Il Pianeta Dinamico

Congresso congiunto SIMP – SGI – So.Ge.l - AIV

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# Geological and numerical modeling to support electric production in geothermal fields: a case test in central Italy

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**Ricerca sul Sistema Energetico - RSE SpA (Milano)**

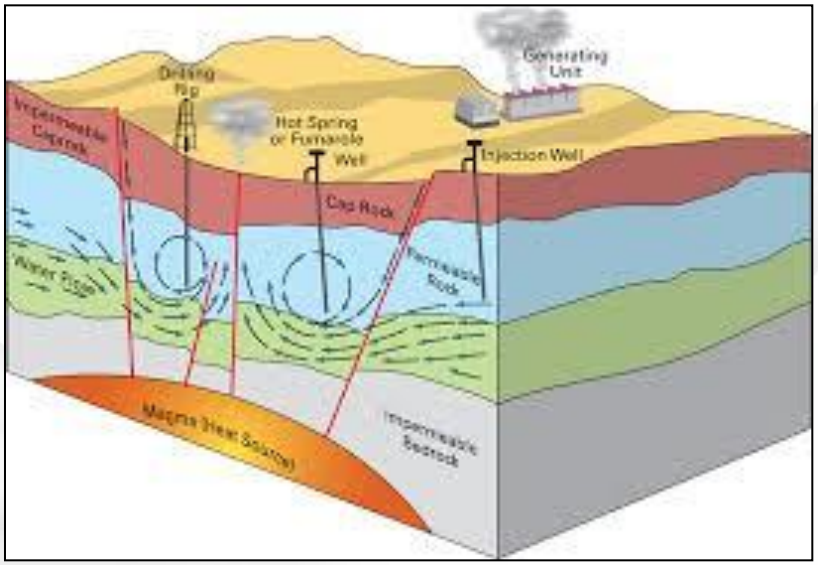
# Agenda

- Introduction
- Case test: a feasibility study for a geothermal 5 MWe pilot plant
- Available data
- Numerical modeling
  - static geological model
  - simulation model
  - natural initial state
  - scenarios of production/re-injection of fluids
- Conclusion

# Introduction

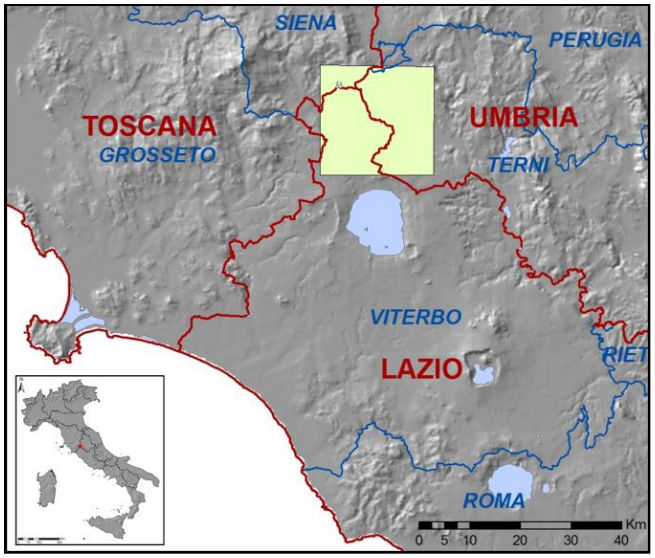
The study describes:

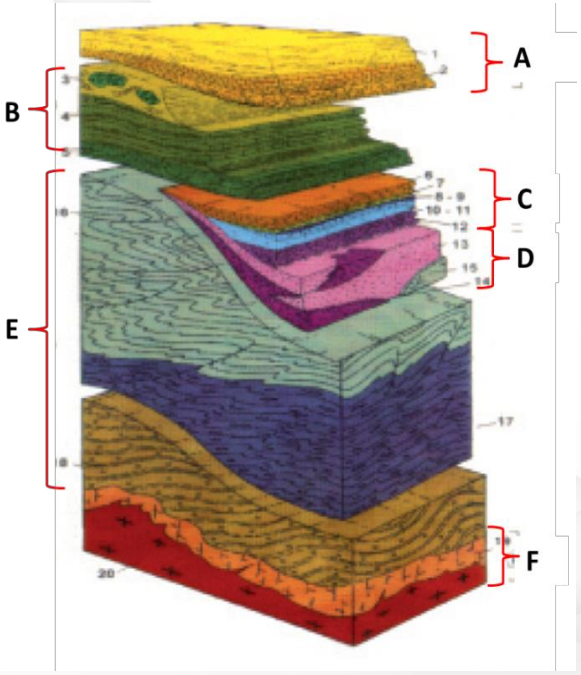
- the **geological and numerical modeling strategies** that can be adopted to support electric production in a medium enthalpy **geothermal field**
- the numerical simulations is a strong tool to verify the **feasibility** and **sustainability** of the resource exploitation
- case test in central Italy: **Castel Giorgio – Torre Alfina**



# Study area: Castel Giorgio – Torre Alfina

- close to Bolsena Lake, between Lazio and Umbria regions
- extension of more than **100 km²**
- feasibility study for a **5 MWe nominal power pilot plant** based on binary ORC technology, designed for zero emission and total fluid re-injection in the same original reservoir



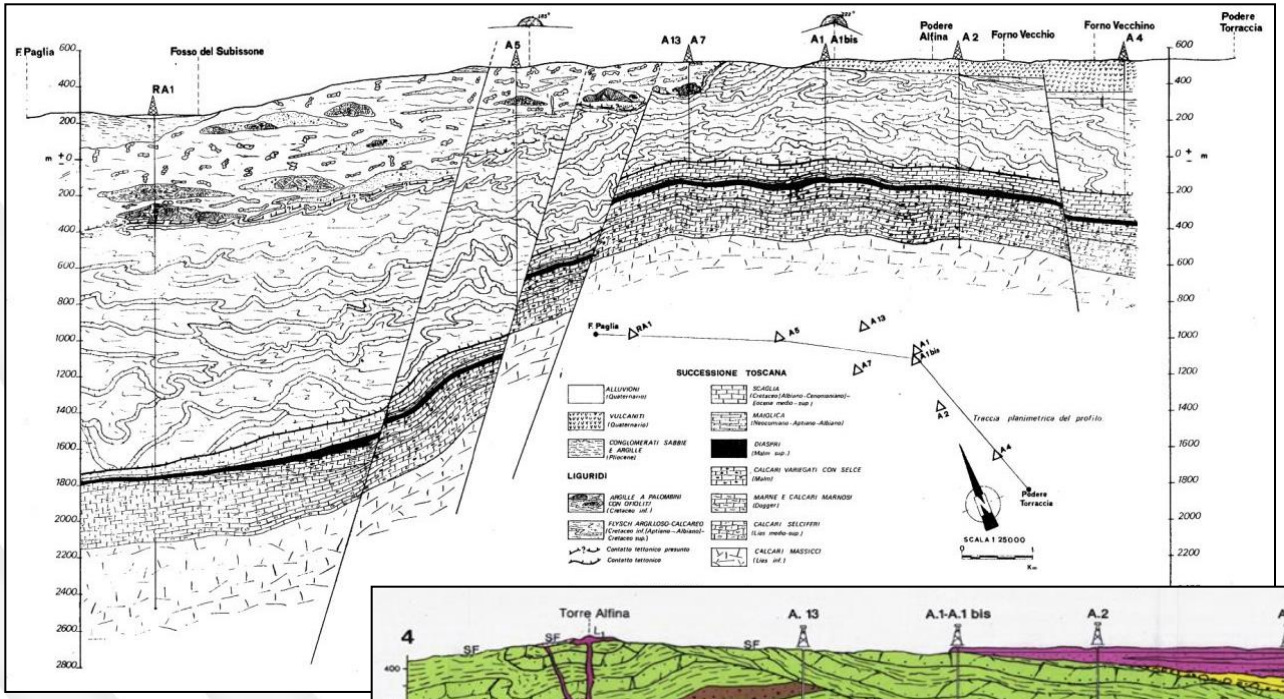



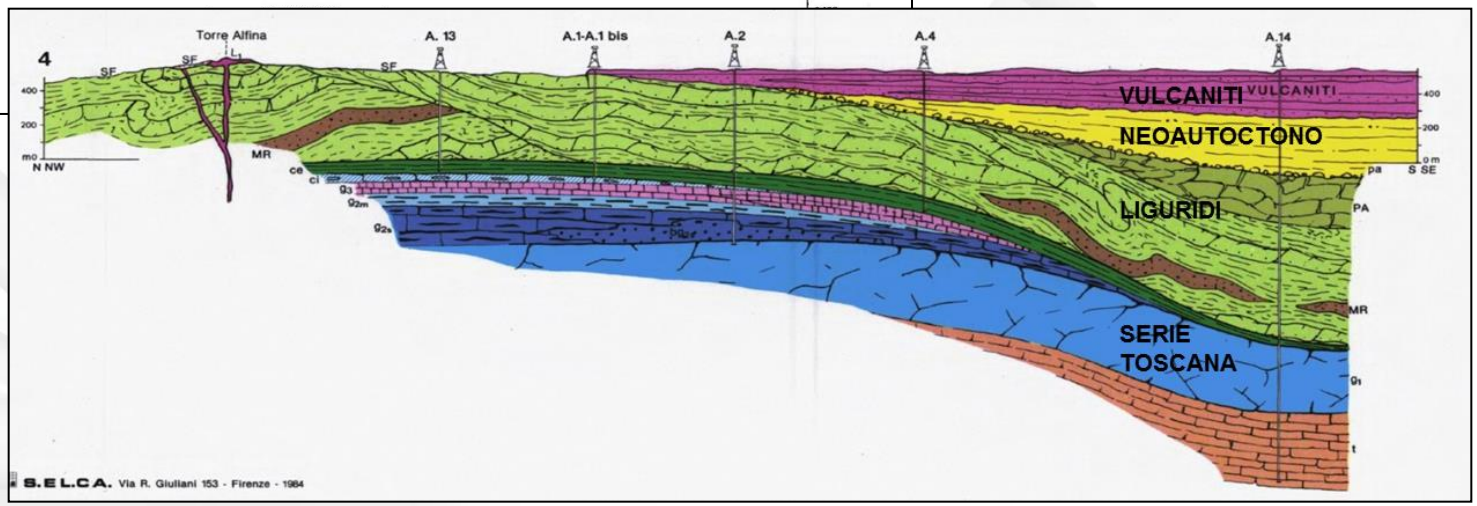

## Stratigraphic succession

- ***Volcanic Complex***
- ***Neoautochthonous Complex (A):*** upper Miocene - middle Pliocene; clayey/sandy and conglomeratic sequence.
- ***Liguride Complex (B):*** Cretaceous-Eocene; flysch and shales.
- ***Tuscan Complex (C):*** lower Cretaceous- upper Triassic; mainly carbonates. This is the ***geothermal reservoir***. T= **125-150°C**
- ***Metamorphic rocks (D, E, F):*** Trias-Paleozoico

