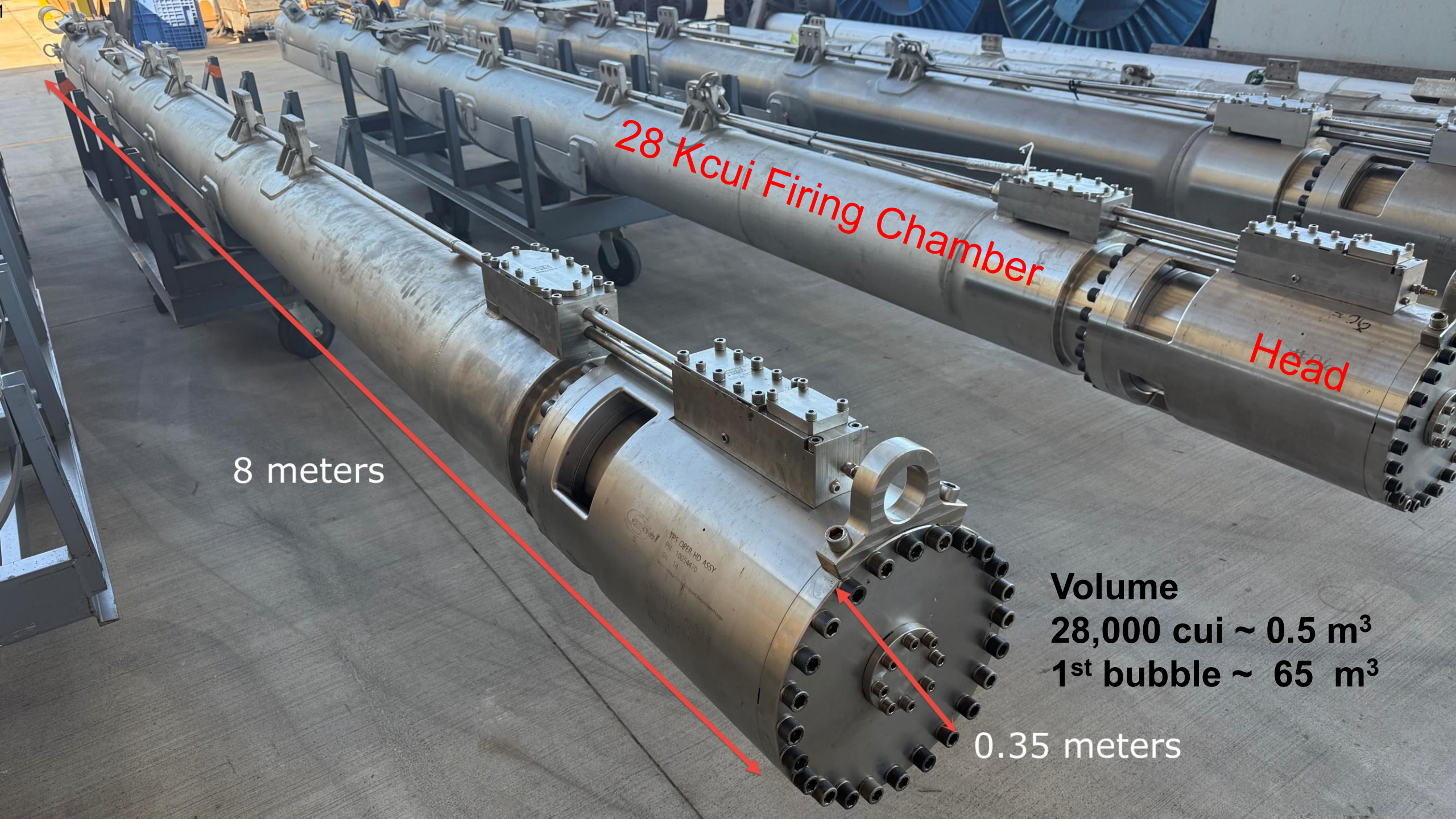
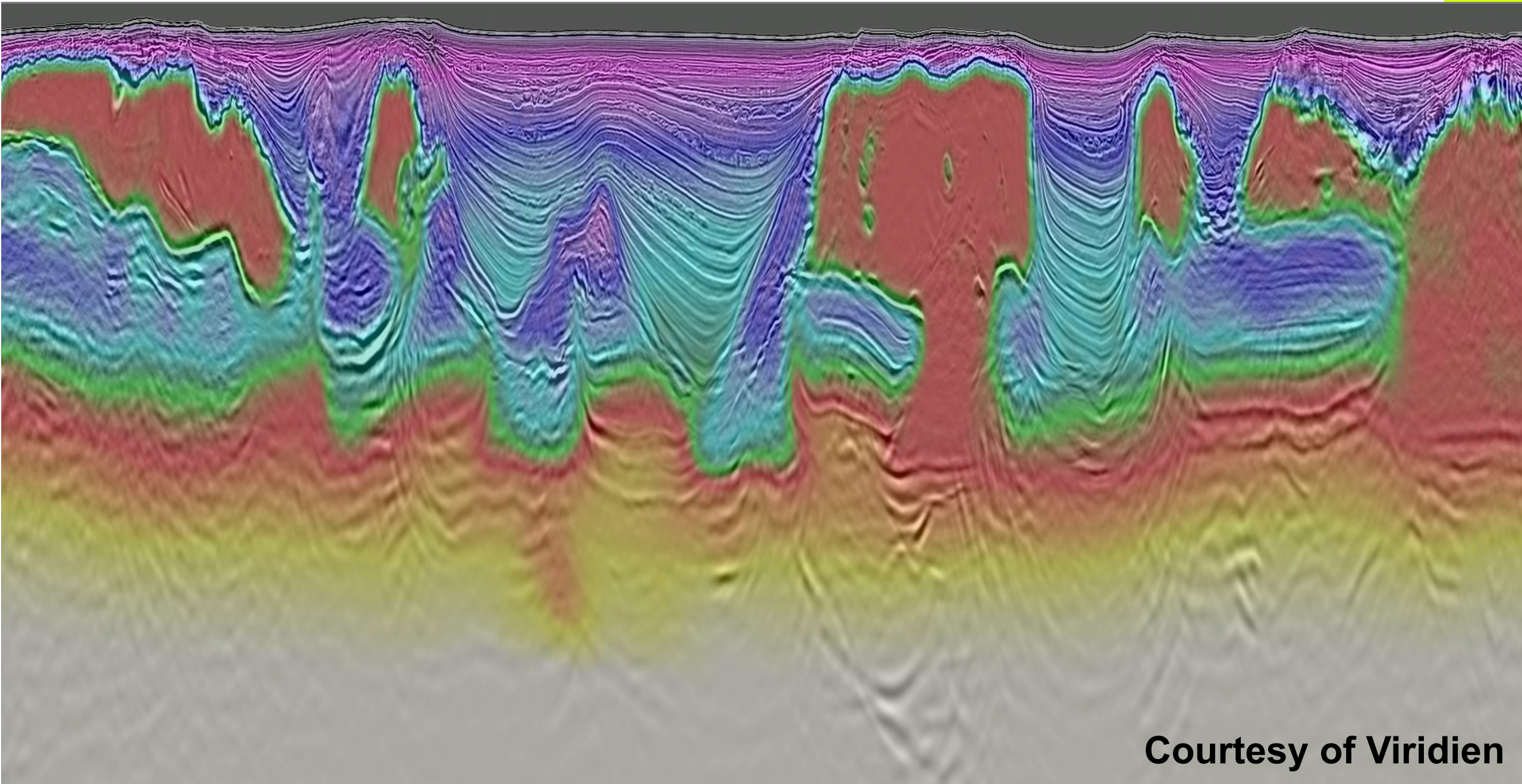
