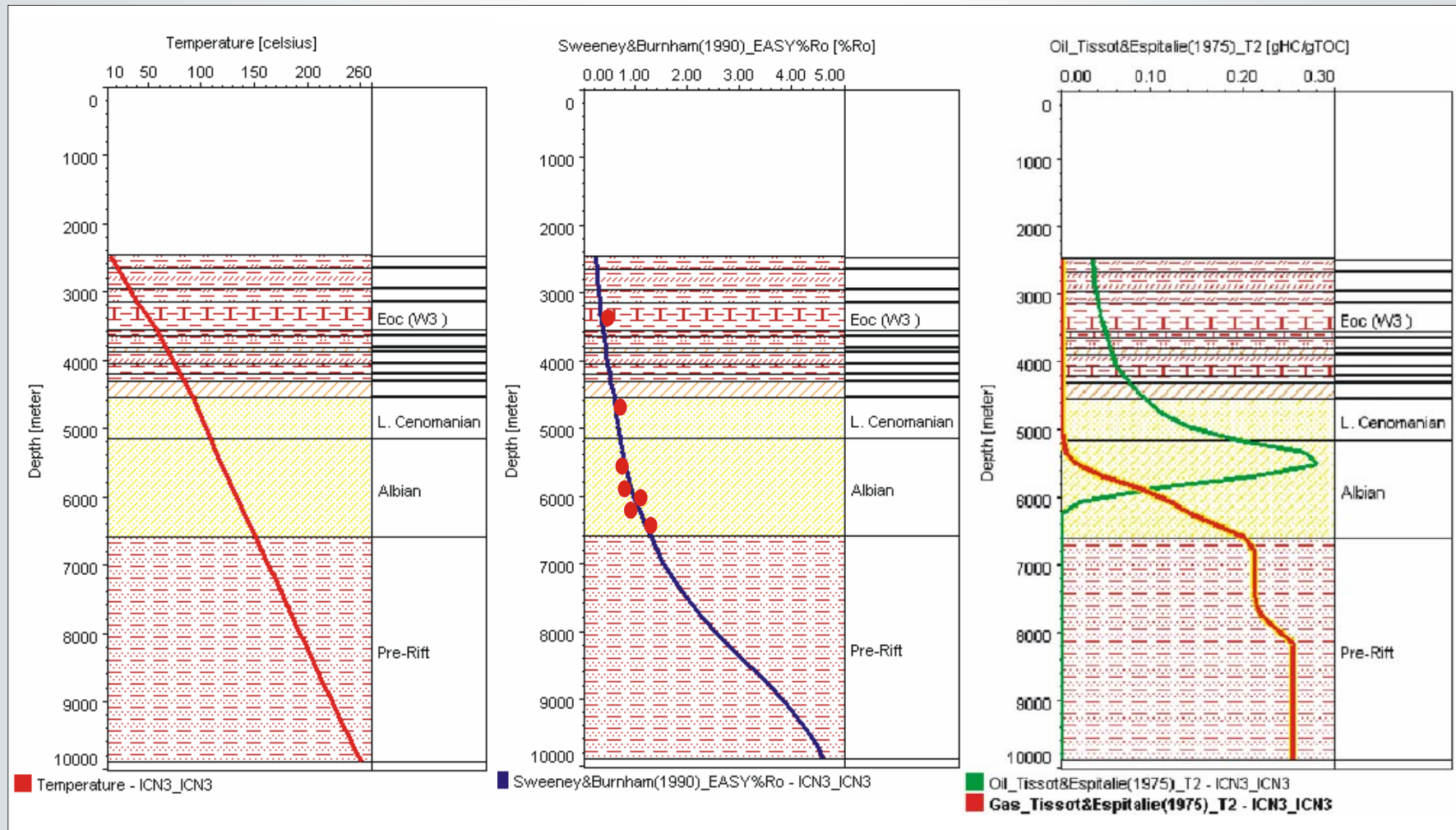


Temperature

Vitrinite Reflectance R_o (%)

Hydrocarbon generation



MATURATION AND RANK		MICROSCOPIC MATURITY PARAMETERS						ZONES OF HC GENERATION		
STAGES OF MATURATION	COAL RANK	VITRINITE REFLECTANCE ¹ (%R _v)	THERMAL ALTERATION INDEX (TAI)		CONODONT ALTERATION INDEX (CAI)	FLUORESCENCE			SOLID BITUMIN REFLECTANCE (%R _b)	
			TAI ²	TAI ³		COLOUR OF ALGINITE ⁴	COLOUR OF SPORINITE ⁵			
DIAGENESIS	Rašeliná	0.2		1.5					BIOGENIC METHANE, HEAVY OIL AND EARLY CONDENSATE	
	Hnědé uhlí	0.3	1		1	GREENISH YELLOW	BLUE-GREEN			
CATAGENESIS	Černé uhlí	0.4		2.3			GREEN		OIL, WET GAS AND CONDENSATE OIL WINDOW	
		0.5		2.5		GOLDEN YELLOW	YELLOW	0.2		
		0.6	2				DULL YELLOW	ORANGE		0.5
		0.7	ORANGE				ORANGE	BROWN		1.0
		0.8		2.8		2				
		0.9		3.0		LIGHT BROWN				
1.0					RED		1.5	START OF MAJOR THERMOGENIC GAS GENERATION		
1.2		3.5		BROWN			2.0			
1.35							2.5			
1.5	3		3.7							
METAGENESIS	Antracit	2.0							WET GAS DRY GAS	
		2.5	4		4	DARK BROWN	non-fluorescent			
META-MORPHOSIS	Meta antracit	3.0							DRY GAS	
		4.0		4.0						
		5.0	5		5	BLACK				

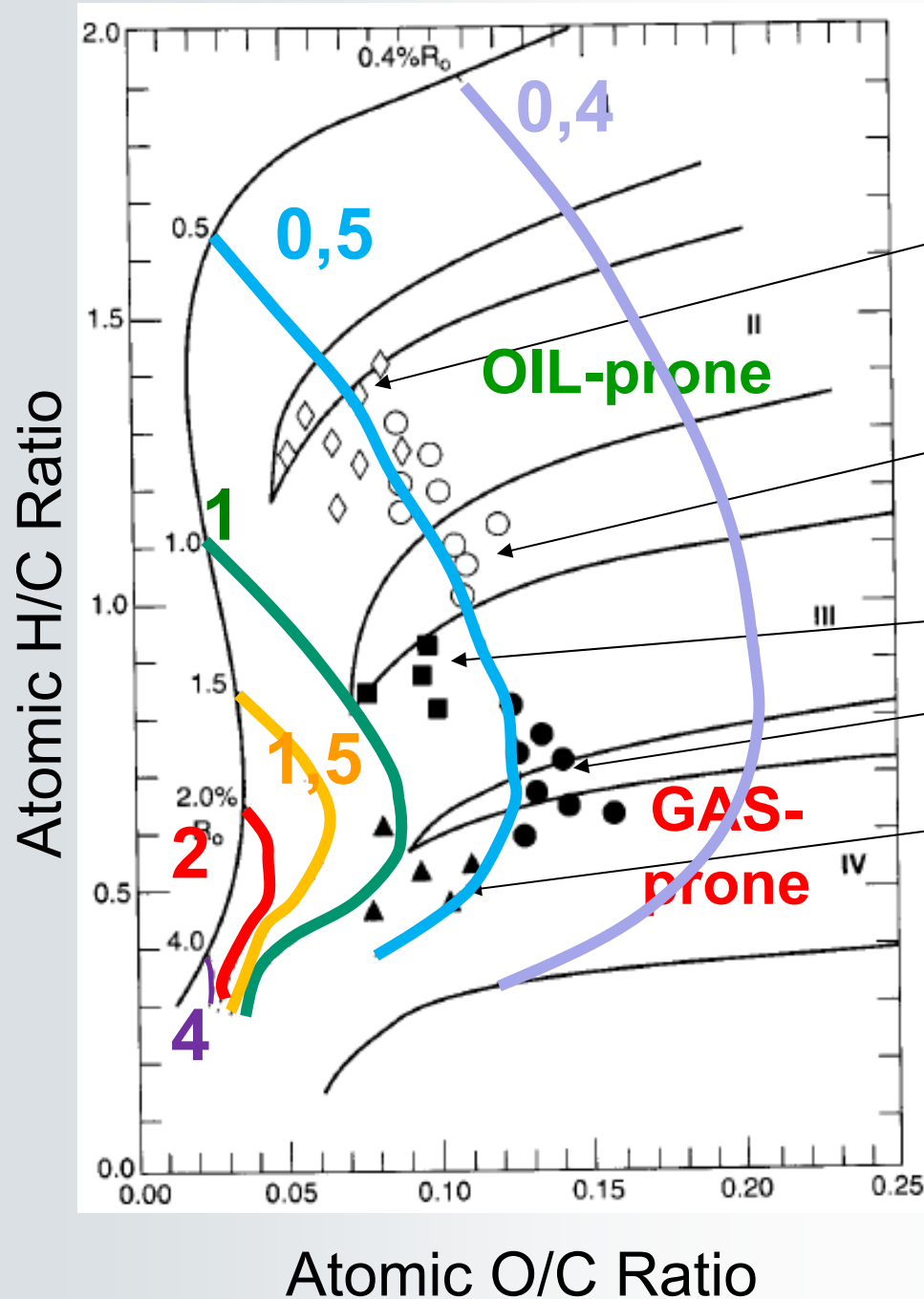
¹from Teichmüller and Teichmüller (1982)

²from Staplin (1969)

³from Jones and Edison (1978)

⁴from Mukhopadhyay and Rullkötter (1986)

Tepelné zrání kerogenu a uhlí



Kerogen Types - North Sea

II Kimmeridge Shale

(restricted marine U. Jur.)

II/III Mixed marine (Tertiary)

with Liptinite

III Coaly Shale (M. Jurassic)

III/IV Open marine (Cretaceous)

IV Red beds (Triassic)

