Petrologie sedimentárních hornin

G421P13, ZS 2/1, 3-4.roč.

5. Kaustobiolity, uhlovodíky (uhlí, černé břidlice, ropa, zemní plyn)

Karel Martínek

Ústav geologie a paleontologie

Organická hmota, kaustobiolity

uhlí - huminové, sapropelové, prouhelnění, koks, antracit; uh. petrologie, macerály (vitrinit, inertinit, exinit)

černé břidlice - bitumen, typy kerogenu, pyrolýza, Van Krevelenův diagram

ropa - ropné okno, generování tekutých uhlovodíků -> tlak fluid, hydraulické fraktury

degradace, maturace org. hmoty; alterace, diageneze, katageneze termální zralost OM, odraznost vitrinitu

uhlí

Table 4.4 **Summary of changes in some bulk characteristics of coal with increasing rank** (After Teichmüller and Teichmüller, 1968)

	Rank stages		ASTM classification*	%C†	% volatiles†	% water	%R‡	Calorific value (kcal/kg)§
				60		75	0.25	
BROWN COAL	SOFT BROWN COAL		Brown coal					
					53	35	0.3	4000
BROWN COAL	HARD BROWN COAL	Dull	Lignite					
				71	49	25		5500
BROWN COAL	HARD BROWN COAL	Bright	Sub-bituminous coal					
				77	42	10	0.5	7000
HARD COAL	BITUMINOUS HARD COAL	Low rank	Bituminous coal: High volatile Medium volatile					
				87	29		1.1	8650
HARD COAL	BITUMINOUS HARD COAL	High rank	Bituminous coal: Low volatile Semi-anthracite					
				91	8		2.5	8650
HARD COAL	ANTHRACITE		Anthracite Meta-anthracite					
				100	0	0	11.0	

* American Society for Testing and Materials.
† As % of dry ash-free weight.
‡ Vitrinite reflectance (see Section 5.6.2).
§ Ash-free value.

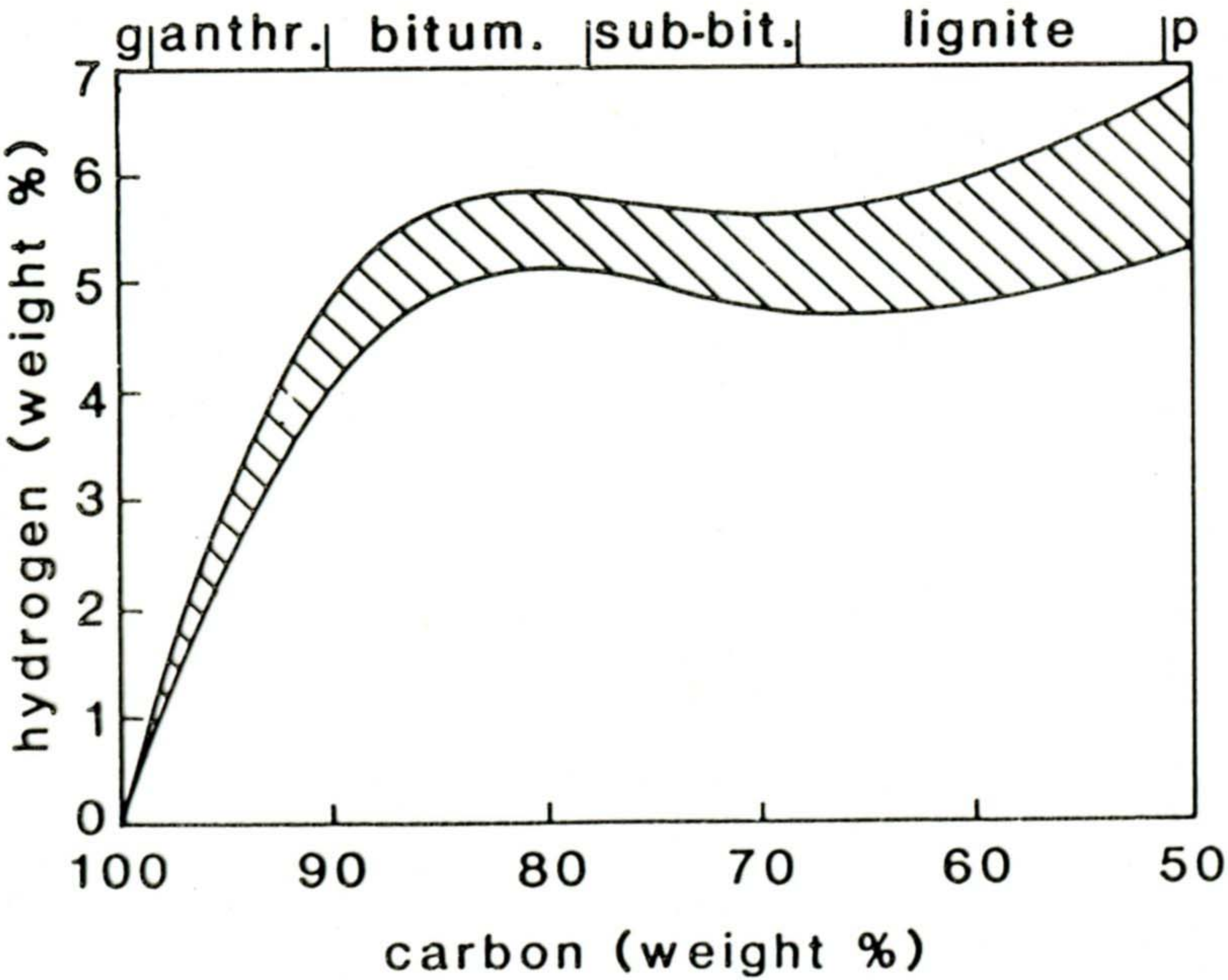


Fig. 8.1 Graph showing broad relationship between

Table 4.3 **Coal maceral groups**

Maceral groups	*Macerals*	*General properties*
Vitrinite	Telinite Collinite	Angular to subangular particles, sometimes show cell structure. Moderate transmittance. Fluorescence usually absent. Intermediate reflectance.
Inertinite	Micrinite Sclerotinite Semi-fusinite Fusinite	Angular, often cellular outline or granular texture. Opaque in transmitted light. No fluorescence. High reflectance.
Exinite	Alginite Sporinite Cutinite Suberinite Resinite Cerinite	Characteristic shape, e.g. algae, resins, spores. High transmittance. Intense fluorescence (at low maturity). Relatively low reflectance.