# Available data

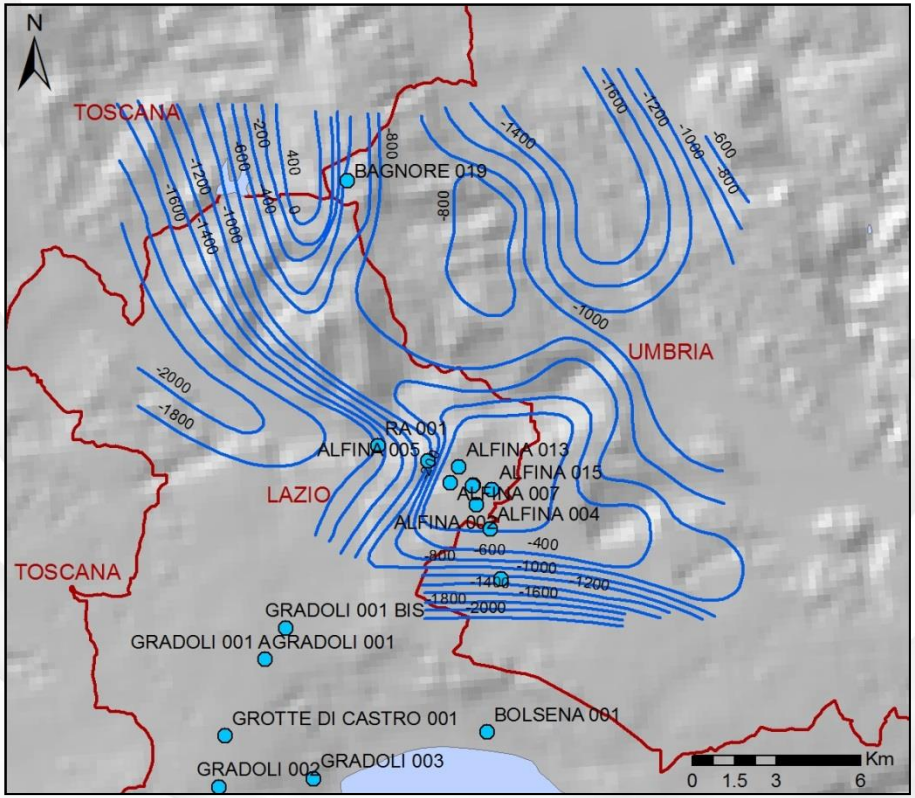
- geological maps and sections



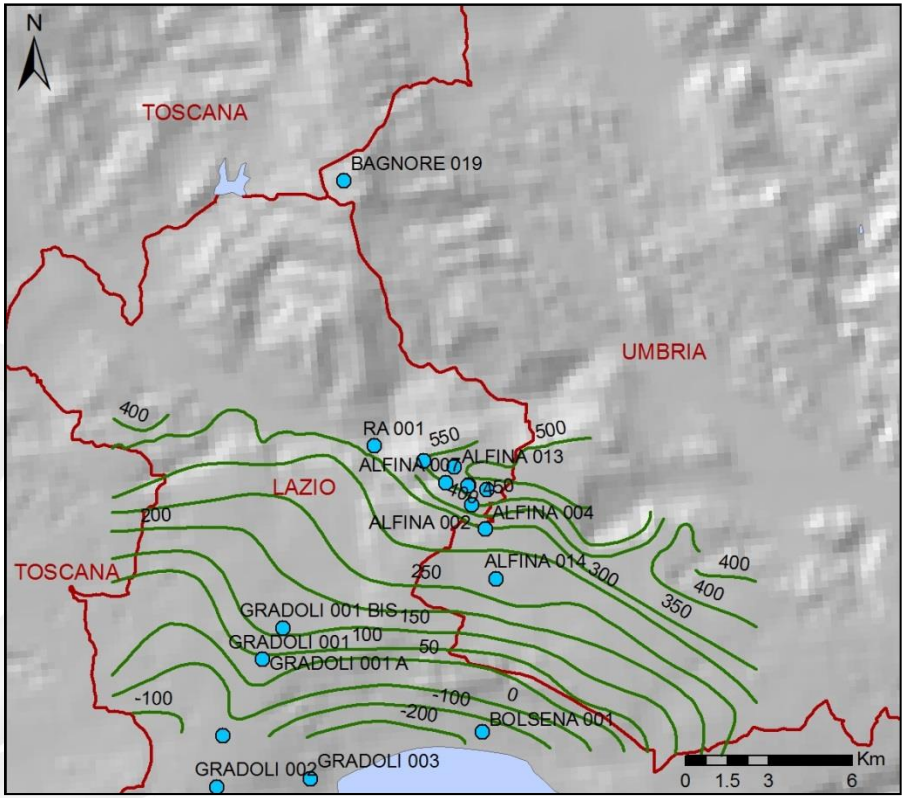



# Available data

- geological maps and sections
- isobaths maps for top of geological formations



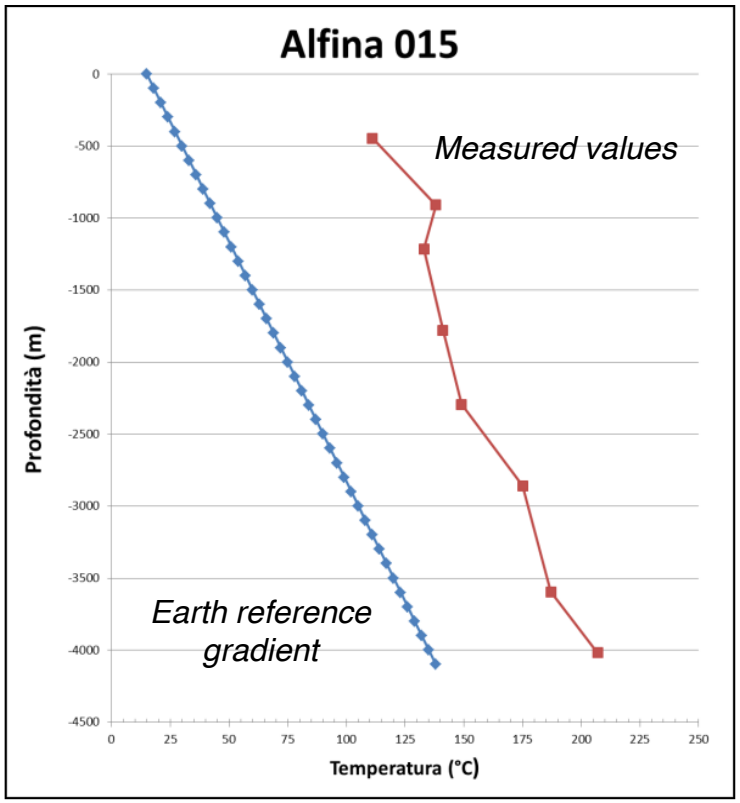

*Top of Tuscan Complex*

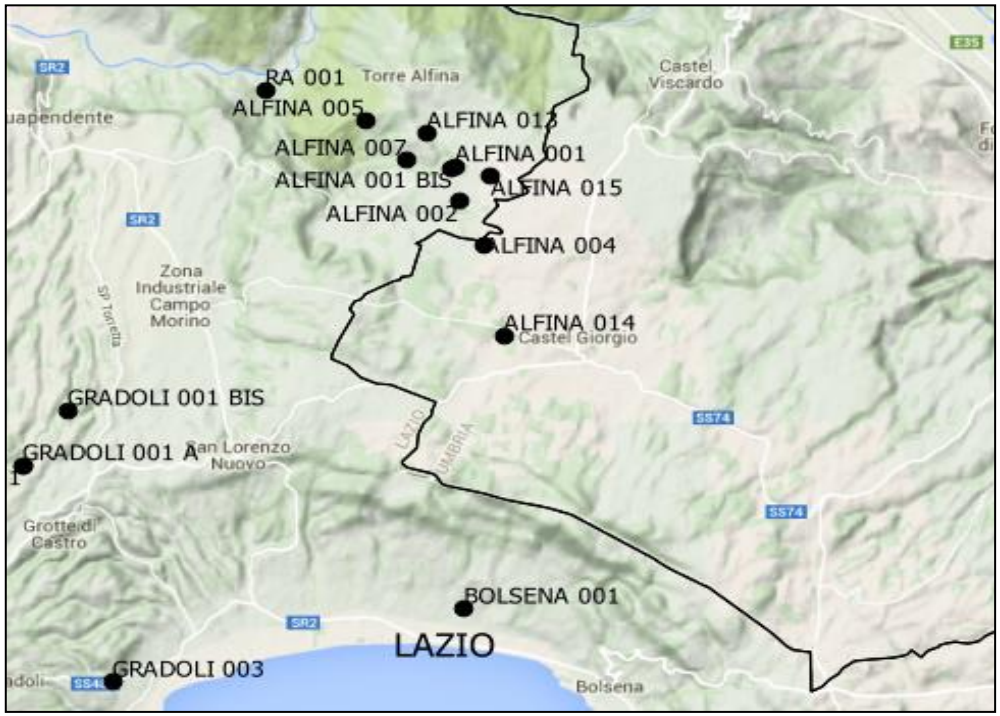



*Top of Vulcanic Complex*

# Available data

- geological maps and sections
- isobaths maps for top of geological formations
- data from drilled wells



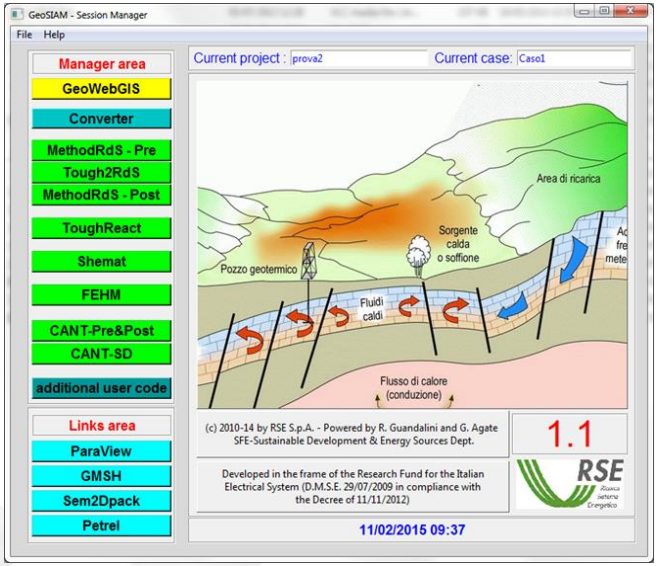



# Numerical modeling

## *Integrated System for GeoModeling Analyses - GeoSIAM*

Developed in **RSE** with the aim of supporting the user for all the modeling tasks. The system:

- is an **integrated modular software** available for the most common platforms (Windows, Linux, Unix)
- is based on **portability**, **flexibility** and **ease-of-use** criteria
- use mainly **OpenSource** basic modules and auxiliary tools (as ParaView for post-processing analysis)
- The fluid dynamic module is based on **Tough2** with a deep revision and a new module for a better 3D mesh generation - **MethodsRdS**

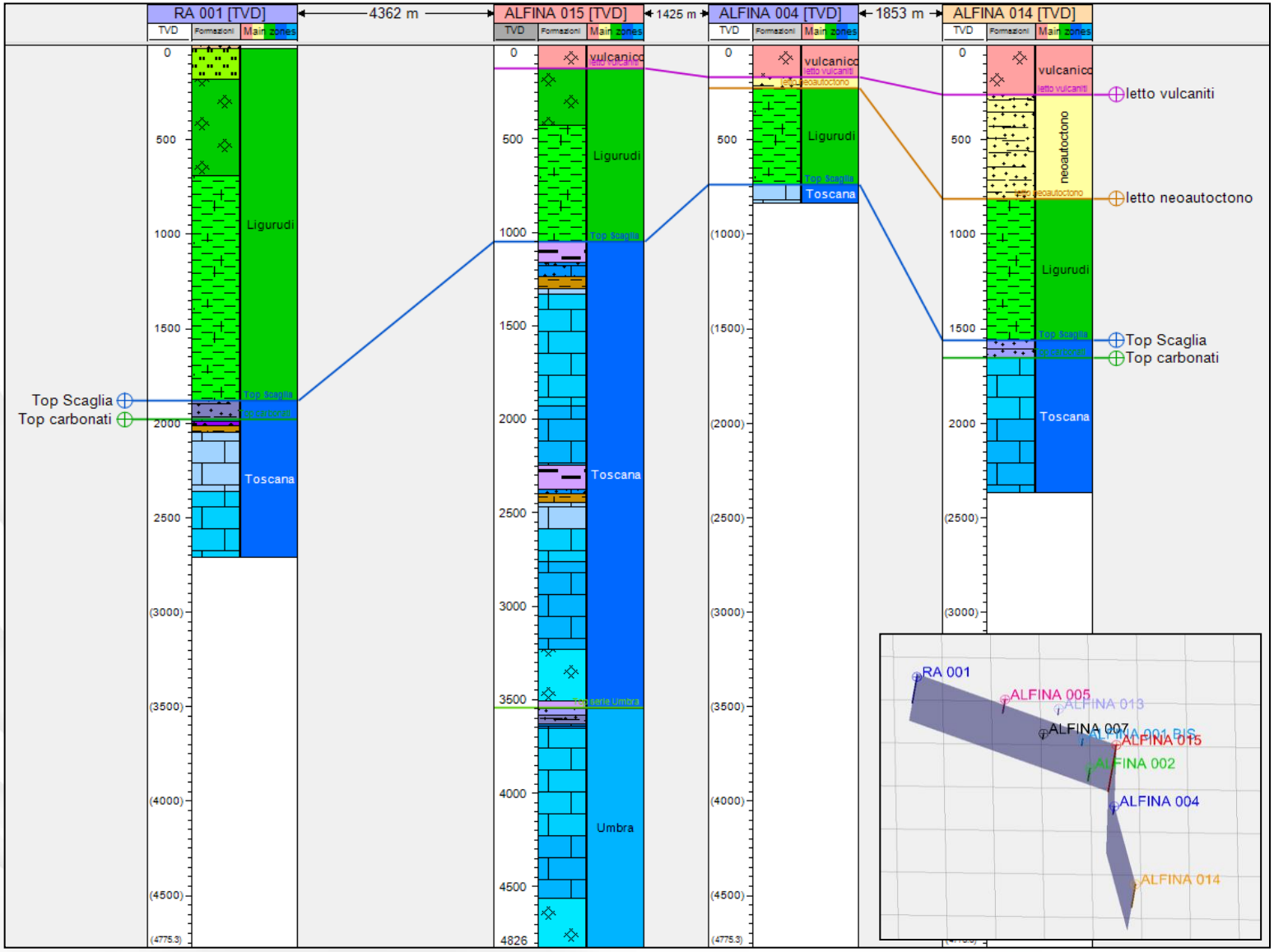



The study has been carried out through three subsequent tasks:

1. creation of the **static geological model** and of the **3D numerical model**
2. simulation of the **natural initial state** of the geothermal field
3. simulation of different **scenarios for production/re-injection** of fluids

The state module (EOS2) chosen can treat **hot water, vapor and high level of $CO_2$**

# Static geological model



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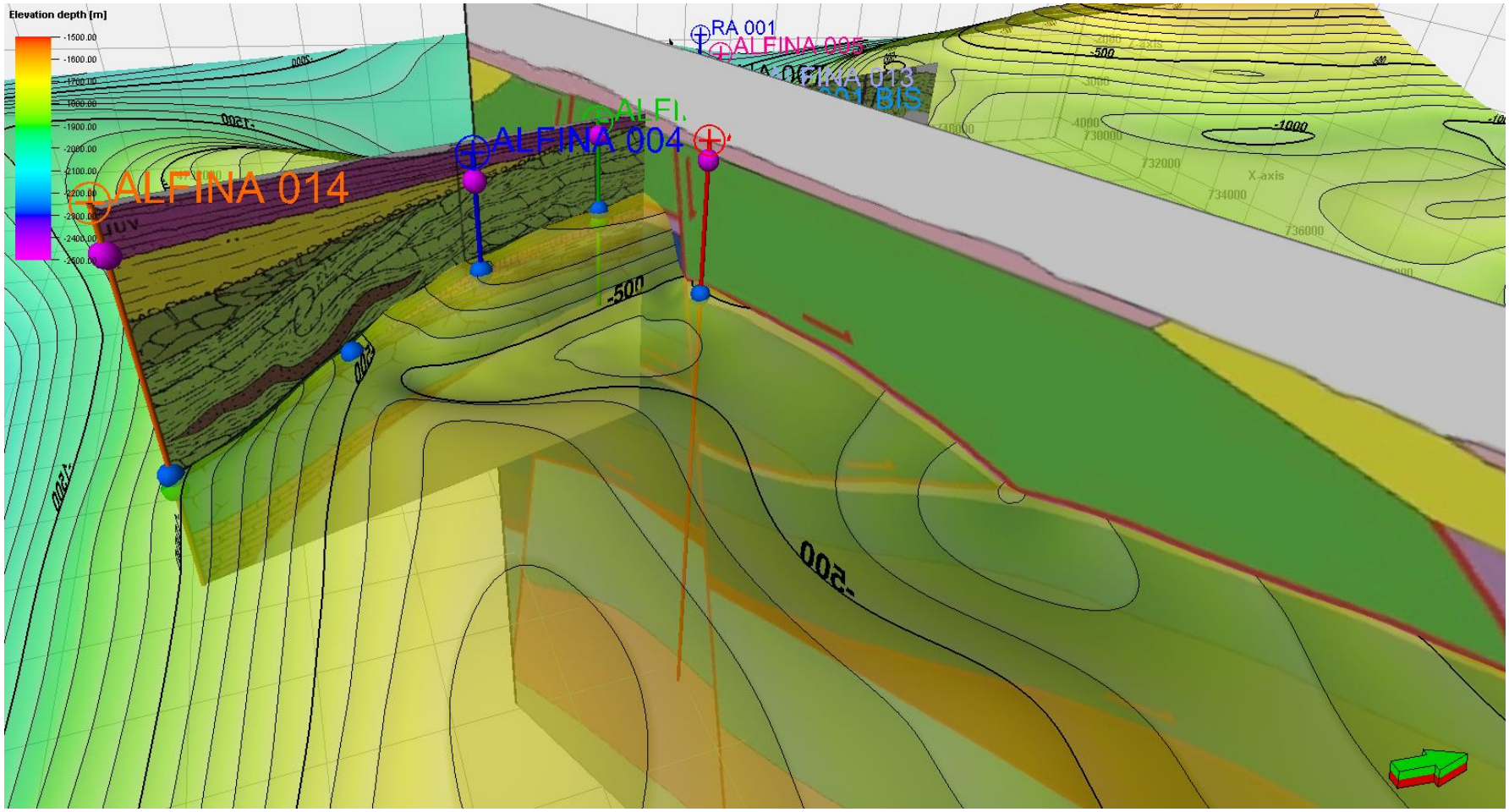

