SpacePart12

Subsurface Density Mapping of Earth and Mars with Cosmic Ray Muons

Hiroyuki Tanaka

The University of Tokyo

X-ray **photo**graphy

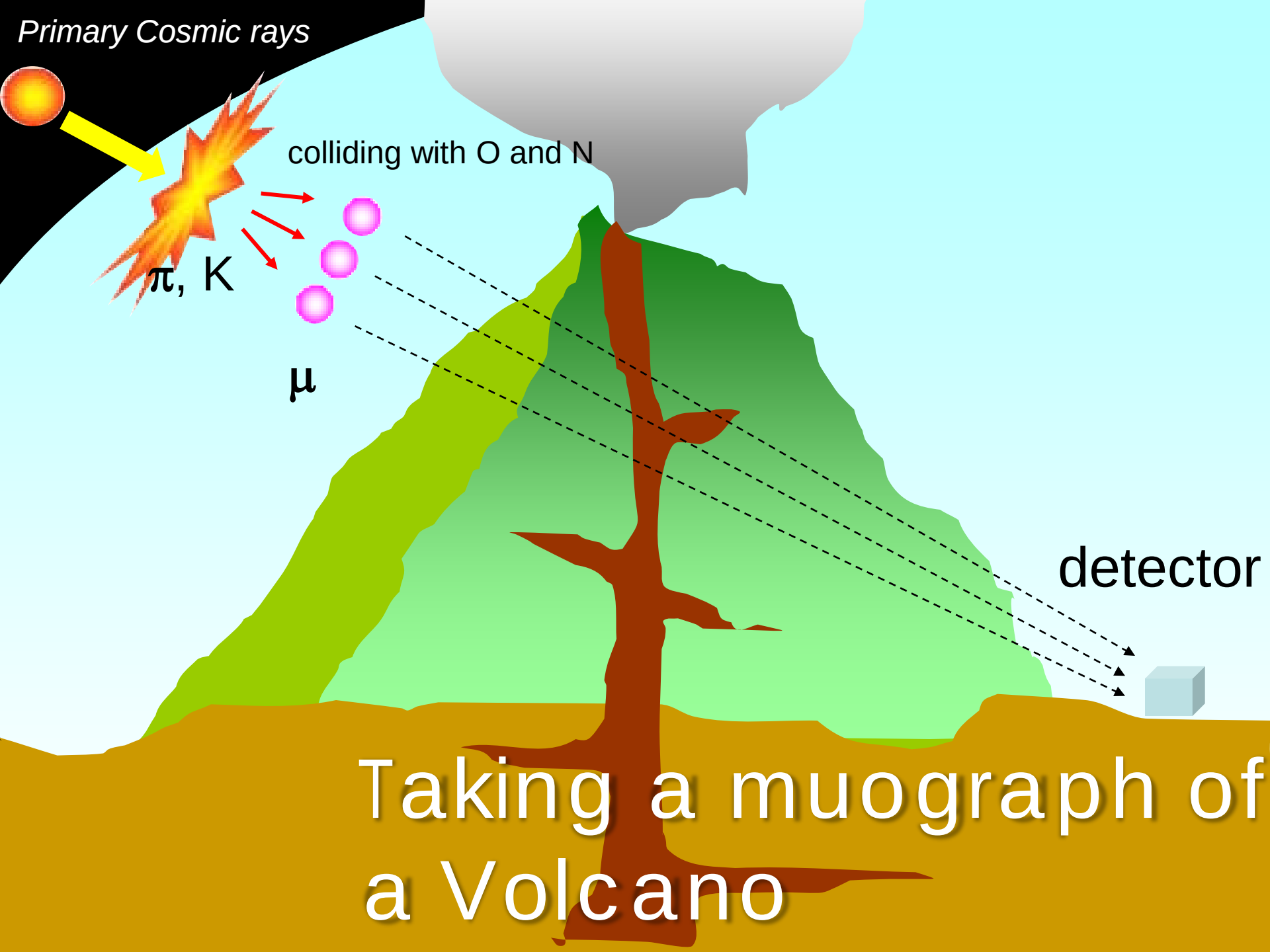
muography

neutrinography

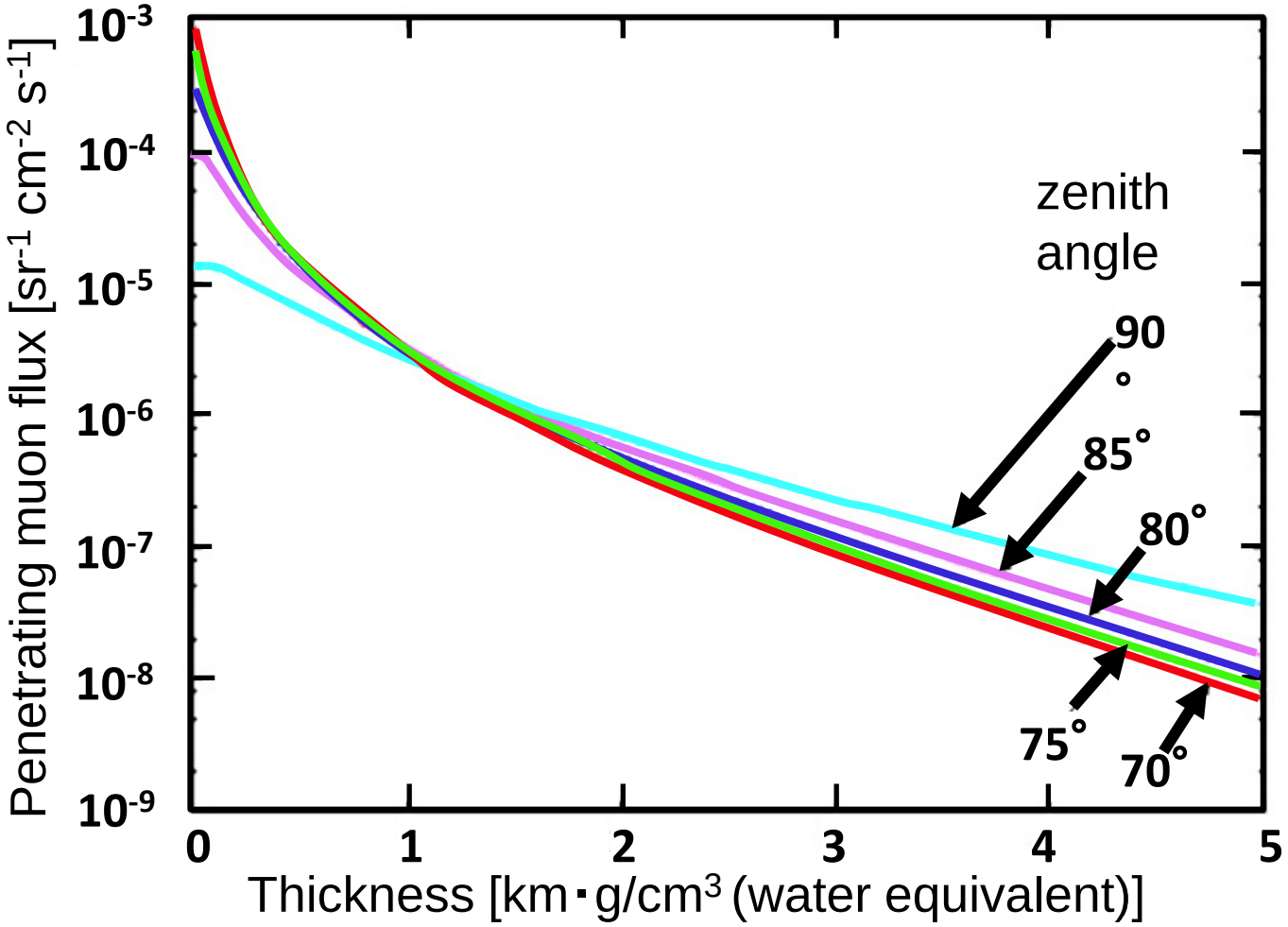
m km Mm Spatial scale

Today's topic

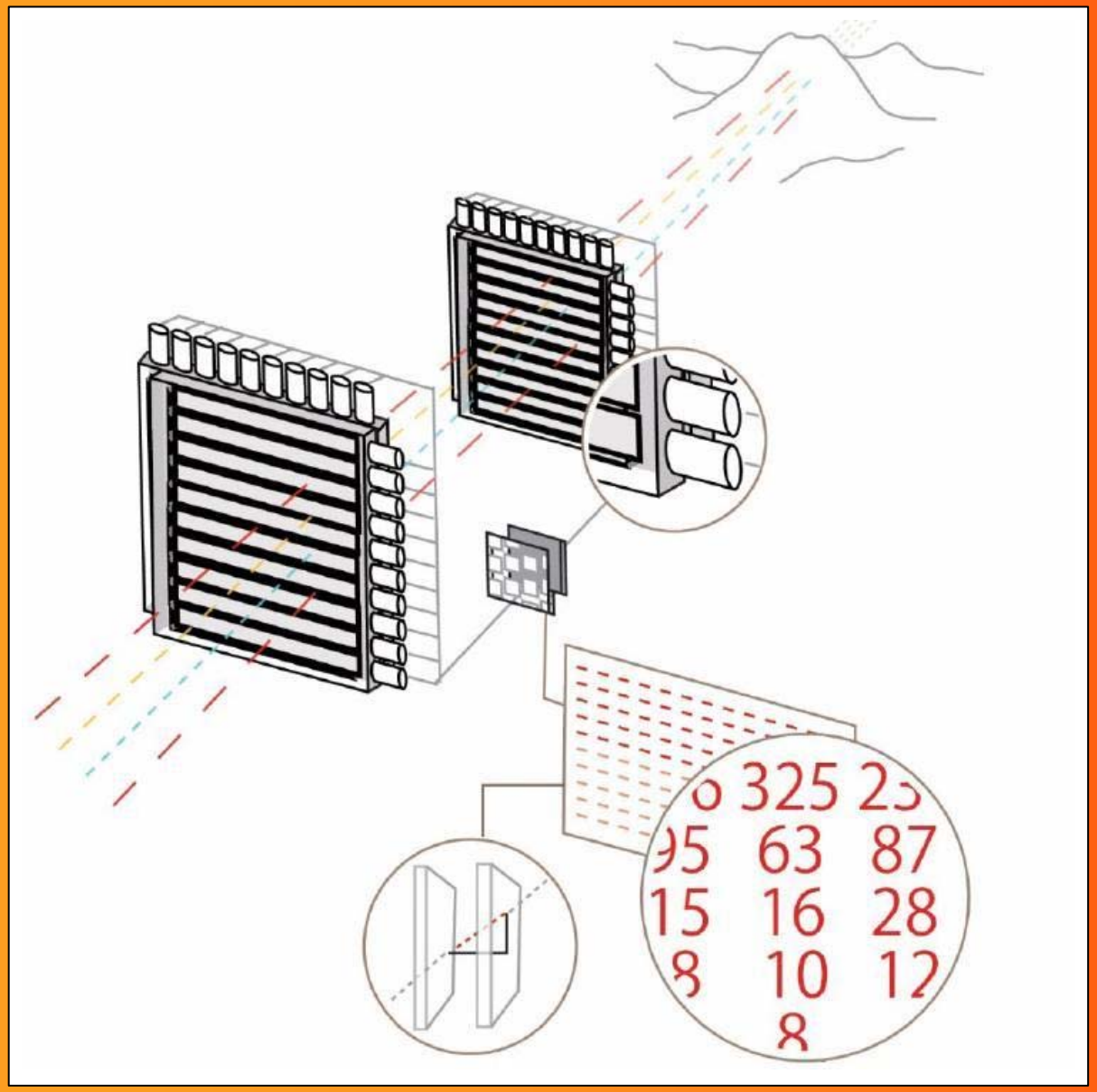
Radiography of Gigantic Objects



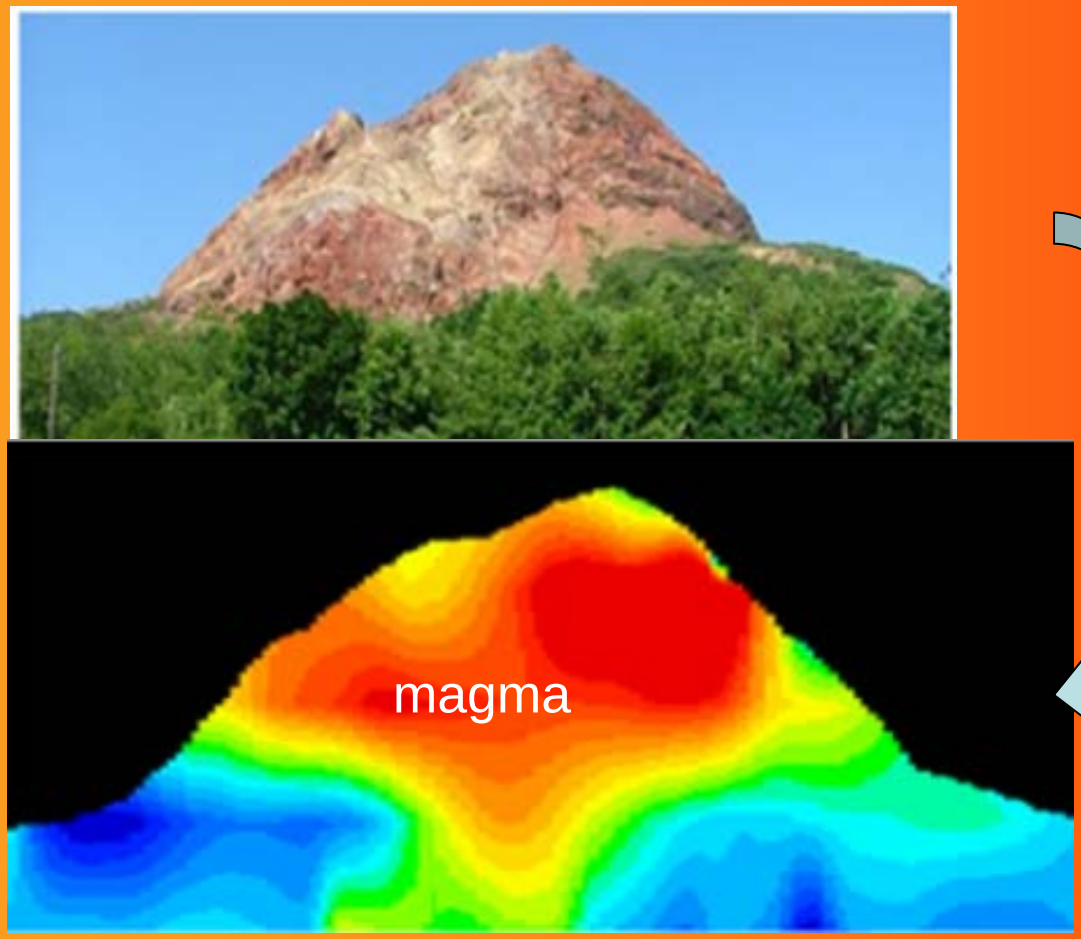
Taking a muograph of a Volcano



How to determine density



Muon Detector



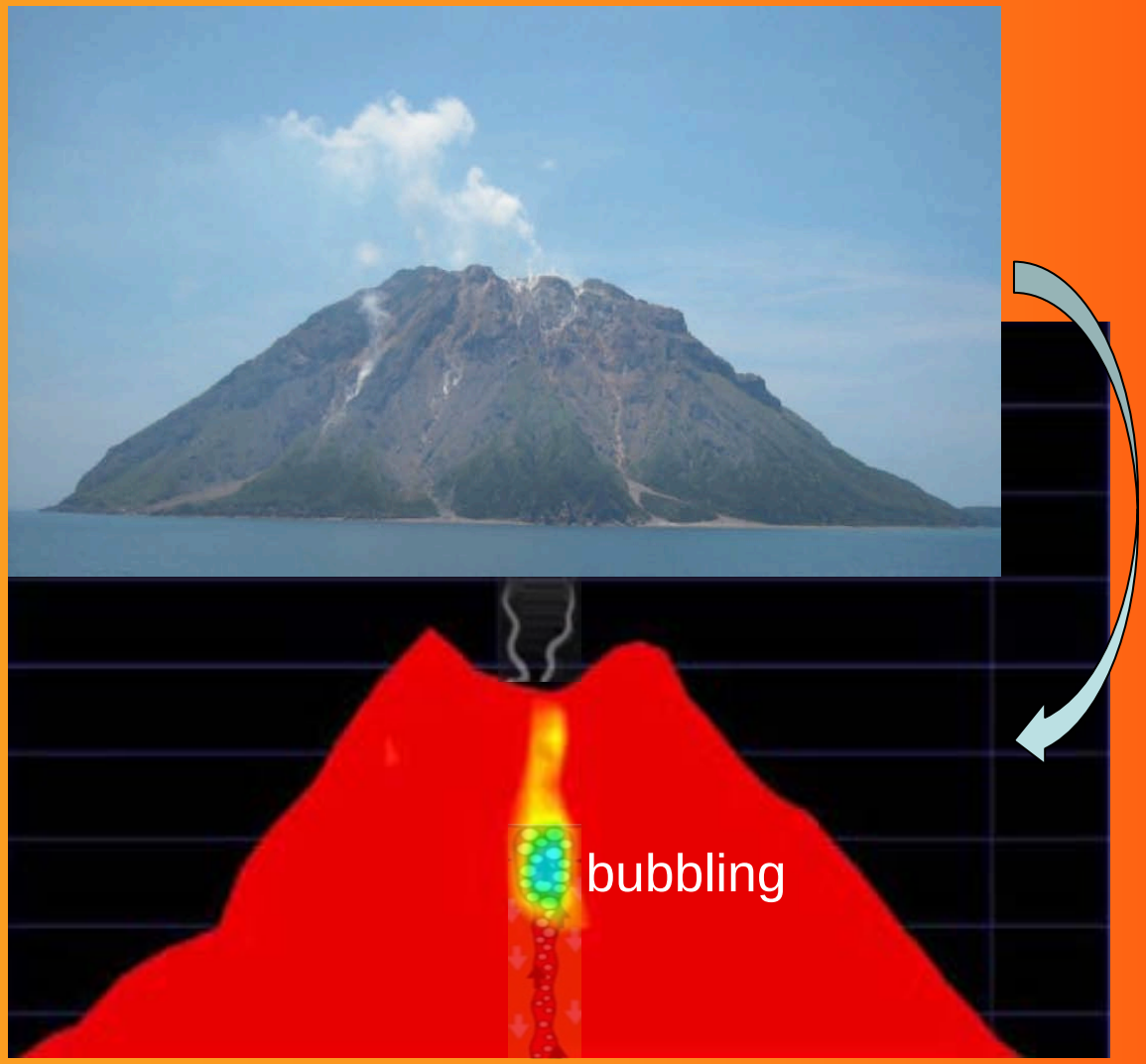
muograph

low

high

Density

Density mapping



Bubbling magma

- Spatial resolution
- Passive
- Real time monitoring

But we cannot see beneath the detector

What is the advantage of muography?