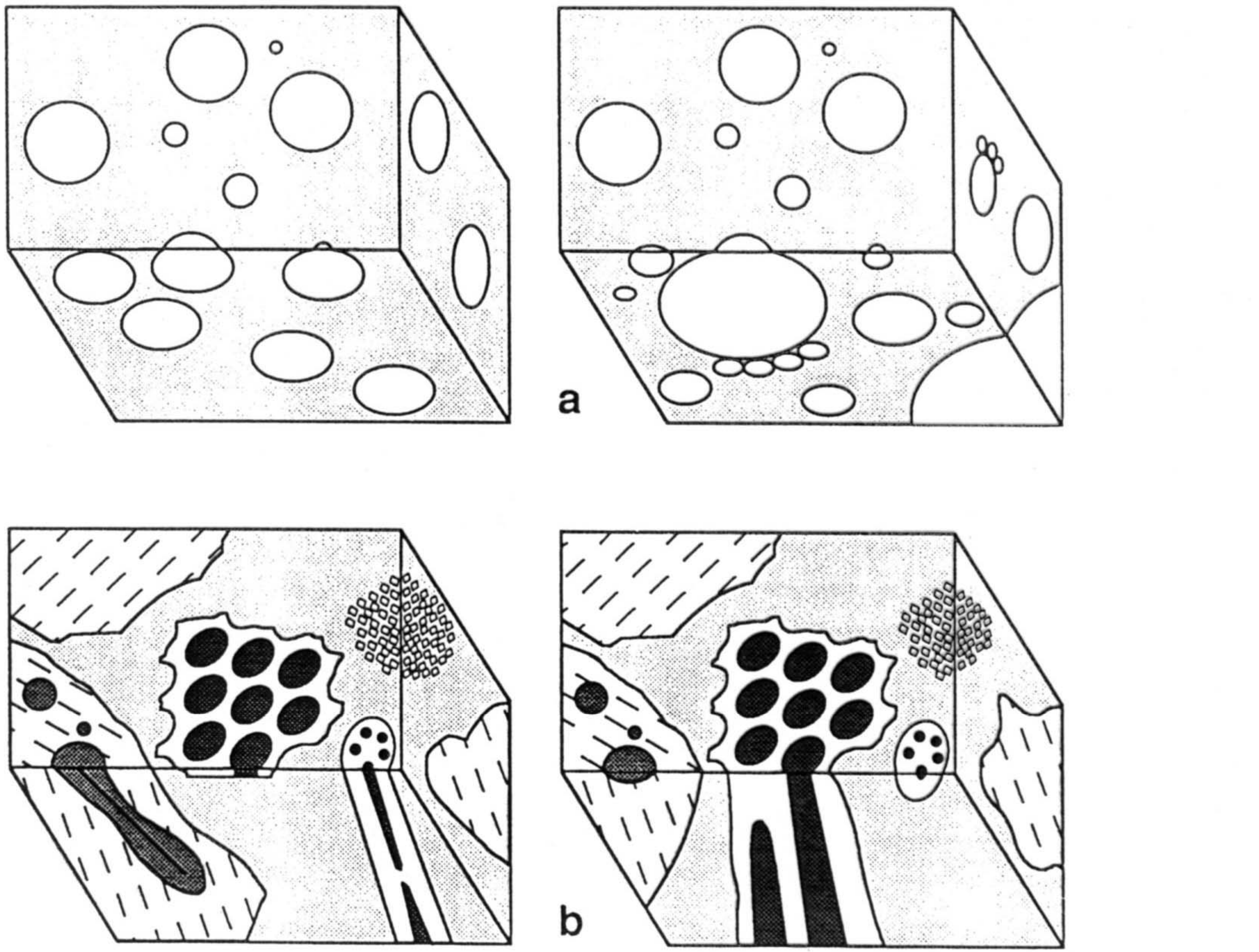
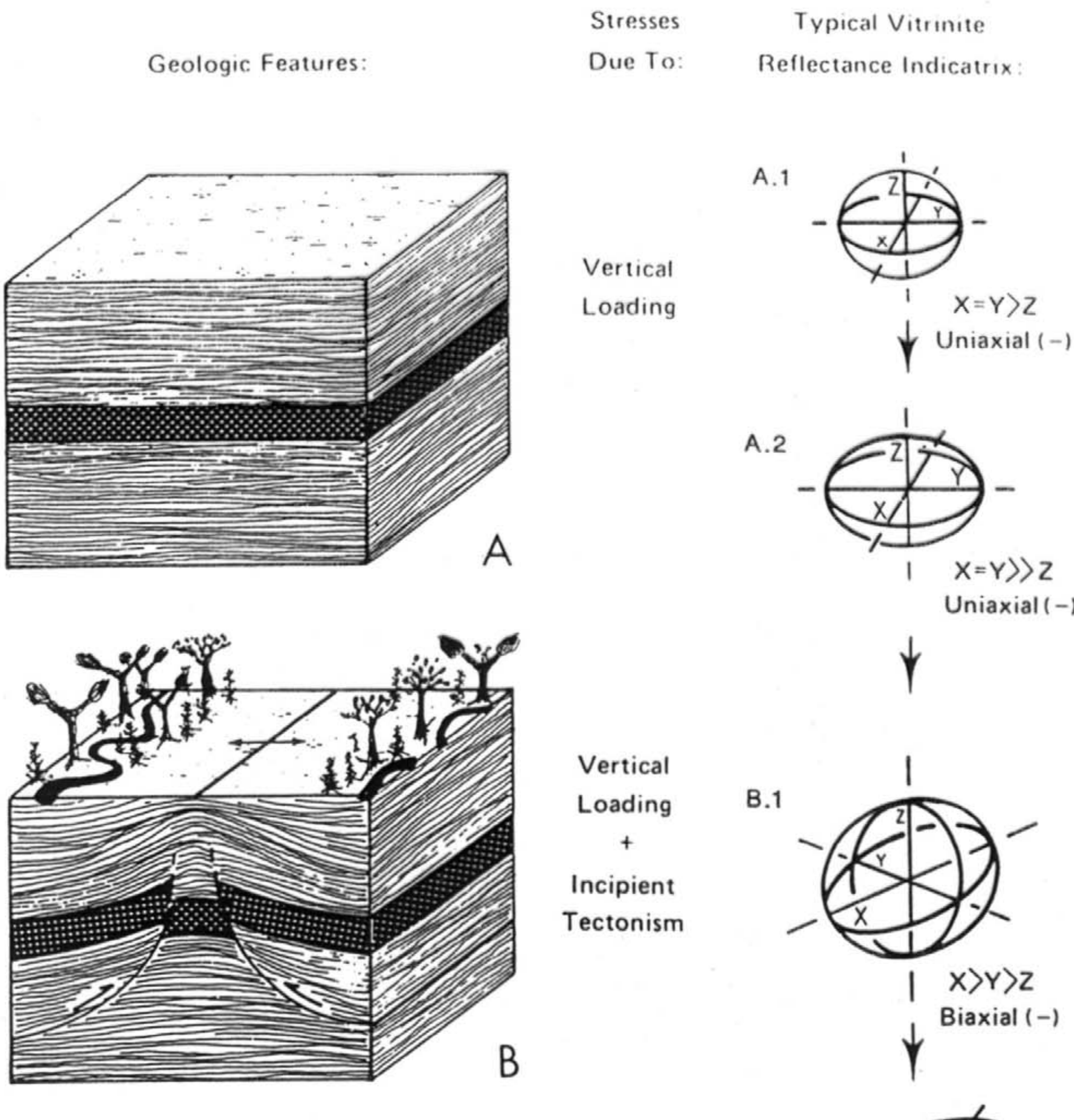


Fig. 7.33. The stereological problem: a) circles of varying diameters on the observed section (top surface) may arise from spheres of one size or a variety of sizes; b) the exact size and morphology of an individual particle in three dimensions cannot be determined from observation of a two- dimensional cross section.


Geologic Features:
Stresses Due To:
Typical Vitrinite Reflectance Indicatrix:
A
Vertical Loading
A.1
Z
Y
X
X=Y>Z
Uniaxial (–)
A.2
Z
Y
X
X=Y>>Z
Uniaxial (–)
B
Vertical Loading + Incipient Tectonism
B.1
Z
Y
X
X>Y>Z
Biaxial (–)

