Analysis of microseismicity in Hengill Geothermal Area, SW Iceland

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INTRODUCTION

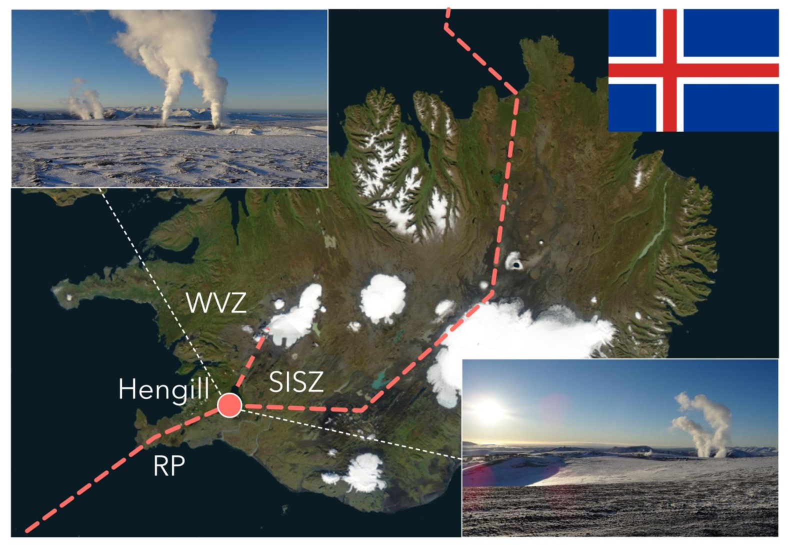

Fig.1: *Study area*

The Hengill geothermal system, SW Iceland, started to be exploited for electrical power and heat production since the late 1960s, and today the two largest operating geothermal power plants are Nesjavellir and Hellisheidi.
This area is a complex tectonic and geothermal site, being located at the triple junction between the Reykjanes Peninsula (RP), the Western Volcanic Zone (WVZ), and the South Iceland Seismic Zone (SISZ).
The region is seismically highly active with several thousand earthquakes located yearly. The origin of such earthquakes may be either natural or anthropogenic.

NETWORK AND DATASET

Since November 2018, within the EU GEOTHERMICA project COSEISMIQ (COntrol SEISmicity and Manage Induced earthQuakes), the number of stations operating in the Hengill geothermal area has increased from 16 to 40. The seismic network consists of permanent and temporary short (5 and 1 s) and broad-band (120 and 60 s) sensors.

