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Coal seams and formations of the Mediterranean Tethys and Paratethys Neogene; application of results of the IGCP No. 25; part 2

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Abstract

After the termination of the project mentioned in the title of the paper, the author, who was its manager, proceeds to a more detailed evaluation of the time and space distribution of coal-bearing formations. In the introductory part of the contribution the author not only discusses, but to a certain extent also redefines the terms concerning the "limnic" and "paralic" genesis of Neogene coal-bearing formations. The author's opinion is that if we want to preserve these terms, the basis of their genetic differentiation should be their paleogeographic position in relation to either extensive freshwater-mesohaline, or marine regions. The contribution provides essential information for further paleogeographic and geodynamic applications in the whole territory between the Atlantic and Indopacific regions in Neogene.

The conclusion of the IGCP project No. 25 gave the possibility of a more profound analysis of the age and space distribution and of the conditions of the evolution of Upper Oligocene and Neogene limnic and paralic coal-bearing sediments on the extensive intercontinental territory between the Atlantic and Indopacific oceans. Their occurrences in the Neogene stages are on the attached maps marked according to their limnic or paralic origin (Figs. 1—10).

Since the majority of coal seams is of limnic origin and they occur mostly in the Central European region, I have concentrated in their age classification above all on chronostratigraphic units (Stages) of the Central and Western Paratethys. Of course, I shall present also their assumed optimal correlation with Neogene Tethys and Eastern Paratethys chronostratigraphic units (see Seneš, 1989). It is evidently necessary to divide further some of the stages into „early", „middle" and „late". As far as the age correlation of the three different stage scales (Mediterranean Tethys, Western-Central Paratethys and Eastern Paratethys) as well as the data used for the evaluation of deposites derived from 540 detailed stratigraphic tables are concerned, I refer to the cited works and to the Final Report of the Project (Seneš, 1985, 1989; Steininger et al., 1985).

While evaluating genetically the coal-bearing sediments, I did not deal with their allochthonous or autochthonous character, since it is not substantially affected by interregional or regional geological events, and thus it would not serve the broader objects of this paper. I prefer to discuss the problem of their limnic or paralic origin, since this feature has undoubtedly a geodynamic background, connected either with subsidences and uplifts, transgressions or regressions.

Unfortunately, in the use of the terms "limnic" and "paralic" we still meet with problems which cannot be completely solved. The substance of the difficulties lies in the fact that these expressions themselves belong to totally different categories of terms.

"Limnic", i. e. freshwater (from greek *limnos* = lake) indicates the opposite of marine. "Paralic" (from greek *pará* = beside, parallelly) does not have anything in common with the gradation of the salinity of seas, inner or isolated seas and lakes, but it indicates the paleogeographic position of the territory of deposits. It indicates the assumption that the deposit was formed parallelly with the open water basin from which it was more or less separated.

Coal-bearing formations of limnic origin were always considered to had been formed in basins either in extremely extensive freshwater or brackish regions, or more frequently in shallow marginal or small isolated basins. It is nevertheless necessary to be aware of the fact that in spite of the almost nil or considerably decreased salt content of these large lakes, their paleogeographic evolution was affected by the same laws of geodynamic processes — i. e. also of emergence and subsidence, transgression and re-

gression — as the evolution of marine environments.

Paralic deposits were formed during a territorially progressing subsidence; a subsiding depression was formed in the front of the transgressing sea or lake. This depression was only later, as a result of a continuing subsidence, flooded by the transgression and its sediments. We assume that such so-called paralic, at least partly flooded depressions with ample vegetation could *also have* (and except the mangrove type it usually also had) freshwater or oligohaline regime.

Thus, in certain cases it is even from the linguistic point of view justified to question the limnic or paralic origin of the basin. (I would like to remark that „paralic" basins could have been formed also during a regression, in the form of flooded morphologic relics. Their occurrence is nevertheless according to the present knowledge only sporadic, since erosion and denudation and thus also trasportation and deposition of the disintegrated material ought to be quicker during emergence than during slight subsidence or equilibrium. However, these basins were in both cases formed mostly during intermittent oscilating slow subsidence or emergence. (I shall call basins formed during transgression *initial*, those formed during regression are termed *final-paralic*.)

I would like to point out that in the evaluation of the forming of deposits in both conditions I take into consideration above all epeirogenic and not orogenic movements, mostly because lithologic alternation of sediments within one sedimentation cycle of a coal-bearing formation is almost always and indication of an alternating, but generally slow intermittent subsidence, whether confined along faults, or caused by general plastic bending of the basement. It is clear that these considerations allow to classify limnic basins also as initial or final.

From the above mentioned facts it clearly follows that the classification of coal-bearing sediments in so-called "limnic" and "paralic" cannot be based on the salinity of the environment, but that we should concentrate on the paleogeographic setting of the sedimentation area. The disagreement on the salinity itself in international geographic nomenclature is apparent also from some examples of the broader Mediterranean region. The low-saline Caspian "Sea" is frequently called Caspian "Lake". The Aral "Lake", on the other hand, is because of its certain salinity often termed Aral "Sea". Thus, from the paleogeographic viewpoint, it is still questionable whether we should talk about Sarmatian, Pannonian, Pontian, Dacian or Romanian seas, or lakes. The recent Black Sea has approximately the same low salinity as the Paratethys in the Sarmatian time. We term it "sea" probably mainly because of its connection with the Mediterranean Sea via the narrow and shallow Bosphorus and Dardanelles straits. The Baltic Sea corresponds by its salinity to some more brackish horizons of the Sarmatian Paratethys, but above all to the Pannonian "lake". Were it not for the shallow Őre Sund, and Great Belt Straits, leading to Kattergat and thus to the North Sea, we would call it undoubtedly "Baltic Lake". And comparing the recent Caspian "Lake" with the extensive water basin of the Great Pontian Sea of Middle and Eastern Europe as well as Western Asia, we come to the conclusion that it is frequently called "lake" not because its salinity was only approx. 1,3 ‰, but above all because of the lack of a connection with the Mediterranean Sea or Atlantic Ocean (which the Black Sea or Baltic Sea do have).

In spite of these considerations I shall continue to use the terms "limnic" and "paralic". Thus, for the purpose of distinguishing their "limnic" or "paralic" character, in the following sections of the paper dealing with the time and space distribution of coal-bearing sediments I shall define the criterion of their paleogeographic position, i. e. their relation to the *"parental"* water regime. I consider them *paralic* when they have a *connection to a full-polyhaline sea*, and *limnic* in the case of the *"parental"* lake being paleogeographically *distant from a sea with normal salinity*.

For example, the coal-bearing strata in Sarmatian, Pannonian and Pontian of the Paratethys region are considered to be limnic, since they were aquatically completely isolated from the Neogene Tethys and their "parental" region were paleogeographically extensive, but with the Mediterranean Sea of that time already not communicating freshwater or brackish lakes. On the other hand, I classify coal-bearing strata of the same age lying in the Tethys region — i. e. in Serravalian, Tortonian, Messinian — (if they are not small, definitely isolated inland lakes) as paralic.

I would like to stress once more that I do not consider salinity to be the first and decisive criterion for distinguishing the paralic or limnic origin of coal-bearing formations, but that it is their *paleogeographic isolation or connection* with an either *freshwater or euryhaline lake* (0 to 20 ‰), or with an *euhaline (polyhaline) sea* (20 to 38 ‰).

On the basis of these criteria we have determined that from the 160 coal-bearing Neogene occurrences registered by us between the Atlantic and Indopacific, 114 were formed in a limnic environment, and only 46 in a paralic one. At the same time, it is not certain whether at least 4 of the so-called paralic basins do not, according to the mentioned criteria, still belong to the category of limnic basins. A list of the number, age and character of coal-bearing occurrences and formations is represented on maps as well as in Tab. 1.

TAB.1

Stage distribution of numbers and percentage of coal seams and formations

Stages	Limnic		Paralic		Total	
	numbers	%	numbers	%	numbers	%
Late Chattian + Aquitanian = Egerian = ± Caucasian	6	46,15	7	53,85	13	8,13
E. — M. Burdigalian = Eggenburgian = Sakaraulian	6	100,00	—	—	6	3,75
M.—L. Burdigalian = Ottnangian + Karpatian = Kozachurian	4	28,57	10	71,43	14	8,75
Langhian = E. Badenian = Tarch (?) + Tchokrakian	6	35,29	11	64,71	17	10,63
E. — M. Serravallian = M. — L. Badenian = Karagan + Konkian	6	60,00	4	40,00	10	6,25
M. — L. Serravall. + E. Tortonian = Sarmatian s. str. = Volhyn + E. Bessarab	10	62,50	6	37,50	16	10,00
Middle Tortonian = L. Pannonian (L. Malvensian) = Maeotian	15	83,33	3	16,66	18	11,25
Late Tortonian + Early Messinian = Pontian (CP) = Pontian (EP)	27	90,00	3	10,00	30	18,75
Late Messinian + Early Zanclean = Dacian = Kimmerian	19	95,00	1	5,00	20	12,50
Late Zanclean + Piacenzian = Romanian = Akchagylian	15	93,75	1	6,25	16	10,00
Total	114	71,25	46	28,75	160	100,00

According to their age, there is a prevalence of limnic deposits from Sarmatian s. s., with an increasing trend in Pannonian, Pontian and Pliocene. On the other hand, occurrences and deposits of paralic character prevail in Upper Oligocene, in Lower and almost in all Middle Miocene.

As far as the space distribution of coal-bearing sediments is concerned, it shows a considerable differentiation. From the end of Oligocene to the beginning of Middle Miocene, limnic occurrences can be found only in Southern Europe, as well as in the Near East, on the boundary region between the Mediterranean Tethys and Paratethys. Occurrences of paralic character were in this time most abundant on the territory of Central and Western Paratethys. The opposite situation occurred in Upper Miocene and in Pliocene, when, due especially to the isolation of Paratethys freshwater or brackish seas from the Mediterranean Tethys and Indopacific, a large number of above all Pannonian, Pontian and Pliocene limnic lignite deposits were formed. Paralic deposits of this age can be found only infrequently, mostly in the recent Mediterranean region.

It is clear that the time and space distribution, as well as from the character of coal-bearing strata between Upper Oligocene and Pleistocene, we can draw further conclusions concerning the paleobotanic and paleoclimatic changes, the changes of the direction of transgressions and regressions, i. e. also the time of subsidences and emergences of the studied

region. The analysis of the origin, age and distribution of coal-bearing sediments is without doubt important for geodynamic-paleogeographic interpretations.