- When? → seismic monitoring

  getting possible

- How long (= magnitude)?] cosmic ray monitoring

  still difficult

- Where?

Eruption Prediction
-3 factors-

buried muon detector

wireless LAN antenna

entrance

Monitoring volcanic eruptions


上田技研レンタル
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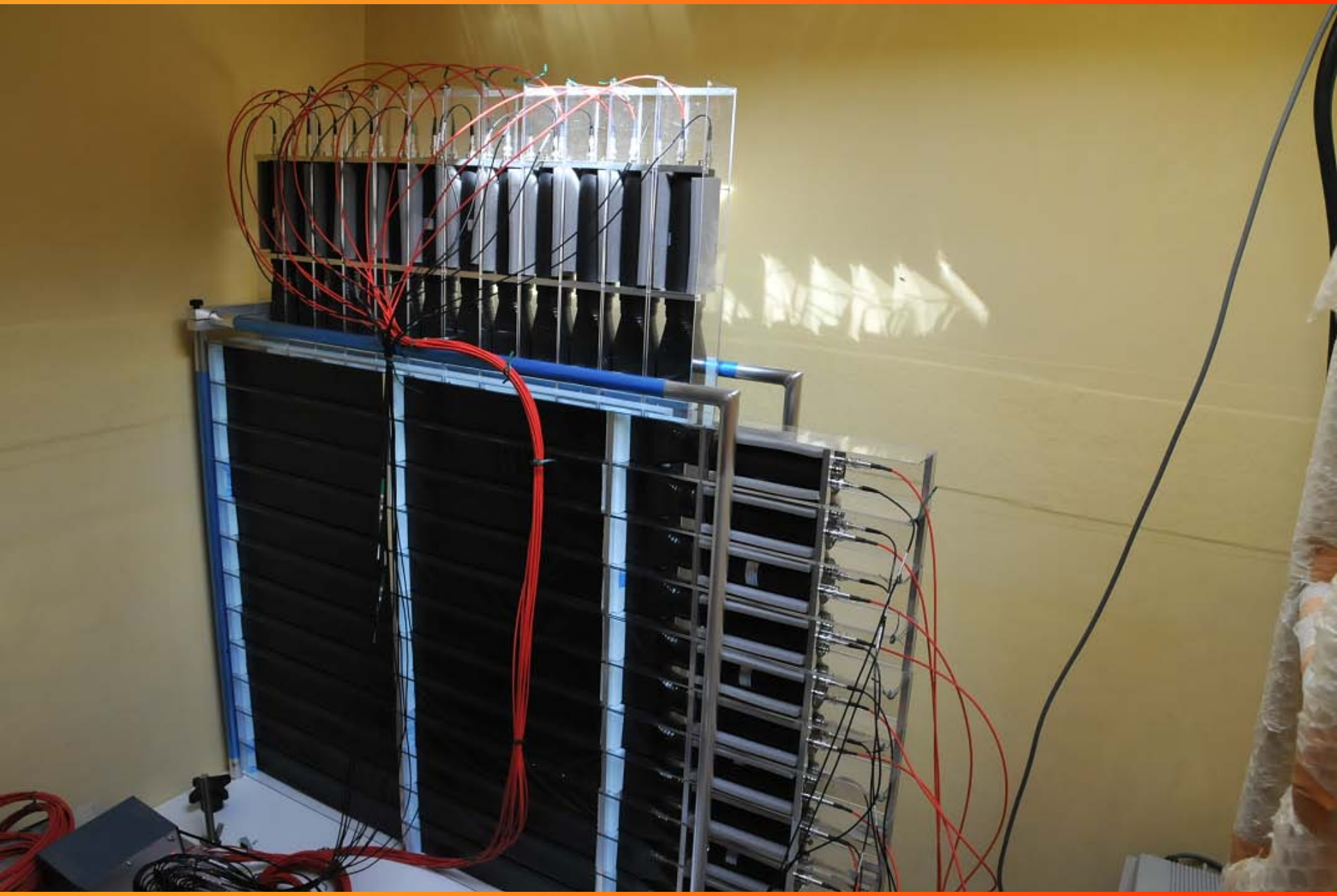

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nature

EDITORIALS

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RESEARCH HIGHLIGHTS

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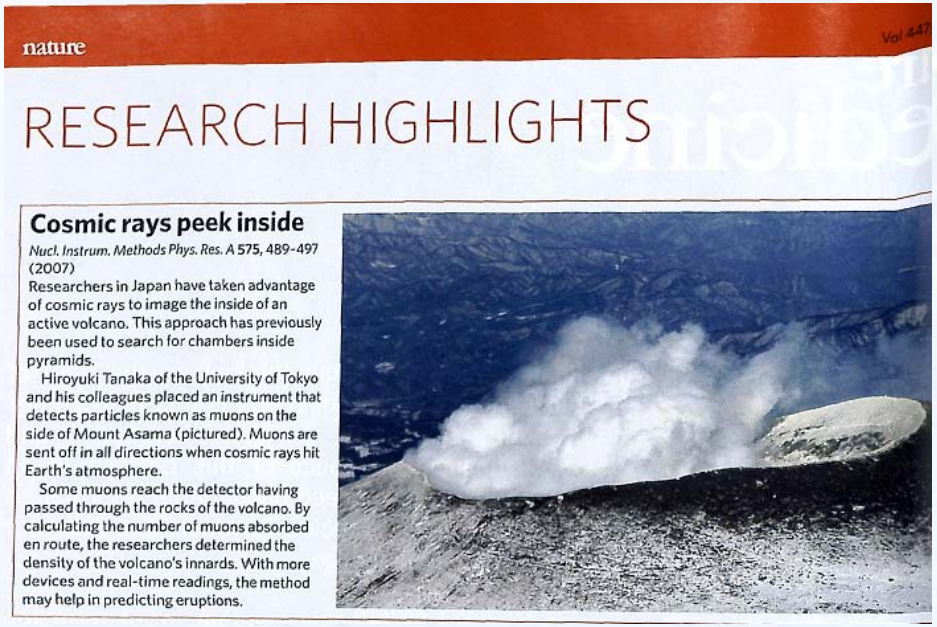
357 JOURNAL CLUB Ocean plankton and climate
Peter S Liss



nature

RESEARCH HIGHLIGHTS

Cosmic rays peek inside

Nucl. Instrum. Methods Phys. Res. A 575, 489-497 (2007)

Researchers in Japan have taken advantage of cosmic rays to image the inside of an active volcano. This approach has previously been used to search for chambers inside pyramids.

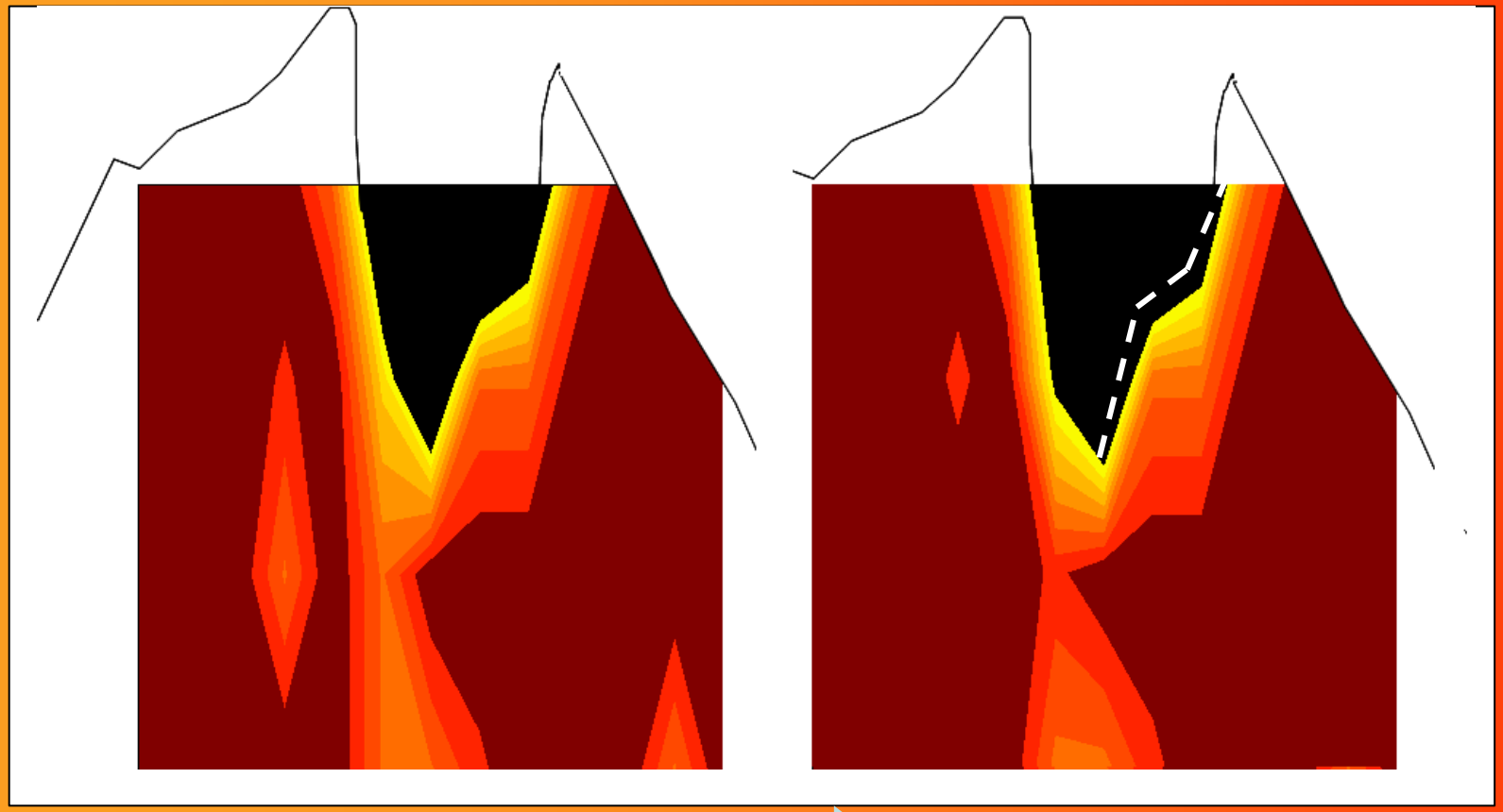
Hiroyuki Tanaka of the University of Tokyo and his colleagues placed an instrument that detects particles known as muons on the side of Mount Asama (pictured). Muons are sent off in all directions when cosmic rays hit Earth's atmosphere.

Some muons reach the detector having passed through the rocks of the volcano. By calculating the number of muons absorbed en route, the researchers determined the density of the volcano's innards. With more devices and real-time readings, the method may help in predicting eruptions.

