

THE PERIODICITY OF GEOTECTONIC STAGES AND COAL GENERATION

PERIODICITA GEOTEKTONICKÝCH ETAP A VZNIK UHLÍ

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Abstract

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The study of the process of coal sequence generation and coalified organic matter accumulation in sediments in relation to large time cycles is described. Derivation of cycles from geotectonic stages (of some 220 million years) is made. The periodicity of geotectonic stages and their hierarchy and phases of development make it possible to consider major cycles of coal genesis. The duration of the main coal genesis period might have been some 40 million years, starting with the end of the third quarter of the geotectonic stage and coming to an end at about the middle of the fourth quarter.

Key words: periodicity, coal, generation

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Introduction

The contribution presented here deals with large cycles showing up in the course of coal generation and the accumulation of coalified organic matter in sediments. It is considered that these large-scale cycles are caused by geotectonic stages and phases, as defined below. Reflections on this subject were presented, for the first time, at a course dealing with coal generation which was held by the Faculty of Natural Sciences of Charles University, Prague, in March 1994.

Initial geological hypotheses

It was the application of synergetics to hierarchical systems (MESAROVIC 1973) and periodicity that induced the development of system approaches using a four-dimensional (time-and-space-related) model of the Earth (KVĚT 1991a). The period of the galactic year is the most significant cycle affecting the Earth's development. The author has shown that our galaxy's supersystem, the Milky Way, affects the solar system that revolves round the centre of the galaxy in intervals of 220 million years.

A period of some 220 million years, according to the interval of the global glaciation of the Earth, had been identified for the duration of a geotectonic cycle and, thus, for that of a galactic year, which resulted in a new conception of periodicity in the geological time table (KVĚT 1991b).

The Earth's subsystem is influenced, in its endogenous development, by a superior supersystem from the distant outer space (Milky Way). The system of the nearer space (the solar system) governs the exogenous development of the Earth in intervals of annual

and diurnal periods (depending on the Earth's travel round the Sun and the Earth's rotation round its axis).

The time interval of 220 million years derived in this manner allowed the author to define geotectonic stages and, in addition, subsystem-related time intervals: phases of geotectonic stages. The 2^n model holds for both of the above cycles. In the case of geotectonic stages multiples of 2^n and in that of phases of geotectonic stages, fractions, i.e. $1/2^n$ (Fig. 1 and Tab. 1) (KvĚT 1992).

Subsequently, a periodic time table has been derived determining the hierarchy of distinct geotectonic stages in compliance with the 2^n model (Fig. 2). The pregeological stage (formation of the Earth) and the Prikamean stage (breaking of the Earth's crust into blocks) are the most significant stages of the first order. Stages of the third order include the Variscan/Hercynian stage which led STILLE (1953) to describe the appearance of Europe as Hercynian. The time sequence of various geologic events (after GRECULA 1982) was modified by the author using experience gained from the division of geotectonic phases. In four phases of a geotectonic stage (of 3rd order) characteristic phenomena have been confirmed (in Czechoslovak territory): rifting in the 1st and 2nd quarter, folding in the 3rd quarter and, in the 4th quarter of the geotectonic stage, the following phases of different duration can be defined: the first of 6th order with a tectonic hiatus and thermometamorphosis, the second of 7th order with folding and secondary foliation, the third also of 7th order with initiating metamorphic flows and granitoid intrusions, the fourth phase of 4th order with the opening of ruptures and metallogenesis and the fifth (last) of 5th order with origin of nappes, retrograde metamorphosis and ore structures destruction and with the origin of a network of predispositions of the Planetary equidistant rupture systems (KvĚT 1987) (Fig. 3).

Initial biological hypotheses

Comparisons of animal evolution according to STARR (1991), together with previous data on the duration of geotectonic stages and their hierarchical phases has allowed assessment of any relationship between and/or extinction of new animal species on the one hand, and some phases and single geotectonic stages on the other (KvĚT 1992). Similar interrelations could be expected to exist in plant and plant community histories.

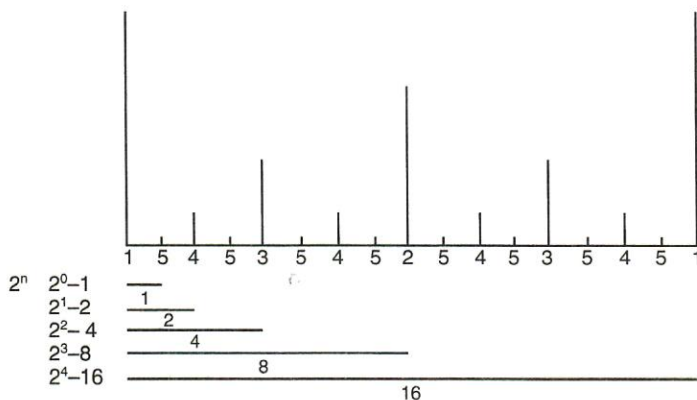


Fig. 1. Graphical demonstration of the mathematical 2^n model (first five levels).
Obr. 1. Grafické znázornění matematického modelu 2^n (prvých pět úrovní).