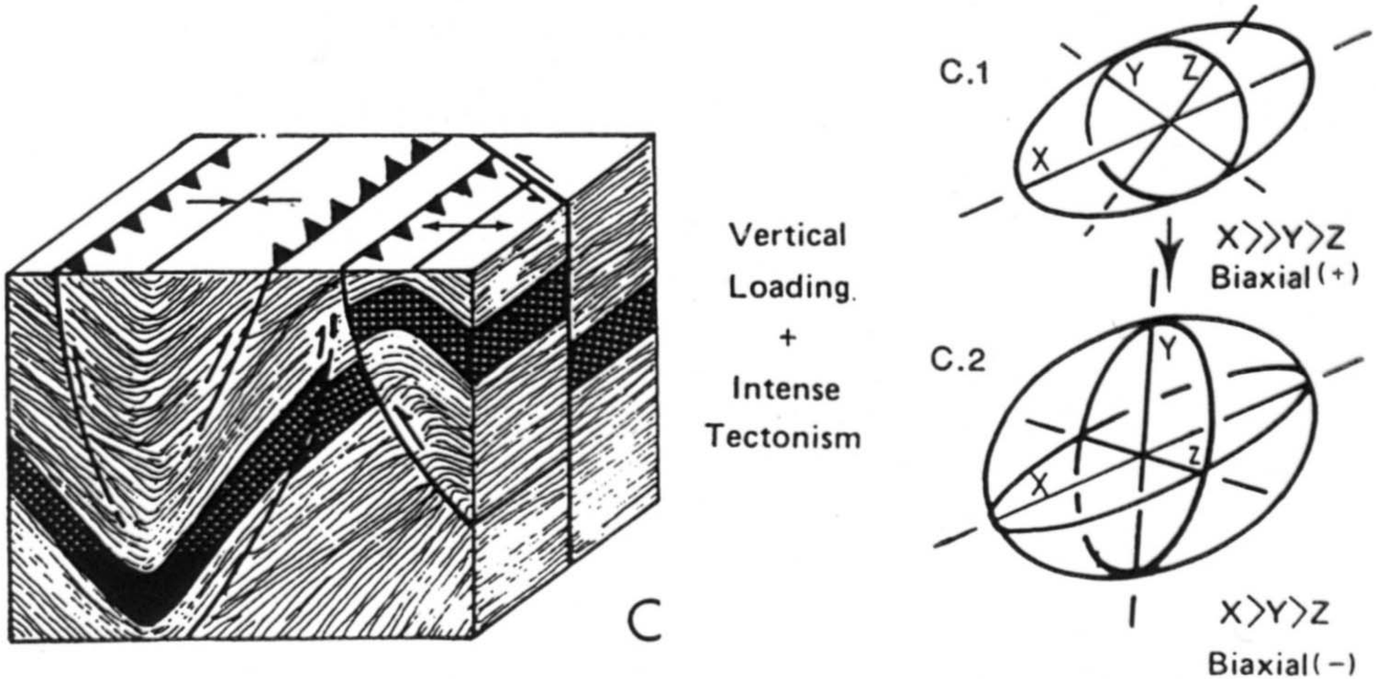
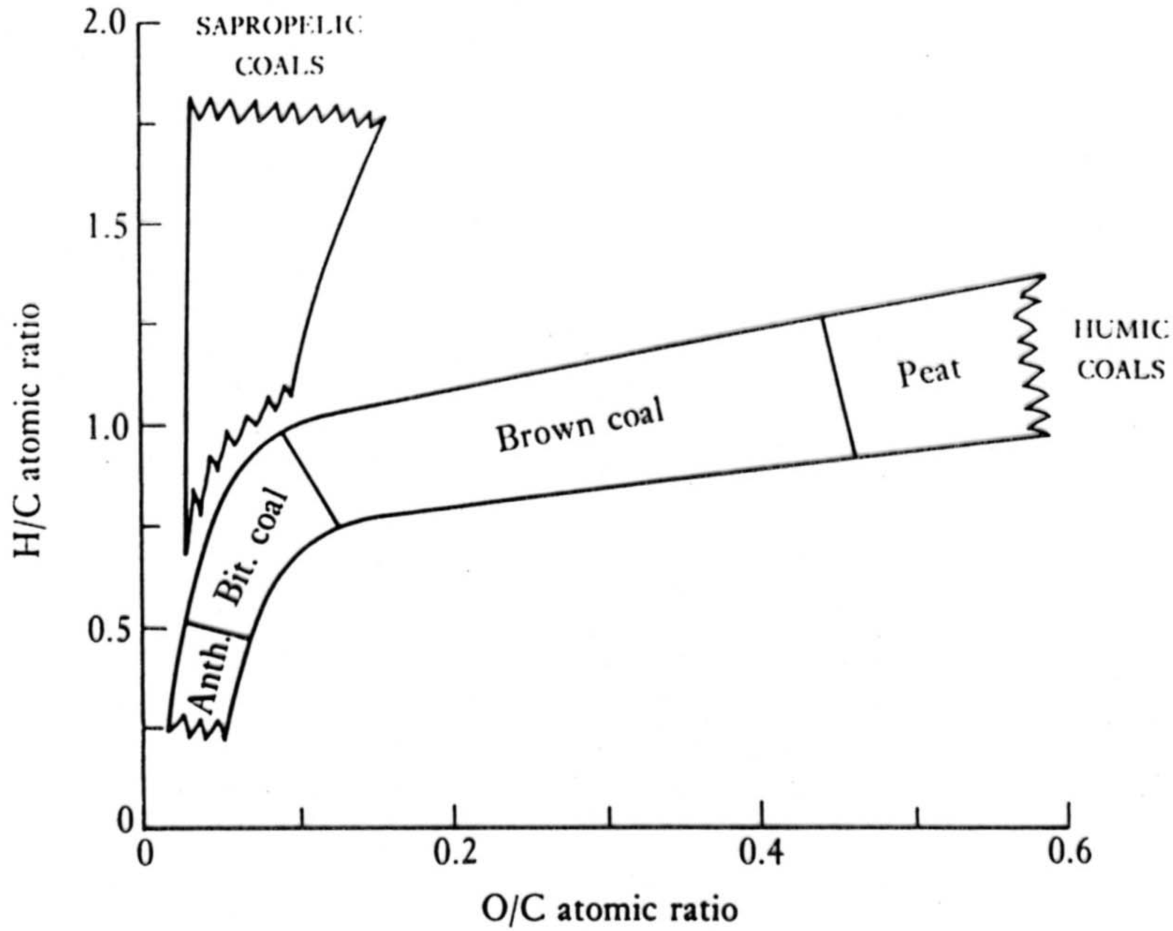
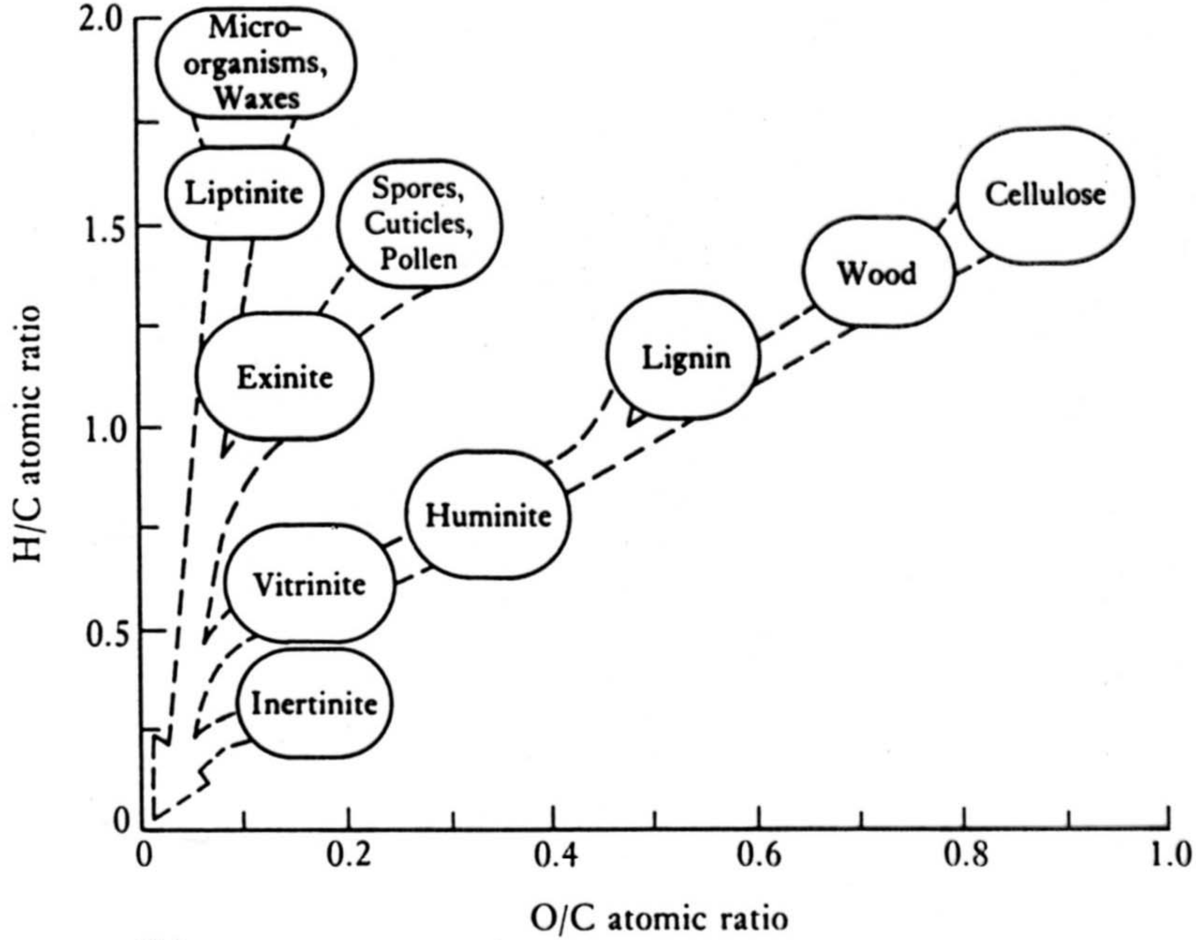


Fig. 8.18. The geometric form of vitrinite reflectance indicatrices (VRIs) is characteristic of the rank attained and the tectonic setting in which they developed, assuming that coalification was at least partly syntectonic. A. Uniaxial negative VRIs (A.1, A.2) are indicative of coalification in tectonically undeformed subsiding basins. B. Biaxial negative VRIs with R_{min} axes near vertical (B.1) are indicative of mild tectonic deformation. C. Biaxial positive VRIs (C.1) indicate tectonic "constriction" and are found in strongly deformed terrains. Strong tectonic oppression may also produce biaxial negative VRIs (C.2). Uniaxial positive VRIs are an unusual transitional form. X represents R_{max}, Y represents R_{int} and Z represents R_{min}. X, Y and Z increase in magnitude with increasing coal rank. (From Levine & Davis, [illegible]b).


SAPROPELIC COALS
HUMIC COALS
Peat
Brown coal
Bit. coal
Anth.
H/C atomic ratio
O/C atomic ratio
2.0
1.5
1.0
0.5
0
0.2
0.4
0.6

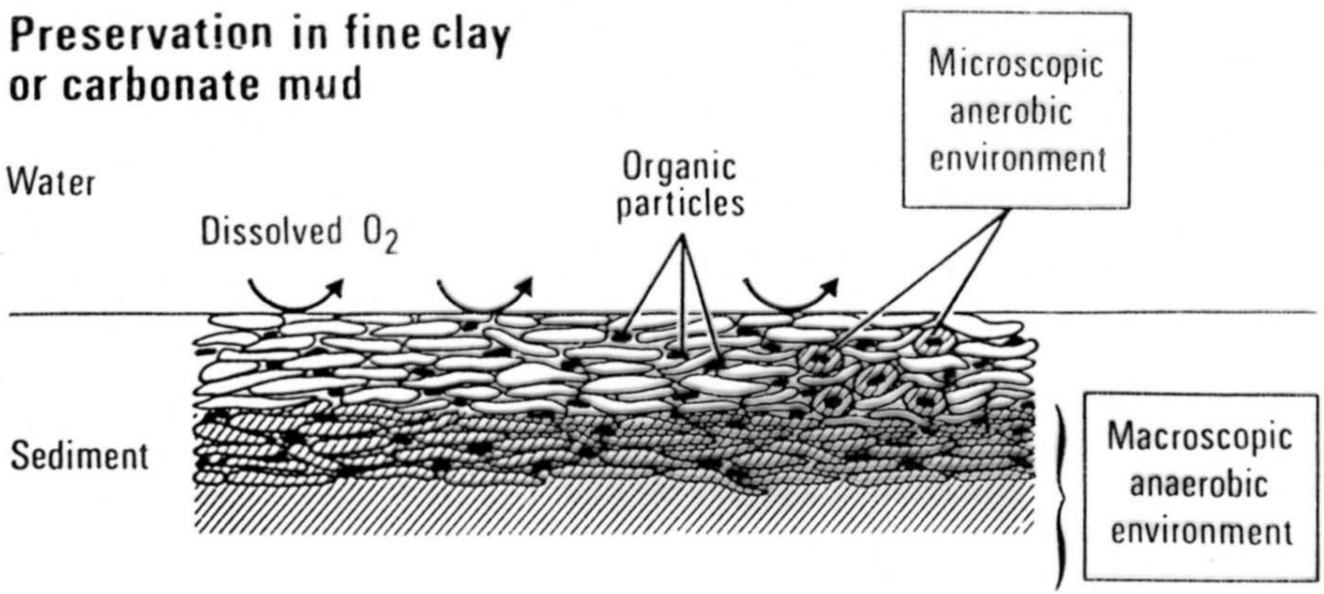
(a)



(b)

Figure 4.2 (a) Van Krevelen diagram showing the main evolutionary trends of sapropelic (cannel and boghead) and humic coals. Four stages are denoted for humic coals, in order of increasing rank: peat, brown coal, bituminous hard coal and anthracite. (b) Van Krevelen diagram showing the position of the main coal macerals and their diagenetic, evolutionary relationships to various components in living organisms (see Section 4.4.2 for an explanation of liptinite).

