Extraterrestrial 3He shows that Mesozoic marl-limestone alternations are mainly driven by CaCO3 variations at the astronomical timescale

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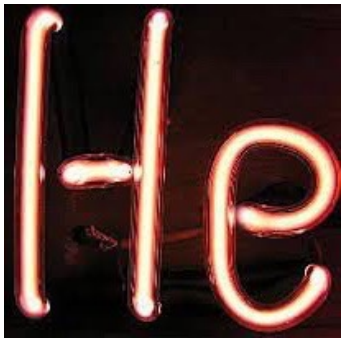
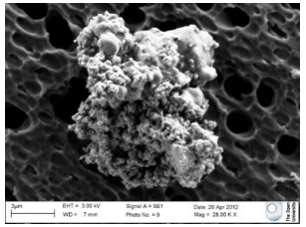
3  ET

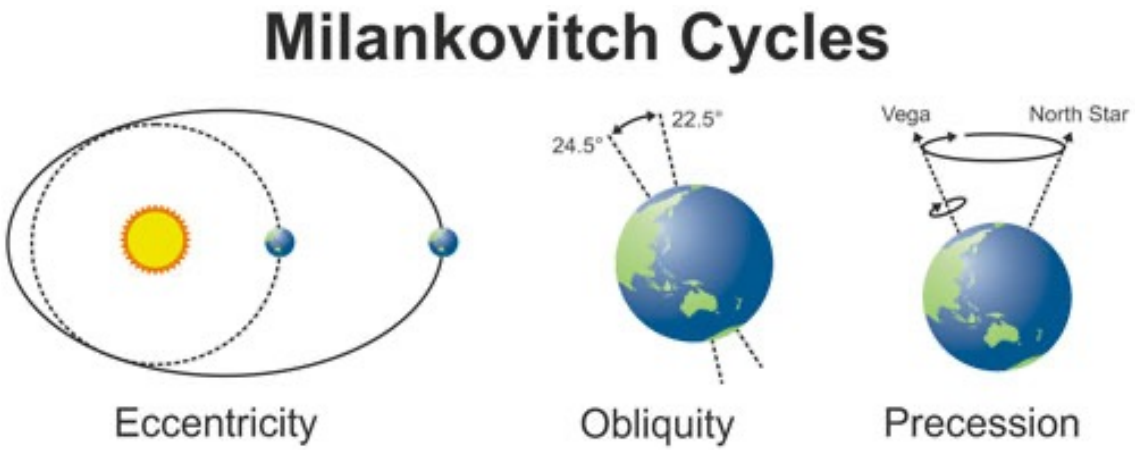
Interplanetary Dust



A new look with Extra Terrestrial ^{3}He!

1 – Scientific question: why are they marl-limestone alternations?

Drôme, France, Hauterivian



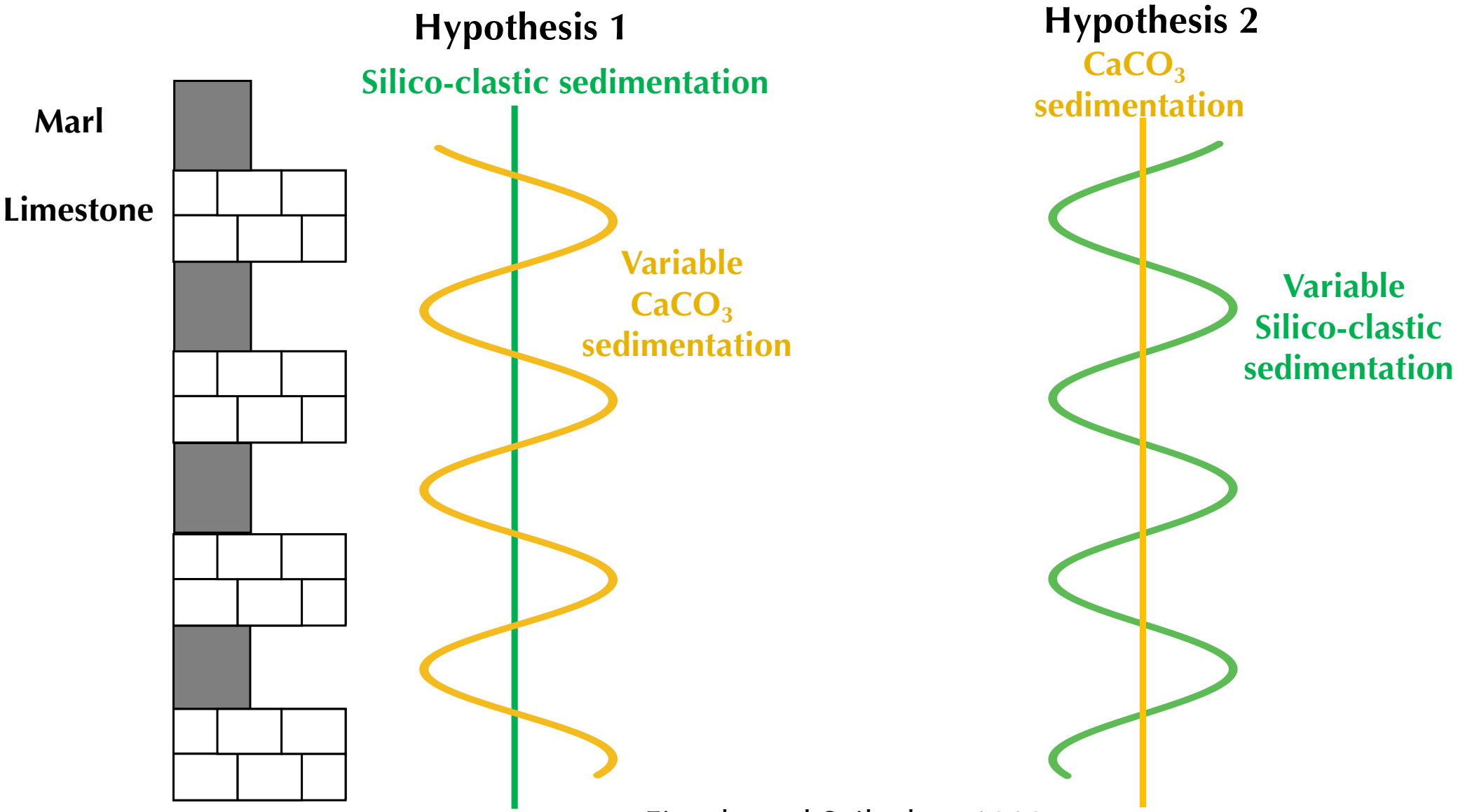
100 ka
400 ka

41 ka

19 ka
23 ka

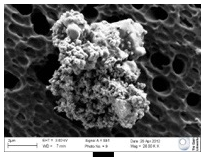
The drivers are the astronomical cycles, but what is the internal mechanism?