Table 1. Hierarchy of chronological division of geotectonic stage (KVĚT 1992).
Tab. 1. Hierarchie časového členění geotektonické etapy (KVĚT 1992).

Order	Fraction	Million years
1	1/1	220
2	1/2	110
3	1/4	55.0
4	1/8	27.5
5	1/16	13.7
6	1/32	6.87
7	1/64	3.44
8	1/128	1.72
9	1/256	0.86
10	1/512	0.43
11	1/1024	0.22
12	1/2048	0.11

Derivation of major coal-generating cycles

From the viewpoint of coal generation, the Hercynian geotectonic stage can be regarded as the most significant one in geological history in all continents. It is considered that the main periods during which organic matter formed and accumulated in sediments, giving rise to the formation of coal basins, can be placed into a certain interval of a geotectonic stage, which lasted, in four different subphases, from the end of the third quarter of the Hercynian stage to over the middle of the fourth quarter of the overall geotectonic stage (Fig. 2), that is to say some 40 million years in total.

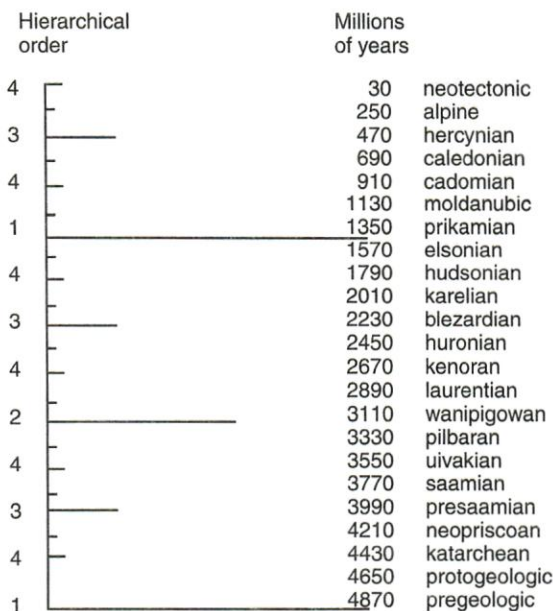


Fig. 2. Significance of the hierarchy of individual geotectonic cycles (according to formula 2^n – see Fig. 1) (KVĚT 1991).

Obr. 2. Uplatnění hierarchie jednotlivých geotektonických etap (podle modelu 2^n – viz obr. 1).