Inside Asama

~100 km from Tokyo

Feb 2009 Asama eruption



before

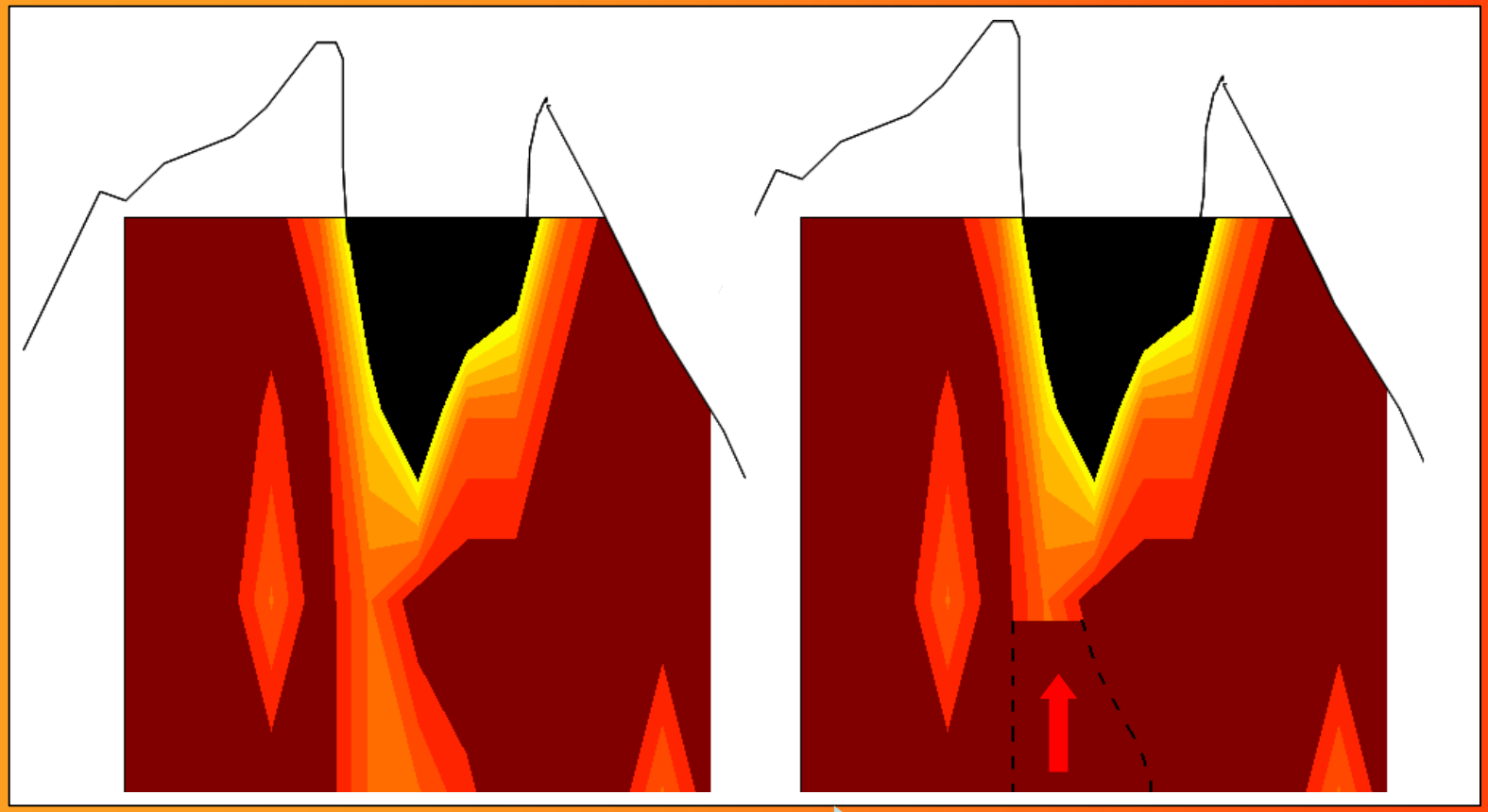
after

low

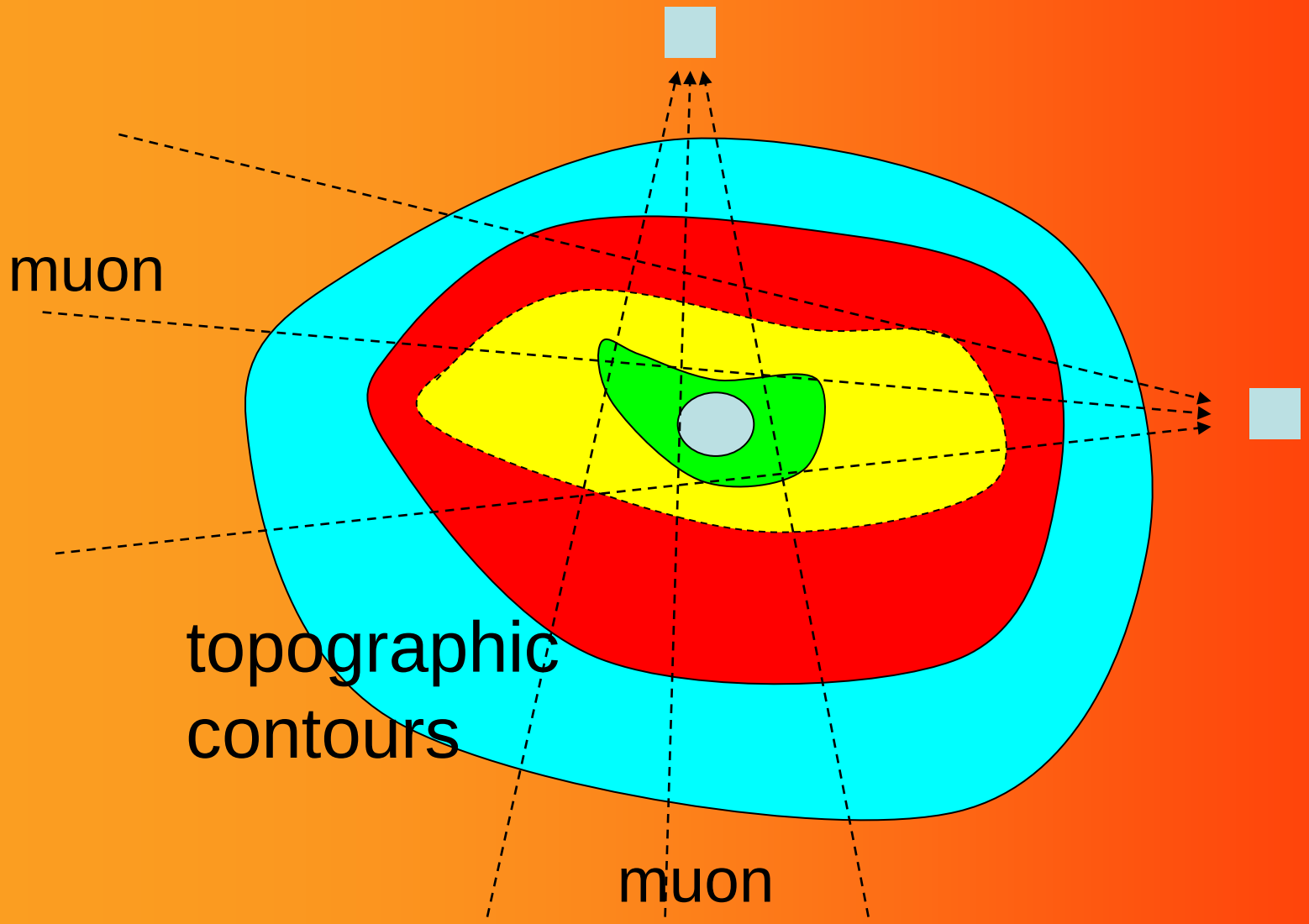
high

Density

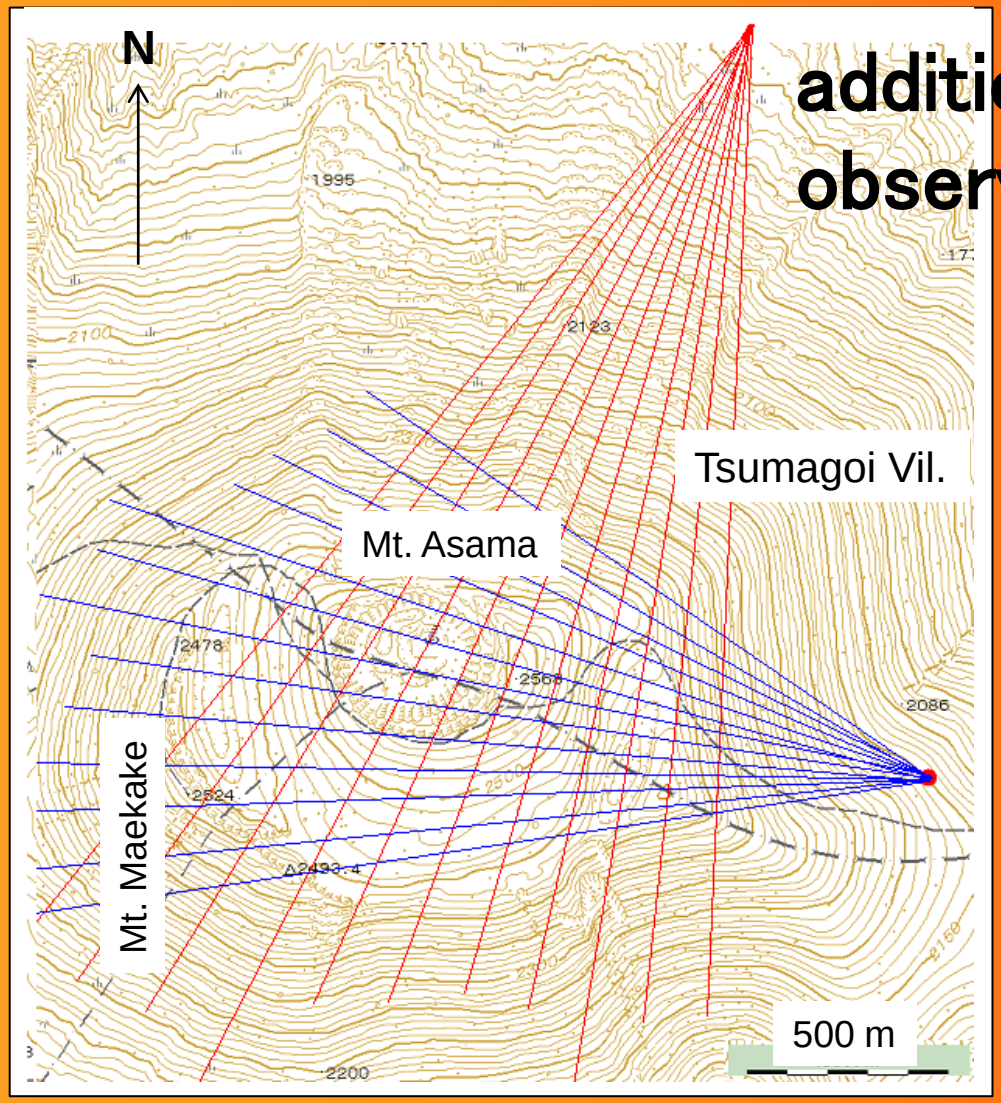
Mapping before and after eruption



If magma ascended…



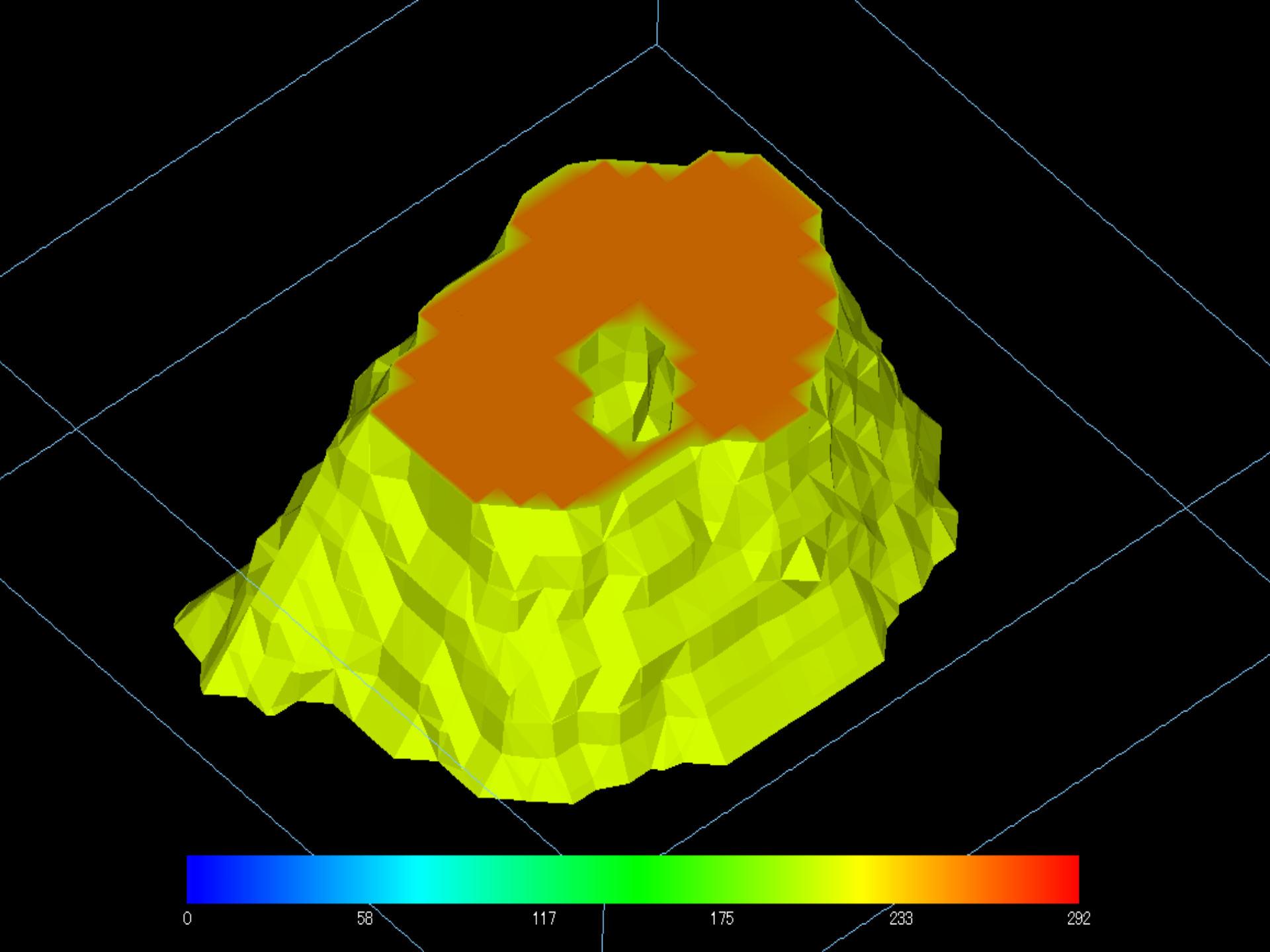
3-d slicing a volcano



additional observation point

original obsevation point

Bidirectional muography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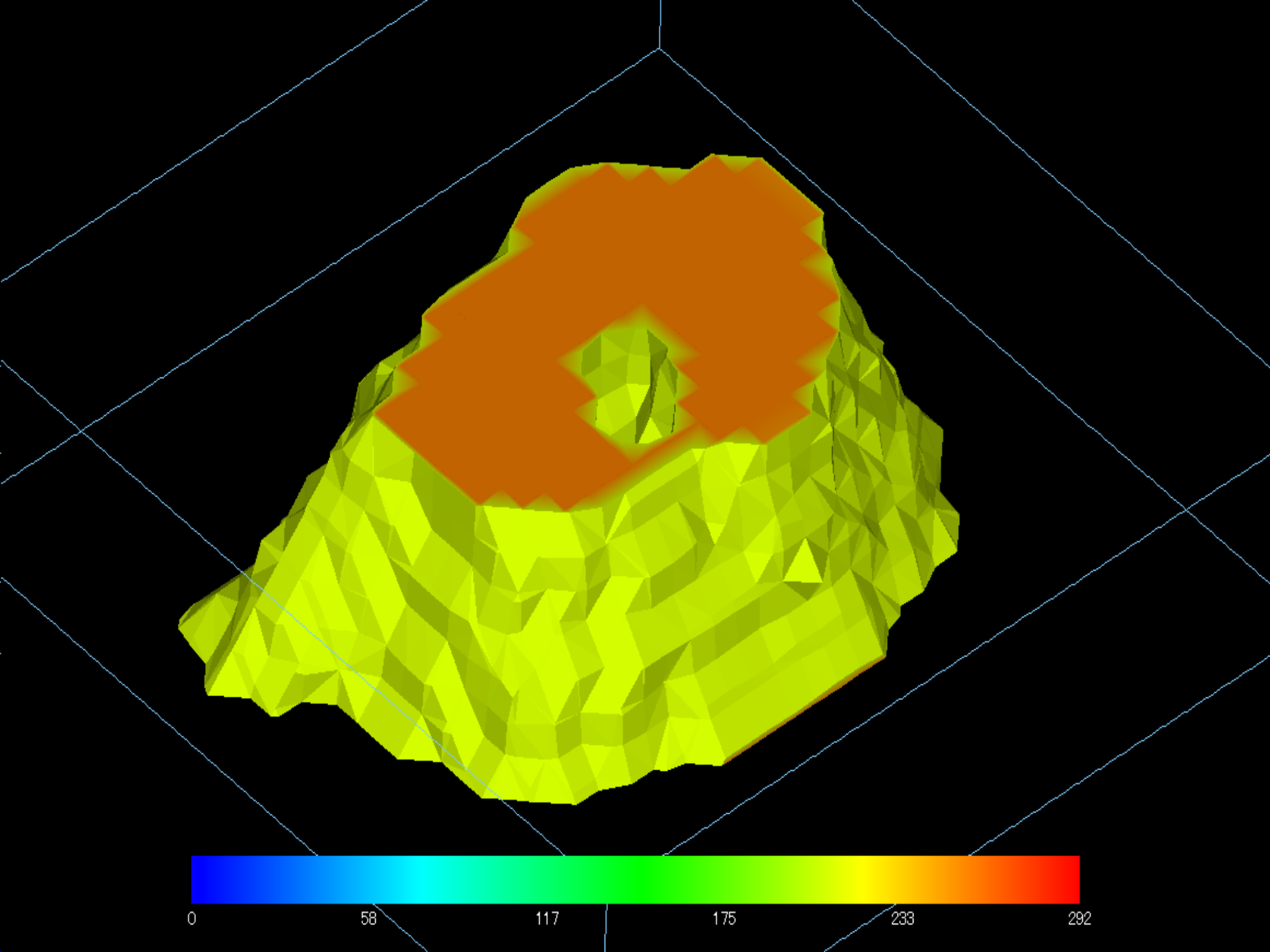