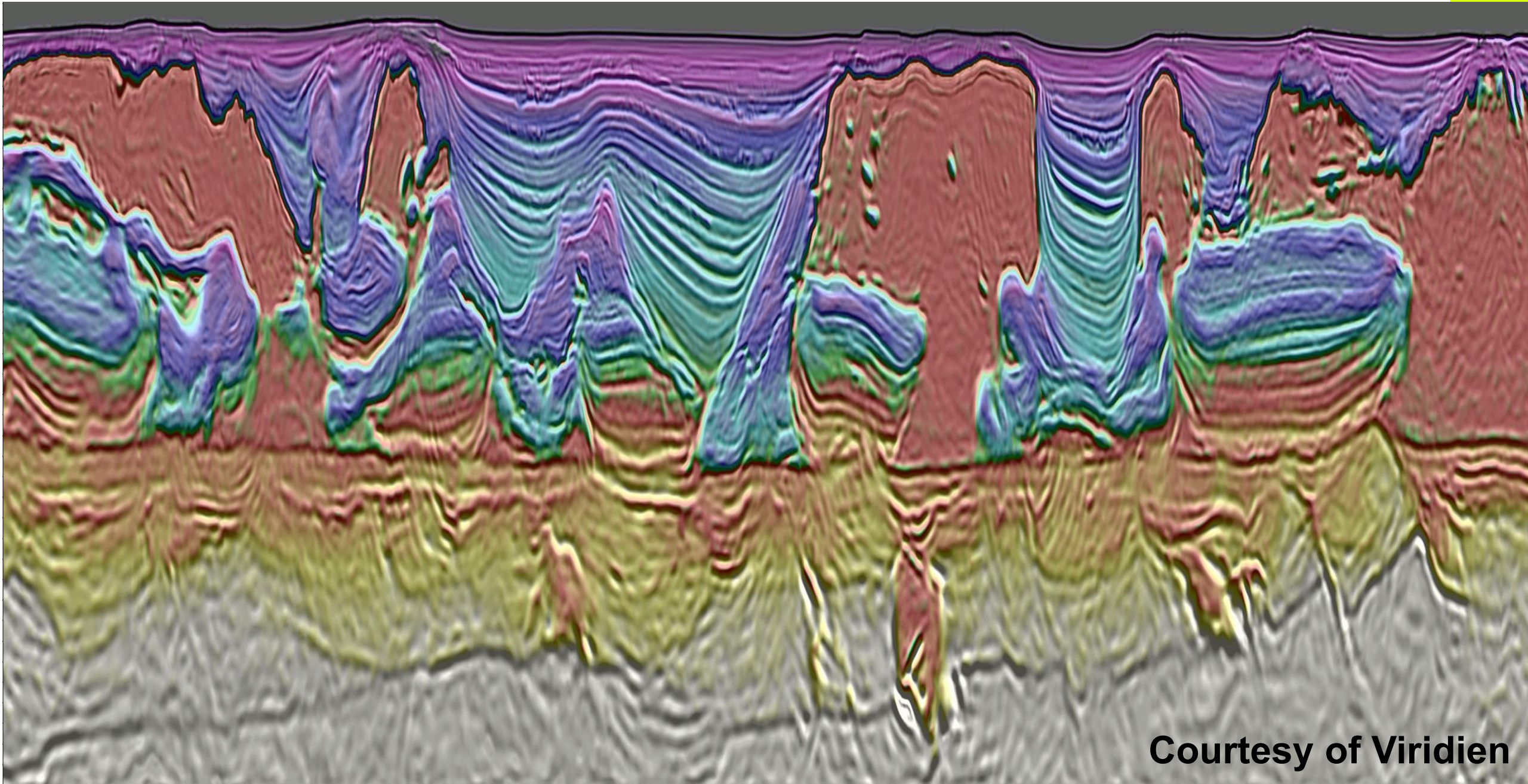