1 – Scientific question: why are they marl-limestone alternations?



Einsele and Seilacher, 1982

2 – Method: extraterrestrial ^{3}He to introduce time into space



^{3}He-rich IDPs

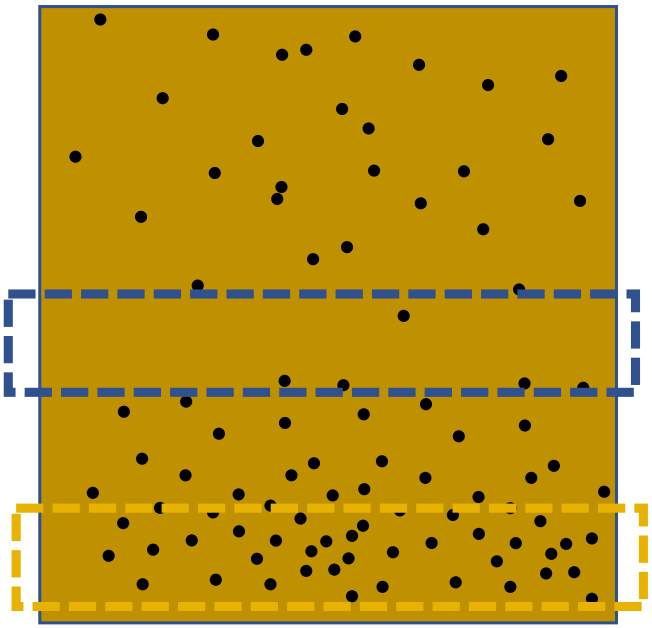
F = ^{3}HeET flux (at.cm^{-2}.ka^{-1})

$S_T = S_{carb} + S_{sil}$ (cm.ka^{-1})

$$S_T = \frac{F}{NCF \times \rho \times {}^3He_{ET}}$$

Measured:
$^3He_{ET}$ concentration (by mass spectrometry).
NCF: non carbonate fraction (by acid digestion)
ρ: dry density (g.cm^{-3}).

F: calibrated and assumed constant
(0.1 pcc/cm2/ka, Farley et al., 2012)



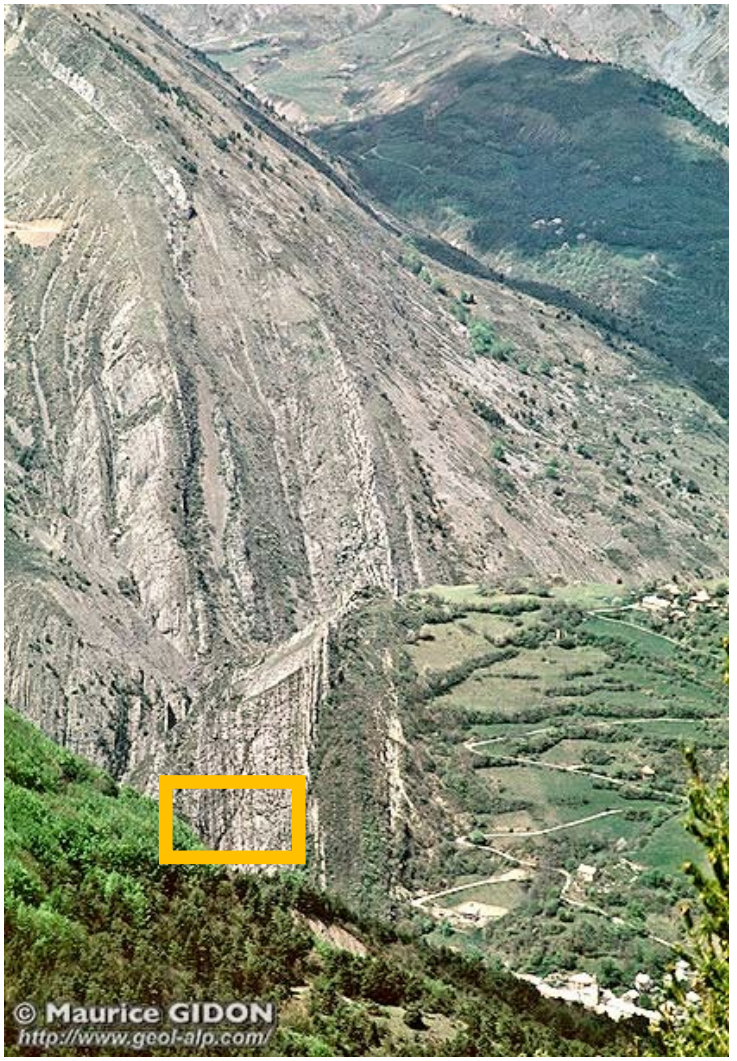
High S => low $^3He_{ETbulk}$

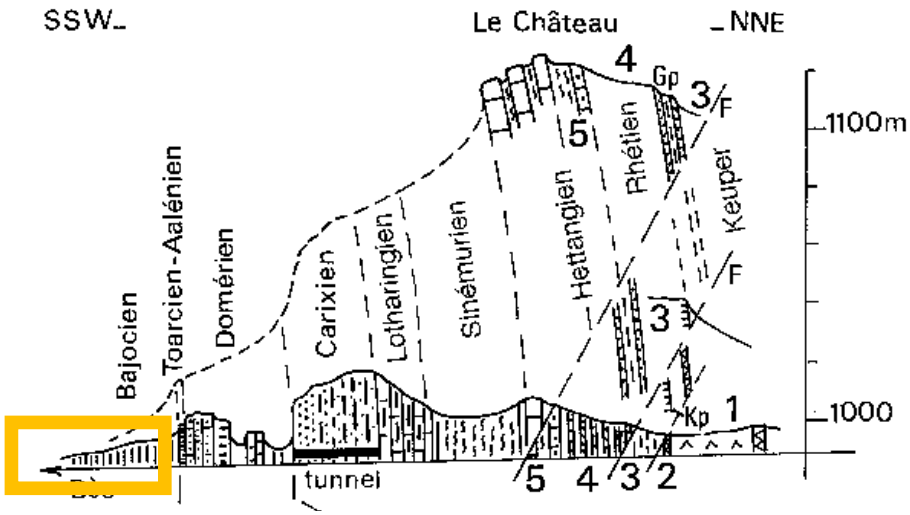
Low S => high $^3He_{ETbulk}$

2 – Geological settings: 2 sampled sections: Bajocian and Valanginian

2 sections in the Southern French Alps:

Bajocian (170 Ma)
Valanginian (135 Ma)



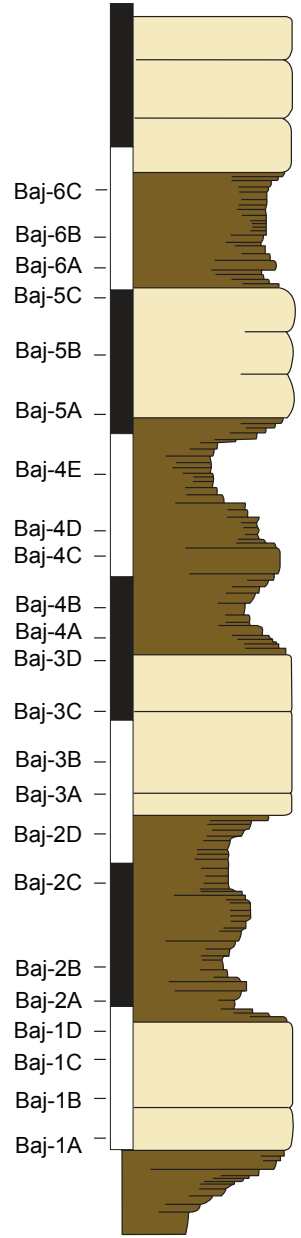


3 – Sedimentation rates results: Bajocian

Bajocian (170 Ma) :

- **3.5 m section**
- **3 marl limestones doublets**
- **23 samples**

Blard et al., in prep



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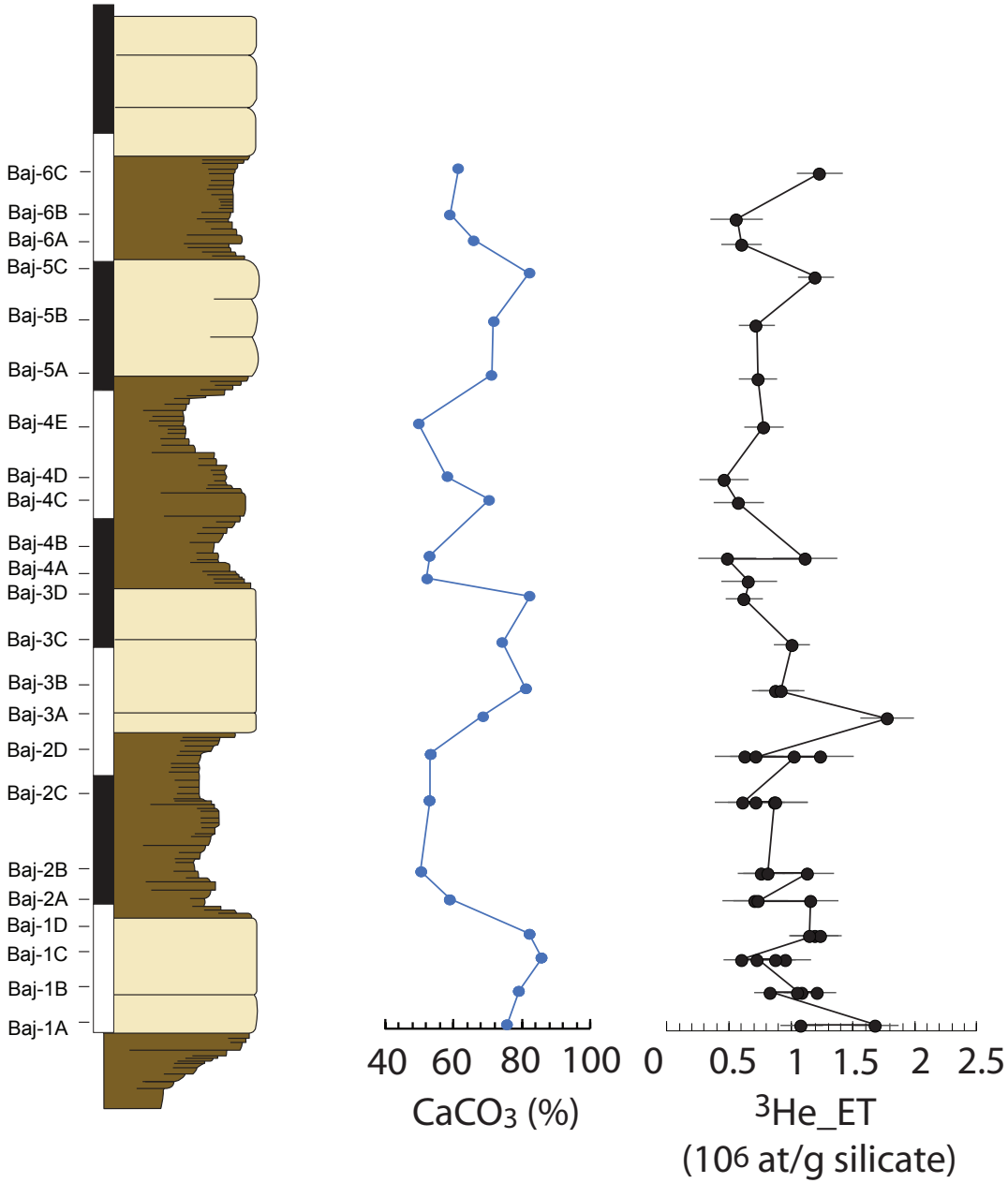
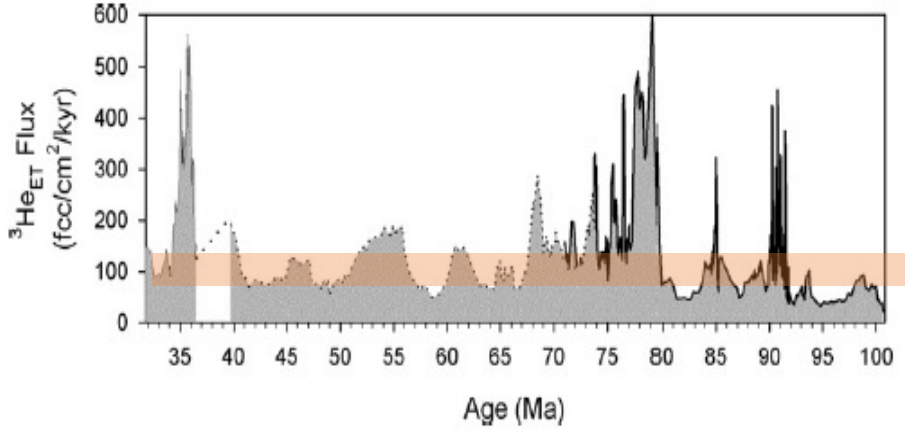