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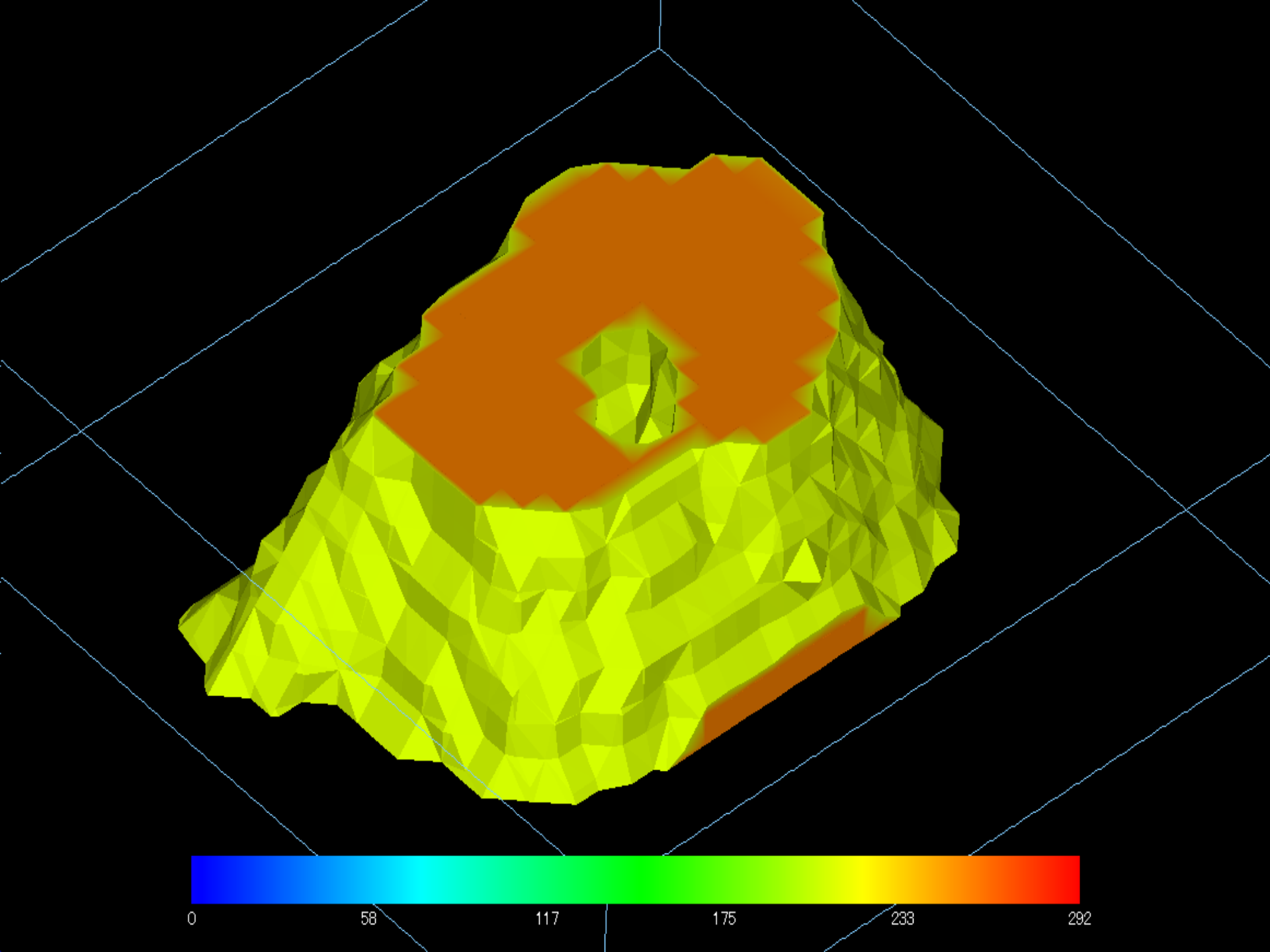
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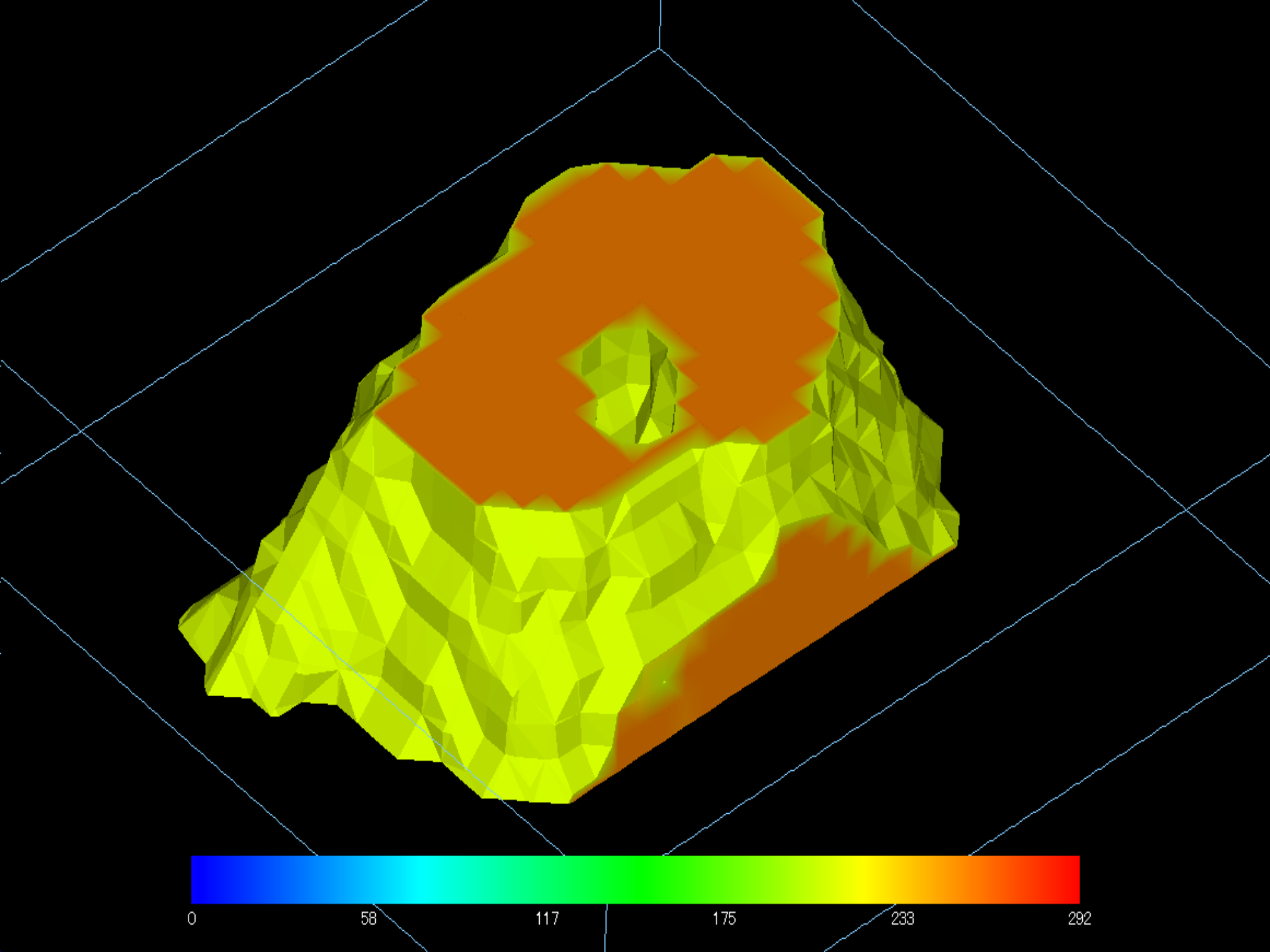
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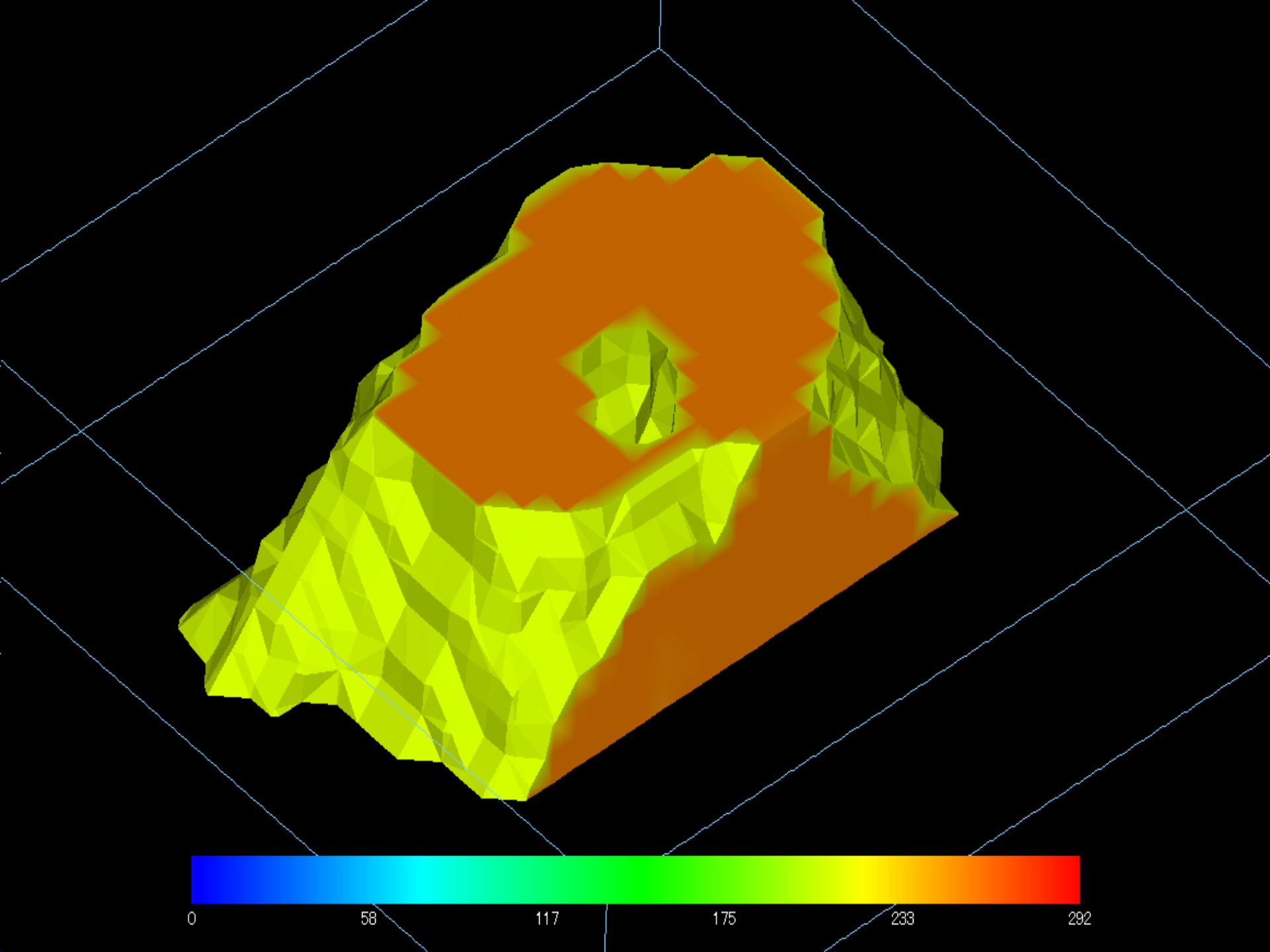
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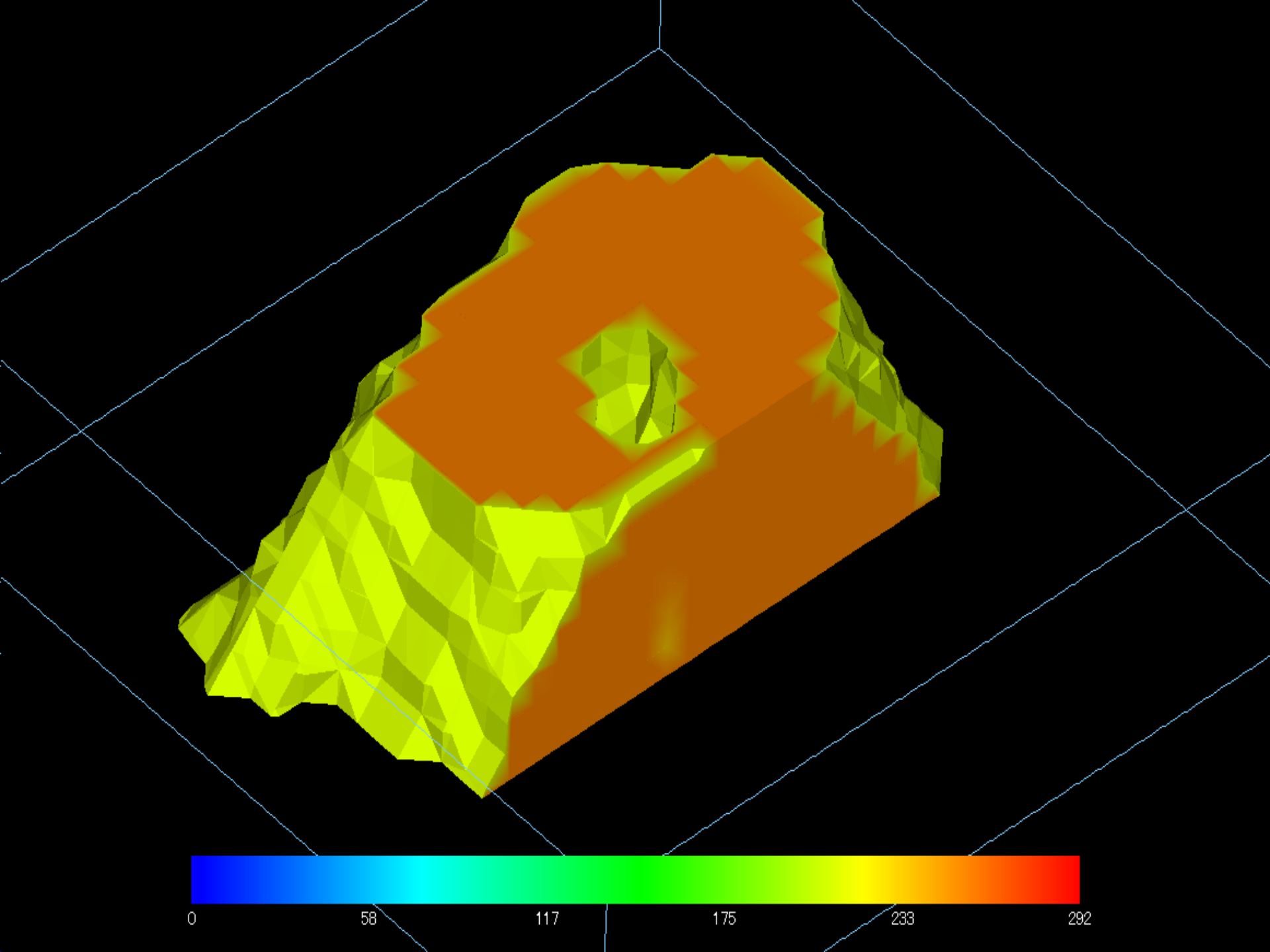
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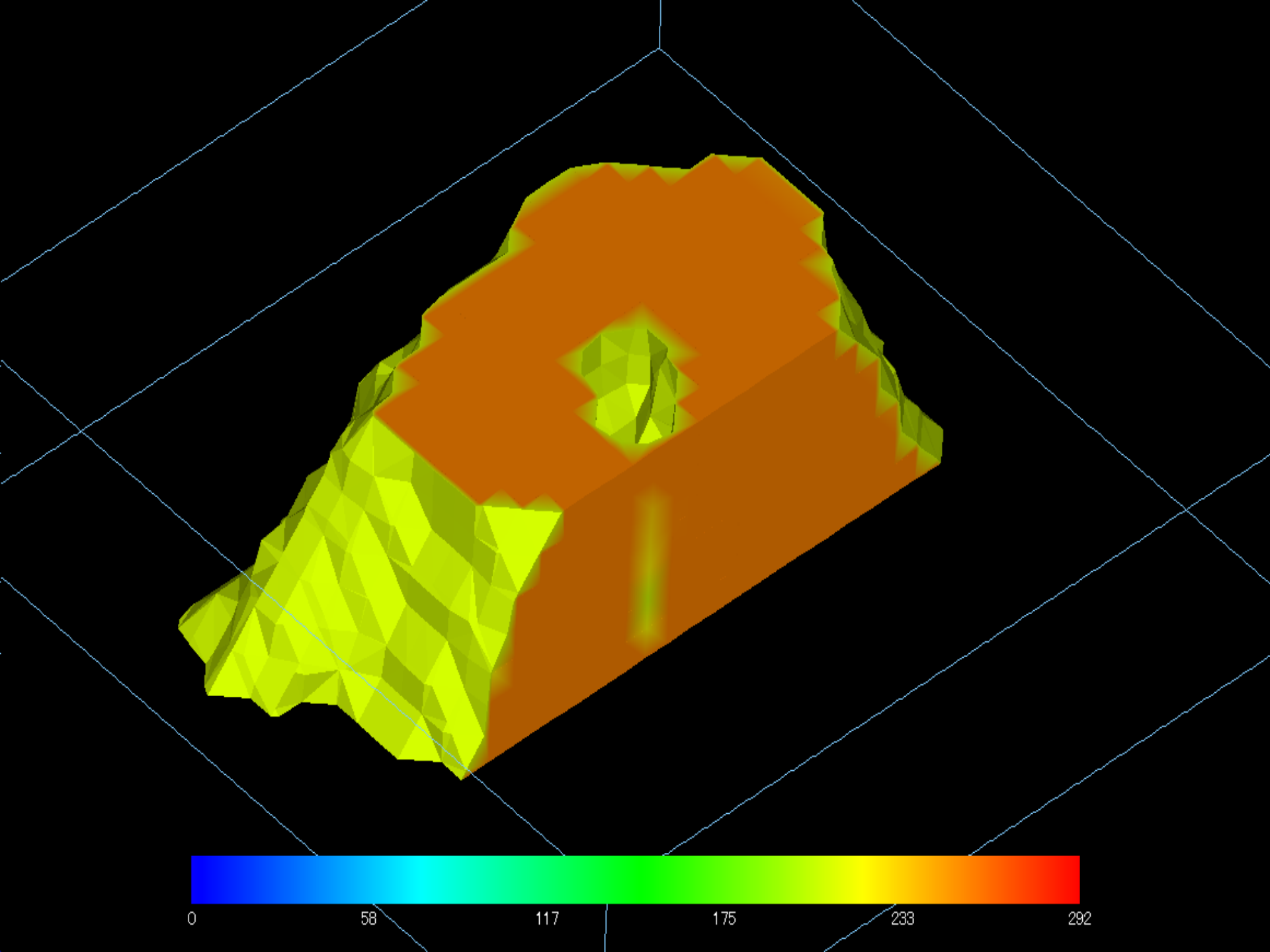
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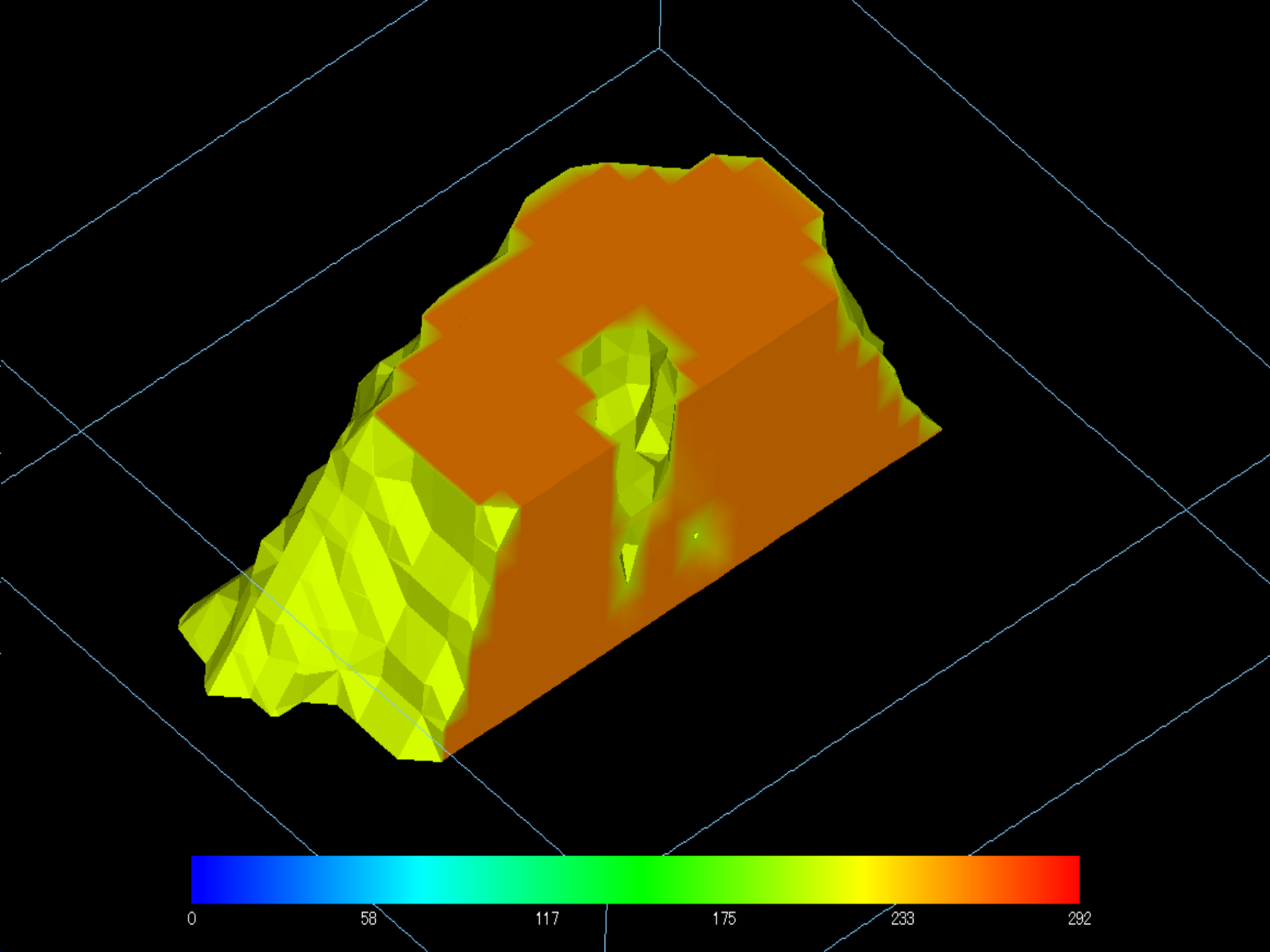