černé břidlice



Destruction in a porous sediment deposited under aerobic conditions

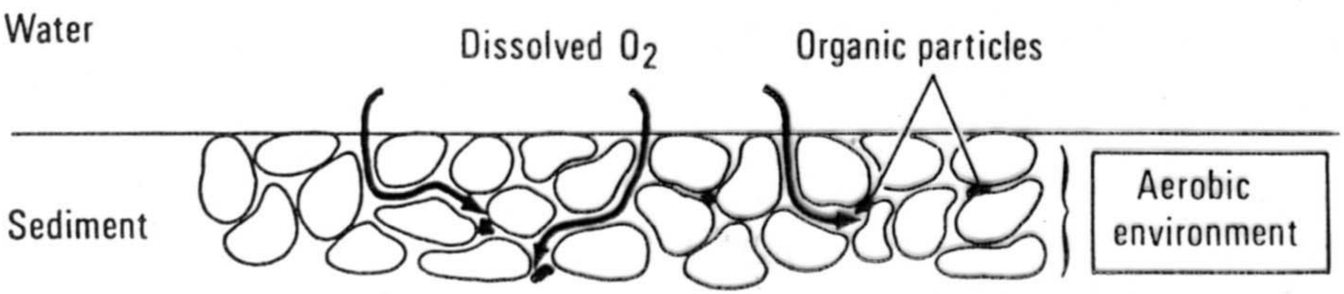


Fig. II.2.1. Preservation or destruction of the organic matter in a freshly deposited sediment. In a fine clay or carbonate mud *(top)*, pore water becomes a nearly closed microenvironment. There is no replenishment of oxygen, and anaerobic conditions are rapidly established, first on microscopic, then on a macroscopic scale. In a porous sand deposited under aerobic conditions *(bottom)*, free circulation of water containing dissolved oxygen results in the destruction of the organic matter

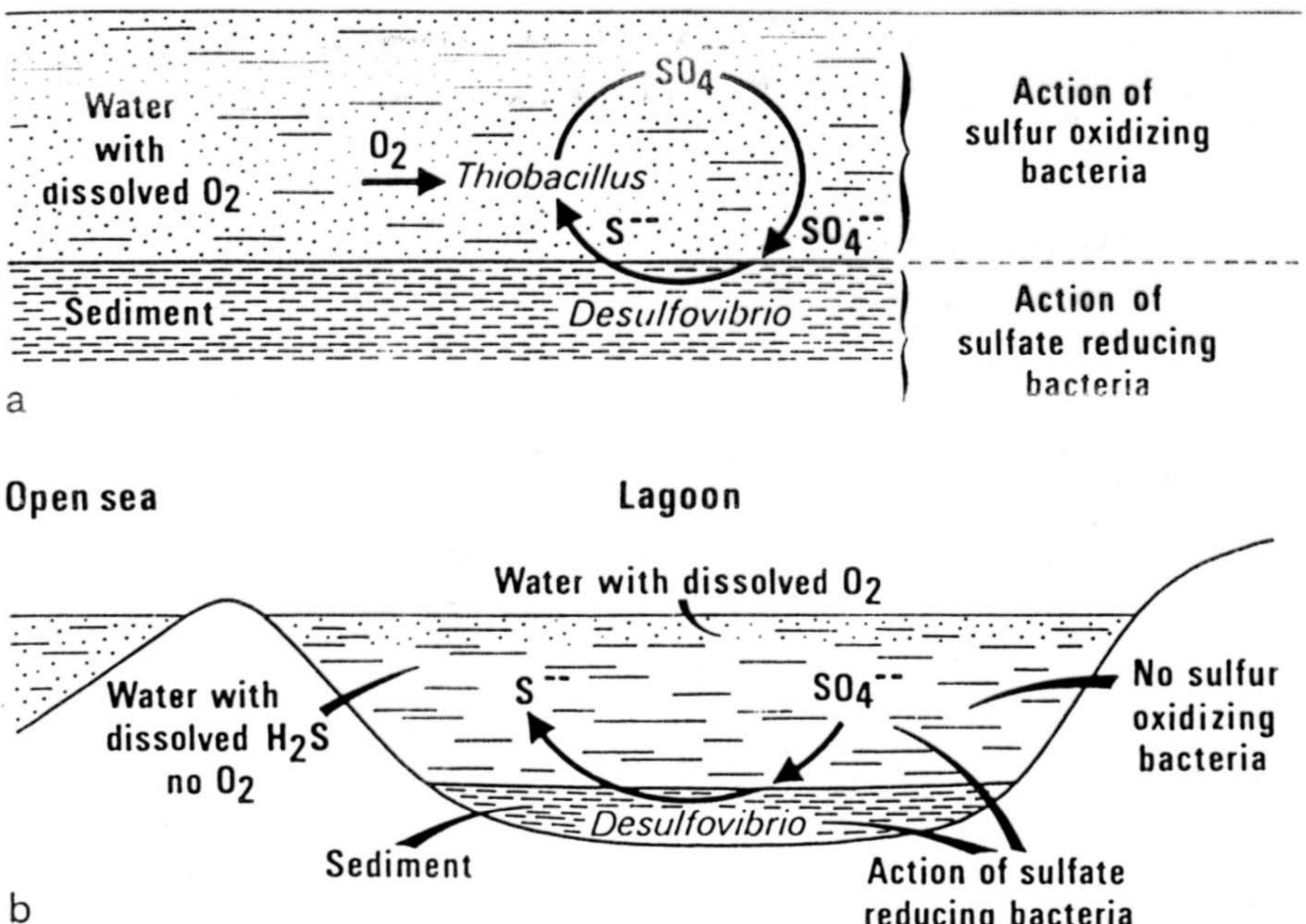


Fig. II.2.2 a and b. Formation and destruction of hydrogen sulfide in sediments and bottom waters. (a) Open sea conditions: there is an equilibrium between formation and destruction of hydrogen sulfide. (b) Restricted water circulation: no dissolved oxygen in bottom waters. This results in the absence of aerobic sulfur-oxidizing bacteria. Thus, there is no destruction of hydrogen sulfide in bottom waters, which are anoxic and contain H_2S

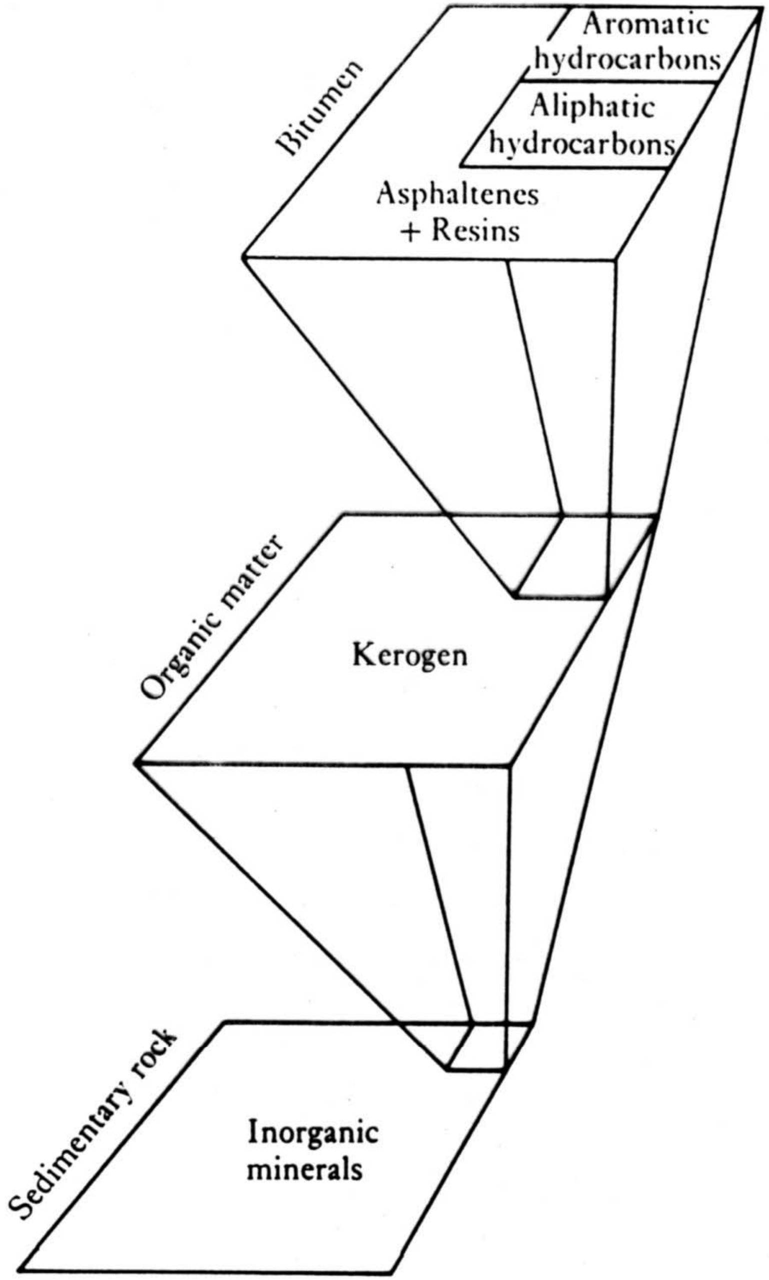
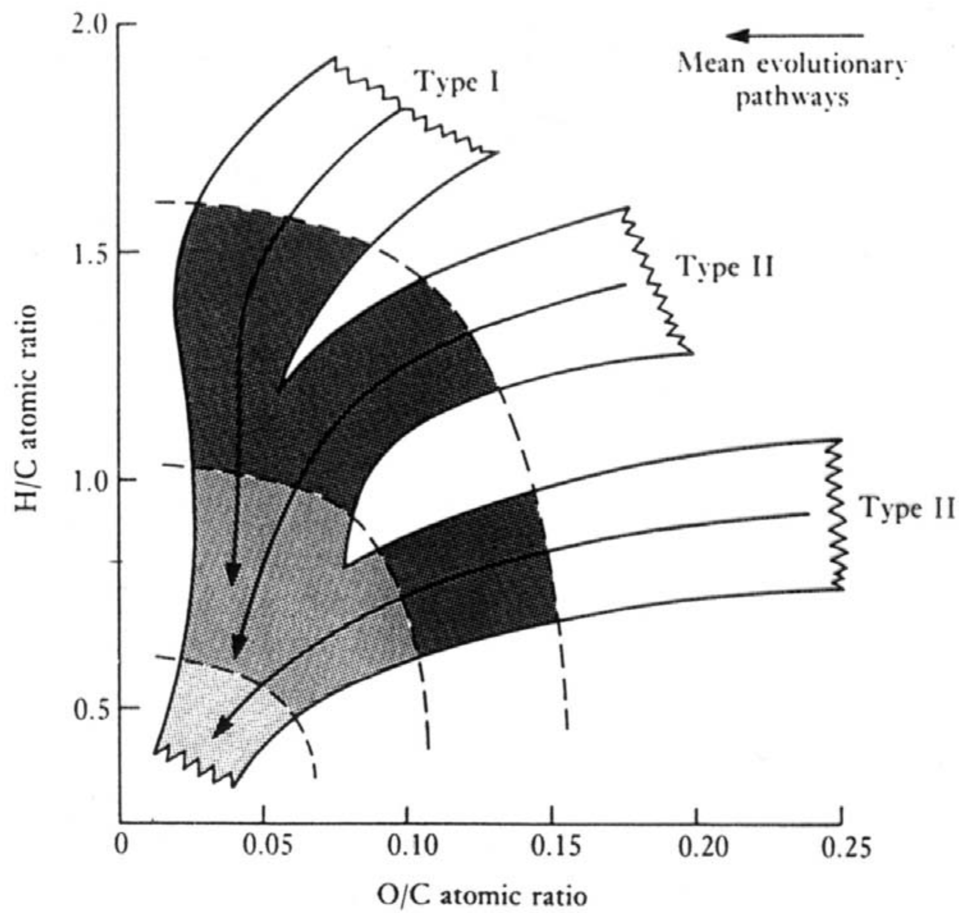


