The multi-2D seismic imaging of the Solfatara Volcano, Italy, inferred by seismic attributes.

by Sergio Gammaldi[1],
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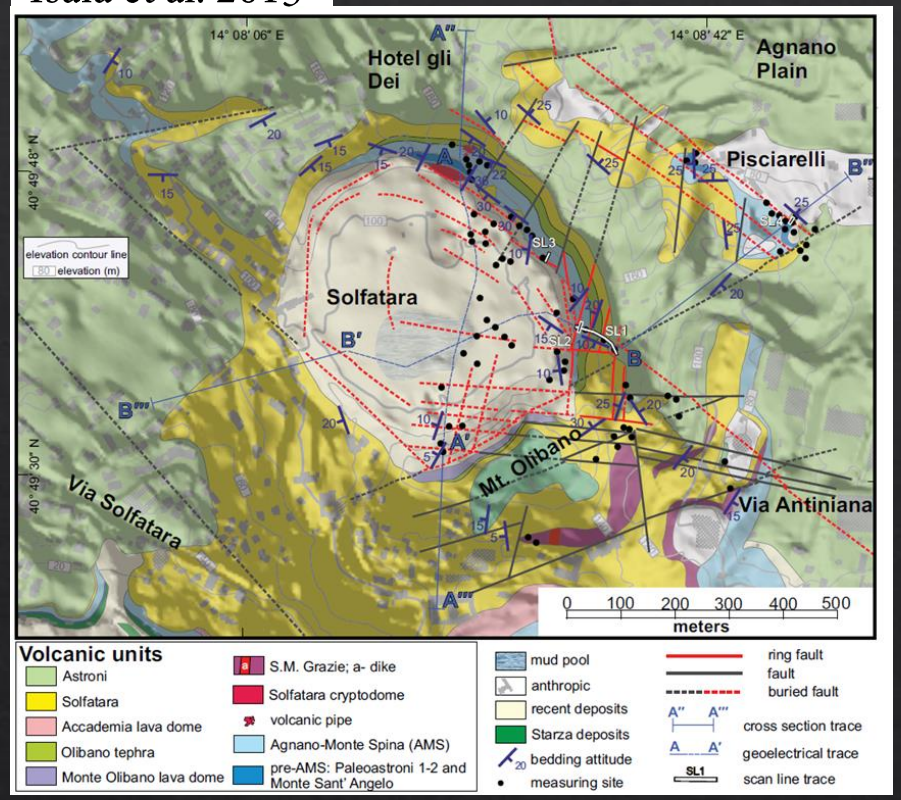
The caldera of the Solfatara Volcano

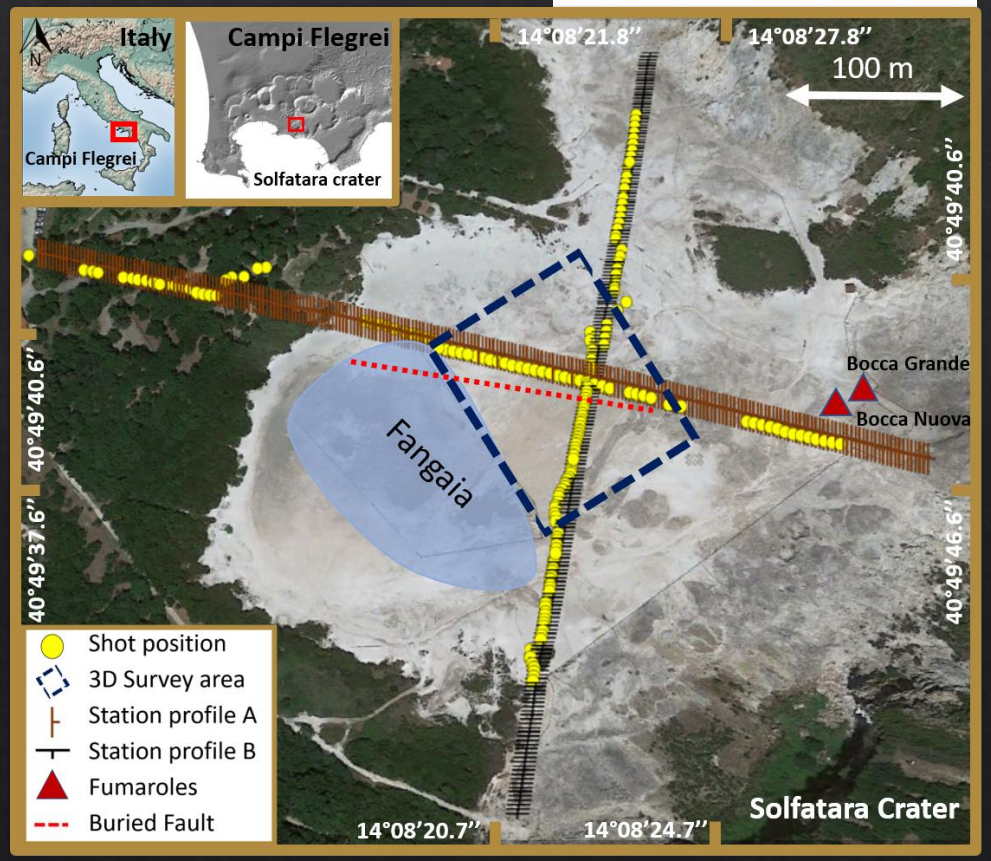
Isaia et al. 2015



Main characteristics of the Solfatara Volcano:

- Maar diatreme structure;
- Eastward semicircle area characterized by high value of resistivity and velocity value due to the consolidated tephra, surface and shallower presence of gas;
- Westward semicircle area characterized by low value of resistivity and velocity due to the unconsolidated tephra and surface and shallower presence of water.

Gammaldi et al. 2018



The experiment

Repeated InduCed Earthquakes and Noise (RICEN) is a geophysical survey performed at volcano Solfatara using the seismic waves (both in passive and active mode) as a diagnostic tool for seismic imaging.