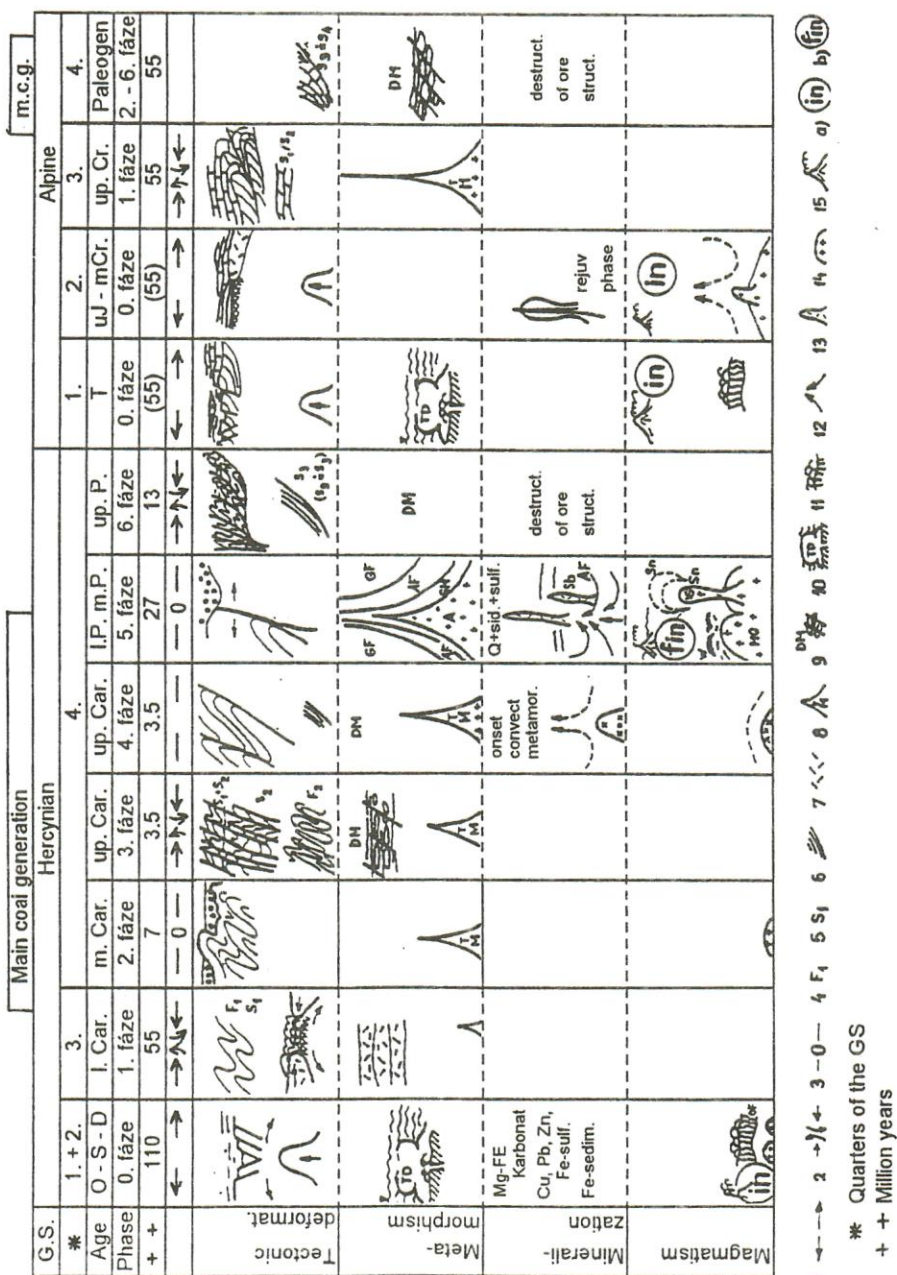


Fig. 3. The time sequence of tectonic, metamorphic and metallogenetic events within the Gemicum (GRECULA 1982) as modified by KVĚT (1987) and period of main coal generation.

Obr. 3. Časová posloupnost tektonických, metamorfních a metalogenetických dějů v gemicu (GRECULA 1987) v úpravě KVĚTA (1987) a hlavní periody vzniku uhlí.

Legend: 1 – Development stage of the sedimentary area, 2 – deformation (compression) stage, 3 – tectonic window, 4 – folds, 5 – schistosity, 6 – fracture cleavage, 7 – regional thermal prograding metamorphism, 8 – thermal metamorphism (GV-green schist facies, AF-amphibolite facies, GM-ultrametamorphism – granitization and migmatization, A-anatexis), 9 – dislocation, metamorphism and retrograding metamorphism, 10 – metamorphism within thermofluid aureoles on the ocean floor and in areas of mid-ocean ridges, 11 – ophiolite complex (MG-metatectic, IG-intrusive, 15 – volcanism (a-initial,

Table 2. Main cycles of organic matter concentration in sediments.
Tab. 2. Hlavní cykly koncentrování organické hmoty v sedimentech.

Geotectonic stage (GS)	Million years	Hierarchy (GS) (see Fig. 1)	Significance of the GS as to the volume of known coalified matter
Alpine	50–90	5	2
Hercynian	270–310	3	1
Caledonian	490–530	5	3
Cadomian	710–750	4	4

It can be argued that organic substances were accumulating for an almost identical time span of 40 million years, generating, thus, during the Alpine geotectonic stage, coal deposits from Upper Cretaceous to Tertiary times. During earlier geotectonic stages, especially the Caledonian, i.e. in the Lower Ordovician, similar conditions of accumulation of organic matter existed within identical subphases, including the accumulation of organic substances. Their concentration, however, did not attain the Hercynian level but it could have led to the generation of carbonaceous shales. By considering the above hypotheses sediments with increased concentrations of coalified plants, should have present in the equivalent time interval of the Cadomian stage in the Proterozoic.

As indicated by the above hypotheses, the principal periods, during which organic matter was concentrating, should have shown up within four geotectonic stages and their associated phases (Table 2).