Figure 4.5 Composition of disseminated organic matter in sedimentary rocks. (After Tissot and Welte, 1984.)



Fluids evolved	Zone	Stage
Carbon dioxide and water	Immature	Diagenesis
Liquid hydrocarbons	Oil	Catagenesis
Gaseous hydrocarbons (C_1–C_4)	Wet gas (condensate)	
Methane	Dry gas	Metagenesis

Figure 4.10 Van Krevelen diagram showing the evolution paths of the three hydrocarbon-generating types of kerogen and the main fluids evolved at different stages of maturity (N.B. not all type III kerogens generate oil). (After Durand, 1980.)

ropa, plyn/
tekuté uhlovodíky

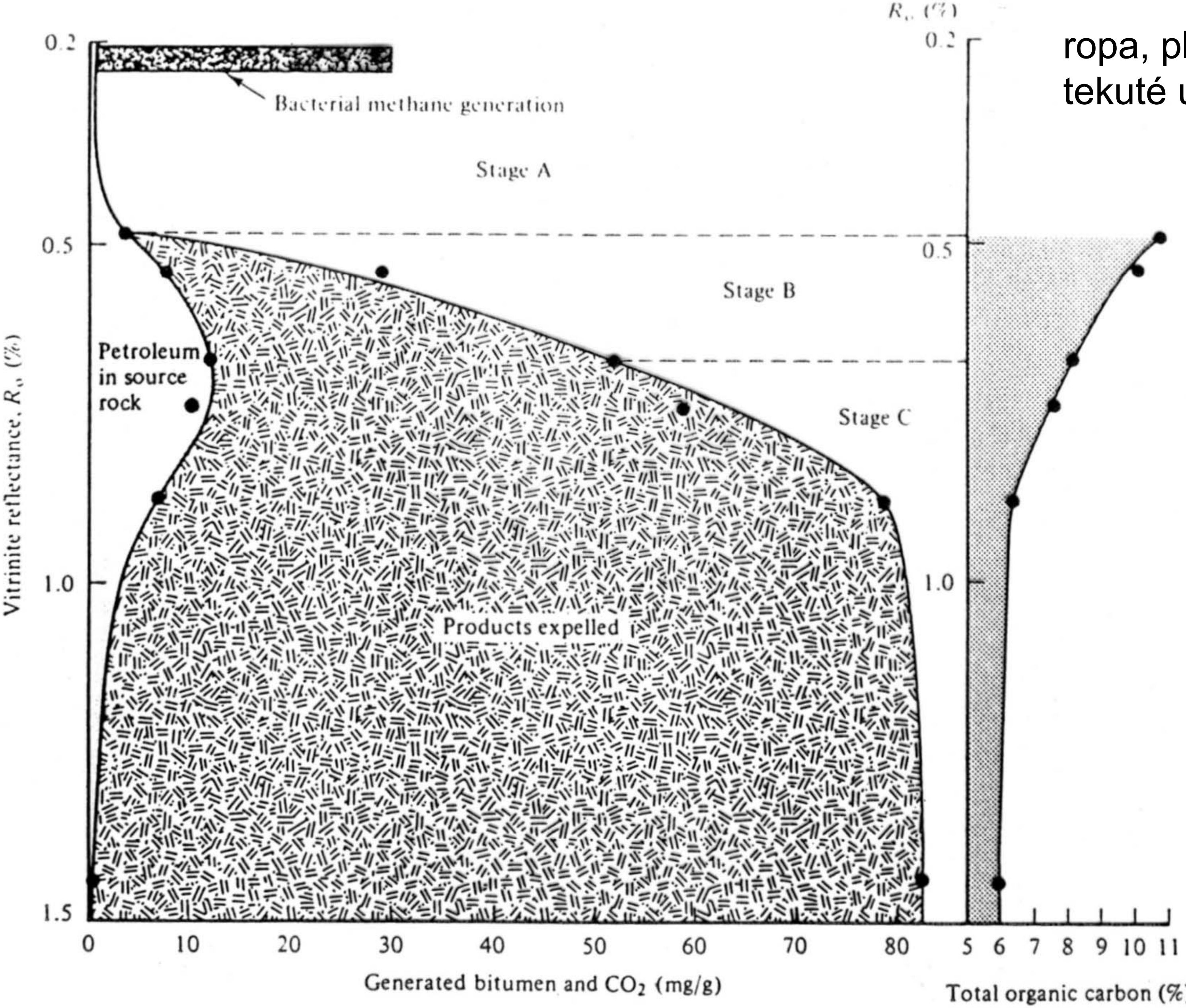


Fig. 4.36. Mass balance of petroleum generation and expulsion in the Posidonia Shale, northern Germany. (After Littke & Welte, 1992).

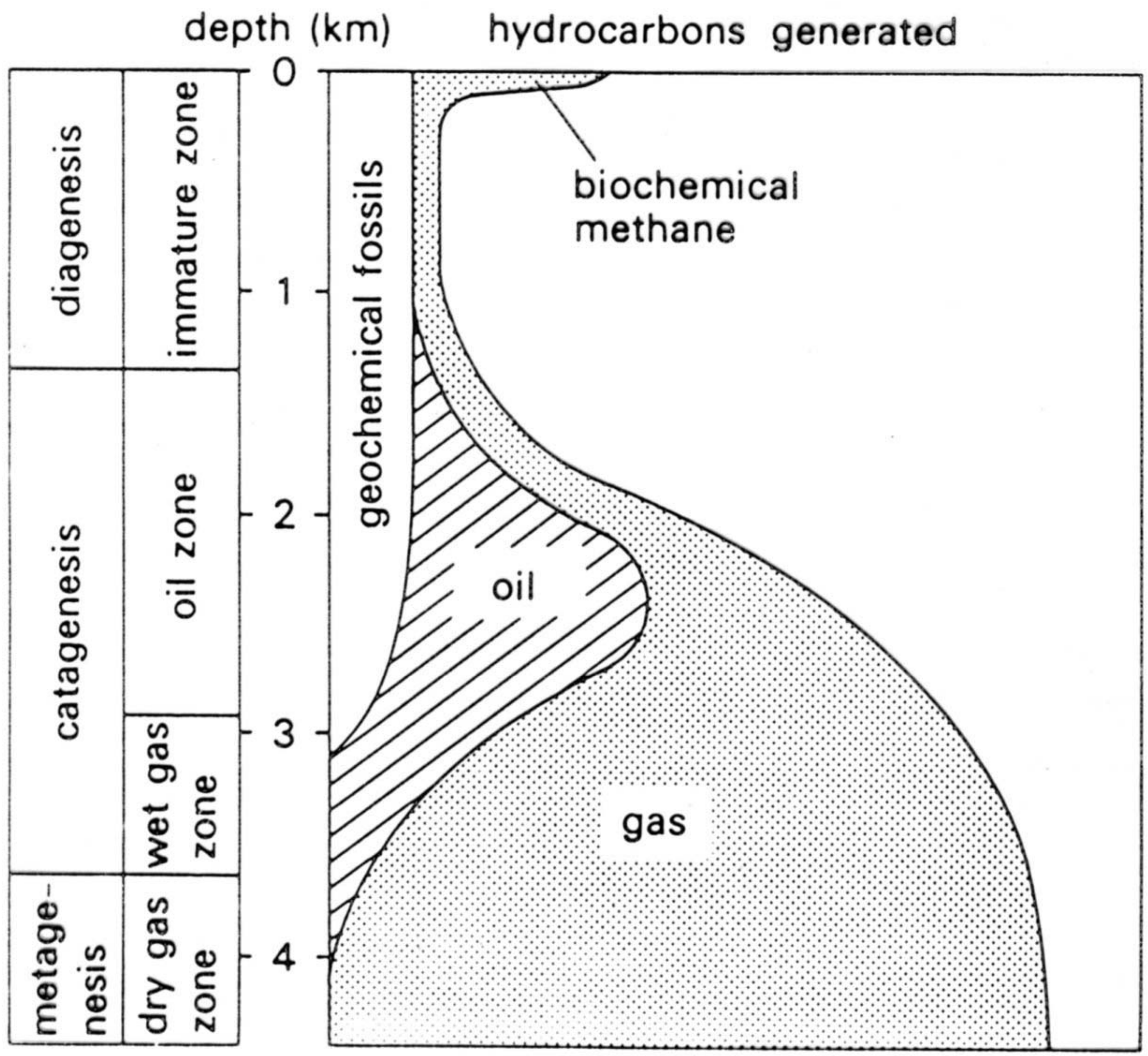


Fig. 8.8 Hydrocarbon generation with depth from organic matter, mainly kerogen contained in sediments. The precise depth at which hydrocarbons are evolved depends on the geothermal gradient, the burial history, and type of kerogen present. After Tissot & Welte (1984).