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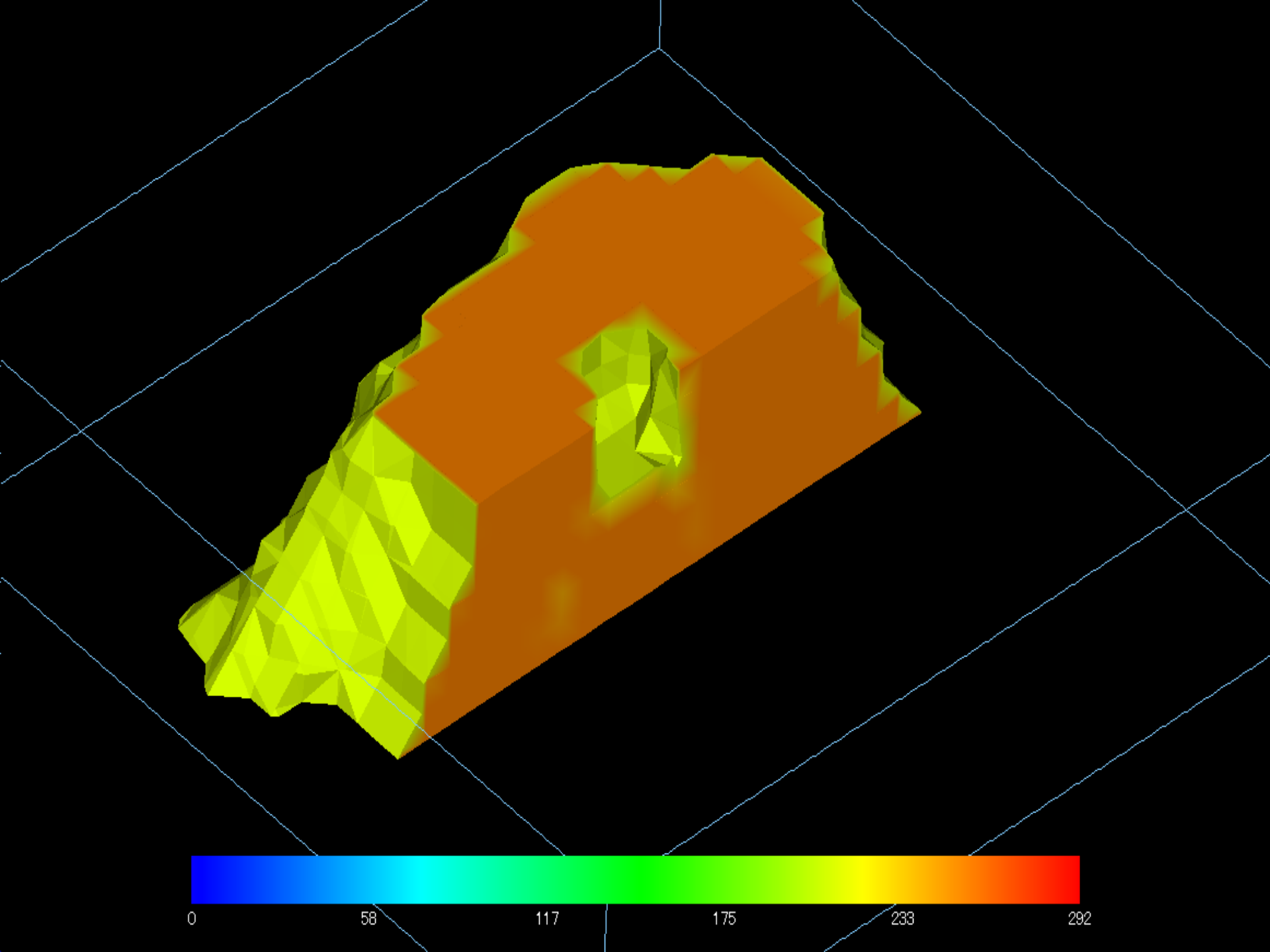
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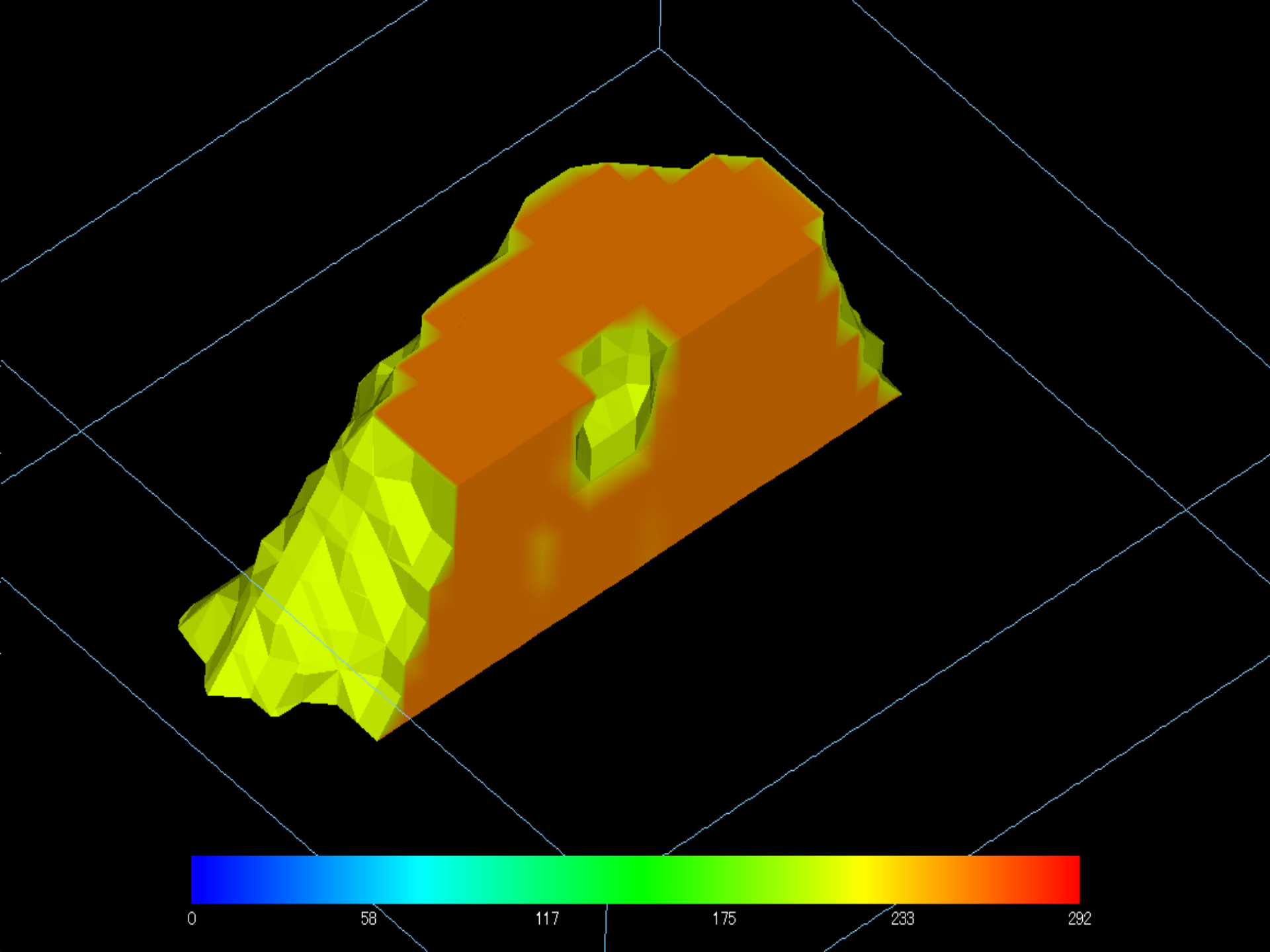
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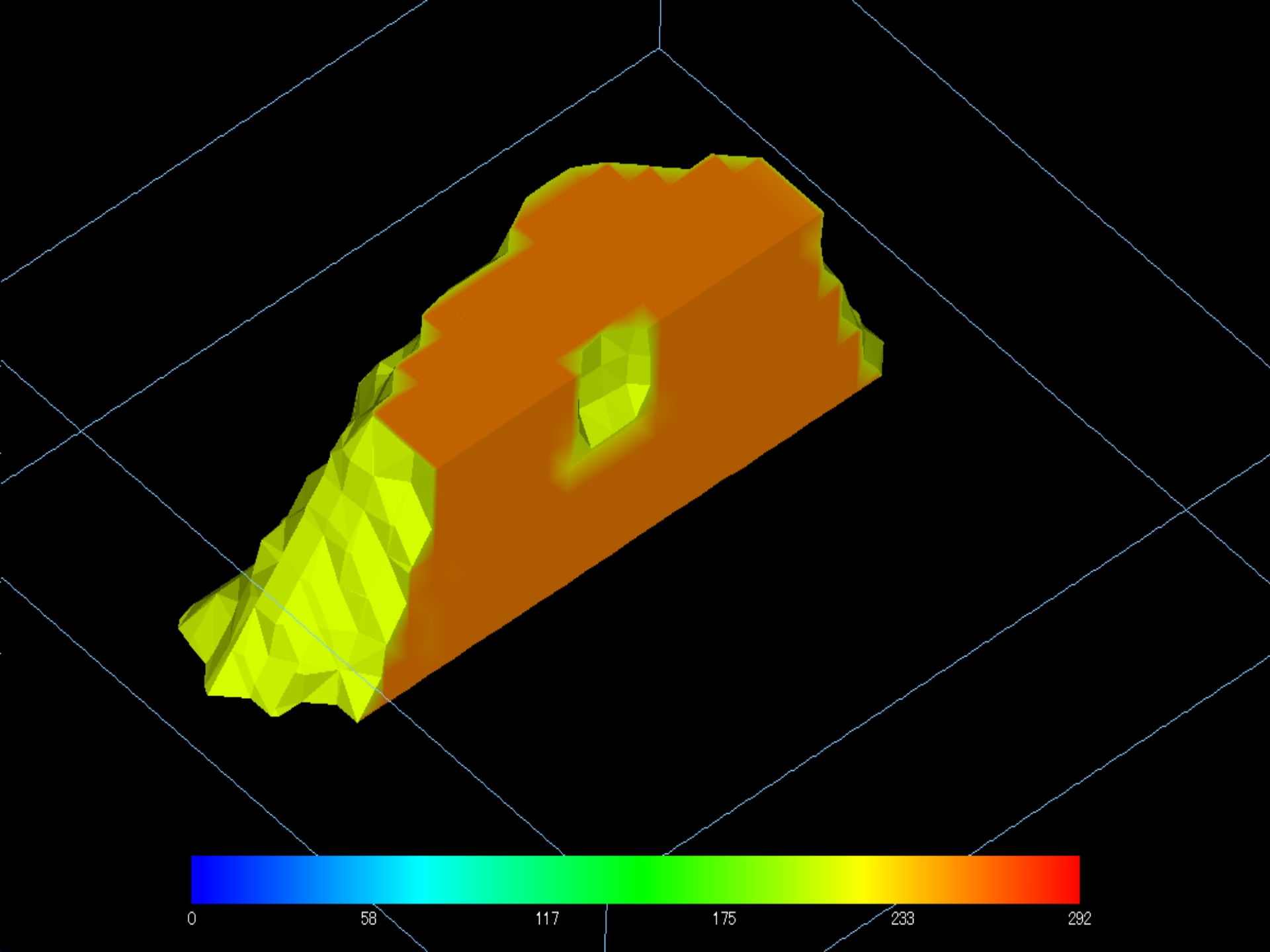
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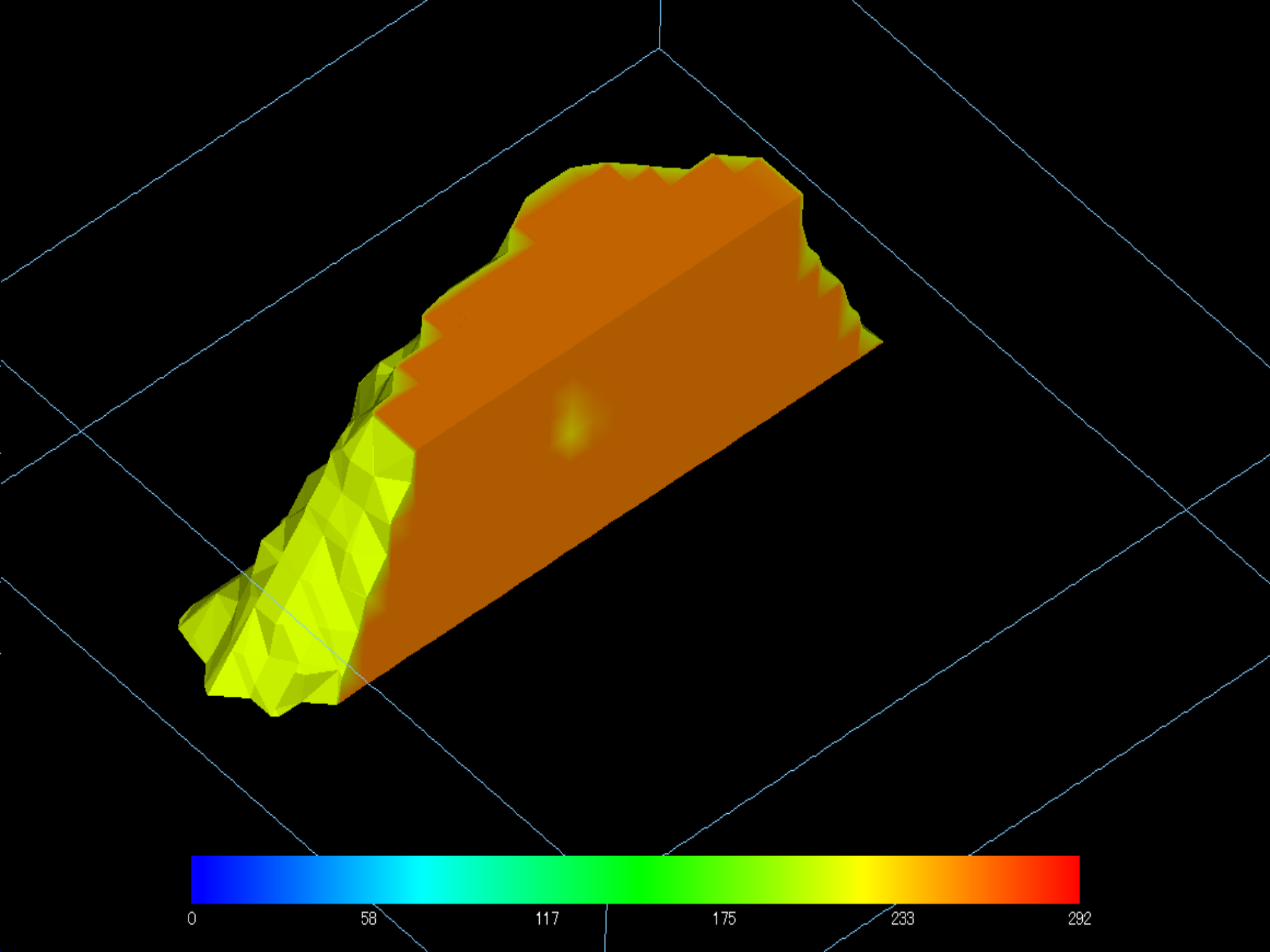
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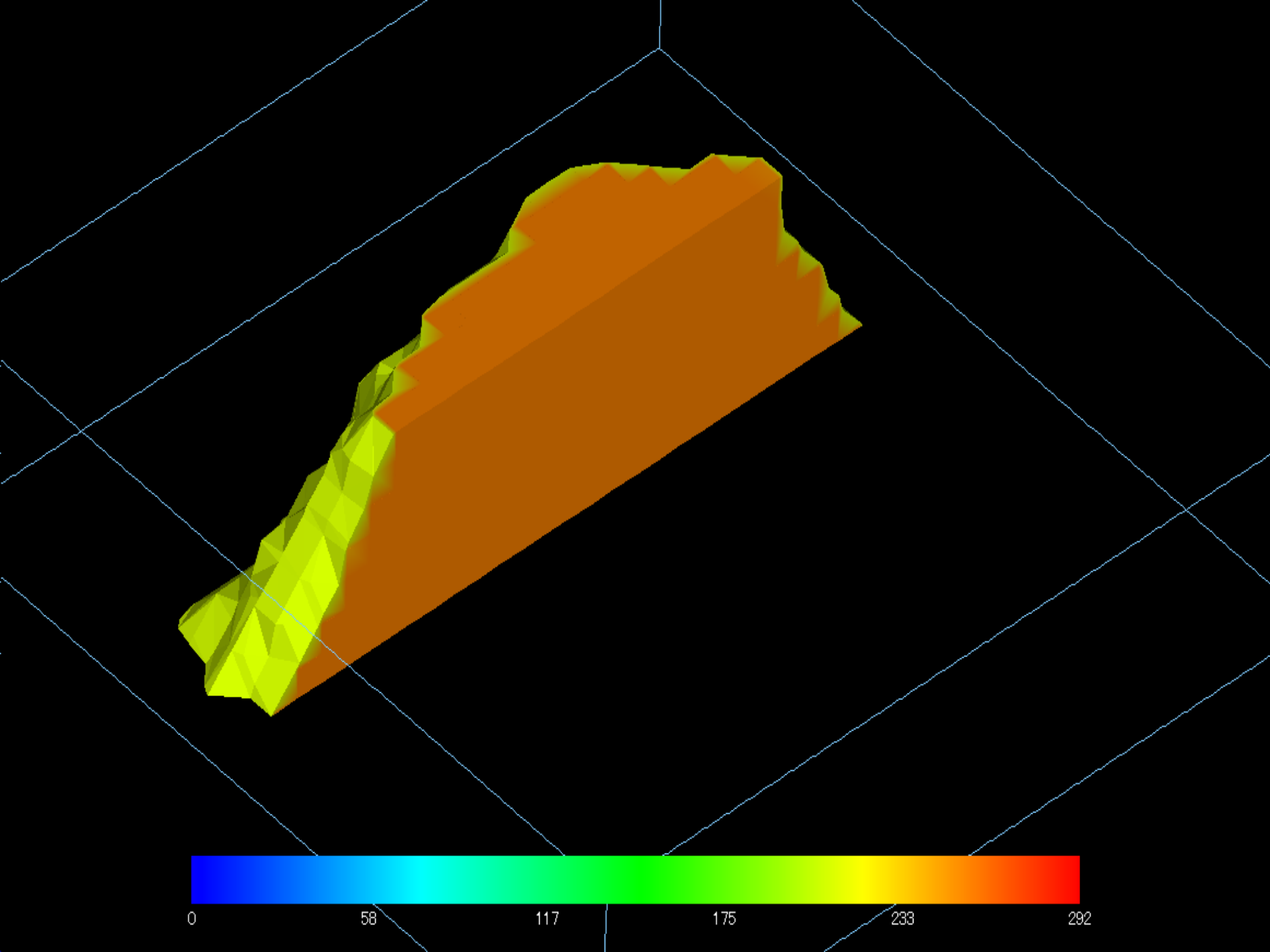