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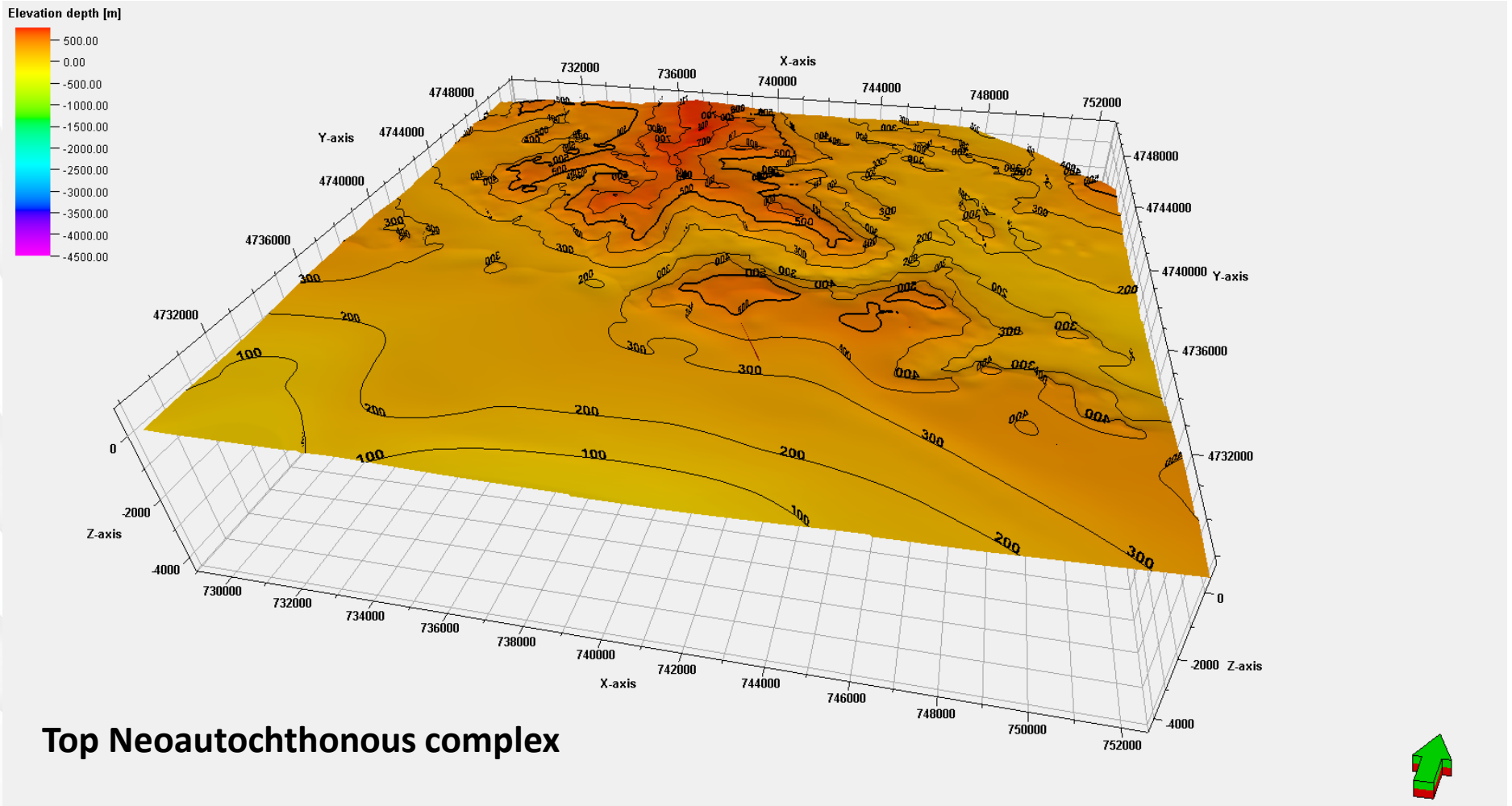
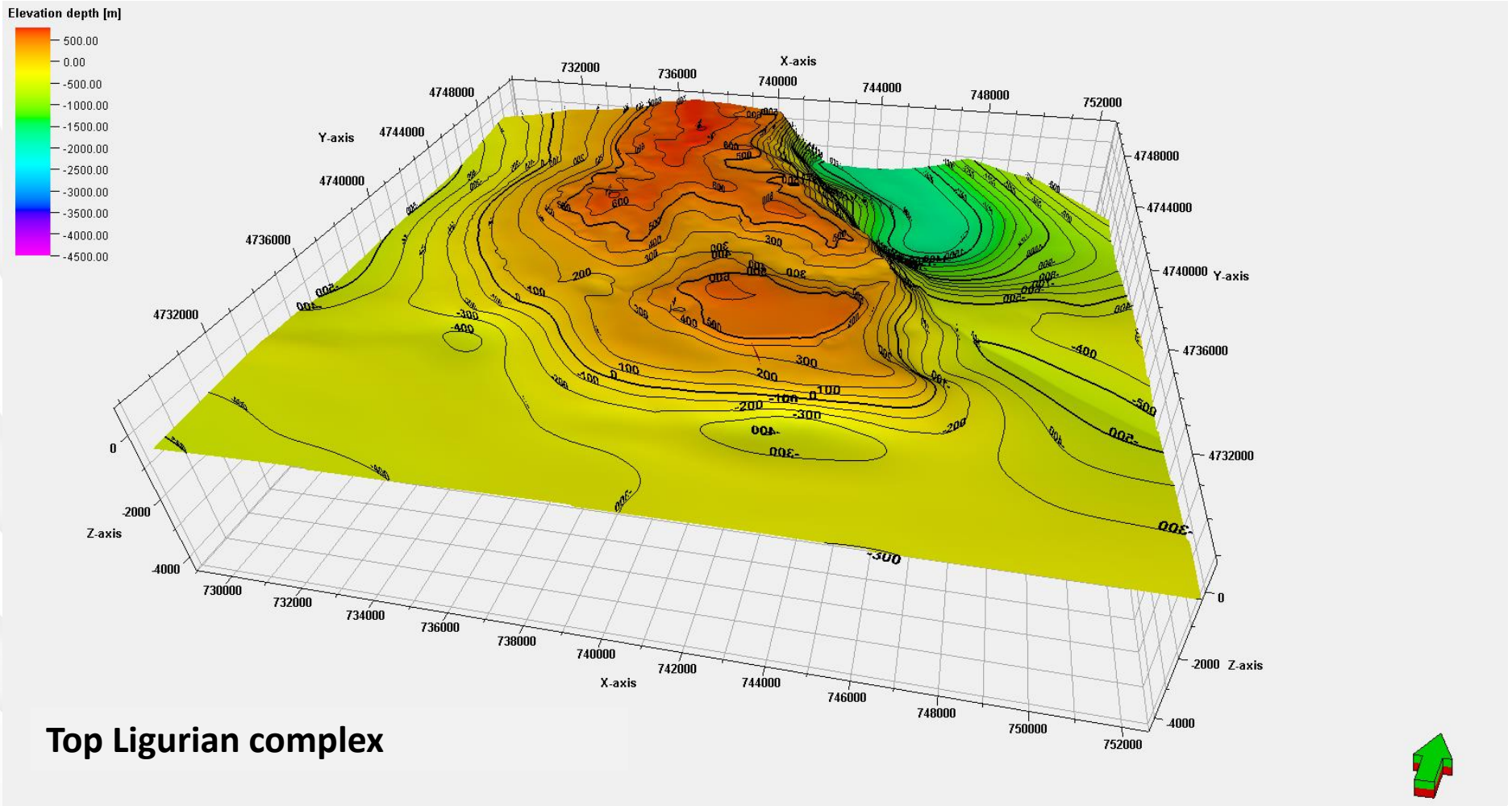