For the numbered locations of the sedimentation areas marked in the maps — see also in Seneš (1989), Steininger et al., (1985).

1. Late Chattian — Aquitanian = Egerian = ± Caucasian (~ 25 – 21,8 MY)

Limnic:

50abd — W., N., SW Thrace (terminal limnic Bds.), TR; **60ab** — Muratdagi, Gediz (base of Kirantarle Fm.), TR; **236a** — Blagevgrad Graben (Huillère Fm.), BG; **237ab** — Plovdiv and Zagore Bs. (Dragoinovo, Maritza Fm., Brod and Kipren Mbs)., BG; **232** — S. Moravian Freshwater and Intracarpathian Bs., YU; **234a** — Freshwater Bs., Sarajevo B. (base of Red Serie), YU;

Paralic:

201b — Subjurassische Molasse (Untere Meeresmolasse, Randbucht-fazies), D; **202b** — Molassezone vom Süd-Sporn der Böhmischen Masse und S. der Donau (Pielacher Tegel), A; **202c** — Molassezone Nördlich der Donau (Melker Serie base), A; **213abc,** — South Slovakian Ipel, Rimava, Lucenec Bs. and N. Hungary (final, intermittent), CS, H; **219a** — Transdanubian Central Mountains (Noszlop Mb), H; **217d** — Transylvanian B., Petrosani-Hateg (low. Sălătruc Fm.), R; **230e** — Danubian Corridor, Bahna-Orsova (Coal Fm. — limnic?), R;

2. Early-Middle Burdigalian = Eggenburgian = Sakaraulian (~ 21,8 – 18 MY)

Limnic:

4e — Valencian Depr. (base Mugrón Fm.), E; **57** — Beypazari — Nallihan, TR; **225** — Slavonia-Syrmian B., YU; **227ab,** — Intradinaridian Marginal Zone, YU; **234a** — Freshwater Bs., Sarajevo B. (base of Main Coal Serie), YU; **266** — The Donbas (low. part of Poltav Gr.), SU;

Paralic:

Occurrence or Formation is not known.

3. Middle-Late Burdigalian = Ottnangian = Kozachurian (~18 – 17,4 MY)

Limnic:

50b — North Thrace (Upper Cöpköy Fm.), TR; **201a** — Niederbayrische and Naab Molasse („Braunkohlen Tertiär" Bds. between Upper Marine and Upper Freshw. Molasse. Final paralic?), D; **237b** — Zagore B. (Troianovo Mb., lower part), BG; **234b** — Freshw. Bs. Livno, Dubno B. (Tušnica coal ser.), YU;

Paralic:

58b — Erzincan - Tercan (Upper Vartic Fm., final paralic), TR; **200b** — Allgäuer Molassezone and Voralberg (Upper Marine Molasse, — final paralic), A; **202c** — Molassezone nördlich der Donau („Sandstreifen Schlier", underlaying Oncophora Bds.), A; **209a** - Sopron Mt. (Brennberg Fm., initial paralic?), H; **213abc** — South Slovakian Ipel and Rimava Bs., North Hungarian B. (Salgótarján Fm., initial paralic), CS, H; **217c** — Transylvanian B., Strei — Brod — Sacarimb (Almasu Mare Fm., overlaying discordantly by Cinis Bds.), R; **221a1,** — West-Steirisches B. (Eibiswald Bds., initial paralic?), A; **221b1,** — Lavanttal, Kärnten (Granitztaler Bds. initial paralic), A; **222** — Mecsek Mts. (Gyulakeszi Fm., initial paralic, underlaying Budafa Fm.), H; **225** - Slavonia — Syrmian B., evaluated from Upper Egerian T-L Bds., overlaying by marine Bds.), YU;

4. Langhian = Early Badenian = Tarkhanian (?) — Tchokrakian (~ 16,6 – 15 MY)

Limnic:

50c — Central Ergene B. (Denismen Fm.) TR; **201b** — Mittelländische Molasse (in "Kalknagelfluh"), CH; **202a** — Molassezone Inn — Bohemian Mass., (Trimmelkamm Ser.), A; **237b** — Zagore B., (uppermost Troianovo Mb.), BG; **274** - South Ciscaucasia (Voroshilov Gr.), SU; **302** - Gallegas Depr. (Fuentes Rodriguez Fm.), E;

Paralic:

101c — Bordure SE de l'Ouarsenis (marine envir. underlaying "Nappes Telliennes"), DZ; **207a1, 2** — Upper Silesia, North part (base Klodnica Fm.), PL; **207a3** — Marginal Zone, Holy Cross Mts. (Lignitic Fm. underlaying Korytnica Mb.), PL; **207a4** — Marginal Zone, Roztocze (Lignitic Fm. underlaying Lithothamnium Mb.), Pl; **218a1** — East Intra-Carpathian Depr., Banat, R; **218a2** — East Intra-Carpathian Depr., Mehadia-Bozôvici (lower part"Limestone-coal" Fm.), R; **219a** — Transdanubian Central Mts. (base Pusztamiske and Hidas Fm.), H; **221a2** — Ost-Steirisches B. (Kohle von Tauchen), A; **222** - Mecsek Mts. (Hidas Fm.), H; **228** — Kolubara B. (denoted as "Praebadenian"?), YU; **266** — The Donbas (middle part of Poltav Gr., denoted as Tarchanian), SU;

5. Early-Middle Serravallian = Middle-Late Badenian = Karaganian — Konkian (~15 – 13,8 MY)

Limnic:

55 — Harmancik (initial lacustr. subsid.), TR; **221b1** — Lavanttal, Kärnten, Klagenfurt Bs (top Dachberg Schotter), A; **230ac** — Danubian Corridor ("Freshwater Fm."), R, YU; **234d** — Freshwater Bs., Plevlje, Montenegro (upper part of the limnic Fm.), YU; **235b** — Cukrovo B. ("Fm. lignitifère"), BG; **302** — Gallegas Depr. (upper Fuentes Rodriguez and Laracha Fms.), E;

Paralic:

2b4 — Granada B. NE., SE. ("Tramo inferior miocenico") E; **209b** — Eisenstädter — Landseer Bucht (base "Walbersdorfer Schlier, M), A; **218a2** — East Intra-Carpathian Depr., Mehadia — Bozovici (upper part "Coal Fm."), R; **229b** — Morava B., Smederevsko — Pozarevacko Podunavlje (final paralic, Badenian top), YU;

6. Middle-Late Serravallian + Early Tortonian = Sarmatian s. str. = Volhynian + early Bessarabian (~ 13,8 – 11,8 MY)

Limnic:

60d — North Simav (Kizilbük Fm.), TR; **62** — Cankiri — Kalecik (Candir Fm.), TR; **202a** Molassezone Inn — Bohemian Mass. ("Kohleführende Süsswasserschichten" top), A; **211** — Nitra and Váh Valley Bs. (Nováky, Handlová Fms.), CS; **215** - East Slovakian B. ("Lower coal Fm.", euxine-euryhaline final), CS; **221a2** — Ost-Steirisches B. (Carinth. coal Bd., euxine-euryhaline final), A; **221b1, 2** - Lavanttal, Kärnten, Klagenfurt B. (Kucheler, Rosenbacher Bds.), A; **233b** — Moravian Freshwater and Intra-Carpathian Bs., Dragacevo — Kosjeric, YU; **242a** — Danubian Region of the Scythian Platform (euxine-euryhaline), SU; **274** — South Cisuralia (Ushkatlin Gr.), SU;

Paralic:

4 — Valencian Depr. (Calizas de Fuencaliente Fm., lower part), E; **17c** — Veneto and Friuli, I; **42d** — Kythira (Kythira Fm., base), GR; **46c** — Crete, Iraklion (initial paralic, Prina Gr.), GR; **49c** — Polemi B. W. (Yolou Fm., base), CY; **113** — Plateau sous-marin de Kerkennah, Golf de Gabes (Beglia Fm., top), TN;

7. Middle Tortonian = Late Pannonian (= Late Malvensian) = Maeotian (~9,6 – 8,8 MY)

Limnic:

15c — Lyon — Dombes — Bresse (Dombes Fm. final paralic?), F; **36b** — Tikves B., YU; **50f1** — Canakkale — Intepe (Kizilhisar Bds.), TR; **51a** — Istanbul — Ambarliköy (Kizilhisar Bds.), TR; **58b** — Erzincan Tercan (Zilfokomu Fm.), TR; **64c3** — SW Anatolia, Zone of Menderes Mass. (middle part „Grey Series"), TR; **208a1** — Vienna B. N. (Kyjov lignit Bds., — early Pannonian), CS; **210ab** — South Slovakian Danube B., Centr. and W. (Lower coal Fm.), CS; **214** — Central and South Slovakian Freshwater Bs. (Mošovce, Martin Bds., — early Pannonian), CS; **215** — East Slovakian B. ("Inter-coal tuffitic Mb., — early Pannonian, "Upper coal Fm.", "Sejkov coal Fm." — middle—late Pannonian), CS; **221a2** — Ost-Steirisches B. (lower coal seams, — denoted as uppermost Pannonian), A; **233a** — West Moravian Freshwater Bs., Cacak — Kraljevo, YU; **234a** — Freshwater Bs., Sarajevo B. ("Koševo Serie"), YU; **271** — Volga — Khoper Interfluv (Prudkov Bd.), SU;

Paralic:

17c — Veneto and Friuli, I; **111** — Cap Bon (Saouaf Fm. — limnic or final paralic?), TN; **112** — Tunisie orientale — Sahel (Saouaf Fm., — limnic or paralic?), TN;

8. Late Tortonian + Early Messinian = Pontian (CP) = Pontian (EP) (~8,8 – 5,8 MY)

Limnic:

15a — Moyenne Vallée du Rhône, Valréas — Faucon (Mistrals Fm., — paralic final?), F; **34** — Kosovo and Methohia Bs., YU; **35a** — Skopje B., Nerezi, YU; **36b** — Tikves B., YU. **40** — Strimon B. (Lefcon Gr., Serres Lignites), GR; **64c2** — SW Anatolia (from the Standard Profile), (base Sekköy-Layers), TR; **206a** — South Subcarpathian Foredeep, Getic Depr. E., Dimbovita — Jiu, R; **208a1** — Vienna B. N. ("Lower Coal Fm.", Dubňany lignit Mb.), CS; **208a2** — Vienna B. N. ("Blaue Serie mit Ligniten"), A; **209b,** — Eisenstädter, Landseer Bucht (Lignit von Zillingsdorf), A; **210ab** — South Slovakian Danube B., Centr. and W. (Lower Coal Fm. II., Sand Coal Fm.), CS; **212** — South Slovakian Danube B., E., CS; **215** — East Slovakian B. (Inačov coal Fm.), CS; **216a** — Zakarpatia B. (Koshelevo Mb.), SU; **217b3** — Transylvanian B. SE., Sercaia — Persani — Racos (Coal Fm. in the "Abichi Bds."), R; **218b2** — East Intra-Carpathian Depr., Apuseni — Borod — Silvania (Coal Fm.), R; **218c** — East Intra-Carpathian Depr., Baia Mare — Oas Region (Freshw. Fm.), R; **221a2** — Ost-Steirisches B. (Upper coal seams, — denoted as early Pontian), A; **224b3** — Transtethyan Trench Corridor, YU; **227a** — Intradinarian marginal Zone, Tuzla B., YU; **228** — Kolubara B., YU; **229a** — Morava B., Beograd Area, YU; **232** — South Moravian Freshw. and Intra-Carpathian Bs., Nis, YU; **233ab** — West Moravian Freshw. and Intra-Carpathian Bs., Dragecevo, Kosjeric, YU; **234a** — Freshwater Bs., Sarajevo B., (overlaying Orlan congl.) YU; **234b** — Freshwater Bs., Livno, Duvno B., YU; **235a** — Sofia B., Hrabarsko Area (Lignit Fm.), BG;

Paralic:

1b — Betic Ranges (TSU-Ne 4 Unit, "Sabiote — Ubeda Gr."), E; **49b** — Dhali Area, South Mesaoria, (Pakhna Fm. top), CY; **96ab** — Guercif Centr. and S. (Khendeck El Aouaiech Bds. — paralic final ?), MA;

9. Late Messinian + Early Zanclean (~5,8 – 3,8 MY) = Dacian (5,8 – 3,6 MY) = Kimmerian (5,8 – 3,4 MY)

Limnic:

2b1 — Granada B. (top "Tramo superior Miocenico", — final paralic ?), E; **12a** — Pyrenean Depr., Cerdana ("Col de Saig" base), E; **18a1** — Val d'Elsa B. (Upper lacustrine Bds.), I; **36b** — Tikves B. (denoted as middle-late Messinian), YU; **43** — Meganololis intermont. B. (base "Makrision Stage"), GR; **205g** — Subcarpathian folded Neogene Foredeep, Dimbovita — Buzau, R; **206b** — South Subcarpathian Foredeep, Getic Depr. W., Dunare — Jiu ("Coal Fm."), R; **208a1** — Vienna B. N., (Upper coal Fm.), CS; **216a** — Zakarpatia B. (Ilnitsa Fm. lower part), SU; **219a** — Transdanubian Central Mts. (Lower coal Mb., Dunántúl Fm.), H; **224b2** — Transtethyan Trench Corridor (Mura Fm.), YU; **224c** — Mura B. (Mura Fm.), YU; **226** — Sava B. (Lower and Middle Paludinian Bds.), YU; **229b** — Morava B., Smederevsko — Pozarevacko Pudunavlje (denoted as Pliocene), YU; **231e** — Lom Depr. (Lignites de Lom), BG; **233a** — West Moravian Freshwater Bs., Cacak — Kraljevo (low. part, — denoted "Pontian"), YU; **235a** — Sofia B., Hrabarsko Area, BG; **236b** — Sandanskie Graben (III. sedim. cycle, base, — initial limnic), BG; **274** — South Cisuralia (III^{d} Hz. of Chebenovsk), SU;

Paralic:

49c — Polemi B. (Mesaoria Gr.) CY;

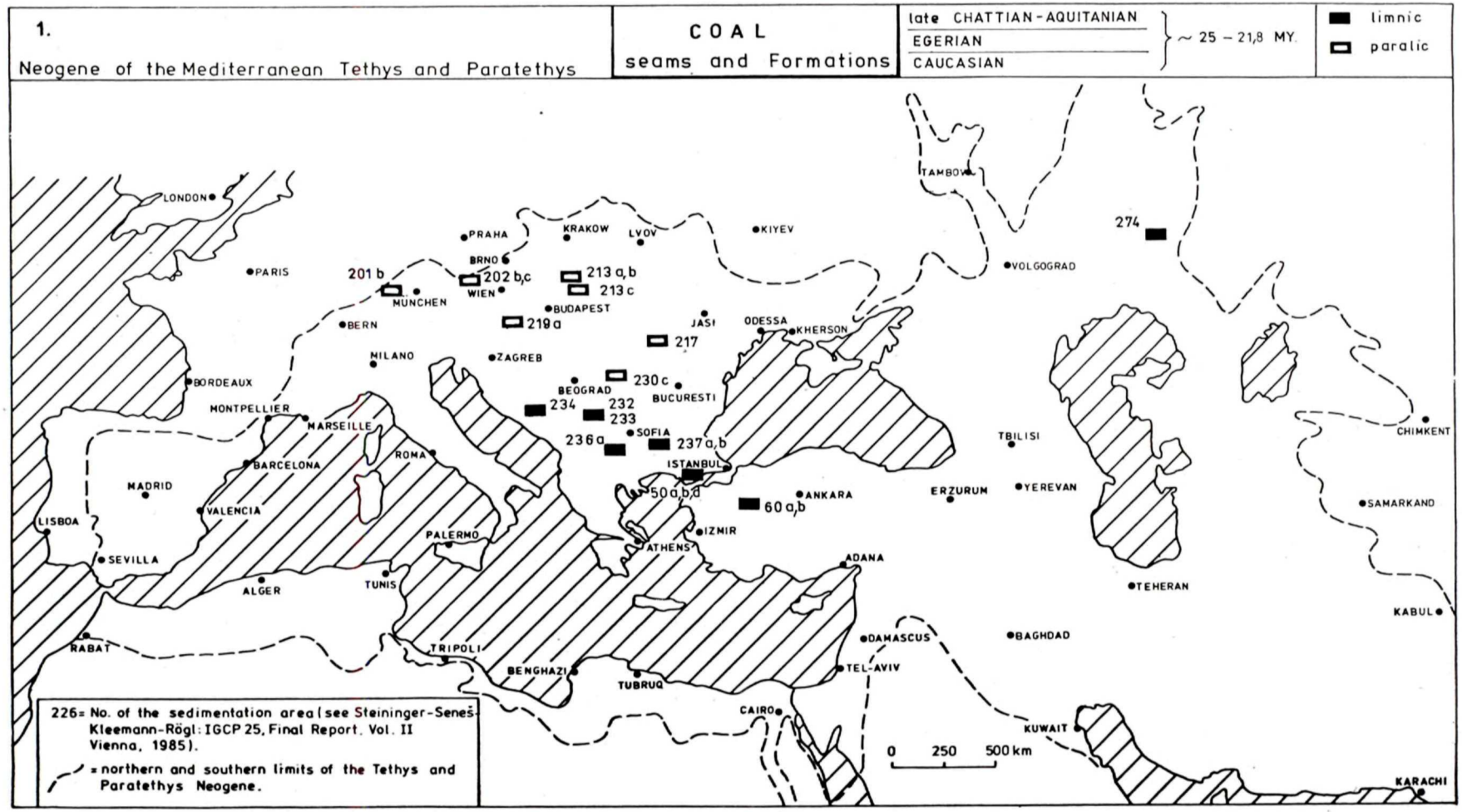
10. Late Zanclean + Placenzian (~3,8 – 1,8 MY) = Romanian (~3,6 – 1,8 MY) = Aktchagylian (~3,4 – 1,8 MY)

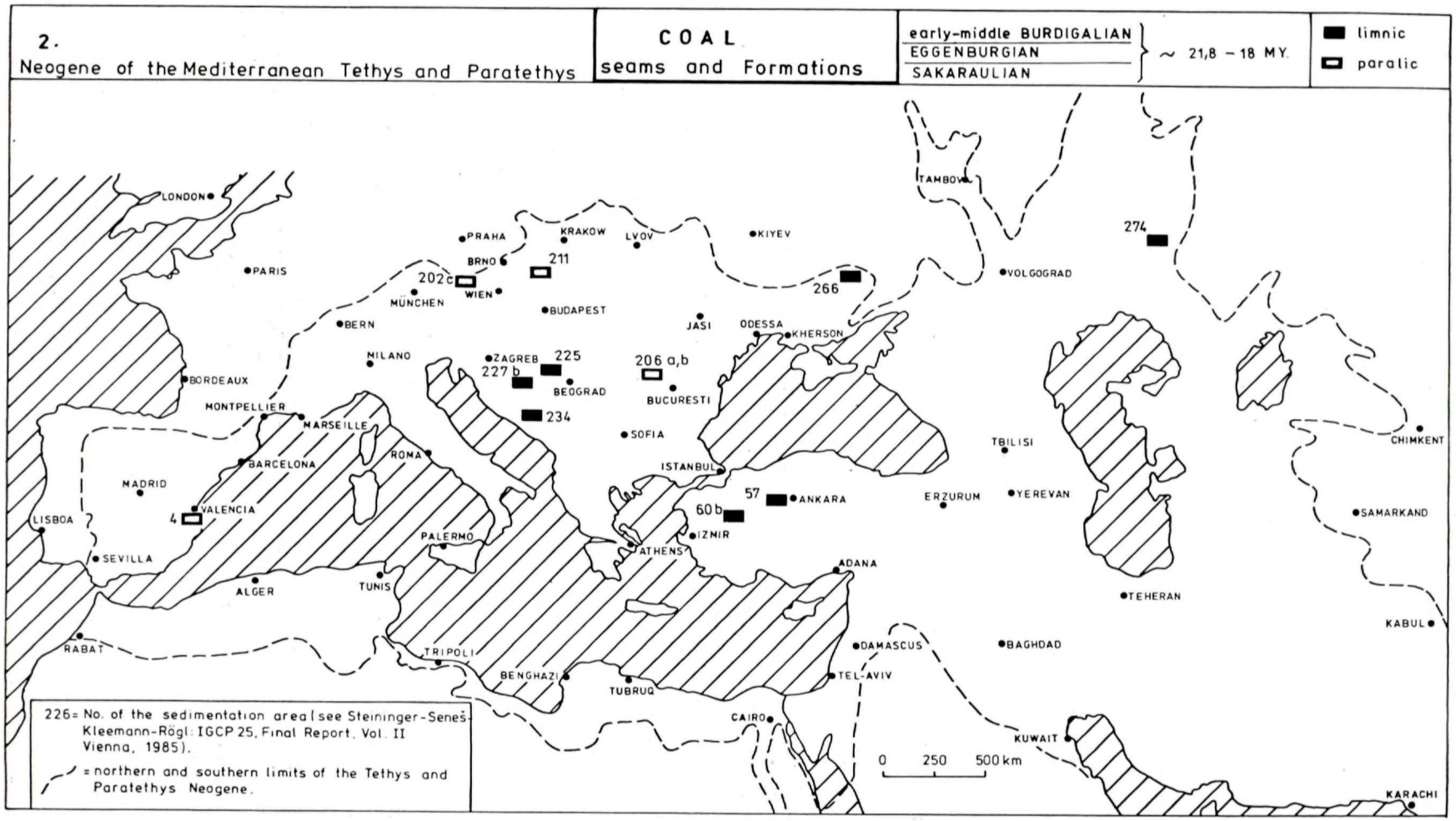
Limnic:

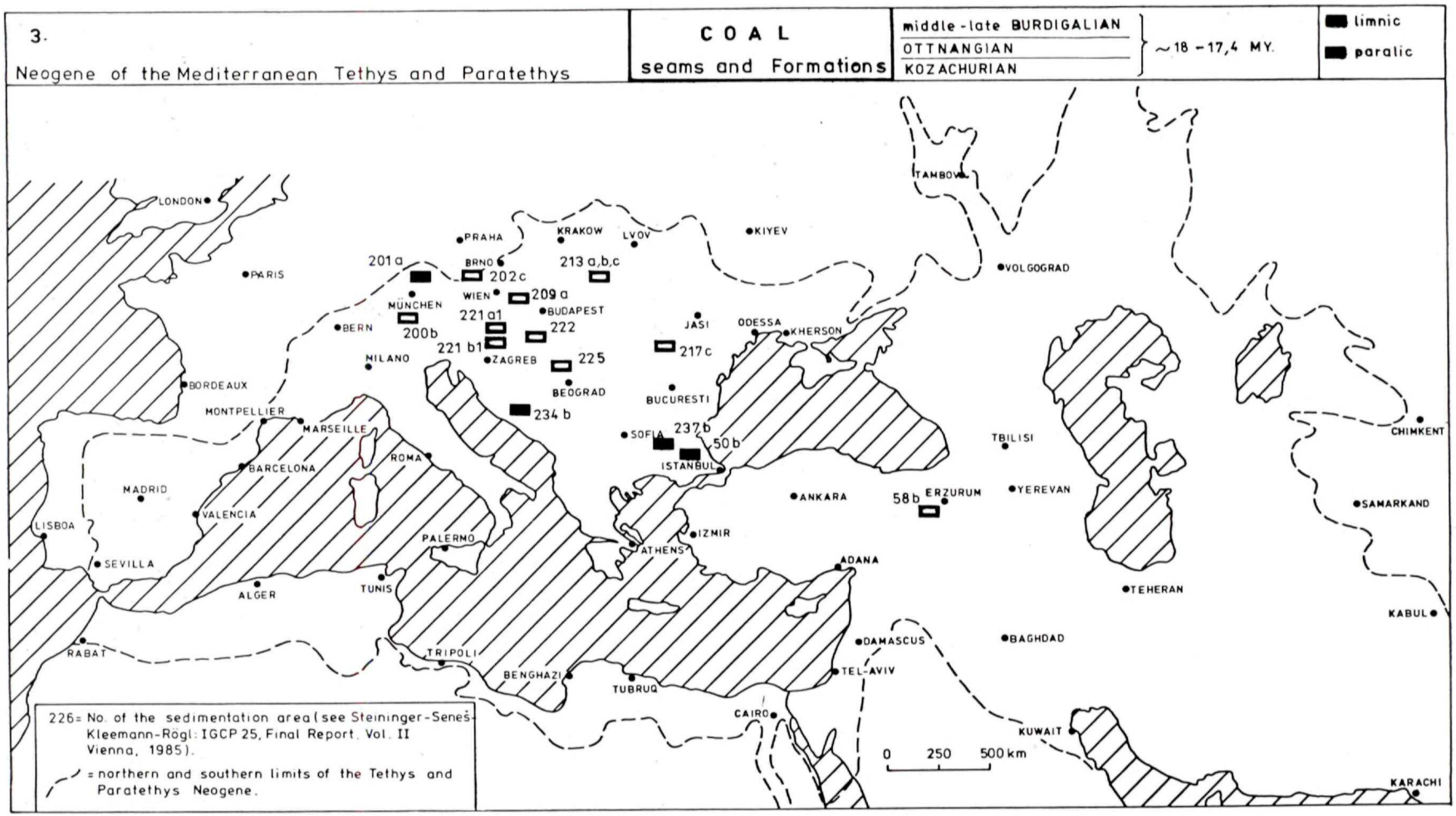
15b — Lyon — Bas Dauphine — Vercors (limite Zanclean/Piacenzian, — final paralic of marin Zanclean ?), F; **15c** — Lyon — Dombes — Bresse (Bresse Fm.), F; **35b** — Skopje B., Bulacani, YU; **43** — Megalonolis Intermontane B. ("Trilophon Stage" base), GR; **205fg** — Subcarpathian folded Neogene Foredeep., Bistrita — Buzau Valleys, Dimbovita — Buzau Reg. (Rimna Fm., Union Bds.), R; **206b** — Subcarpathian Foredeep, Getic Depr. W., Dunare — Jiu ("Smooth Unionidae Bds."), R; **209ac** — Sopron Mts., West Hungarian B. (Dunántúl Fm. top, Torony Mb.), H; **213c** — North Hungary, Budapest, Börzsöny, Tokaj Mts. (Dunántúl Fm.), H; **216a** — Zakarpatia B. (Ilnitsa Fm. upper part), SU; **217b2** — Transylvanian B. S., Sadu — Sercaia ("Piemontan Depr. w. coal), R; **219a** — Transdanubian Central Mts. SW (Dunántúl Fm.), H; **223bc** — Banat B. N and S. (Lower and Middle Paludinian Bds.), YU; **224a** — Hungarian part of Zala — Drava B. (Dunántúl Fm., Torony Mb.), H; **238** — Dacic B. (Freshwater Fm.), R; **270** — Oka — Don Lowland (Uryvskiye Bds.), SU;

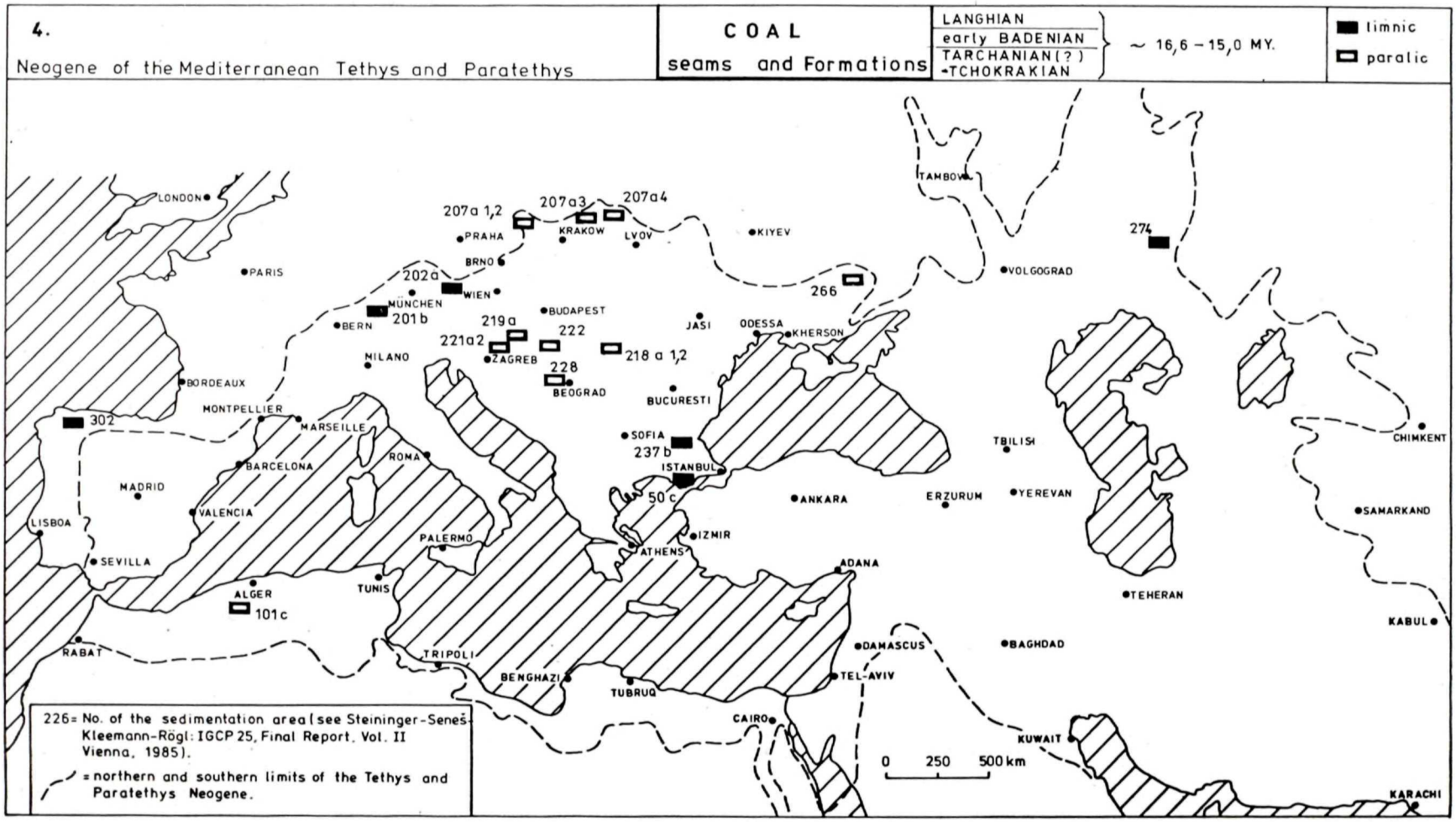
Paralic:

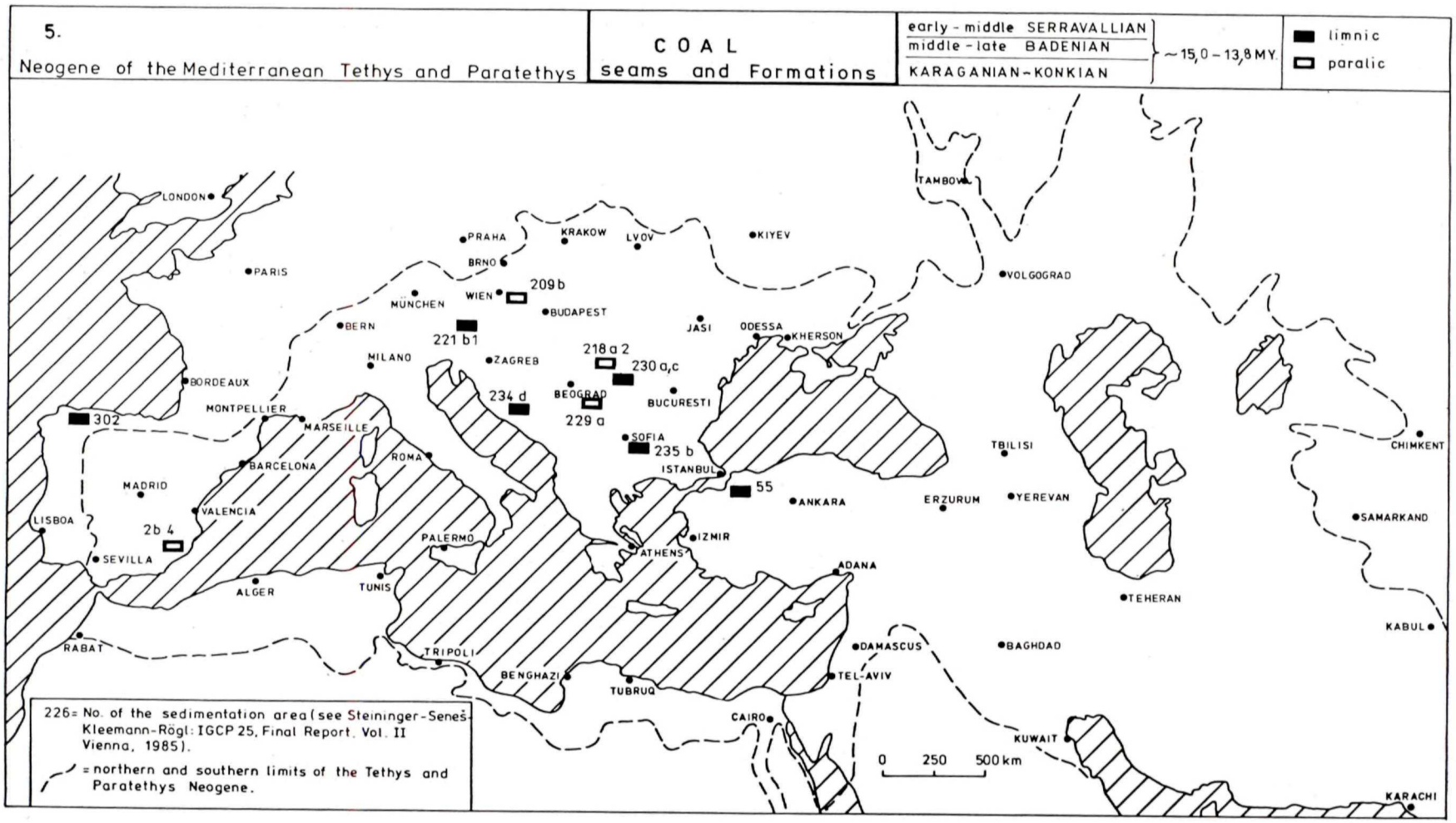
48 — Rhodos (Vasti Fm.), GR;

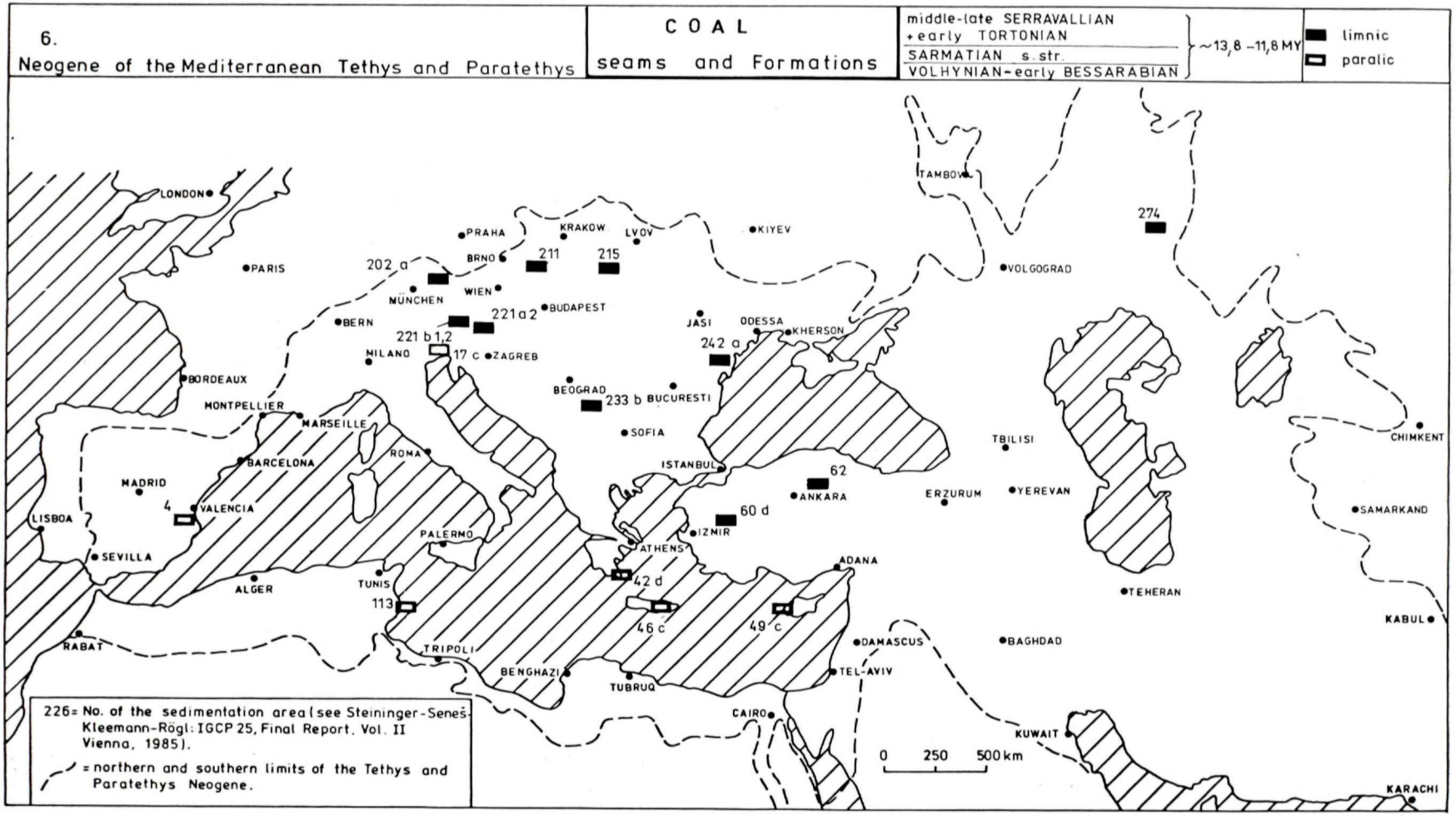

1.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
late CHATTIAN - AQUITANIAN
EGERIAN
CAUCASIAN
~ 25 – 21,8 MY.
limnic
paralic
LONDON
PARIS
PRAHA
KRAKOW
LVOV
KIYEV
TAMBOV
VOLGOGRAD
BRNO
WIEN
MÜNCHEN
BERN
BUDAPEST
JASI
ODESSA
KHERSON
MILANO
ZAGREB
BEOGRAD
BUCURESTI
BORDEAUX
MONTPELLIER
MARSEILLE
BARCELONA
ROMA
MADRID
VALENCIA
LISBOA
SEVILLA
ALGER
TUNIS
PALERMO
TRIPOLI
BENGHAZI
TUBRUQ
RABAT
SOFIA
ISTANBUL
ATHENS
IZMIR
ANKARA
ADANA
CAIRO
DAMASCUS
TEL-AVIV
BAGHDAD
KUWAIT
TEHERAN
ERZURUM
YEREVAN
TBILISI
CHIMKENT
SAMARKAND
KABUL
KARACHI
201 b
202 b,c
213 a,b
213 c
219 a
217
230 c
234
232
233
236 a
237 a,b
50 a,b,d
60 a,b
274
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report. Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.

