ANALELE ŞTIINŢIFICE ALE UNIVERSITĂŢII „AL. I. CUZA" IAŞI
Geologie. Tomul LIII, 2007

COAL GENESIS, QUANTITATIVE AND QUALITATIVE FACTORS IN THE COMANESTI BASIN AND IN THE FALTICENI AREA

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Abstract

We have analyzed the quantitative and qualitative factors which controlled the coal genesis in the Comăneşti Basin and in the Fălticeni area.

The superior ranks in the Comanesti Basin are reached due to the following factors: the geothermic gradients have high values; the tectonic factors have an active role in the formation of the basin. The coaling degree reached is reflected by the caloric power (Table 4) of the coal petrographic constituents illustrated in Table 3.

The other coal-bearing formations are the superior Volhynian at Fălticeni (12-13 m.y) and the Upper Bessarabian – Chersonian at Comanesti (10-11 m.y.). The depth of these formations is not the source of their difference; the generating paleoflora, which is arborical, is generally characteristic to forestrial peat bogs in both cases.

Keywords: tectonics, gitology, subsidence, accumulation rate, paleophytocenose, paleotemperature, geologic age.

The Comanesti Basin deposits were formed in the Lower Bessarabian – Chersonian stratigraphic period, while those in the Faltineni area were formed during the Volhynian. However, they all belong to the East Carpathian foreland basin.

There are major differences between the two areas, mainly because of a different subasement, whose initial tectonics and evolution during this stratigraphic period influenced the number of coal strata, along with their thickness and their spreading area, decisively.

We will analyze the main qualitative and quantitative factors that controlled the coal genesis in these two regions, namely the paleography and tectonics, the accumulation rate of the organic material and the gitology, all from a quantitative point of view, and the paleophytocenoses, the paleotemperatures and the influence of geologic time from a qualitative point of view.

Numerous authors have already studied the paleography and the tectonics of the basin filling formations, as well as those of the subasement.

Micu et al. (1985) described the first complex genetic model of coal deposits and devised the geologic map of the Comanesti Basin.

The initial extension of the basin formations was much larger at first, as the isolated patches of erosion show in the south of the Doftana basin and in the north of the Tasbuga foot. There is a conglomeratic Sarmatian patch in the north, upstream the Tazlaul Sarat River, near Bolatau, which proves that the initial extension of the basin was almost double in the north-south direction.

The raising movements of the subasement reverse faults were greater than the ulterior deposits of the basin formations, permitting, thus, the superposition of the Paleogenic subasement formations over the Sarmatian ones (the Galeon-Tigla fault) or of the Sarmatian formations over the younger Meotian ones (the Leorda-Valea Rea fault). The same authors mentioned the faults west of the Trotus using the mapping data and those resulted from the drillings for coal, while in the eastern sector, between Comanesti and Moinesti, the subasement faults can be traced using the data provided by the drilling for hydrocarbon.

The tectonic style is rendered by a greater redressing of the western sides, which leads to a dissymmetry of the cuvette axis, which is shifted eastwards, as can be seen in Fig. 1.

The section was made after the geologic map of the Comanesti basin, 1: 50.000 (Micu and Ticleanu), and the isobate map of the Paleogenic subasement (geological report). For the Vasiesti Cuvette subasement, the data from the hydrocarbon drillings were used.

An initial individualization of the cuvettes is recognized paleogeographically due to an erosion period that preceded the flooding of the basin during the Upper Bessarabian. The ulterior evolution of the basin and the reactivation of the subasement faults determined the subsidence rhythms which permitted or not the installment of the telmatic environment and, afterwards, the formation of the coal strata. The cuvettes are placed on five parallel alignments, namely, from west to east, Lapos, Asau-Salatruc, Laloaia-Galeon, Vasiesti-Darmanesti-Dofteana and Larga.

Grasu et al. (2004) established a tectonic model in the evolution of the basin. The distension and the subsidence are initiated due to the reactivation of the subasement longitudinal faults that influence the three digitations of the Tarcau Thrust and, consequently, these structures and the cuvettes are placed approximately parallel from north to east.