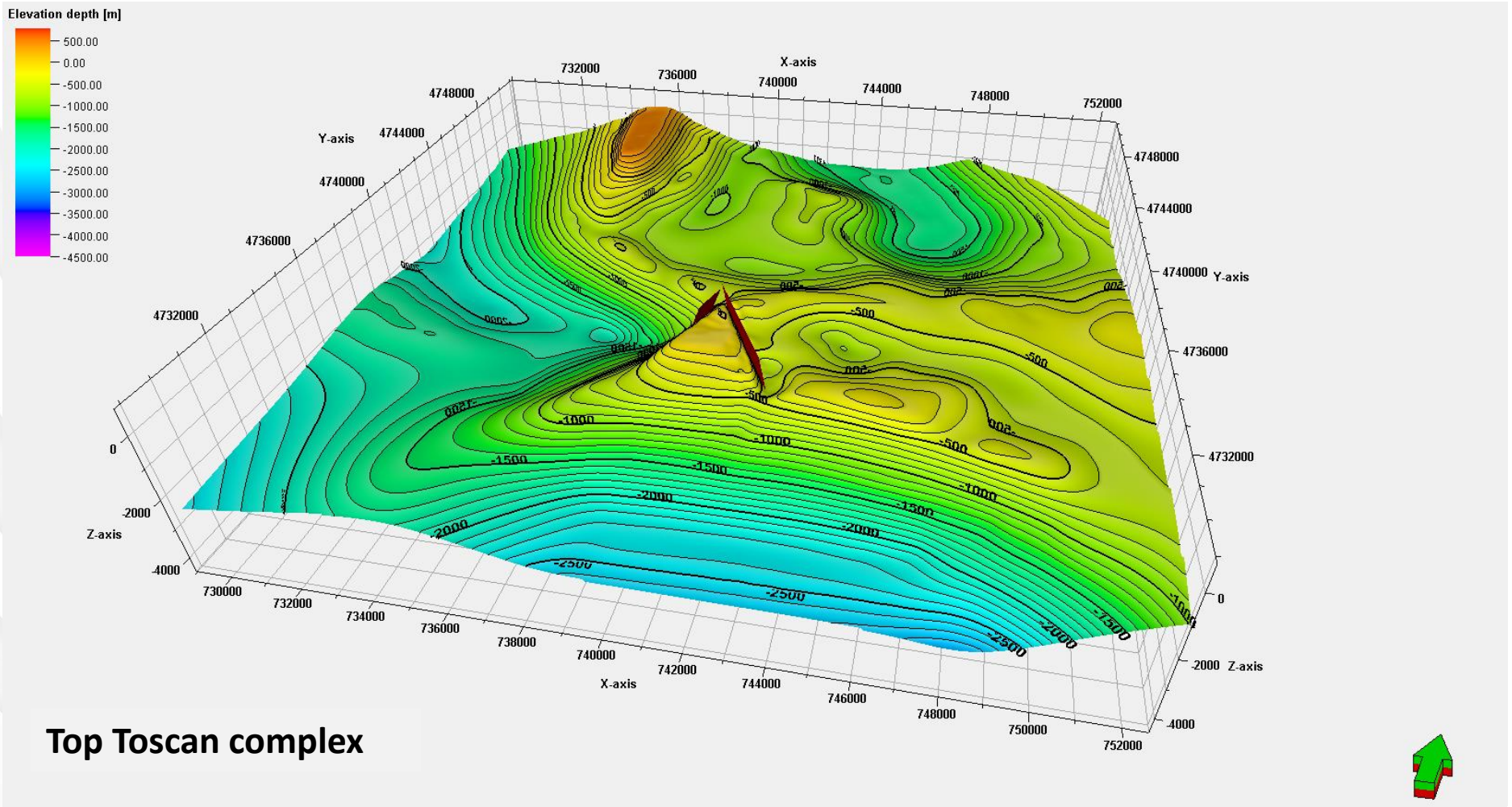

**Top Neoautochthonous complex**

# Static geological model



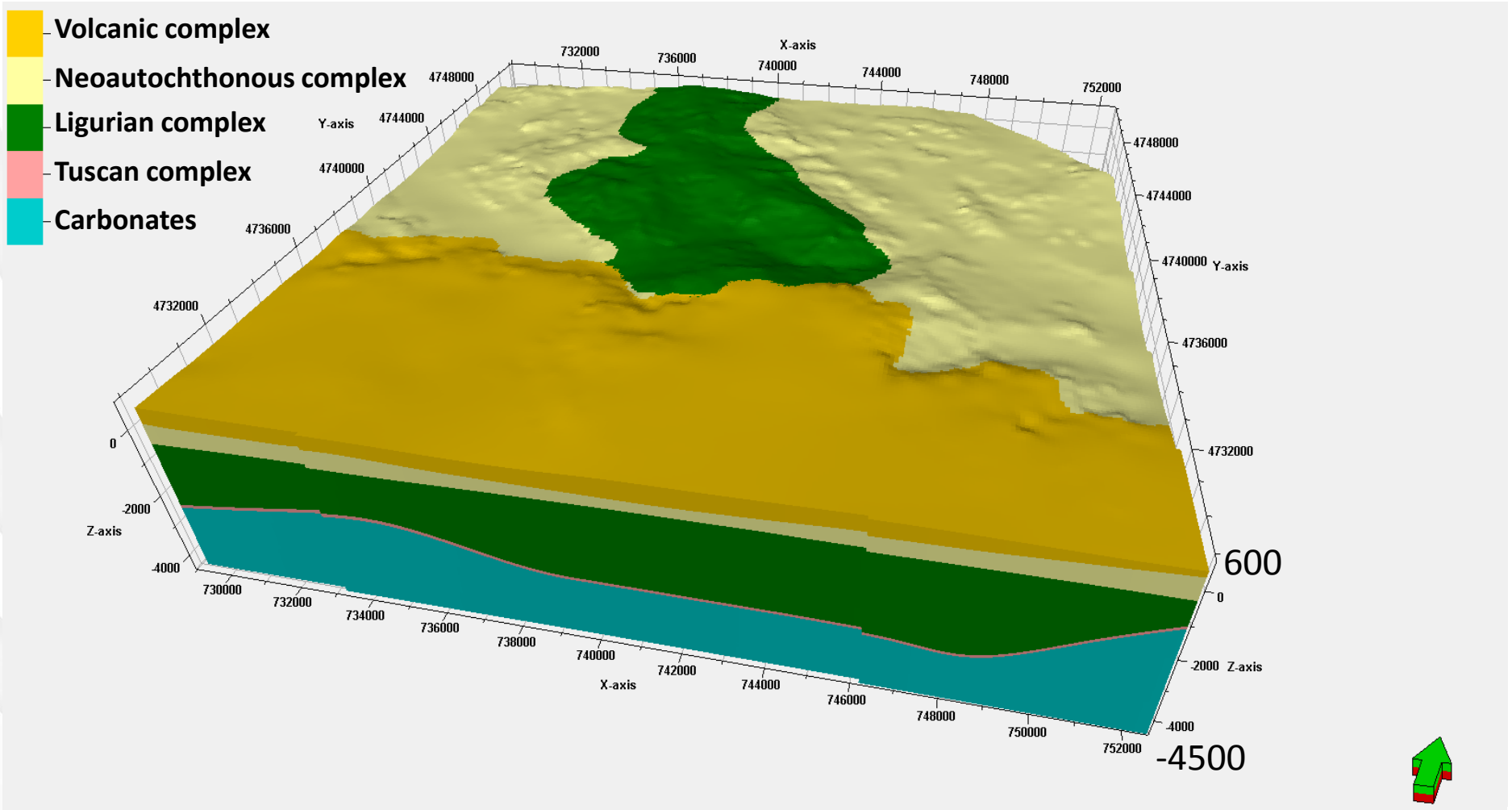

**Top Ligurian complex**

# Static geological model



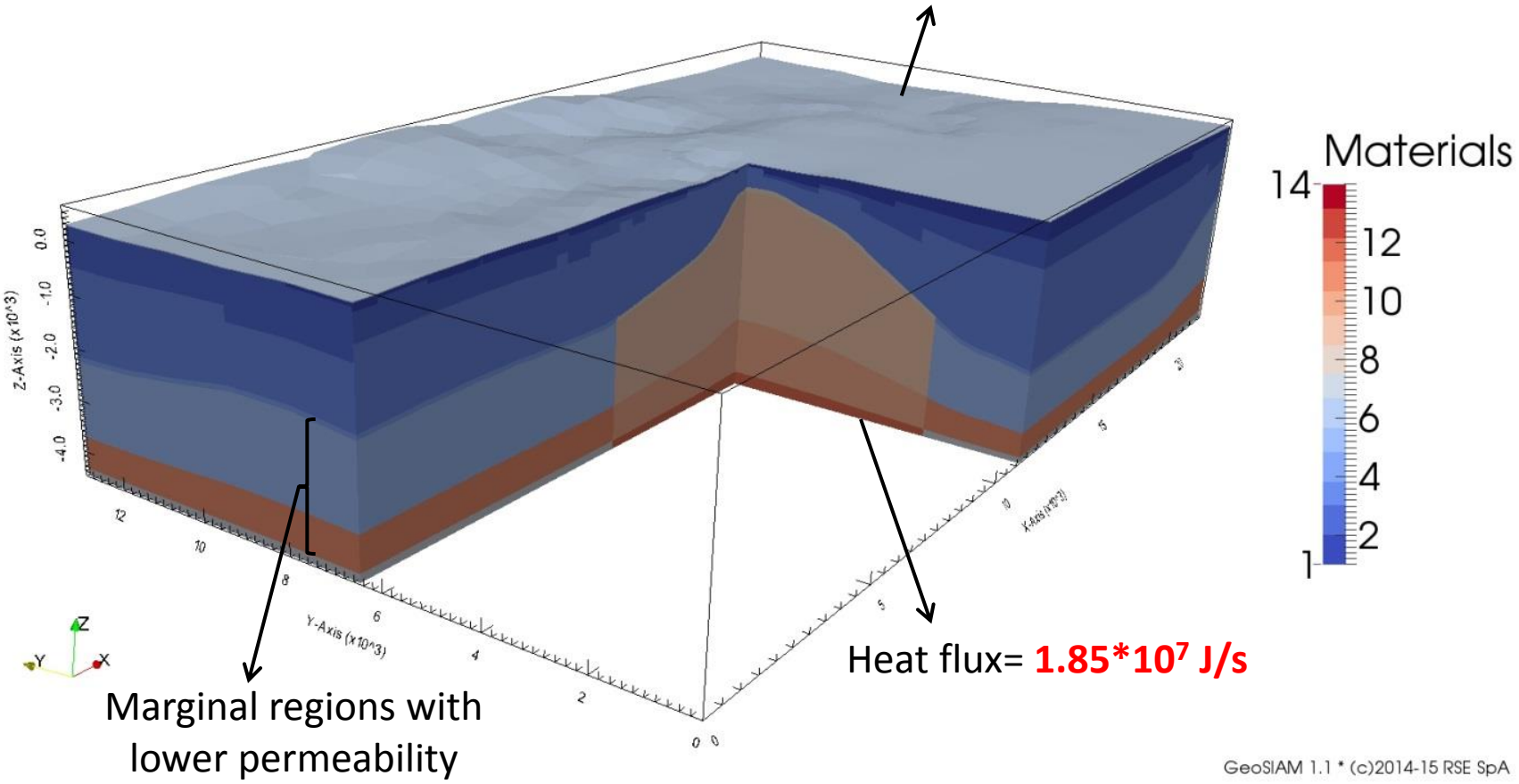

**Top Toscan complex**

# Static geological model



# 3D simulation model

The surface is constrained to 15°C and 1 bar




Heat flux= **$1.85*10^7$ J/s**

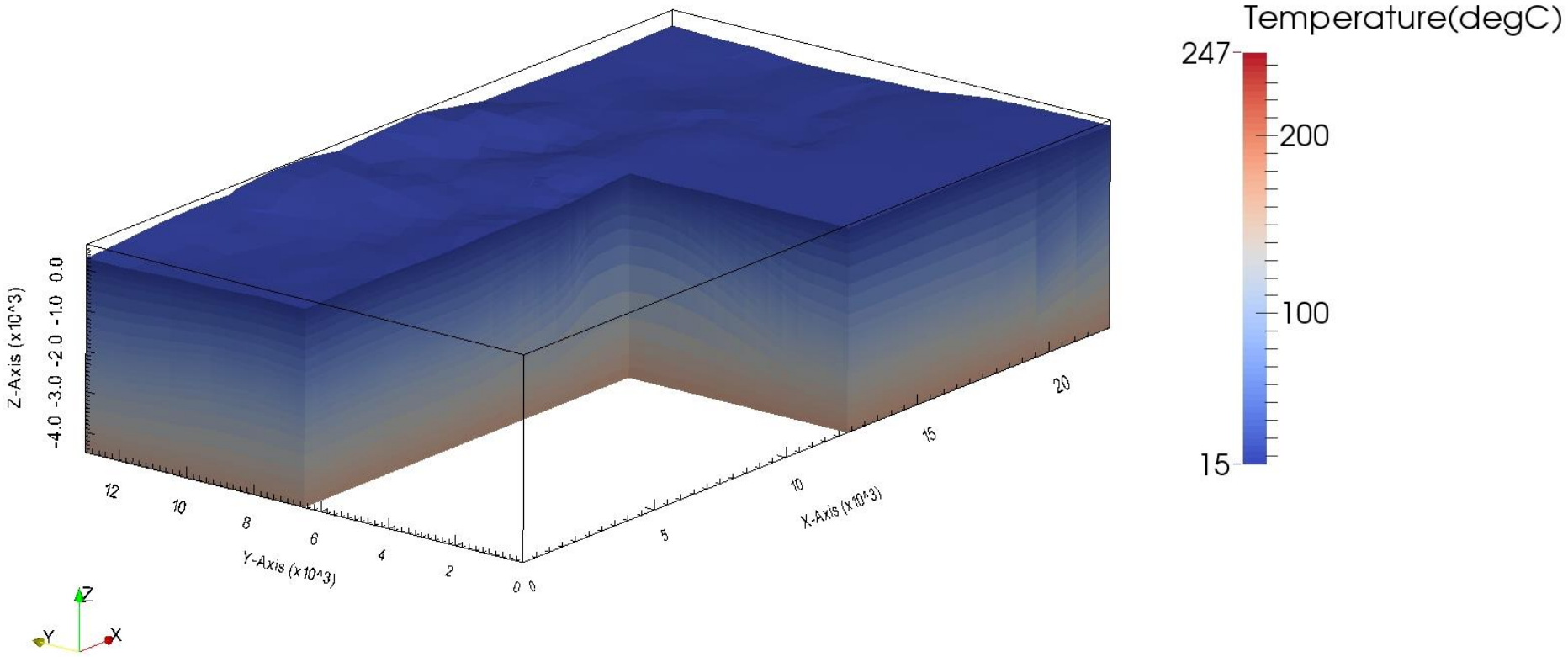
Marginal regions with lower permeability

# Natural initial state

Elements: 23700
Nodes: 48236
Layers: 30

## *Temperature gradient trend*

## *Heating transient*



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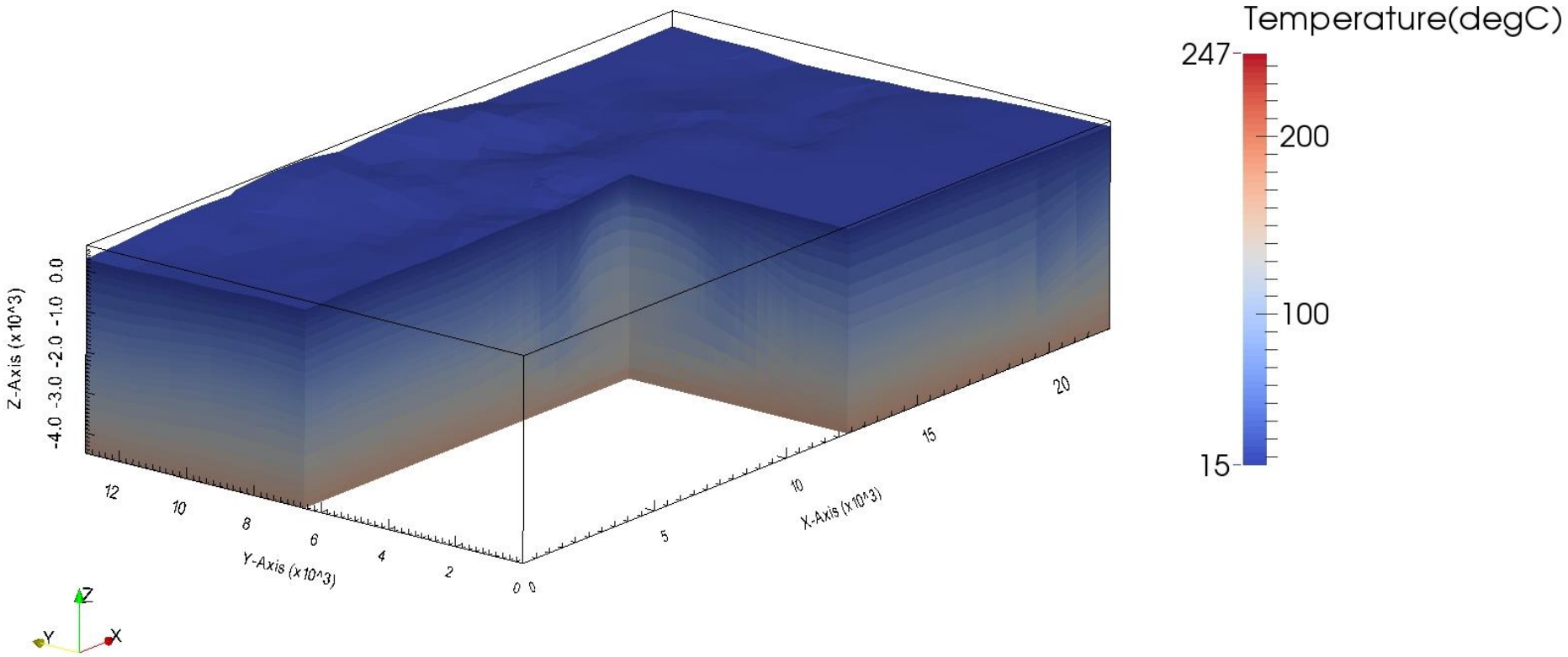

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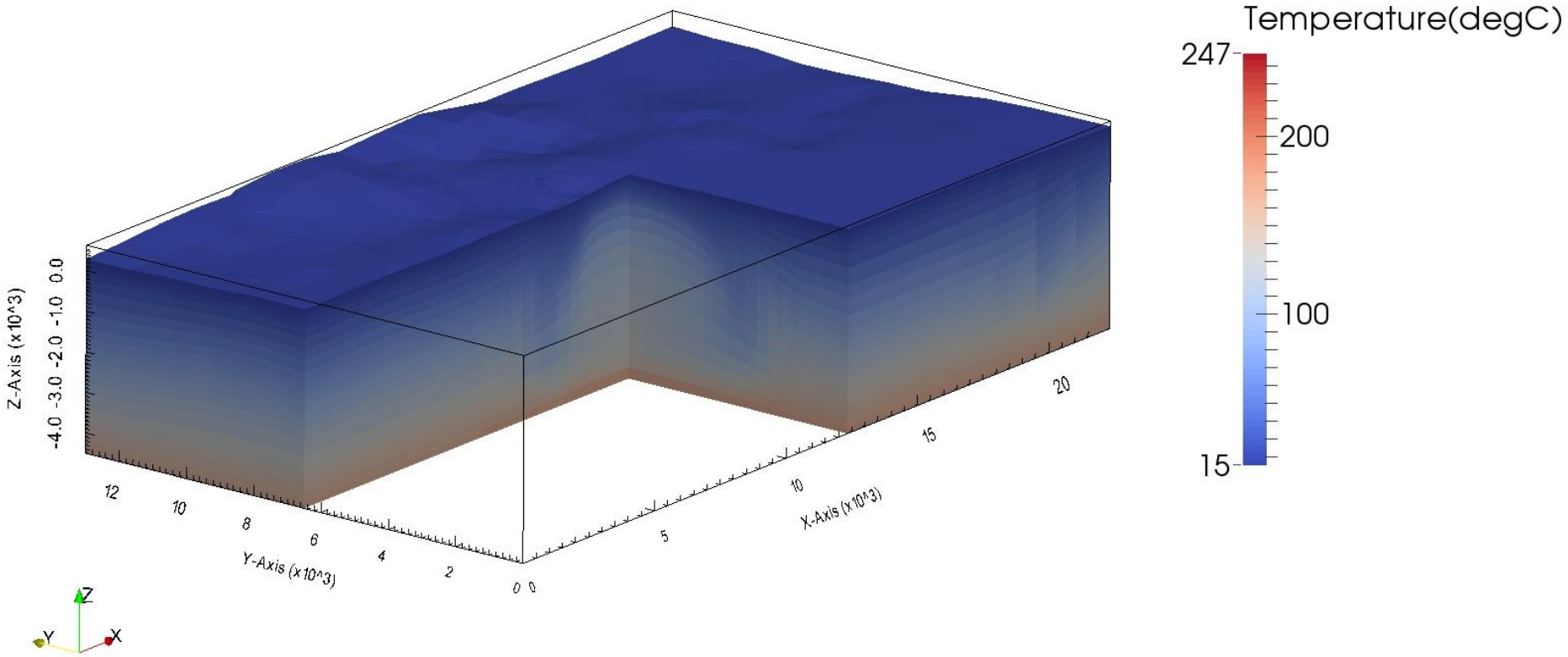

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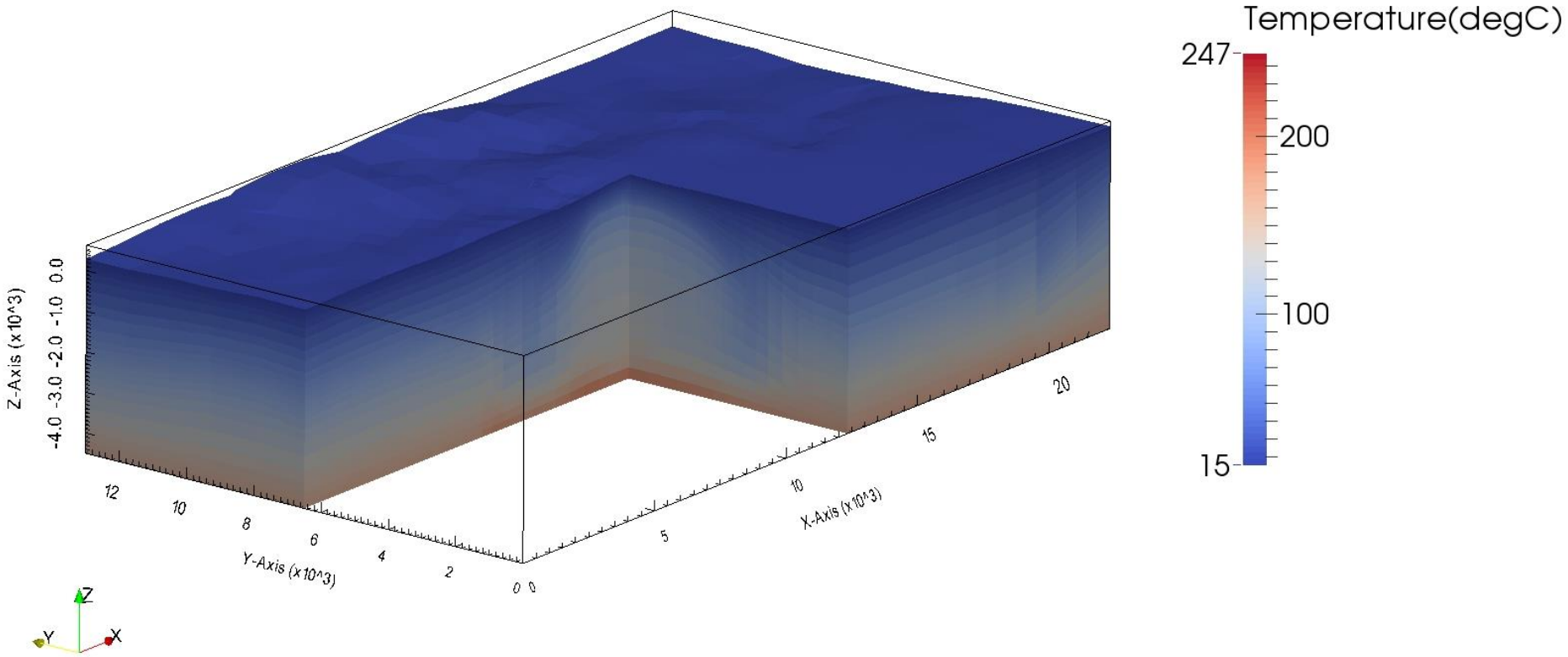

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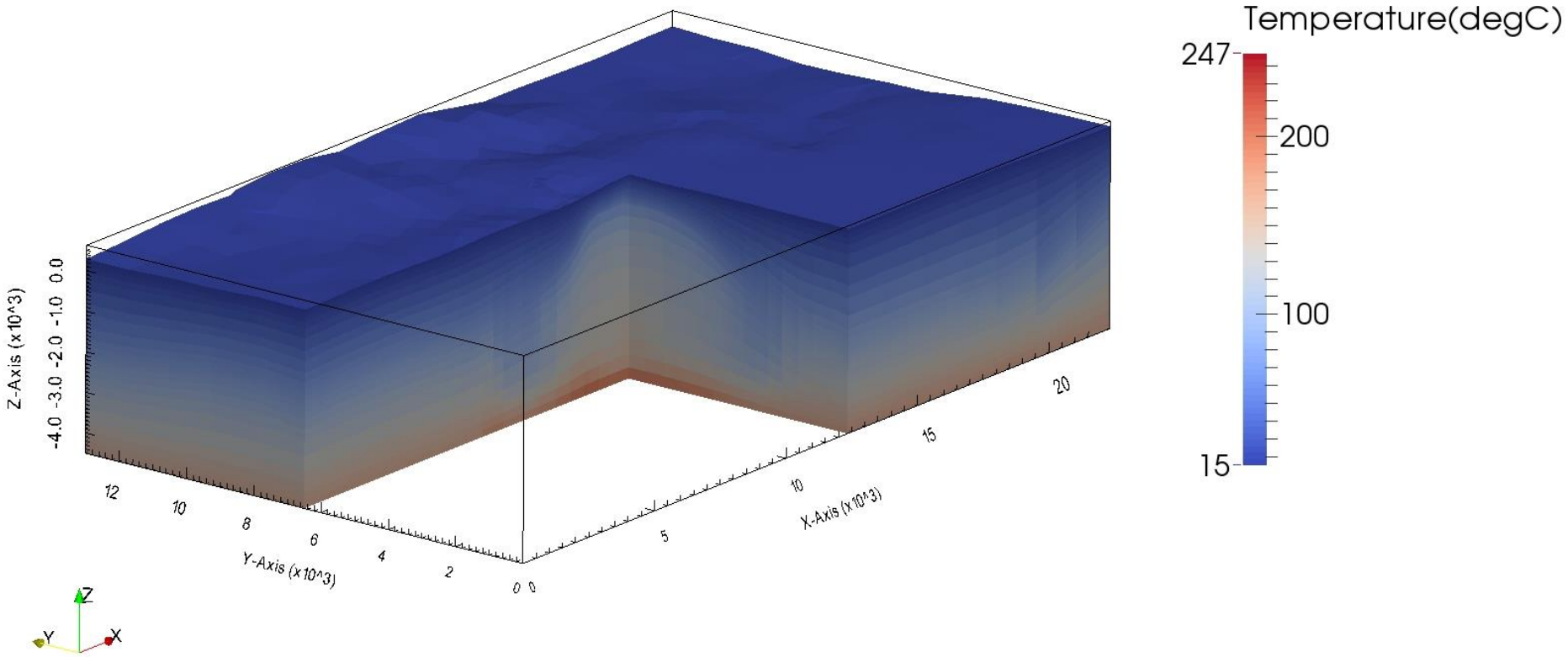

