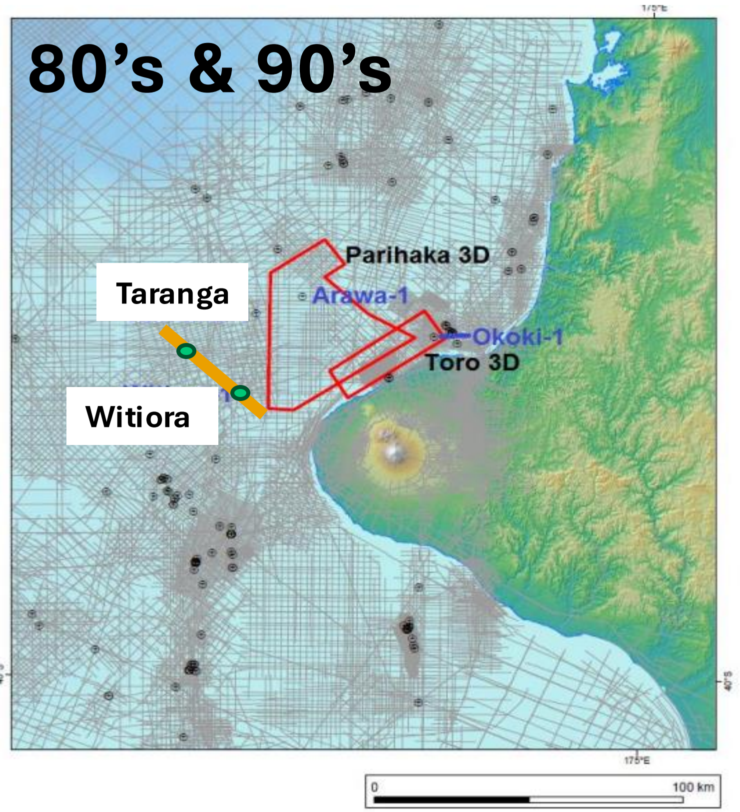
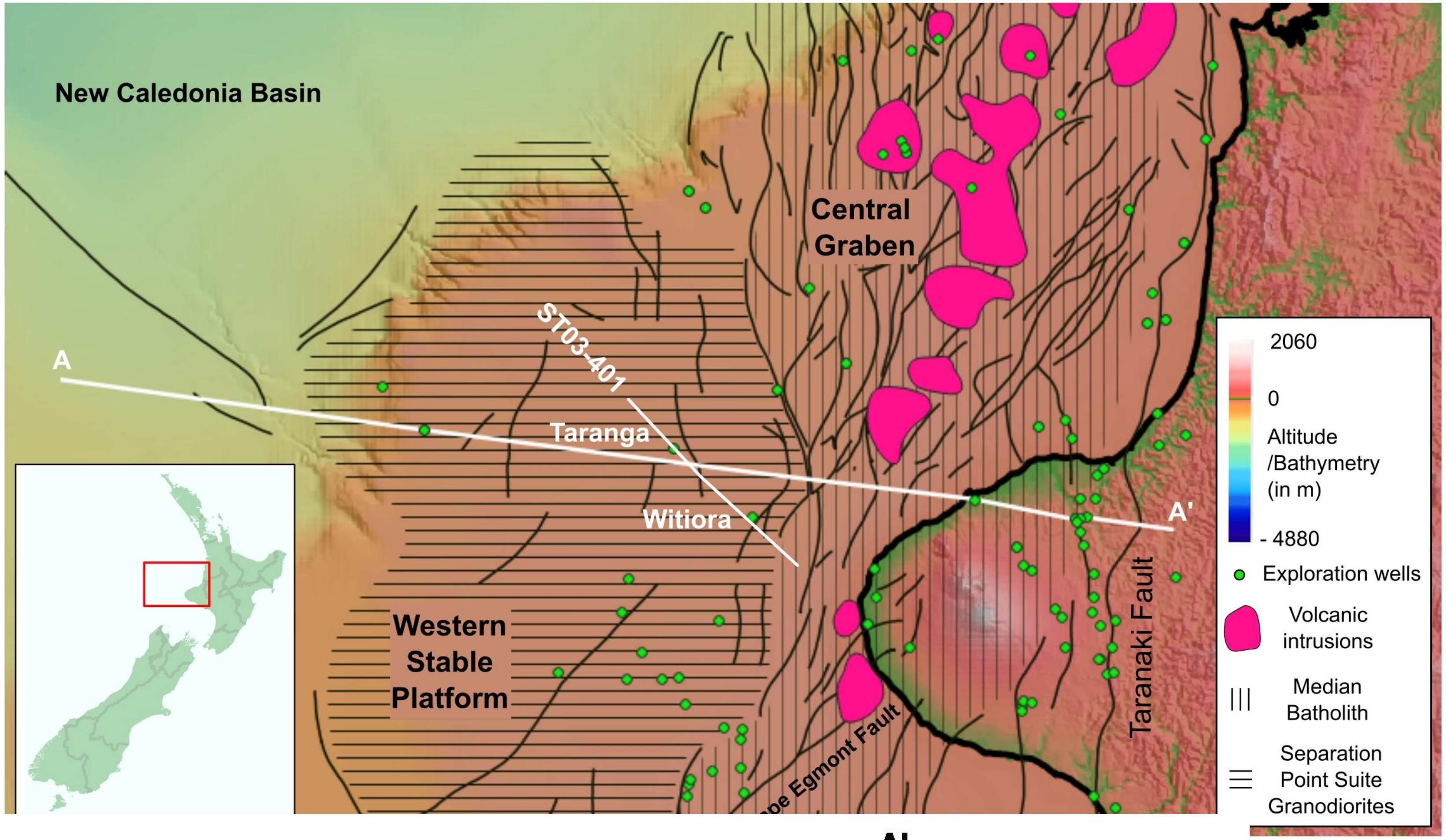
Comment adapter PETROMOD à l'exploration H2 ?

