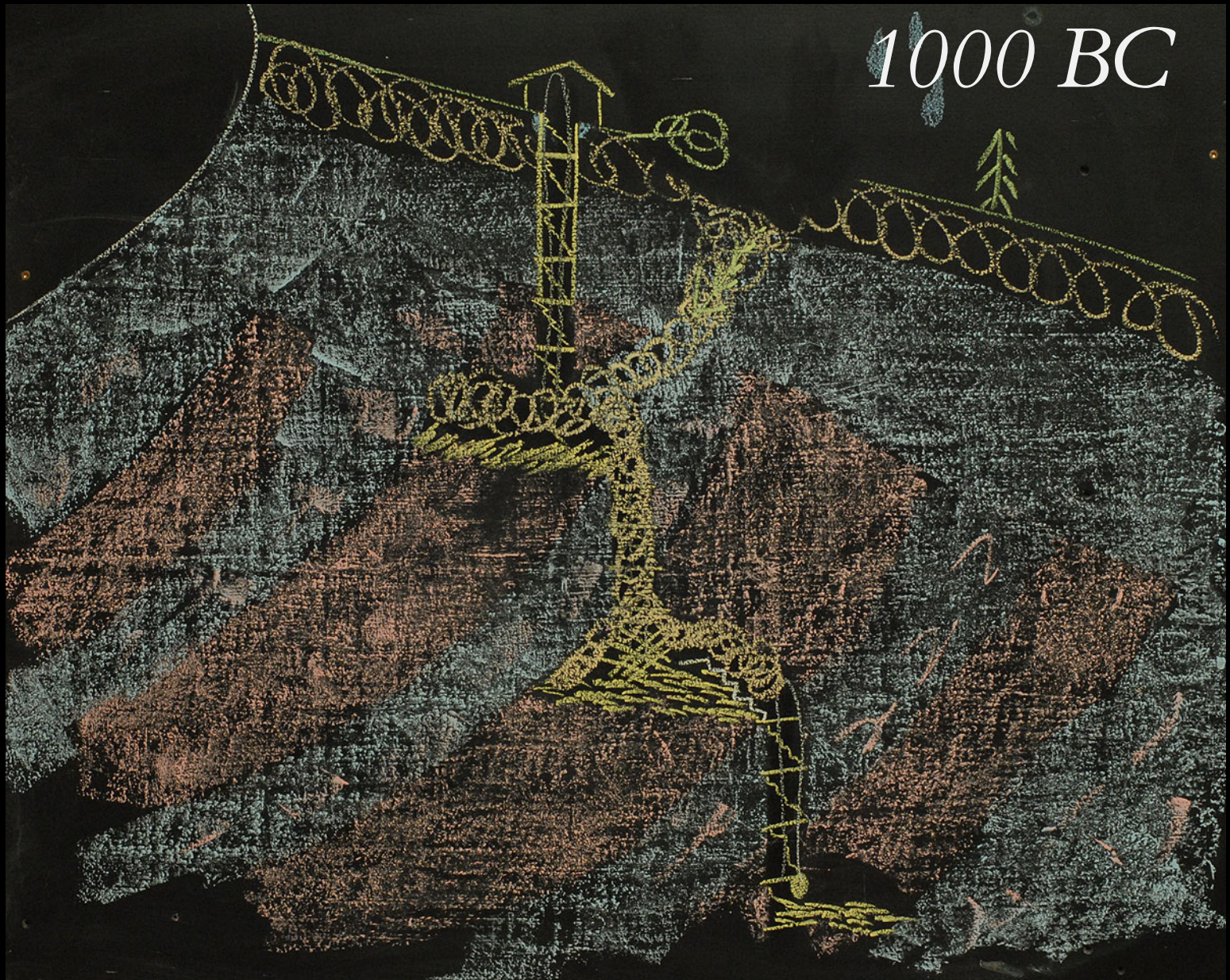


*1000 BC*



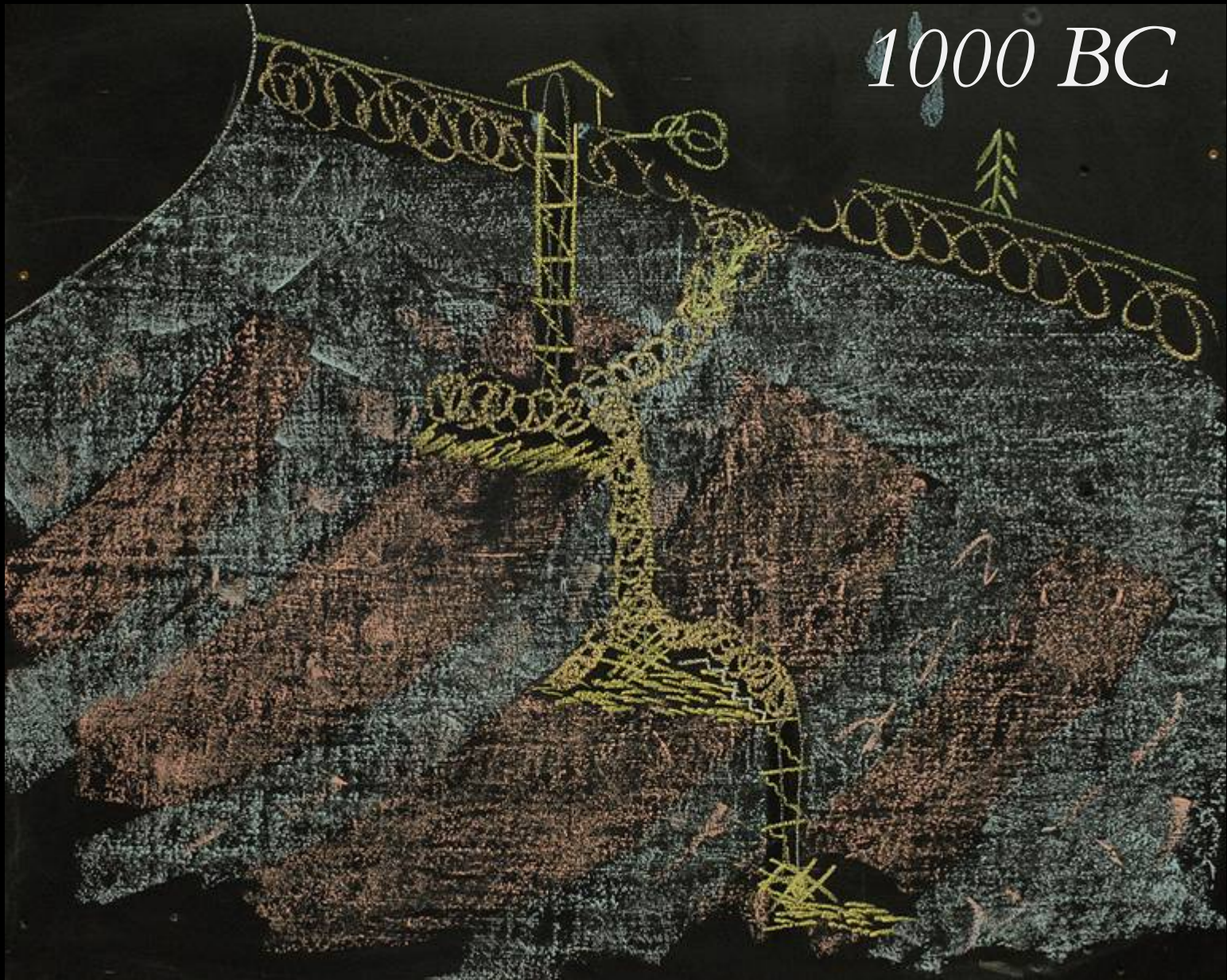


1000 BC



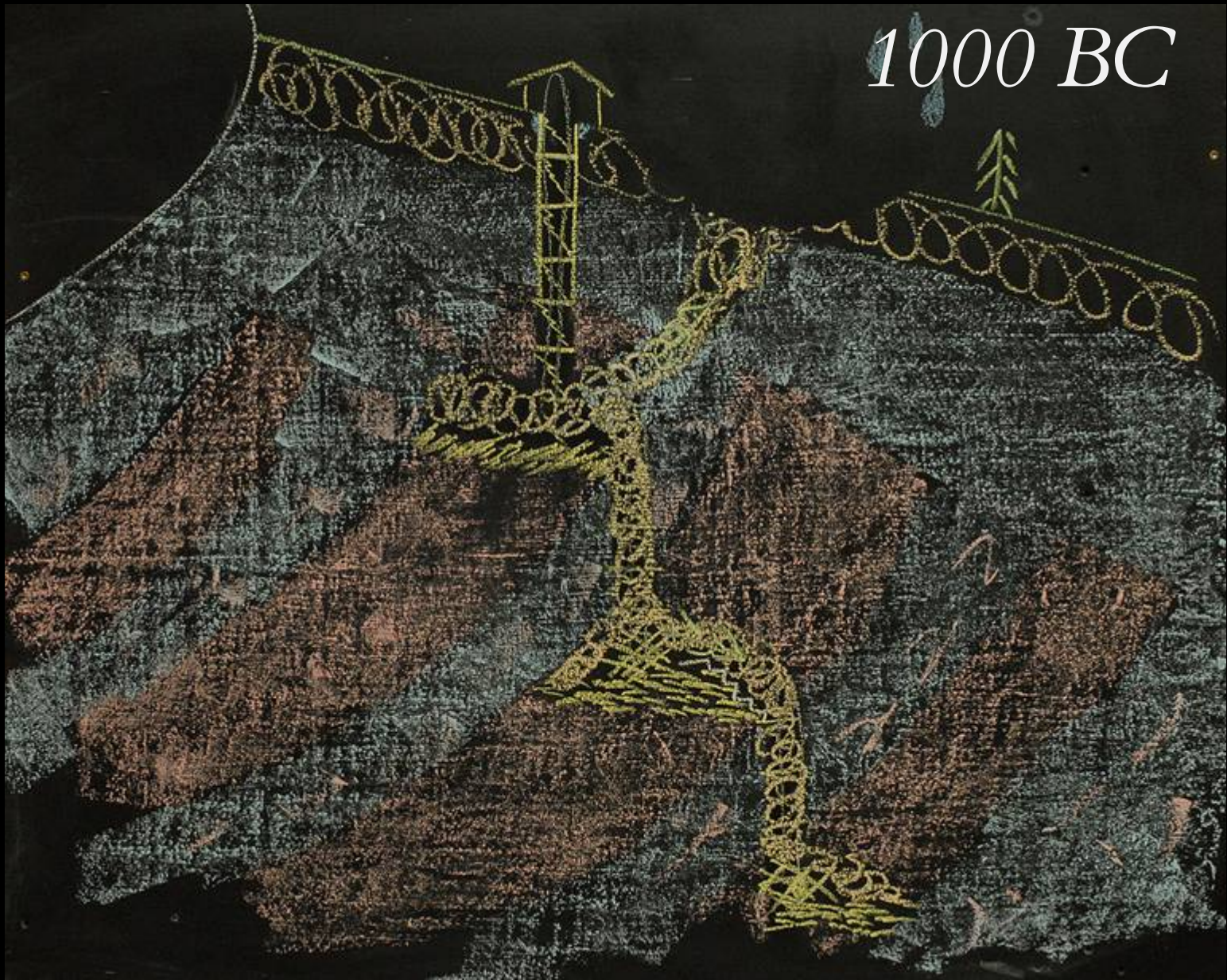


1000 BC



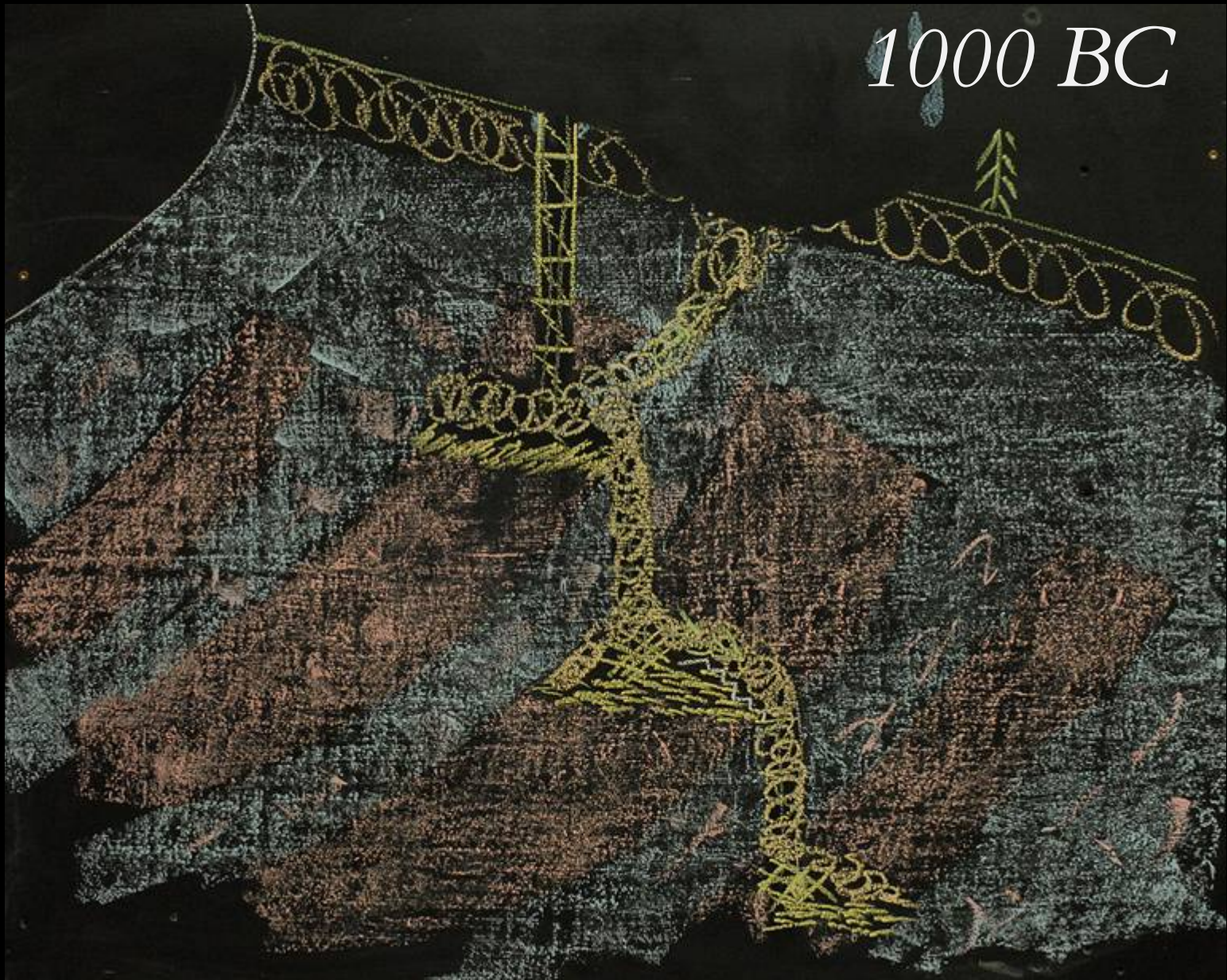


*1000 BC*



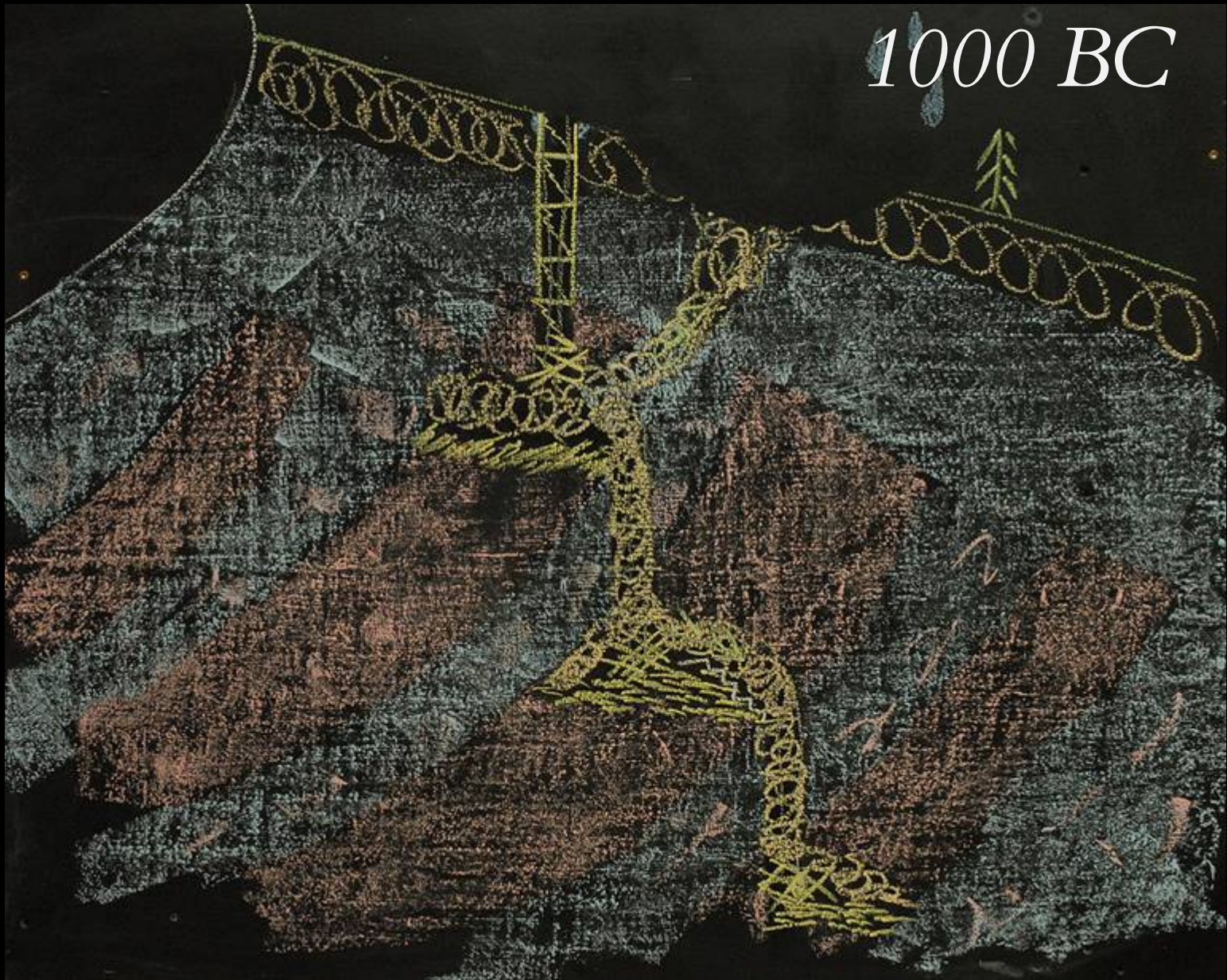


1000 BC





*1000 BC*





*1000 BC*





1000 BC





*1000 BC*





1000 BC





1000 BC





*1000 BC*





1000 BC





*1000 BC*





1000 BC





*1000 BC*





1000 BC





1000 BC