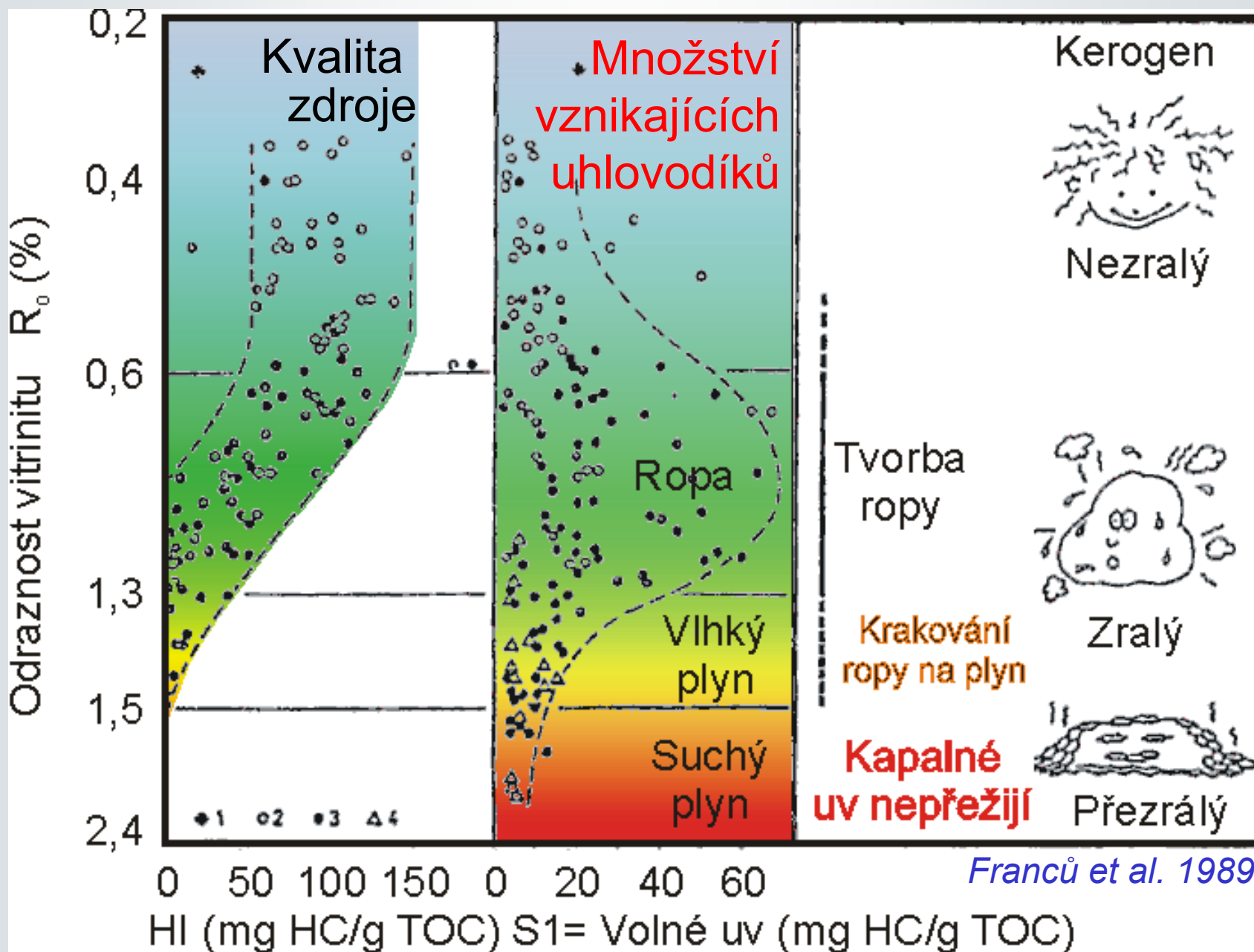
Vitrinite + inertinite

Atomic O/C Ratio

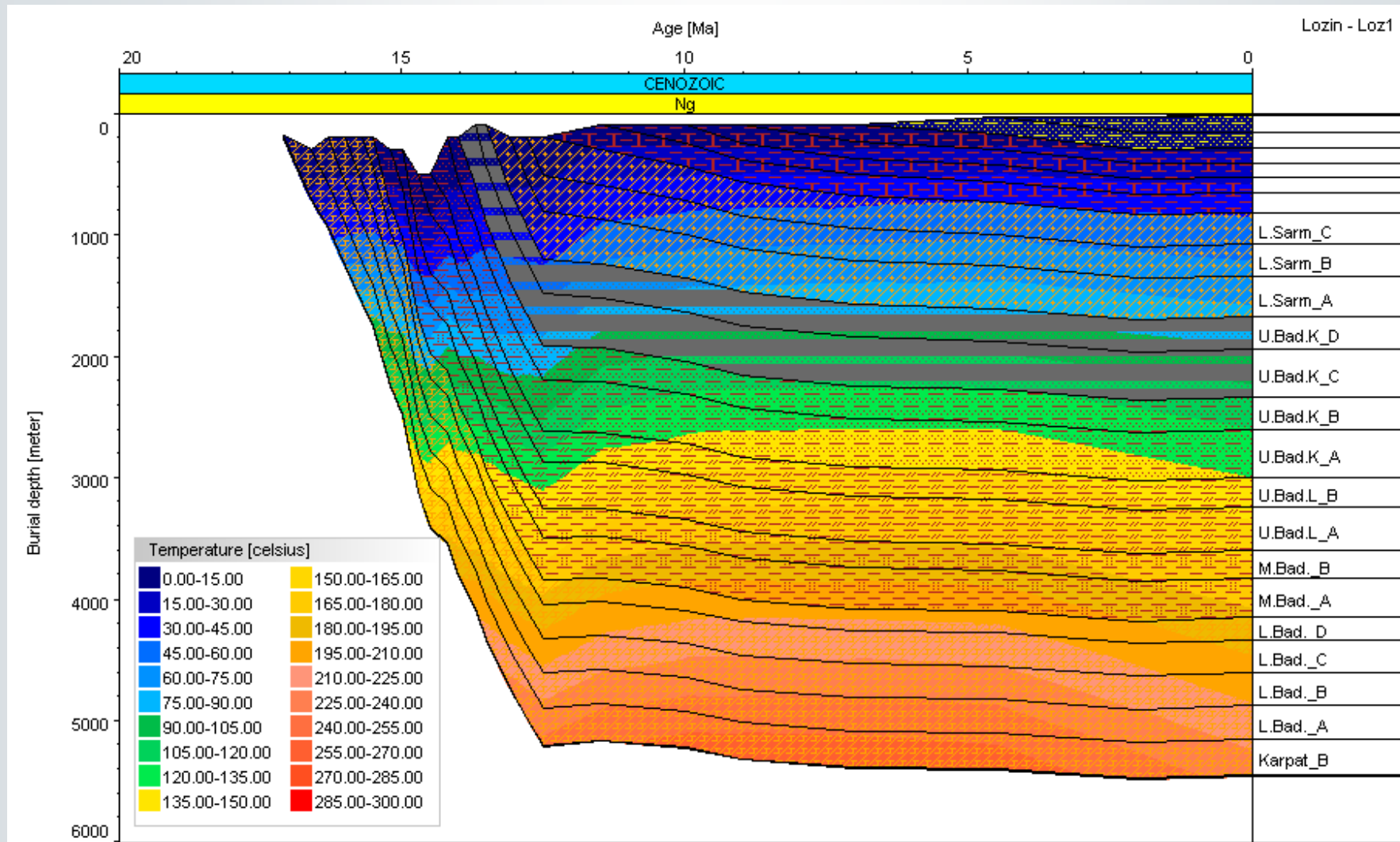
Jones (1987) in Hunt (1996)