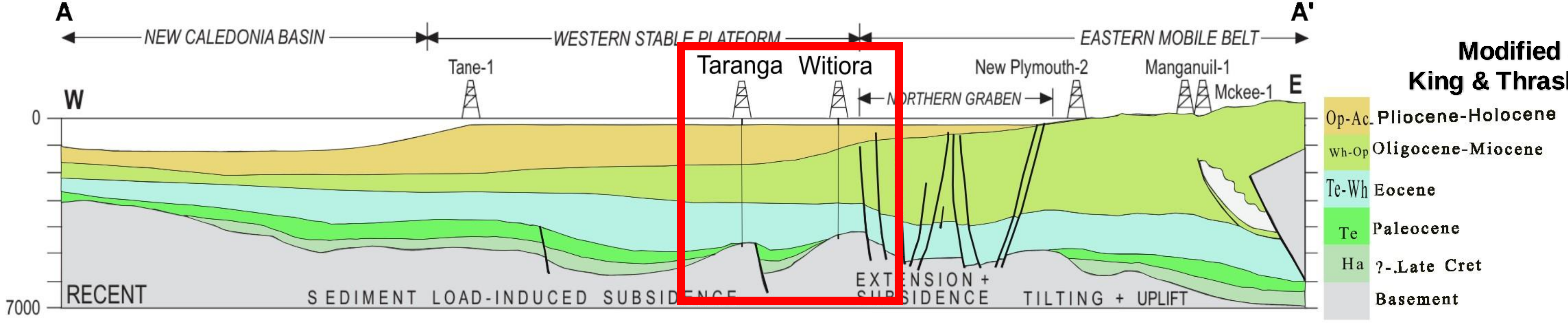
Aurélien GAY

& Muhammed Abdullahi

Contexte géologique

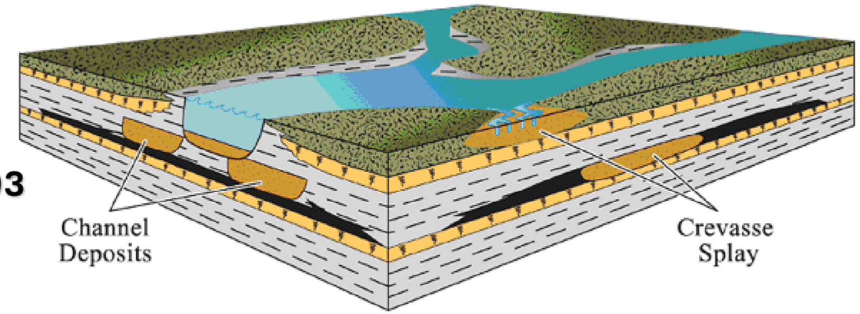






Modified after King & Thrasher, 1996

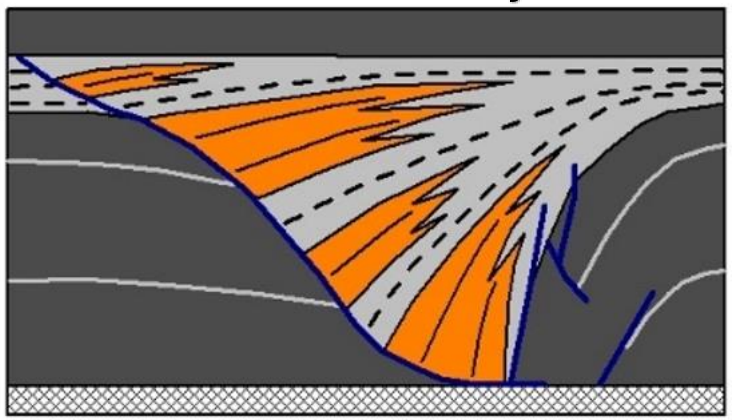
Contexte géologique

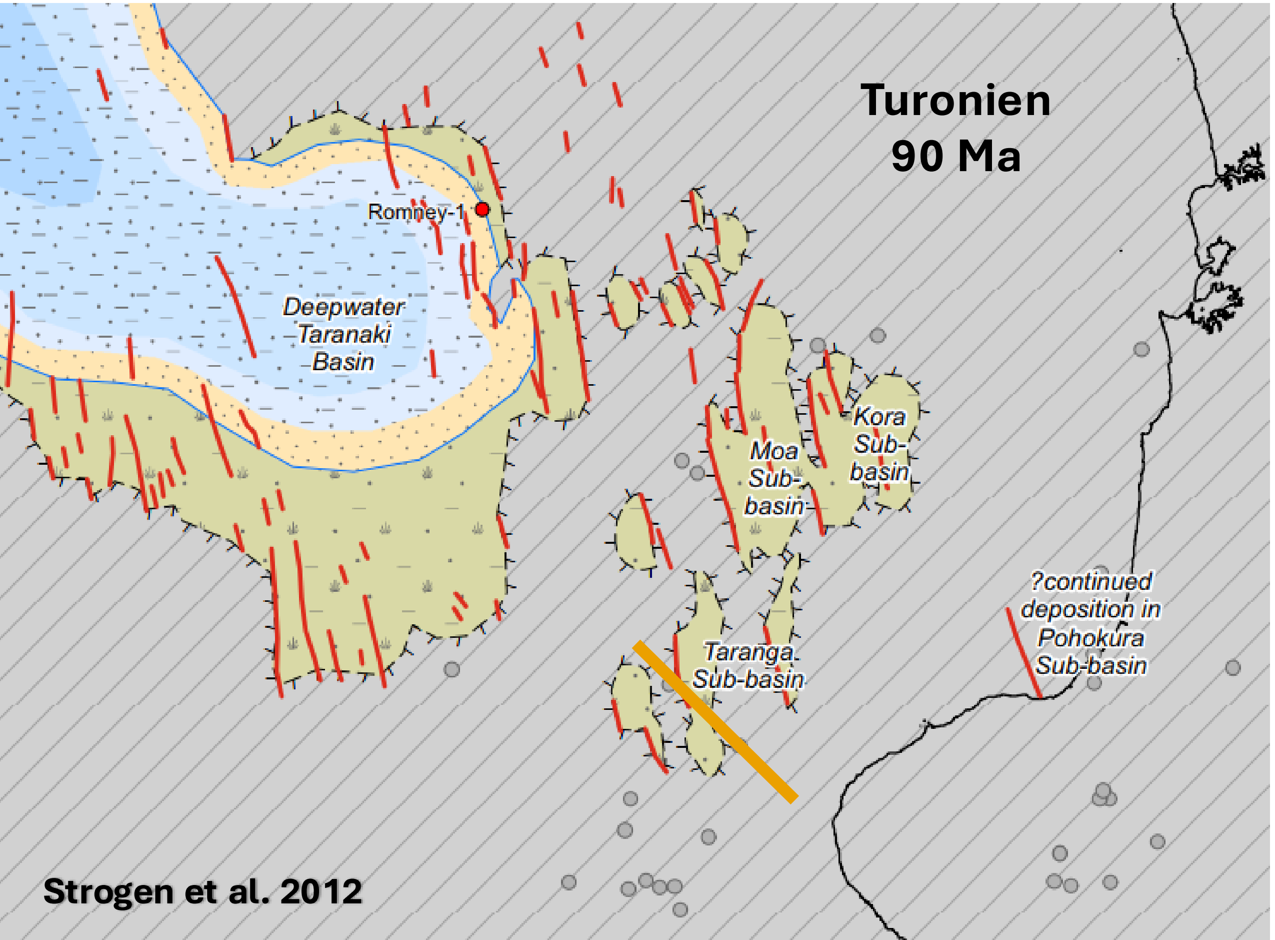


Lange 2003

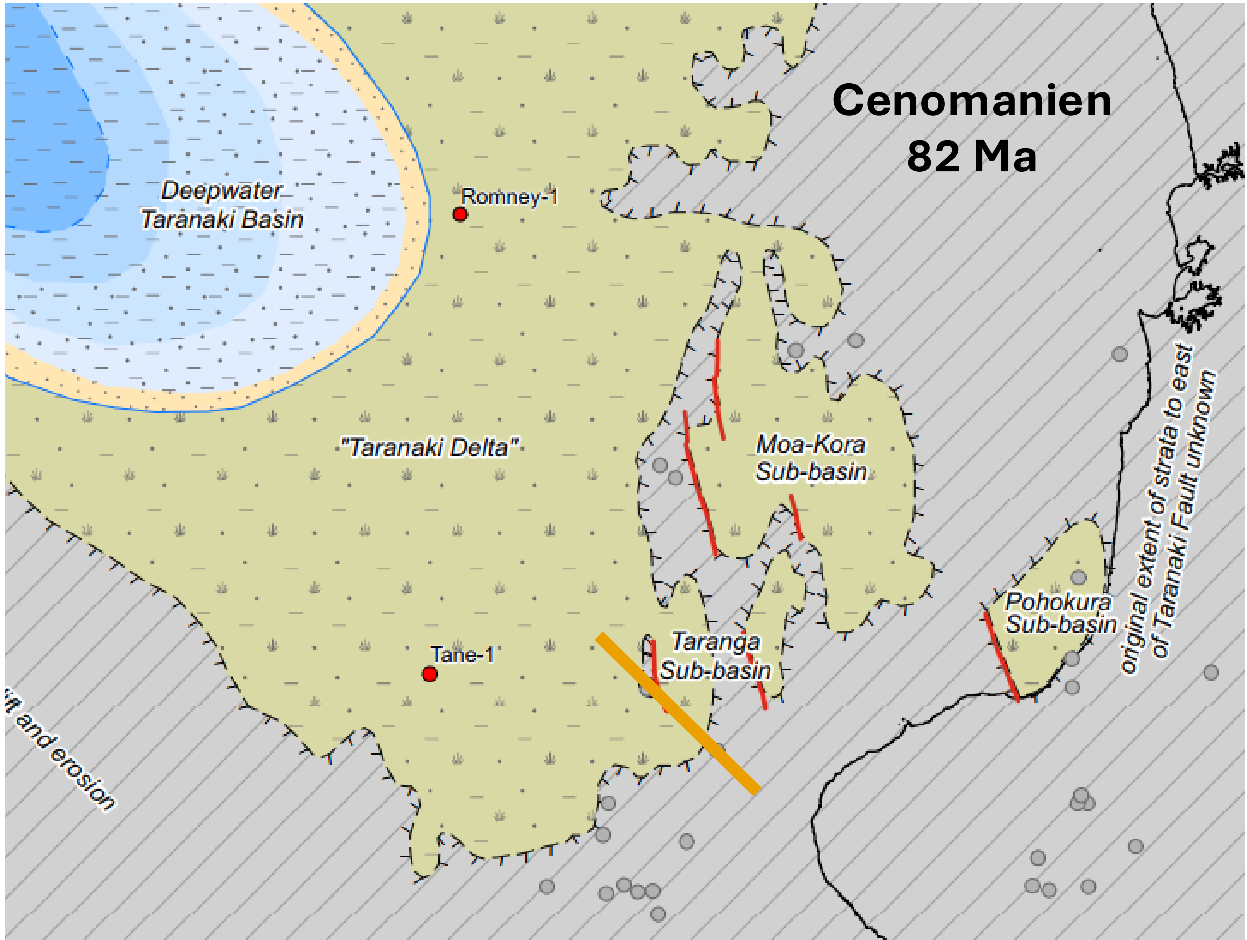
Confined alluvial system
Floodplain
Peat/swamps