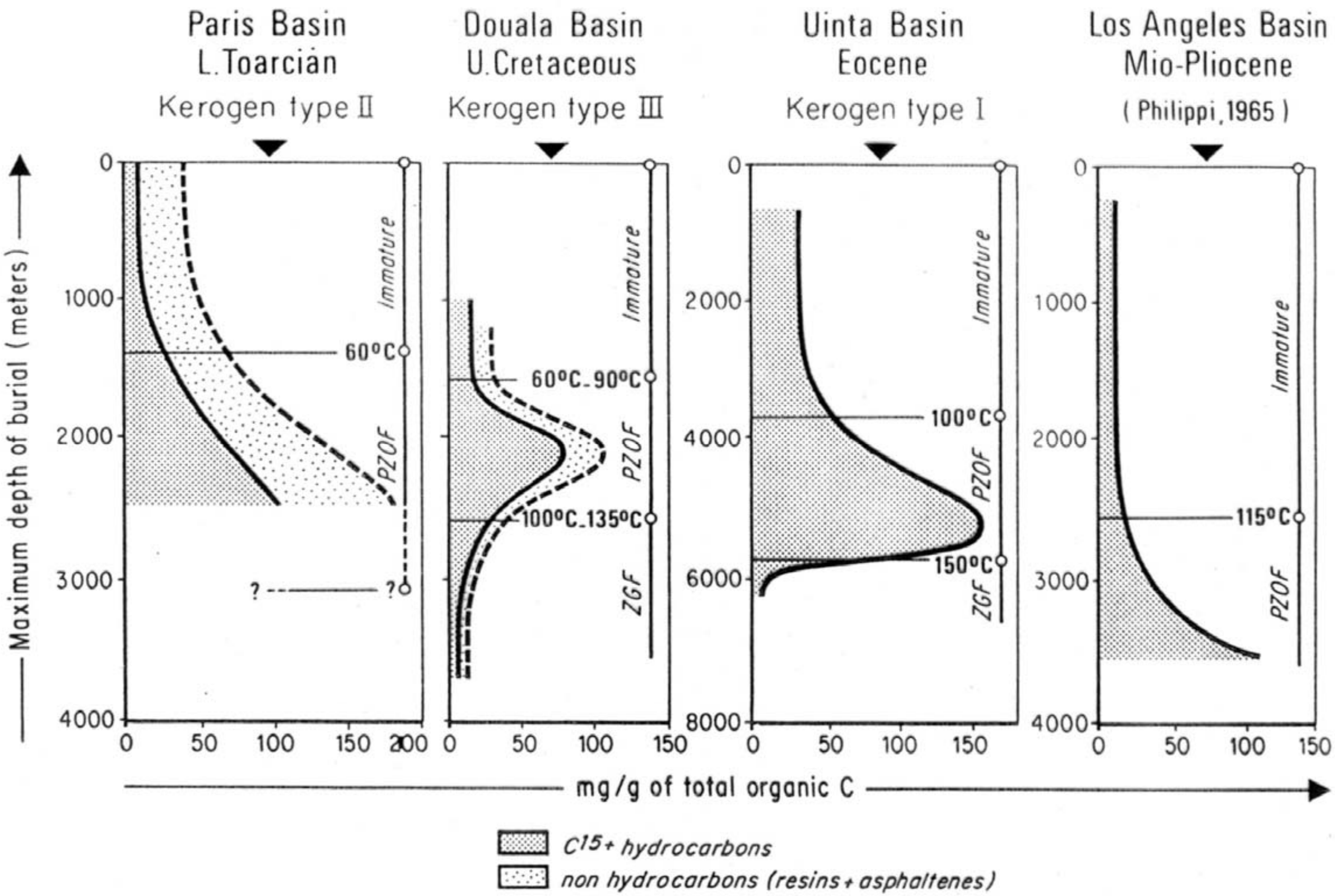


Fig. II.5.12. Formation of hydrocarbons and nonhydrocarbons (resins and asphaltenes containing N, S, O) as a function of burial depth, in different basins (cf. also Fig. II.5.11). The major steps of evolution of the organic matter are marked: "immature", "PZOF" (principal zone of oil formation), and "ZGF" (zone of gas formation by cracking). Corresponding temperatures are shown according to present geothermal gradients. In the Douala Basin, the first temperature is the present one the second temperature is a calculated paleotemperature according to Tissot and Espitalié (1975)

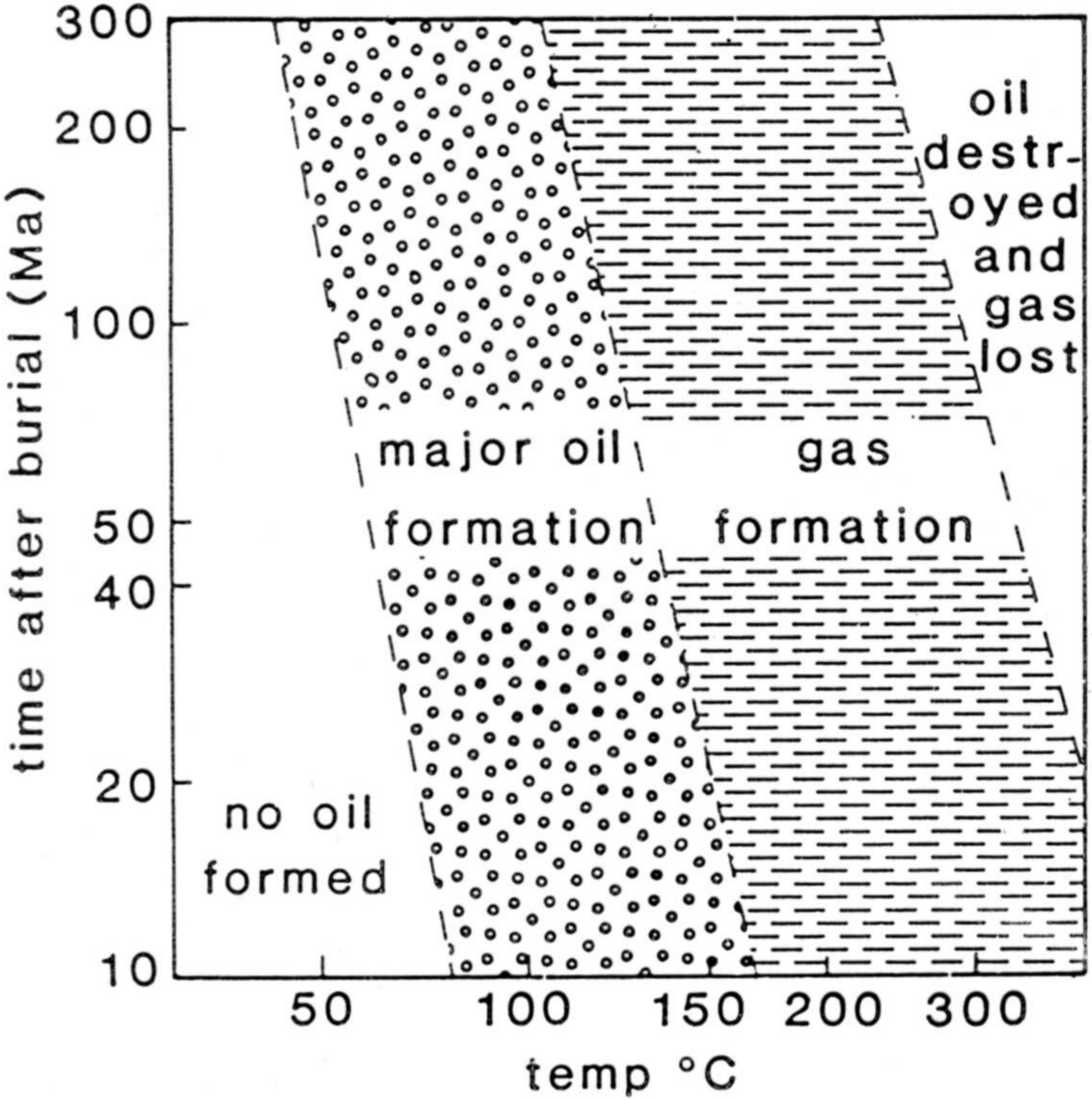


Fig. 8.9 Schematic representation of the relationship between time after burial of source rocks and the temperatures for oil and gas generation.