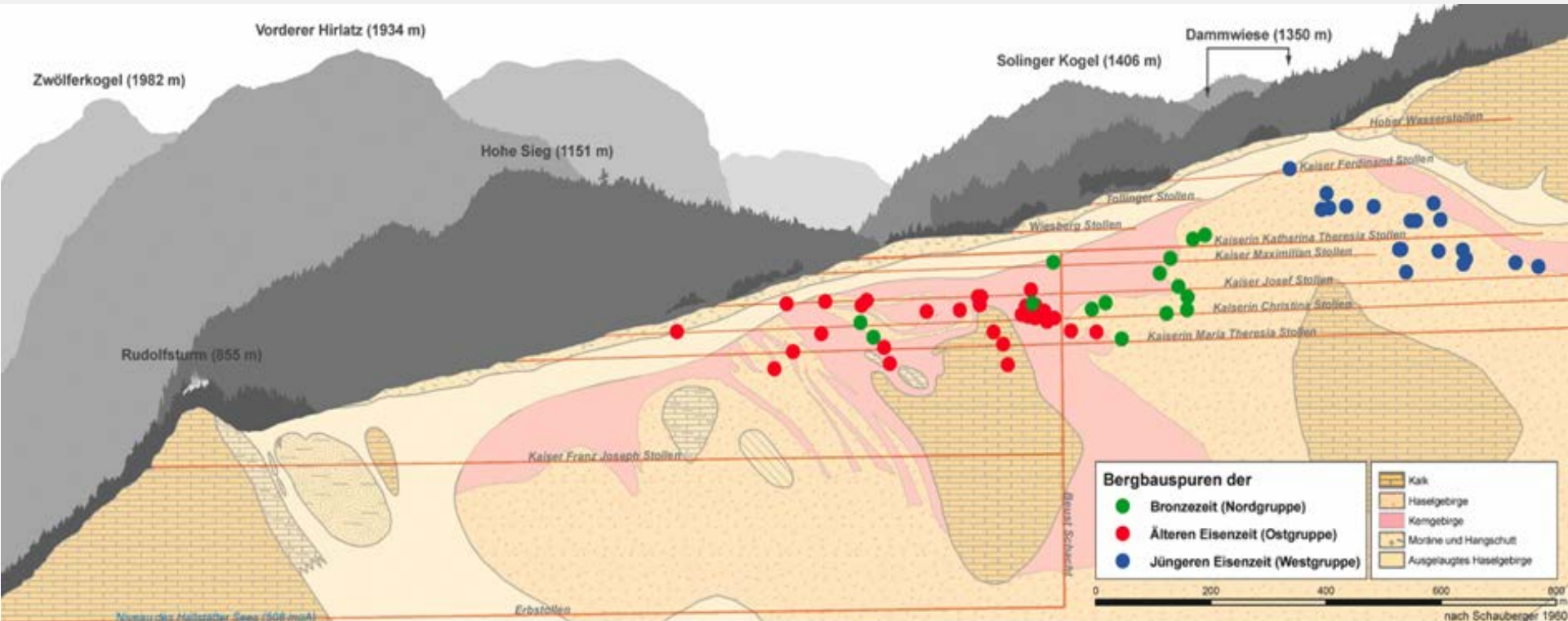








# Spots...

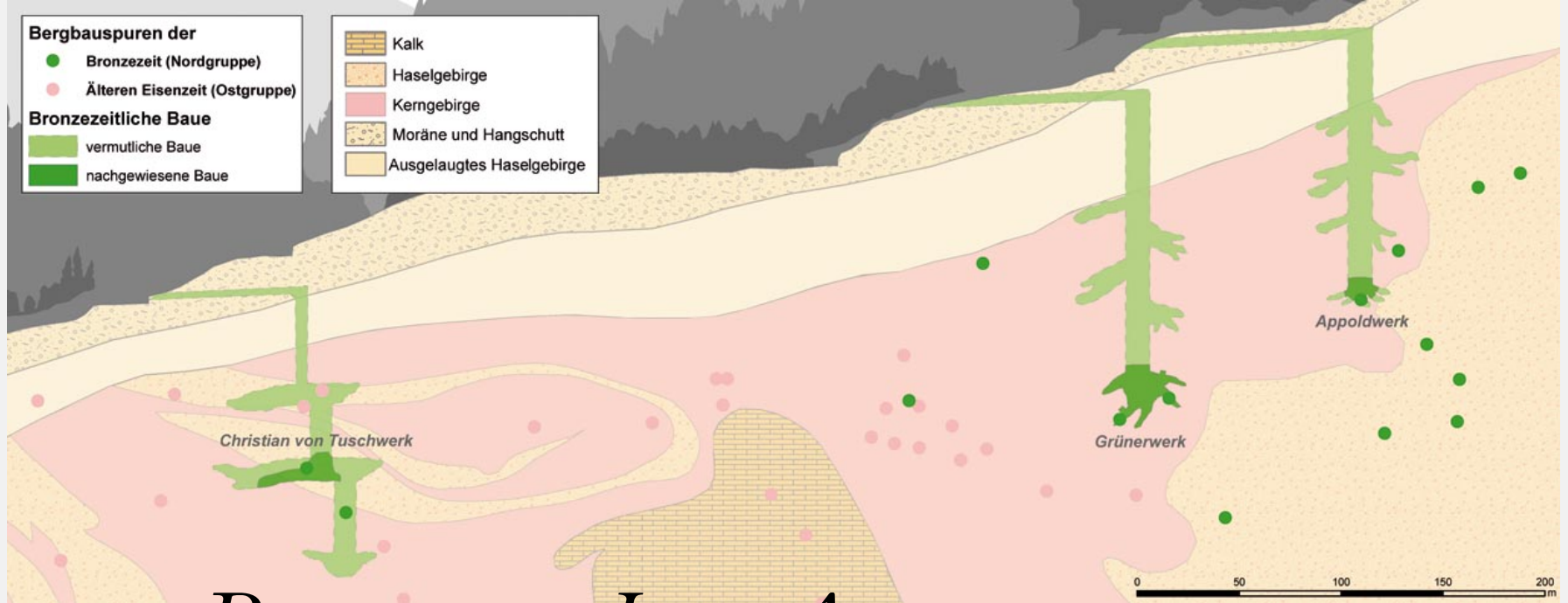




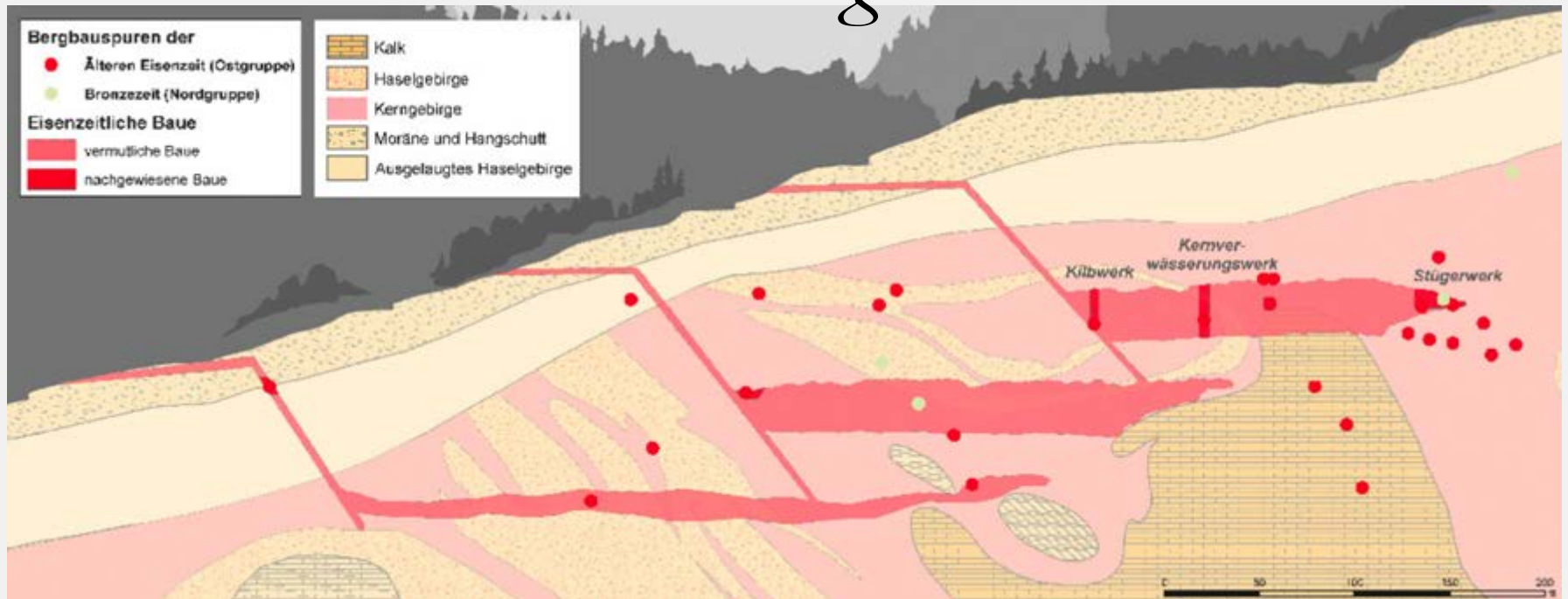
*Iron Age Mining  
(850-350 BC)*







# Bronze vs. Iron Age





# *Findings...*













































































































































































# Oldest Wooden Staircase of Europe (1108 BC)



Sparkling Science  
Wissenschaft ruft Schule  