28 Kcui Firing Chamber
Head
8 meters
0.35 meters
Volume
28,000 cui ~ 0.5 m³
1st bubble ~ 65 m³

2014 Technology (Stagseis survey): Airguns, Full Azimuth Streamer, 15 Hz Reverse Time Migration



2024 Technology (Laconia survey): Tuned Pulse Source, Ocean Bottom Nodes, 8Hz Elastic Full Waveform Inversion



TPS OBN EFWI interpretation of deep geology

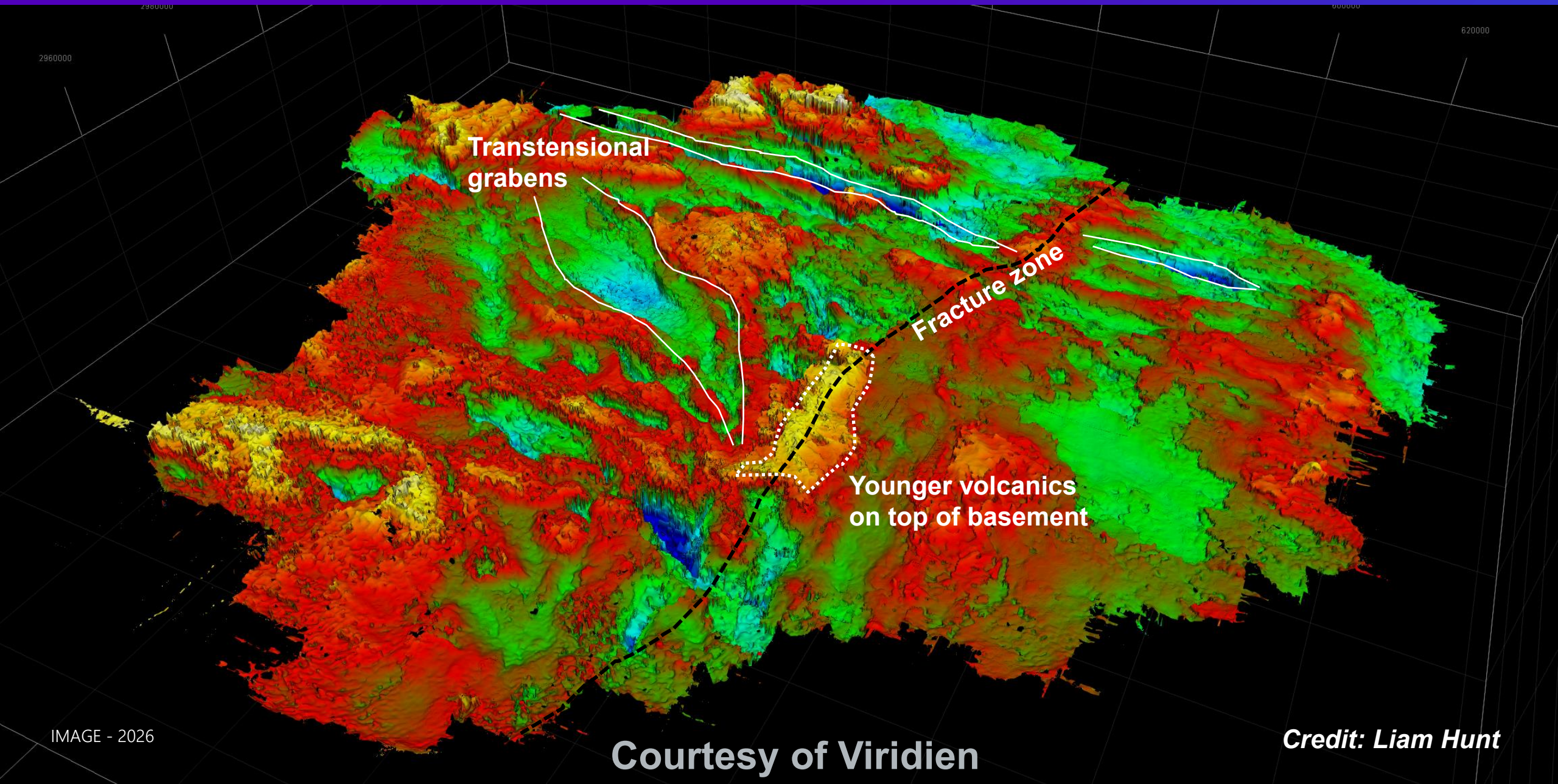


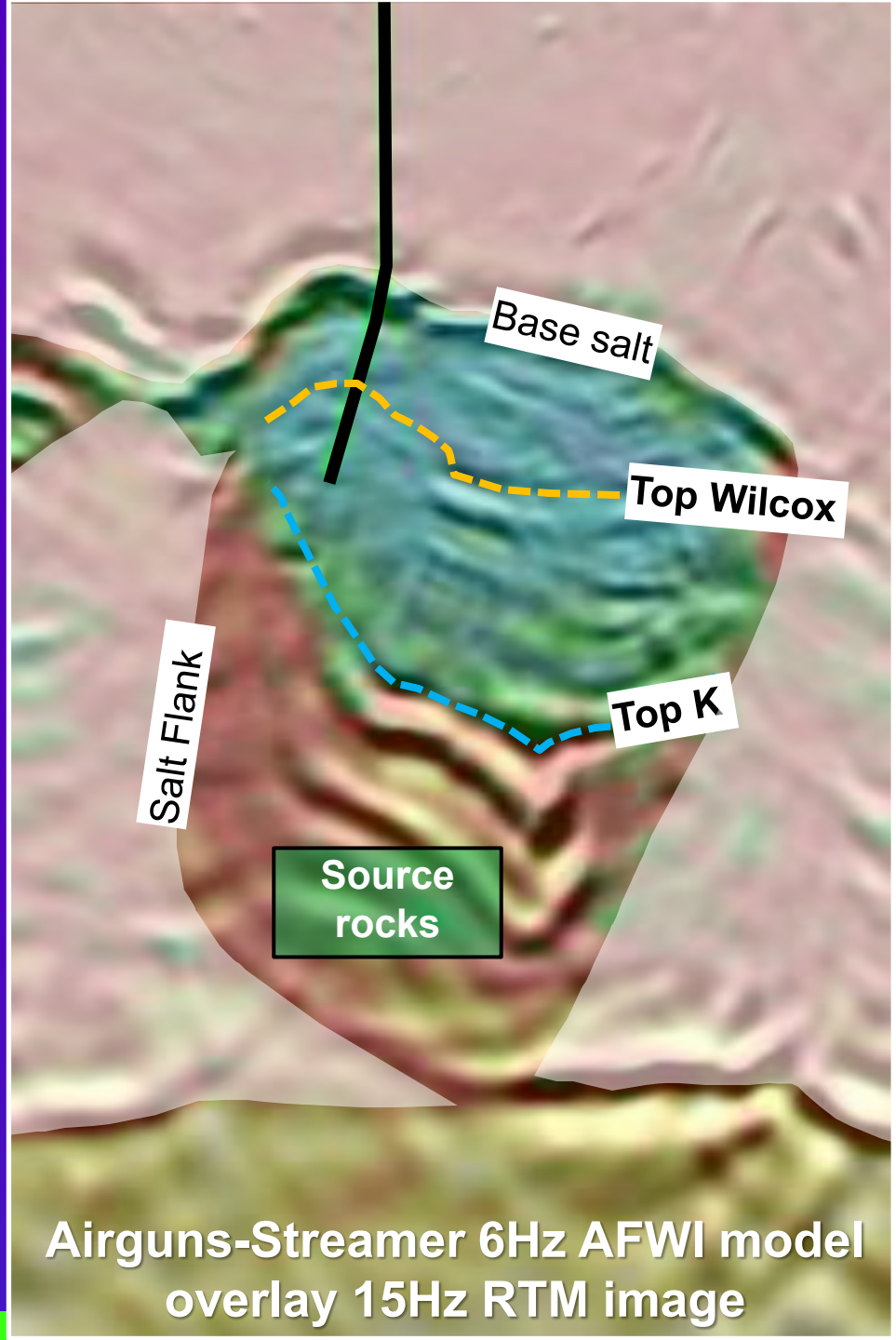
IMAGE - 2026

Courtesy of Viridien

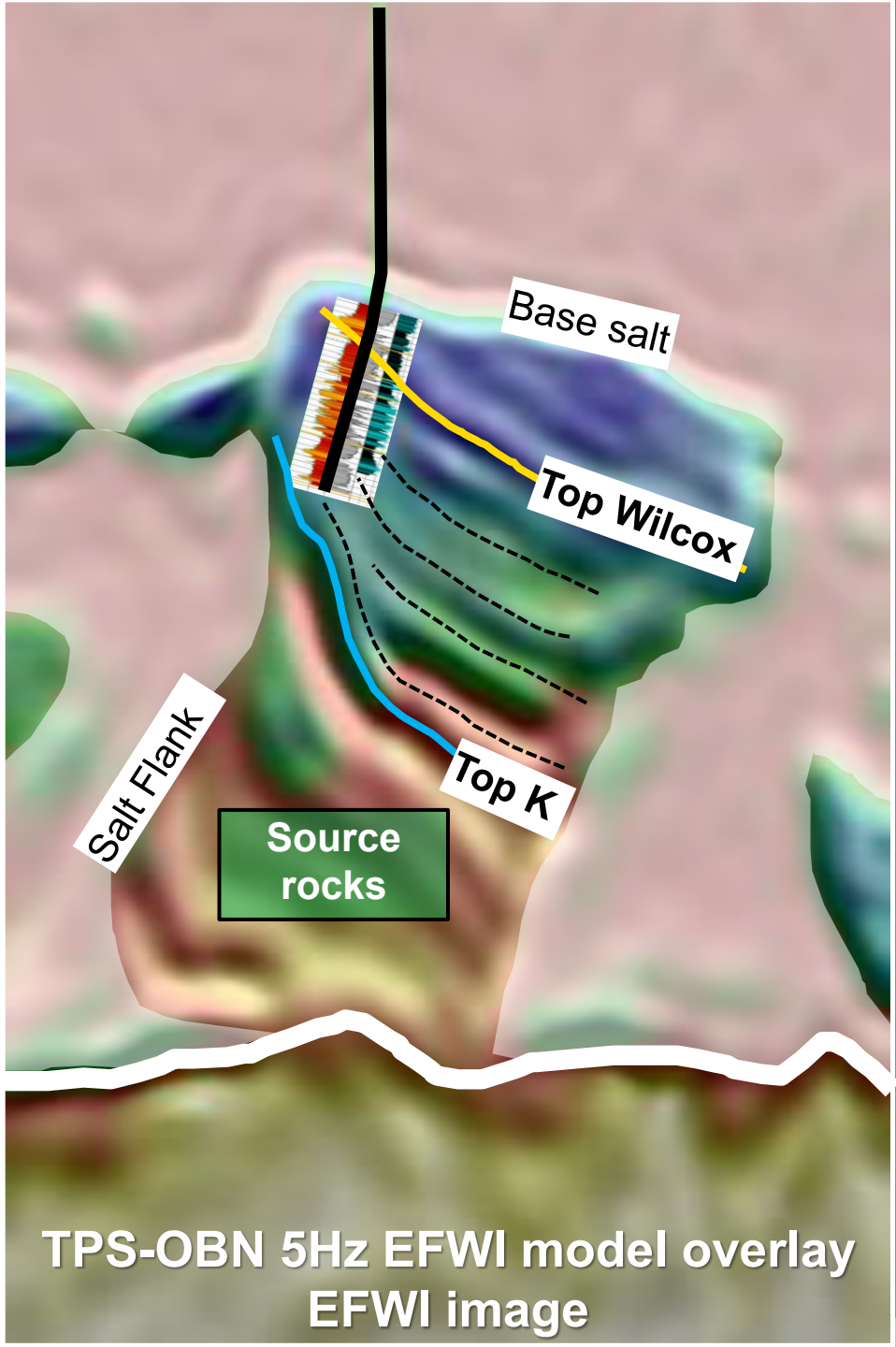
Credit: Liam Hunt

Kingsholm Review

- Improved image
- Reduced uncertainty
- Fresh perspectives



Airguns-Streamer 6Hz AFWI model overlay 15Hz RTM image

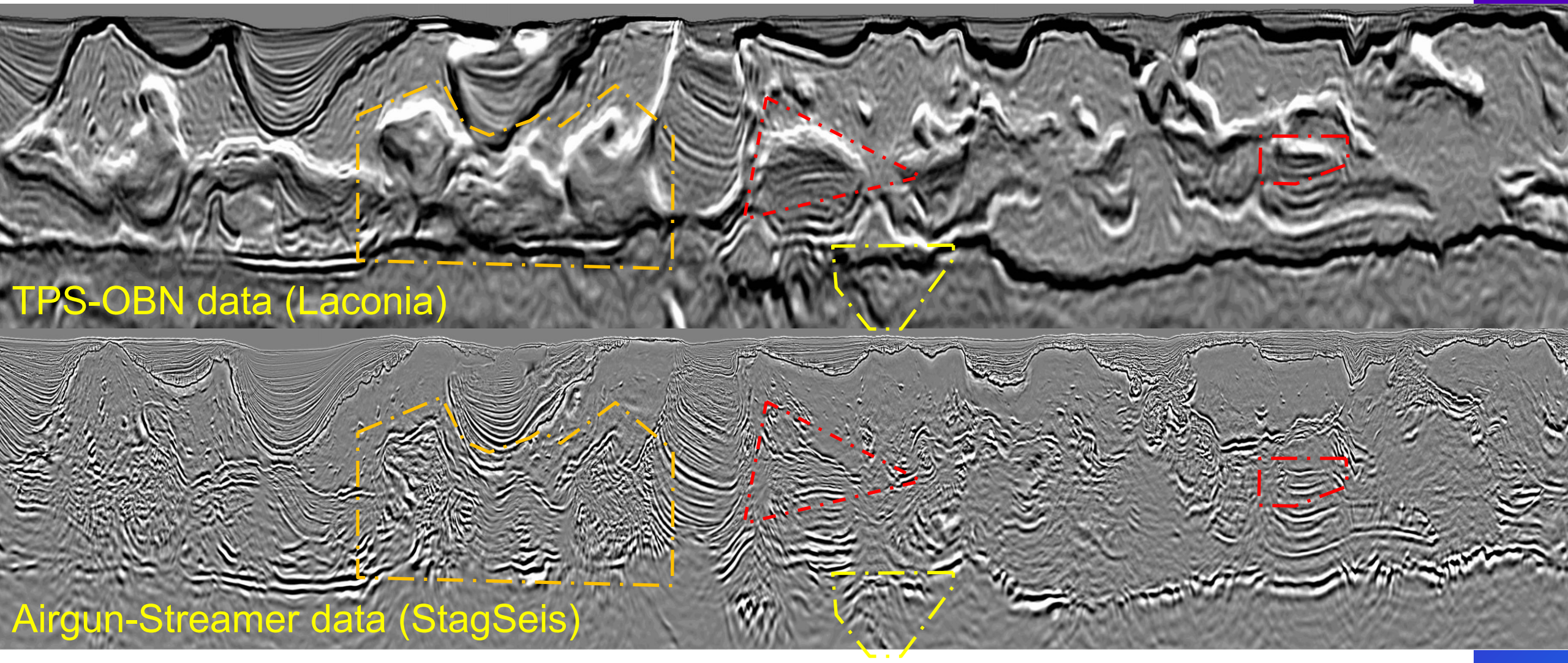