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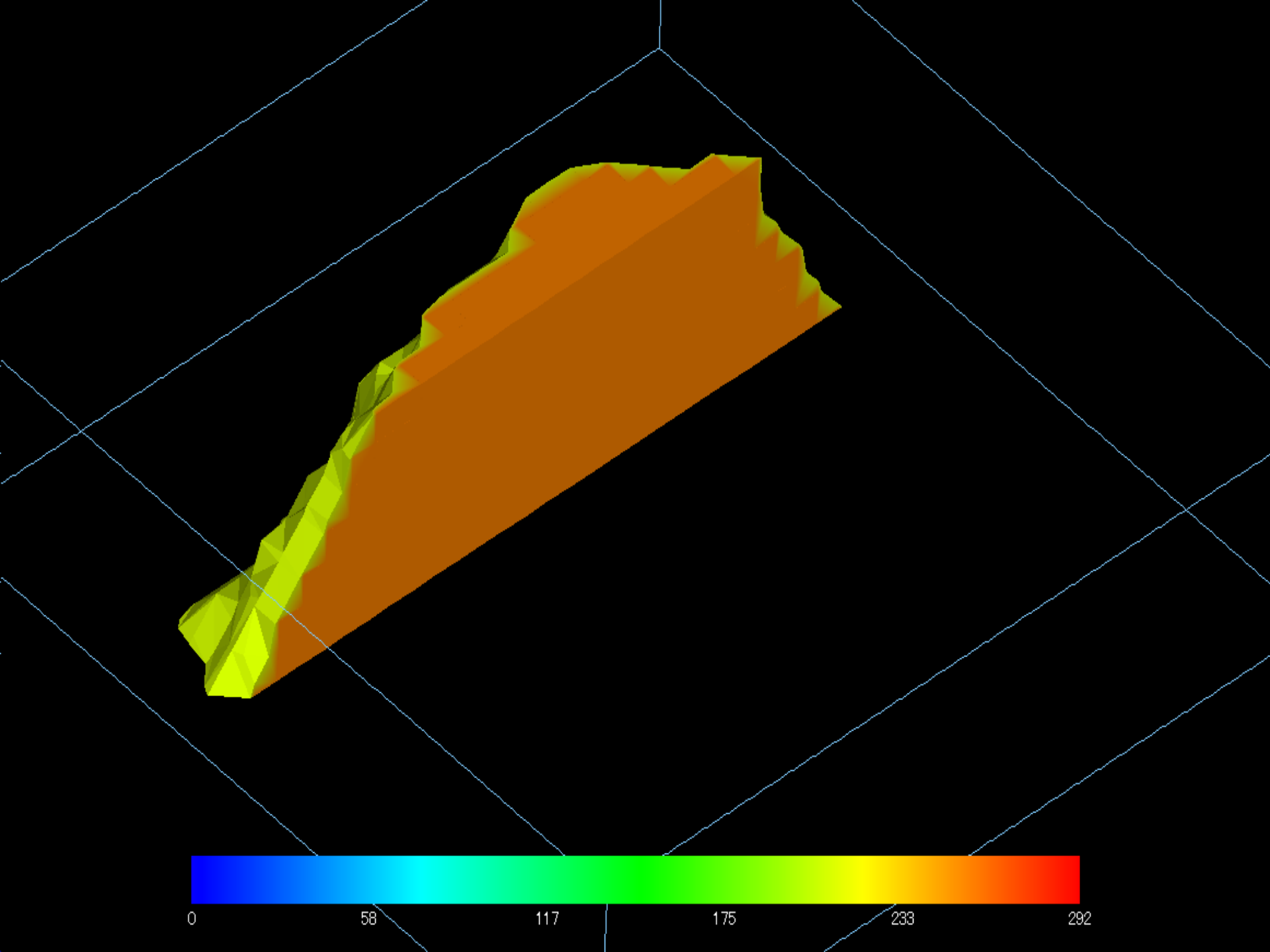
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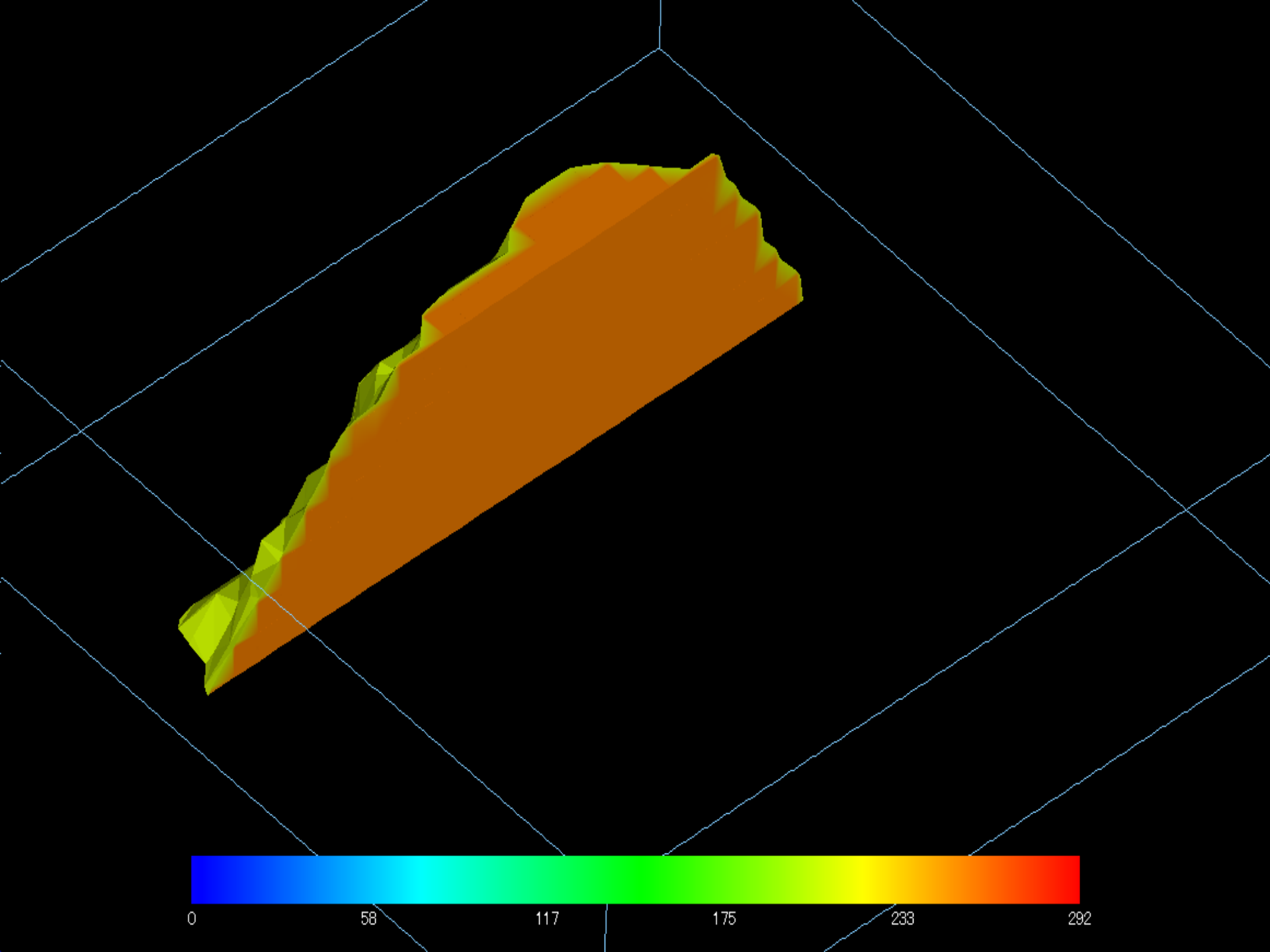
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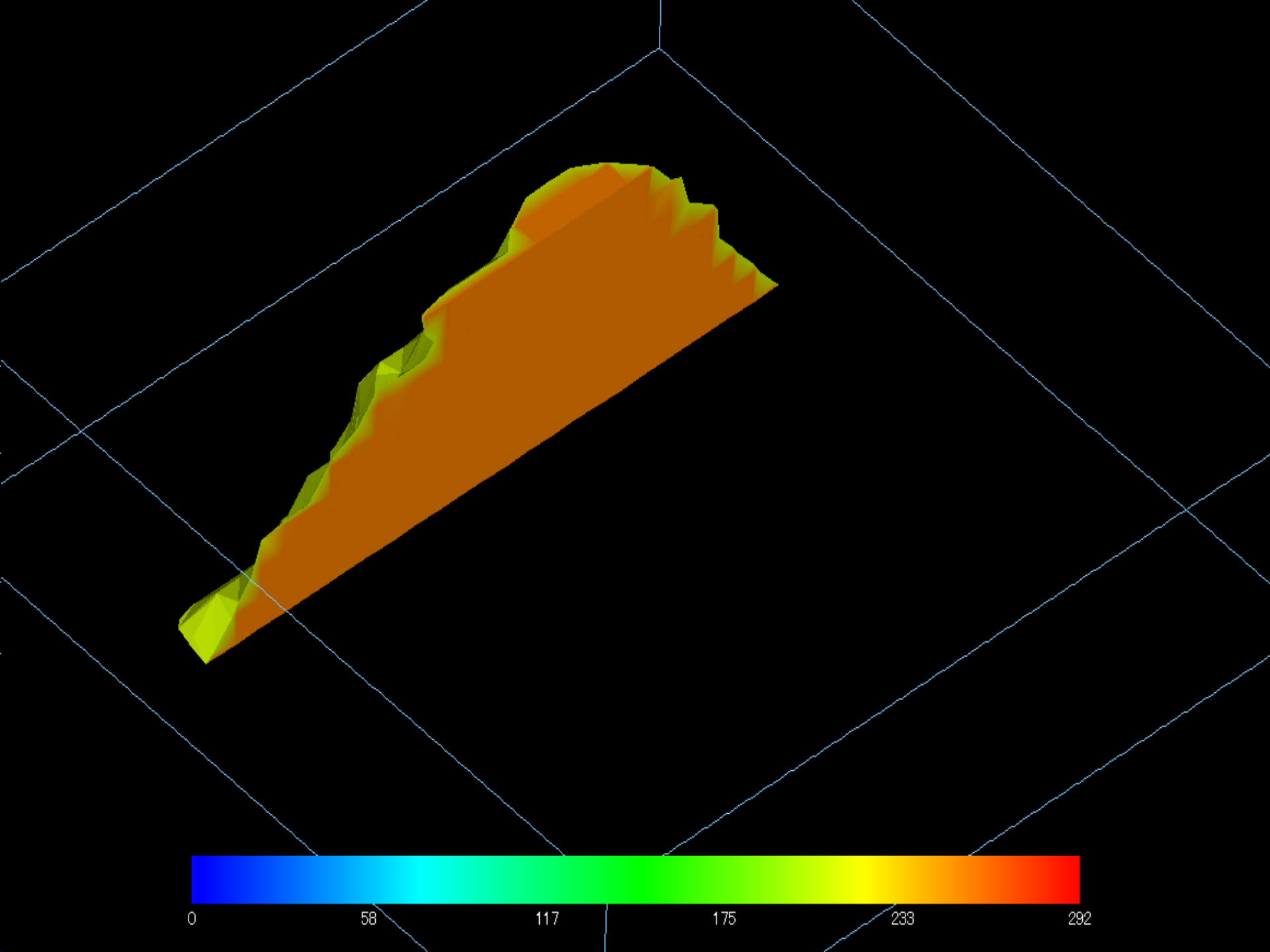
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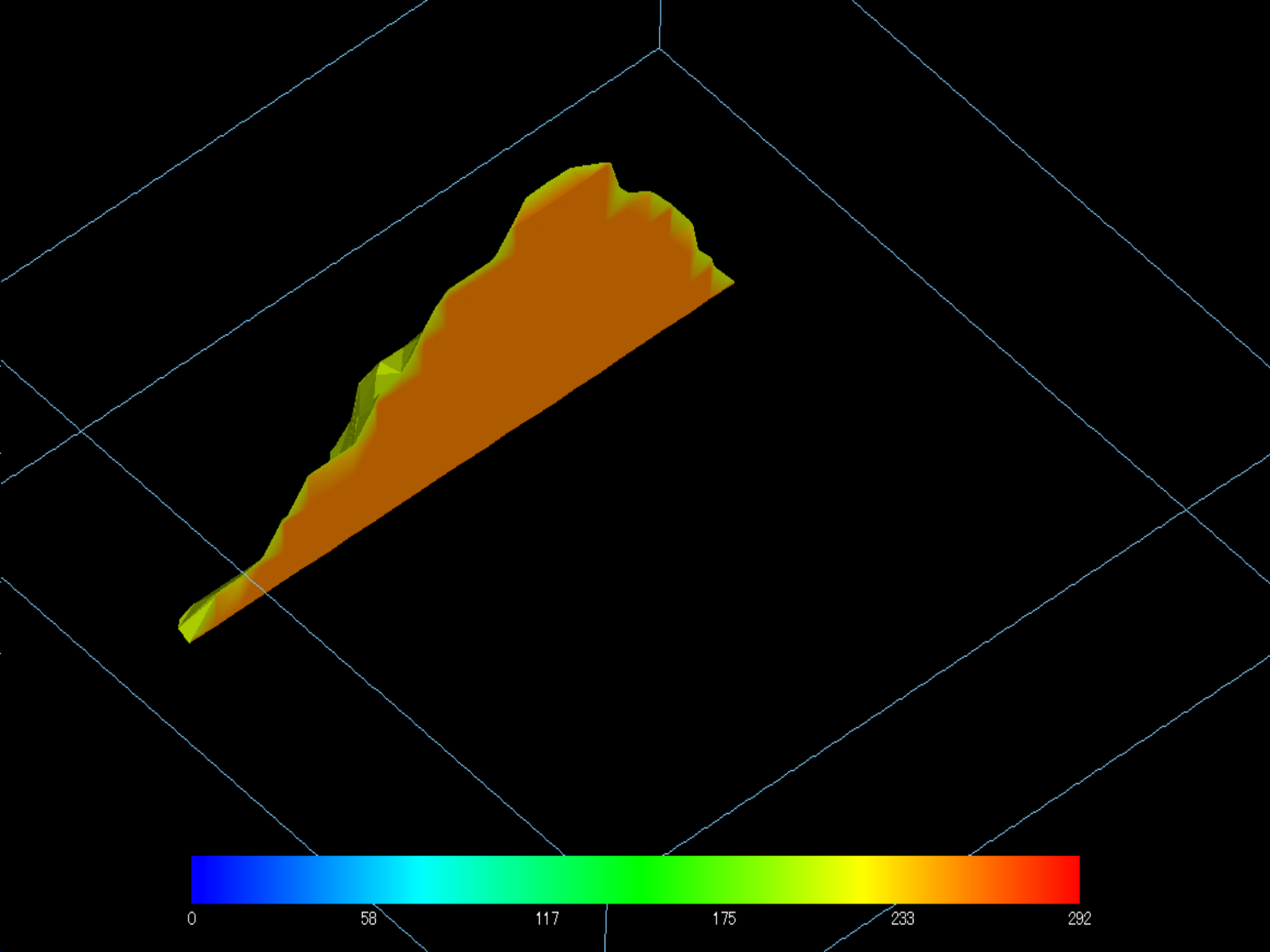
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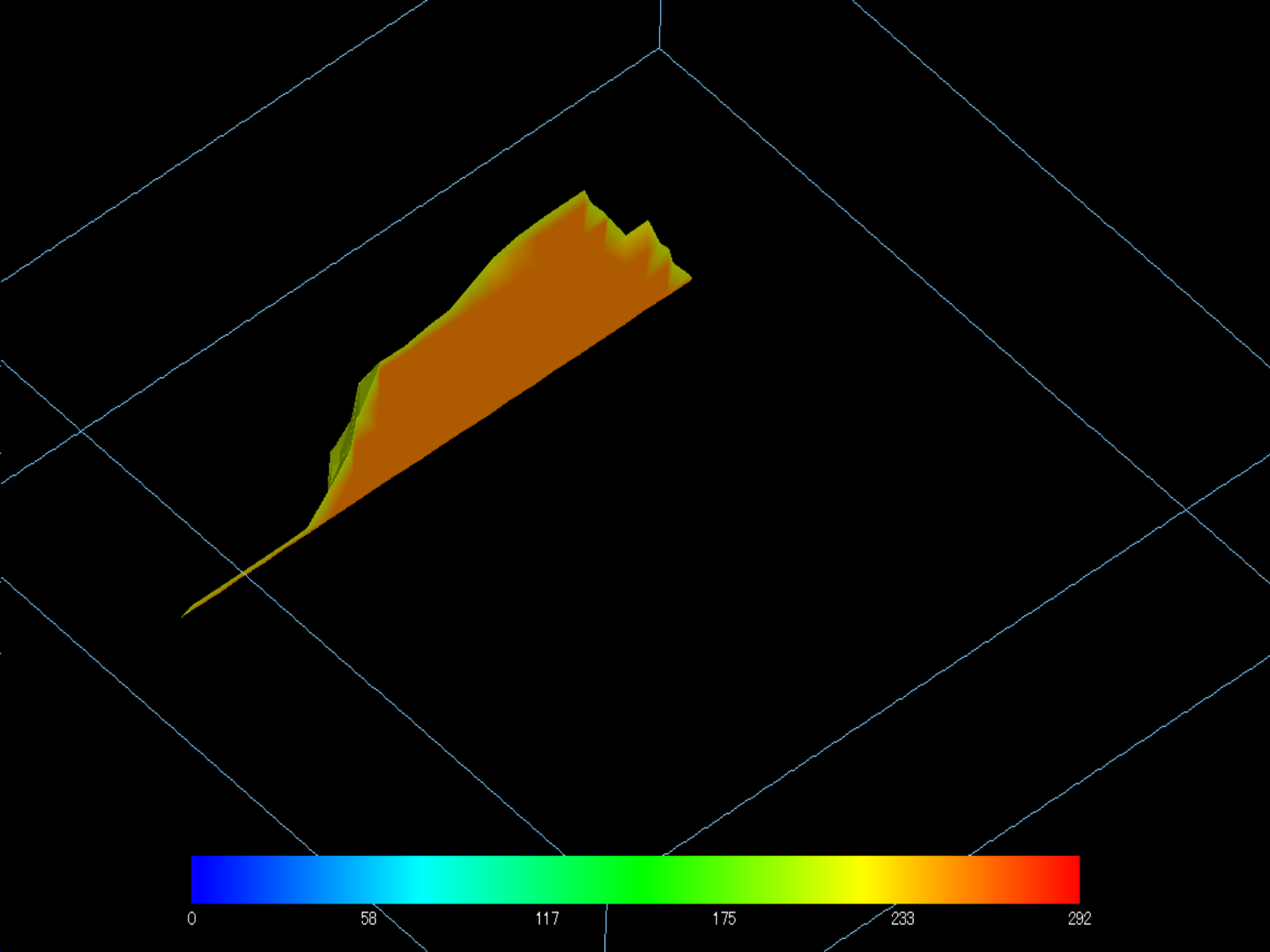
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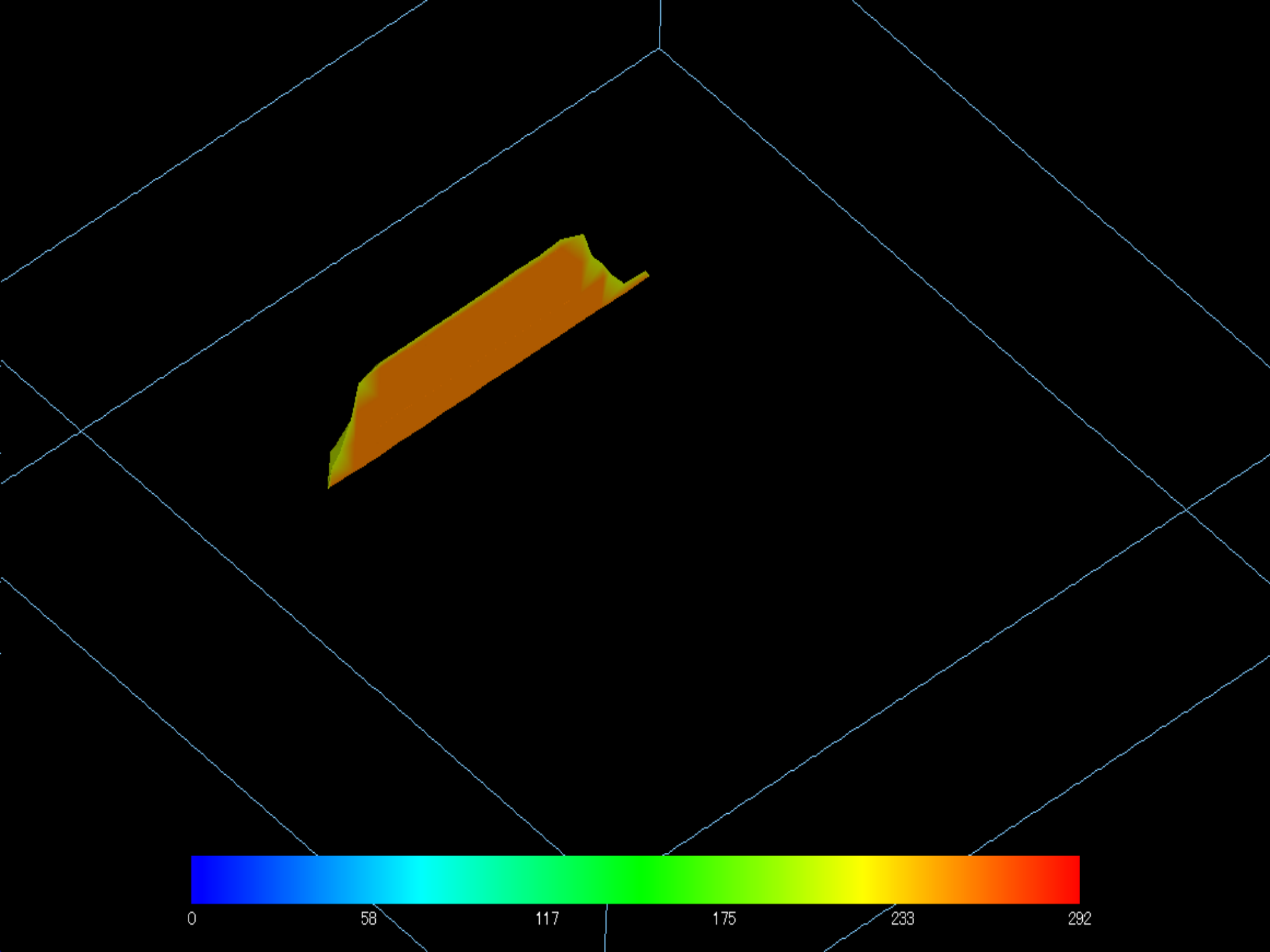