Novotny et al. 2024

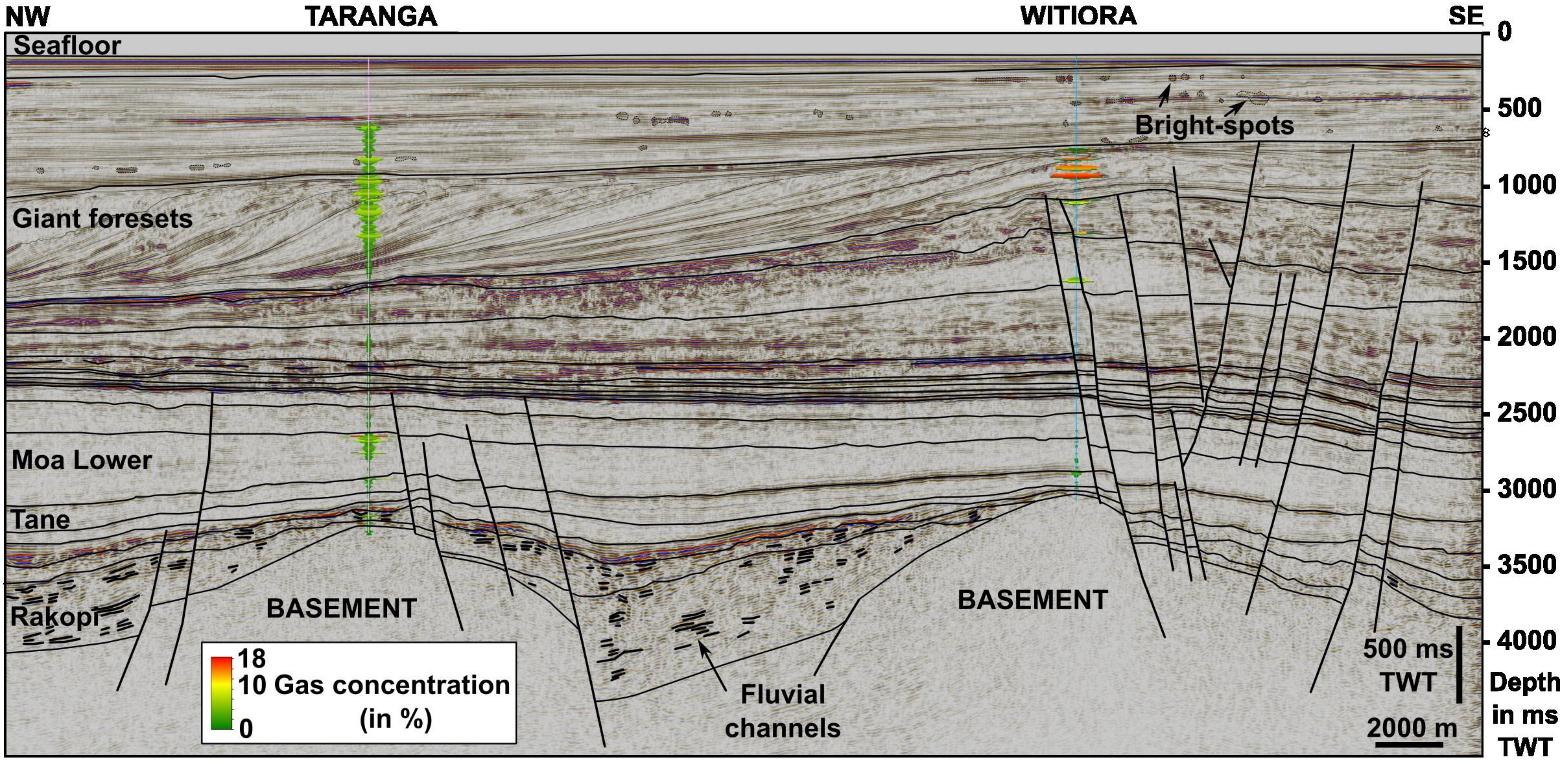




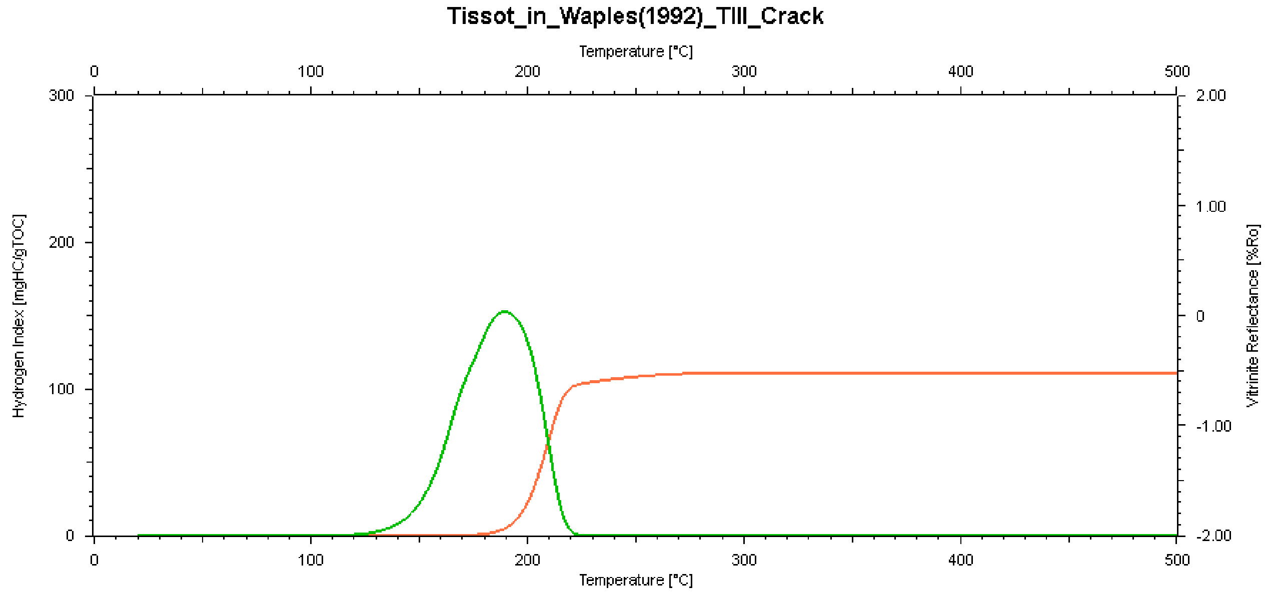
Strogen et al. 2012

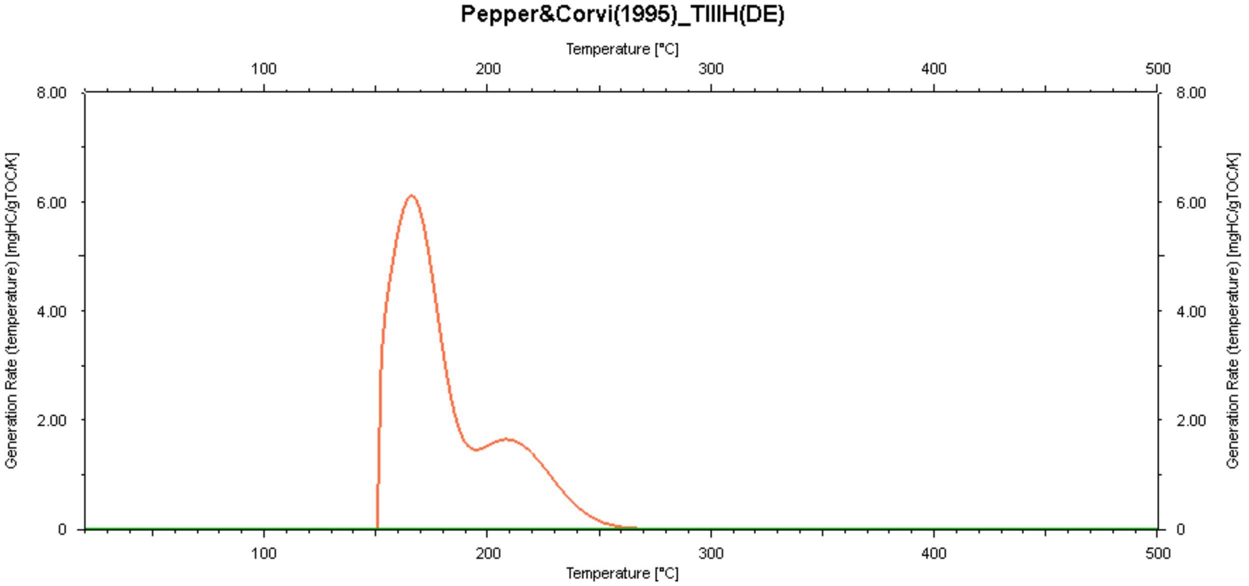


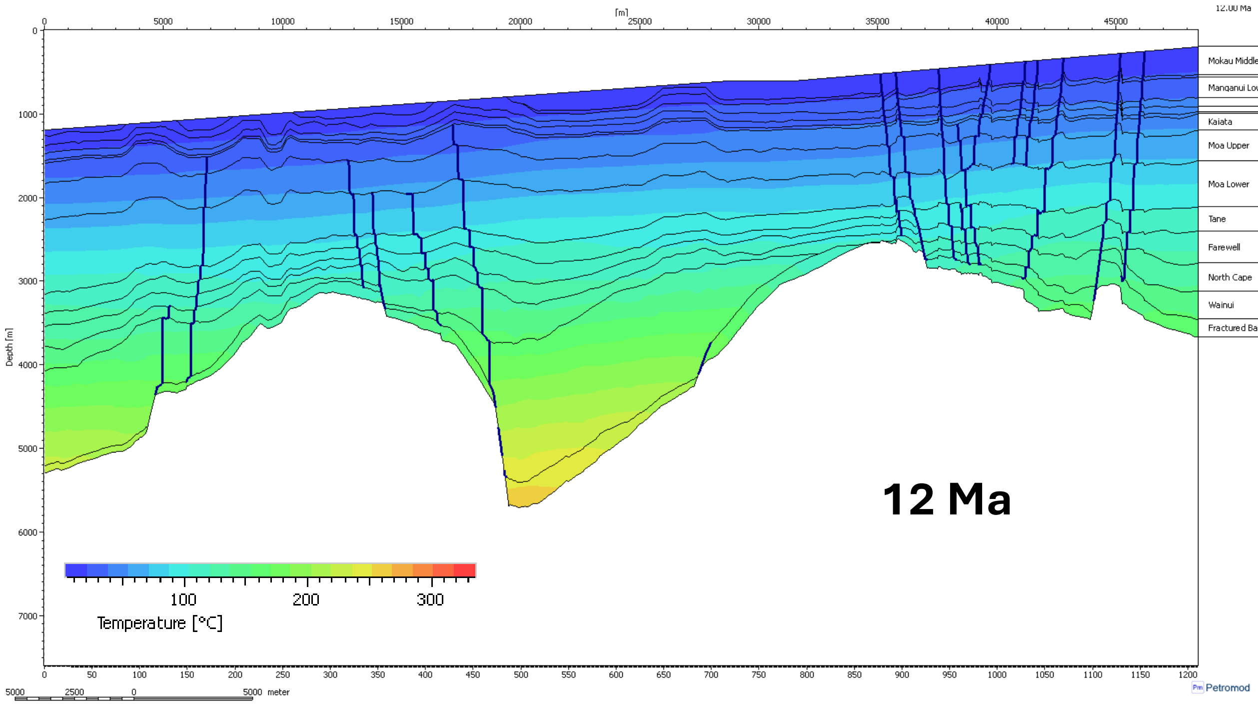
Interprétation sismique

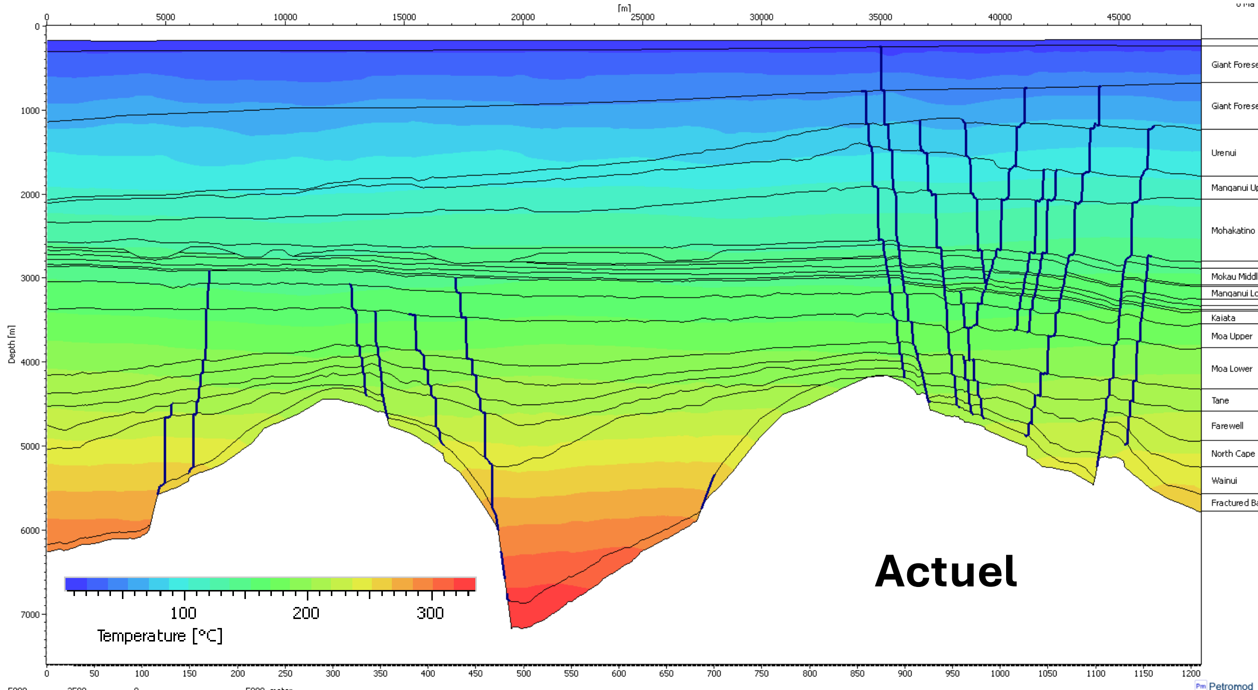