6. Zdrojové horniny - Tepelná zralost

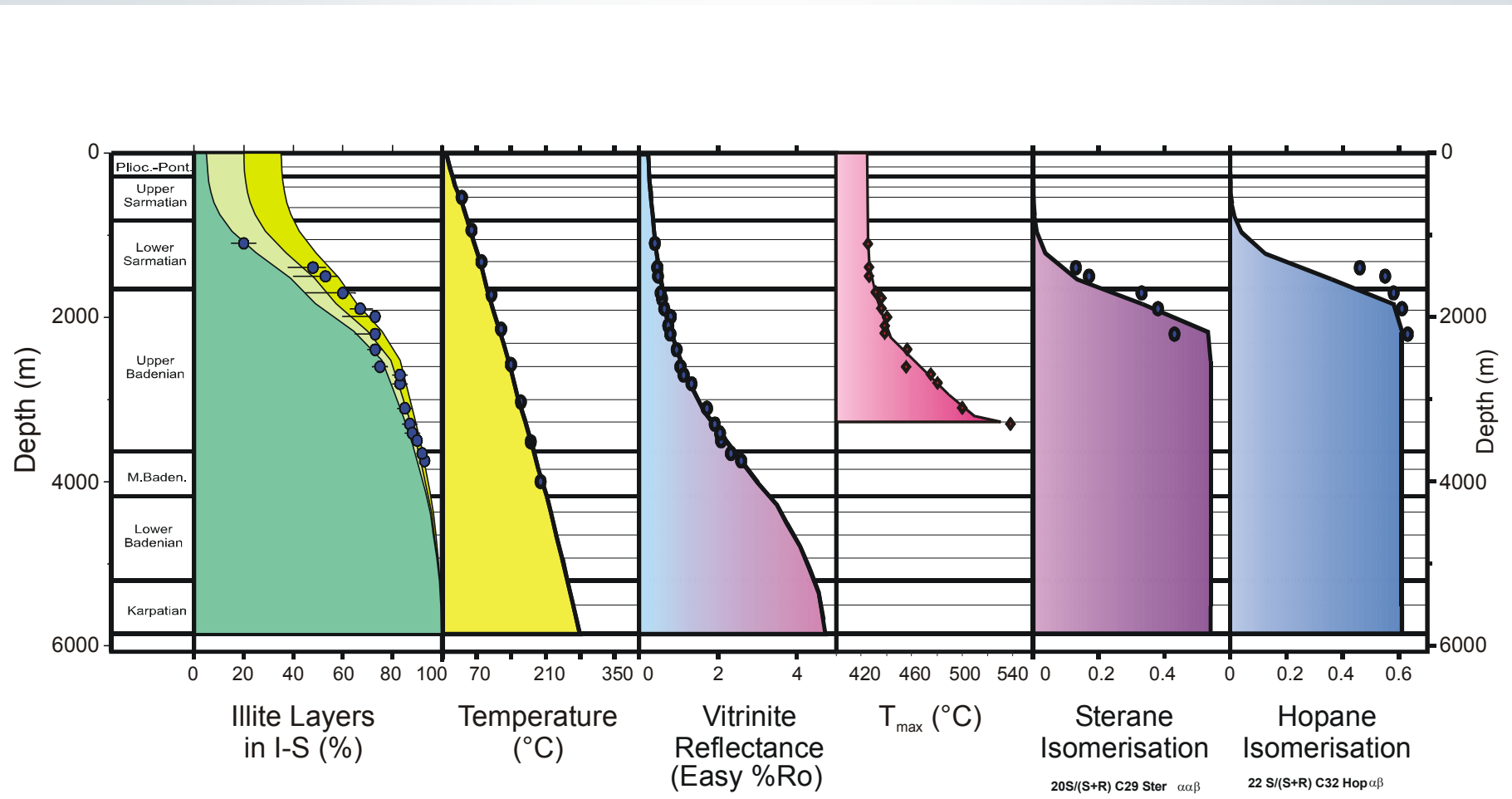
v--- Hloubka, Teplota, zralost



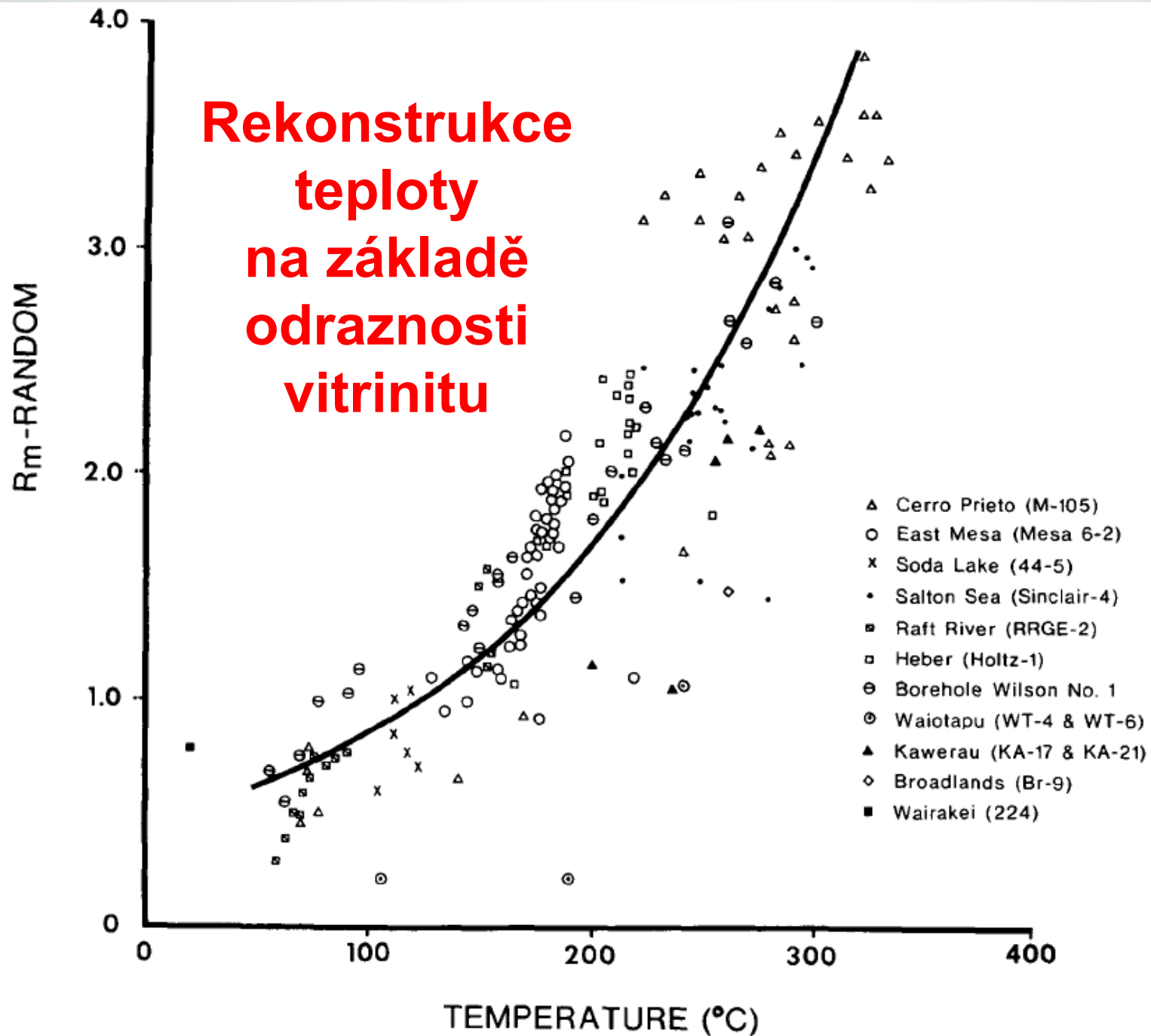
Continuous Deposition Model



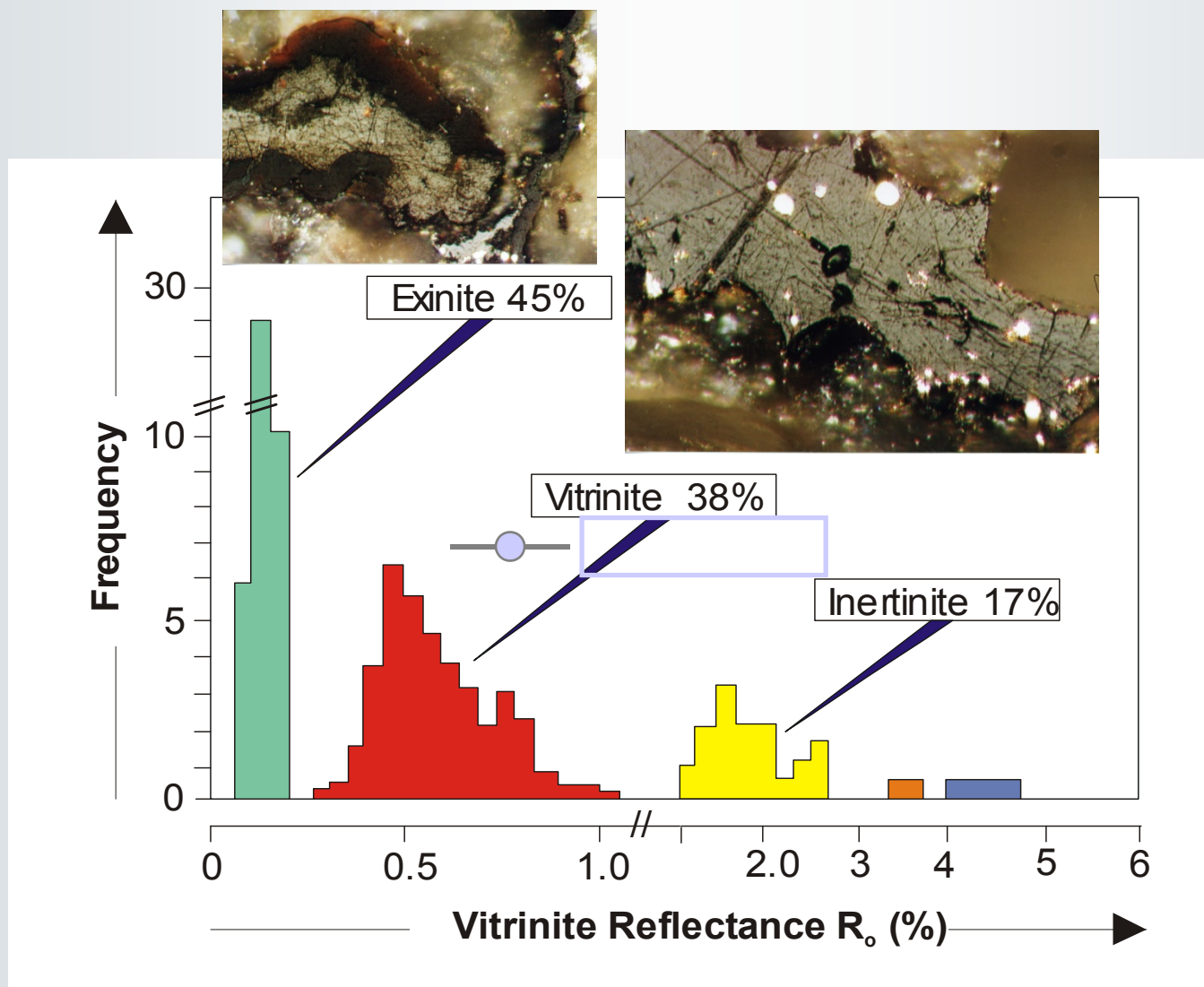
Calibration by I-S clays, Present Temperature, Ro, Tmax and Biomarkers



**Rekonstrukce
teploty
na základě
odraznosti
vitritinitu**

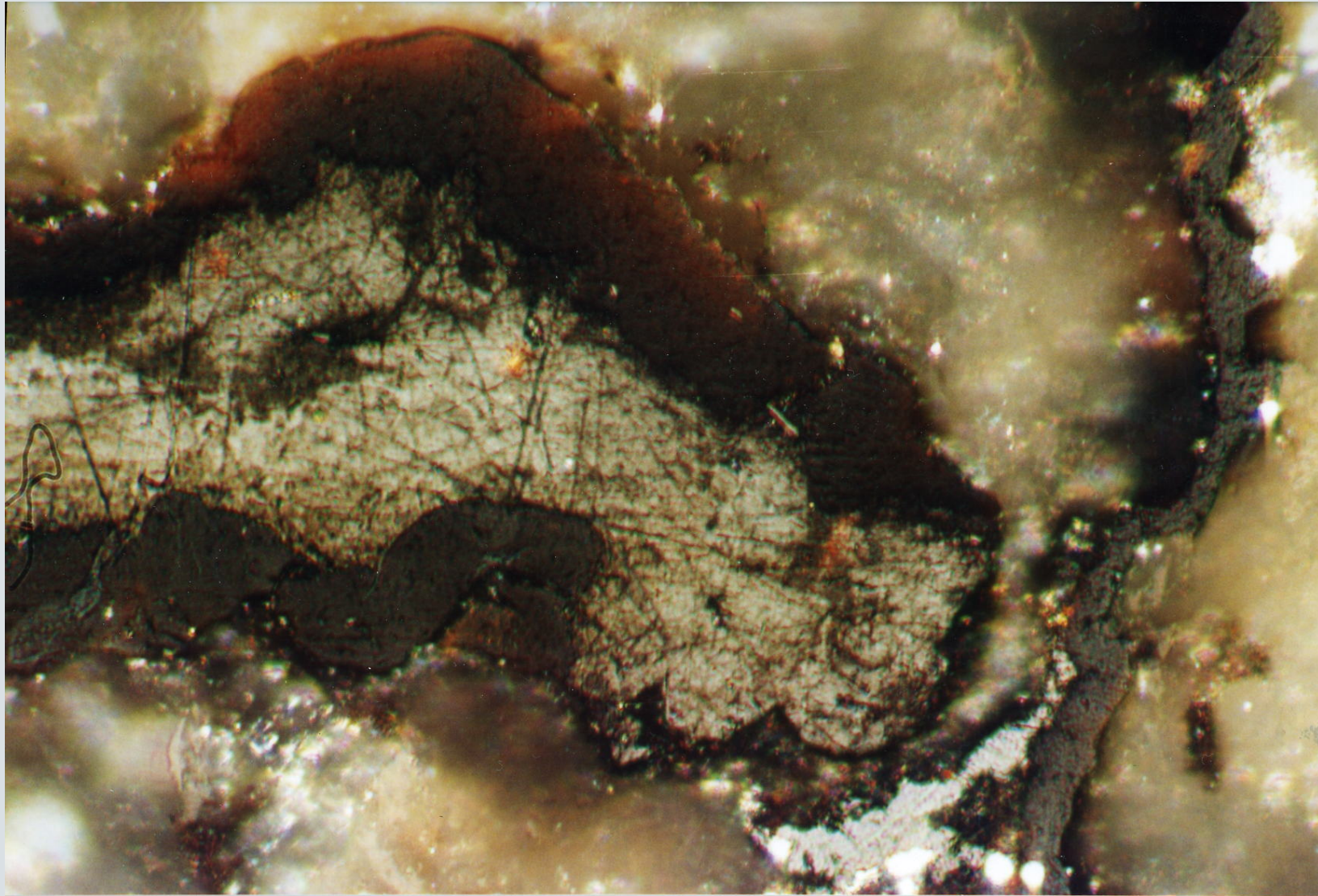


Calibration Parameters - Vitrinite Reflectance



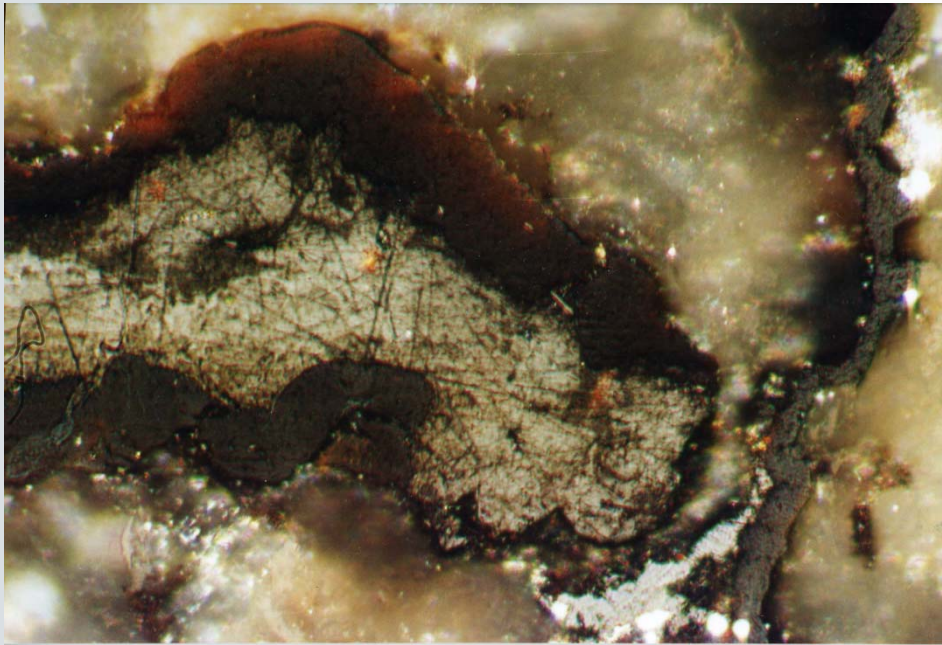
Only vitrinite indicates the thermal history