diageneze

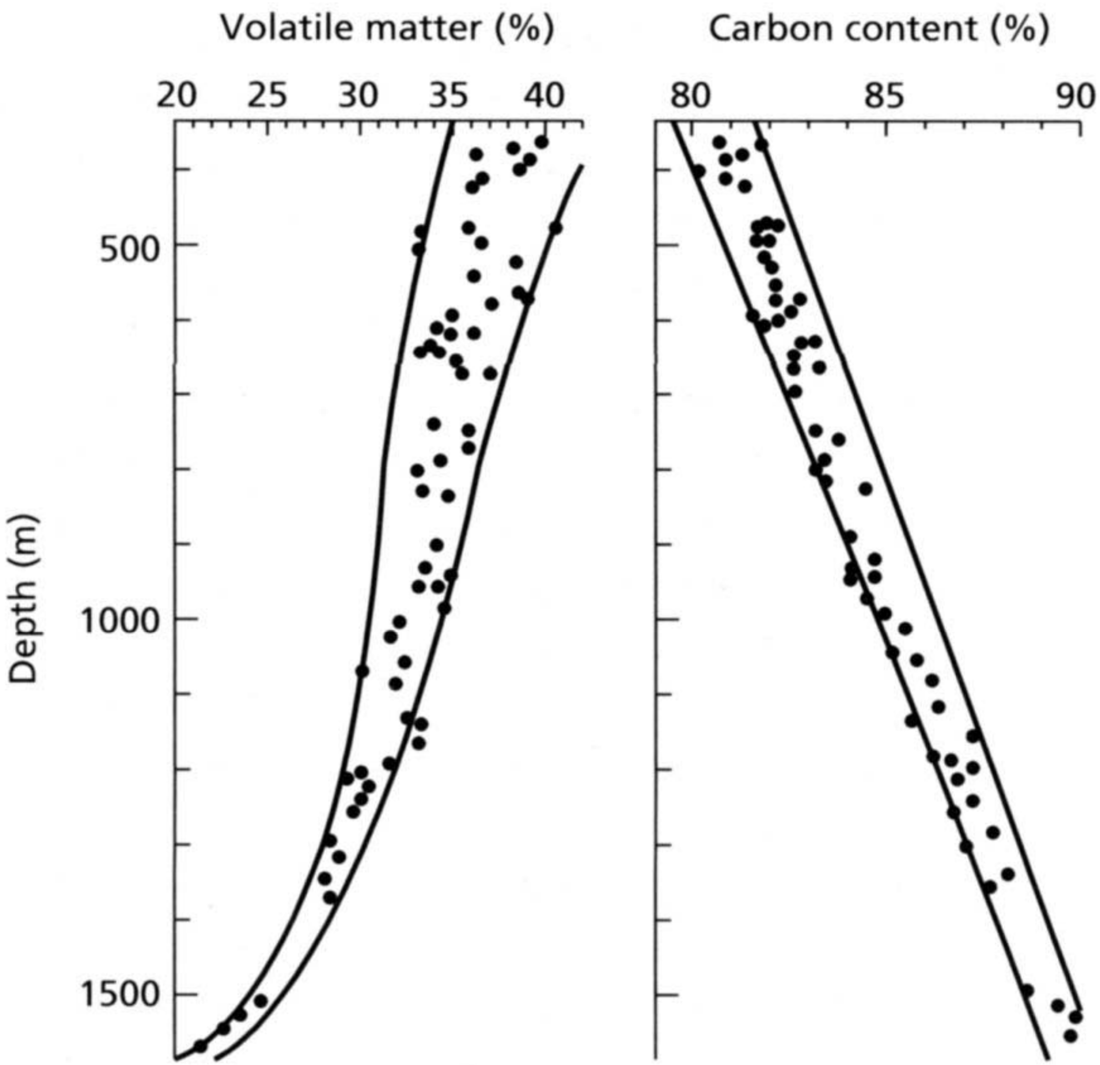


Fig. 8.4 An example from the Carboniferous Westphalian Coal Measures of Germany of the increase in coal rank with depth, on the basis of volatile matter and carbon contents (both dry-ash free). After Teichmuller (1987).

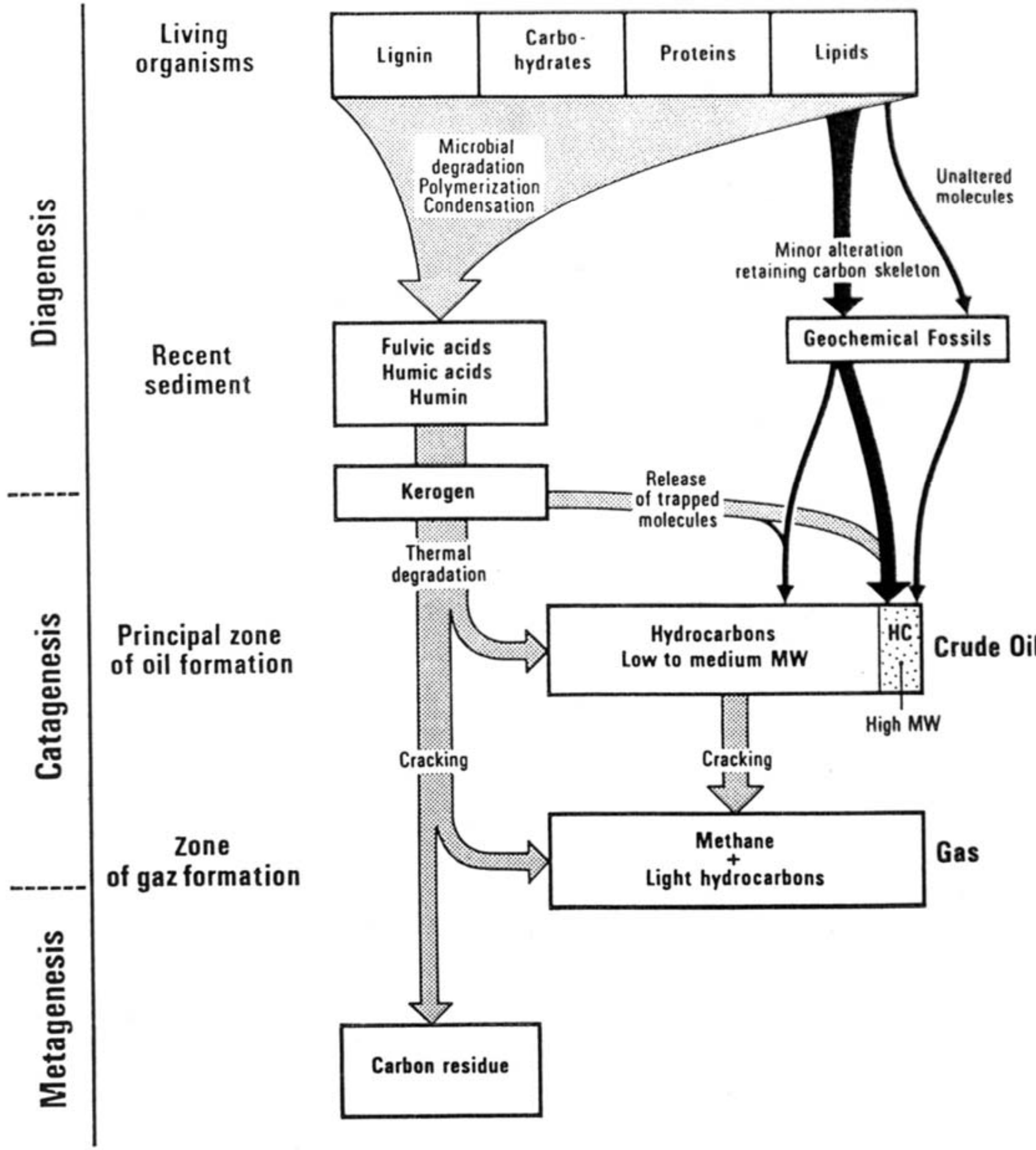


Fig. II.3.1. Sources of hydrocarbons in geological situations, with regard to the evolution of organic matter. Geochemical fossils represent a first source of hydrocarbons in the subsurface *(black solid arrows)*. Degradation of kerogen represents a second source of hydrocarbons *(grey dotted arrows)*