Schule ruft Wissenschaft



naturhistorisches  
museum wien

















# *Interpretation of the Finds*

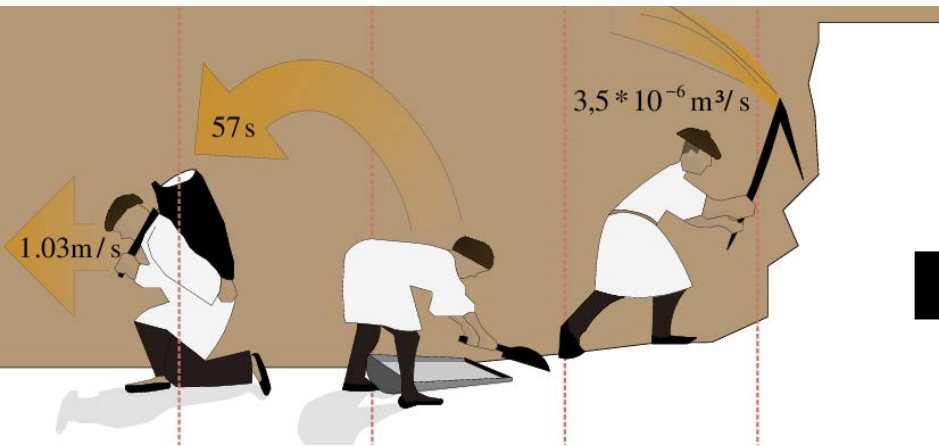


- standardization
- functionality
- specialization
- segmentation



# Simulation of Salt Mining

measured work process

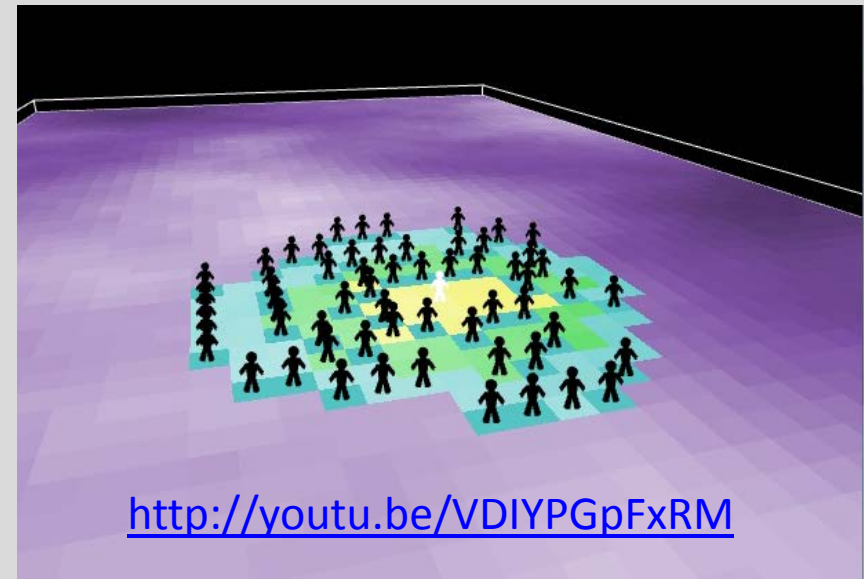


*number of years until  
full exploitation*

(e.g. 25 miners 3 layers » 13 years)

Parameters:

- *number of miners*
- *number of layers*