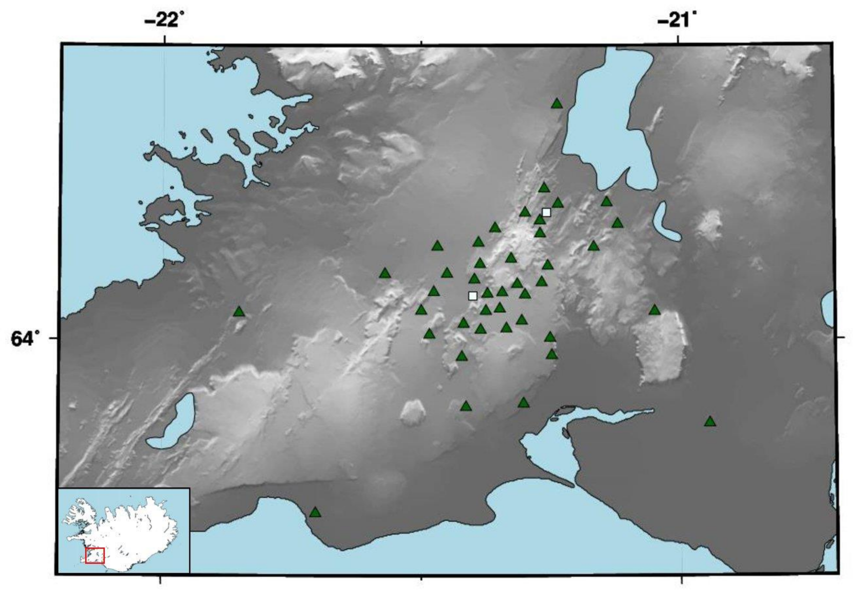

Fig.2: *Seismic network*

- About 367 seismic events with 0.8 < ML < 4.7 recorded between the end of 2018 December and 2019 January 30.
- The mainshock occurred on 2018-12-30, with ML = 4.7.
- Large number of low magnitude events, with high frequency and noise contaminated signals, affecting the magnitude estimation process.
- A bandpass filter from 2 to 15 Hz has been applied for the entire dataset.

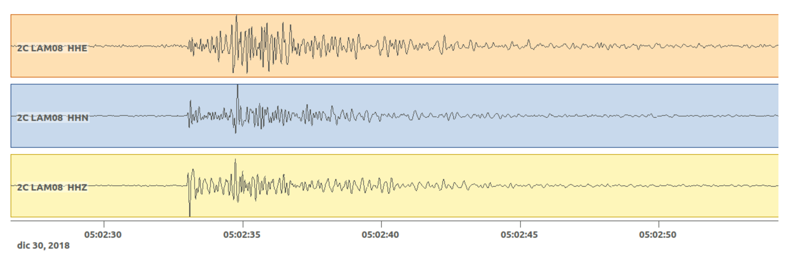

Fig.3: *Filtred seismic waveforms*

EARTHQUAKES LOCATION

Earthquake location has been performed by using the LOKI algorithm (Location of seismic events through traveltime staking, Grigoli et al. 2013), which performs detection and location based on a waveform coherence analysis.

- Three different velocity model have been tested.
- 3D cartesian grid space set to $136x126x50\ km^3$ with 0.4 km grid spacing
- Short-time window length in range of 0.1 - 0.15 s, the long time window is twice as long

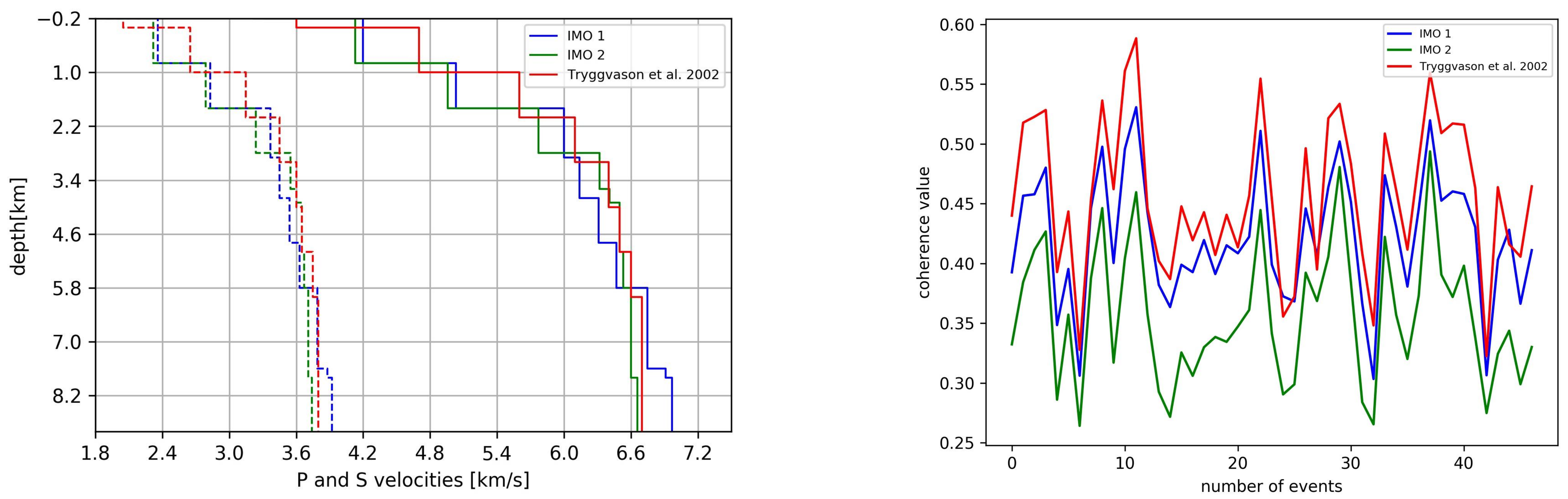

Fig.4: *Coherence values for three velocity models used: the velocity model from Tryggvason et al., 2002 has the best value of coherence*