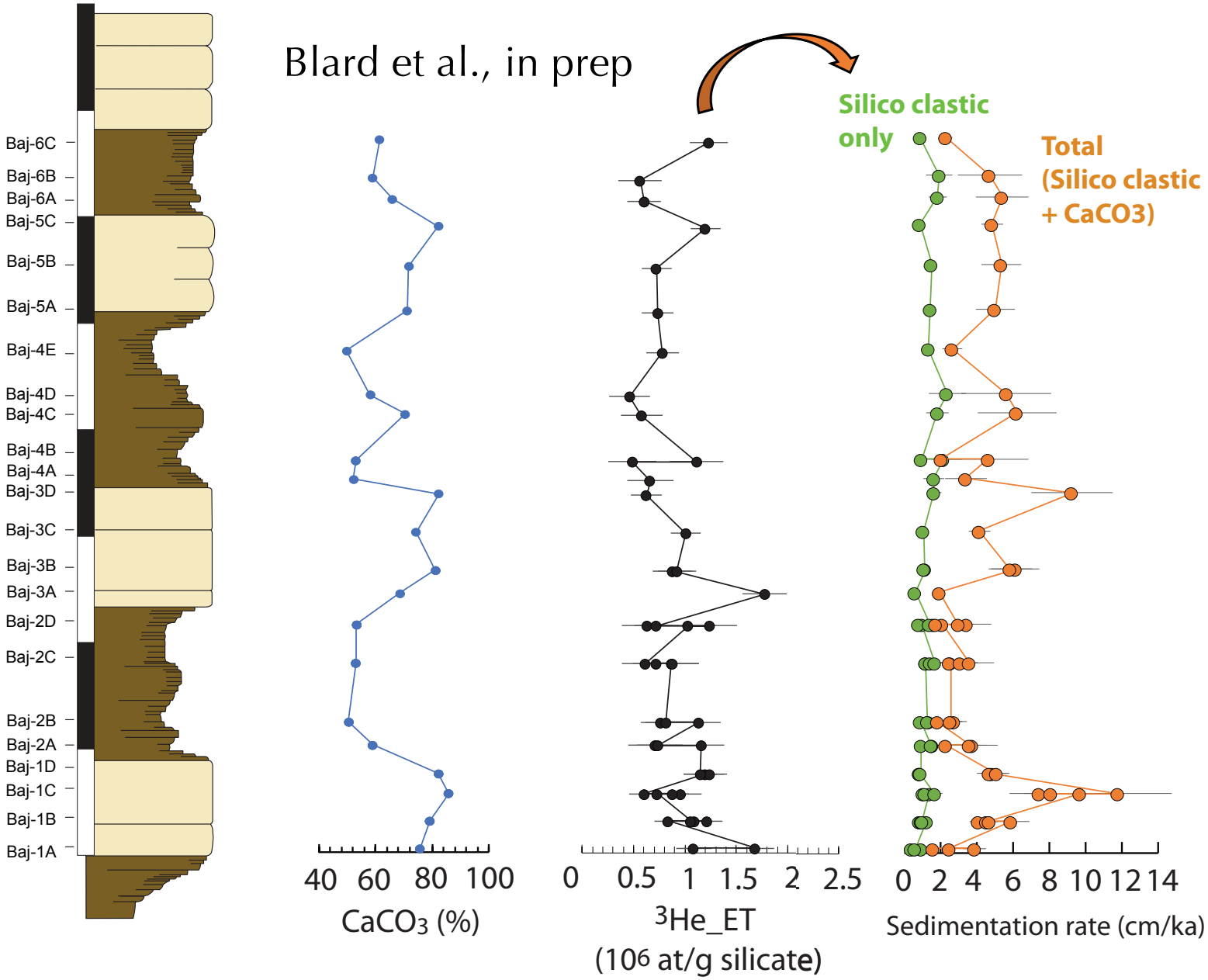
F = ^{3}HeET flux = 0. 1 pcc.cm^{-2}.ka^{-1}



Farley et al., 2012

Blard et al., in prep

3 – Sedimentation rates results: Bajocian



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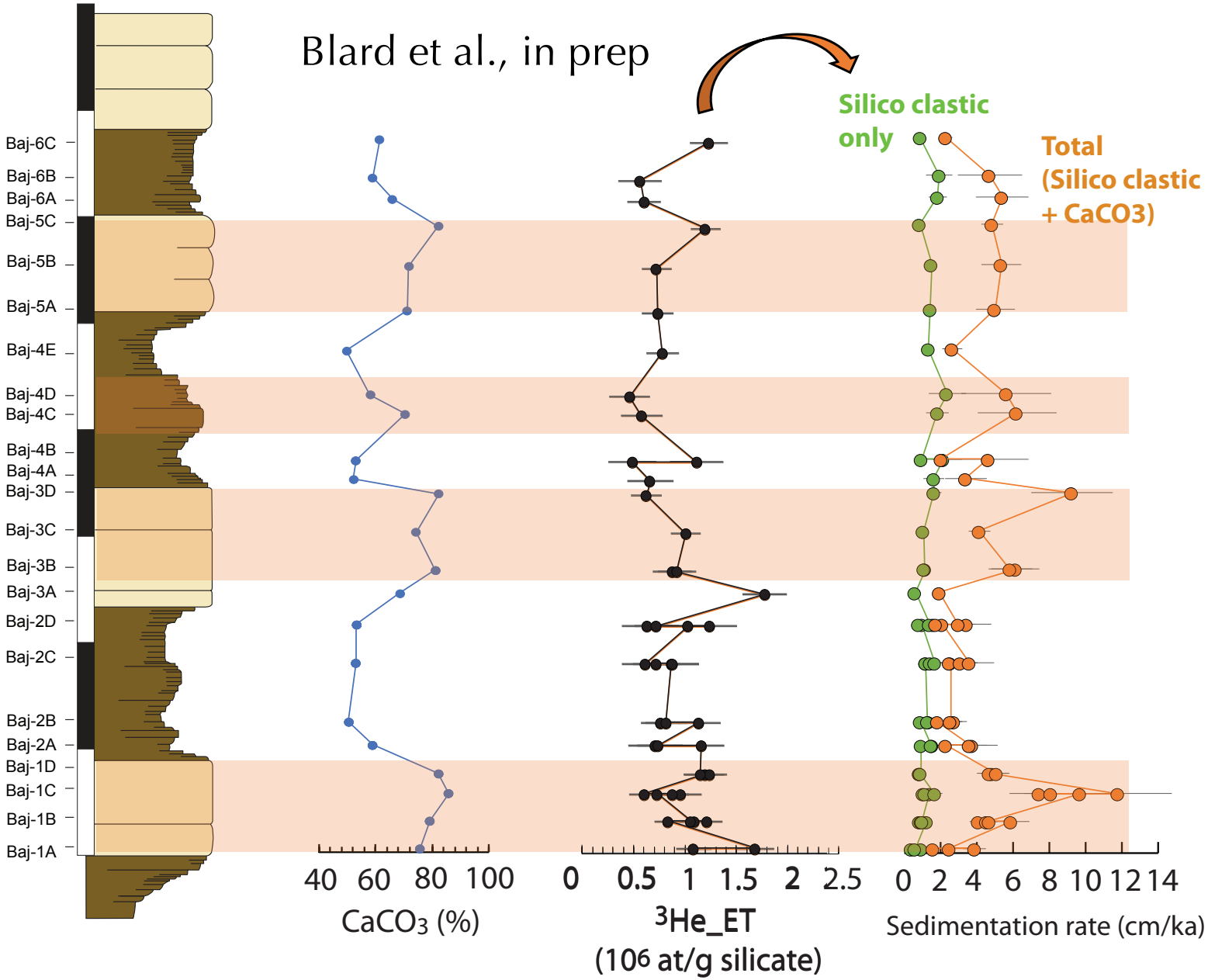