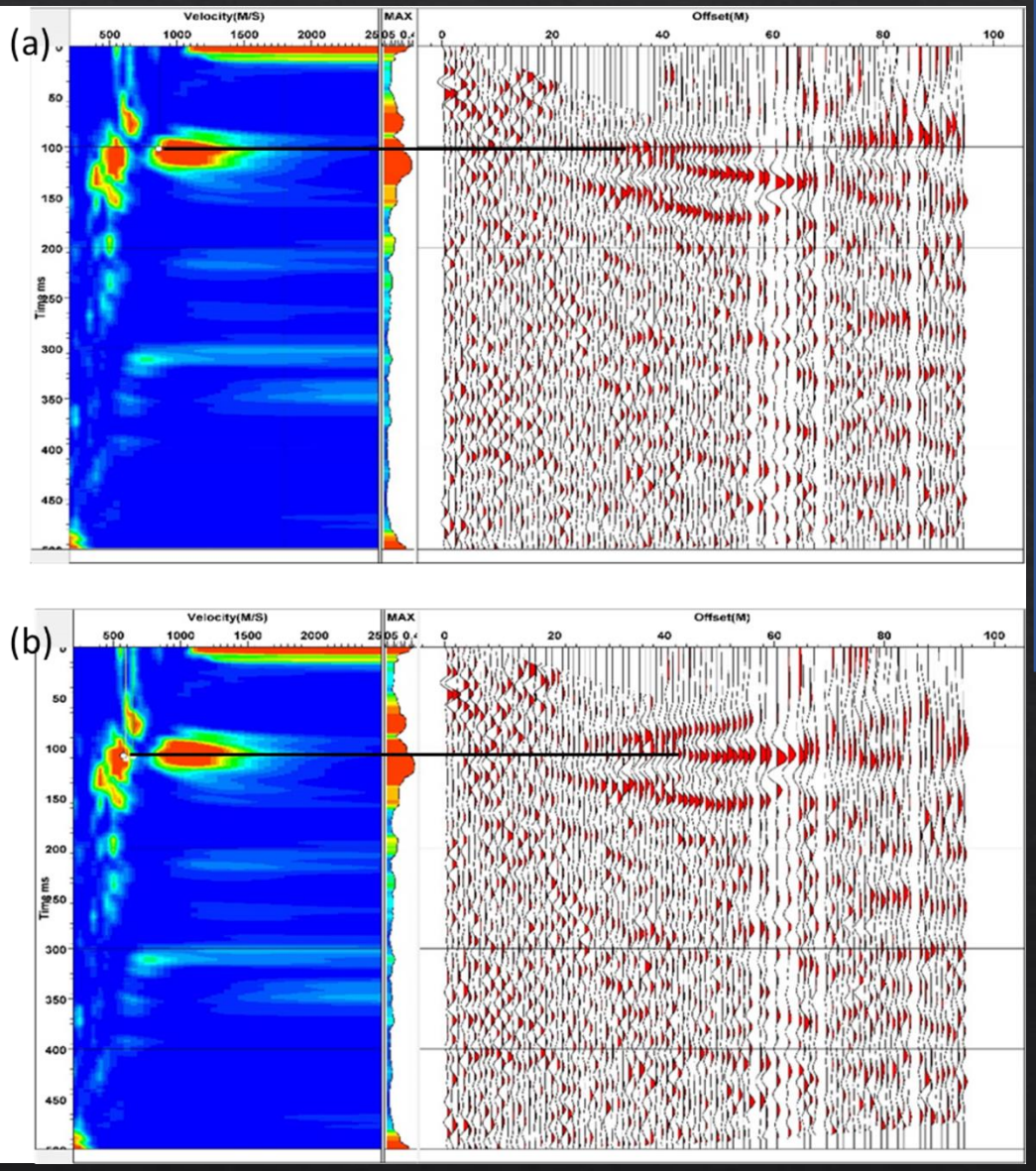
In particular the experiment acquired:

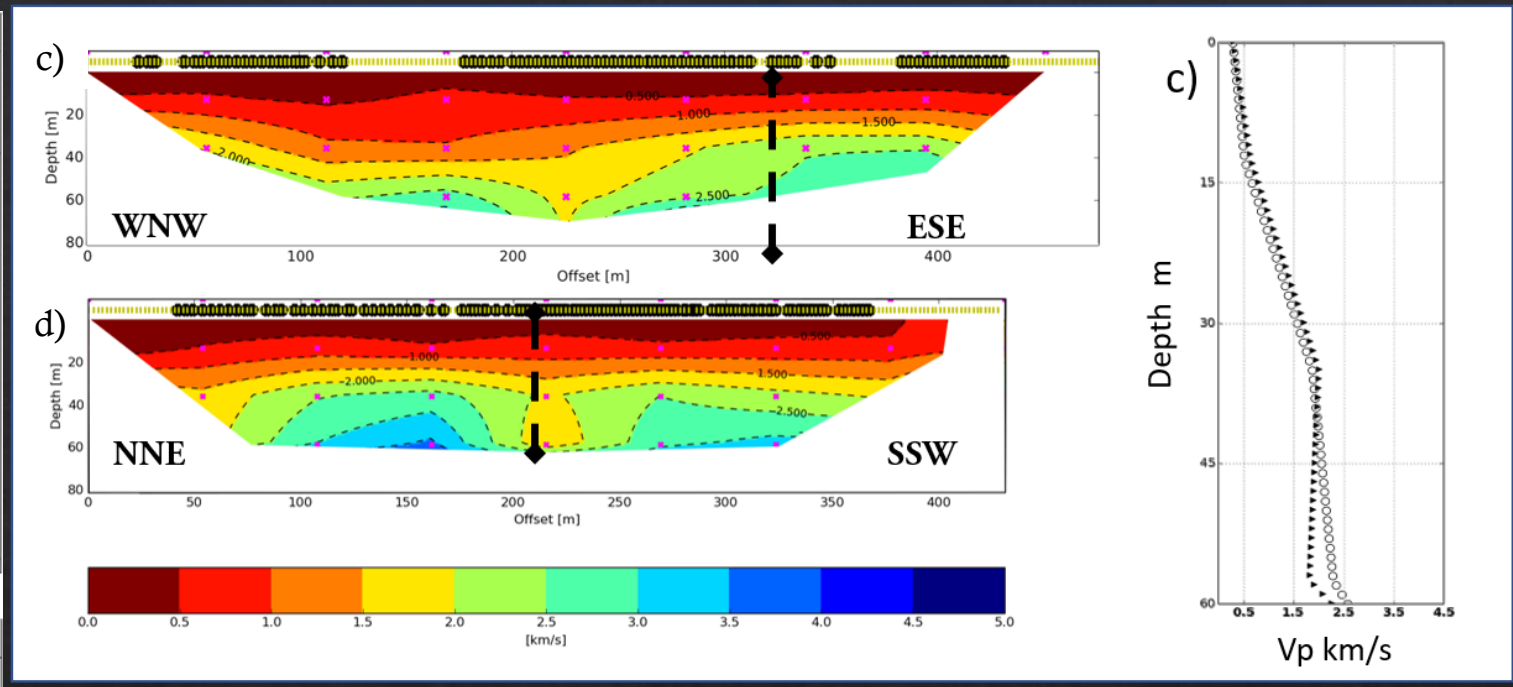
- Ambient Noise
- 3D acquisition
- Two 2D profiles:
  1. WNW-ESE (Profile A)
  2. NNE-SSW (Profile B)

Acquisition Parameter :

- Signal from Vibroseis a 6400 kg IVI-MINIVIB ® with a theoretical pick force of ~27 KN and a frequency between 5-125 Hz
- Frequency rate 1000 Hz
- 75 and 116 sources with a sampling space of ~ 4m
- 240 and 215 receivers sampling space of ~ 2m