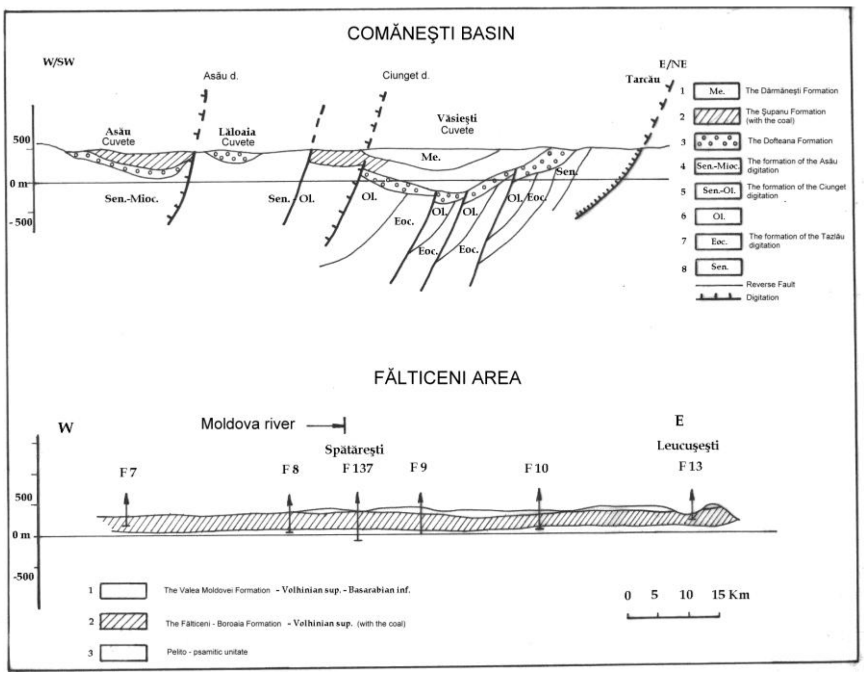

Fig.1. Geological section

The thickness of the deposits within the cuvettes grows from west to east and this is the result of the deforming of a sedimentary prism that is thicker to the east, as well as of ulterior erosion.

In the section visible in Fig. 1, we are on the northern pericline and the cuvettes represented are Asau, Laloaia and Vasiesti. The section was made after the geological map of the Comanesti basin 1:50.000 (Micu and Ticleanu, 1985) and the isobate map of the Paleogenic subbasement (geologic report), while for the Vasiesti cuvette data from hydrocarbon drillings, which recorded different formations of the subasement, were used. The basin formations lie over the Oligocene or Eocene digitations of Ciunget and Tazlau. The reverse faults which give the complexity of the subasement structure were reactivated and those represented by us have a large enough jump to bring Eocene formations over Oligocene ones.

Their reactivation led to the substratum unevenness that, in turn, determined the unevenness of the entire area of the coarse detritic formation deposited at its base. Given the fact that the water is deeper here, it did not allow the appearance of peat bogs, and the detritic formations accumulated in the Sarmatian are separated into three complexes, namely Sa. basal, Sa intermediate and Sa superior, with porosities of 10-20%, all with a reservoir rock character, but the hydrocarbons of the deposit are tertiary migrated from the productive Oligocene and Eocene formations of the subasement. There are no oil mother rocks in the basin formations.

The great unevenness of the extension area of the coal strata and the existence of Paleogenic crests are arguments in favour of the assumption that not all vegetal matter has been transformed into coal. The initial extension of peat bogs cannot be estimated, but, surely, there were emersion zones that did not enter the coalification process, the vegetal matter being destroyed there.

The main argument in favour of the subdivision of the peat bog sector was underlined by Chiriac (1959) and Givulescu (1996), and it is represented by the different distribution of coal strata from one cuvette to another. In small cuvettes, coal strata are placed in the middle, while in the large Vasiesti-Darmanesti-Dofteana cuvette it lies on the sides, coal being replaced by coal schists and black clays in the middle. In Ghivulescu's opinion, the main cuvette functioned atypically from the perspective of coal genesis. The development of the peat bogs and the accumulation of organic matter were short-timed and they repeated less than within the small cuvettes. These strata are not uniform on all sides; they are more developed in the south and become thinner to the north, the peat bog acquiring a semicircle aspect on the eastern, southern and western sides.

It is known that, out of the three possible relations between the subsidence (Vs) and the accumulation (Va) of the vegetal matter, only the relative equilibrium one, when Vs=Va, is favourable to the formation of a peat bog and it is mandatory that it be covered by water afterwards so that the hydrostatic level in the swampy forest that generates the vegetal organic matter be 0.2-0.5-1 m high.