Macerals - Reflectance



Vitrinite & Cutinite (Exinite) – Reflected Light

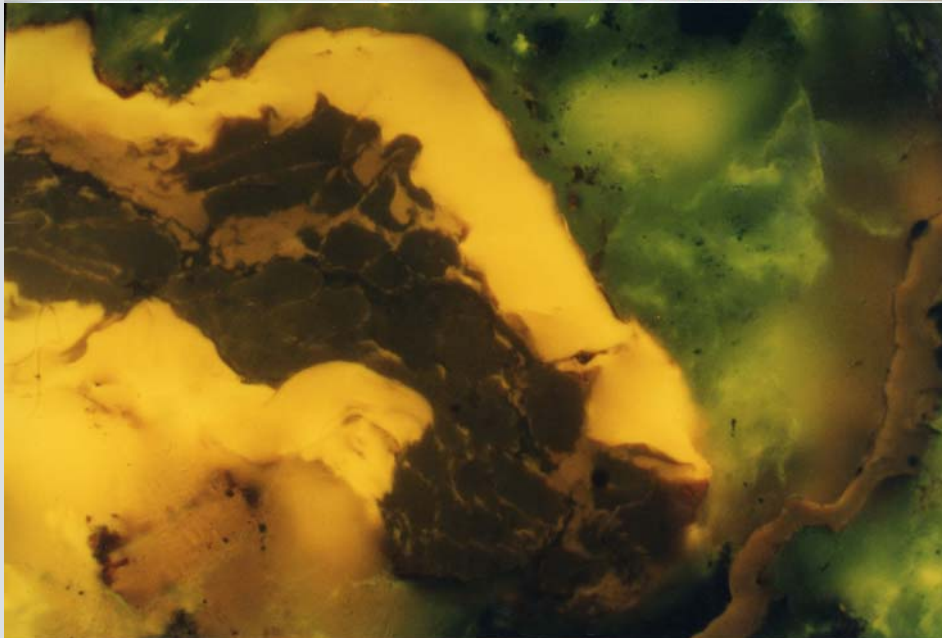
Supressed Reflectance



**Vitrinite & Cutinite
(Exinite)**

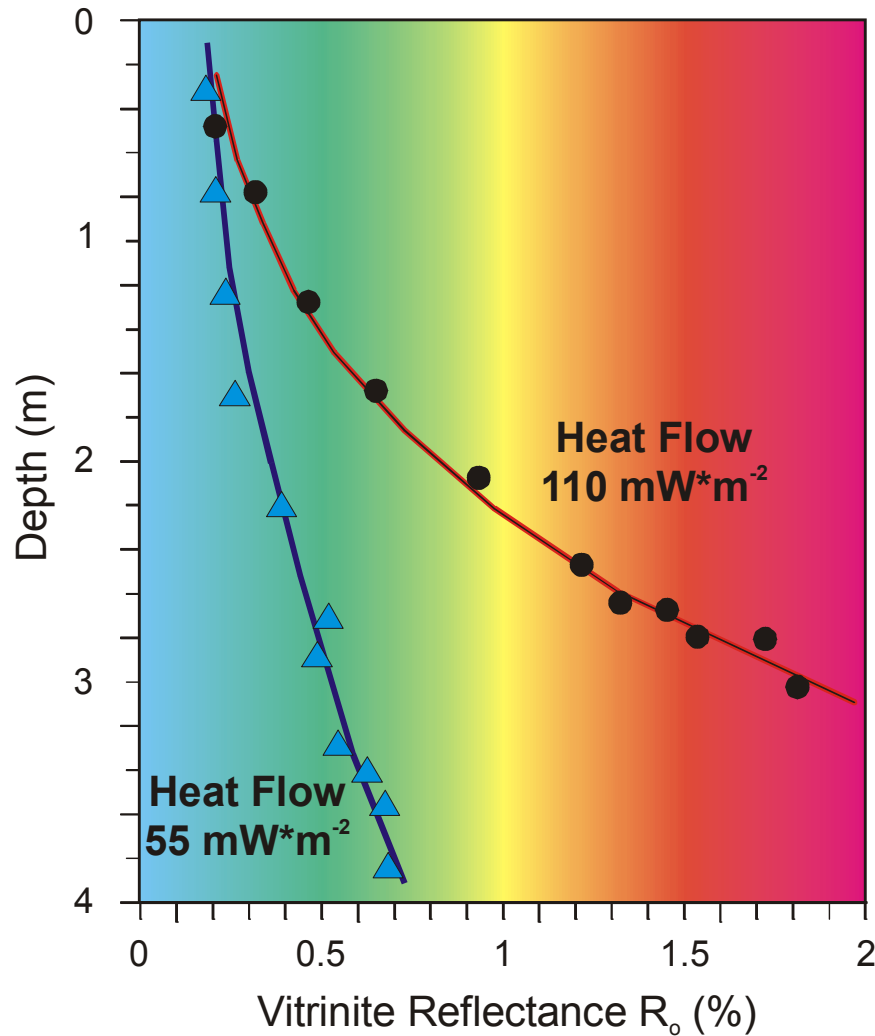
– **Supressed Vitrinite
Reflectance** due to oily
Impregnation

**Cutinite is dark in
reflected light**



– **Fluorescent Light
Liptinite - yellow fluo.**

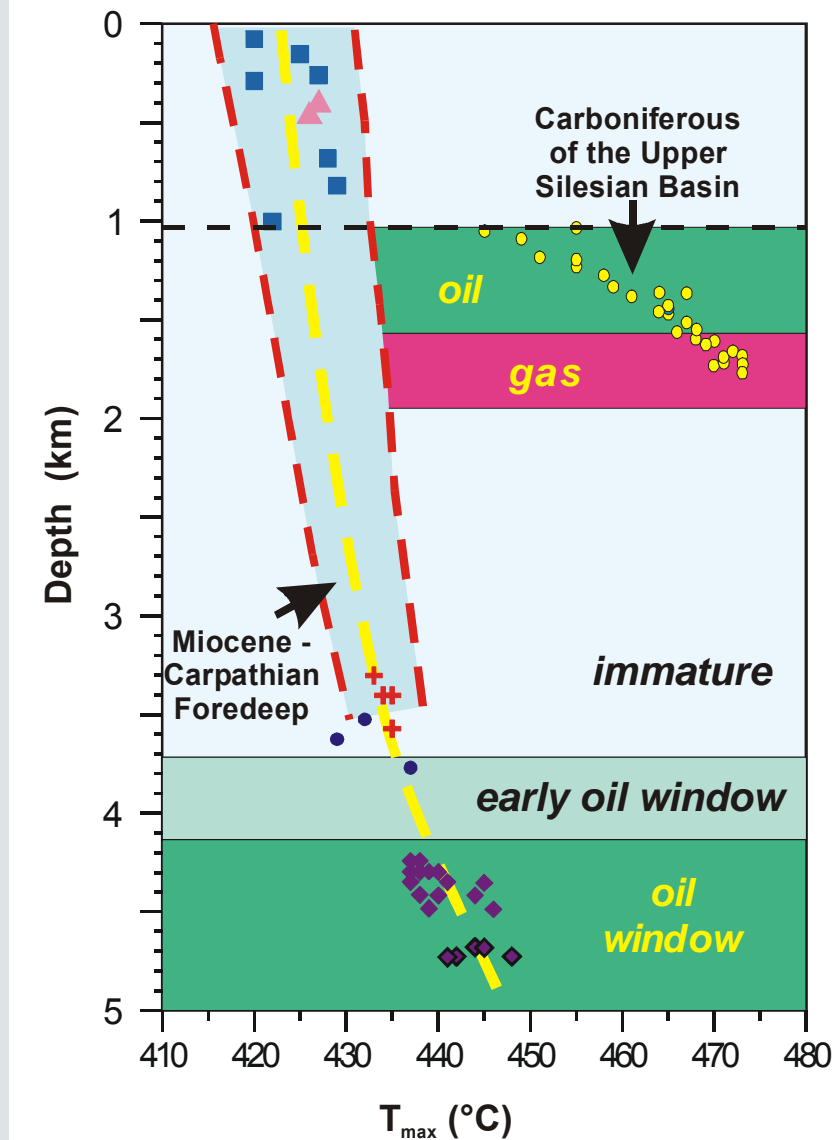
Maturity Trends



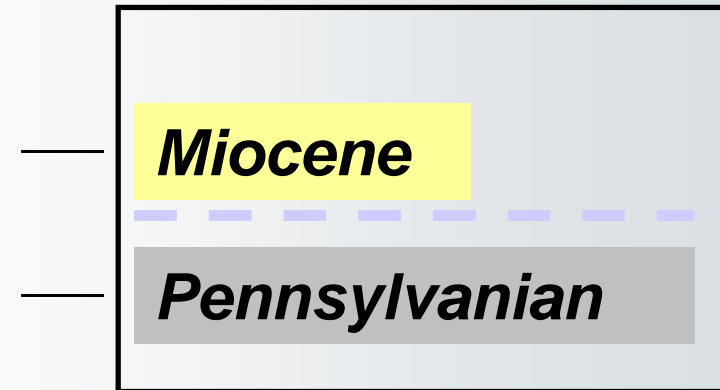
**Maturity trends
with depth in
Mio-Pliocene
basins
“cold” Vienna and
“hot” Pannonian**