Velocity analysis after the bayesian estimation





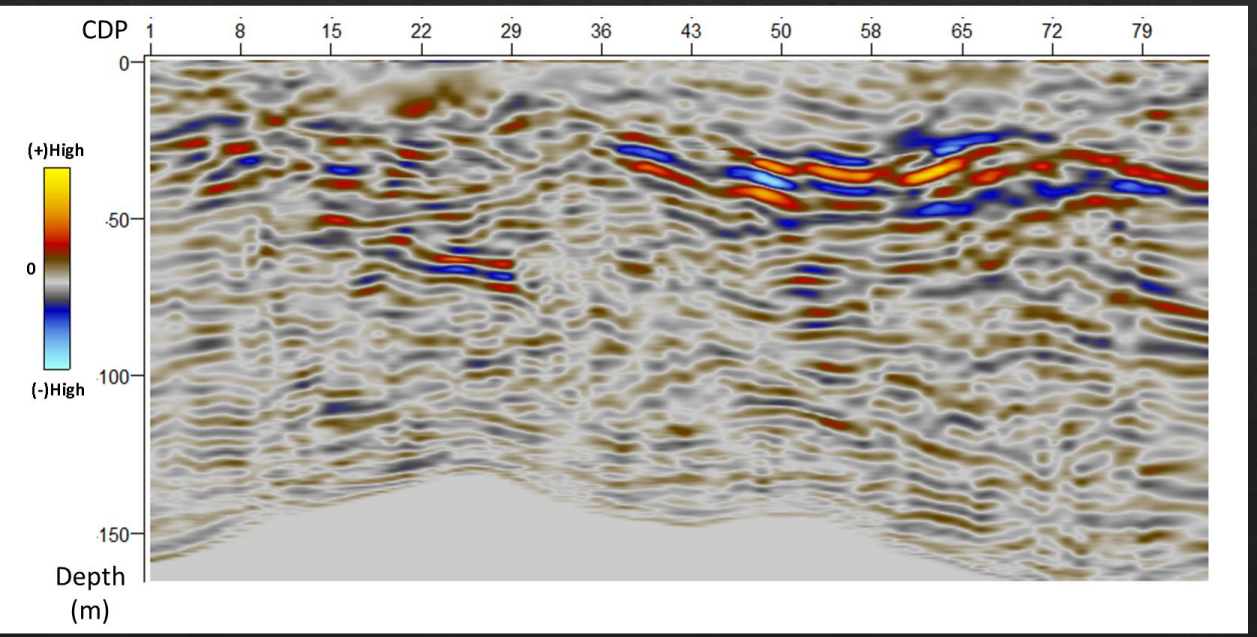
On the left: example of picking of the stacking velocity on a semblance plot. (a) represents the picking for the reflection phase. (b) represents the picking of the refraction phase. However, only the lower stacking velocity has been picked since it is related to the reflection event.
Above: 2D model extract from Gammaldi et al 2018 used to identify the first reflection during the velocity analysis and picking.

(Ismail et al., 2020)

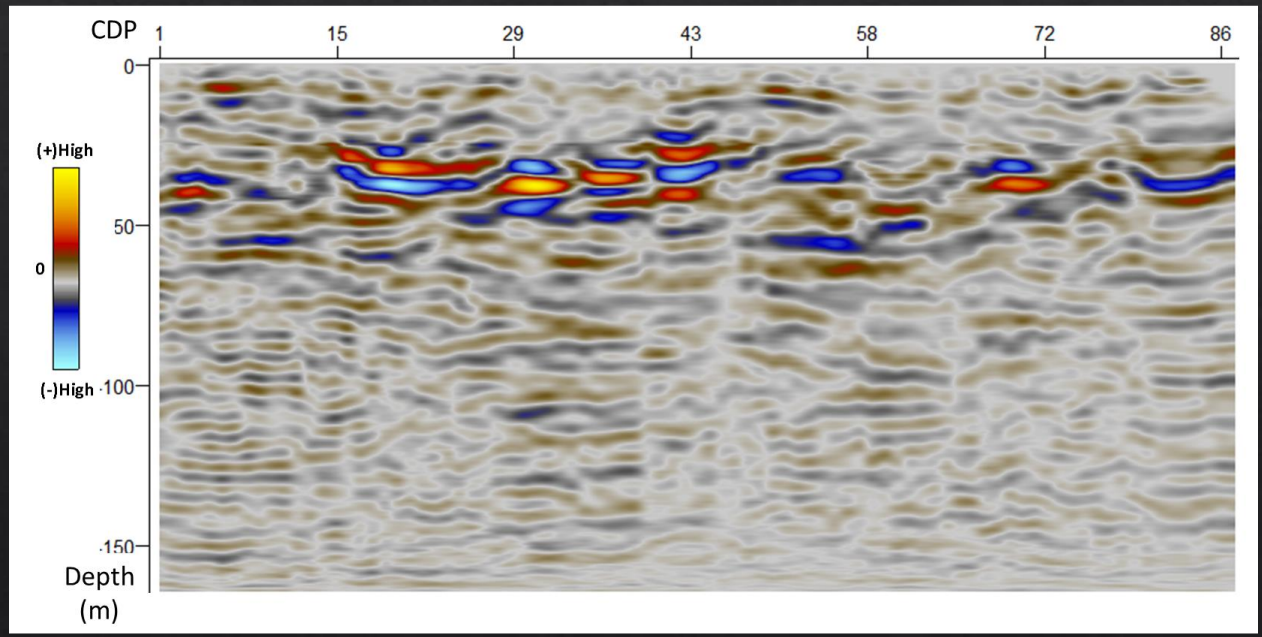
Seismic stack

Can we improve this image?

Seismic attributes highlight the main characteristic, i.e. gas or fluids evidence.



Profile A



Profile B

(Ismail et al., 2020)