TPS-OBN 5Hz EFWI model overlay EFWI image

Blocky model

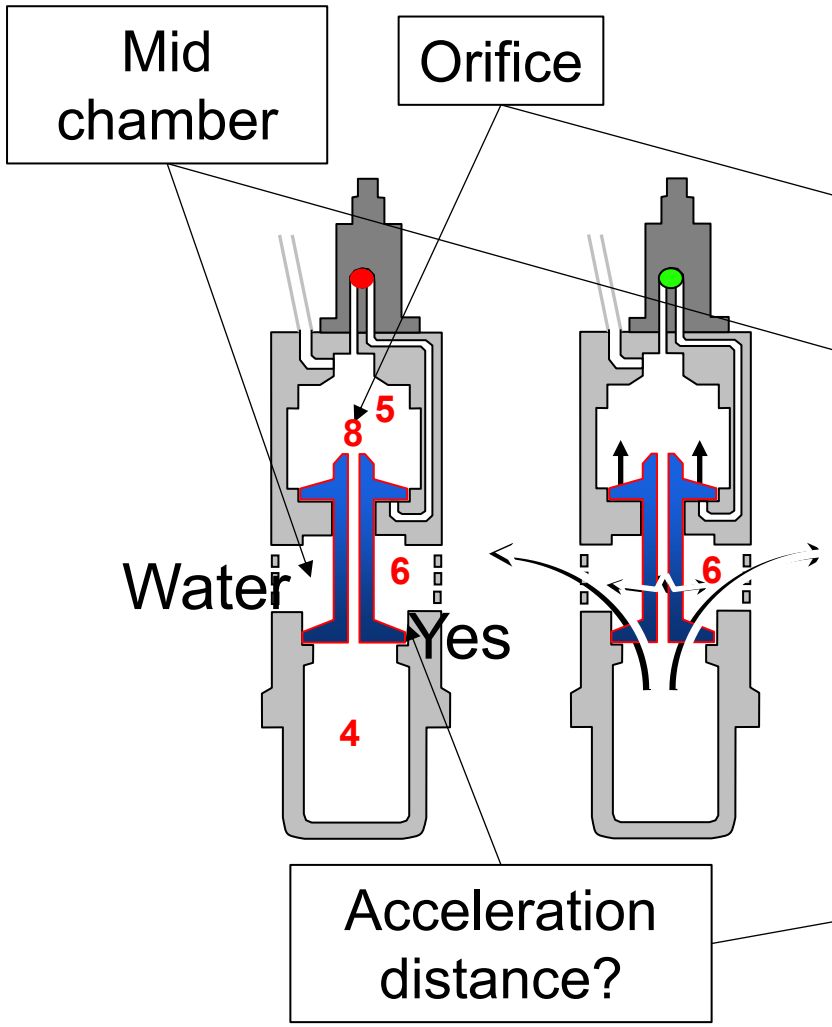
Imaging

Resolution



Courtesy of Viridien

Design features: TPS ≠ Airguns



Feature	TPS	Airgun	Purpose
Mid-chamber (6)	Air filled	Water flooded	**Avoid cavitation**
Acceleration distance	Zero	A few cm	**Reduce slope**
Orifice (8)	Direct	In the shuttle	**Prevent auto-fires**