**Similar Age,
Similar Lithology,
No erosion
just different
heat flow**

Miocene trend (23-5 Ma) based on 5 wells

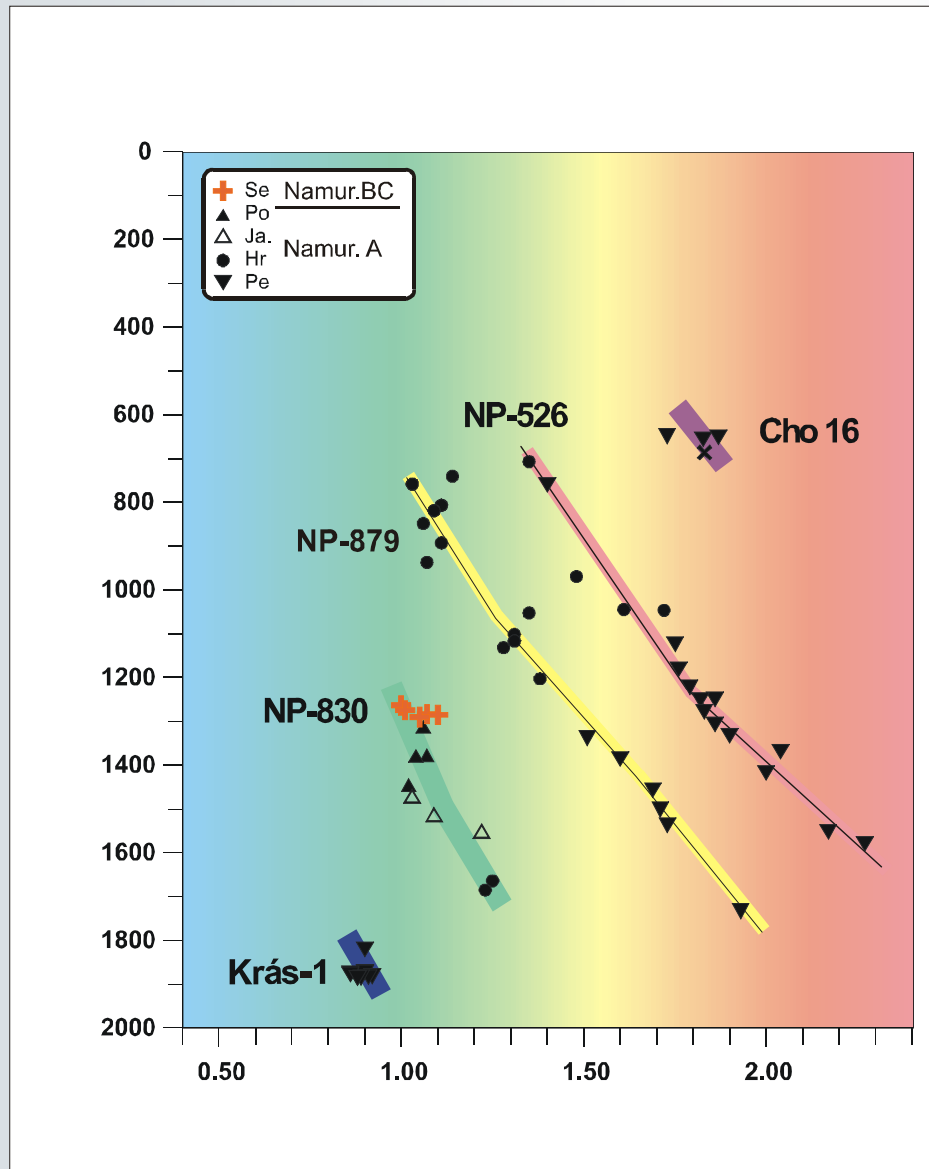


Single well



Heat flow
during Neogene

Maturity Trends in Inverted (Uplifted) Basins



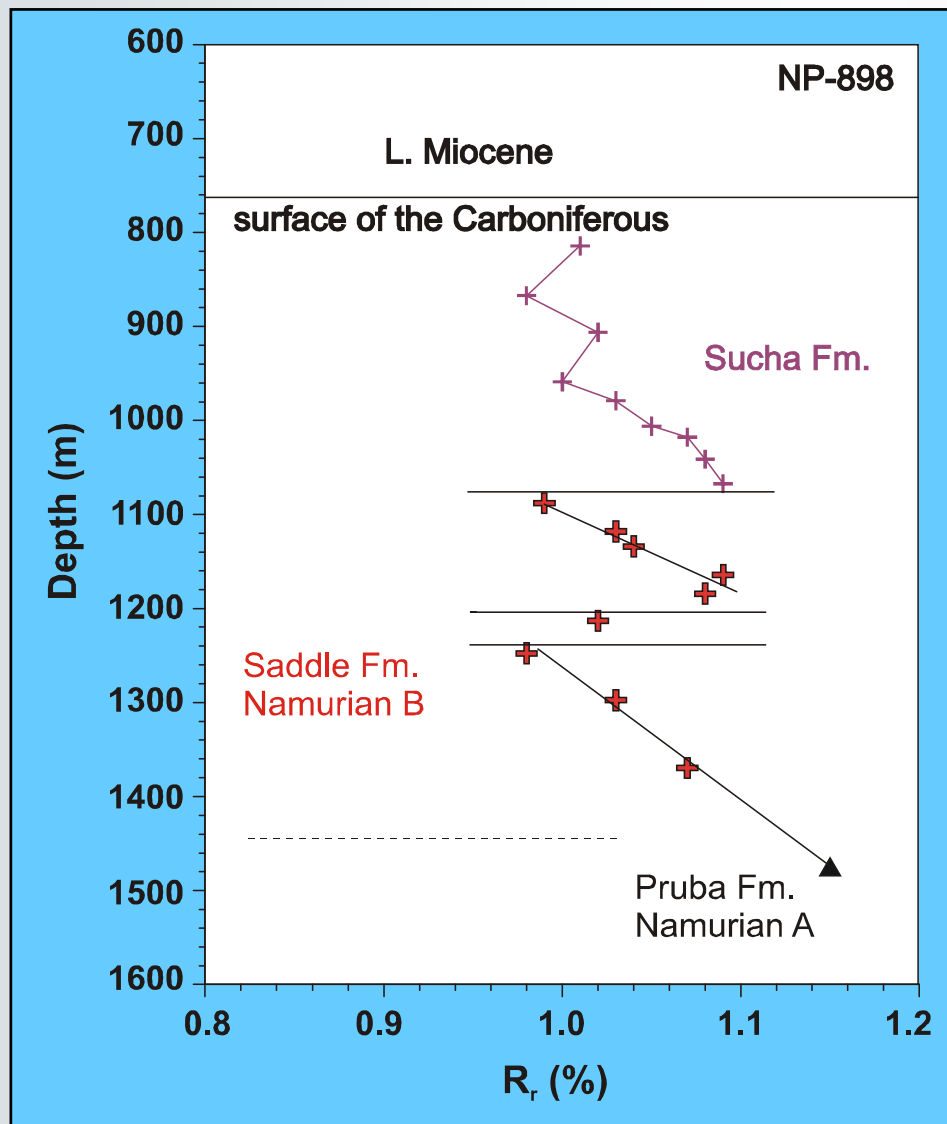
**“Parallel”
maturity trends
with depth**