As follows from the table, the importance of the Hercynian stage as to the intensity of coal-generating events remains unsurpassed even with regard to the hierarchical level of the geotectonic stage (Fig. 3). As life on Earth was developing, the concentration of plant remains in sediments continued to increase up to the present day. As far as the volume of the coal mass is concerned, the Alpine stage is thus of greater importance than the Caledonian one, though they are of the same order. The Cadomian stage, however, which is hierarchically more important than the two stages mentioned above, since it accompanied the onset of significant plant evolution, remained the least significant as to the volume of coalified substances. Tables 2, 3 also demonstrates that, in the four stages mentioned above, the main stages of coal or carbonaceous-shale formation occur in the following periods:

1. In the Hercynian geotectonic stage – from the Lower Carboniferous to Lower Permian,
2. In the Alpine stage – from the Upper Cretaceous to Paleocene,
3. In the Caledonian stage – from the Upper Cambrian to Lower Ordovician,
4. In the Cadomian stage – in the Upper Proterozoic.

As is obvious from comparing the information gained from Table 2 with the data on the principal coal reserves as related to age of the coal deposits (Table 4), the main coal-bearing beds of the world's coal deposits fall into the period of organic-matter accumulation mentioned above. The only obvious inconsistency can be noted for Jurassic coal. The time of its generation cannot be explained by applying the above hypothesis. It could be believed, however, that, during the Alpine geotectonic stage (the youngest completed stage), as enormous plant evolution was going on, the duration of the period that brought about the concentration of organic matter and coal generation was extended. Possibly another less significant stage could have existed prior to the main cyclical phase that was characterized by the accumulation of organic matter.

Table 3. Chronological division of the geological history (KvĚT 1991).
Tab. 3. Časové členění geologické minulosti (KvĚT 1991).

Geotect. stage after Květ and generation of PER system	Orogenesis after Krystek	Radiometr time Mill. years	Eon	Era	Period	Epoch	Age
Neotectonic		0,01		Quaternary	Holocene		
		0,1			Pleistocene		
		1,8				Pliocene	Badenian
		3					
		5					
Alpine network	Alpine	10	Phanerozoic	Tertiary	Neogene	Miocene	
		15					
		20					
		22,5					
		25					
		30					
		35					
		40					
		45					
		55					
		65					
		70					
		100					
		110					
		141					
		150					
		195					
		200					
		210					
		220					
230	Mesozoic	Cretaceous	Upper				
240					Lower		
251							
260							
280							
290							
345							
370							
395							
435							
450							
460							
470							
500							
510							
570							
650							
670							
690							
890							
1000							
2600							
3000							
4000							

dotted line – generation of the individual networks of PER systems in the given geotectonic stage (G.S.) and inclusion in the corresponding geological epoch.
dashed line – the boundaries of G.S. are placed to the boundaries of geological stages.

Table 4. Percentual distribution of coal reserves as related to the age of the deposits (after DOPITA et al. 1985).
Tab. 4. Rozložení zásob uhlí podle stáří ložisek v procentech (DOPITA et al. 1985).

Country	Paleozoic			Mesozoic		Cenozoic	In total
	devonian	carbonifer.	permian	triassic	jurassic	cretac.	
SSSR	(0.1)	7.7	22.5	(0.1)	12.6	4.1	48.1
USA	–	6.9	–	0.2	–	8.0	25.4
P. R. of China	–	3.8	6.7	–	3.5	–	14.2
Australia	–	0.2	1.7	0.2	(0.1)	–	2.6
West Germany	–	2.2	–	–	(0.1)	–	2.4
Great Britain	–	1.6	–	–	–	–	1.6
Poland	–	1.0	–	–	–	0.2	1.2
Canada	–	–	–	–	(0.1)	1.0	1.2
India	–	0.4	0.1	–	0.1	(0.1)	0.7
Others	–	0.5	0.7	–	0.5	0.2	2.7
In total (%)		24.3	31.7	0.4	16.8	13.3	100.0

Conclusion

Consideration of an apparent periodicity of geotectonic stages as well as the hierarchy of these stages and their phases, suggests a conclusion that major cycles of coal generation or those concerning the accumulation of coalified organic substances are a function of these stages. The main generation period, the duration of which is thought to be about 40 million years, started prior to the end of the third quarter of the geotectonic stage concerned, which lasted 220 million years, to the end at about the middle of the fourth quarter.

SOUHRN

Vznik uhlí – tj. kumulace organické hmoty v sedimentech a následné zuhelnňovací pochody – lze dát do vztahu s dlouhými časovými cykly. V uvedeném příkladu je využito geotektonických etap o trvání 220 milionů let. Periodicita geotektonických etap, jejich hierarchie i členění fází umožňují ukázat, že existuje vztah hlavních cyklů genese uhlí k jisté fázi geotektonické etapy. Trvání hlavní fáze – periody vzniku uhlí se pohybuje kolem 40 milionů let. Začíná na konci třetí čtvrtiny geotektonické etapy a končí přibližně uprostřed čtvrté čtvrtiny.

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