mining in staircase fashion, in volume of  $100\text{m} \times 40\text{m} \times 20\text{m}$  (salt distrib.  $\sim 80\%$ )



# *Previous Mental Model*





*Simulation  
Outcome*





# Updated Mental Model

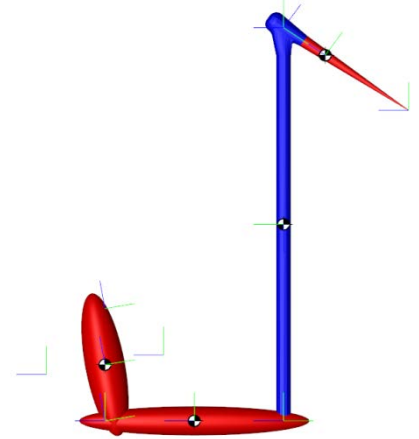




# Physics Simulation

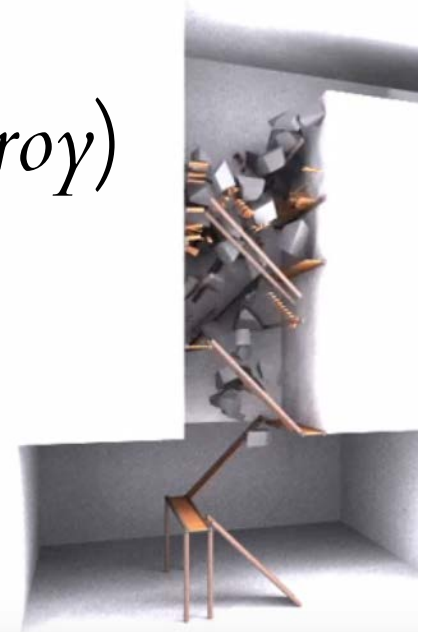
mechanics of

- tool handling,
- lifting (*roap, reflector roll, sack*)



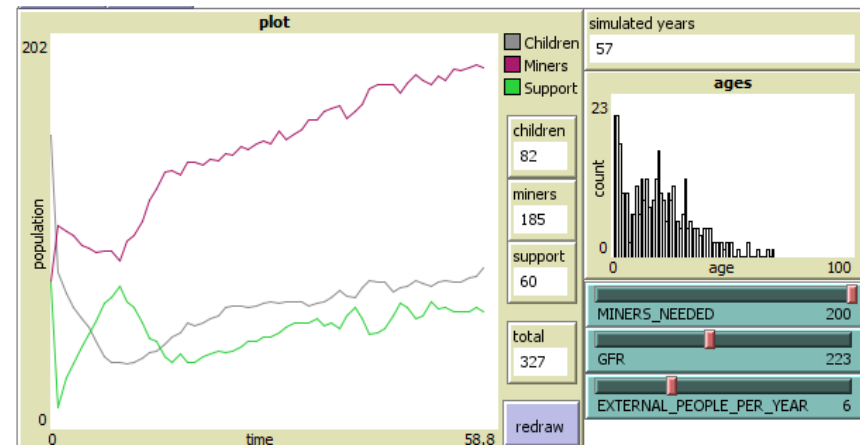
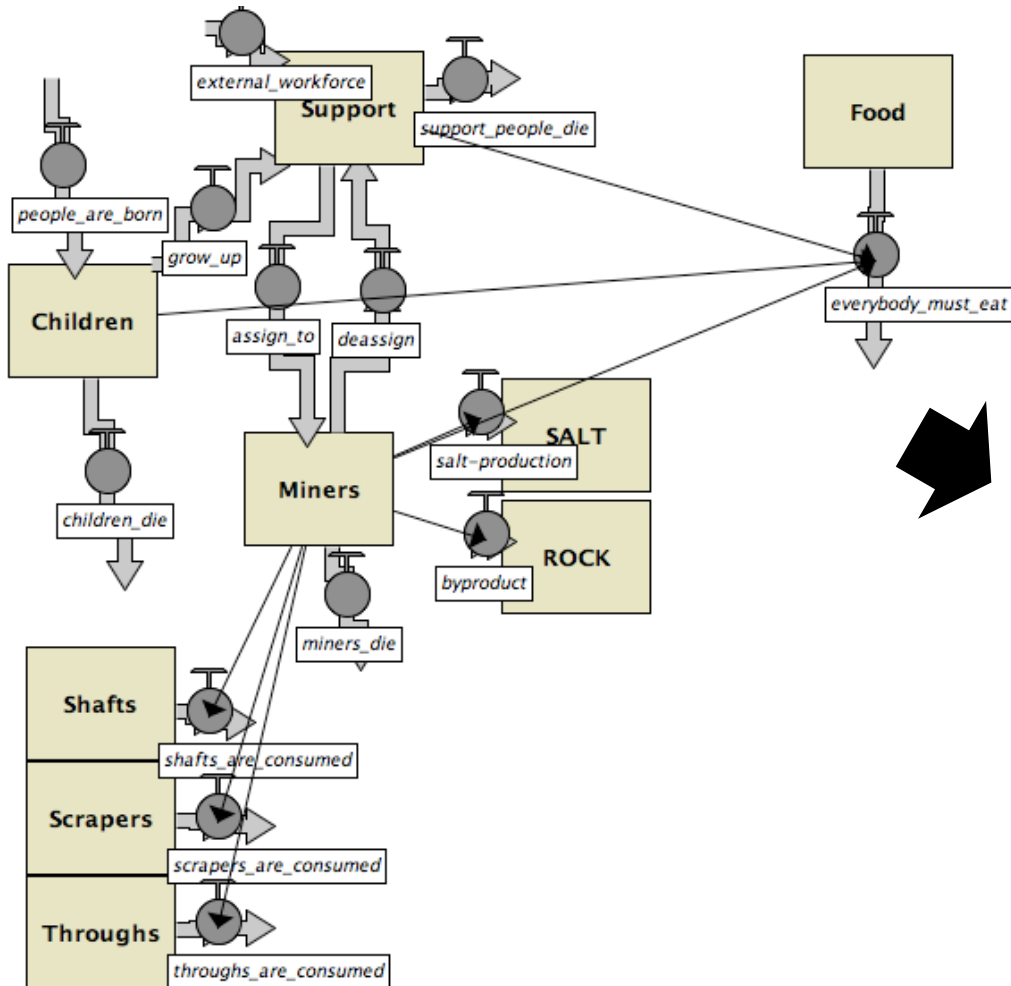
physically-driven