show similar

**paleo-heat flow /
geothermal gradients**

**but different
uplift and
second burial**

Maturity Trends in Overthrust Systems



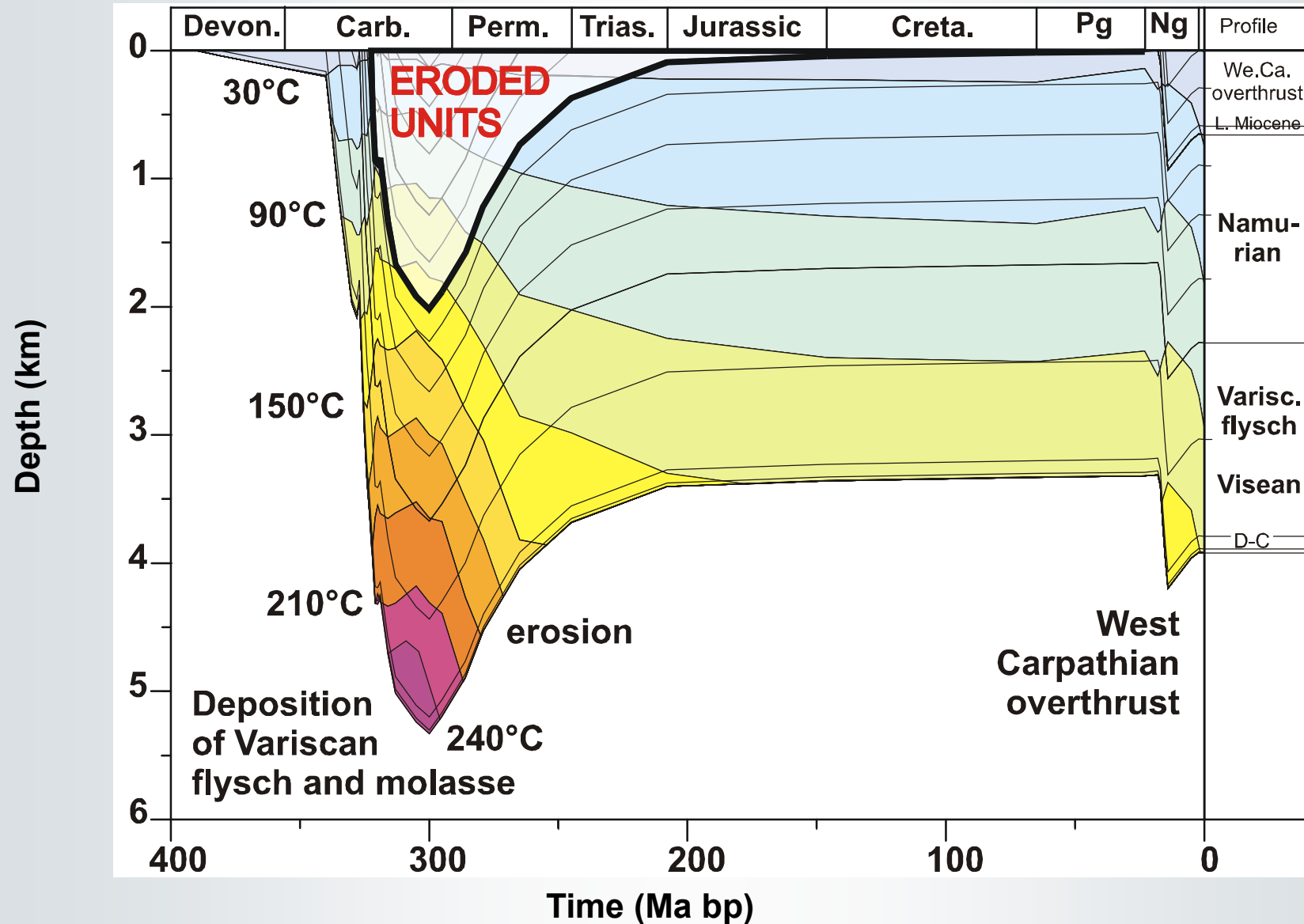
**Vitrinite
reflectance
with depth**

**example
of deformation
(imbrication and
stacking) after
maximum
coalification**

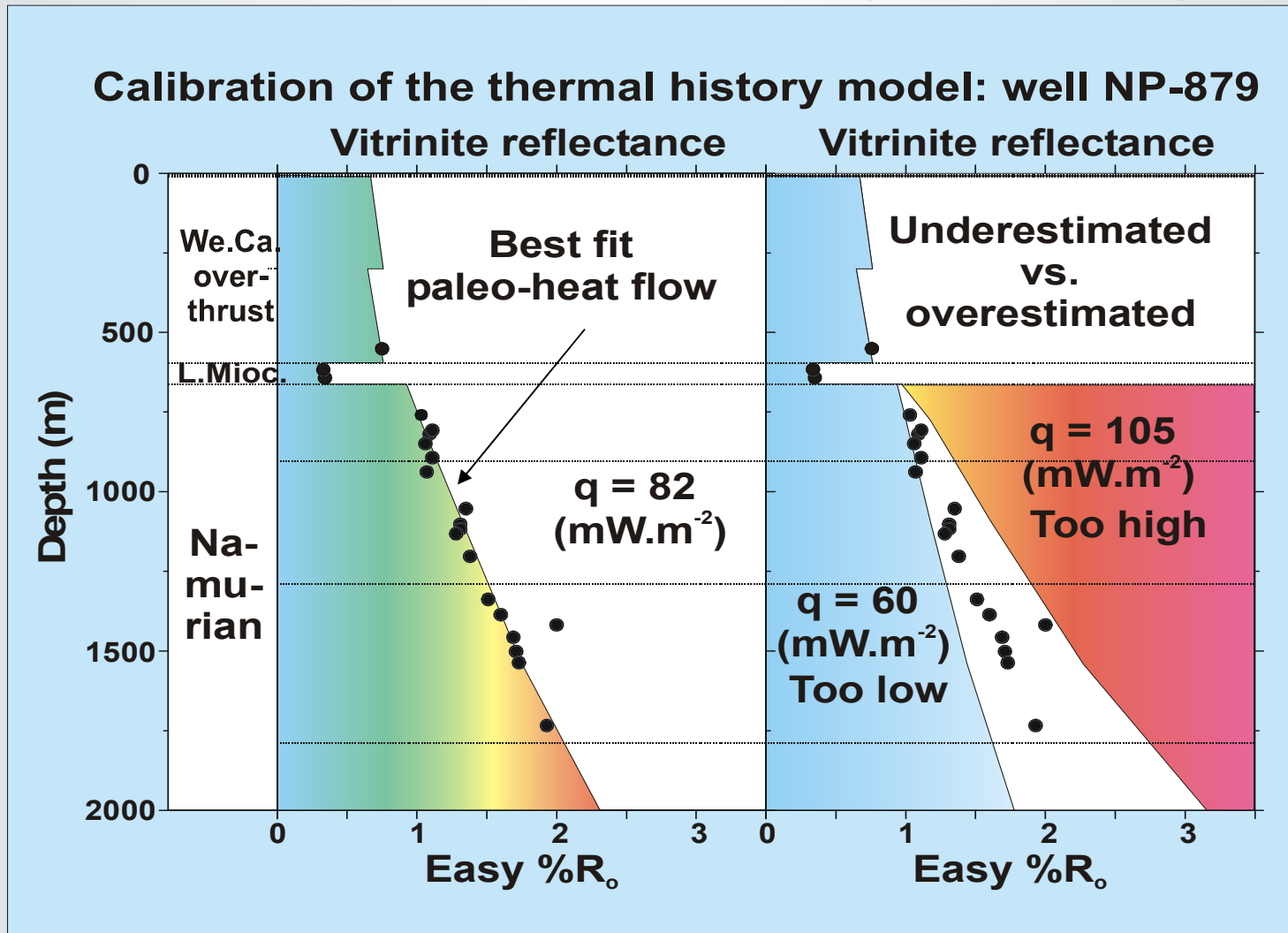
**Variscan foreland b.
U. Silesian Basin**

Calibration

Burial History with Uplift and Erosion



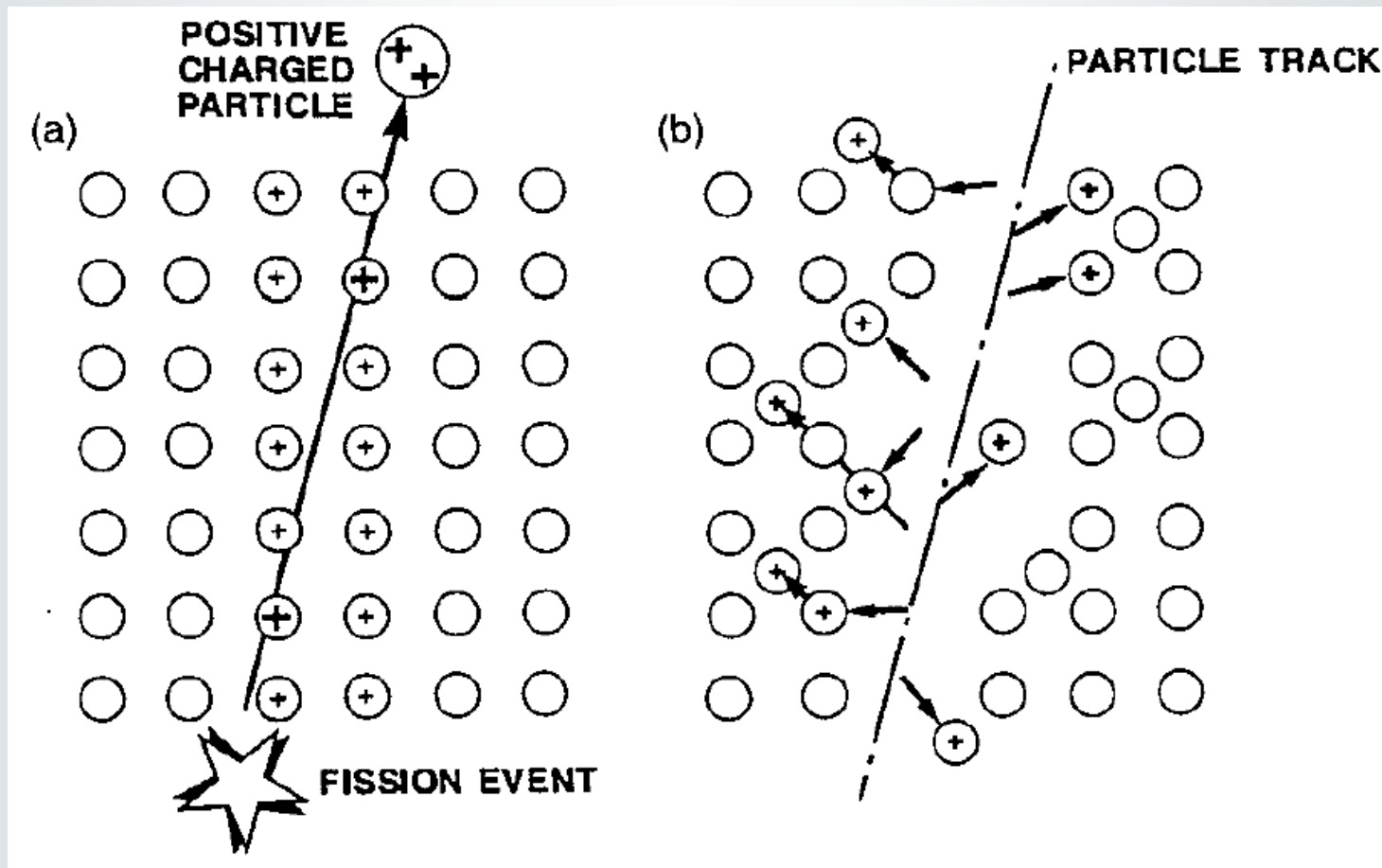
Testing Alternative Scenarios of Heat Flow History for the Late Paleozoic Phase (330-295 Ma)



Apatite Fission Tracks Štěpné stopy uranu v apatitech a zirkonech

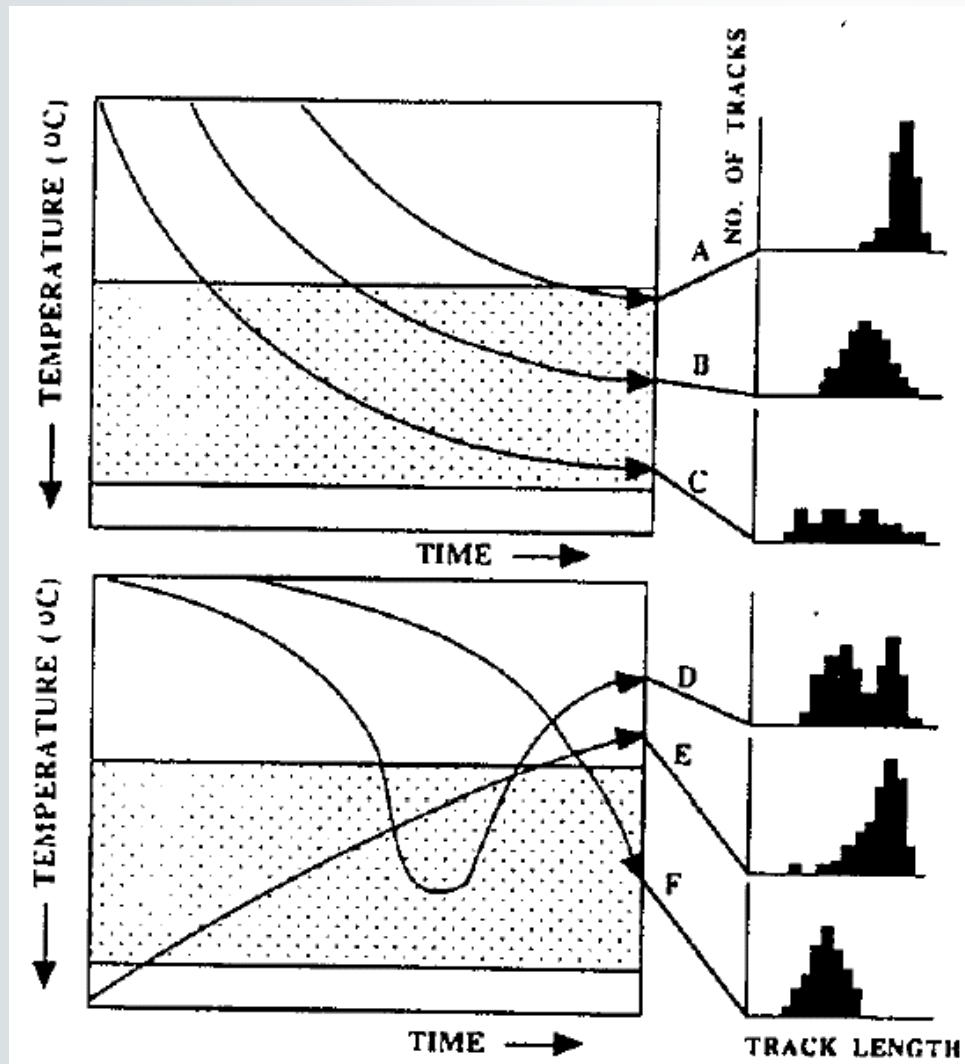


Radioaktivní rozpad uranu vyzařuje částice které proráží "tunely" v krystalové mřížce minerálů