Seismic attributes

Post-stack seismic attributes Profile A

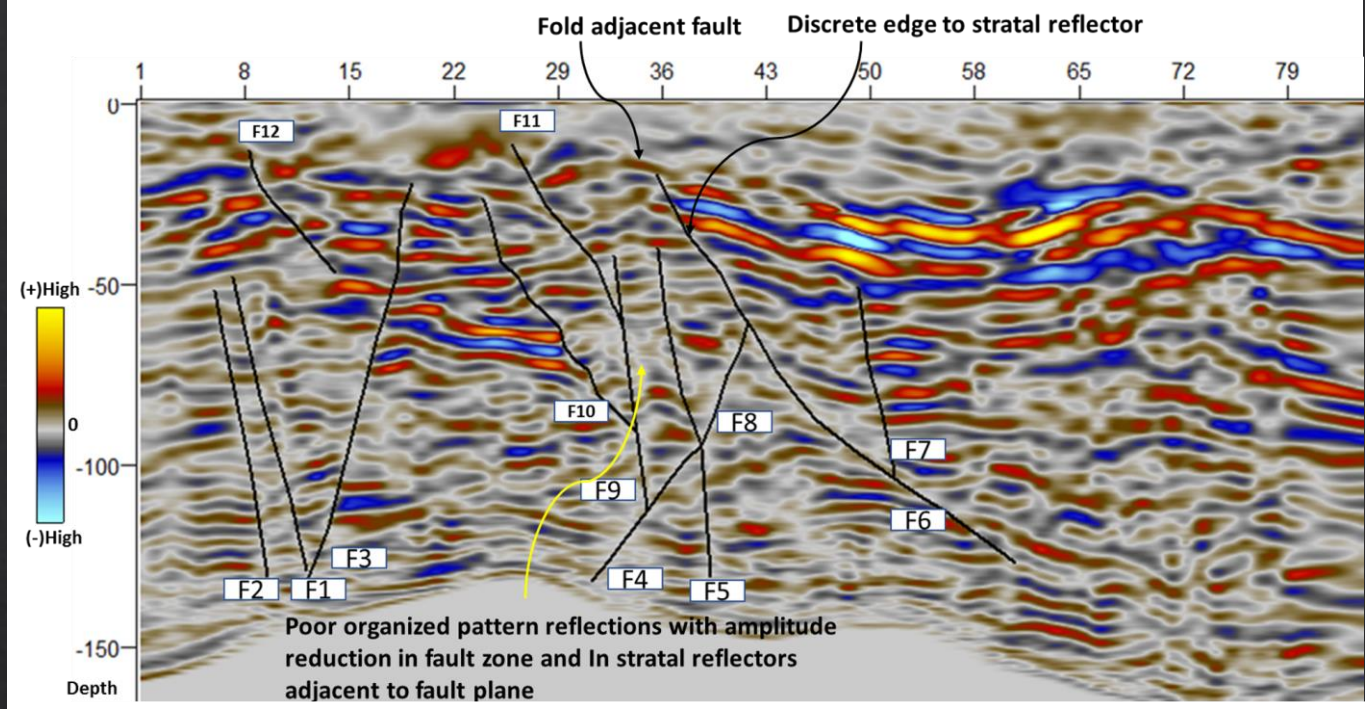
1. Time gain attribute

Recoverage of the amplitude in time lost for the geometrical spreading.

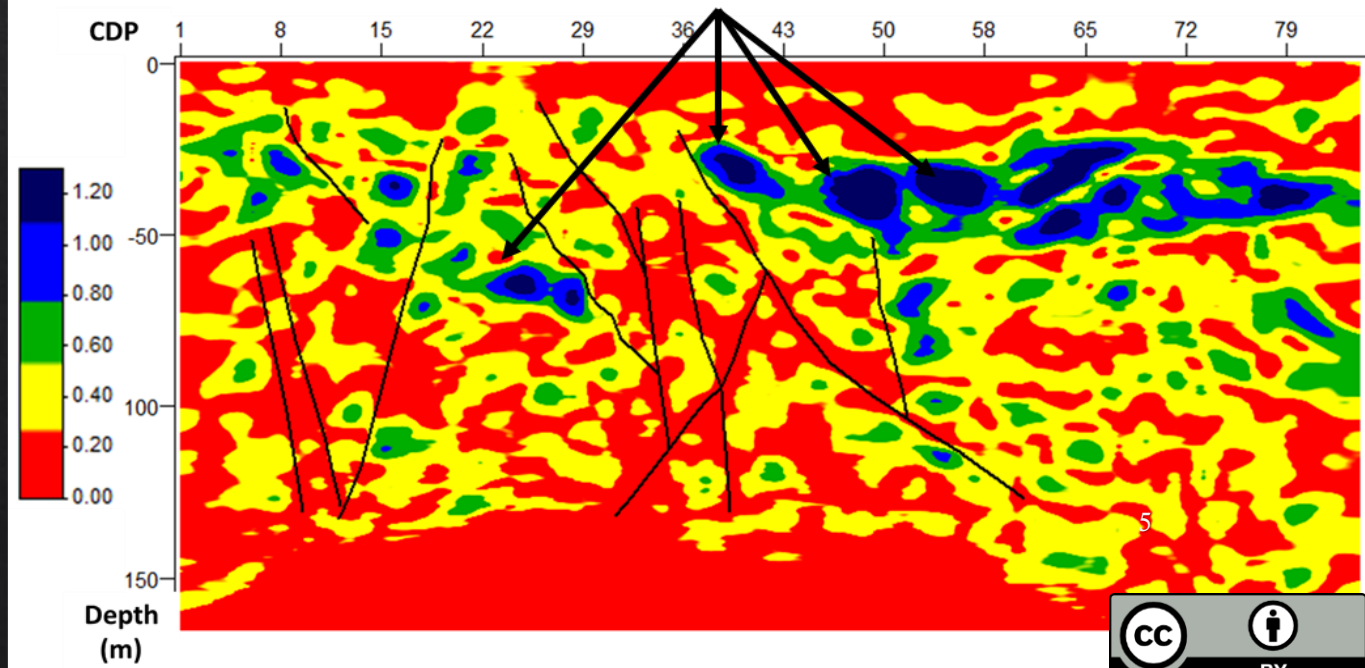
2. Envelope attribute

The entire instantaneous energy through the analytical trace, both real and imaginary parts and is independent of phase, that make it more suitable to analyze the amplitude anomalies or acoustic impedance contrast in detail.

(Ismail et al., 2020)