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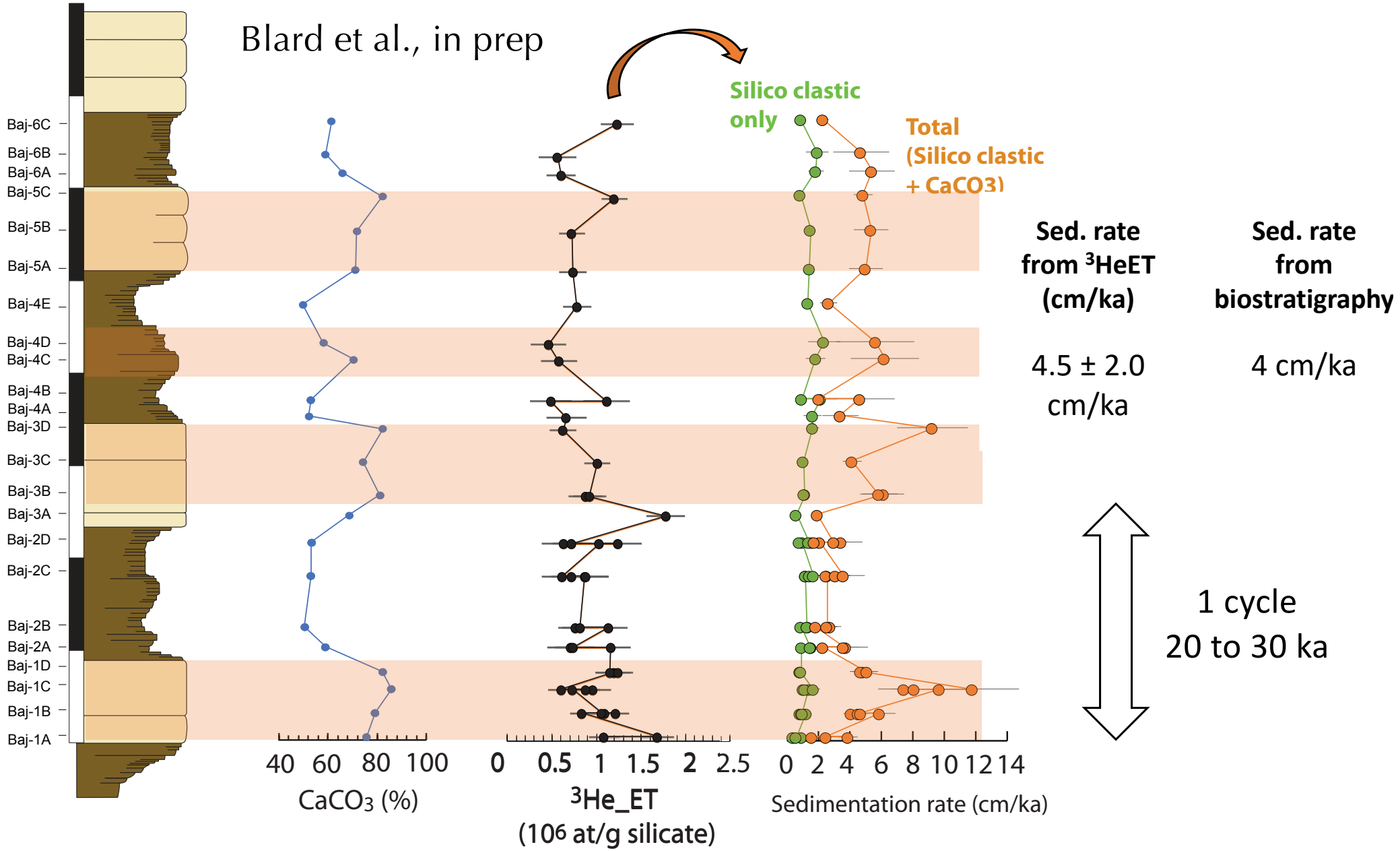
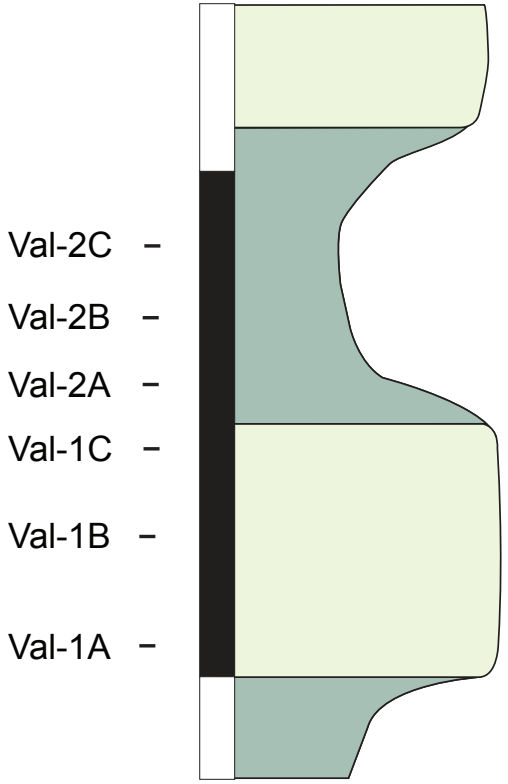