- stair collapse tests (*assemble & destroy*)
- landslide sim<sup>\*</sup>
- air circulation computation<sup>\*\*</sup>





# Simulated Population Dynamics



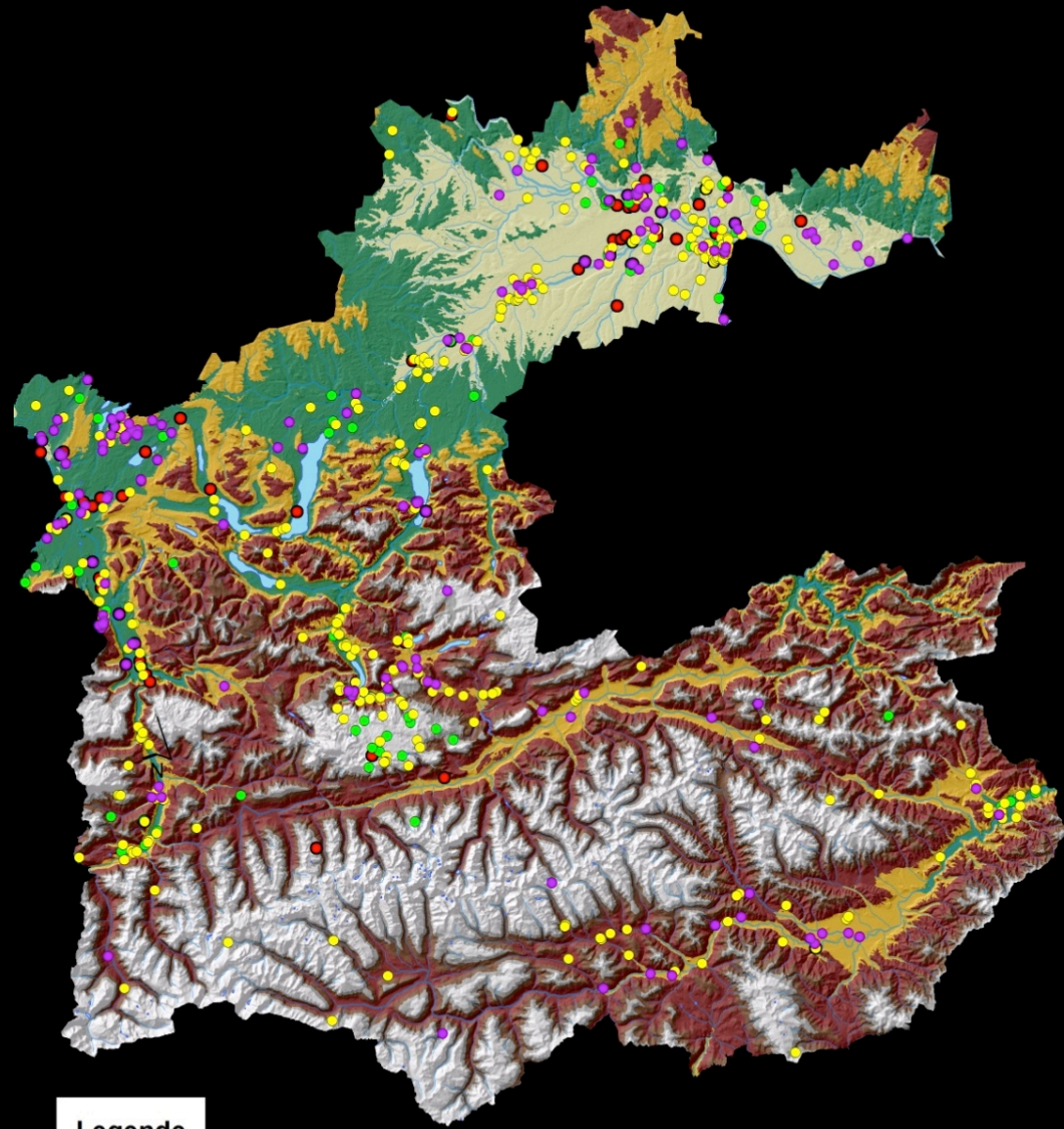
[video \(swf\)](#)

*population & workforce size*



# *Regional Implications*

- carrying capacity
- socioeconomic development
- wider political context



## Legende

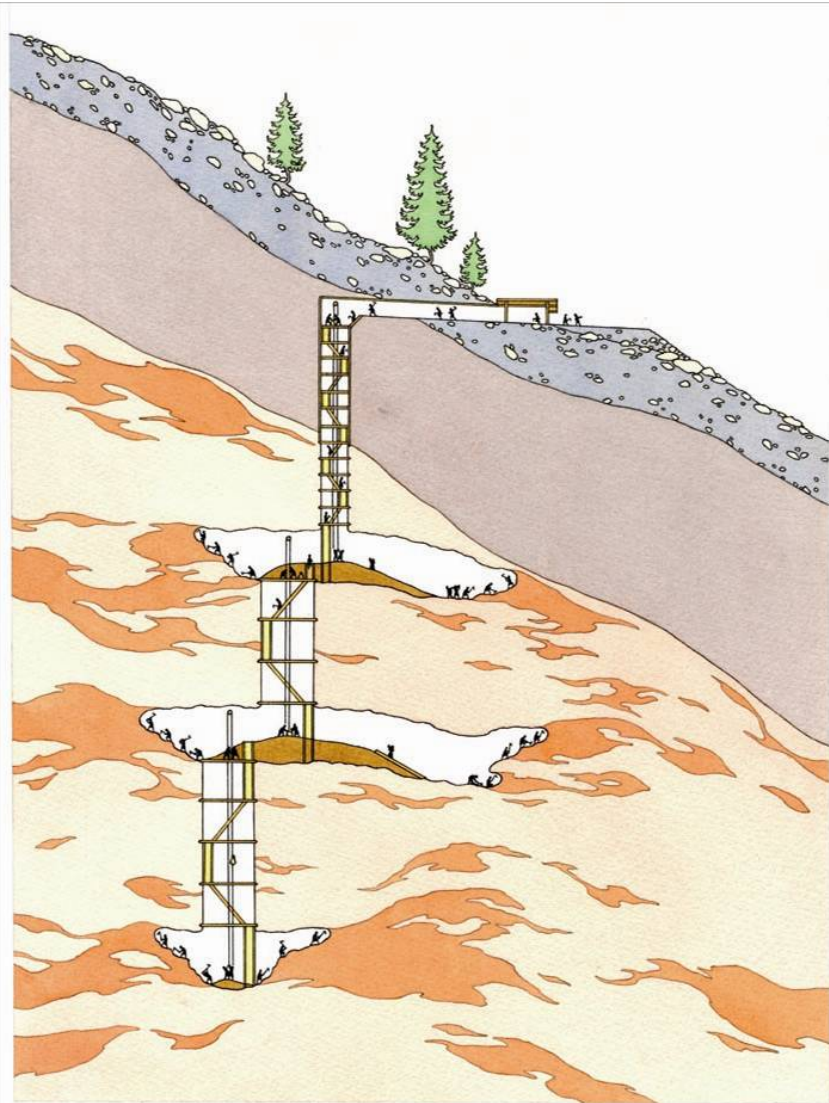
- FBZ
- MBZ
- UFZ
- HAZ



0 5 10 20 30 40 Kilometer



# Feedback Loop – Coupled Simulation



*whole mine model* using inputs from population dynamics:

- number of miners
- produced shafts, scrapers, throughs

[video \(swf\)](#)



# Physical Simulation (Experimental Archaeology)

Ritschat (stew) made of...