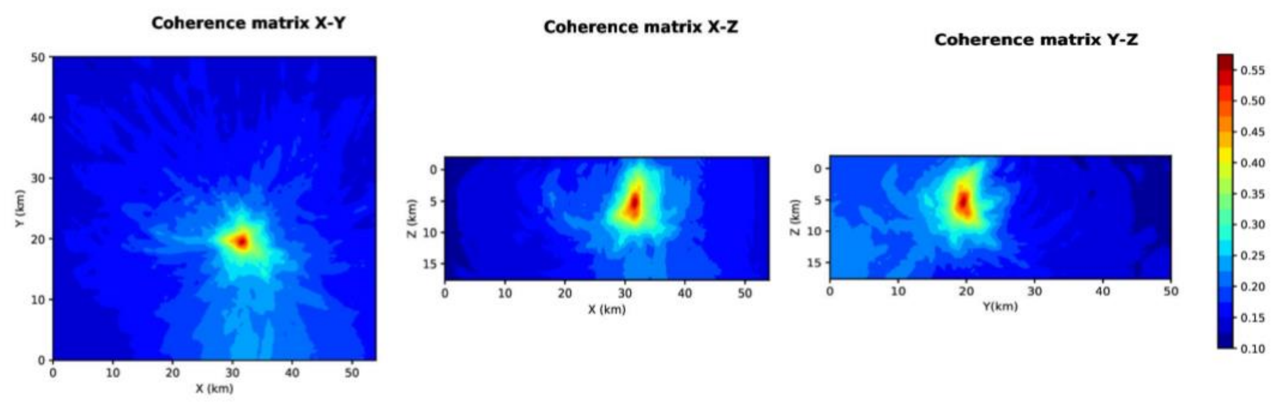

Fig.5: *coherence matrices XY, XZ, and YZ related to the earthquake occurred on 2018 December 30.*