Dark blue zones represent the maximum total instantaneous energy values



Seismic attributes

Post-stack seismic attributes Profile B

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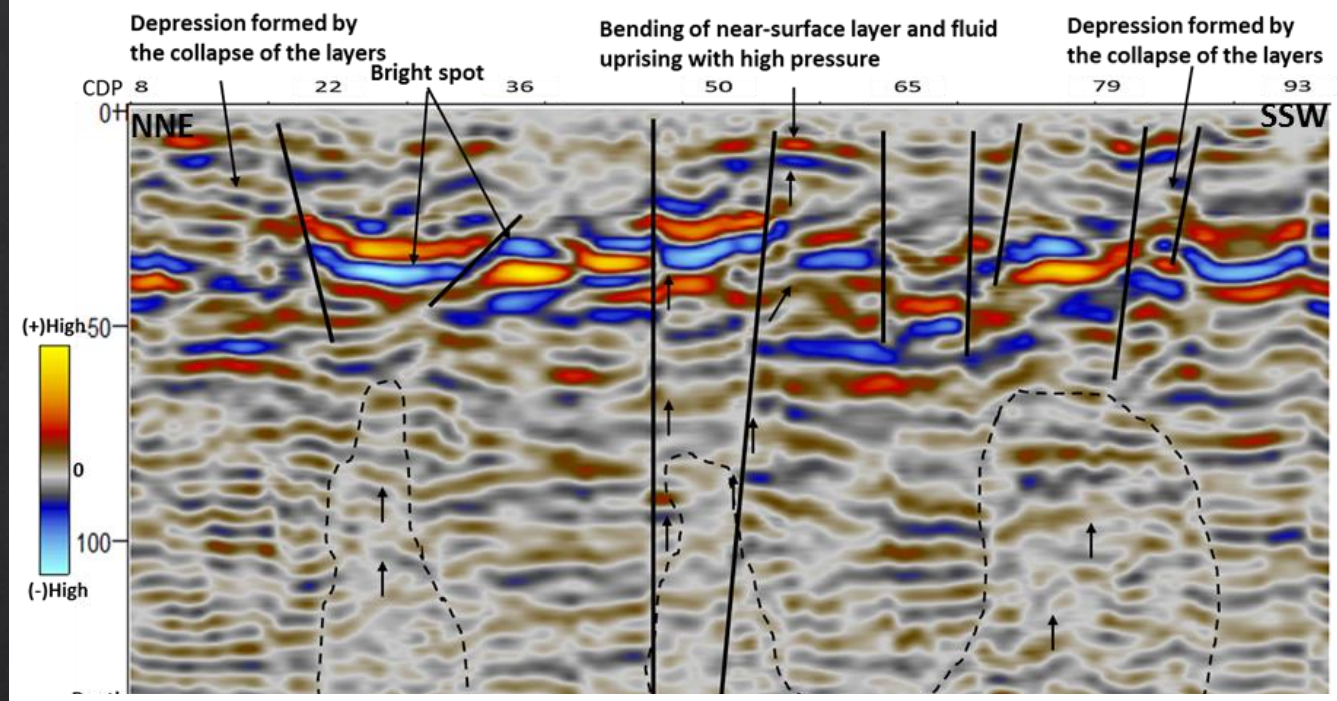
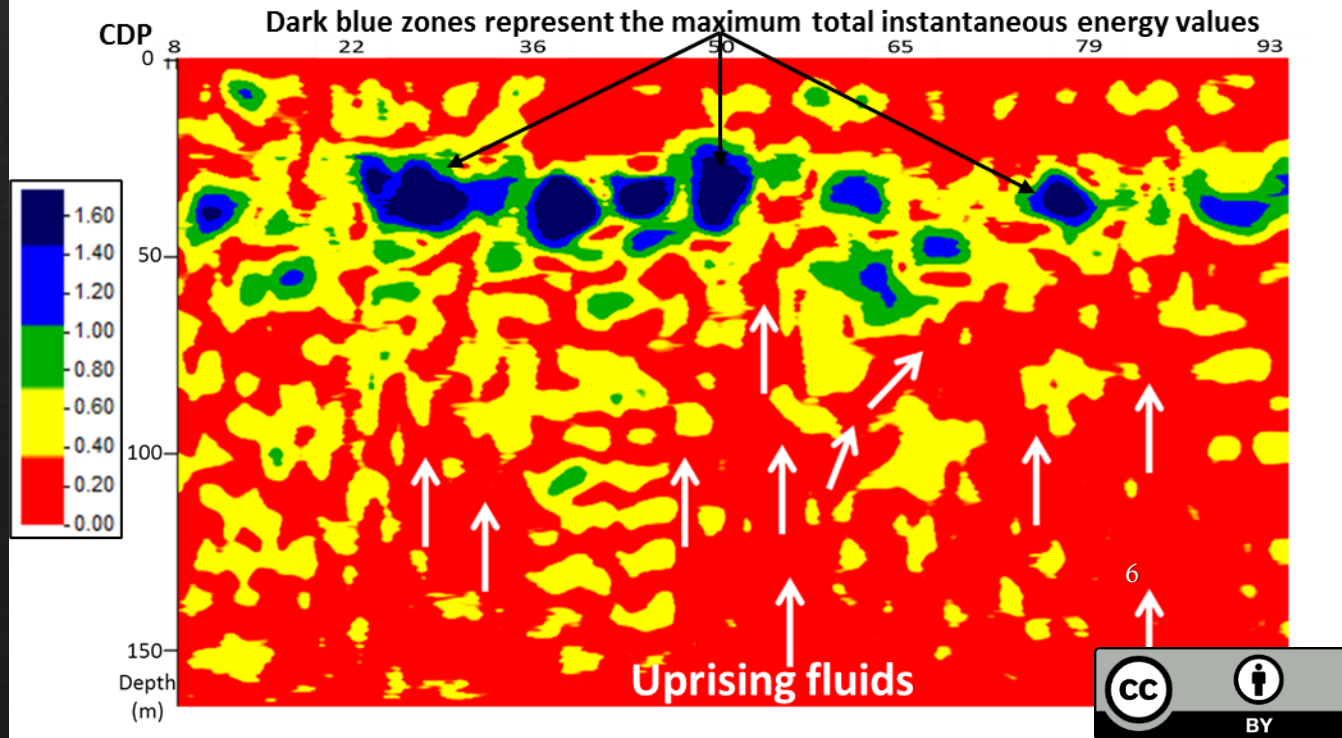