Stopy se uchovají, rostou a množí při $T < 60^{\circ}\text{C}$

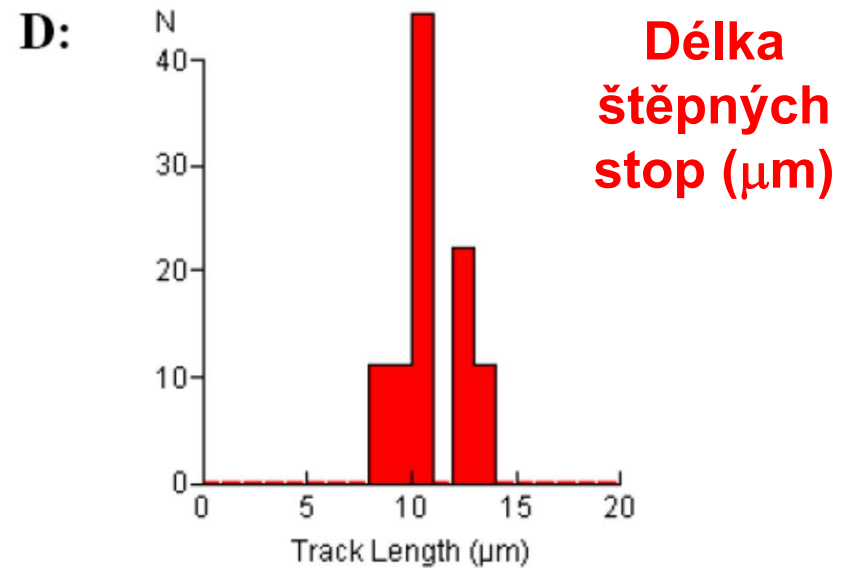
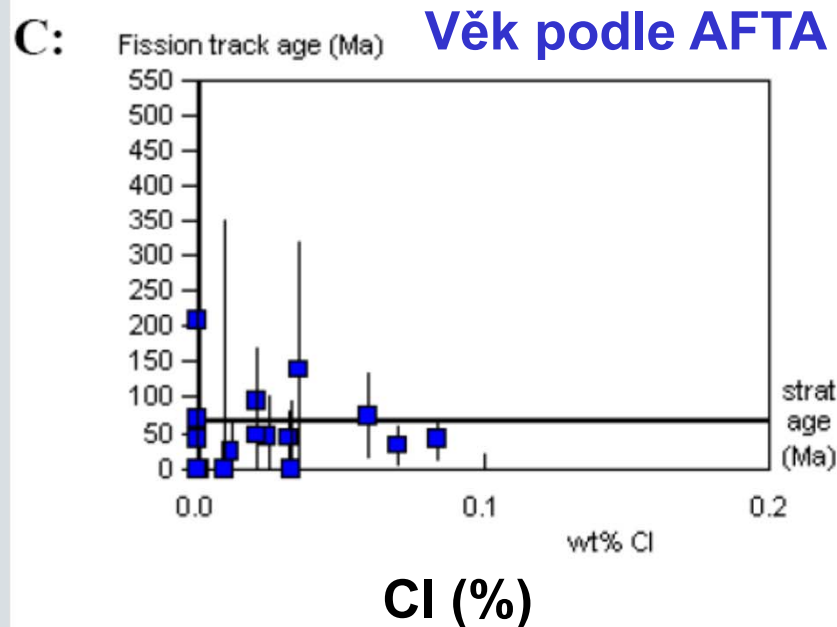
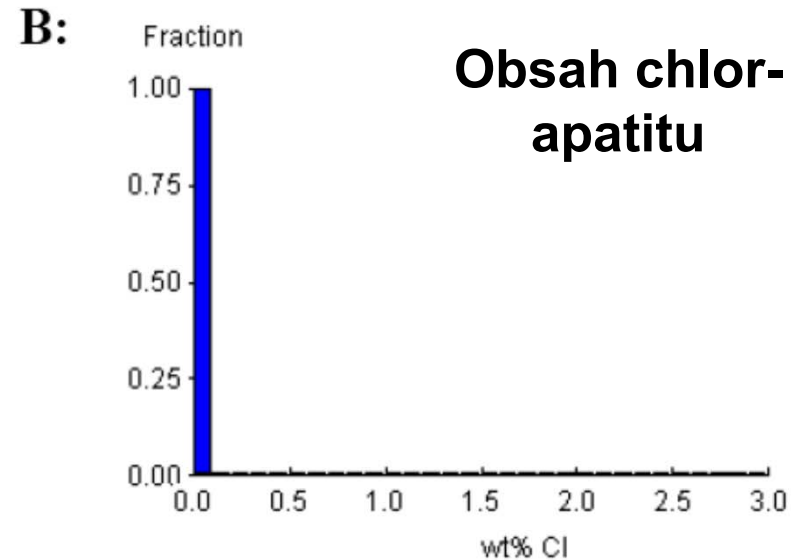
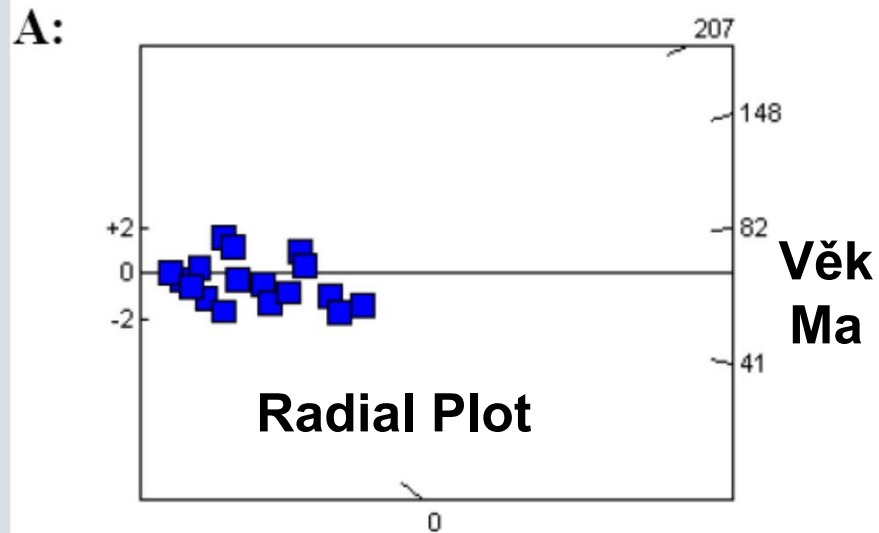
Jak se teplota v zemských hlubinách zapiše do hornin v podobě histogramu AFT



**Monotonní
pokles a
překrytí**

**Výzdvih =>
E = ochlazování**

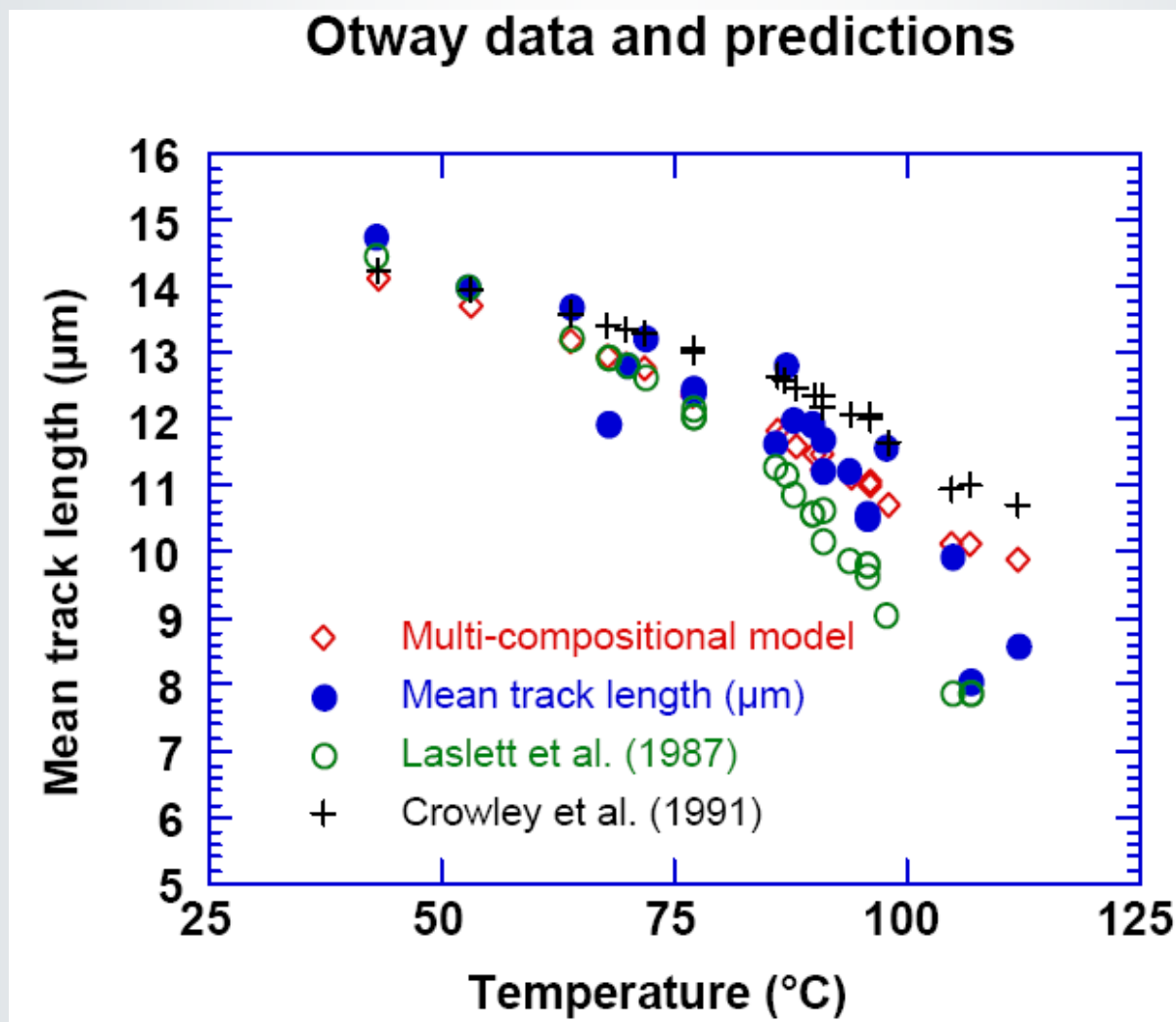
AFTA Diagramy



Mean track length $10.97 \pm 0.50 \mu\text{m}$ Std. Dev. $1.51 \mu\text{m}$ 9 tracks

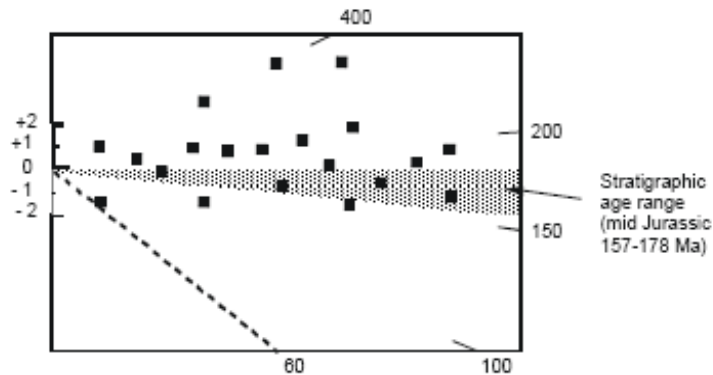
Délka štěpných stop AFT a Teplota vrstev Otway Basin reference wells

AFTA

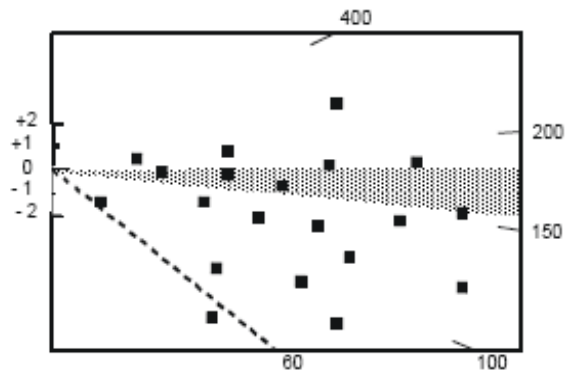


from Green et al, 1989a

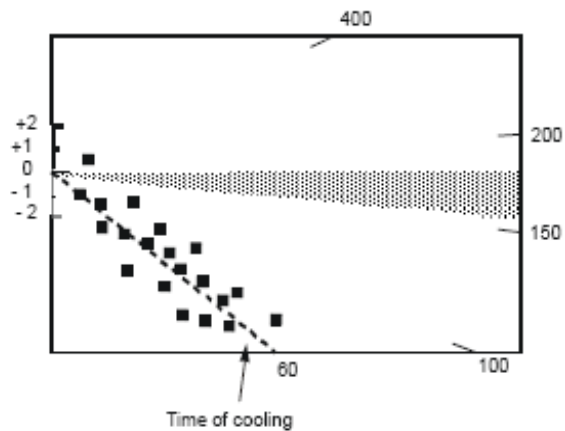
Little or no post-depositional annealing ($T < 60^\circ\text{C}$)