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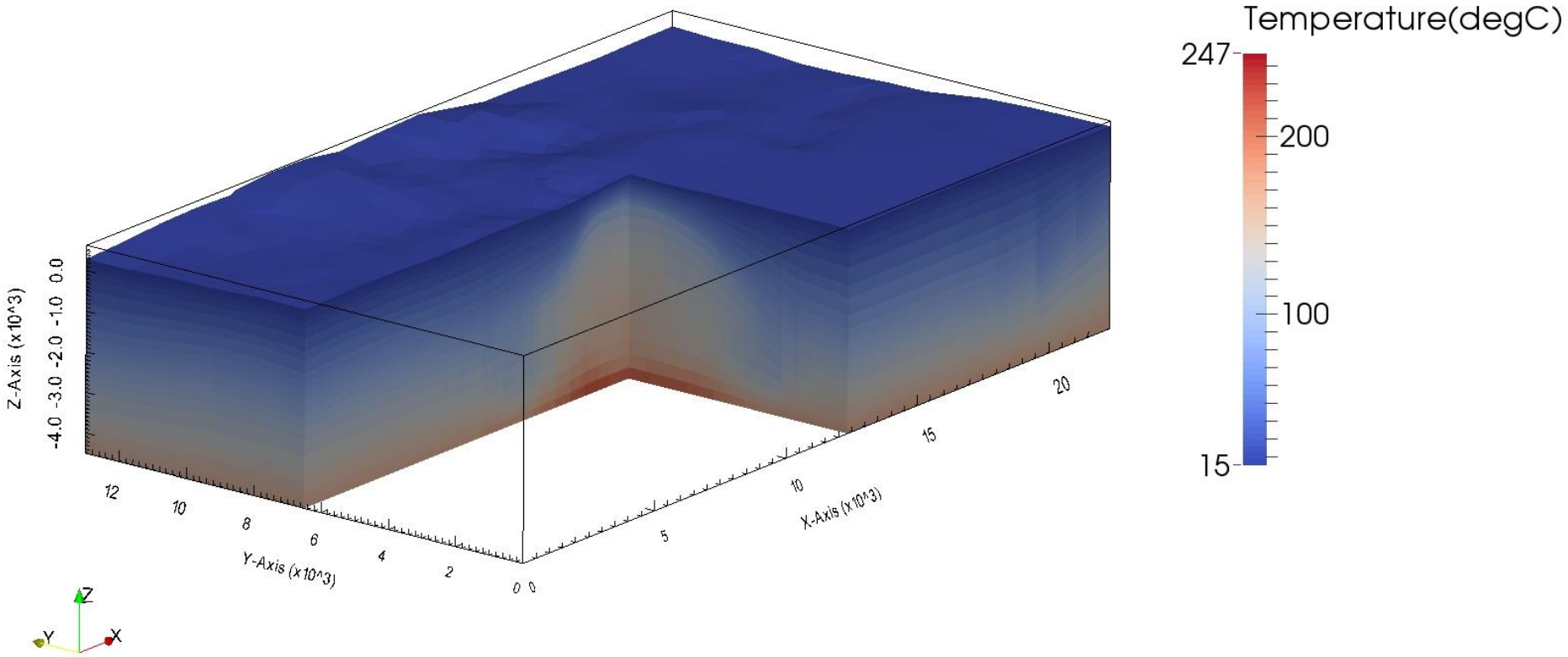

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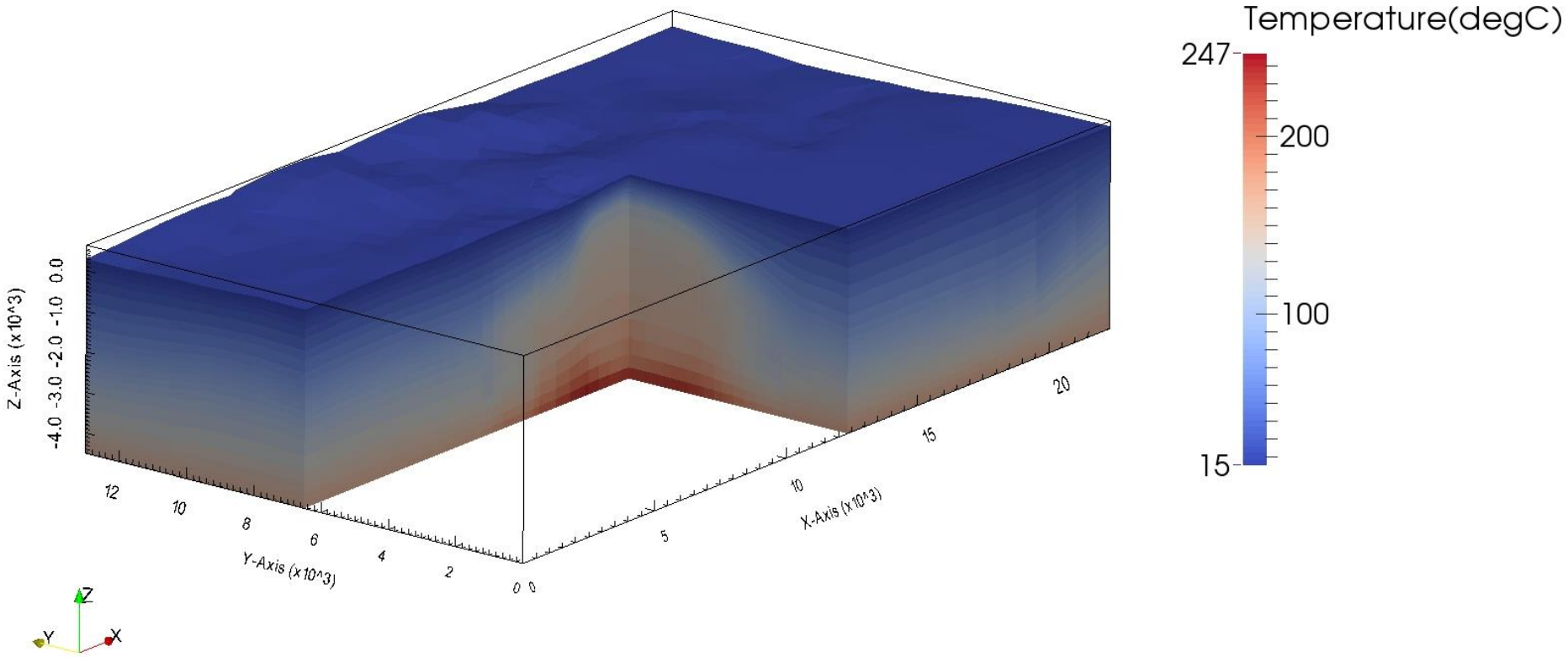


Time: 100000.00 years

GeoSIAM 1.1 * (c)2014-15 RSE SpA

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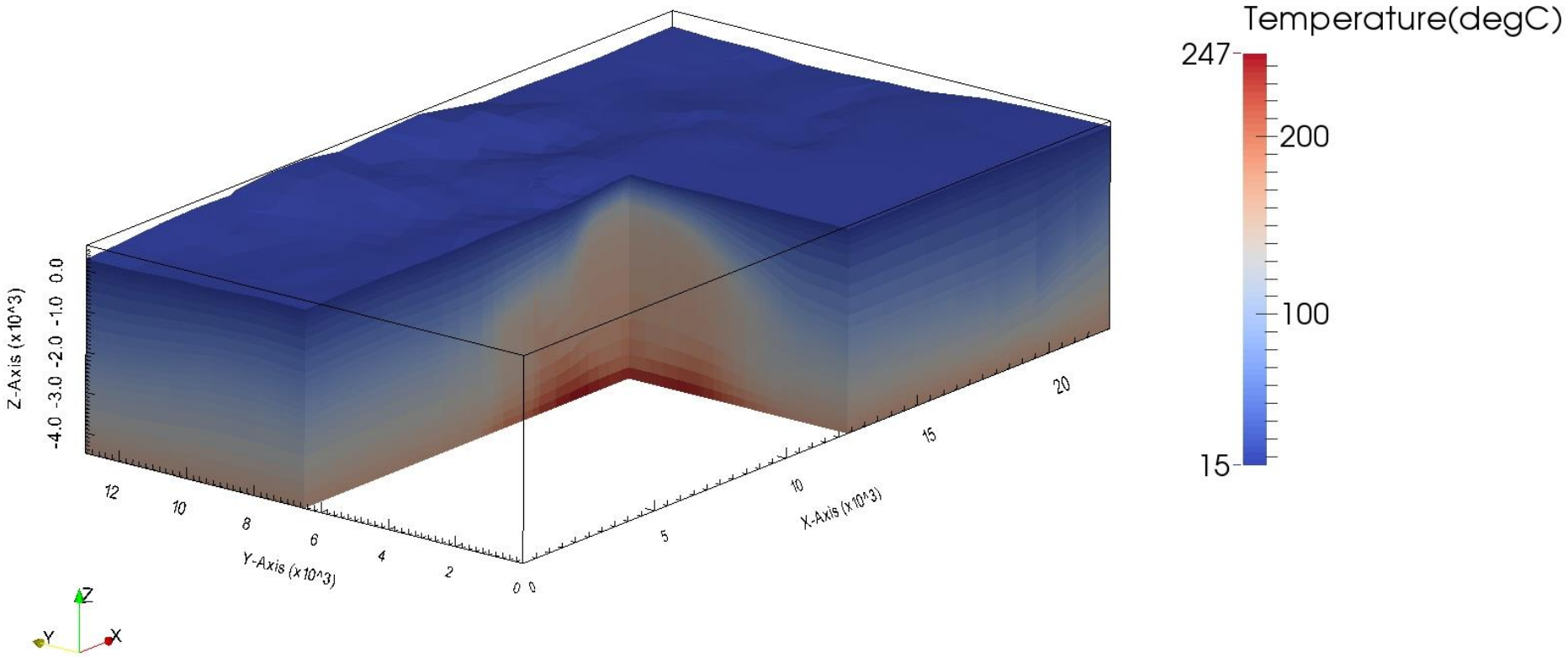

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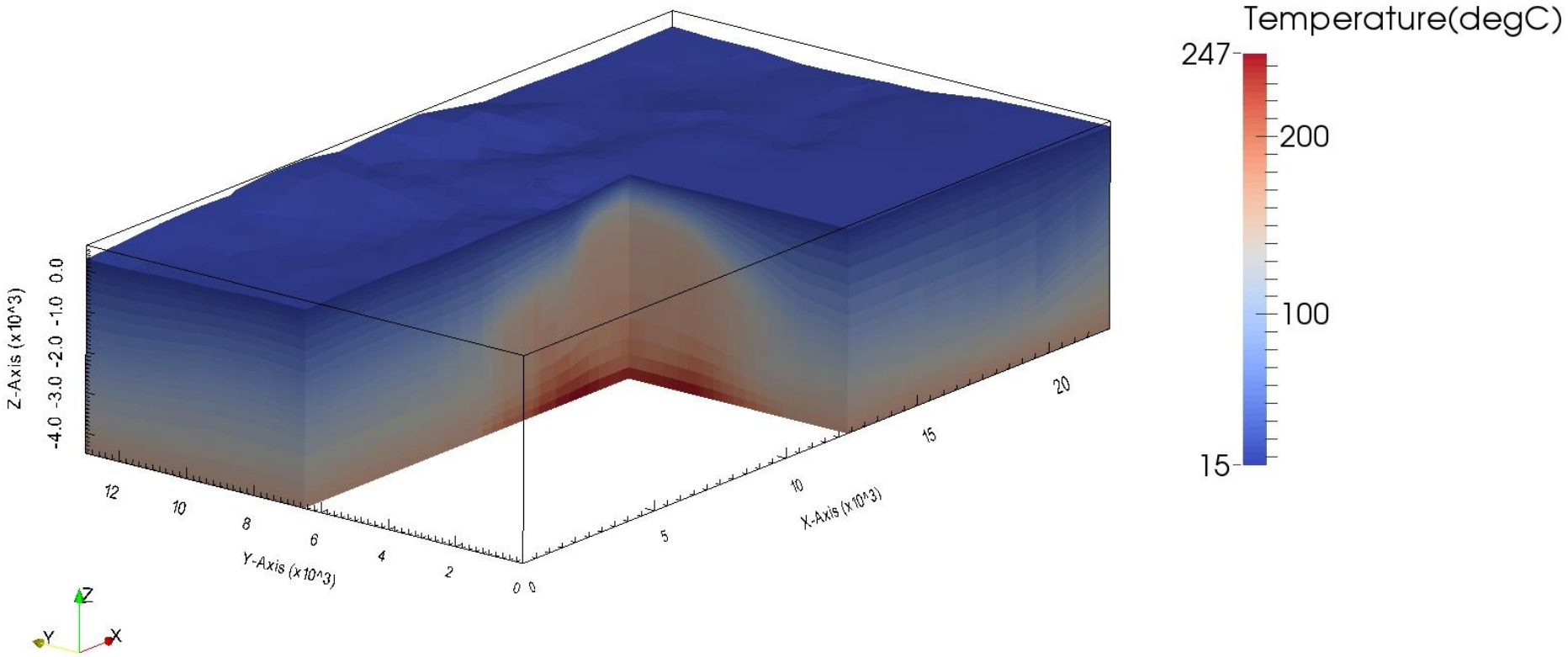

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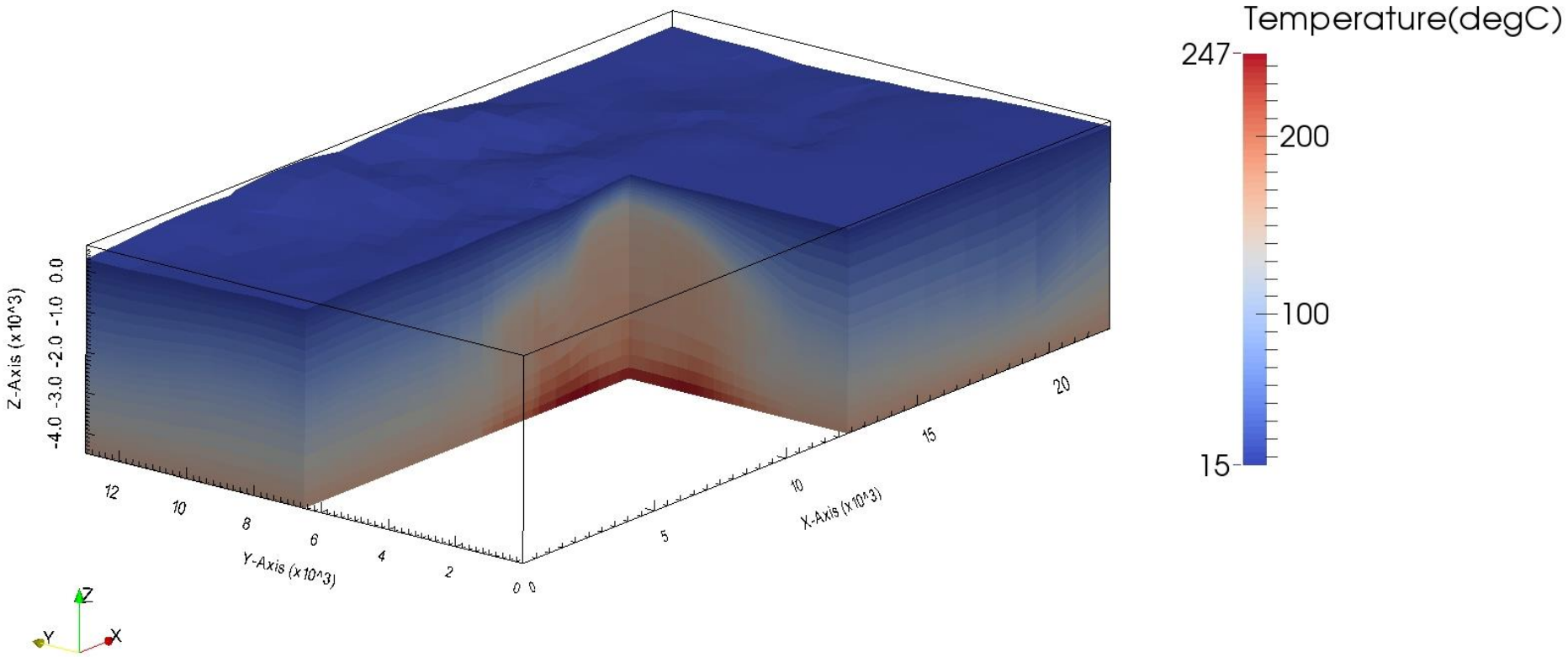