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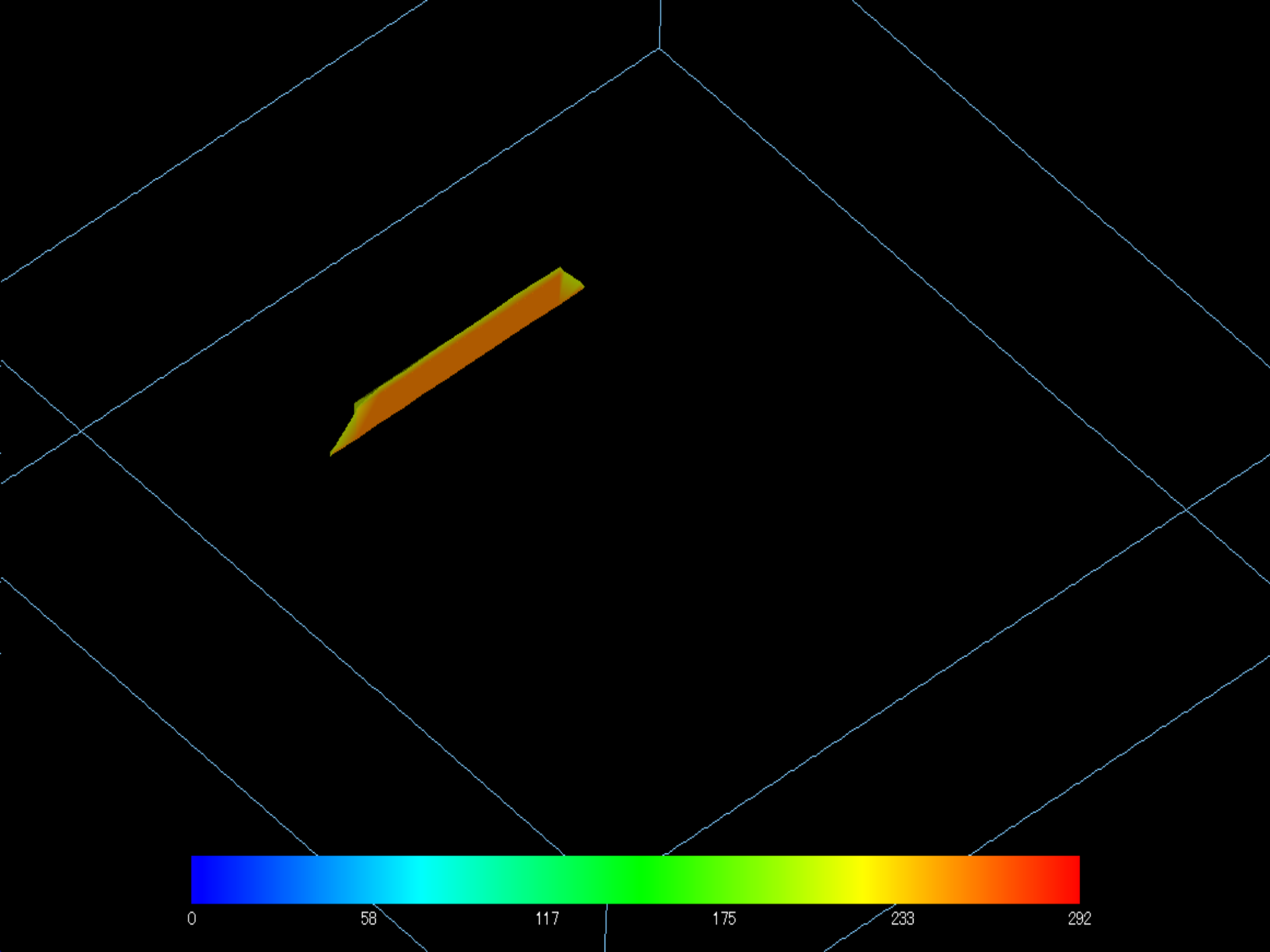
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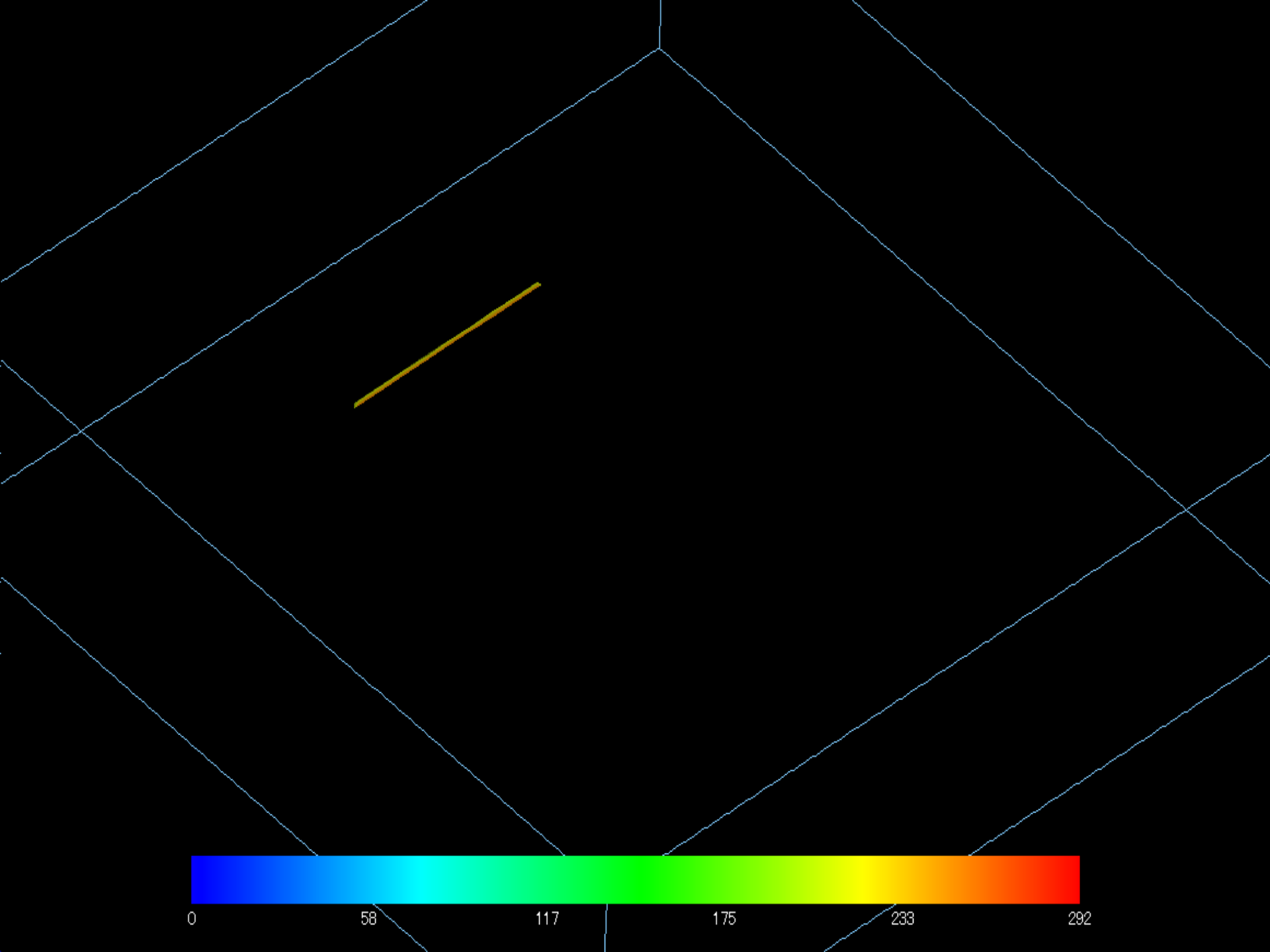
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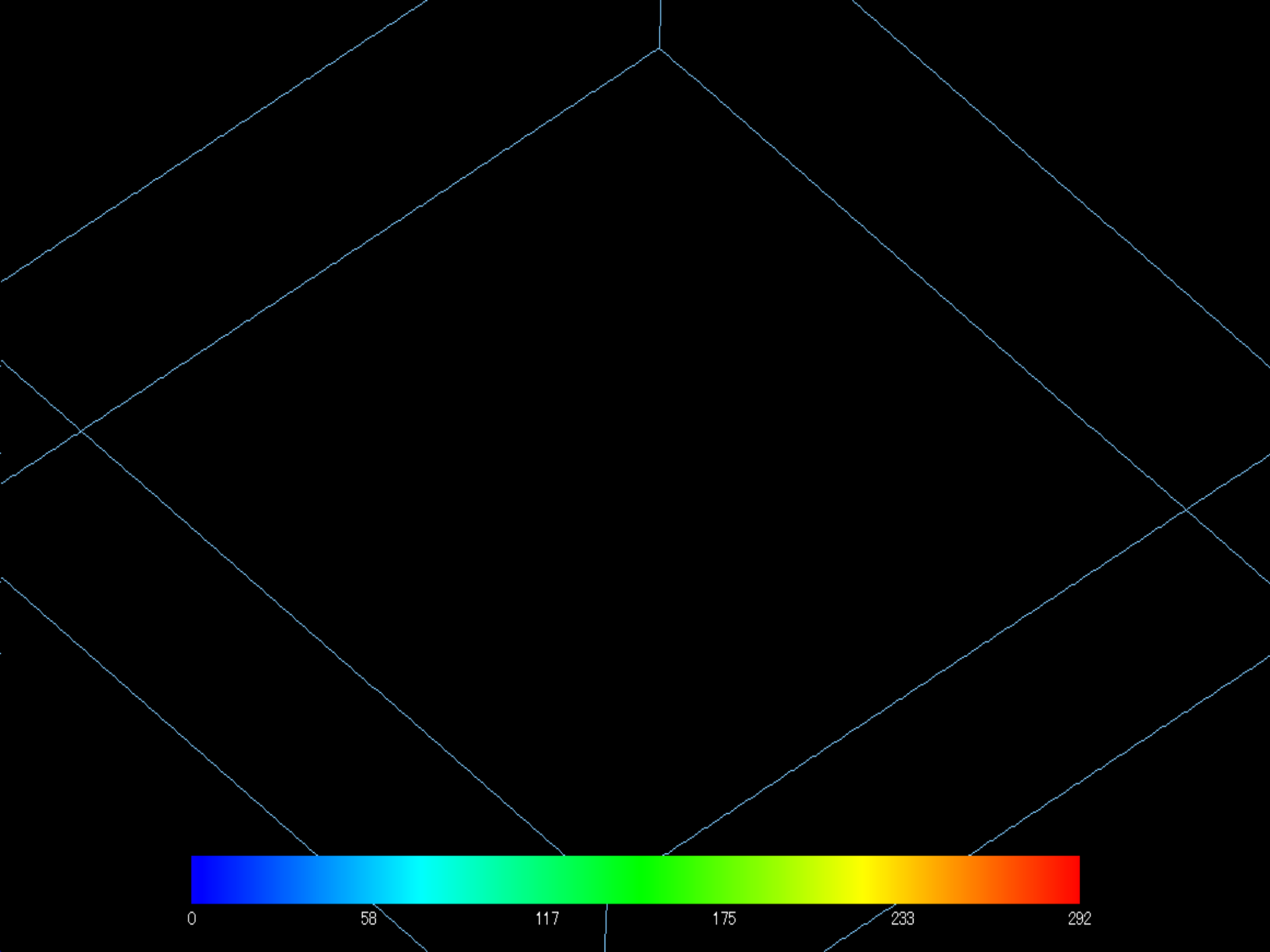
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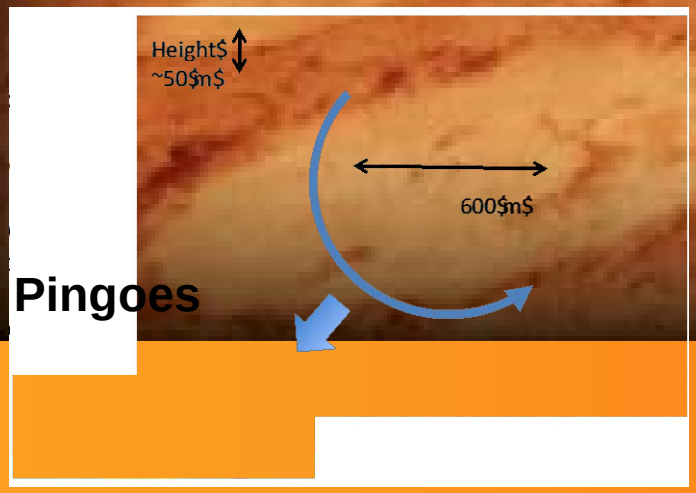
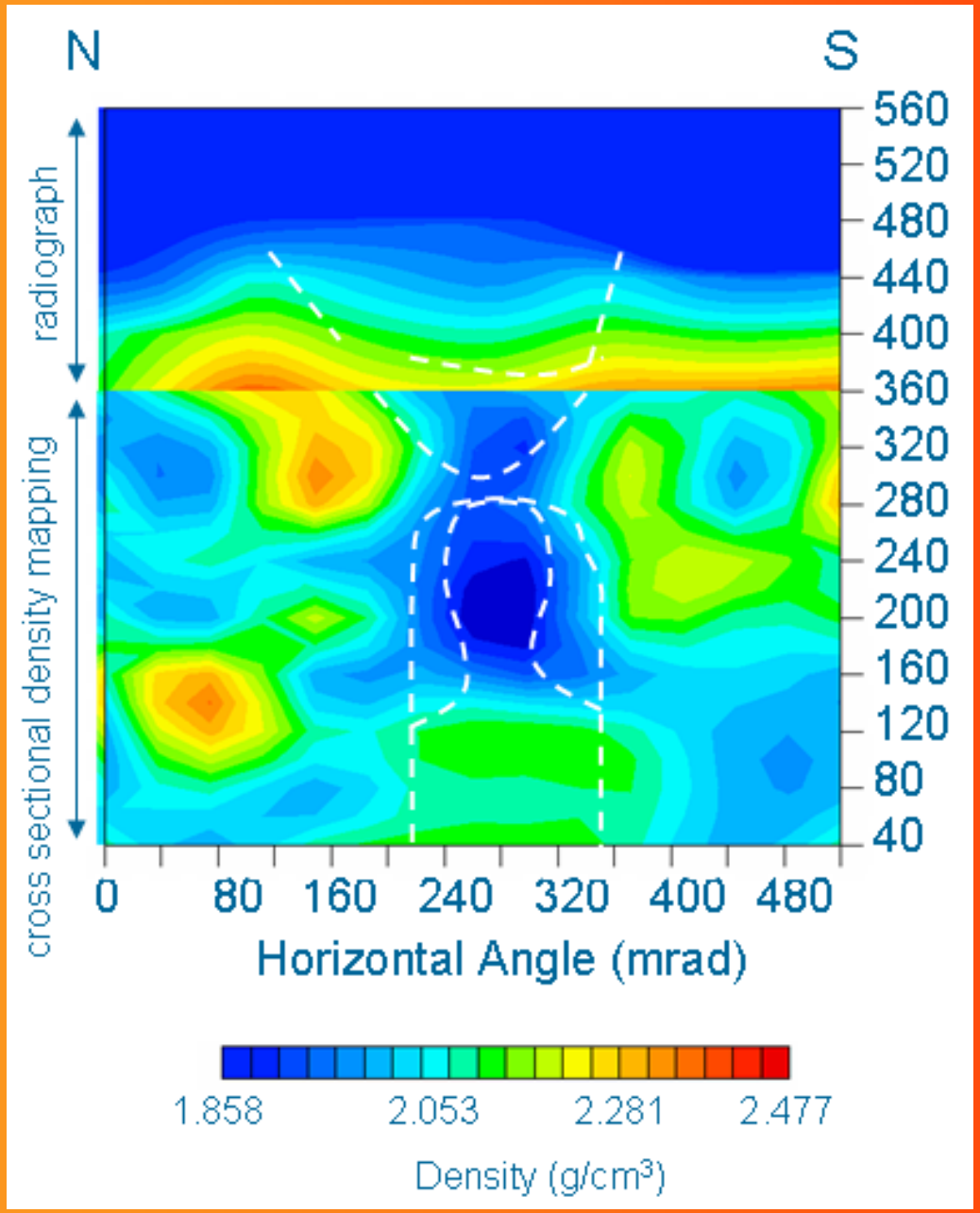
Jet Propulsion Laboratory
California Institute of Technology