Moderate post-depositional annealing ($T \sim 90^\circ\text{C}$)



Total post-depositional annealing ($T > 110^\circ\text{C}$)



AFTA

**Radialní diagramy měření
jednotlivých zrn**

Chladné vrstvy

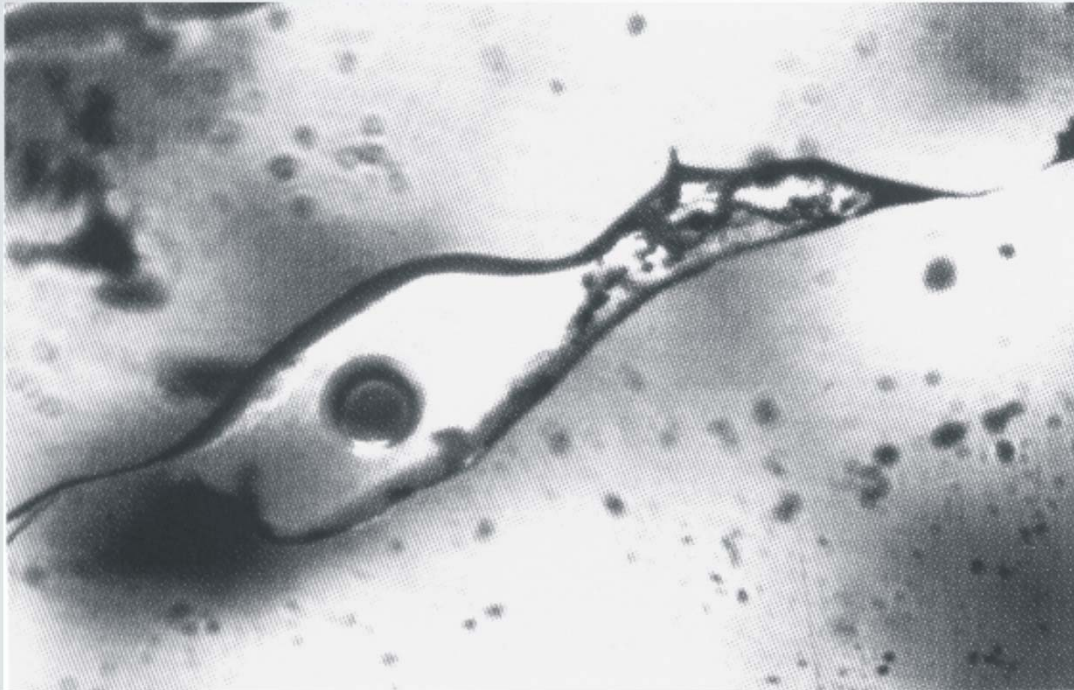
**Středně pohřbené
a prohřáté (90°C)
horniny**

**Silně prohřáté
horniny při
hlubokém
pohřbení**

Green et al, 1989a

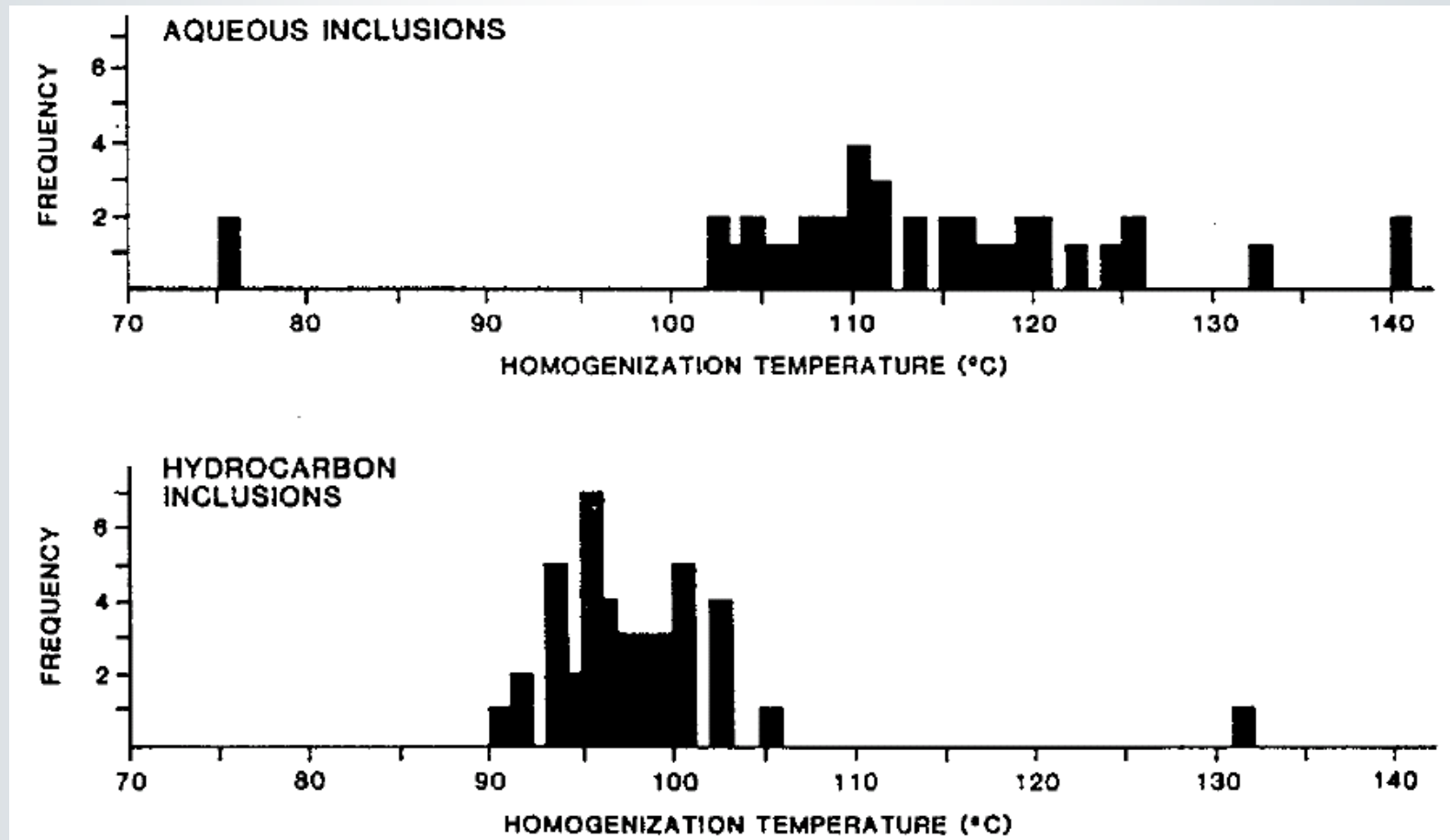
Plyno-kapalné uzavřeniny (inkluze) v pískovcích a kalcitových nebo Q žilách

Teplota => Fázová koexistence



**Plynová bublina
Kapalina
Krystalky soli**

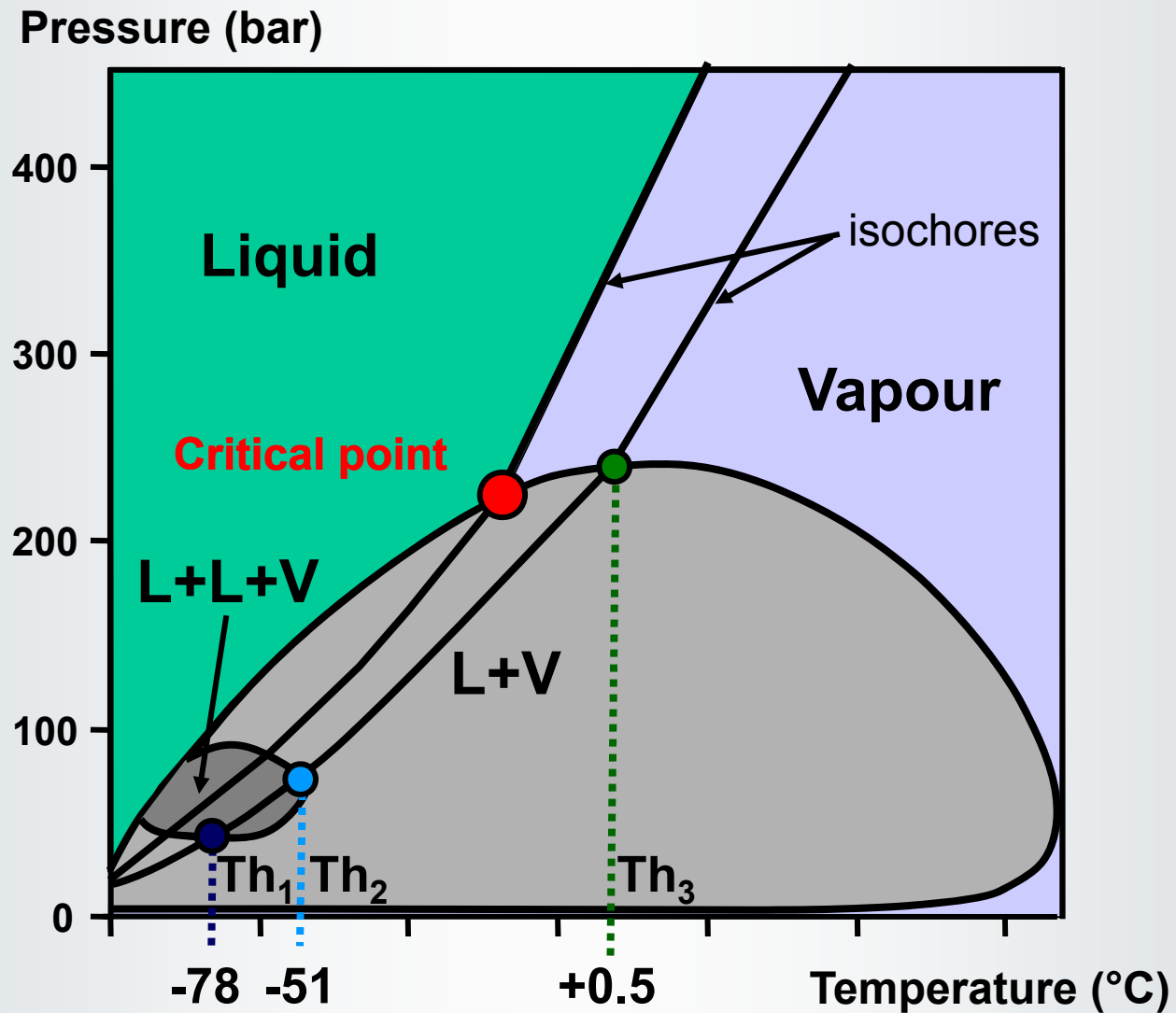
Výsledky měření plyno-kapalných uzavření



Homogenizační Teplota

Plyno-kapaln  inkluze

P, T interpretace homogenizace



Shrnutí - plyno-kapalné inkluze

**Z p T podmínek fázových změn
(bublina - roztok - krystalek)
Ize vyčíst podmínky vzniku celého
krystalu - teploty a hloubky pohřbení**

6. Summary - Calibration

- **Calibration make model closer to reality**
- **From maturity data we read the paleo-heat flow and estimate the amount of erosion**
- **Only calibrated models can provide reasonable calculation of generated oil and gas**