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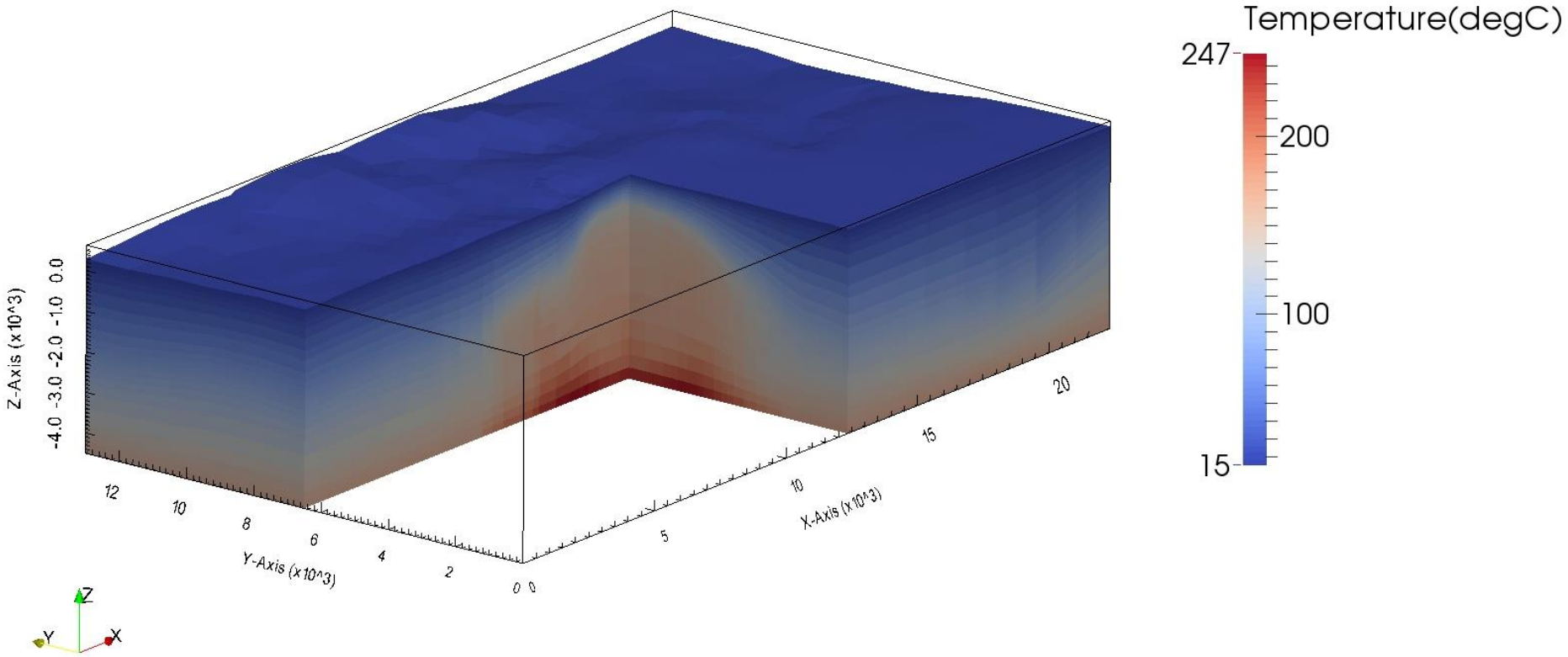


Time: 1000000.00 years

GeoSIAM 1.1 * (c)2014-15 RSE SpA

# Natural initial state

Elements: 23700
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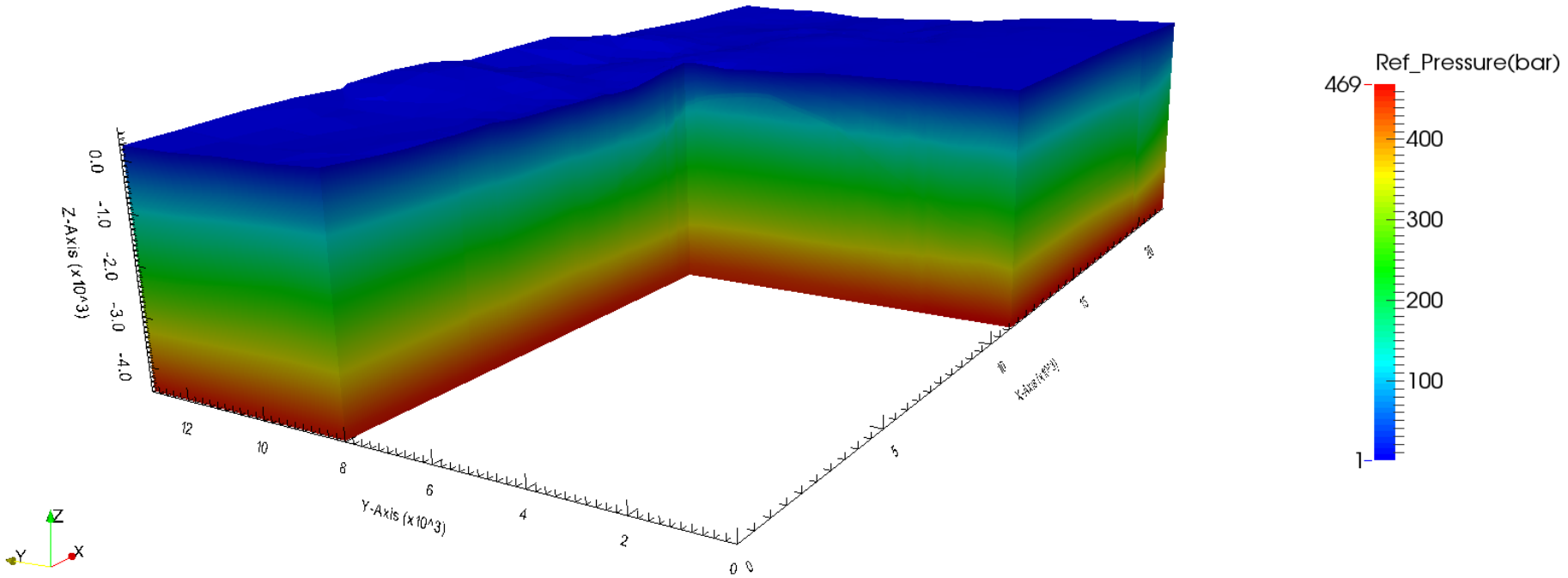
## *Pressure gradient trend*