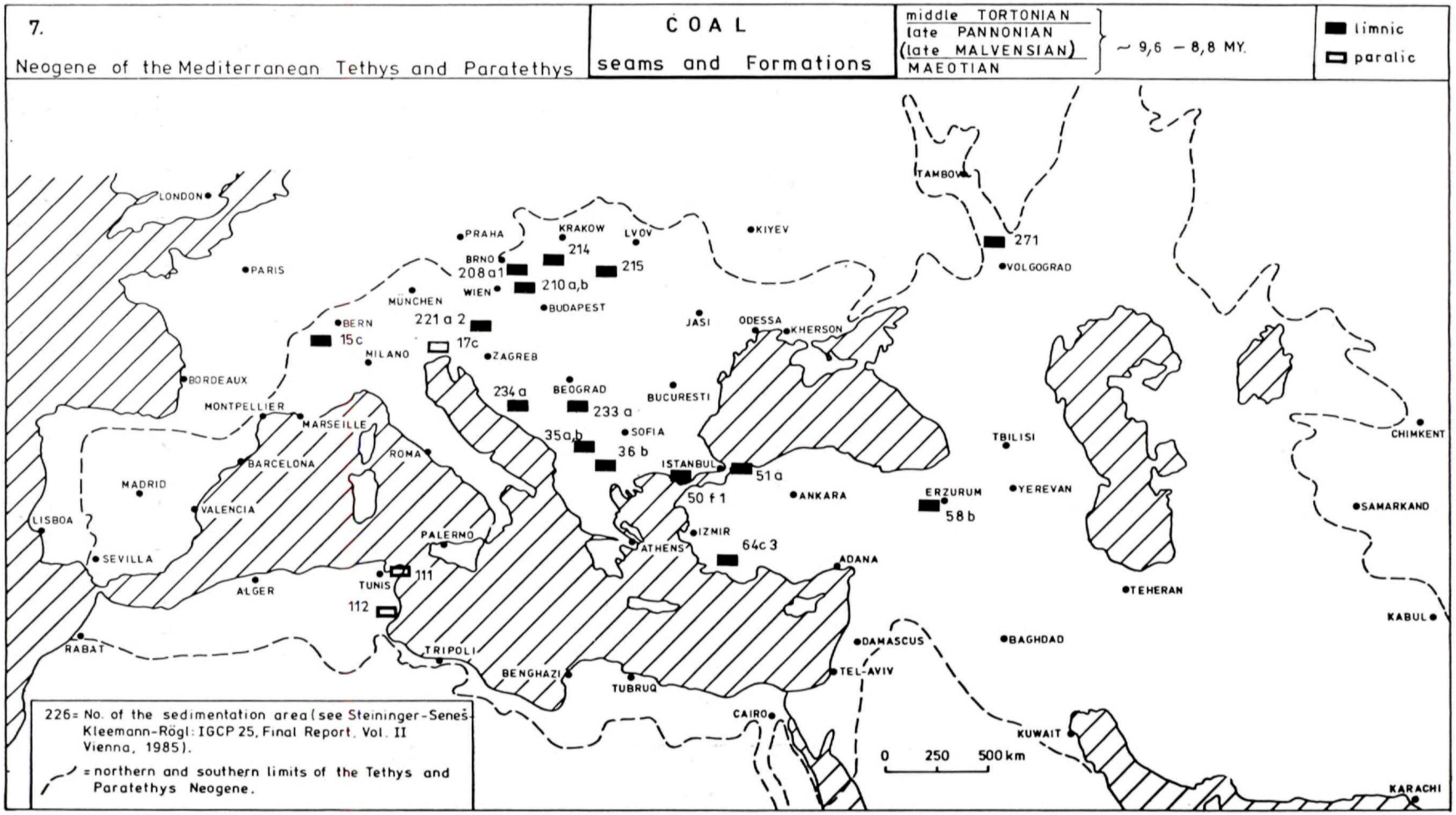

2.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
early-middle BURDIGALIAN
EGGENBURGIAN
SAKARAULIAN
~ 21,8 – 18 M.Y.
limnic
paralic
LONDON
PARIS
BORDEAUX
MONTPELLIER
MARSEILLE
BARCELONA
MADRID
VALENCIA
LISBOA
SEVILLA
ALGER
TUNIS
RABAT
TRIPOLI
BENGHAZI
TUBRUQ
PALERMO
ROMA
MILANO
BERN
MÜNCHEN
WIEN
PRAHA
BRNO
KRAKOW
LVOV
KIYEV
BUDAPEST
ZAGREB
BEOGRAD
SOFIA
BUCURESTI
JASI
ODESSA
KHERSON
ISTANBUL
ATHENS
IZMIR
ANKARA
ADANA
CAIRO
TEL-AVIV
DAMASCUS
TAMBOV
VOLGOGRAD
TBILISI
ERZURUM
YEREVAN
TEHERAN
BAGHDAD
KUWAIT
KARACHI
KABUL
SAMARKAND
CHIMKENT
4
202c
211
227 b
225
234
206 a,b
266
274
57
60 b
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.

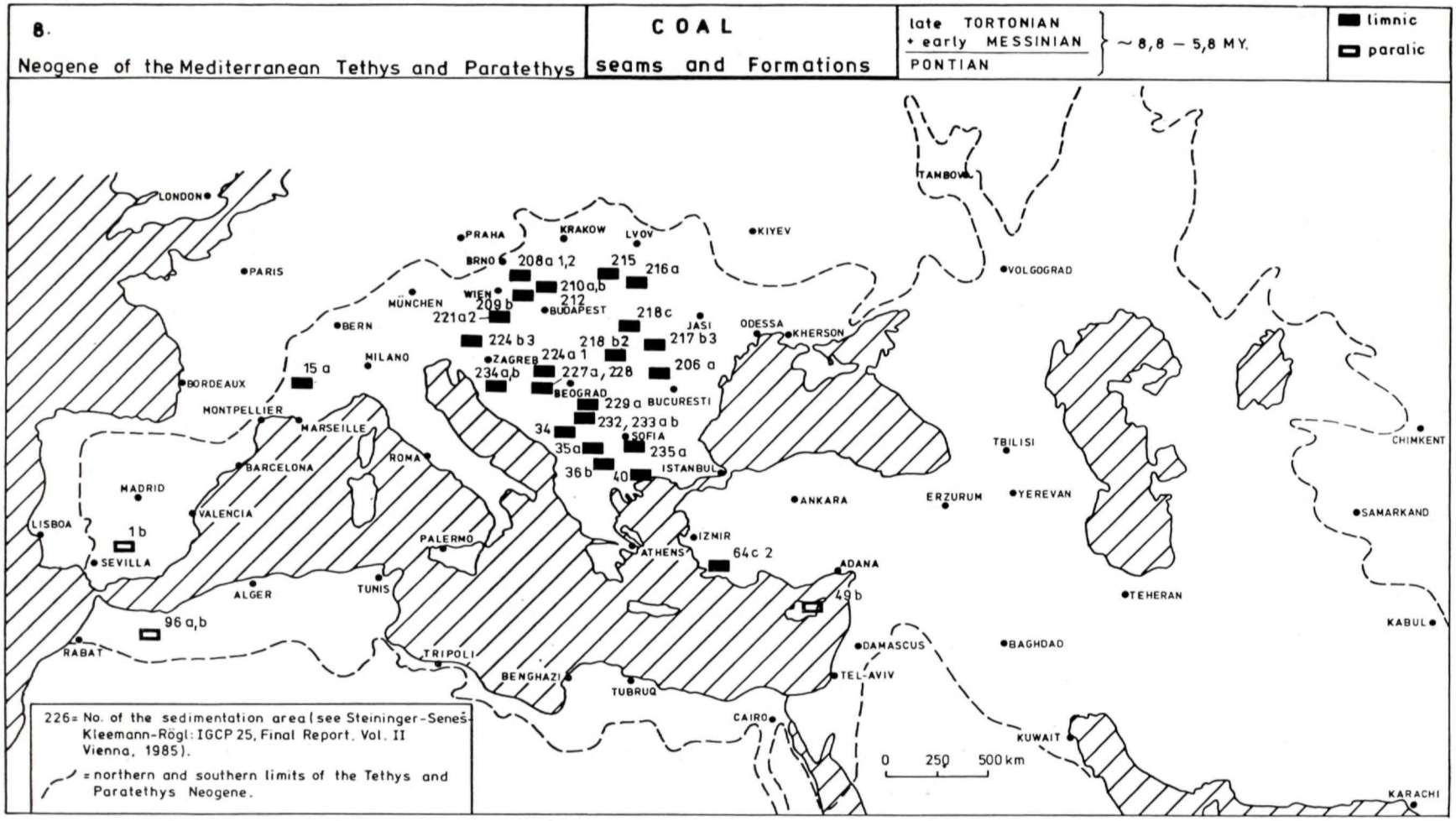

3.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
middle-late BURDIGALIAN
OTTNANGIAN
KOZACHURIAN
~18 - 17,4 MY.
limnic
paralic
LONDON
PARIS
BERN
BORDEAUX
MONTPELLIER
MARSEILLE
BARCELONA
MADRID
VALENCIA
LISBOA
SEVILLA
ALGER
TUNIS
RABAT
PALERMO
ROMA
MILANO
MÜNCHEN
WIEN
PRAHA
BRNO
KRAKOW
LVOV
KIYEV
BUDAPEST
ZAGREB
BEOGRAD
SOFIA
ISTANBUL
ATHENS
IZMIR
ANKARA
ADANA
TRIPOLI
BENGHAZI
TUBRUQ
CAIRO
DAMASCUS
TEL-AVIV
JASI
ODESSA
KHERSON
BUCURESTI
TAMBOV
VOLGOGRAD
TBILISI
ERZURUM
YEREVAN
TEHERAN
BAGHDAD
KUWAIT
KARACHI
KABUL
SAMARKAND
CHIMKENT
201 a
202 c
213 a,b,c
209 a
221 a1
222
200 b
221 b1
225
217 c
234 b
237 b
50 b
58 b
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.