Système pétrolier



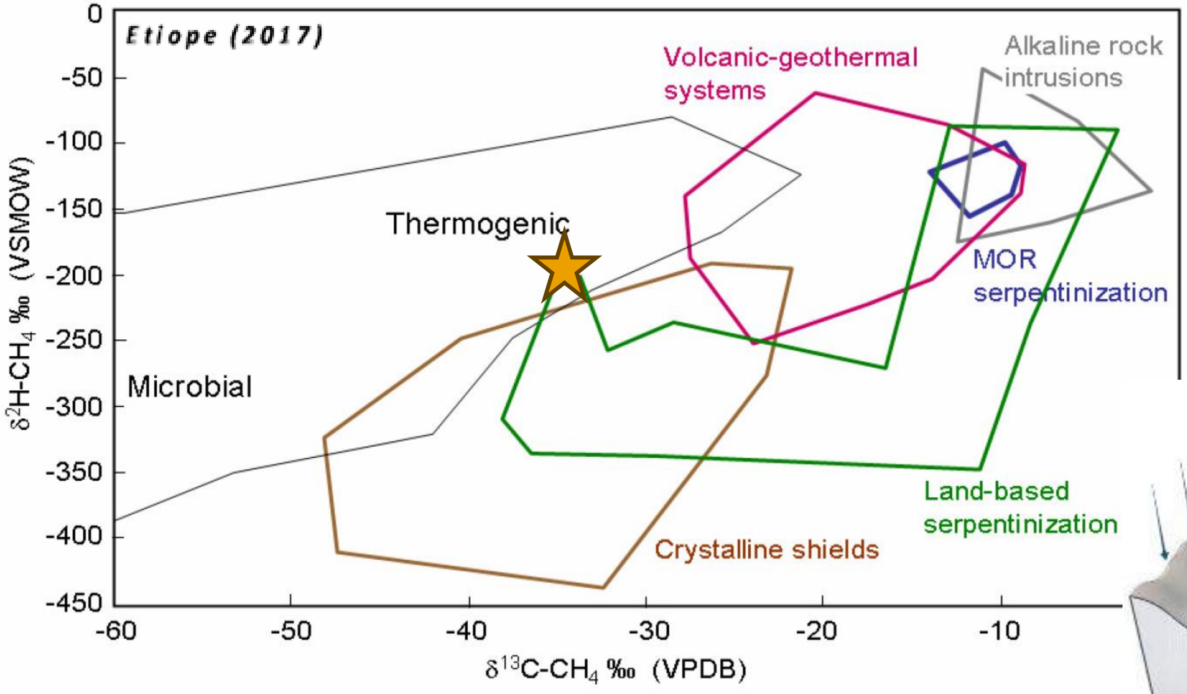






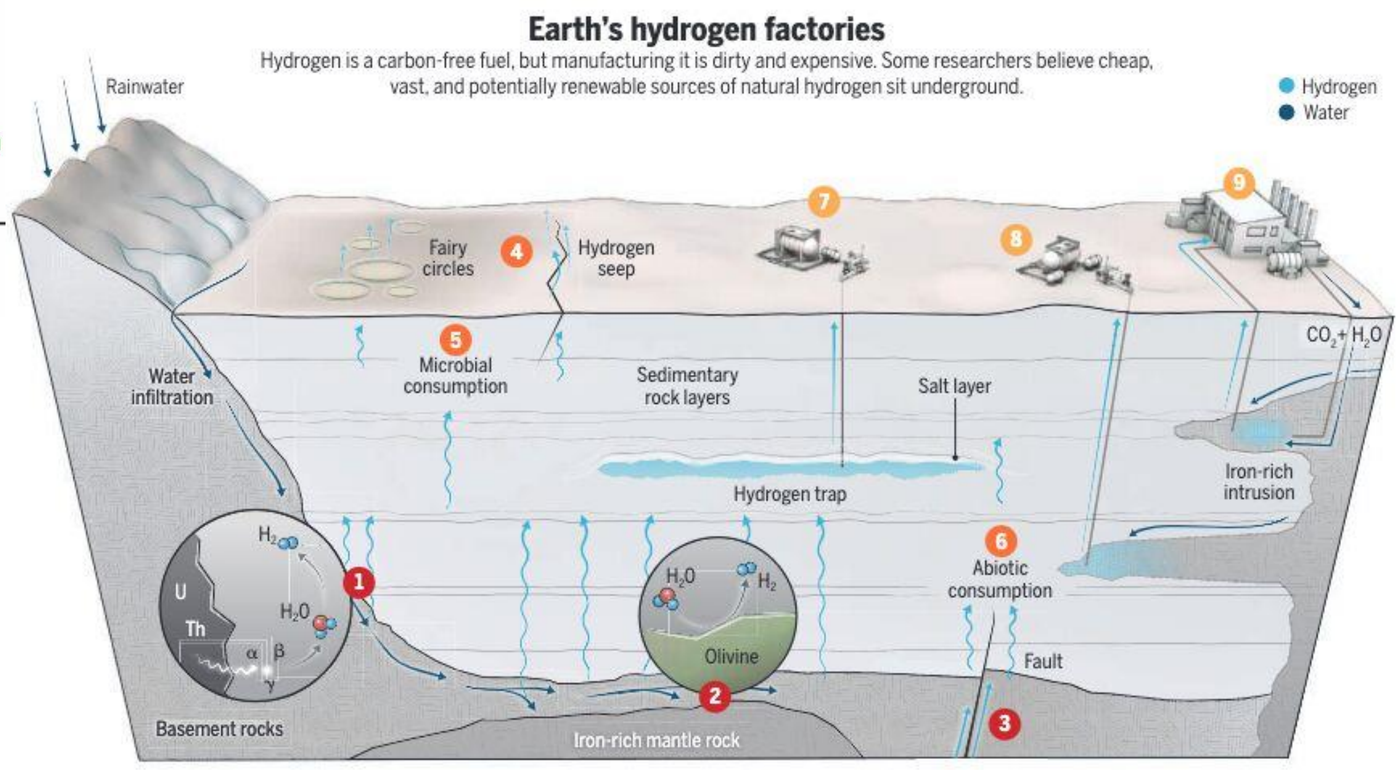
Origine du méthane

Signature isotopique de mélange entre thermogénique et xxxxx ?



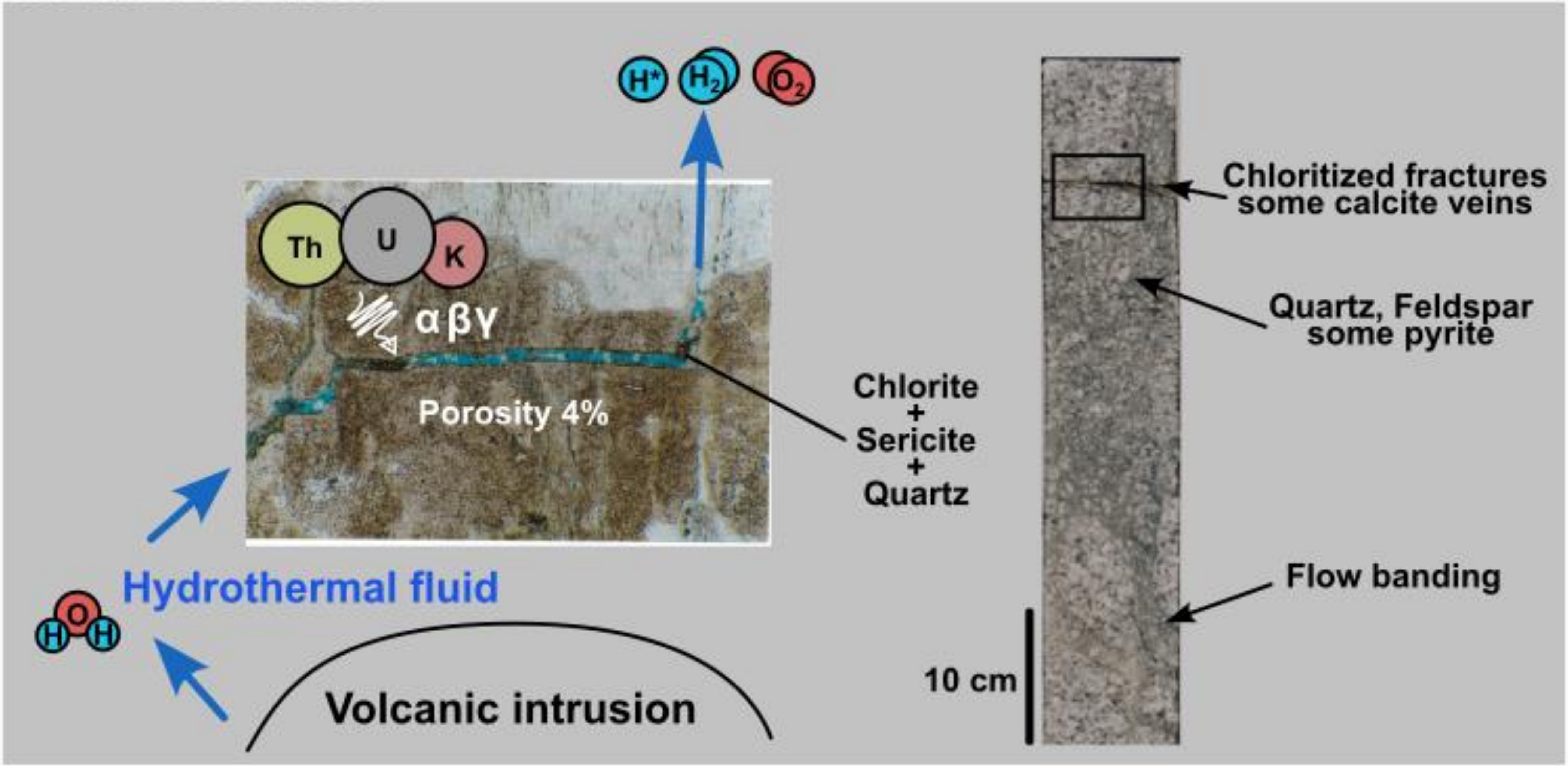