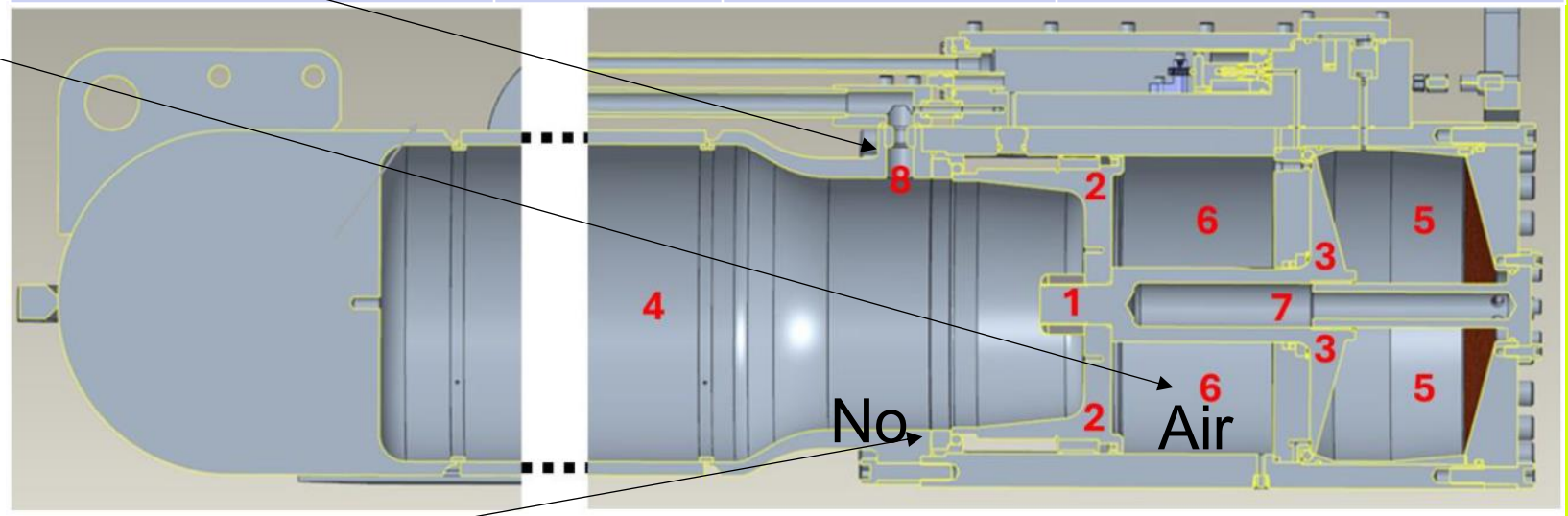


Figure 9. Schematic cross-section of the TPS. The shuttle assembly (1) consists of a shaft and two pistons: a firing piston (2) and an operating piston (3). This source contains four air-filled chambers: the large firing chamber (4), the operating chamber (5), the mid chamber (6), and the shaft chamber (7), which collectively control piston motion and prevent ballistic behavior. The use of air in all chambers avoids cavitation—a common issue in water-filled air guns. Air is supplied and drained via an orifice (8) located outside the shaft, preventing unintentional auto-fires and enhancing crew safety.

Tuned Pulse Source compared to Airguns

Deliberate design features
based on “what is wrong with Airguns?”

Geophysical motivation (**low frequency**)

- Ability to discharge larger volumes of air: up to 28,000 cui instead of up to 2,000 cui

Environmental motivations

- Lower pressure: 1000 psi instead of 2000
- Air-filled mid-chamber instead of water flooded mid-chamber to **prevent cavitation**
- Eliminate acceleration distance to increase rise time and **reduce pressure slope**

Crew safety motivation

- Direct air-drainage instead of indirect via the shuttle to **prevent auto-fires**





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Environmental impact data—example

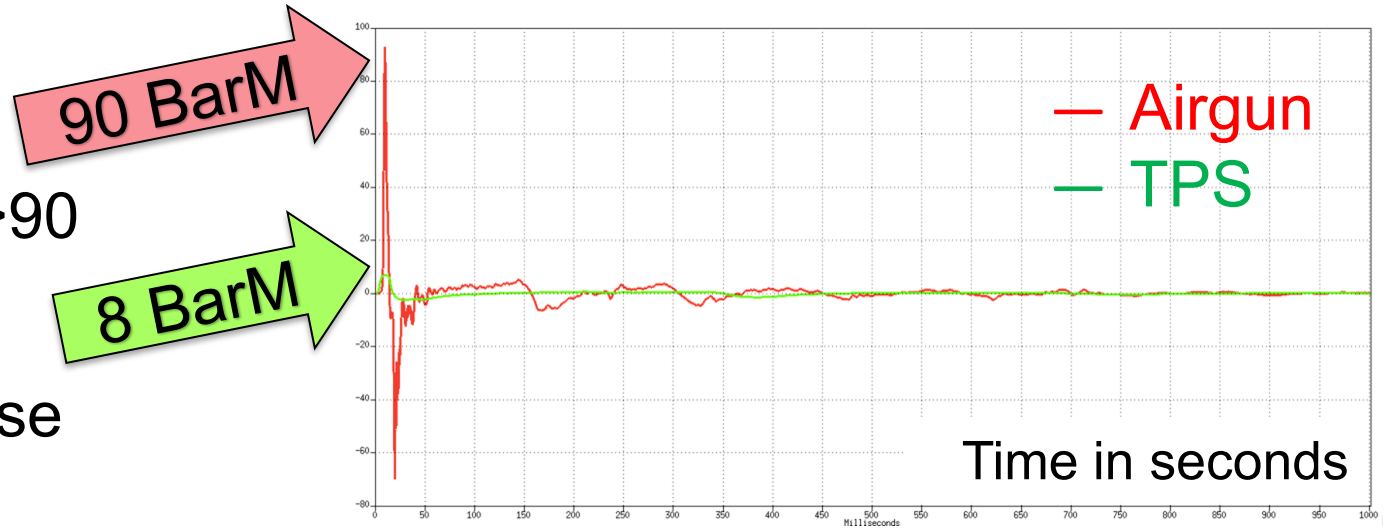
- Ocean Bottom Node: Sercel operated Loggerhead SNAP
- Deployment and retrieval: ROV operated contracted by TGS
- Gulf of Mexico, 2021
- Depth 2707, 2815 meter (2 OBNs)
- Continuous recording
- 10 microseconds sampling interval
- 100 kHz sampling frequency
- 50 kHz Nyquist frequency
- Apples-to-apples sources
- Co-located Airgun, TPS, Gemini
- Customer: Shell

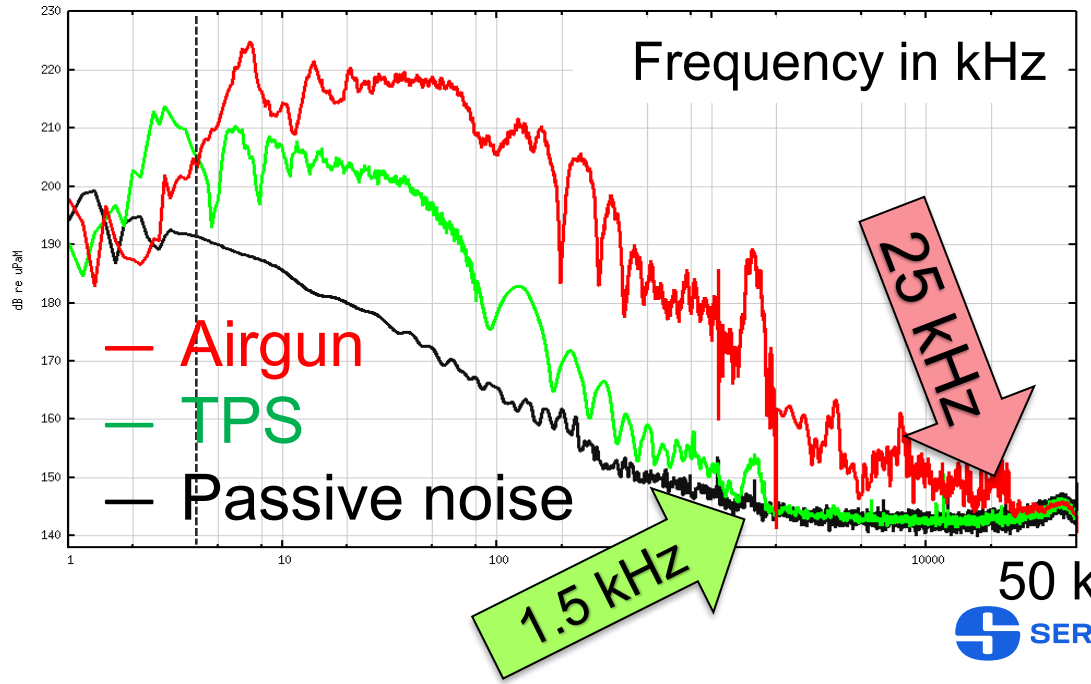


Lower environmental impact

- **Time domain**
  - Bar-meter: <8 compared to >90
- **Frequency domain**
  - TPS spectrum ~ ambient noise spectrum at 1500 Hz
  - Airgun spectrum joins the spectrum of the ambient noise at 25 kHz

