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Upscaling of elastic properties in carbonates: A modeling approach based on a multi-scale geophysical dataset

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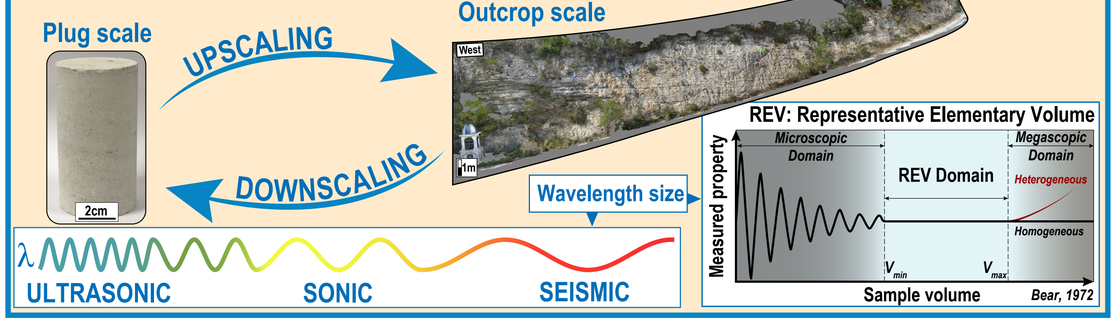
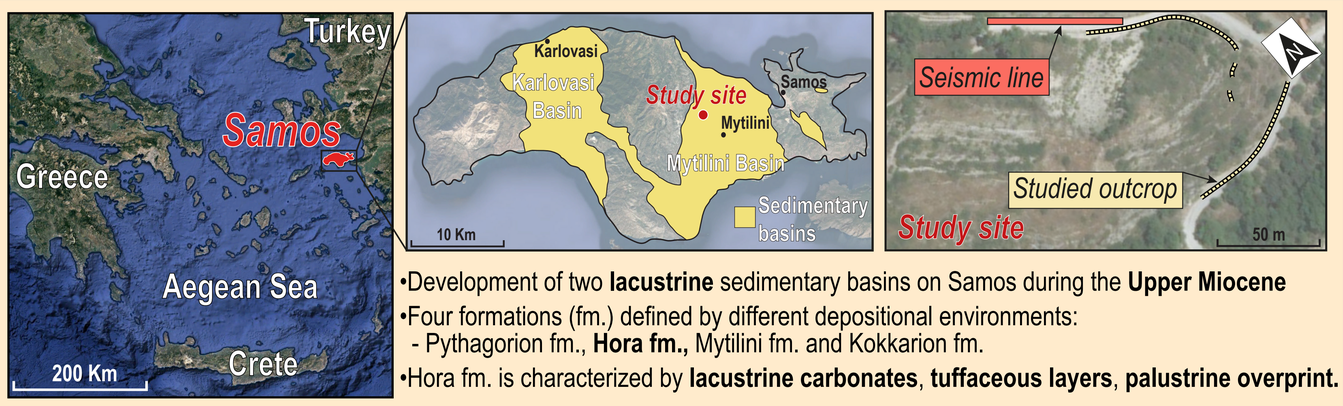
JGR Solid Earth
Bailly et al., 2019b
Flash me!

1. RESEARCH QUESTION

How to link the macro- and microstructure of lacustrine carbonates with elastic wave velocities?