Thick

Thin



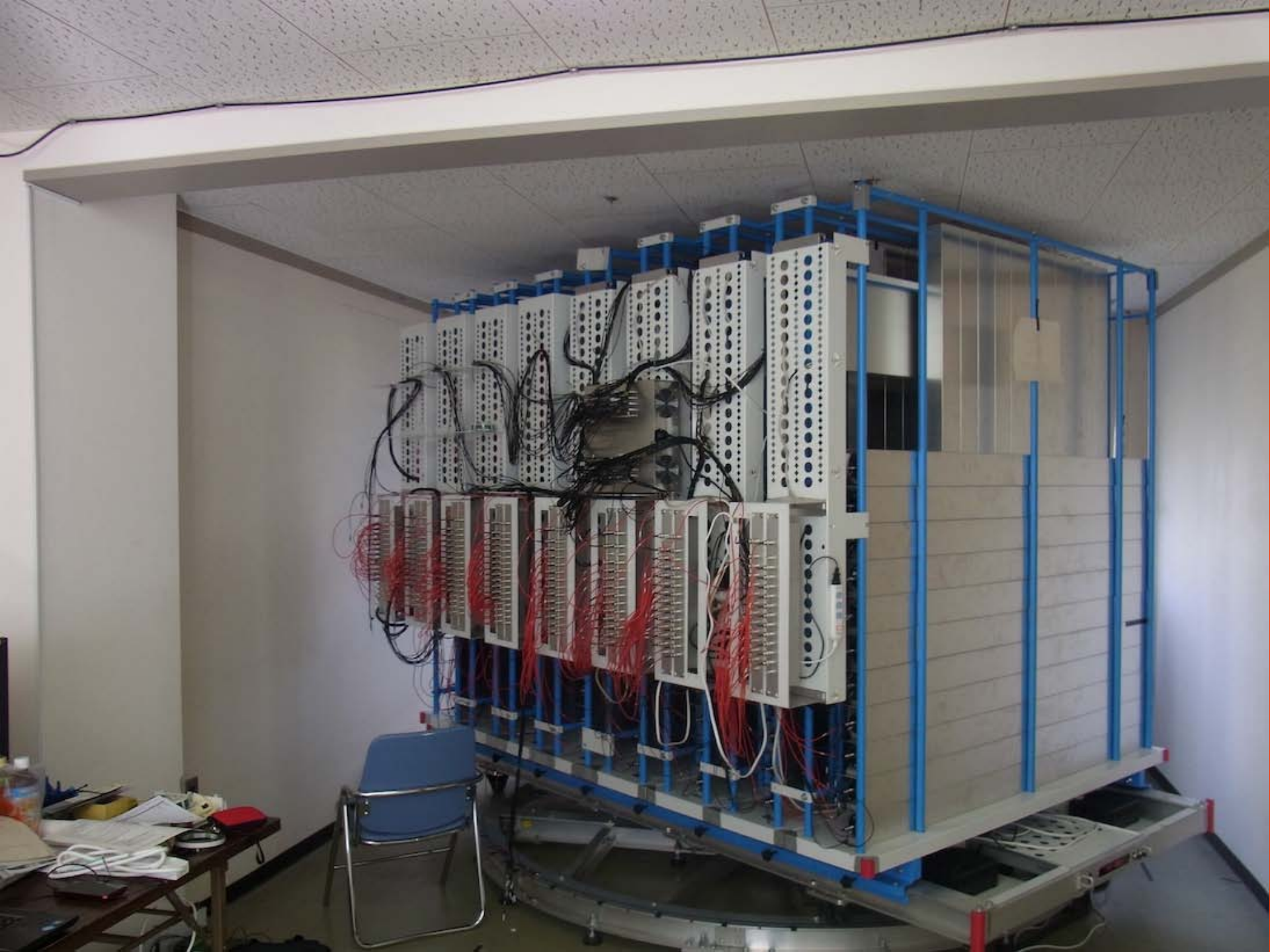
Towards Mars


N
S
radiograph
cross sectional density mapping
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
80
160
240
320
400
480
Horizontal Angle (mrad)
1.858
2.053
2.281
2.477
Density (g/cm3)

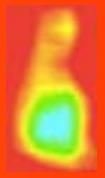
In addition to volcanoes

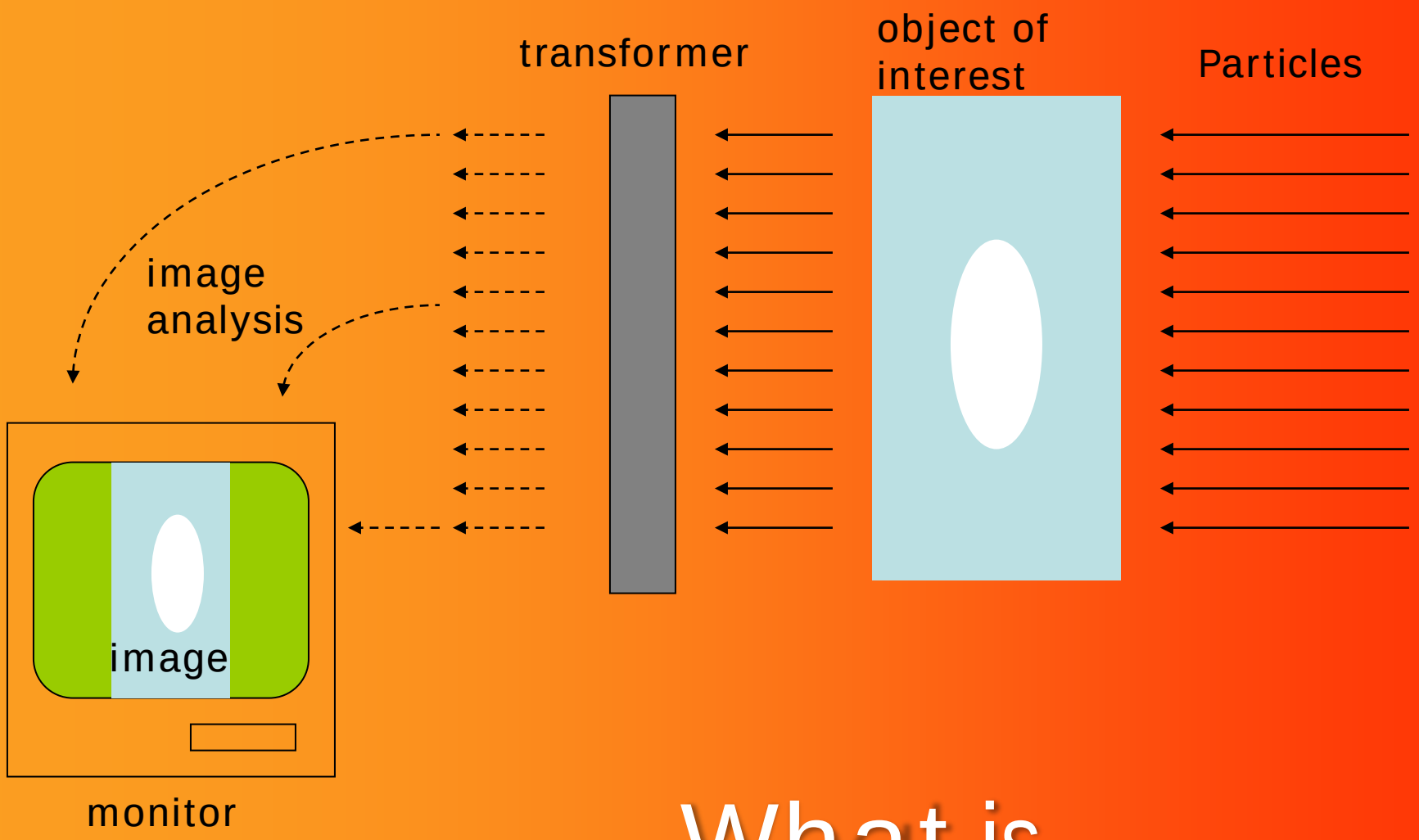
Various kinds of interests in the shallow crust

- Fracture zone of a shallow seismic fault
- Underground water table (using a tunnel)
- Soil density mapping (using a drill hole)
- Ore body detection (Canadian group)

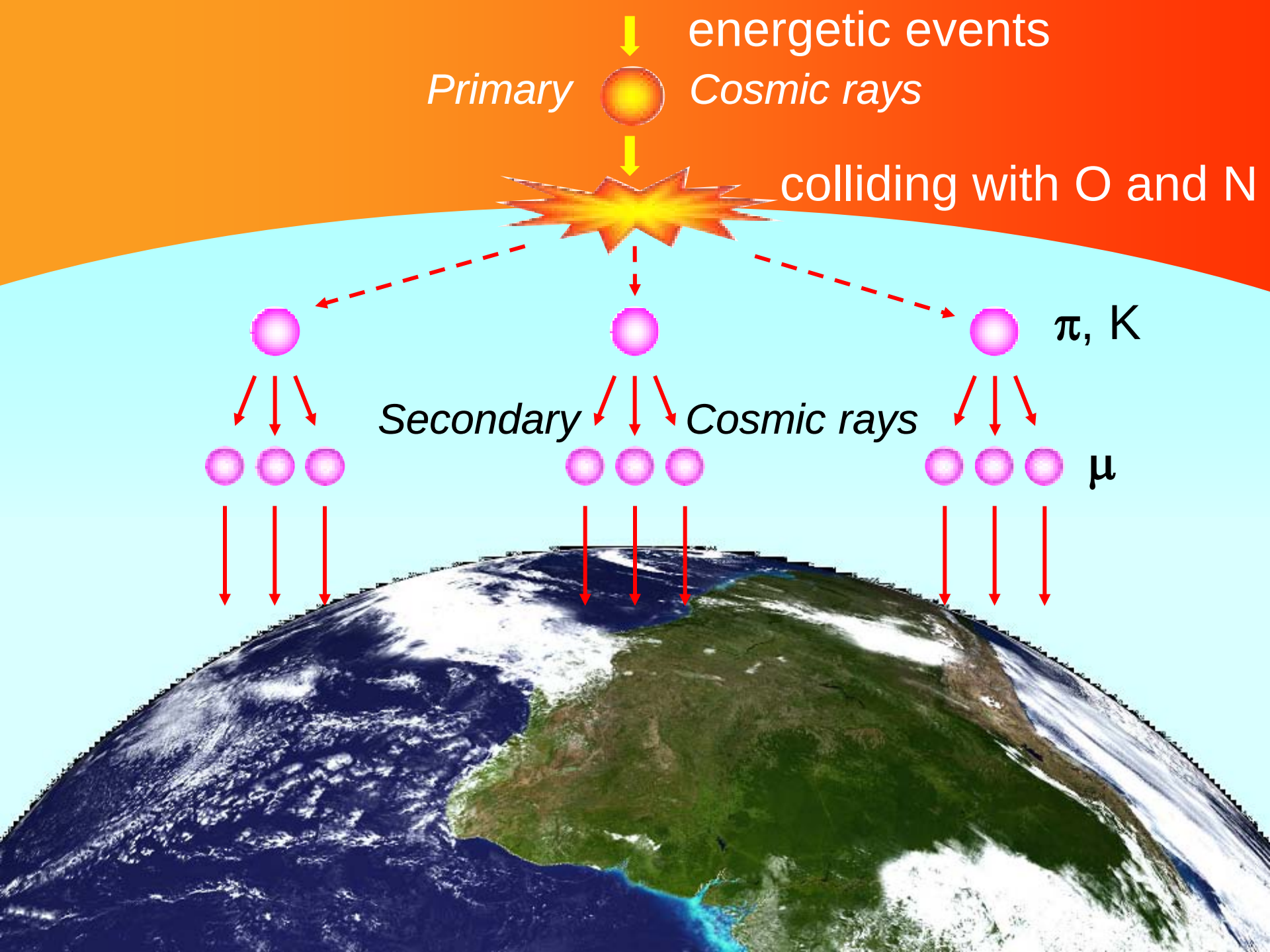


ミュオンは、
一晩に100万個
体を通り抜ける





What is Radiography?


energetic events
Primary
Cosmic rays
colliding with O and N
π, K
Secondary
Cosmic rays
μ

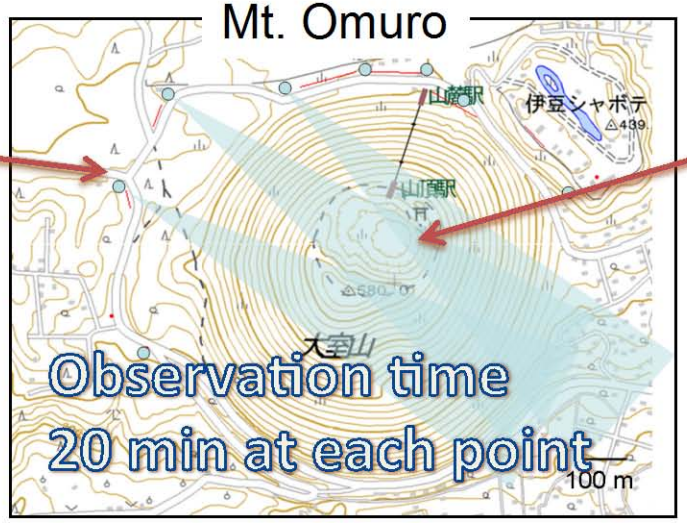
Jet Propulsion Laboratory
California Institute of Technology

Recent Field Demo of a Mobile Low-Power, Lightweight Muon Detector

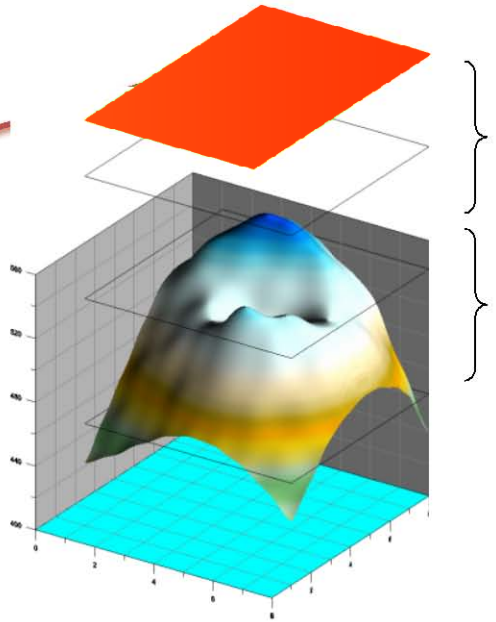
A MSL-sized mobile muon detector roves around Mt. Omuro
Imaging the interior in 6 hours
"

Mobile Muon Detector

Battery–operated electronics



Total observation time
20 x 18 = 360 min



Exterior shape information is not necessary.
Real-time changing target is possible, e.g., growing lava dome

[Recent results from H. Tanaka et. al. 2011-2012]