Seismic attributes

Post-stack seismic attributes Profile A

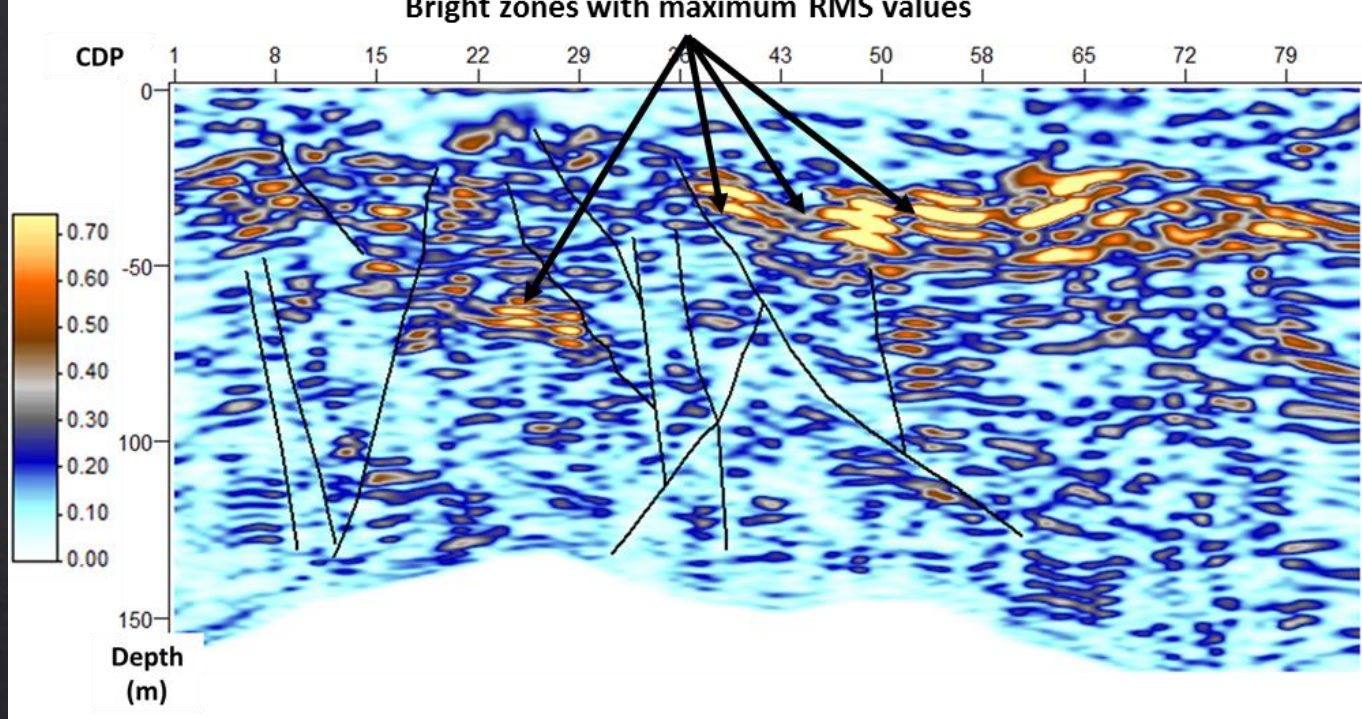
3. RMS attribute

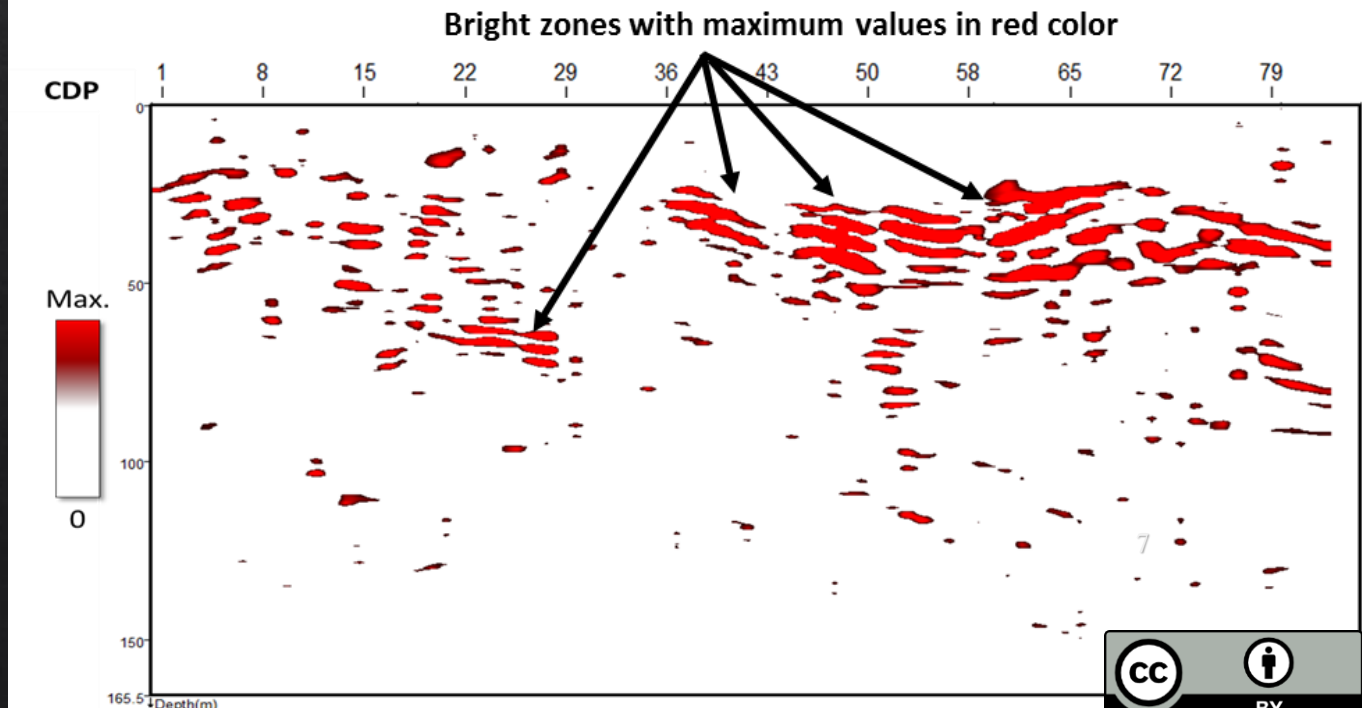
The Root mean square attribute is a good indicator for high amplitudes values as throughout the extraction of it the amplitude values are squared firstly before averaging.

4. Energy attribute

We have extracted energy attribute since it is one of the best based-amplitude attributes to highlight gas zones and lateral continuity.

(Ismail et al., 2020)