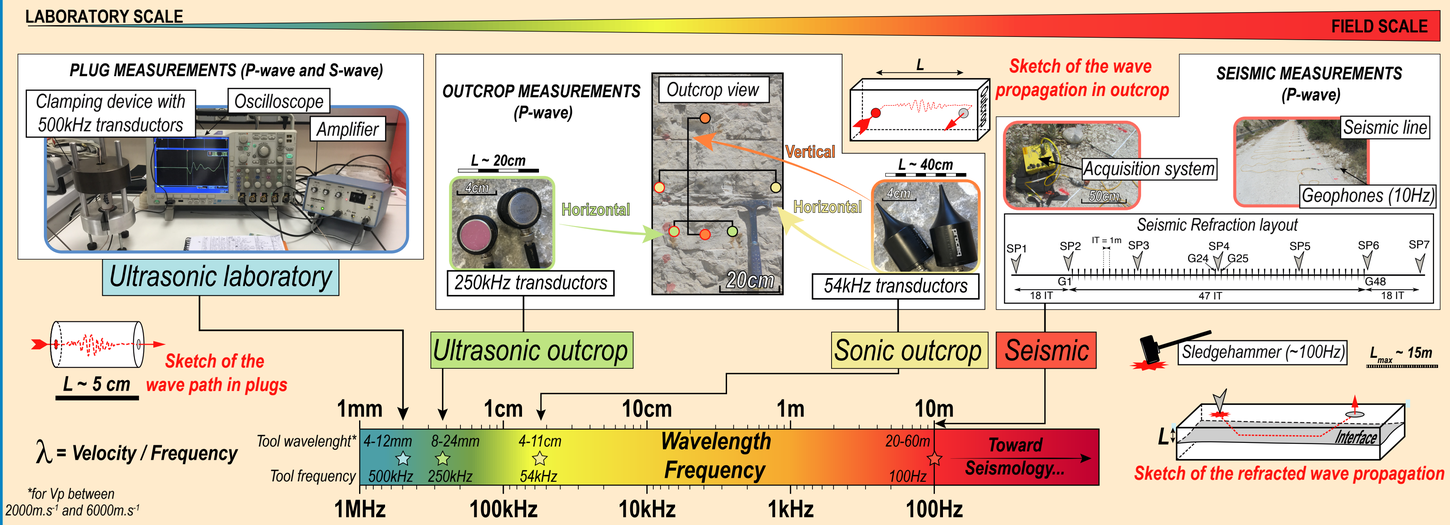


2. GEOLOGICAL FRAMEWORK

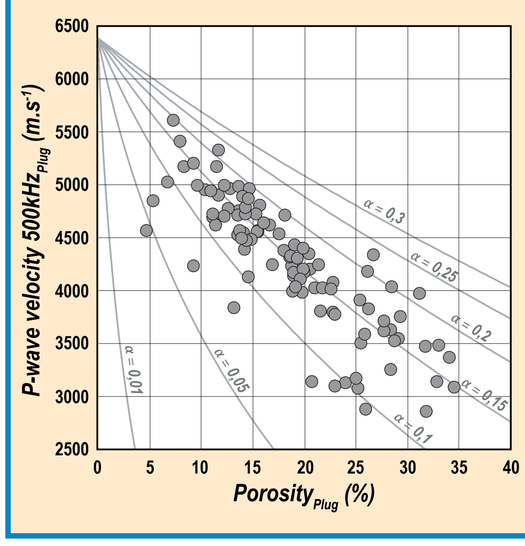


- Development of two **lacustrine** sedimentary basins on Samos during the **Upper Miocene**
- Four formations (fm.) defined by different depositional environments:
  - Pythagorion fm., **Hora fm.,** Mytilini fm. and Kokkarion fm.
- Hora fm. is characterized by **lacustrine carbonates**, **tuffaceous layers**, **palustrine overprint.**