- Data from a special node Δt=10 usec
  - Nyquist frequency = 50 kHz

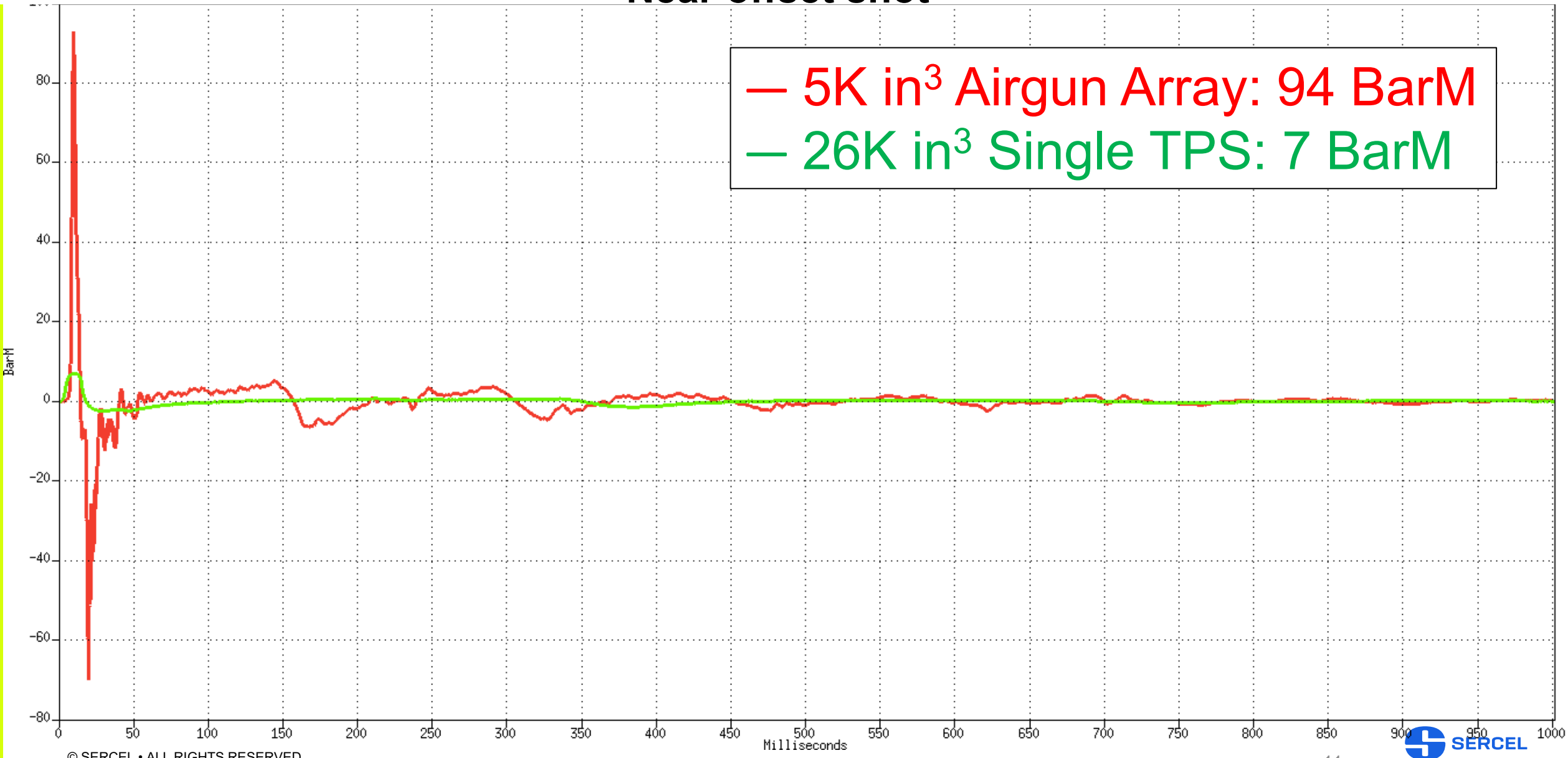




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Far field data recorded by same OBN