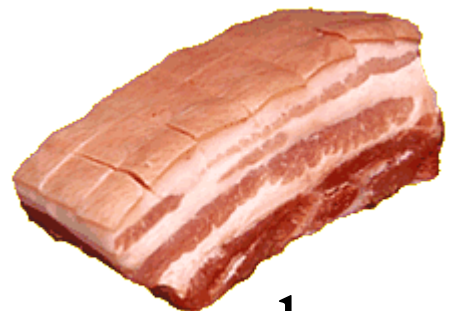
barley



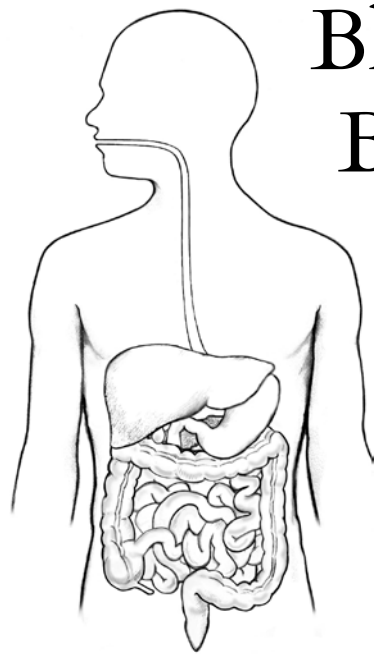
millet



broad bean



pork



Black  
Box





*A Few Other Methods:  
Reference to Archaeological Record*



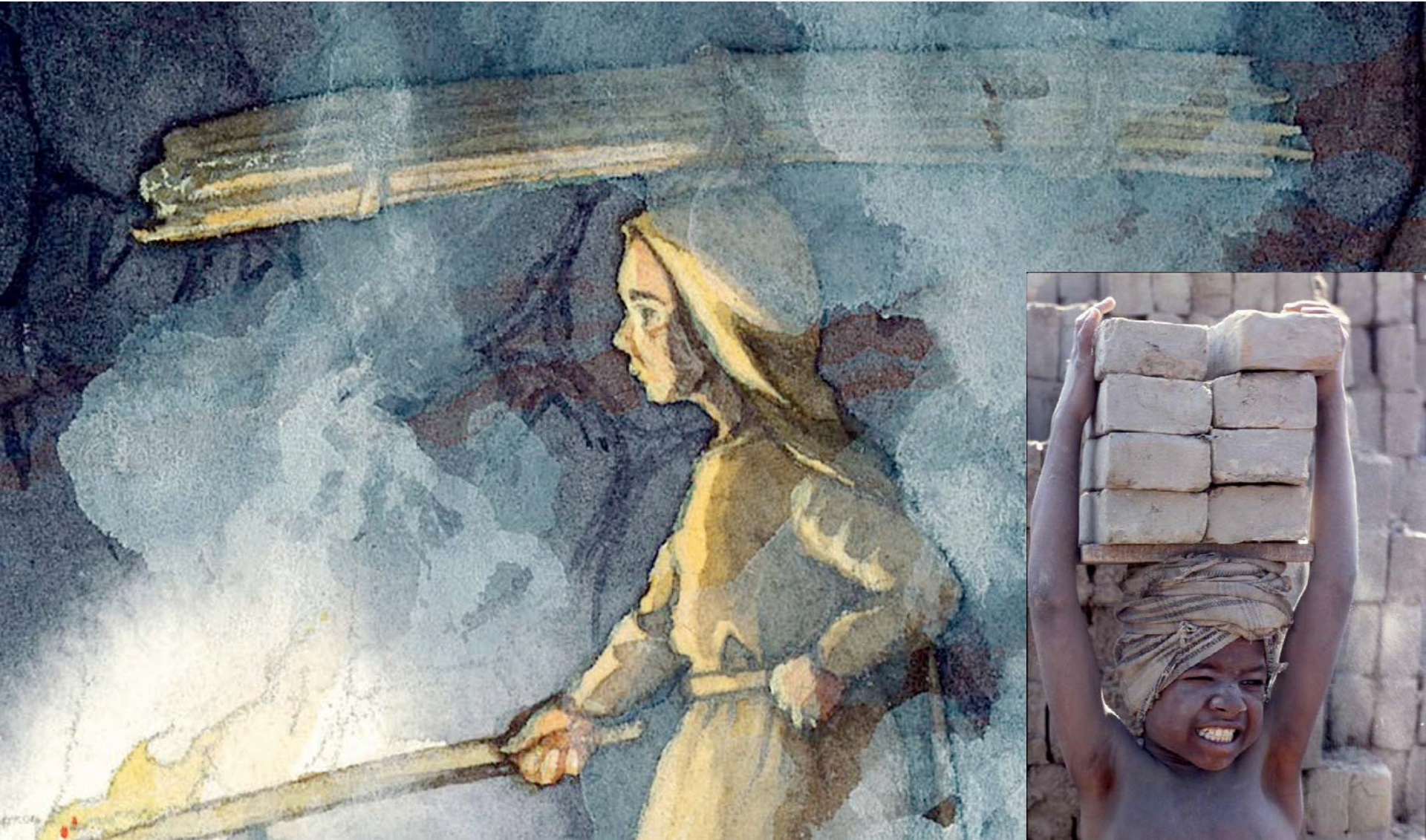


# *A Few Other Methods: Anthropology*





*A Few Other Methods:  
Ethnographic Analogies*











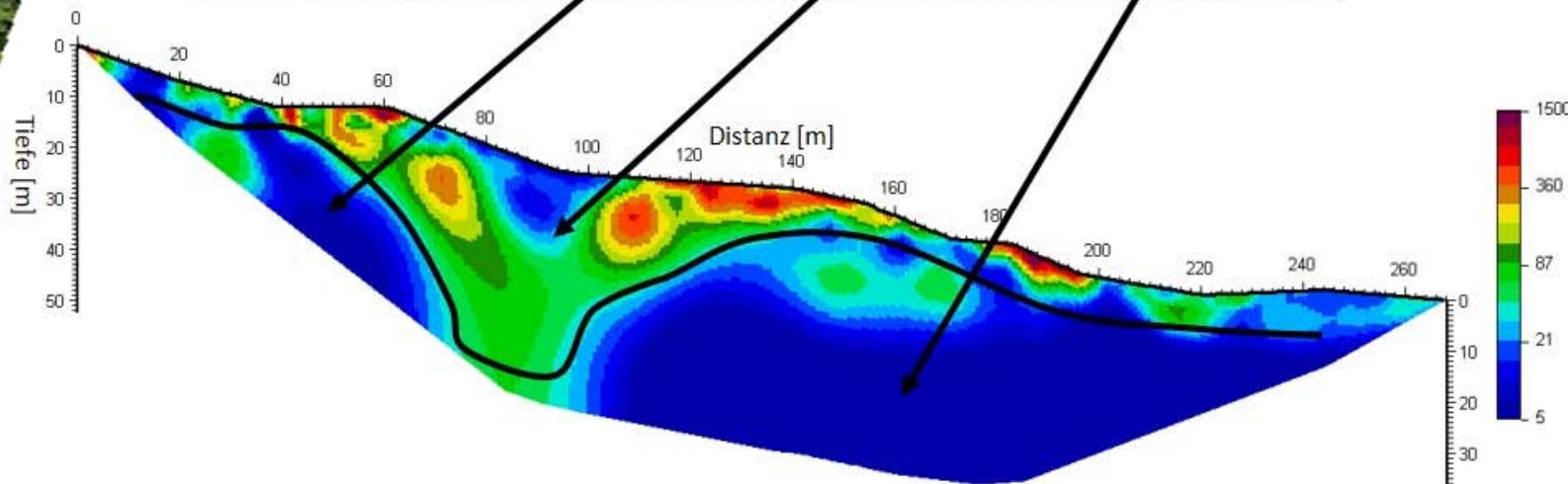
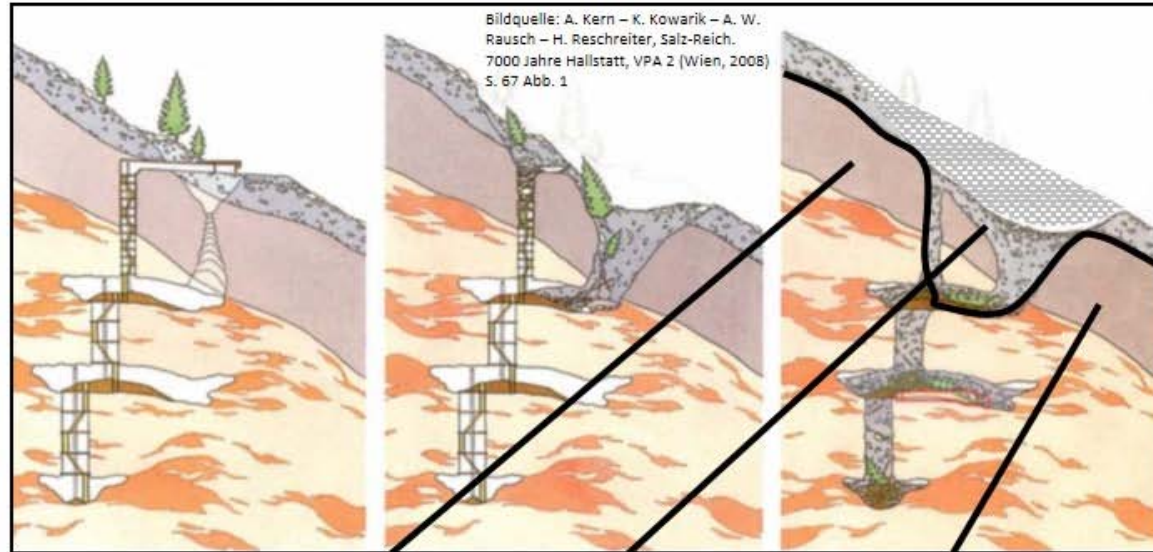
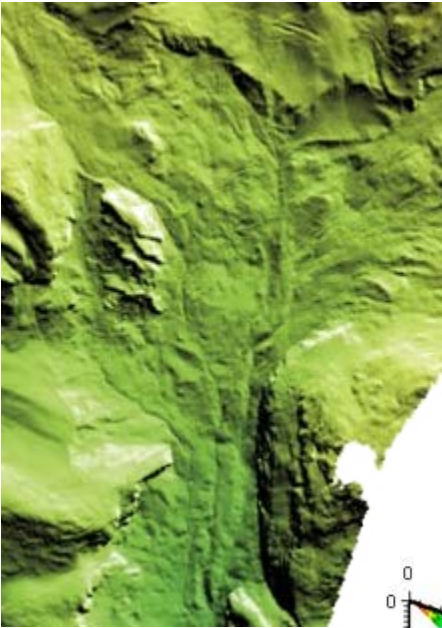