3. MULTI-SCALE METHODOLOGY: FROM ULTRASONIC TO SEISMIC

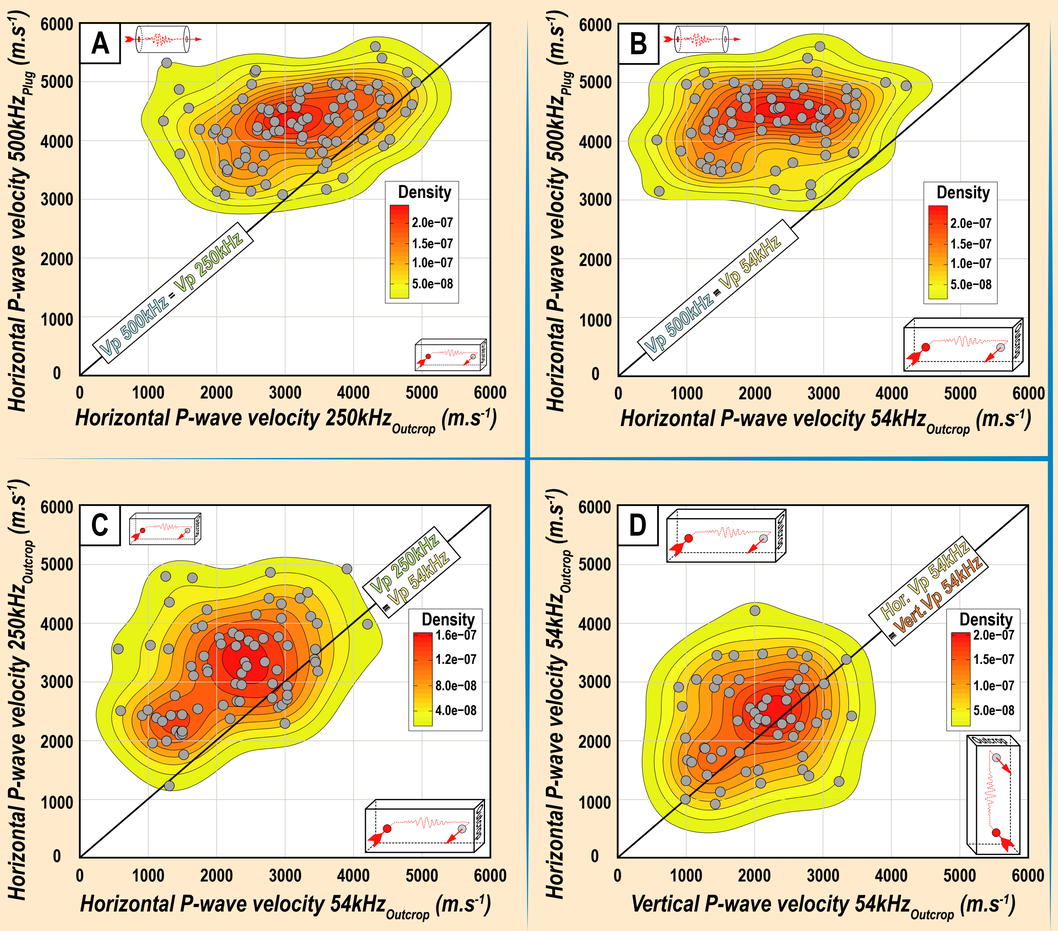


4. PLUG ULTRASONIC LABORATORY DATASET



- To explain the **dispersion** of Vp-Porosity data, we use the **asymptotic approximations** given by **David & Zimmerman (2011)**, valid for aspect ratio (α) as high as 0,3 (**"crack-like pores", Differential Effective Medium Scheme - DEM**).
- The **trend Vp - Porosity** fits with an **average pore aspect ratio** between **0.1** and **0.2**.
- This **aspect ratio range** is close to the **reference value** of carbonates (α = 0,1 - 0,15) given by **Fournier et al. (2018).**
- **Bailly et al. (2019a)** explain the **microstructural control** of this laboratory dataset.

5. OUTCROP DATASET



- **Crossplots** of **P-wave velocity** measurements acquired from the **same location**, at **laboratory** and **outcrop**, with **different frequencies**. The **Probability Density Law** (**PDL**) for each crossplot is indicated in colors.

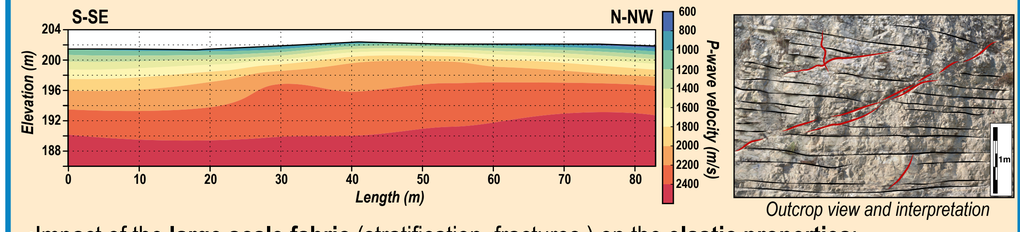
A. *Vp_{500} versus Vp_{250}*
Vp_{500} are higher than Vp_{250}. The **porosity control of plug scale** seems to be **lost at outcrop scale** (no trend).

B. *Vp_{500} versus Vp_{54}*
Vp_{500} are higher than Vp_{54}. No clear relation for this dataset, similar as case A.

C. *Vp_{250} versus Vp_{54}*
The **PDL** shows a **linear trend** for this dataset implying that the **P-waves** are almost **sensitive to the same features**.