Apport de CH_4 abiotique ?

$$CO_3^{2-} + 4H_2 \rightarrow CH_4 + H_2O + 2OH^-$$

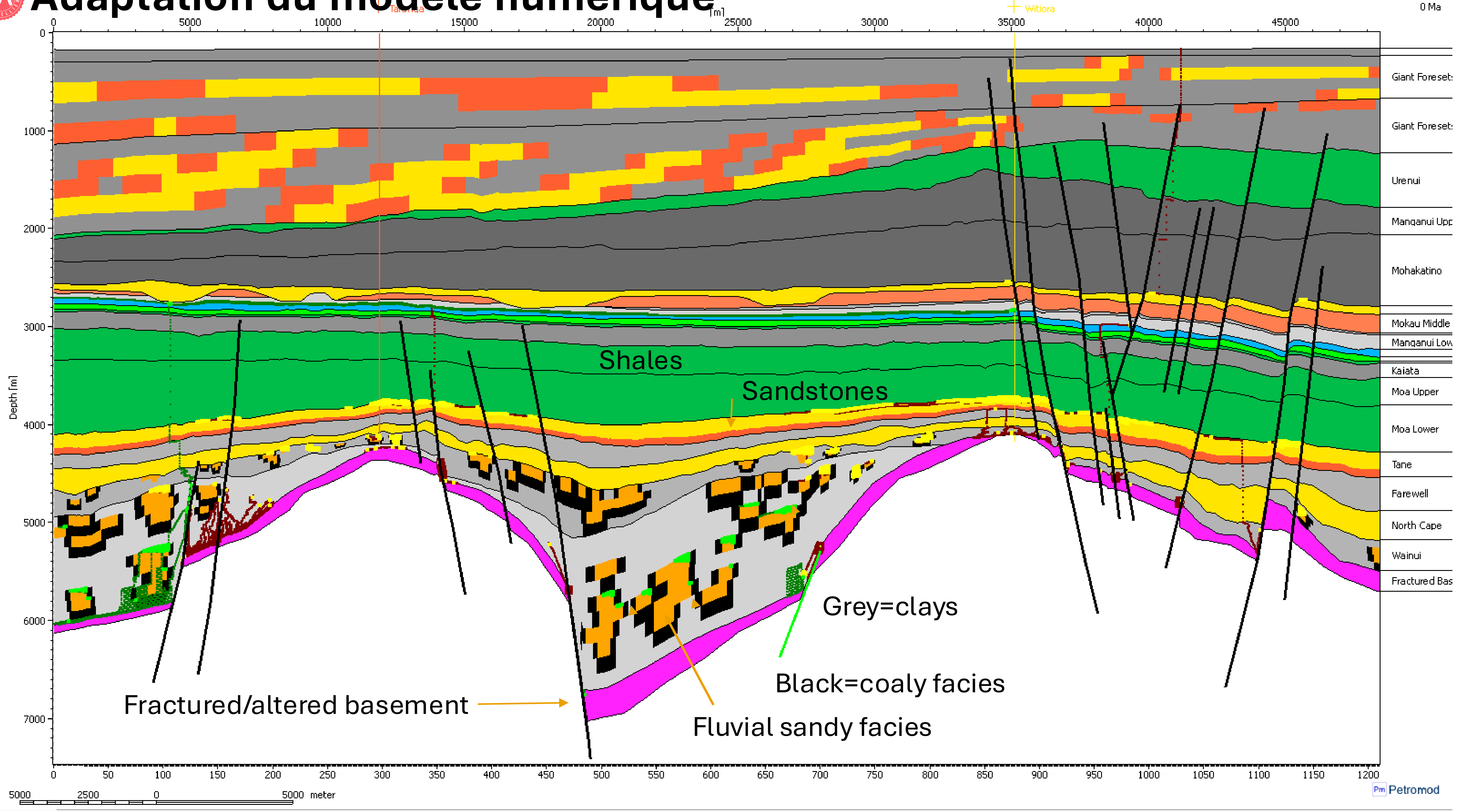


Socle altéré: conséquences

Effet de la radiolyse de l'eau



Adaptation du modèle numérique



Comment calculer la production d'H2 dans le socle ?