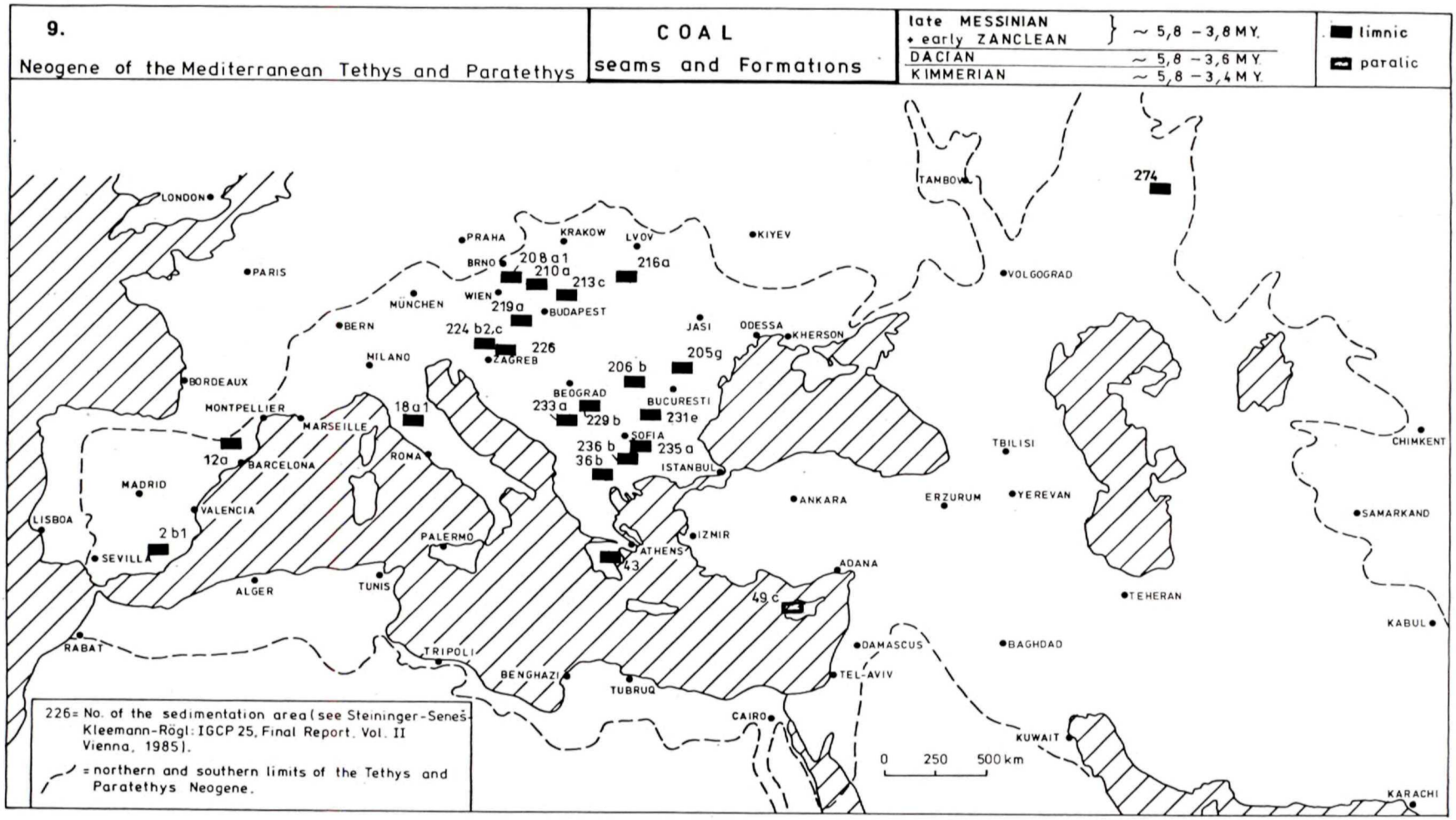

4.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
LANGHIAN
early BADENIAN
TARCHANIAN(?)
-TCHOKRAKIAN
~ 16,6 – 15,0 MY.
limnic
paralic
LONDON
PARIS
BORDEAUX
MONTPELLIER
MARSEILLE
BARCELONA
MADRID
VALENCIA
LISBOA
SEVILLA
RABAT
ALGER
TUNIS
PALERMO
ROMA
MILANO
BERN
MÜNCHEN
WIEN
BRNO
PRAHA
KRAKOW
LVOV
KIYEV
BUDAPEST
ZAGREB
BEOGRAD
BUCURESTI
JASI
ODESSA
KHERSON
SOFIA
ISTANBUL
ATHENS
IZMIR
ANKARA
ADANA
TRIPOLI
BENGHAZI
TUBRUQ
CAIRO
DAMASCUS
TEL-AVIV
TAMBOV
VOLGOGRAD
TBILISI
ERZURUM
YEREVAN
TEHERAN
BAGHDAD
KUWAIT
KARACHI
KABUL
SAMARKAND
CHIMKENT
302
101c
201b
202a
207a 1,2
207a3
207a4
219a
221a2
222
228
218 a 1,2
237 b
50 c
266
274
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.

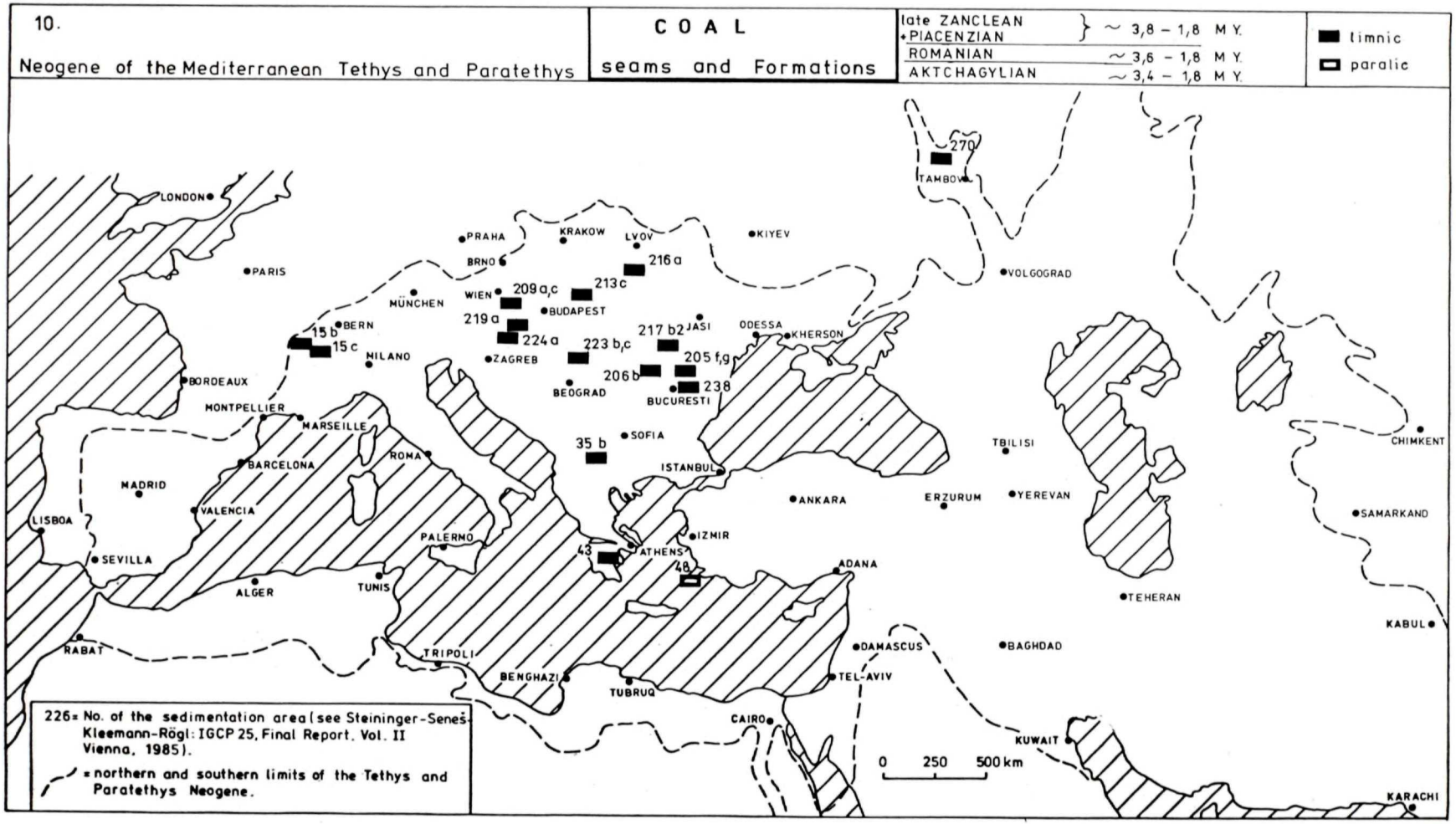

5.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
early - middle SERRAVALLIAN
middle - late BADENIAN
KARAGANIAN - KONKIAN
~15,0 – 13,8 MY.
limnic
paralic
LONDON
PARIS
PRAHA
KRAKOW
LVOV
KIYEV
BRNO
WIEN
209 b
MÜNCHEN
BUDAPEST
BERN
221 b1
JASI
ODESSA
KHERSON
MILANO
ZAGREB
218 a 2
230 a,c
BORDEAUX
234 d
BEOGRAD
229 a
BUCURESTI
MONTPELLIER
302
MARSEILLE
SOFIA
235 b
ROMA
BARCELONA
ISTANBUL
55
MADRID
VALENCIA
LISBOA
2b 4
PALERMO
IZMIR
SEVILLA
ATHENS
ADANA
ALGER
TUNIS
RABAT
TRIPOLI
BENGHAZI
TUBRUQ
DAMASCUS
TEL-AVIV
CAIRO
TAMBOV
VOLGOGRAD
TBILISI
ANKARA
ERZURUM
YEREVAN
TEHERAN
BAGHDAD
KUWAIT
CHIMKENT
SAMARKAND
KABUL
KARACHI
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report. Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.


6.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
middle-late SERRAVALLIAN
+early TORTONIAN
SARMATIAN s.str.
VOLHYNIAN-early BESSARABIAN
~13,8 -11,8 MY
limnic
paralic
LONDON
PARIS
PRAHA
KRAKOW
LVOV
KIYEV
TAMBOV
VOLGOGRAD
BRNO
202 a
211
215
274
MÜNCHEN
WIEN
BUDAPEST
221 a 2
BERN
JASI
ODESSA
KHERSON
221 b 1,2
MILANO
17 c
ZAGREB
242 a
BORDEAUX
BEOGRAD
233 b
BUCURESTI
MONTPELLIER
MARSEILLE
SOFIA
TBILISI
CHIMKENT
BARCELONA
ROMA
ISTANBUL
62
MADRID
ANKARA
ERZURUM
YEREVAN
4
VALENCIA
LISBOA
60 d
IZMIR
SAMARKAND
PALERMO
SEVILLA
ATHENS
ADANA
ALGER
TUNIS
42 d
TEHERAN
113
46 c
49 c
KABUL
RABAT
TRIPOLI
DAMASCUS
BAGHDAD
BENGHAZI
TEL-AVIV
TUBRUQ
CAIRO
KUWAIT
0 250 500 km
KARACHI
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.


7.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
middle TORTONIAN
late PANNONIAN
(late MALVENSIAN)
MAEOTIAN
~ 9,6 – 8,8 MY.
limnic
paralic
LONDON
PARIS
PRAHA
KRAKOW
LVOV
KIYEV
TAMBOV
VOLGOGRAD
BRNO
WIEN
MÜNCHEN
BUDAPEST
BERN
MILANO
ZAGREB
JASI
ODESSA
KHERSON
BORDEAUX
MONTPELLIER
MARSEILLE
BEOGRAD
BUCURESTI
SOFIA
ROMA
BARCELONA
MADRID
VALENCIA
LISBOA
SEVILLA
PALERMO
ISTANBUL
ATHENS
IZMIR
ANKARA
ERZURUM
YEREVAN
TBILISI
CHIMKENT
SAMARKAND
ADANA
TEHERAN
KABUL
ALGER
TUNIS
RABAT
TRIPOLI
BENGHAZI
TUBRUQ
DAMASCUS
TEL-AVIV
BAGHDAD
CAIRO
KUWAIT
KARACHI
271
214
215
208 a1
210 a,b
221 a 2
17c
15c
234 a
233 a
35 a,b
36 b
51 a
50 f 1
58 b
64c 3
111
112
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report. Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.