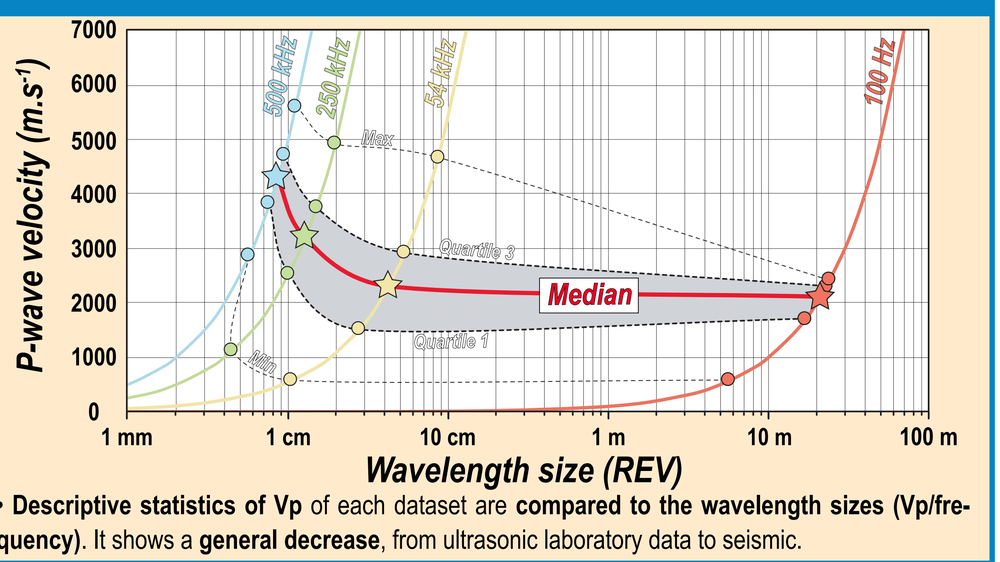
D. *Hor. Vp_{54} versus Vert. Vp_{54}*
Even if the dataset shows a big dispersion, the PDL indicates an **elastic isotropy**.

6. SEISMIC DATASET



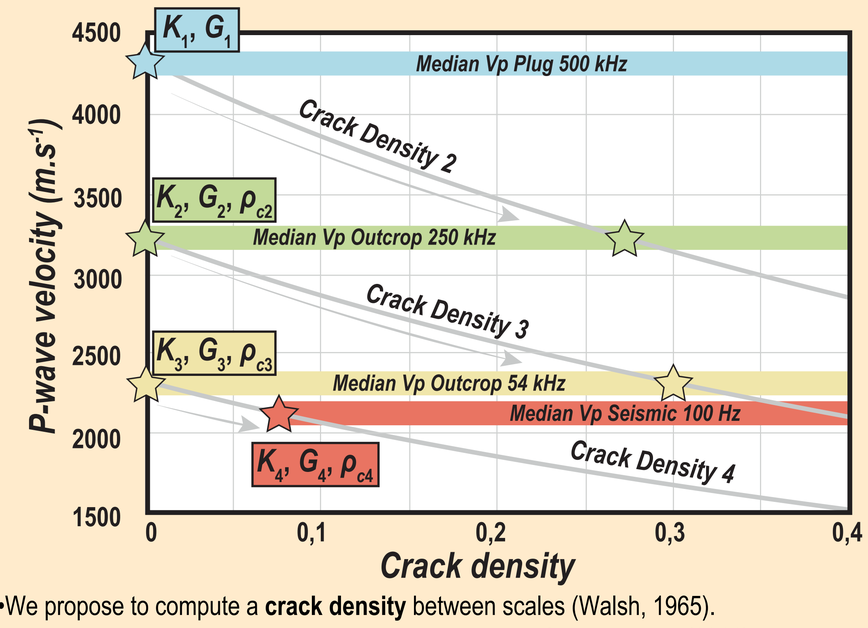
- Impact of the **large scale fabric** (stratification, fractures,) on the **elastic properties**: **Low P-wave velocities** (Maximum of 2400 m.s-1)