Hoffmann, 1992
Lin et al., 2005
Bouquet et al., 2017

i represents an α, β, and γ irradiation

Ei ($J\ kg^{-1}\ sec^{-1}$) is the apparent dose rate from the decay of U, Th, K, and Rb

W is the weight ratio of pore water to rock (1.48×10^{-2} for a **porosity of 4%** and a **rock density of 2.7 g/cm³**

$$E_{net_i} = \frac{E_i \times W \times S_i}{1 + w + s_i}$$

S*i* is the stopping power of the silicate matrix ($S_\alpha = 1.5$, $S_\beta = 1.25$ and $S_\gamma = 1.14$)

E_{net} (Jkg-1 sec^{-1}) is the net absorbed dose rate of pore water

Y ($mole\ kg^{-1}\ sec^{-1}$) is the **H_2 production rate**

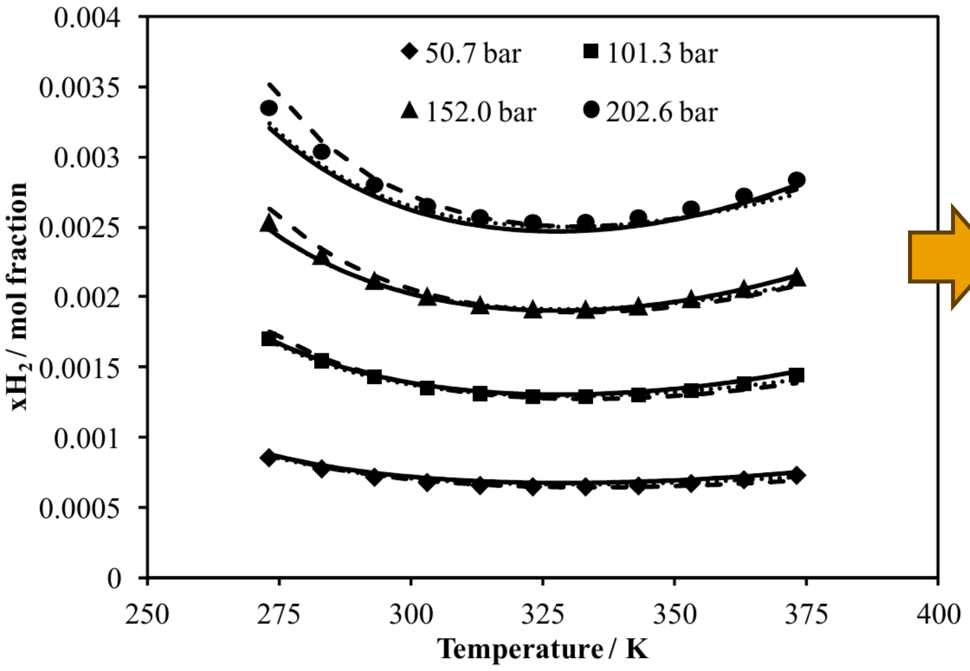
$$Y = \sum E_{net_i} \times G_i$$

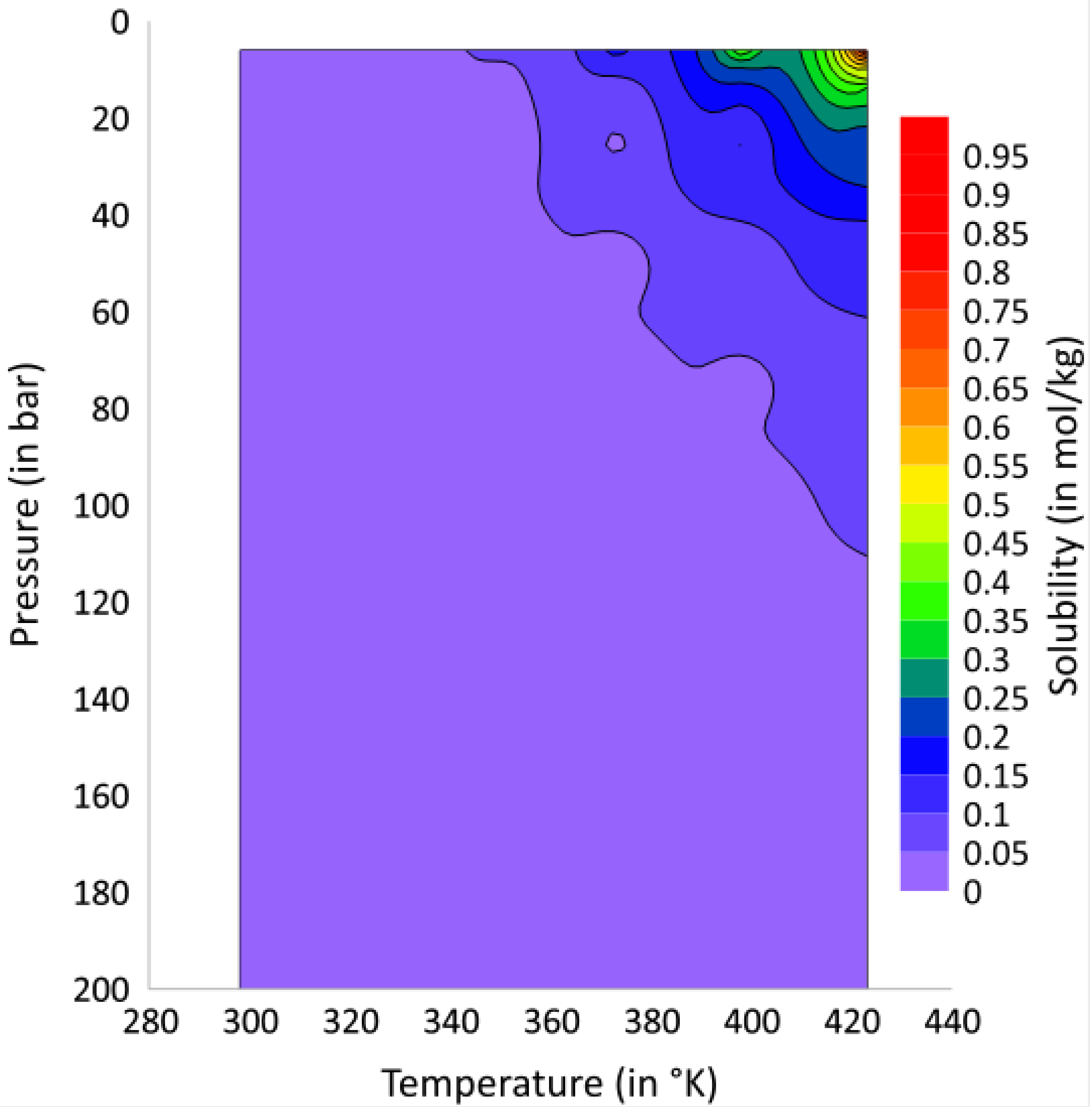
G*i* ($mole\ J^{-1}$) is the H_2 yield per unit of absorbed energy