Seismic attributes

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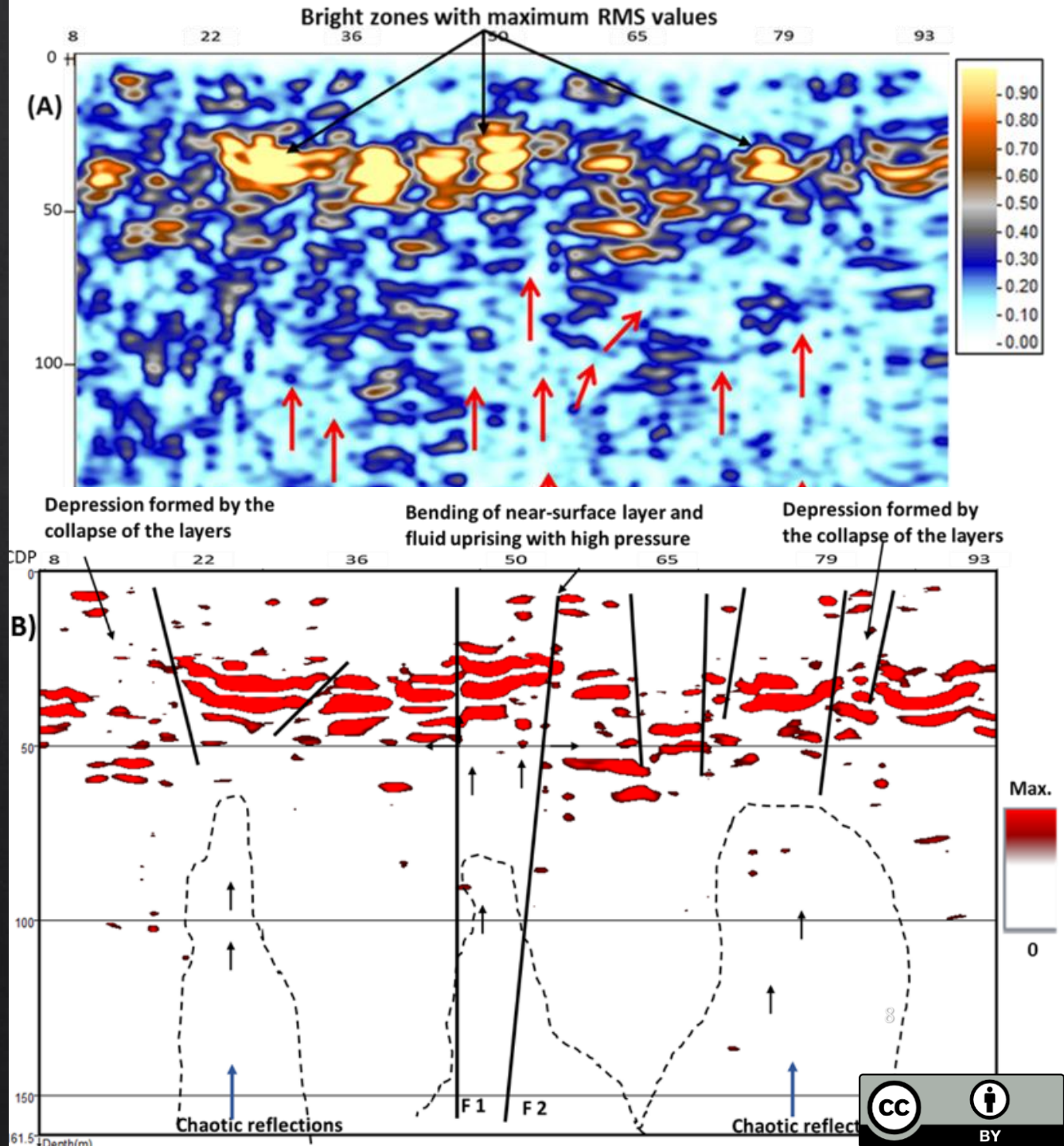
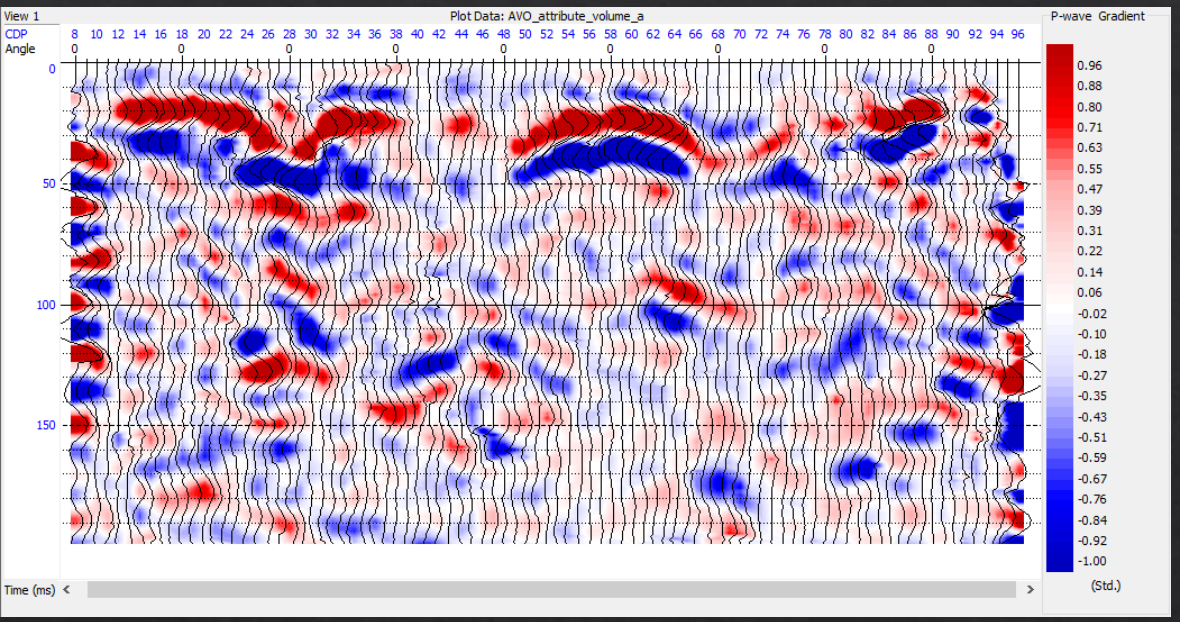
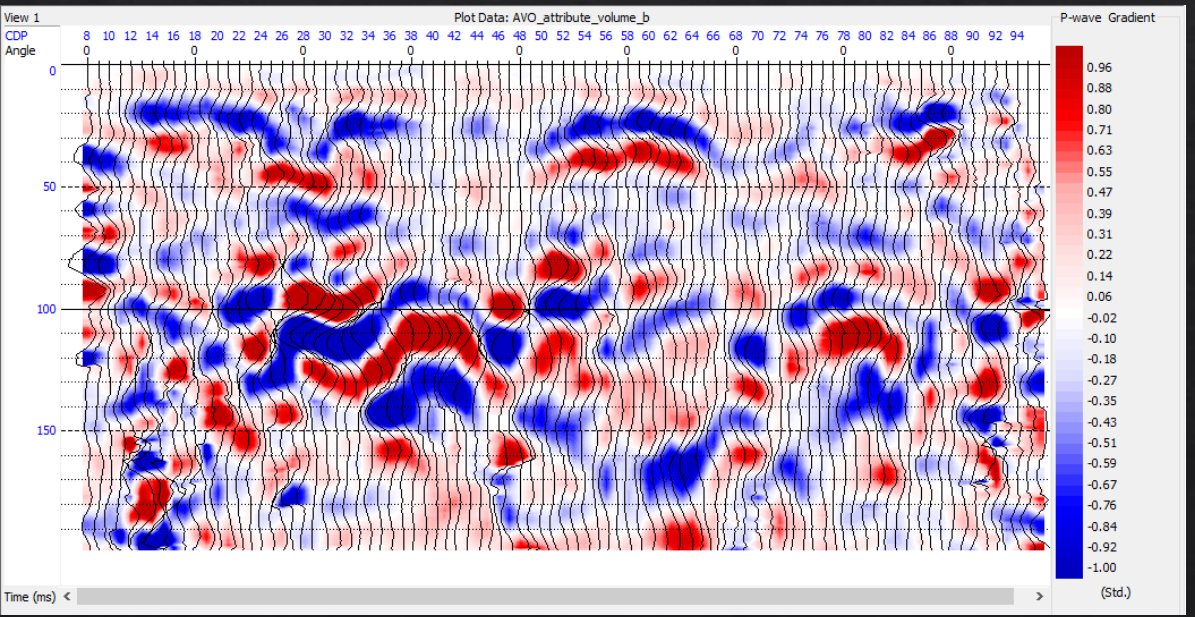


Amplitude versus offset analysis (AVO)