3 – Sedimentation rates results: Valanginian

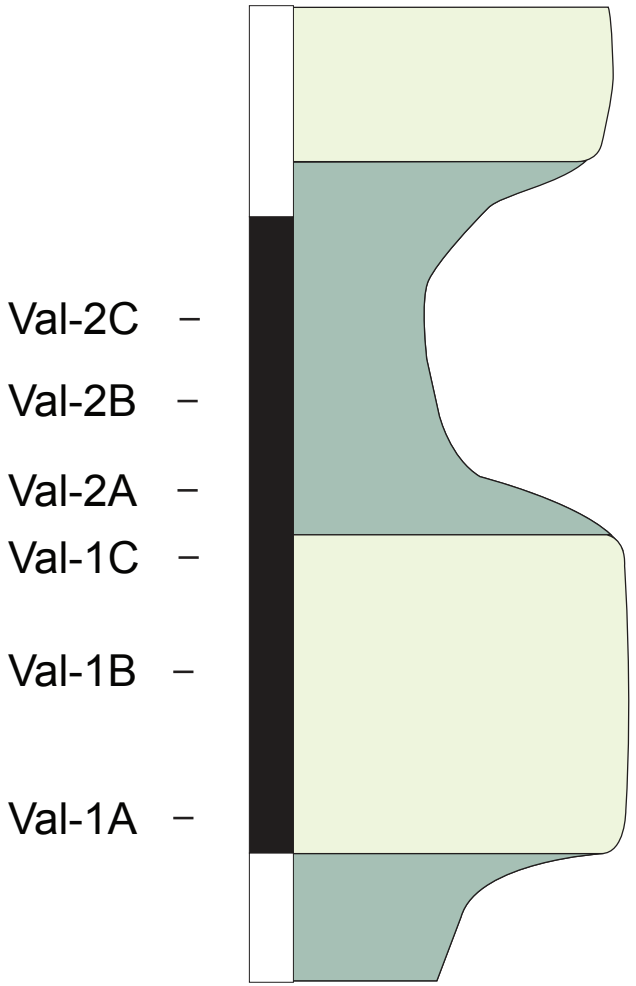
Valanginian (135 Ma) :

- **0.9 m section**
- **1 marl limestones doublets**
- **6 samples**

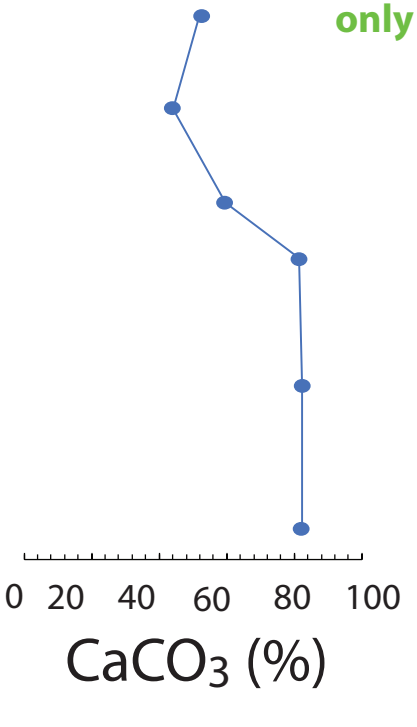
Blard et al., in prep

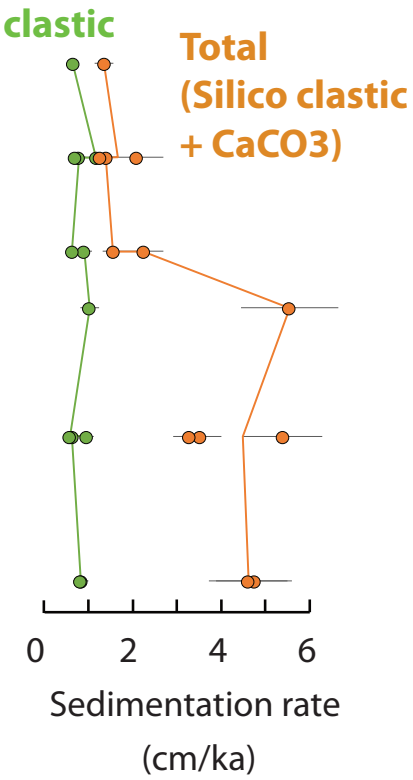


3 – Sedimentation rates results: Valanginian

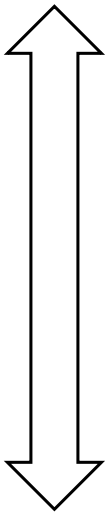


Blard et al., in prep



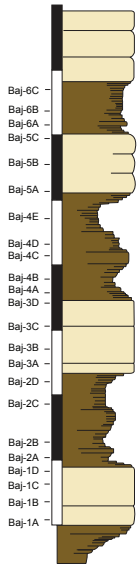


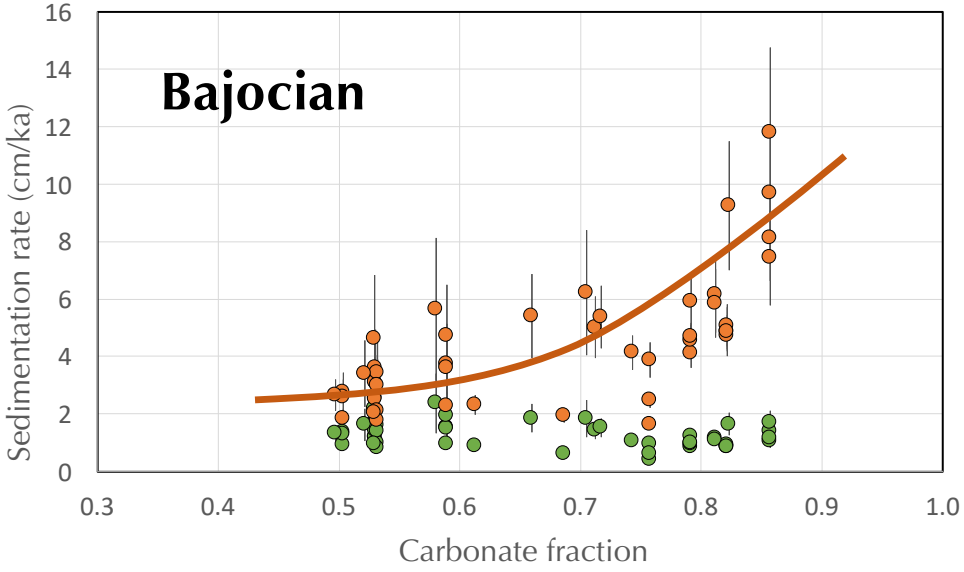
Local sed. rate from ^{3}HeET (cm/ka)	Sed. rate from biostratigraphy
3.1 ± 1.7 cm/ka	3 cm/ka