# *A Few Other Methods: Dendrochronology (& Sediment Analysis)*





# *A Few Other Methods: Remote Sensing, Geomagnetetics, Geology...*





# *Conclusions*

excellent preservation → comparison,  
reconstruction, model-building & simulation

prehistoric mining

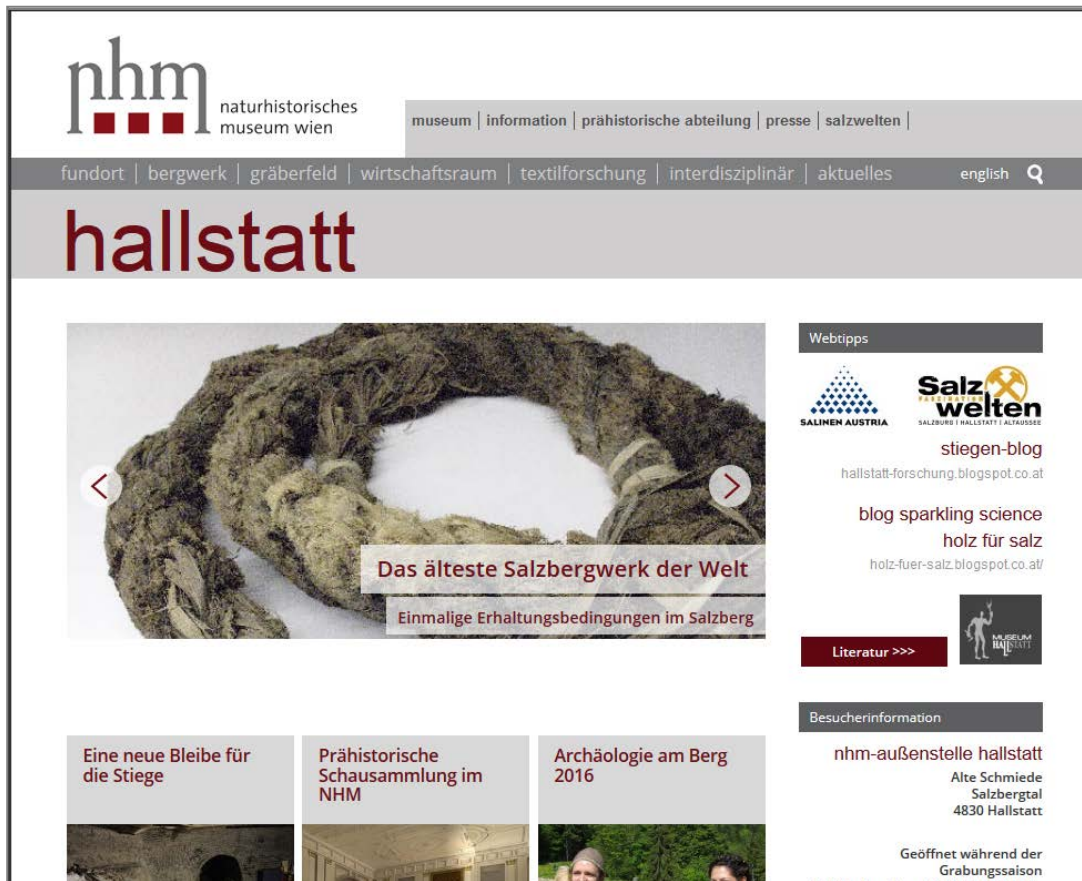


current mining





# Further Reading on Prehistoric Mining in Hallstatt

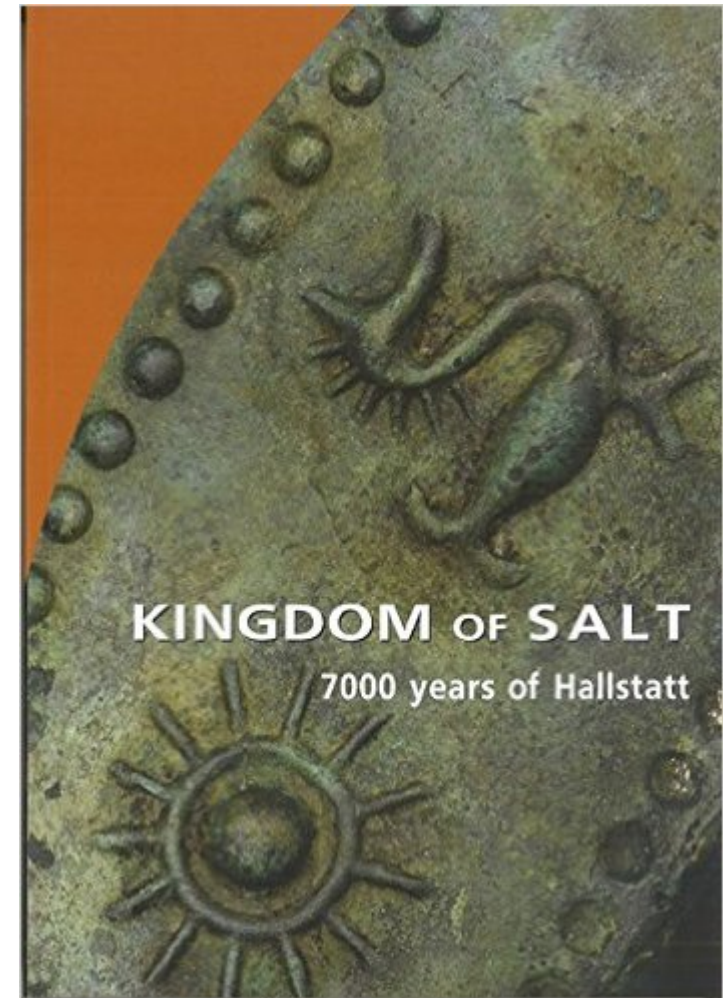


The screenshot shows the website for the Naturhistorisches Museum Wien (NHM) dedicated to Hallstatt. The header includes the NHM logo and navigation links for museum, information, prähistorische abteilung, presse, and salzwelten. Below the header is a search bar and a navigation menu with categories like fundort, bergwerk, gräberfeld, wirtschaftsraum, textilforschung, interdisziplinär, and aktuelles. The main heading is "hallstatt".

The main content area features a large image of a circular object, likely a salt ring, with the text "Das älteste Salzbergwerk der Welt" and "Einmalige Erhaltungsbedingungen im Salzberg". To the right, there are sections for "Webtipps" (websites) and "Literatur >>>" (literature). The "Webtipps" section lists "Salz welten" (Salzberg, Hallstatt & Altkopsee) with a "stiegen-blog" link and "blog sparkling science" (holz für salz) with a link. The "Literatur >>>" section features a "MUSEUM HALLSTATT" logo.

At the bottom, there are three small featured articles: "Eine neue Bleibe für die Stiege", "Prähistorische Schausammlung im NHM", and "Archäologie am Berg 2016". A "Besucherinformation" section provides details for the "nhm-außenstelle hallstatt" (Alte Schmiede, Salzbergtal, 4830 Hallstatt) and notes it is open during the "Grabungssaison".

<http://www.nhm-wien.ac.at/hallstatt>



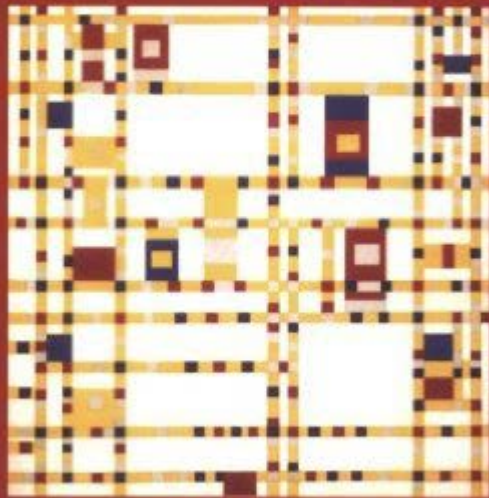


# Further Reading on Simulation in Archaeology

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## GROWING ARTIFICIAL SOCIETIES