A: Intercept

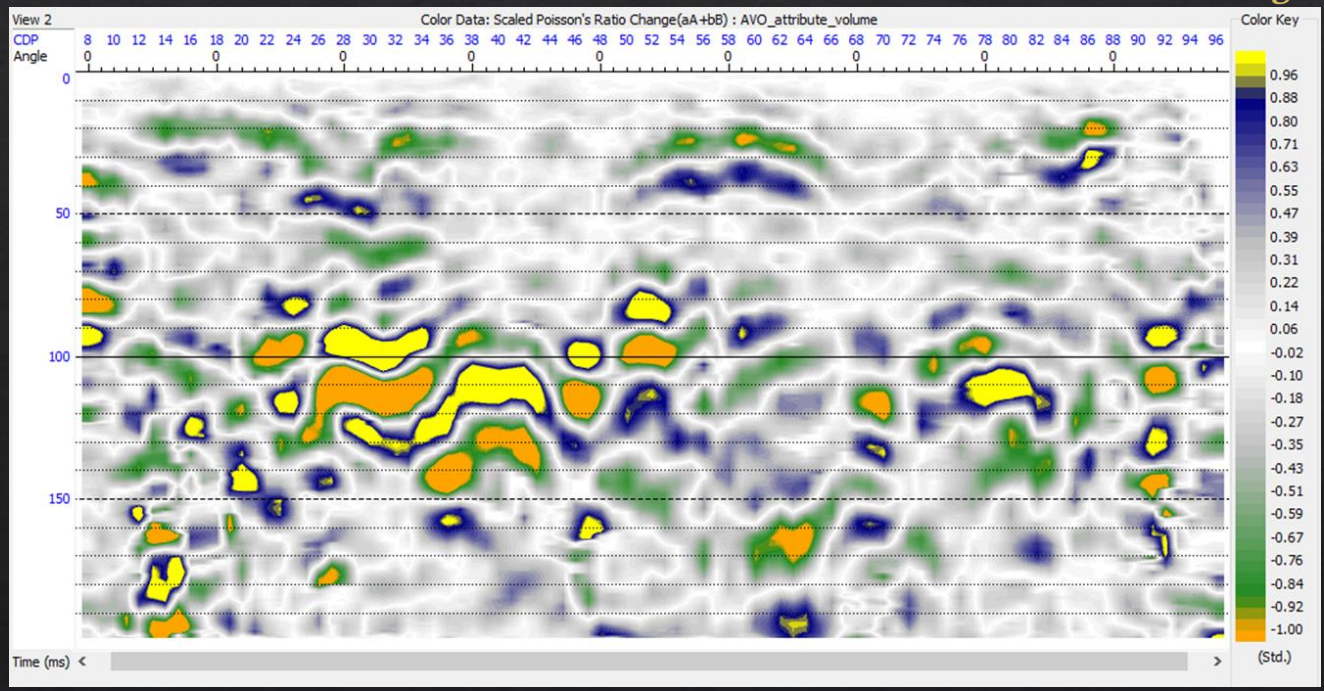


B: Gradient



The AVO attributes can identify and distinguish between the change in lithology and fluid content by the anomalies that we can get from the AVO analysis. The calculation of the intercept (A) and gradient (B) from the prestack seismic dataset proceeds using the velocity data from Vrms model obtained in the velocity analysis. Scaled Poisson's ratio is used to discriminate/ identify the gas-saturated zones according to the relation we mentioned between (A+B) and Poisson ratio.

Scaled Poisson ratio change

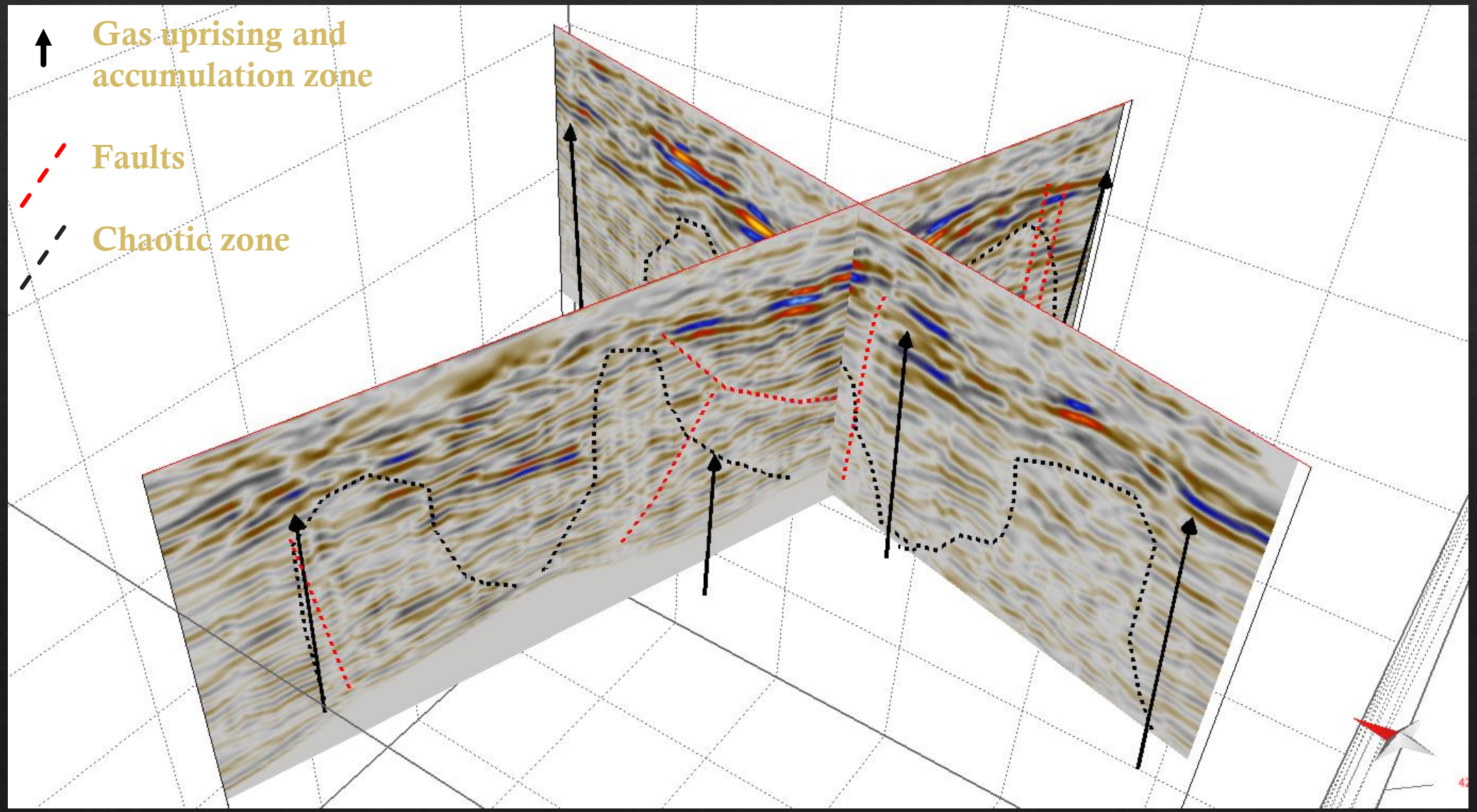


$$A + B = \frac{9}{4}\Delta\sigma$$

The sum A+B is proportional to the change in Poisson ratio.
We are interested to the orange area which are associated to precense of gas

The multi 2D seismic image of the solfatara Crater

With the arrows we show the possible gas uprising in time on the image in depth. The image is breakdown for the shallow detection of the gas in the Solfatara Crater. The extraxtion of the main faults and chaotic zone following respectively termination of layer and poor



amplitude value zone let us to merge the arrows whose represent, according with the cross plots, the way of gas uprising and accumulation zone.
In addition to the multi 2D image of Gammaldi et al 2018 the present further suggest the way where the gas come out and detect the zone where it is mostly trapped by a cap rock.

Thank you for the attention

References

- Gammaldi, S., Amoroso, O., D'Auria, L and Zollo, A., 2018. High resolution, multi-2D seismic imaging of Solfatara crater (Campi Flegrei Caldera, southern Italy) from active seismic data. Journal of Volcanology and Geothermal Research. Volume 357, 15 May 2018, Pages 177-185.
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- Isaia, R., Vitale, S., Di Giuseppe, M.G., Iannuzzi, E., Tramparulo, F.D.A., Troiano, A., 2015. Stratigraphy, structure and volcano-tectonic evolution of Solfatara maar-diatreme (Campi Flegrei, Italy). Geol. Soc. Am. Bull. 1485-1504 (9), 127.