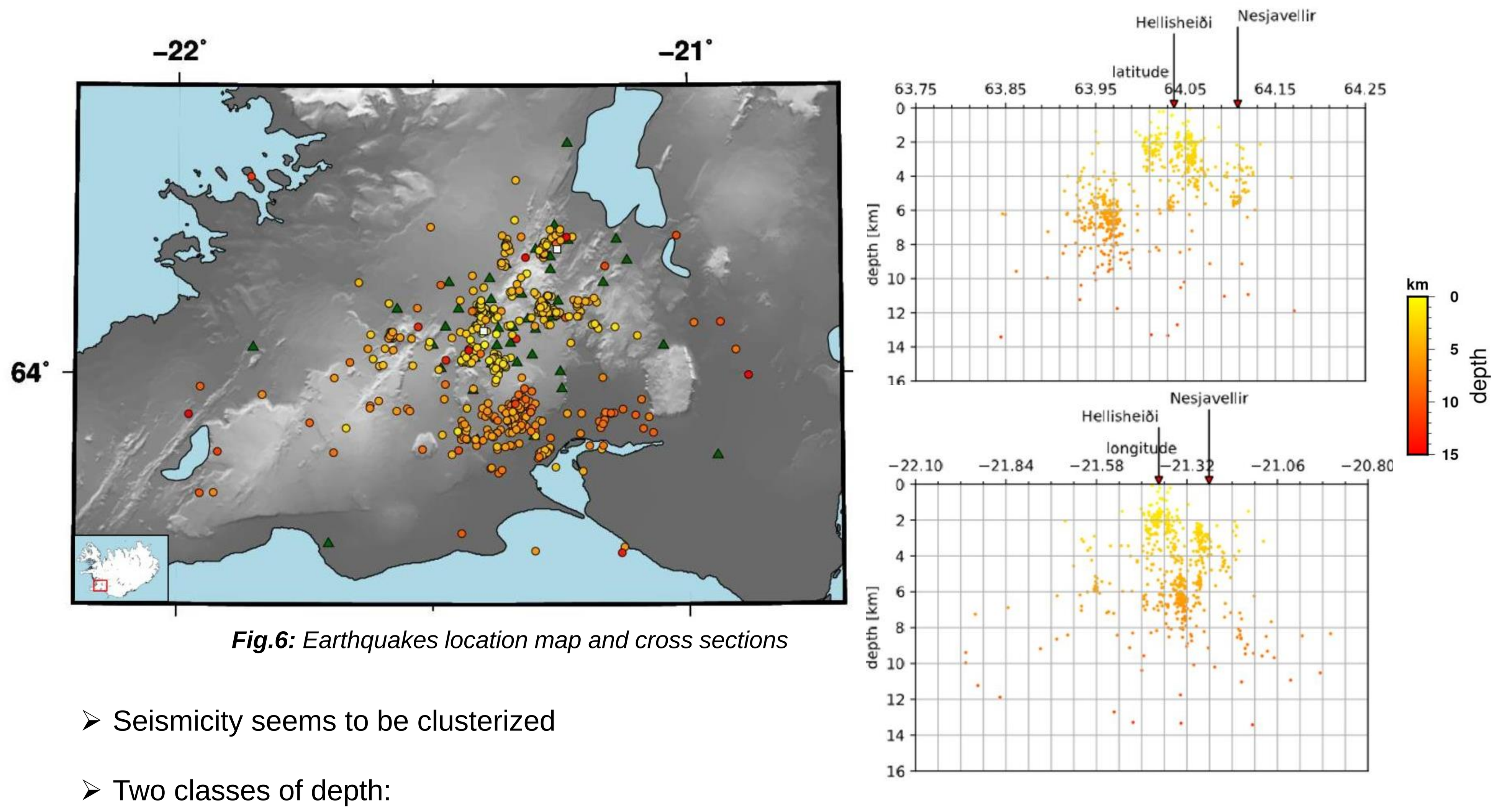

Fig.6: *Earthquakes location map and cross sections*

- Seismicity seems to be clusterized
- Two classes of depth:

1) Shallower events occurred in the proximity of the geothermal plants, and most of them have depth < 3 km.

1) Deeper events appear as a bigger separate cluster located outside the geothermal area, on the neighboring SISZ.

HYPOCENTRAL CLUSTERING

Hypocentral clustering has been computed using seiscloud, a clustering algorithm for seismicity based on the DBSCAN clustering (Density-Based Spatial Clustering of Applications with Noise)(Ester et al., 1996).