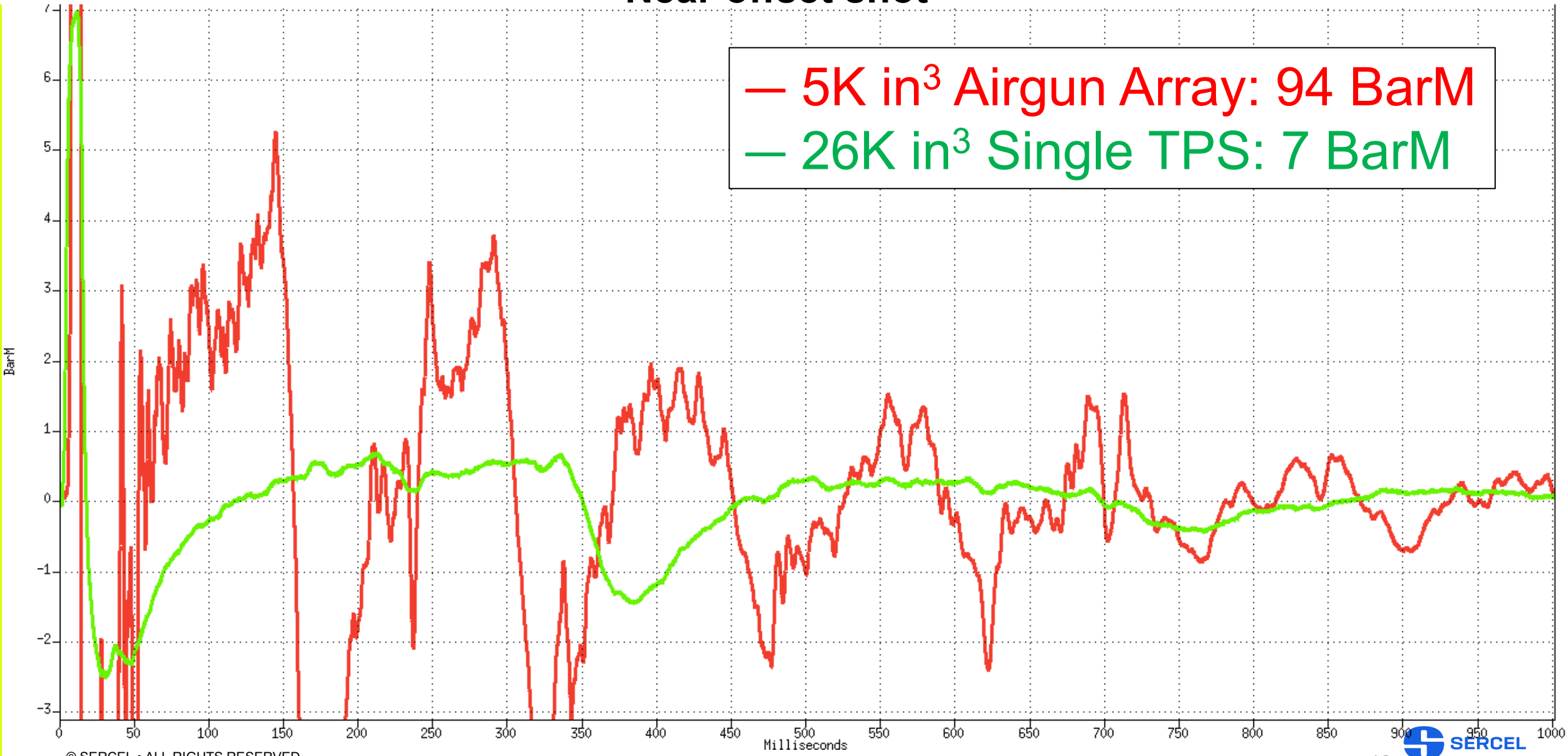
Near offset shot



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Far field data recorded by same OBN

Near offset shot

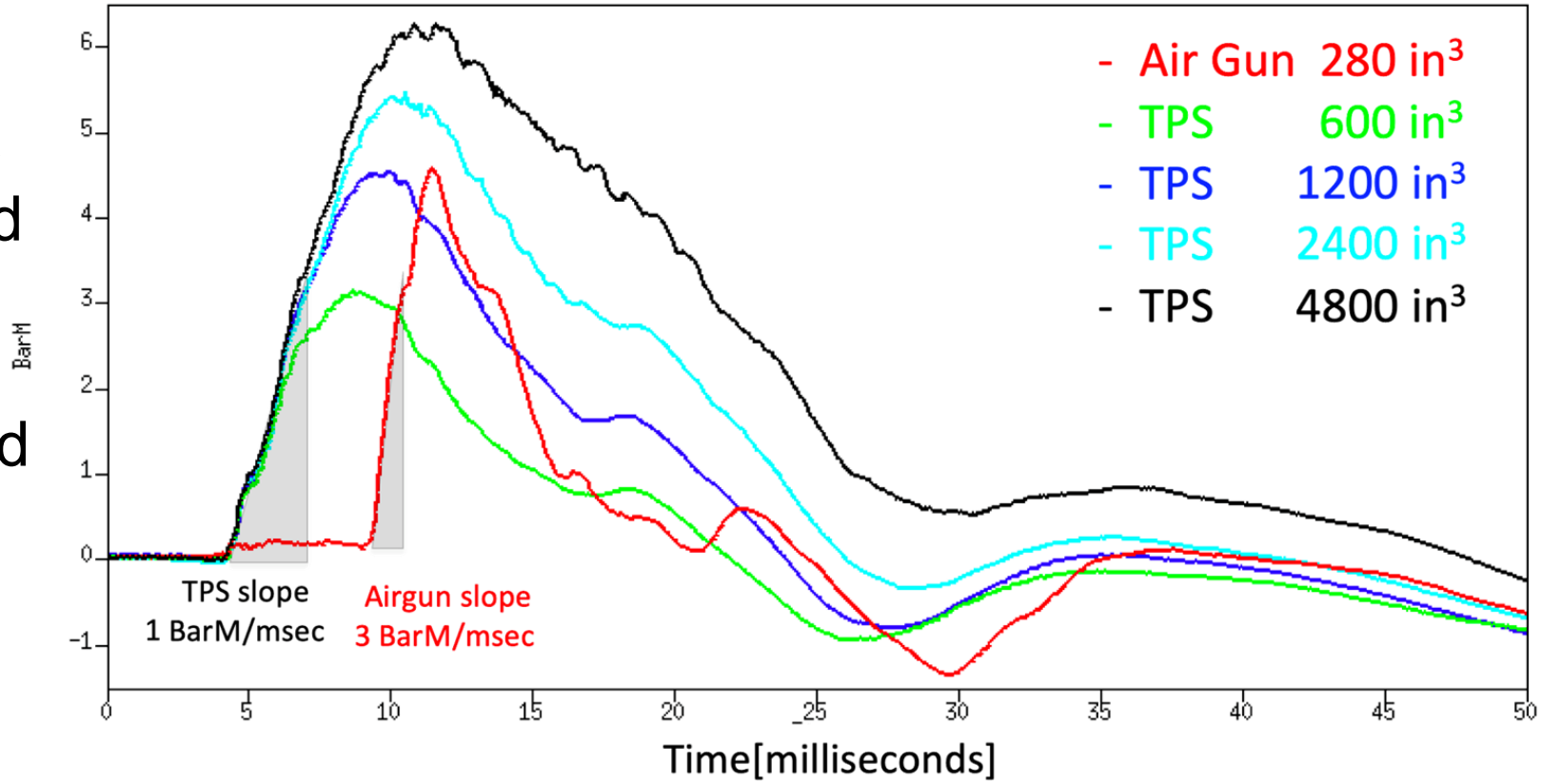


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Slope and shoulder

The shoulder

- The shuttle accelerates
- Air is not yet discharged through the ports
- The water in the mid chamber are discharged
- Cavitation **(bad!)**!
- Only Airguns
- TPS has no shoulder



- **The Slope**

- Airguns' slope is x3 higher because the ports open faster
- Pressure is proportional to particle velocity
- Slope is proportional to particle acceleration
- Acceleration is proportional to force → **we want to reduce the slope**