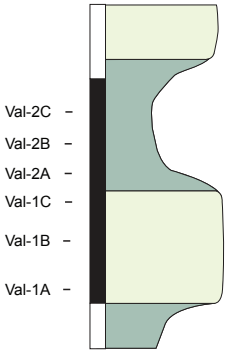


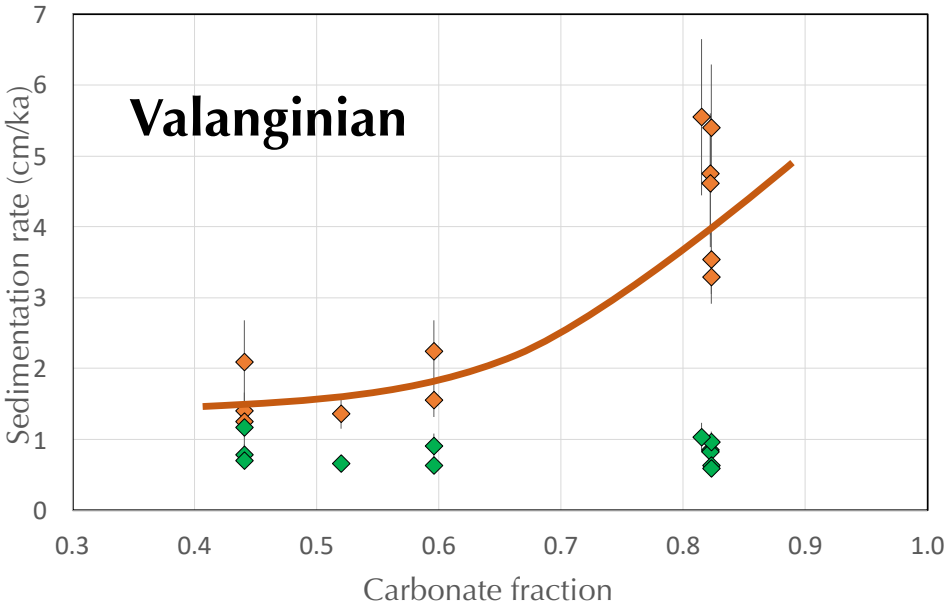
1 cycle
40 ka

3 – Sedimentation rates summary









Blard et al., in prep

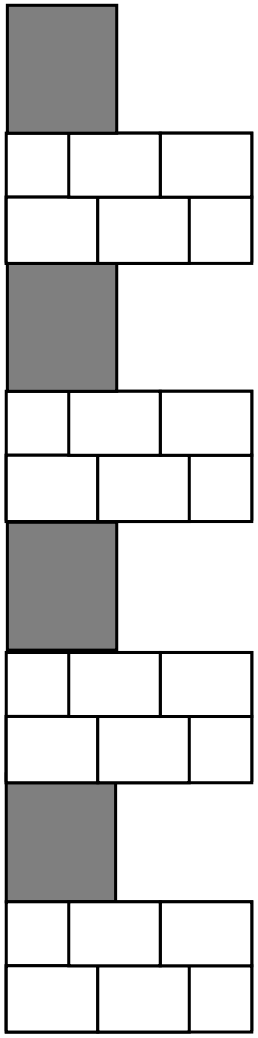
S_T = Total sed. rate

S_{sil} = Silico clastic sed. rate

Equation of a dilution by $CaCO_3$ (Ricken, 1993):

$$S_T = \frac{S_{sil}}{1 - NCF}$$

4 – Conclusion: ^{3}HeET shows constant terrigenous flux



Hypothesis 1

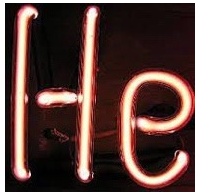
Silico-clastic sedimentation

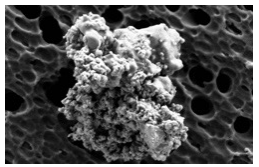
Variable $CaCO_3$ sedimentation

Haute Provence

Blard et al., in prep.

3





Hypothesis 2

$CaCO_3$ sedimentation

?

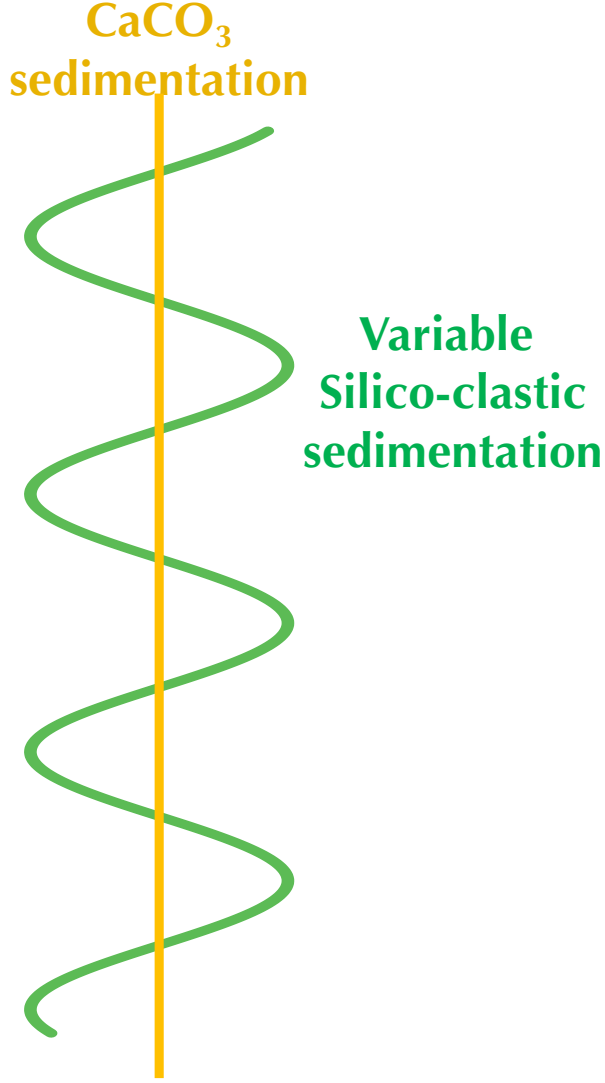
Variable Silico-clastic sedimentation

Now hiring a new PhD at CRPG about
^{3}HeET in the Cretaceous marl-limestone alternations
Application deadline: June 15th 2022
Contact: blard@crpg.cnrs-nancy.fr