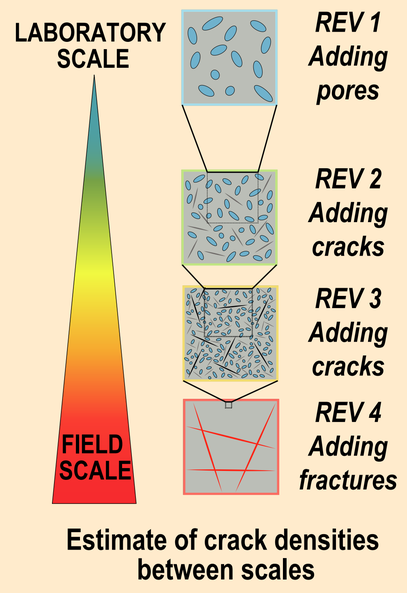
7. UPSCALING DATASET



- **Descriptive statistics of Vp** of each dataset are **compared to the wavelength sizes (Vp/frequency)**. It shows a **general decrease**, from ultrasonic laboratory data to seismic.

8. UPSCALING MODEL

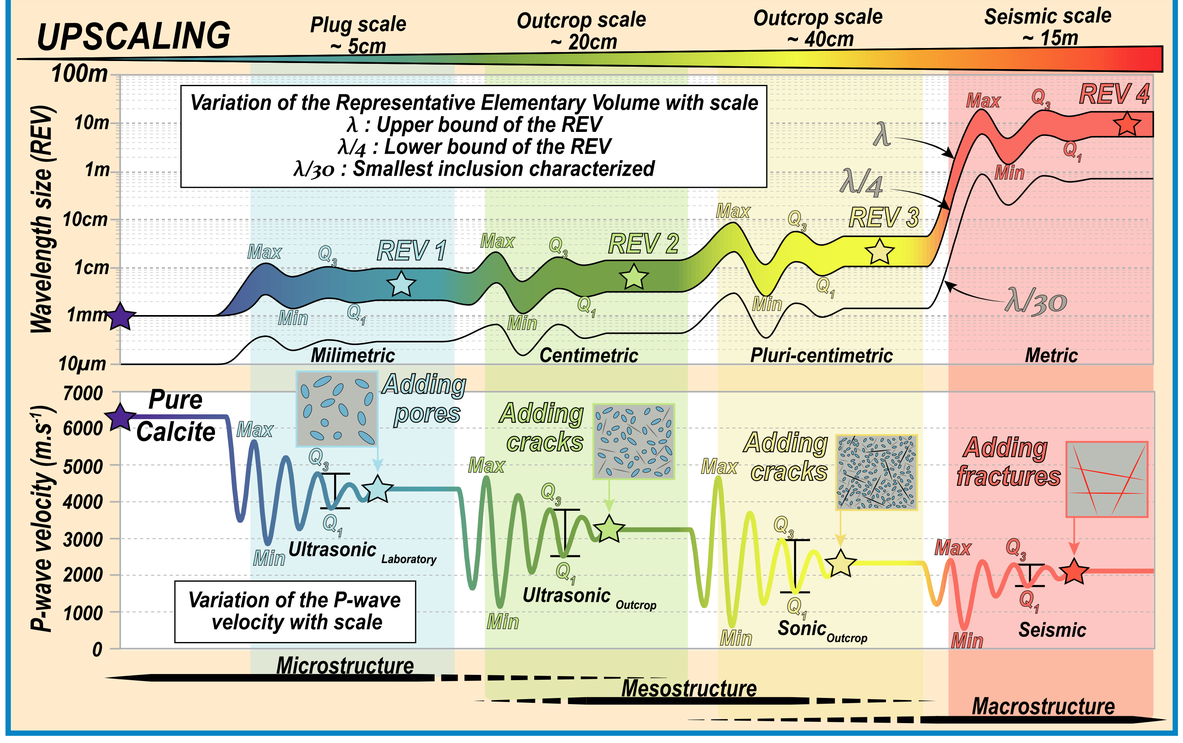




Estimate of crack densities between scales

- We propose to compute a **crack density** between scales (Walsh, 1965).
- Using the **asymptotic approximations** given by David & Zimmerman (2011), we **reverse the Vp changes** in terms of crack density (DEM scheme).
- As indicated by David & Zimmerman (2011), this DEM scheme is only valid for **cracks with aspect ratio lower than 0,01**.

9. TAKE HOME MESSAGE



10. REFS

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