H2 ➡ 12.8mg/g/Ma

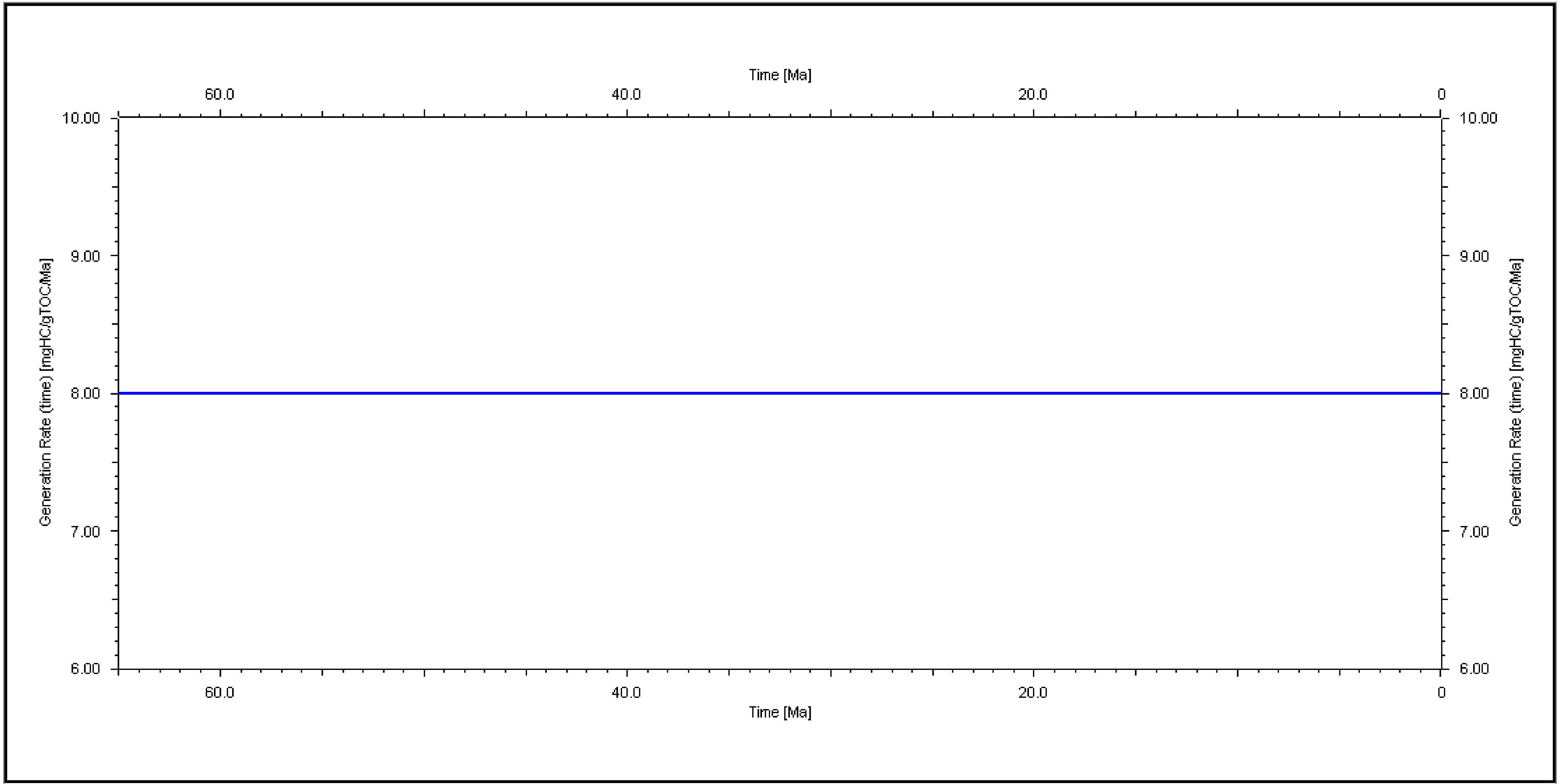
Solubilité de l'H2

Chabab et al., 2020

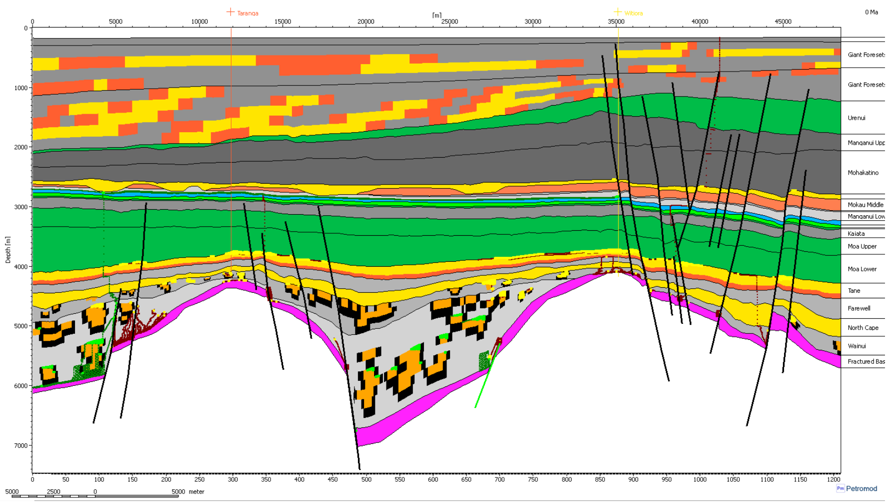




Petromod = Cinétiques



Injection forcée

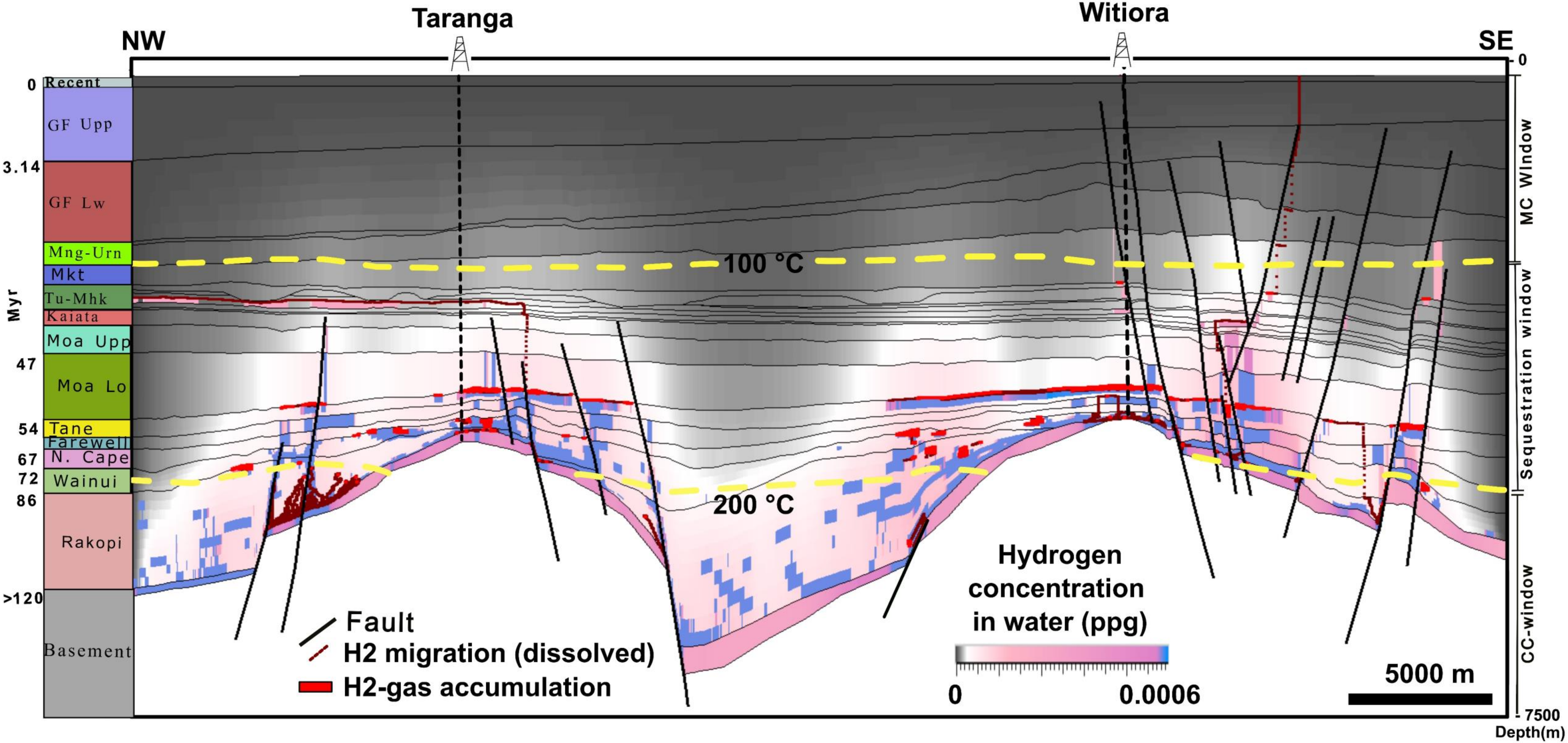


	Cell 0	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9	Cell 10	Cell 11
Component_Injection_Map_1	500.000	500.000	500.000	500.000	500.000	500.000	500.000	500.000	500.000	500.000	500.000	500.000

Age from [Ma]	Age to [Ma]	Component	Vertical Mode	Layer	Depth [m]	Horizontal Mode	X-Location [m]	Y-Location [m]	Well	Value [Mtons]	Map
103.00	0.00	Hydrogen_01	Layer	Fractured Basement		Map					Component_Injection_Map_1