SOCIAL SCIENCE FROM THE BOTTOM UP

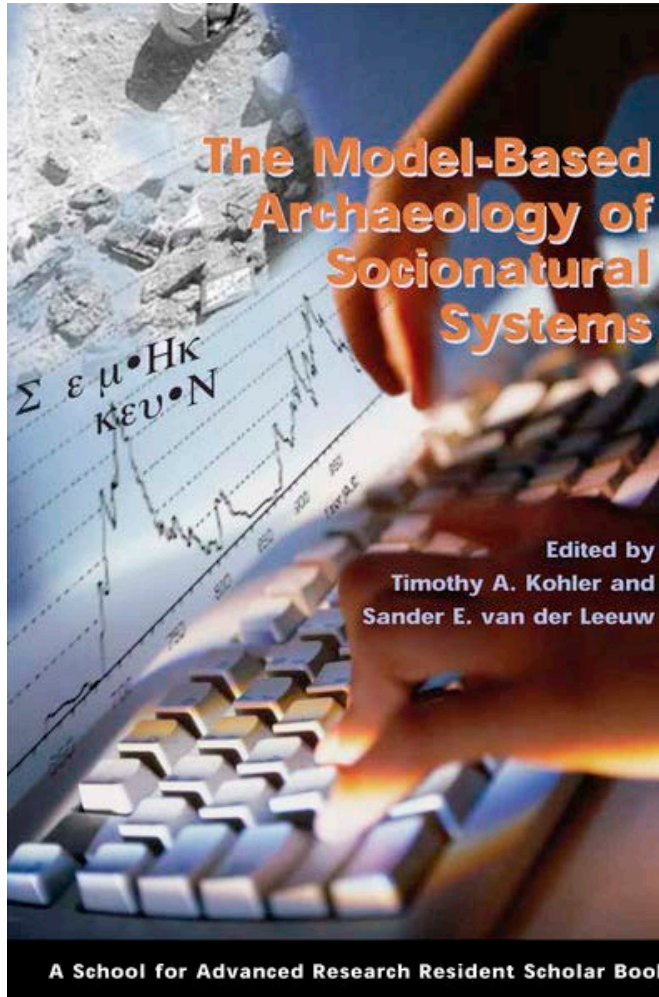


JOSHUA M. EPSTEIN  
ROBERT AXTELL

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## The Model-Based Archaeology of Socionatural Systems


Edited by  
Timothy A. Kohler and  
Sander E. van der Leeuw



Advances in Geographic Information Science

Gabriel Wurzer  
Kerstin Kowarik  
Hans Reschreiter *Editors*

## Agent-based Modeling and Simulation in Archaeology

 Springer



*Further Sites to Visit:  
Natural History Museum Vienna*





*Hallstatt:  
UNESCO World Heritage*



Museum Hallstatt



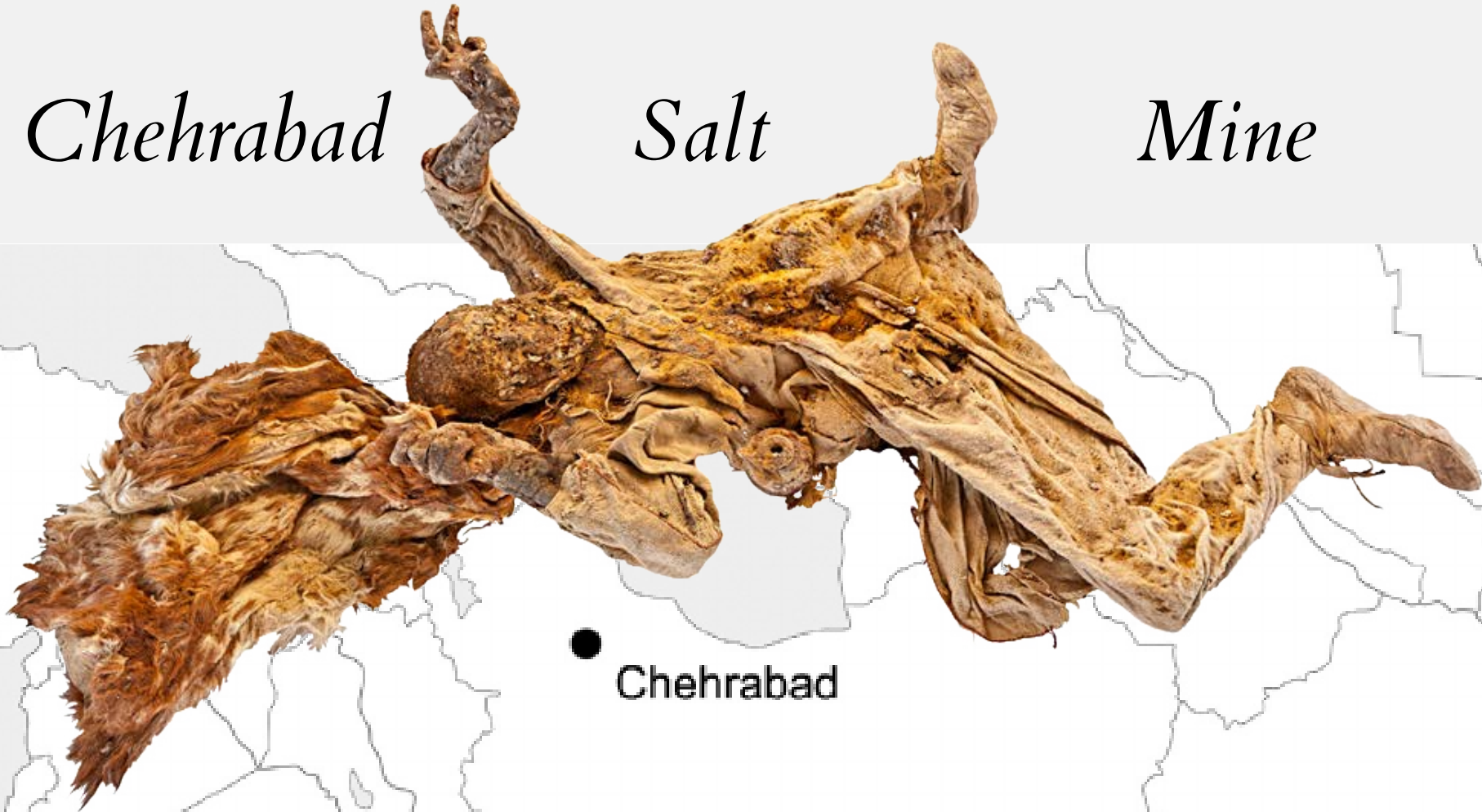
Salzwelten Mine Tour  
(Hallstatt & Hallein)



*Chehrabad*

*Salt*

*Mine*



Chehrabad

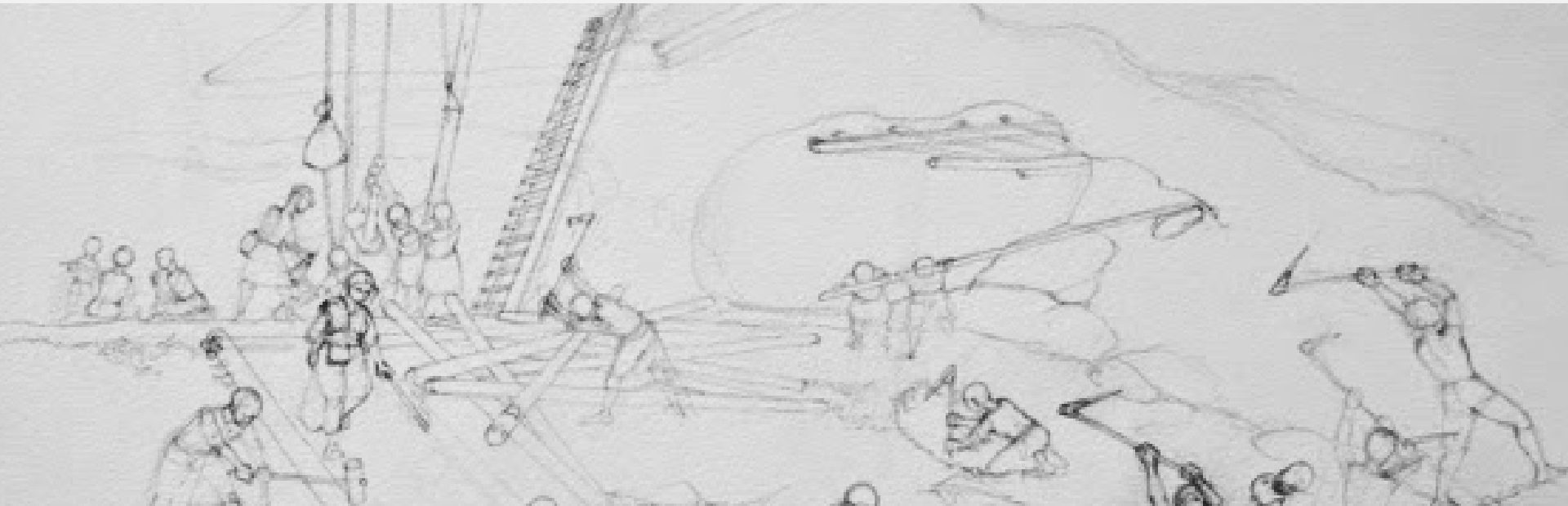
IRAN



# *Acknowledgements*

Images shown are courtesy of

- *each respective author (too many to list here)*
- *photos by Andreas Rausch – anwora.at*
- *artist renderings by Dominic Gröbner*





# The Prehistoric Salt Mines of Hallstatt

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*Perfect preservation leading to insightful simulation*



*Hans Reschreiter, NHM Wien*

*Kerstin Kowarik, NHM Wien*



TECHNISCHE  
UNIVERSITÄT  
WIEN

*Gabriel Wurzer, TU Wien*