- Minimum number of sample = 10
- $\mathcal{E}$ = 1 km

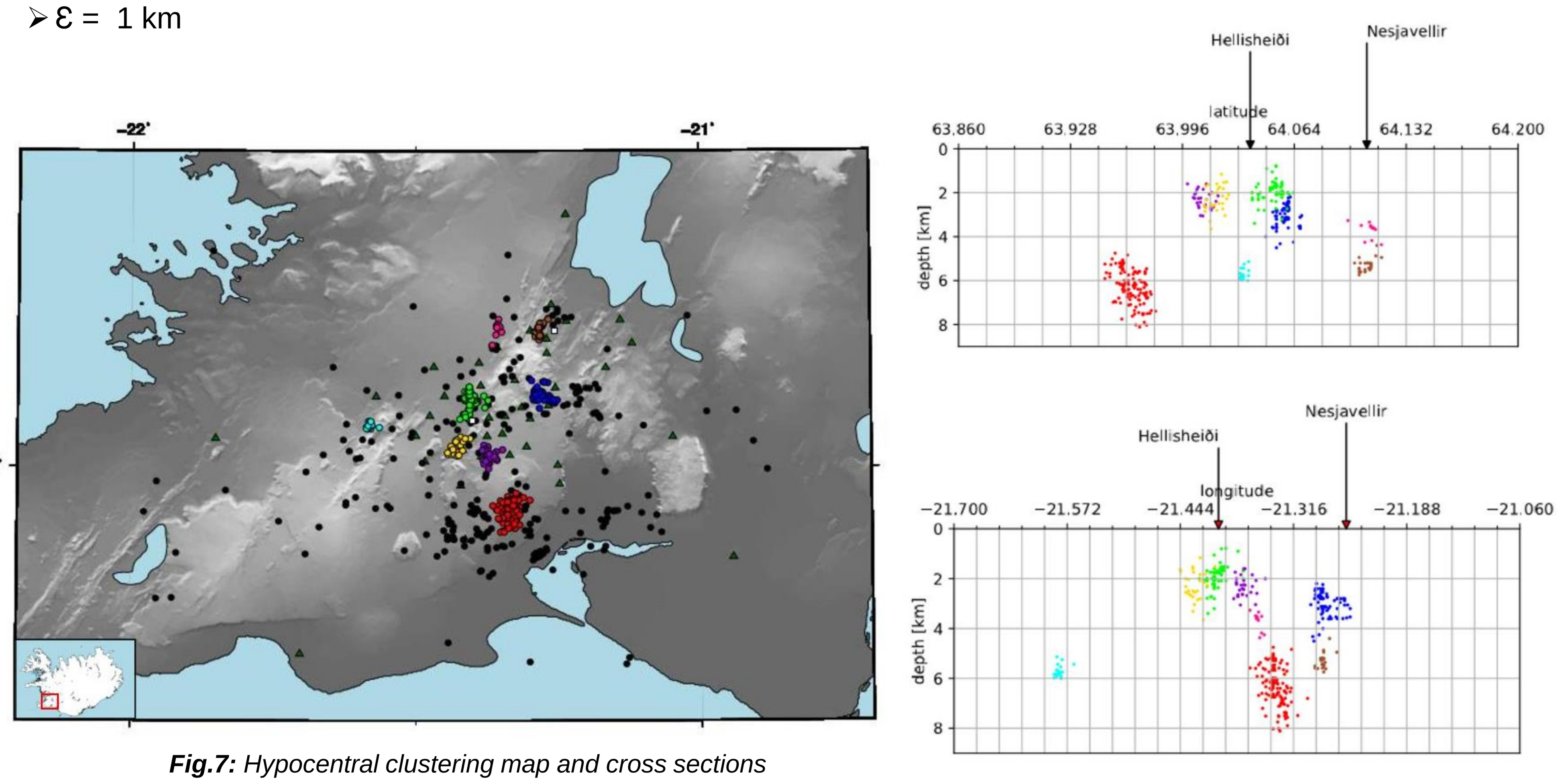

Fig.7: *Hypocentral clustering map and cross sections*

- 8 clusters
- Clusters in the centre of geothermal area are shallower and located in the vicinity of one geothermal plant.
- Other clusters are deeper and occurred at the edge of geothermal site.
- the biggest one (in red) is deeper and located further south of geothermal area respect to other clusters, and its depth trend show an E-dipping. The mainshock of seismic sequence belong to this cluster.

DISCUSSION AND CONCLUSION

- We can divide the seismicity in two main groups:

  The first group is represented by shallower clusters, located close to geothermal sites, and seems to be associated to some extent geothermal energy exploitation operations in the area.

  The second group consists on deeper clusters that seems to border the geothermal area.
  The biggest cluster is quite separate from the others and seems to be mosly associated to tectonic transform zone.

- We have a fully automated and robust tool for the location of microseismic data, whose solutions was directly used for seismological analysis and advanced interpretation in a complex tectonic and geothermal site.

REFERENCES FOR THIS WORK

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