	Name	Color	Type	MW [g/mol]	Tb [°C]	Tc [°C]	Pc [MPa]	Vc [m^3/kmol]	acentric factor	Rackett Zra	Se	Density in Liquid [kg/m^3]	Rel. Deg. Rate	Deg. Frac. [%]	Method	Diffusion coefficient D0 [e-11m^2/s]	Diffusion coefficient EA [kcal/mol]	Water solubility
1	Nitrogen			28.014	-195.8000	-147.0500	3.3940	0.0901	0.0403	0.28971	0	809.40	0.00	100.00	None			none
2	Oxygen			31.999	-182.9800	-118.5700	5.0430	0.0734	0.0218	0.28962	0	1142.10	0.00	100.00	None			none
3	Carbon Monoxi...			28.01	-191.4500	-140.2300	3.4990	0.0931	0.0663	0.28966	0	0.00	0.00	100.00	None			none
4	Carbon Dioxide		CO2	44.01	-78.4800	31.0400	7.3820	0.0940	0.2276	0.27275	0	818.00	0.00	100.00	None	380257.10	4.49	Carbon Dioxide...
5	Hydrogen Sulp...		H2S	34.082	-60.3500	100.3800	8.9630	0.0985	0.0827	0.28476	0	801.40	0.00	100.00	None	55771.03	3.36	Hydrogen Sulfi...
6	Sulfur Dioxide			64.065	-10.0200	157.6000	7.8840	0.1220	0.2451	0.26729	0	1394.60	0.00	100.00	None			none
7	Hydrogen			2.016	-252.7600	-239.9700	1.3130	0.0642	-0.215	0.31997	0	0.00	0.00	100.00	None			none
8	Wet Gas			30.186	-123.1800	-0.7500	4.8010	0.1345	0.0624	0.28493	0	0.00	0.00	100.00	None			none
9	Dry Gas			17.943	-159.7500	-75.7300	4.8500	0.0977	0.0221	0.27992	0	0.00	0.00	100.00	None			none
10	Hydrogen_01			2.016	-252.7600	-239.9700	1.3130	0.0642	-0.215	0.31997	0	111.00	0.00	100.00	None	1777000.00	1.00	Hydrogen_Cha...

Résultats ? Plutôt une aide à la réflexion/conceptualisation



Conclusions

> On peut adapter Petromod à l'explo H2 !

> Définir des cibles exploratoires

> Ne pas négliger les données « vintage »

Perspectives

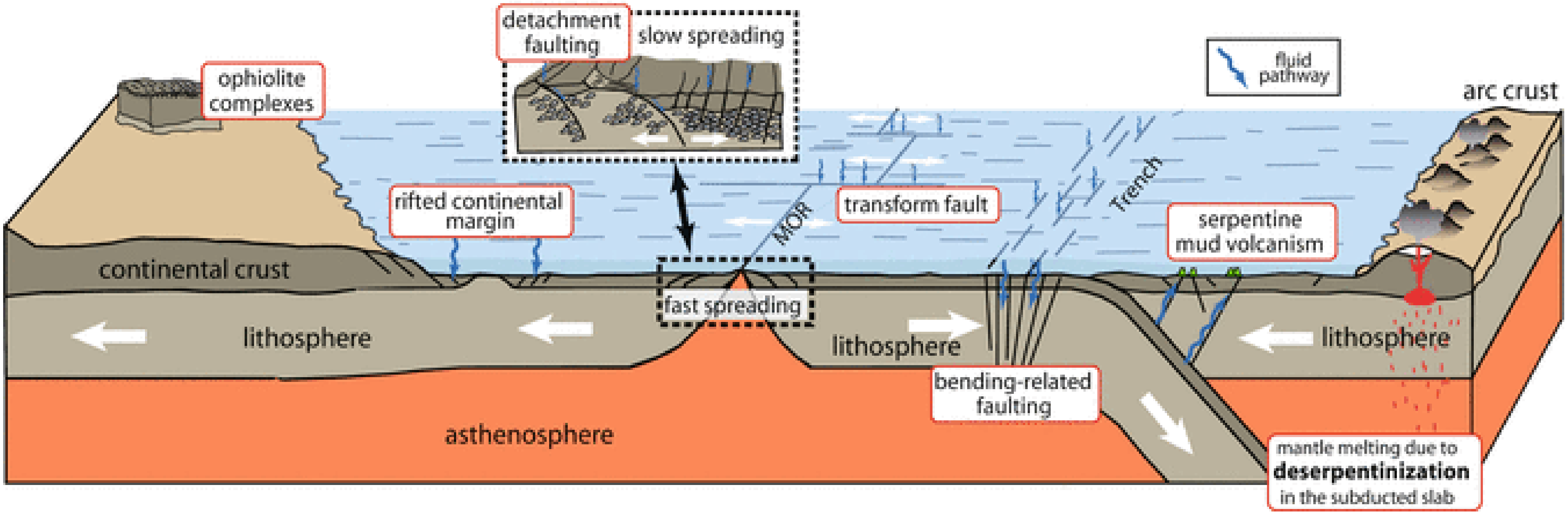
> H2 radiolysis module in Petromod (2026 ?)

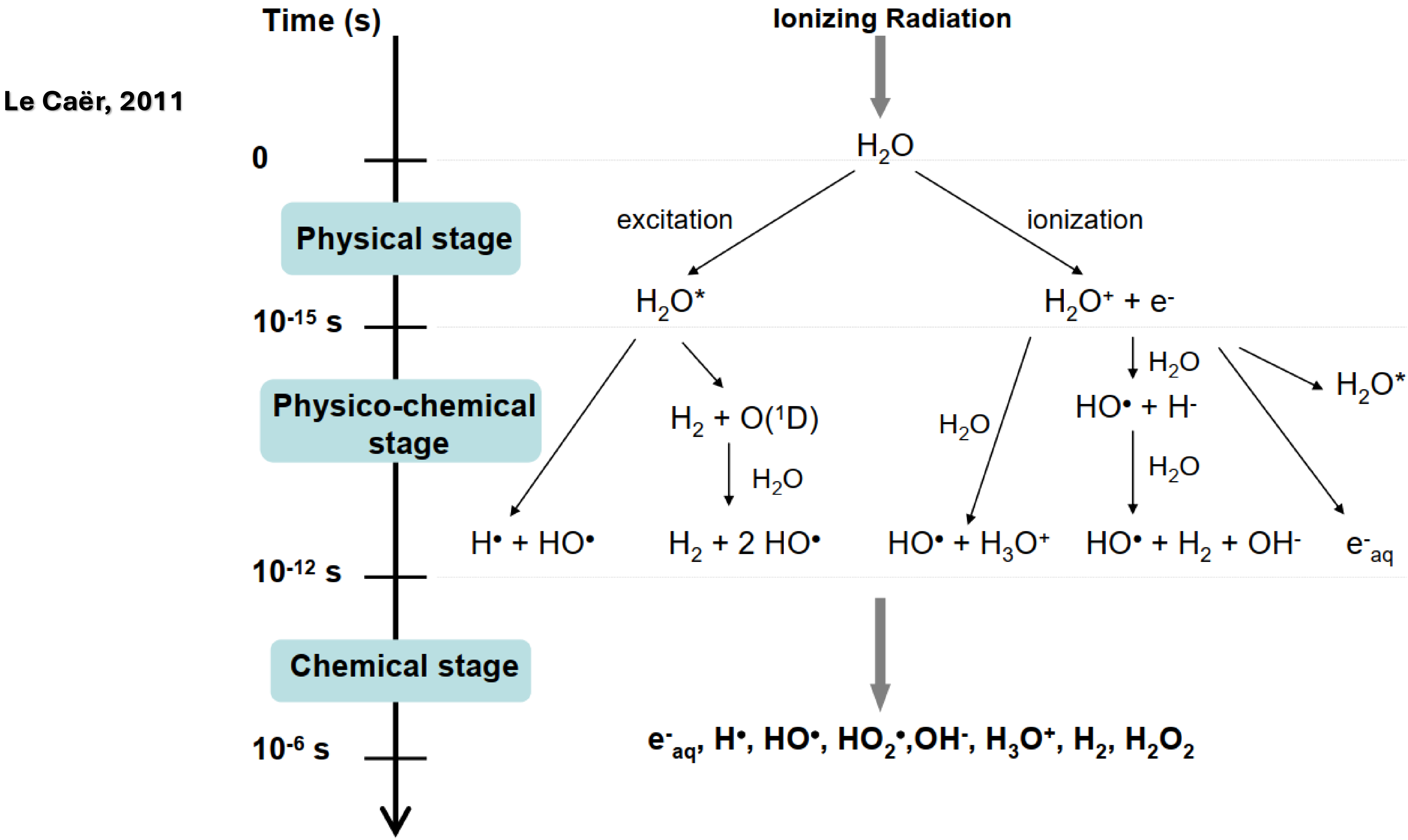
> Introduire les réactions (génération de méthane abiotique, coalification etc...)

DEMO

Muhammed Abdullahi

PhD
2024-2026


detachment faulting
slow spreading
ophiolite complexes
fluid pathway
arc crust
rifted continental margin
MOR
transform fault
Trench
serpentine mud volcanism
continental crust
fast spreading
lithosphere
lithosphere
lithosphere
bending-related faulting
asthenosphere
mantle melting due to
deserpentinization
in the subducted slab



Time (s)
Ionizing Radiation
Le Caër, 2011
H2O
0
excitation
ionization
Physical stage
H2O*
H2O+ + e-
10-15 s
H2O
H2O*
Physico-chemical stage
H2 + O(1D)
H2O
HO• + H-
H2O
H2O
H• + HO•
H2 + 2 HO•
HO• + H3O+
HO• + H2 + OH-
e-aq
10-12 s
Chemical stage
10-6 s
e-aq, H•, HO•, HO2•,OH-, H3O+, H2, H2O2