Cretaceous

Blakey, 2018

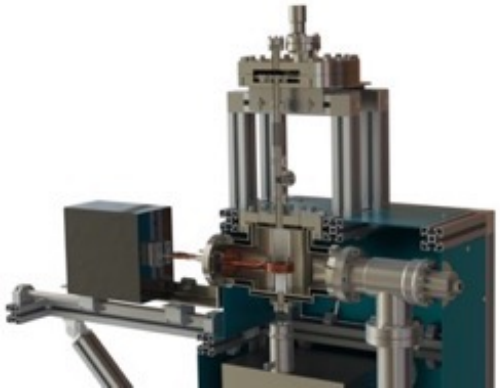
Hypothesis 2



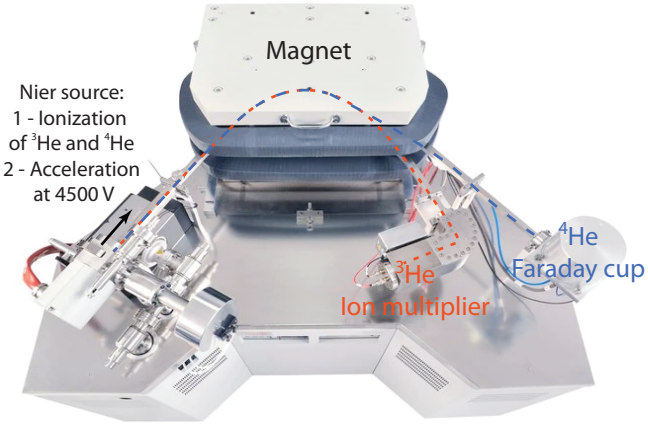
Locklair et Sageman, 2008


Thank you!!
Merci !!
Grazie !!
Danke !!
¡¡ Gracias !!

2 – Method: sample preparation



CRPG induction furnace
Zimermann et al., 2018



CRPG SFT

1 – Gentle crushing

2 - Weighting

3 – 48 h in HCl 10%

4 – Drying (60°C) and weighting => $\underline{CaCO_3}$ fraction

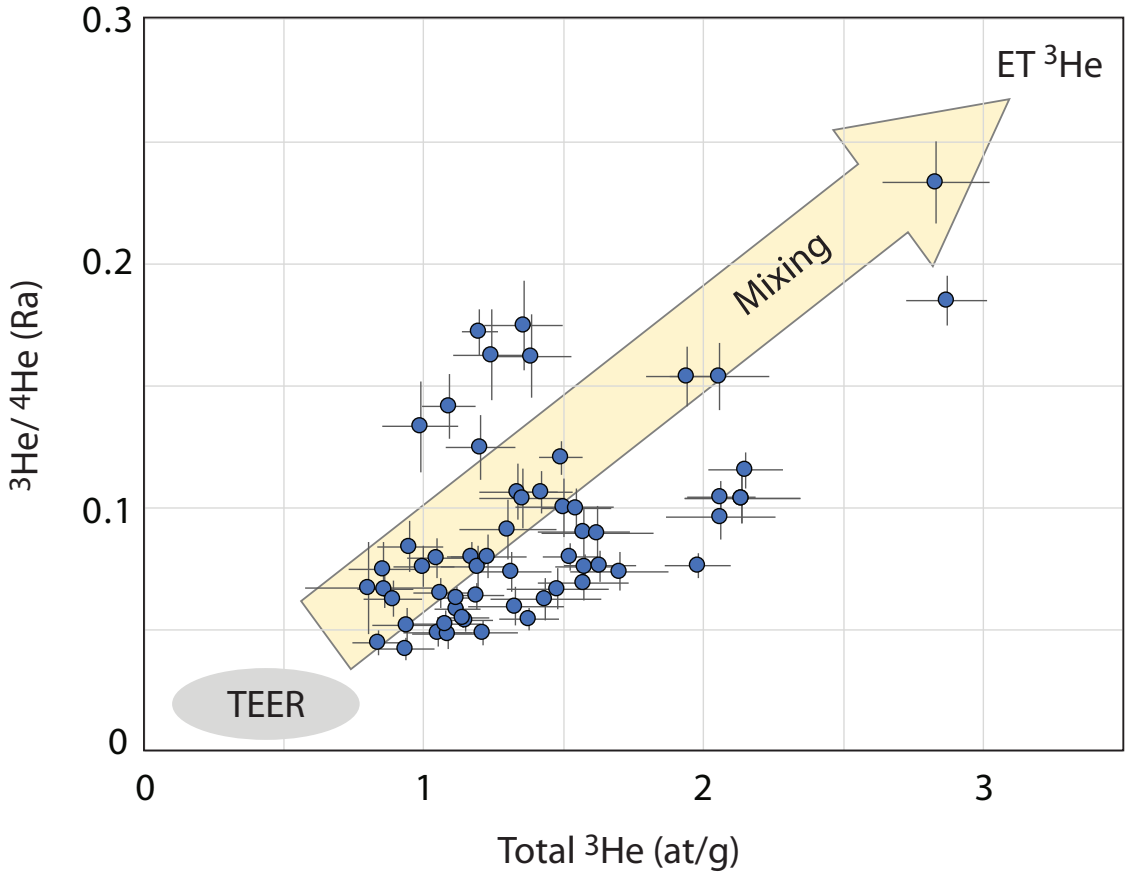
5 – Heating in high vacuum furnace 15 min 1400°C

6 – ^{3}He ^{4}He measurements with the SFT at CRPG

3 – Results: calculation of the IDP-Terrigeneous mixing

Calculation of 3HeET concentrations : 2 component mixing

$$\left[{}^3He_{ET}\right] = \left(\frac{1 - \frac{{}^3He/{}^4He_{TERR}}{{}^3He/{}^4He_{meas}}}{1 - \frac{{}^3He/{}^4He_{TERR}}{{}^3He/{}^4He_{IDP}}}\right) \cdot \left[{}^3He_{meas}\right]$$



Endmembers

$^3He/^4He$ IDP = 300 Ra ± 50%
$^3He/^4He$ TERR = 0.02 Ra ± 50%

⇒ 60 to 90% of ^3He is ET in these samples

Blard et al., in prep