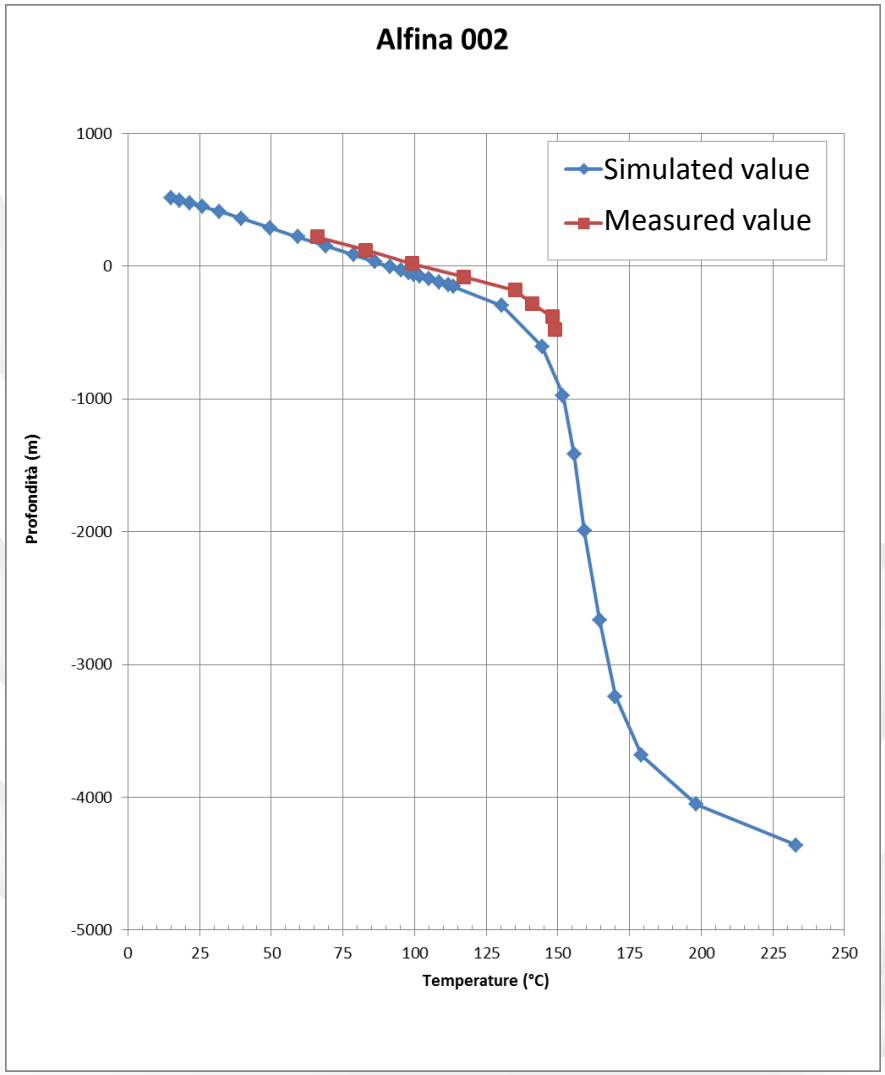


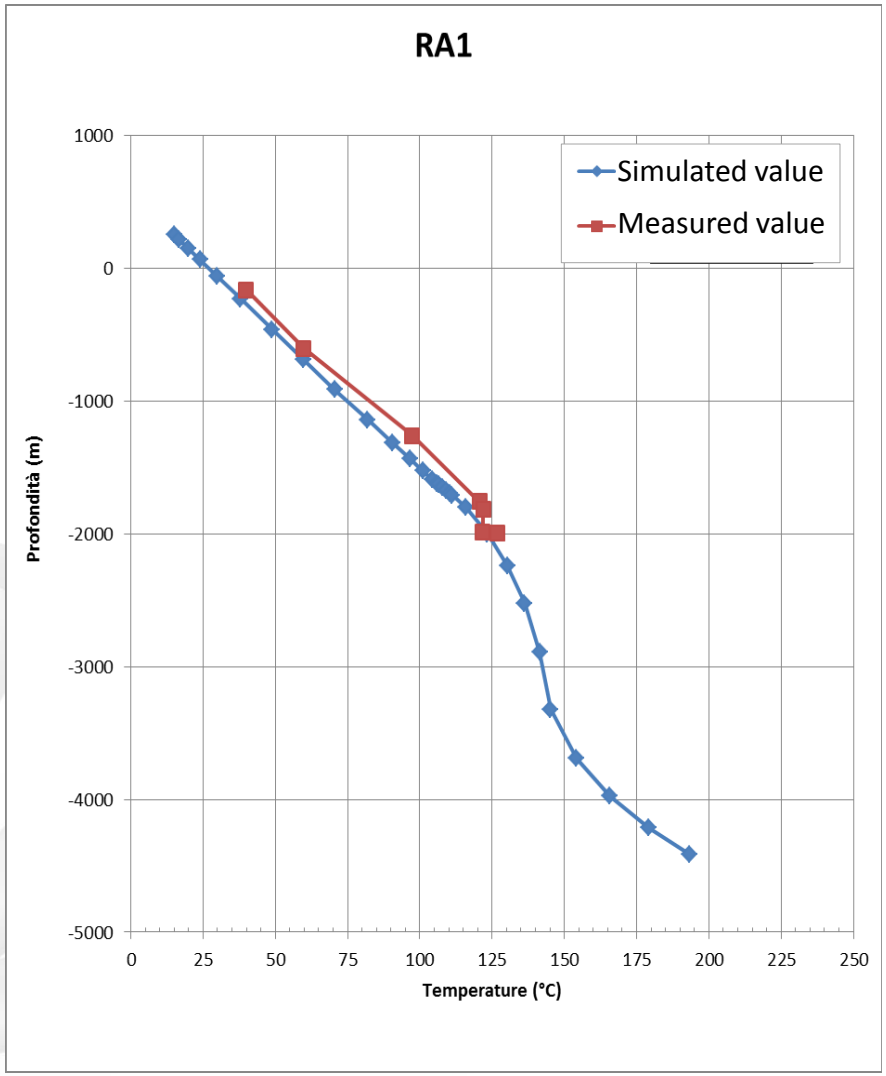

Time: 1000000.00 years

GeoSIAM 1.1 * (c)2014-15 RSE SpA

# Natural initial state

## Comparison simulated and measured temperature



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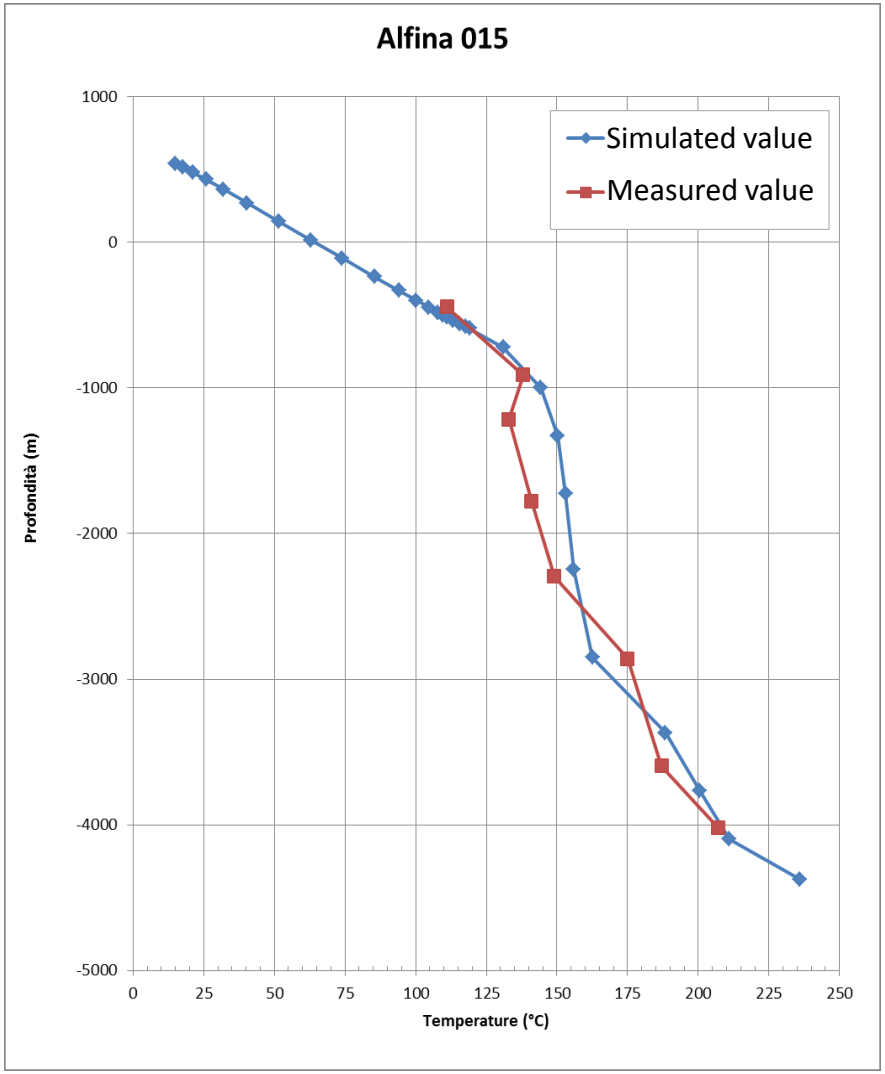
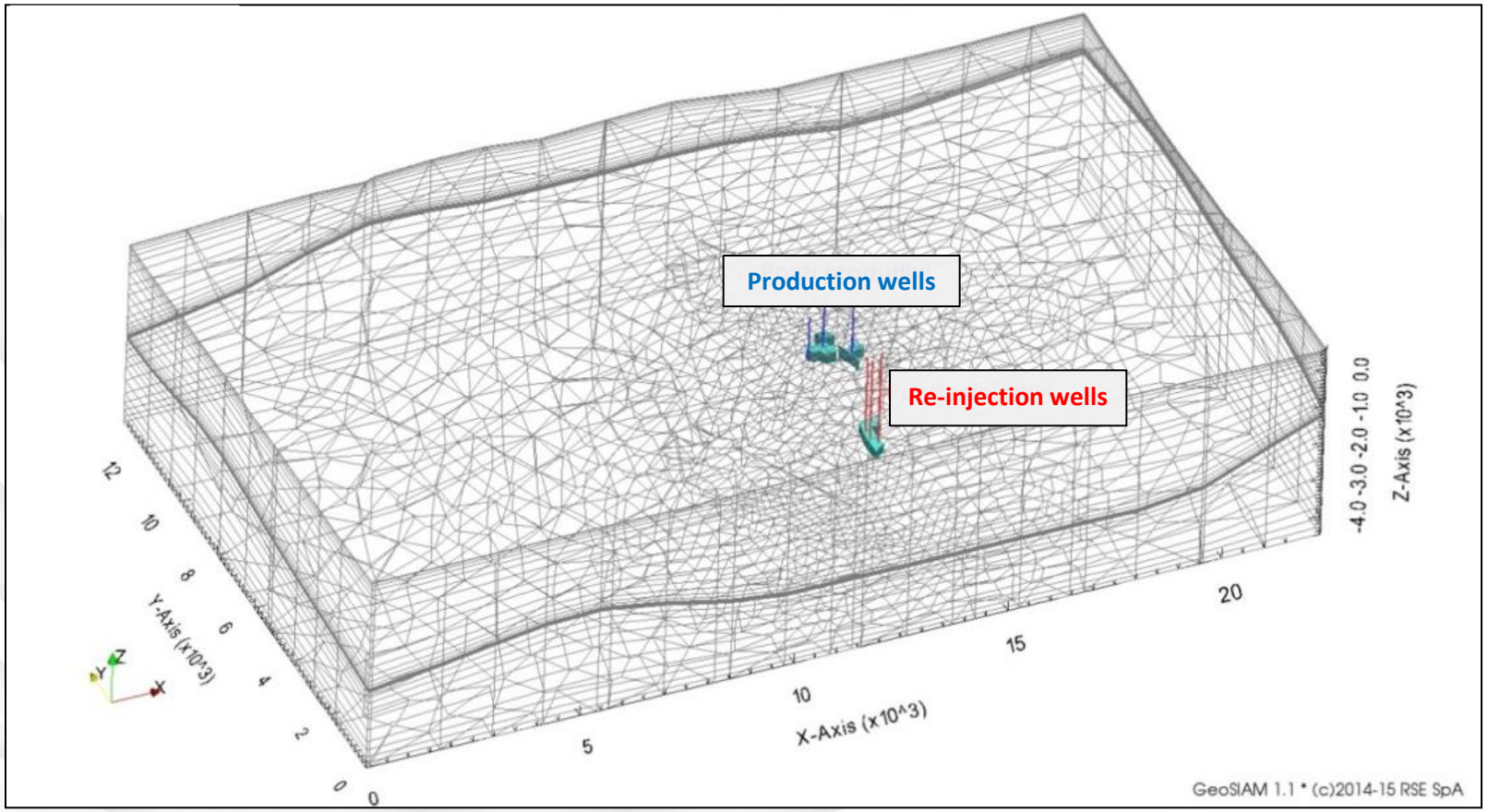


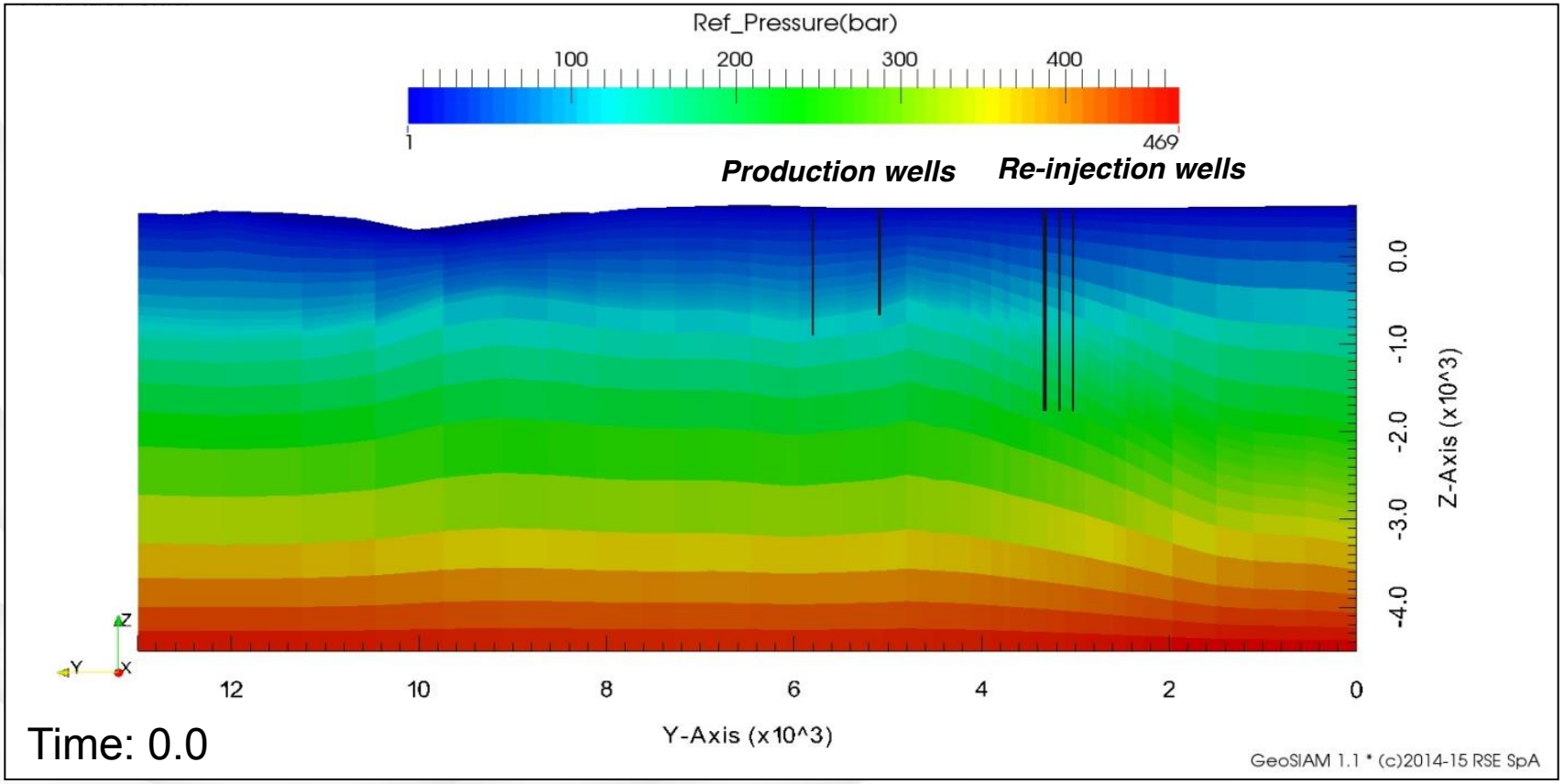
# Production/re-injection scenarios

- **5 production wells** and **4 re-injection wells** have been modeled
- different **scenarios** varying total flow, well distance and/or active length of wells have been simulated and compared



# Production/re-injection scenarios

- Fluid flow of **1050 ton/h** for **50 y**
- Active length 500 m
- Total simulated time **10000 years**



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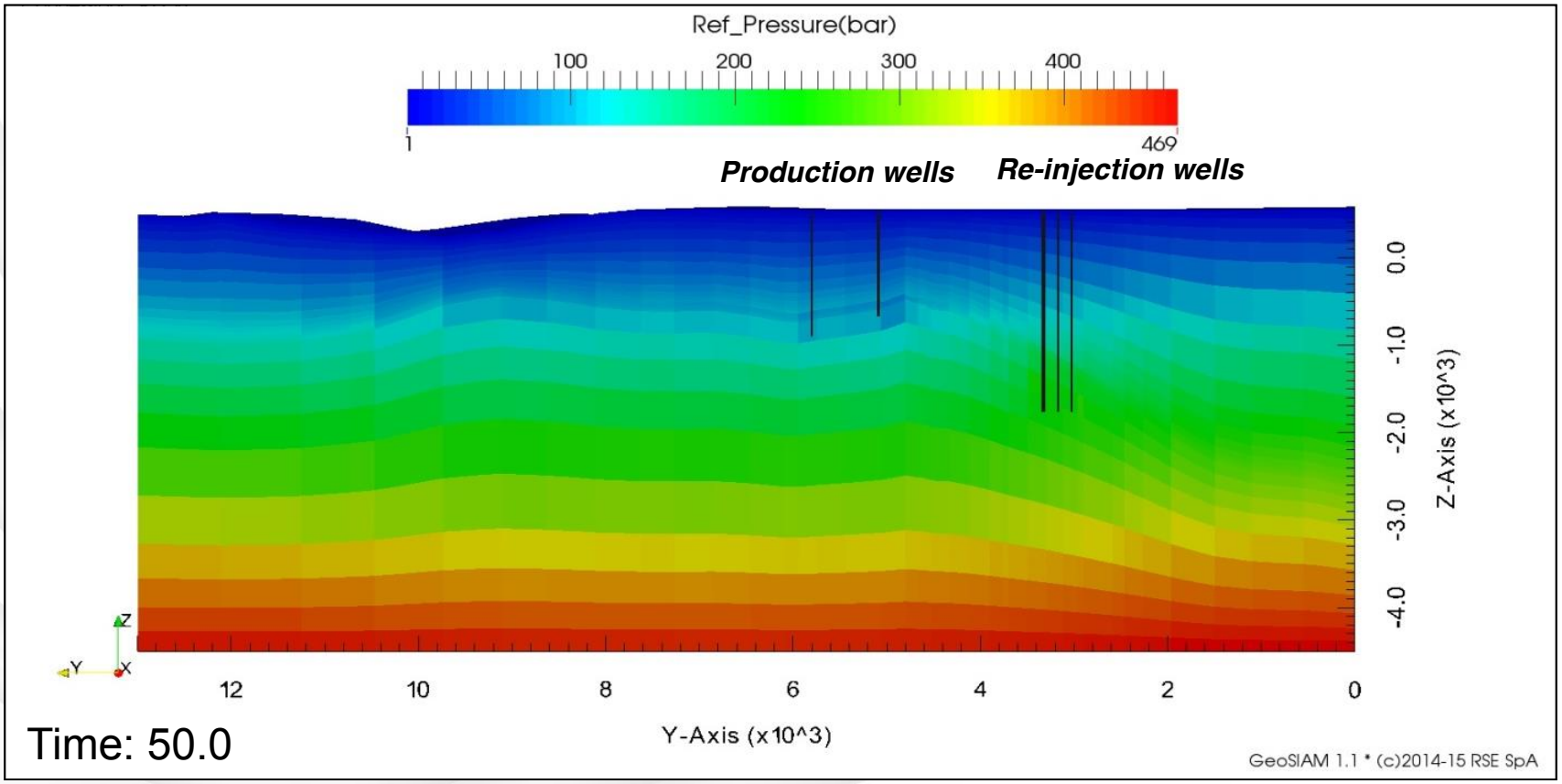

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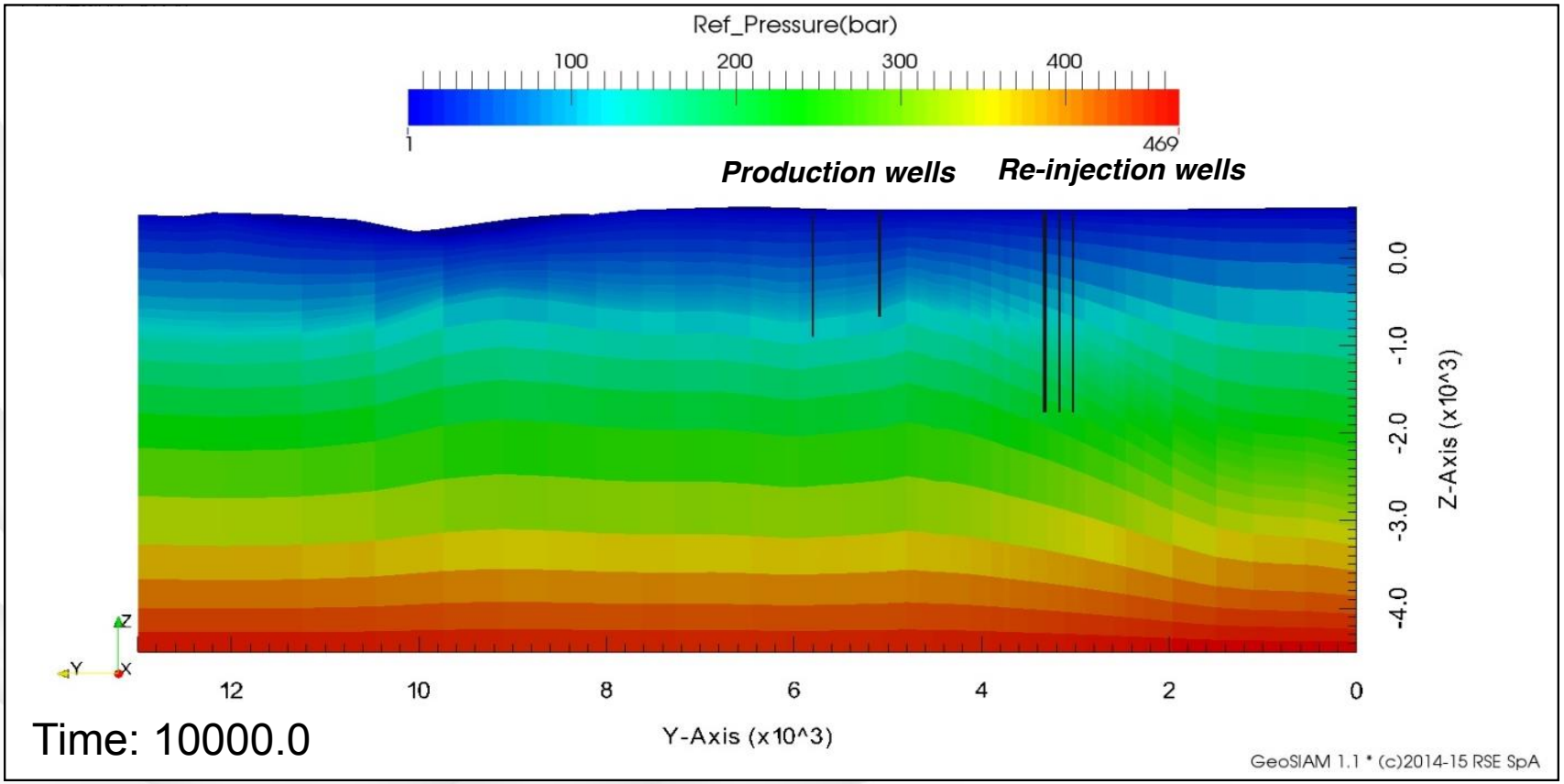