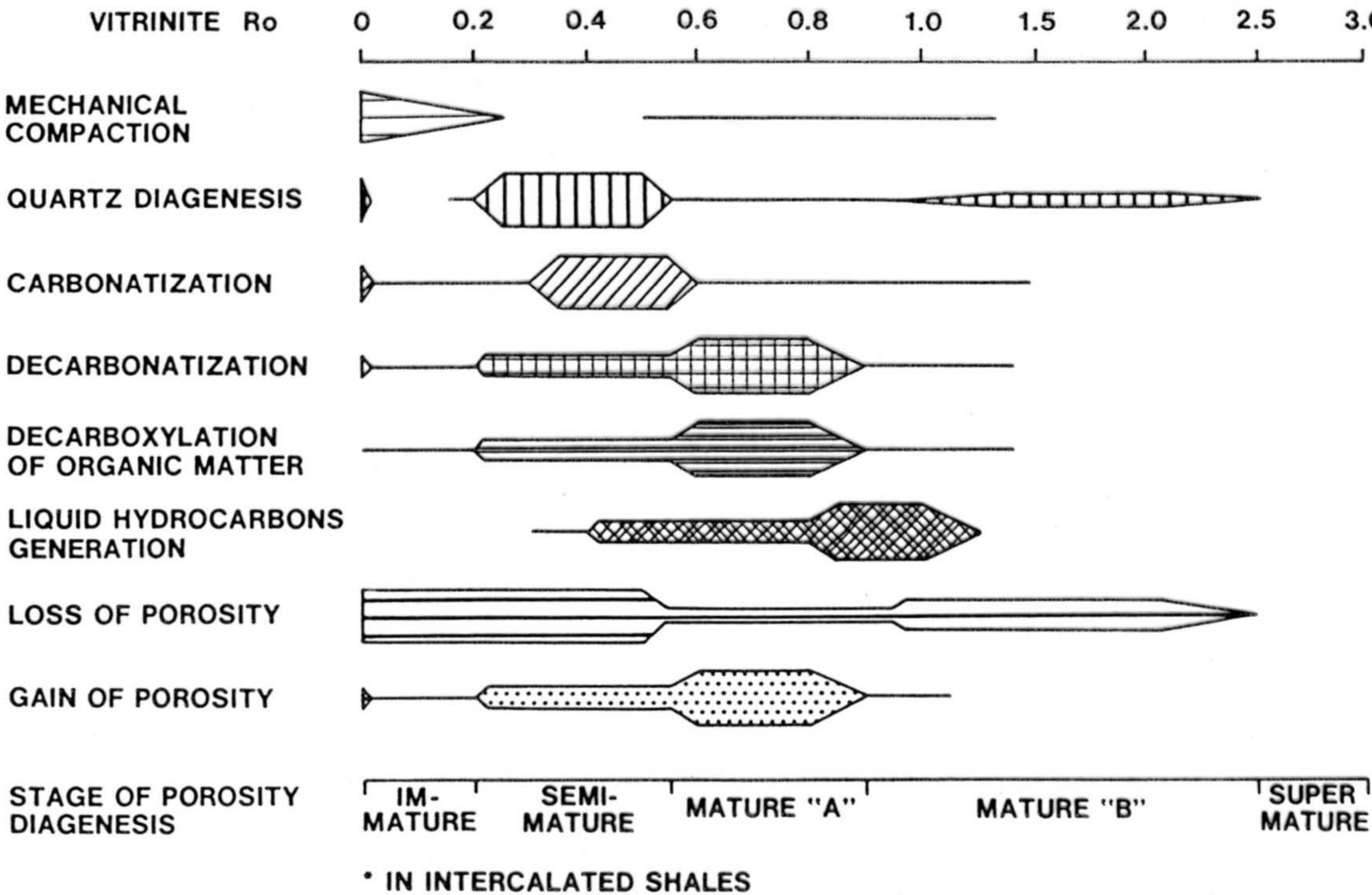


Fig. 8.5. Burial diagenesis of quartz arenites. (From Schmidt & McDonald, 1979).

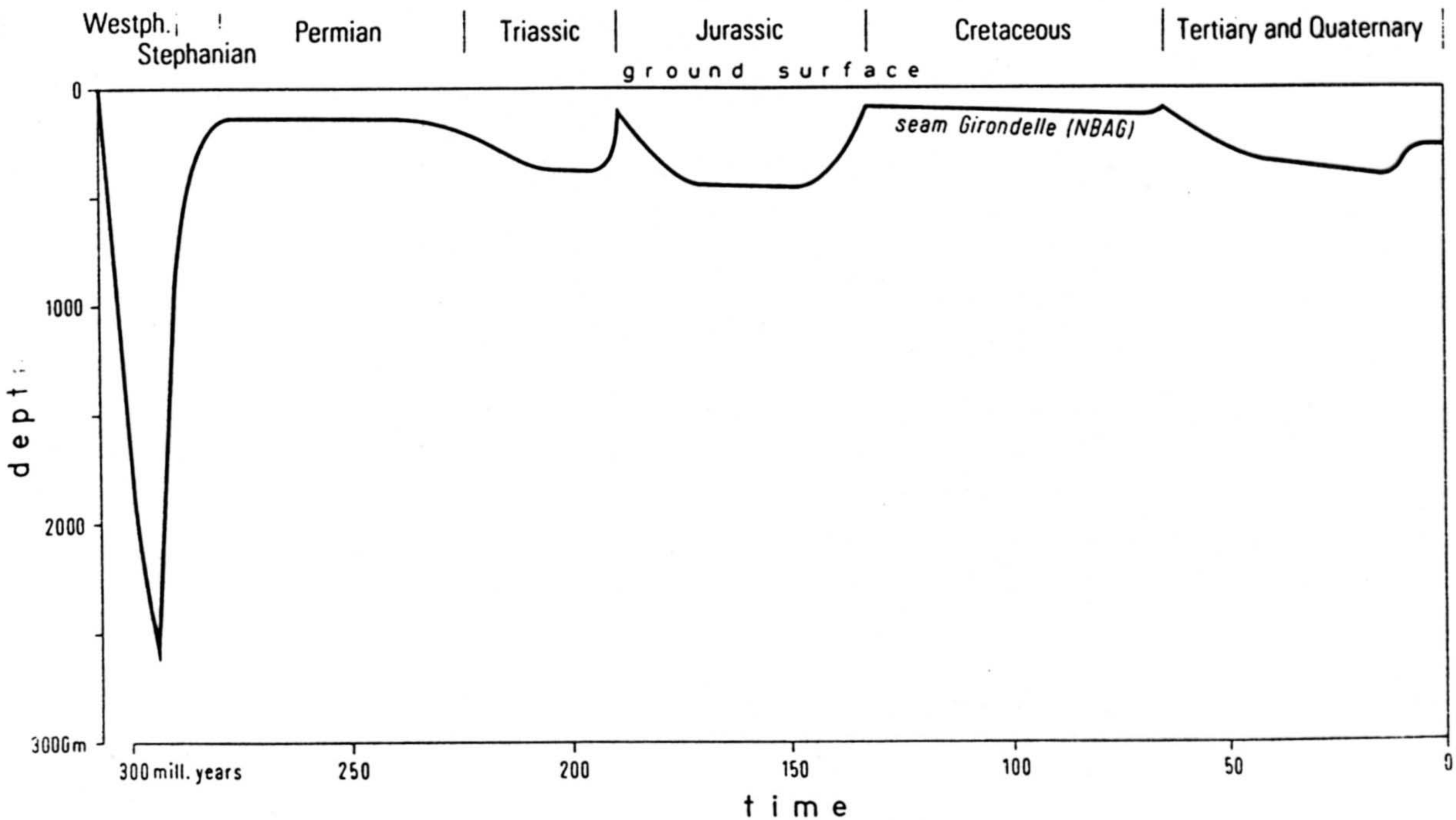


Fig. 8.26. Burial history of a seam (Girondelle) in the Westphalian A of the Lower Rhine Basin. (After Teichmüller & Teichmüller, 1986).

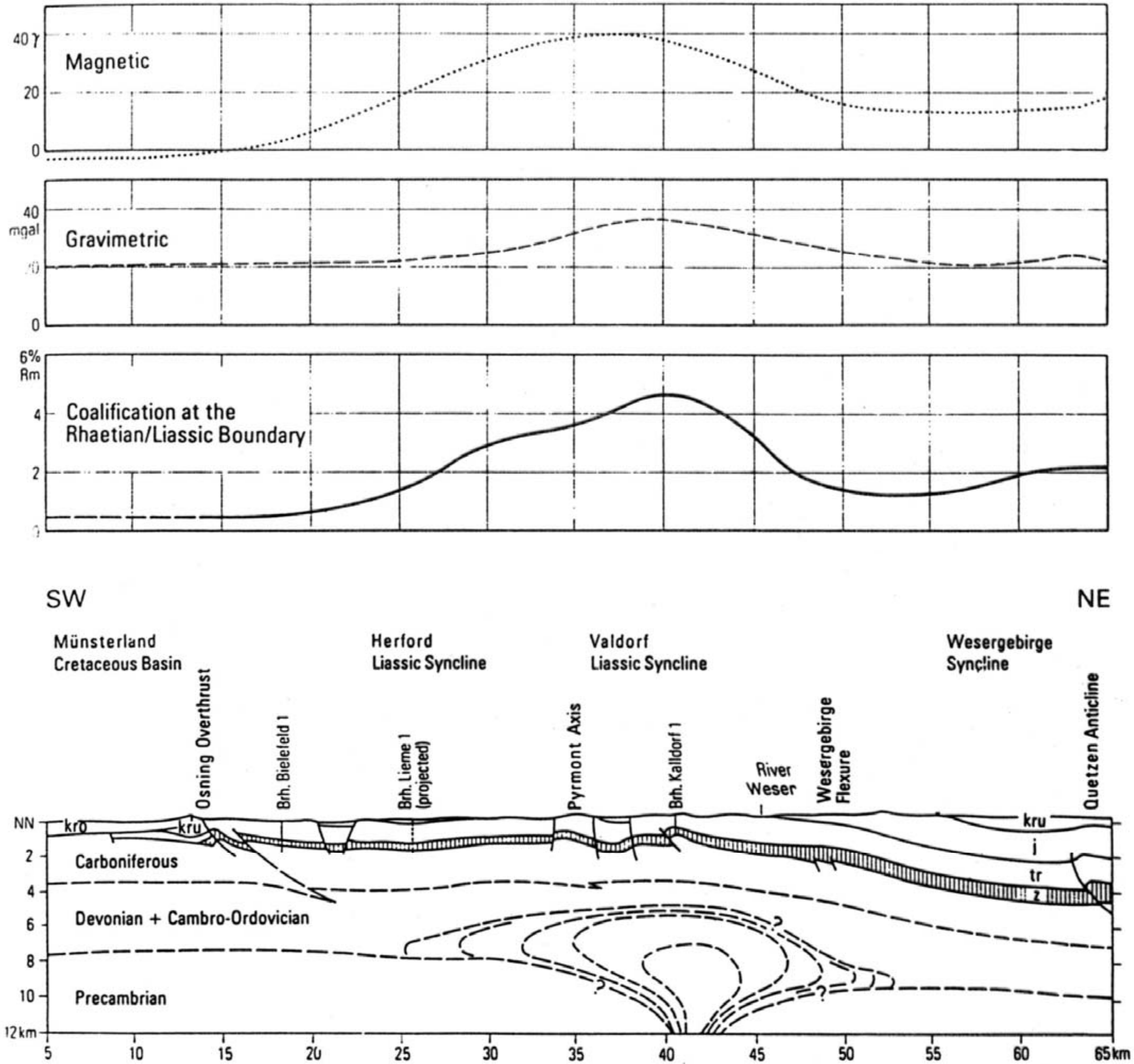


Fig. 8.27. Section across the Vlotho Massif on the basis of magnetics, gravimetry and vitrinite reflectance. (After Deutloff et al., 1980).

čtení:

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