8.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
late TORTONIAN
+ early MESSINIAN
PONTIAN
~ 8,8 – 5,8 MY.
limnic
paralic
LONDON
PARIS
BERN
MÜNCHEN
WIEN
PRAHA
BRNO
KRAKOW
LVOV
KIYEV
TAMBOV
VOLGOGRAD
BORDEAUX
MONTPELLIER
MARSEILLE
MILANO
ZAGREB
BEOGRAD
BUDAPEST
BUCURESTI
SOFIA
ISTANBUL
ODESSA
KHERSON
JASI
ROMA
BARCELONA
MADRID
VALENCIA
LISBOA
SEVILLA
ALGER
TUNIS
PALERMO
TRIPOLI
BENGHAZI
TUBRUQ
RABAT
CAIRO
ATHENS
IZMIR
ANKARA
ADANA
DAMASCUS
TEL-AVIV
BAGHDAD
KUWAIT
TEHERAN
ERZURUM
YEREVAN
TBILISI
CHIMKENT
SAMARKAND
KABUL
KARACHI
15 a
1 b
96 a,b
221 a 2
209 b
208 a 1,2
210 a,b
212
215
216 a
218 c
224 b 3
218 b 2
217 b 3
224 a 1
206 a
234 a,b
227 a, 228
229 a
232, 233 a b
34
35 a
36 b
40
235 a
64 c 2
49 b
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report. Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.


9.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
late MESSINIAN + early ZANCLEAN ~ 5,8 – 3,8 M.Y.
DACIAN ~ 5,8 – 3,6 M.Y.
KIMMERIAN ~ 5,8 – 3,4 M.Y.
limnic
paralic
LONDON
PARIS
BORDEAUX
MONTPELLIER
MARSEILLE
BARCELONA
MADRID
VALENCIA
LISBOA
SEVILLA
ALGER
TUNIS
RABAT
BERN
MÜNCHEN
MILANO
ROMA
PALERMO
TRIPOLI
BENGHAZI
TUBRUQ
PRAHA
BRNO
WIEN
KRAKOW
LVOV
BUDAPEST
ZAGREB
BEOGRAD
SOFIA
ATHENS
ISTANBUL
IZMIR
ANKARA
ADANA
CAIRO
DAMASCUS
TEL-AVIV
KIYEV
JASI
ODESSA
KHERSON
BUCURESTI
TAMBOV
VOLGOGRAD
TBILISI
ERZURUM
YEREVAN
TEHERAN
BAGHDAD
KUWAIT
KARACHI
KABUL
SAMARKAND
CHIMKENT
12a
2 b1
18 a1
224 b2,c
226
219a
208 a1
210 a
213 c
216a
206 b
205g
233 a
229 b
231e
236 b
36 b
235 a
43
49 c
274
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.


10.
Neogene of the Mediterranean Tethys and Paratethys
COAL
seams and Formations
late ZANCLEAN + PIACENZIAN ~ 3,8 – 1,8 M.Y.
ROMANIAN ~ 3,6 – 1,8 M.Y.
AKTCHAGYLIAN ~ 3,4 – 1,8 M.Y.
limnic
paralic
LONDON
PARIS
PRAHA
BRNO
KRAKOW
LVOV
KIYEV
VOLGOGRAD
TAMBOV
270
216 a
213 c
209 a,c
WIEN
MÜNCHEN
BUDAPEST
219 a
224 a
223 b,c
217 b2
JASI
ODESSA
KHERSON
205 f,g
206 b
238
BUCURESTI
BEOGRAD
ZAGREB
MILANO
BERN
15 b
15 c
BORDEAUX
MONTPELLIER
MARSEILLE
BARCELONA
ROMA
MADRID
VALENCIA
LISBOA
SEVILLA
ALGER
TUNIS
PALERMO
35 b
SOFIA
ISTANBUL
ATHENS
43
48
IZMIR
ANKARA
ERZURUM
YEREVAN
TBILISI
CHIMKENT
SAMARKAND
ADANA
TEHERAN
KABUL
RABAT
TRIPOLI
BENGHAZI
TUBRUQ
DAMASCUS
TEL-AVIV
BAGHDAD
CAIRO
KUWAIT
KARACHI
0 250 500 km
226 = No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.

Uhoľné ložiská a uhľonosné formácie neogénu mediteránnej tetýdnej a paratetýdnej oblasti; aplikácia výsledkov projektu IGCP č. 25; časť 2.

Ukončenie projektu poskytlo možnosti analyzovať okrem vekového a priestorového rozšírenia aj podmienky vzniku vrchnooligocénnych a neogénnych limnických a paralických uhľonosných súvrství na interkontinentálnom území medzi Atlantikom a Indopacifikom. Na priložených mapách sú vyznačené výskyty v jednotlivých obdobiach podľa ich limnického alebo paralického pôvodu (obr. 1—10).

Pri ich hodnotení sa nezameriavame na ich autochtónny alebo alochtónny charakter, lebo nie je ovplyvnený interregionálnymi geologickými udalosťami. Preferujeme ale závažnú „problematiku" ich limnického alebo paralického pôvodu, keďže táto charakteristika by mala mať nesporne geodynamické pozadie.

Žiaľ, pri používaní pojmov „limnický" a „paralický" (dodnes nedostatočne definované) narážame na ťažkosti v tom, že samotné výrazy patria do úplne odlišných kategórií pojmov. „Limnický", teda sladkovodný, označuje jasne protiklad morského. „Paralický" však nemá nič spoločného s odstupňovaním slanosti, ale označuje *paleogeografickú* polohu ložiska, predpoklad, že súvrstvie alebo ložisko vzniklo rovnobežne s otvorenou vodnou plochou, od ktorej mohlo byť viac-menej oddelené. Rozhodne však aj takáto, tzv. paralická, vodou aspoň sčasti zaplavená prehlbenina s bujnou vegetáciou mohla mať (a obyčajne aj mala) sladkovodný režim. Aj z hľadiska lingvistického významu pojmov je teda oprávnená otázka, či v určitých prípadoch ide o panvu limnického alebo paralického pôvodu.

Za uhľonosné súvrstvia limnického pôvodu pokladáme výskyty alebo panvy, ktoré vznikli v extrémne veľkých vysladených regiónoch alebo v ich okrajových, plytkých, odškrtených panvičkách. Za paralické pokladáme uhľonosné súvrstia, ktoré vznikli prevažne v čele subsidenčných sné súvrstia, ktoré vznikli prevažne v čele subsidenčných transgresívnych morských oblastí.

Treba si ale uvedomiť, že bez ohľadu na značne znížený alebo polyhalinný charakter materského prostredia uplatňovali sa v ich paleogeografickej sfére väčšinou tie isté zákonitosti geodynamických procesov, teda aj emergencie a subsidencie, transgresie a regresie.

Pri hodnotení obidvoch prostredí berieme do úvahy predovšetkým epeirogénne, a nie orogénne pohyby. To hlavne z dôvodu, že striedanie litologického charakteru sedimentov v rámci cyklu vzniku jednej uhľonosnej formácie poukazuje temer vždy na striedavú, ale celkove pomalú intermitentnú subsidenciu, a to temer vždy, bez ohľadu na to, či sa odohráva ohraničene pozdĺž zlomov alebo celkovým plastickým ohybom podložia. Je samozrejmé, že tieto úvahy nás oprávňujú klasifikovať paralické, ale aj limnické panvy ako iniciálne a finálne.

Pri analýze časového a priestorového rozšírenia uhľonosných sedimentov na rozlišovanie limnického od paralického charakteru definujeme kritérium izolovanosti alebo spojitosti (paleogeografická poloha) ložiskovej oblasti s „materským" vodným režimom. Za paralické ich pokladáme pri ich spojitosti s normálne slaným morom a za limnické v prípade, keď „materská" panva bola už od mora s normálnou slanosťou paleogeograficky vzdialená.

Za limnické pokladáme preto napr. uhľonosné polohy sarmatu, panónu, pontu v oblastiach Paratetýdy, pretože boli od neogénnej Tetýdy akvaticky úplne izolované a ich „materskou" oblasťou boli síce geograficky rozsiahle, no s vtedajšími moriami už nekomunikujúce sladkovodné alebo väčšinou brakické jazerá. Oproti tomu uhľonosné súvrstvia v rovnakom období tetýdnej oblasti, teda v seravale, tortóne, messiniane (pokiaľ nejde o tamojšie menšie, vyslovene izolované jazerá vo vnútrozemiach), označujeme ako paralické.

Na základe týchto kritérií zisťujeme, že zo 160 nami registrovaných význačnejších uhľonosných výskytov alebo formácií v neogéne medzi Atlantikom a Indopacifikom vzniklo 114 v limnickom a len 46 v paralickom prostredí. Súhrn počtu, veku a charakteru uhoľných výskytov a formácií znázorňuje okrem priložených máp aj tab. 1.

Vekove zrejmá je prevaha limnických výskytov a ložísk v období začínajúcom sa v sarmate (s. s.), so zvyšujúcou sa tendenciou v panóne, ponte a v pliocéne. Oproti tomu výskyty a ložiská paralického charakteru prevládajú vo vrchnom oligocéne, v spodnom a temer v celom strednom miocéne.

Uhľonosné sedimenty vykazujú značnú diferenciáciu priestorového rozloženia. Od konca oligocénu až po začiatok stredného miocénu sú ložiská limnického pôvodu prevažne len v južnej Európe a na Blízkom Východe na hraničnom území medzi mediteránnou Tetýdou a Paratetýdou. Najviac sedimentov paralického charakteru je v tomto období na území centrálnej a západnej Paratetýdy. Opačne je to vo vrchnom miocéne a v pliocéne, keď zvlášť v dôsledku izolácie paratetýdnych morí od mediteránnej Tetýdy a od Indopacifiku vznikol veľký počet hlavne panónskych, pontských a pliocénnych lignitových ložísk limnického pôvodu. Paralické ložiská sa v tomto období vyskytujú len v malom počte, prevažne v dnešnej mediteránnej oblasti.

Je samozrejmé, že na základe časového a priestorového rozloženia, ako aj charakteru uhľonosných formácií medzi vrchným oligocénom a pliocénom môžeme ďalej usudzovať tiež na zmeny paleoklimatické, zmeny smerov transgresie a regresie, teda obdobia subsidencie alebo emergencie jednotlivých oblastí. Analýza veku, pôvodu a rozmiestnenia uhľonosných sedimentačných formácií má teda nesporne význam pre geodynamicko-paleogeografické a domnievame sa, že aj pre palinspastické interpretácie.