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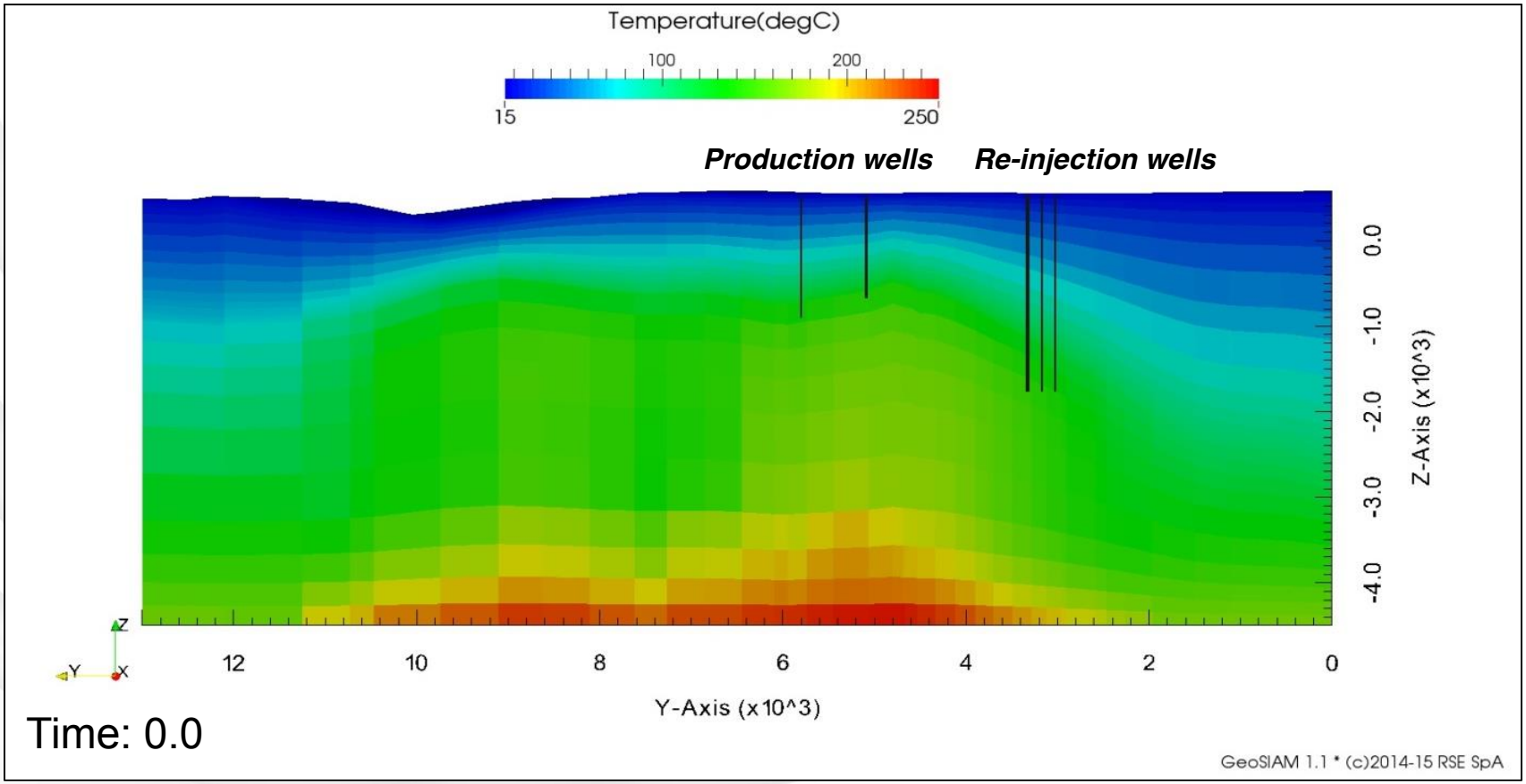

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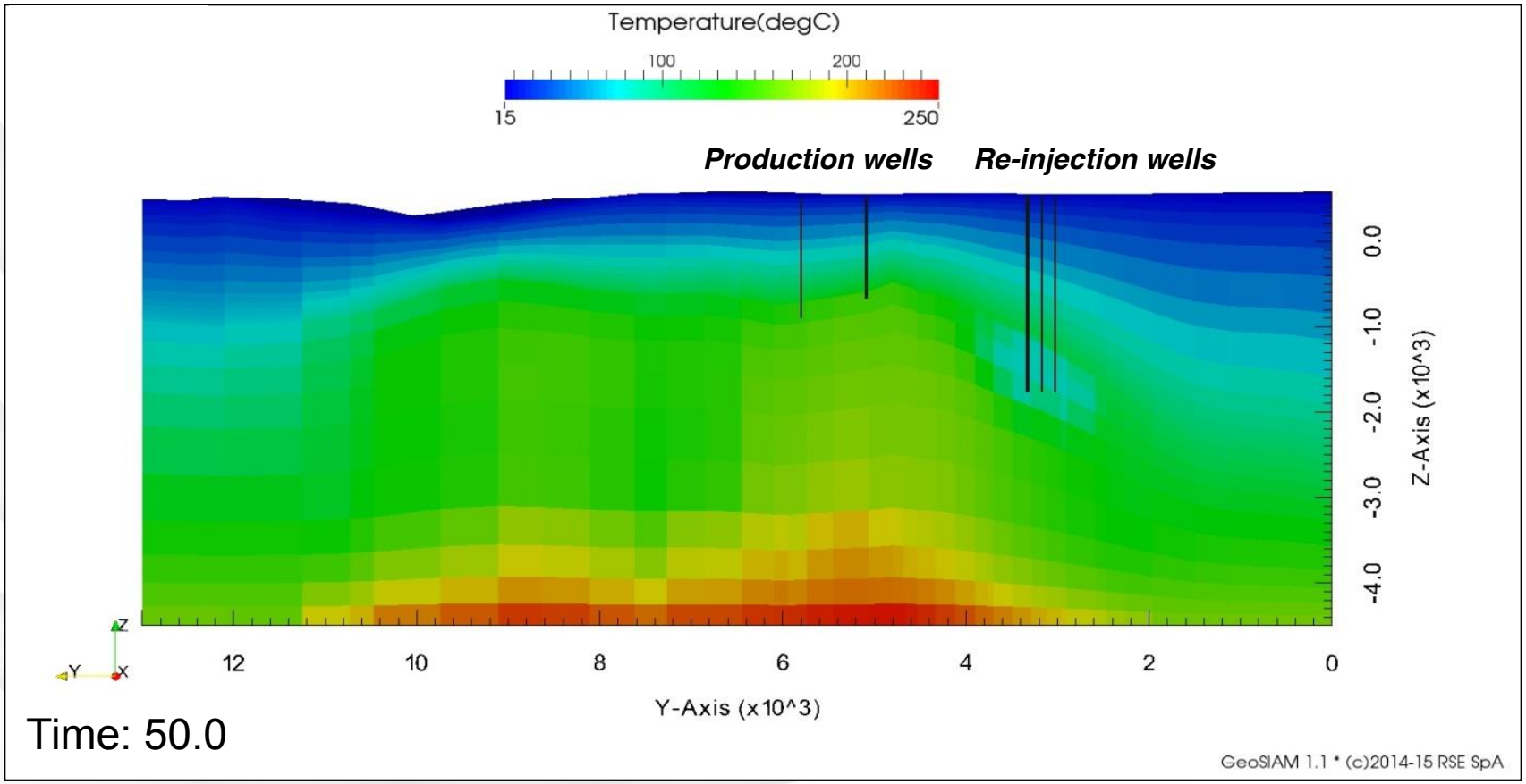

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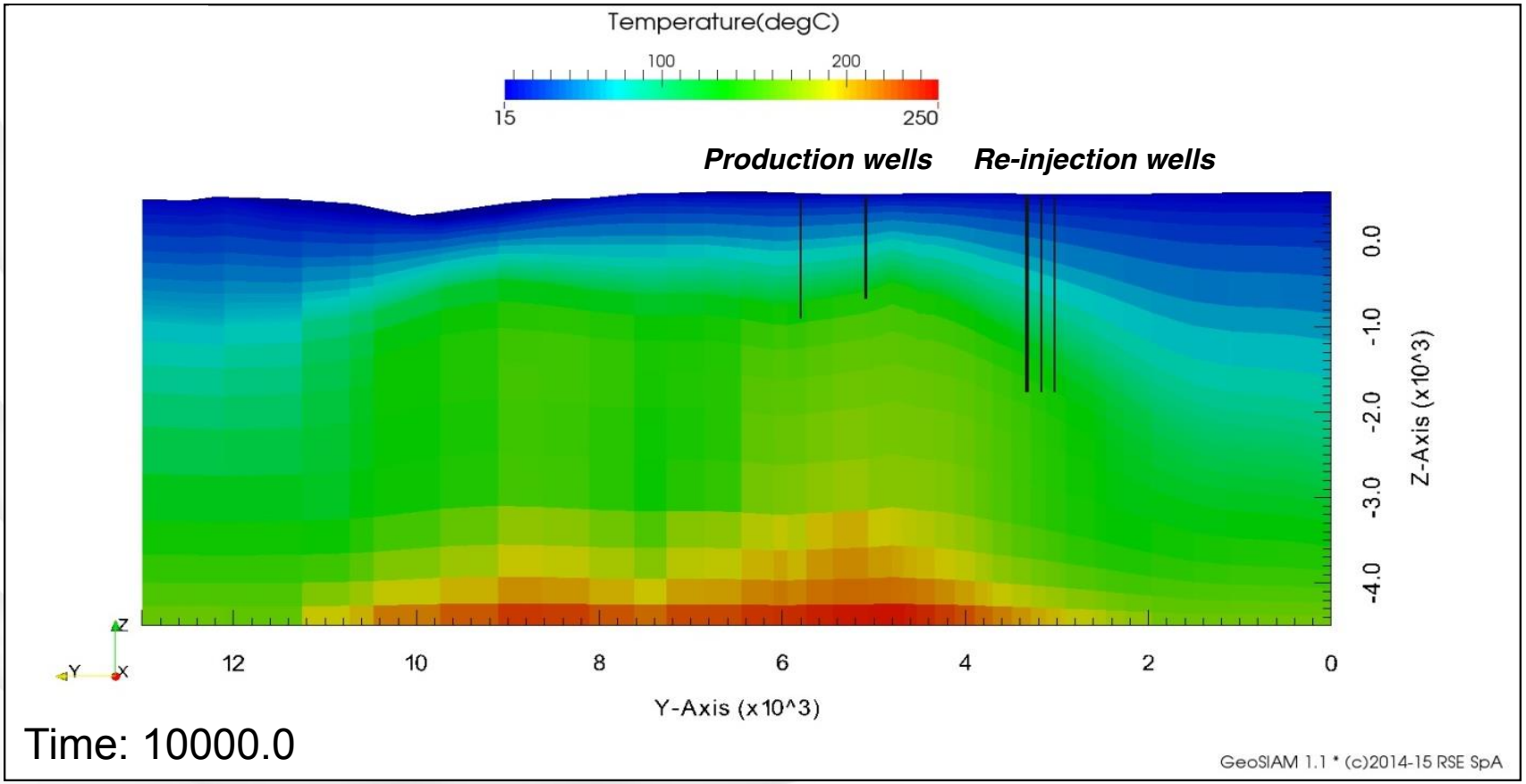
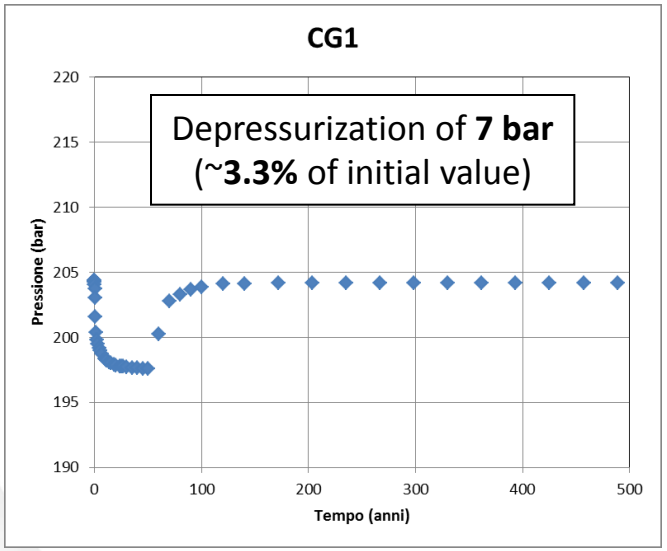
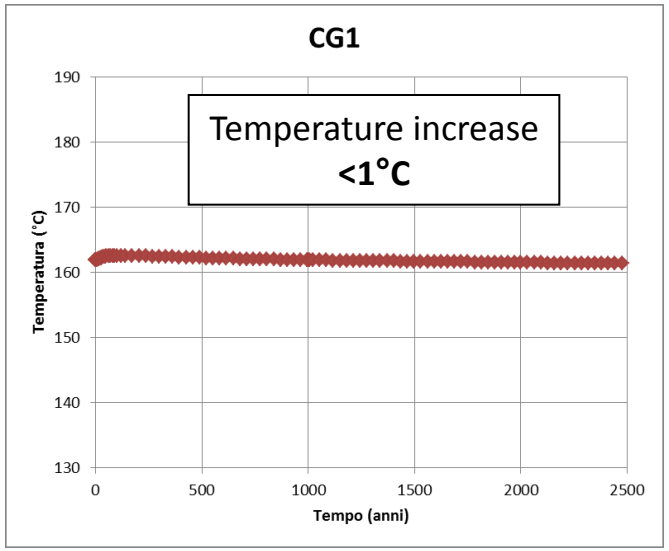


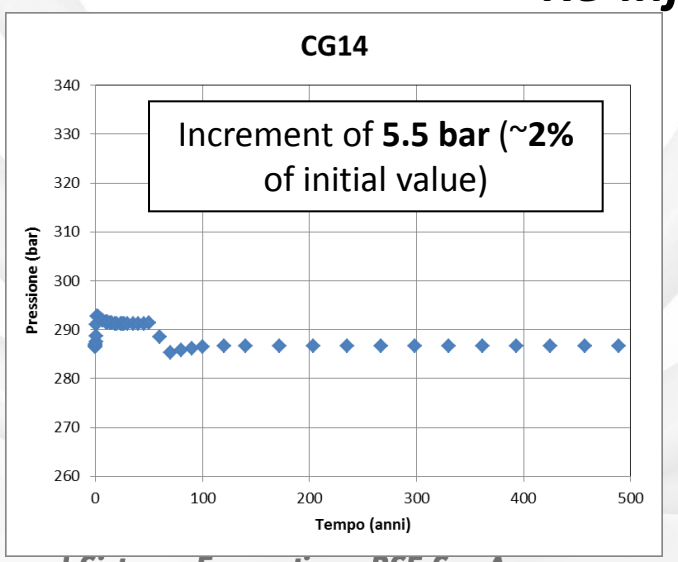
# Production/re-injection scenarios

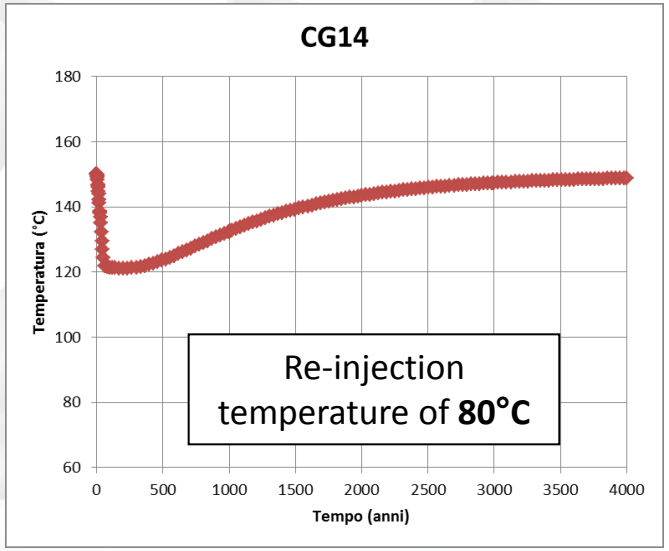
## Production wells




## Re-injection wells



# Conclusion

**For Castel Giorgio – Torre Alfina area an accurate 3D numerical model has been realized in order to verify the sustainability for geothermal electric production by a 5 MWe nominal power pilot plant:**

- **The accuracy of natural state of the field has been verified by comparing simulated and measured temperatures.**
  **A very efficient convective circulation inside the geothermal system has been observed.**

- **The scenarios of production/re-injection of fluids that have been carry out with a flow rate of 1050 t/h for 50 years have shown that the production sustainability is guaranteed for all the period.**
  **The over pressure field around the re-injection wells is limited to 2% of pre-existing one and no interference effect has been highlighted between the production and re-injection wells.**

# *Thanks for your attention*

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***Acknowledgments***
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