In the other two cases, either the subsidence is active, the water depth increases and the sedimentation becomes detritic, at Vs>Va – the Vasiesti Cuvette, or the vegetal matter reaches the aerobian medium and it is subjected to degradation under the influence of external factors, at Vs < Va.

All three situations are found in the Comanesti Basin due to the tectonic activity that led to different rhythms of the subsidence. They are shown in Fig. 1: the Asau cuvette, Vs=Va, has the longest equilibrium time and the result is the presence of the most strata (8+1), with the greatest thicknesses, all being exploitable, the Vasiesti cuvette, Vs>Va, with coal strata only on the sides and great water depth in the middle, with detritic sedimentation, and the Laloaia cuvette, Vs<Va, without a coal formation.

From a tectonic point of view, the Falticeni area is situated on a fallen block of the East-European crystalline footing west of the Siret fault (Visarion et al.)

The foreland basin took shape here during the Badenian, over a paleorelief resulted from a previous exondation, Cretacic-Lower Badenian in age. The Miocene deposits have a greater thickness here in comparison with the eastern part of the platform and, in agreement with the model proposed by Grasu et al. (1999), this area superposes the depozone over the foredeep in the east and over the wedge in the west. The progressive thinness of the hinterland is characteristic to the wedge top sediment, while at the limit between the depozone and the foredeep its thickness should be maximum.

In his doctoral thesis, Tibuleac pointed out the existence of a previous relief, represented by a depression on the Sasca-Praxia direction, surrounded by a higher frame to the west, north and north-east, using as a guide-mark the coal strata for which he realized the isobate map of the layer (str. B and C). This bay of the Sarmatian Sea was supposedly losing its connection with the basin temporally and the appearance of telmatic media became, thus, possible. The phenomenon takes place in the general context of the south-east withdrawal of the Sarmatian Sea, due to the building of the Carpathian Orogen in the Moldavian phase of the orogenesis.

The appearance of the peat bogs that generated the coal alternated several times, taking into consideration the local variations of the withdrawal under the influence of the tectonic factor and of the sea level fluctuations in the littoral plain of the Sarmatian Sea.

In the section visible in Fig. 1, devised on the west-east direction, the coal formation (Falticeni-Boroaia, Upper Volhynian) was illustrated using drilling data.

Gitology

The accumulation rate of the organic matter represents another qualitative factor reflected by gitology. The accumulation of vegetal matter is controlled by subsidence and by climate factors that determine the vegetation type.

Micu et al. (1981, 1985) considers that, based on paleofloristic data in the Upper Bessarabian – Chersonian period, there might have been a temperate-warm to subtropical climate with high humidity which favoured the development of vegetation in the Comanesti basin area. The same climate can be accepted for the Falticeni area as well (the paleoflora signaled on the Tiganca-Rasca stream by Tibuleac (1998).

The sedimentary stack of the Comanesti basin was separated into three formations: Dofteana, Supanu and Darmanesti. The Supanu coal formation is of an age determined on the basis of the Upper Bessarabian – Chersonian mollusks, which means an absolute age of approximately 1.5 m.a. (following the stratigraphic scale of the Central and Eastern Paratethys, Steininger et al., 1996). In the Asau cuvettes, where the subsidence was favourable for a longer period of time, the coal-bearing formations reach a 300 m thickness, and the added thickness of the coal strata is of only 7 m, as can be seen in Tale. 1. Given a peat sedimentation rhythm of 1m/750 years (Nerbert, 1989) and a reduced sinking coefficient of 2.5 (specific to forestrial peat bogs), the 7 m of coal formed in approximately 13-15.000 years.

If we consider this time interval in relation to the period of sedimentation of the 1.5 m.y. formation, we will notice that the telmatic environment that generated the peat settled in a very short time.

The great variety of the number of strata from one cuvette to another, within the cuvettes from the sides to the center or from north to south, the existence of the complex strata and even the modification of the thickness of the main strata (see table below) show a permanent migration of the optimum conditions of the telmatic environment, which takes place under the influence of a permanent tectonic activity.

Table 1

Stratum Thickness (m)	Razesu - Biţoianu	Chiriac	Petrescu (1987)	Barren gangue
str. 10	0.55		0.55	
Agachi-8	0.35-0.41	0.02-1.35 (N)	0.30-0.70 (N)	0.15 (S)-85-90 max
Chivoiaia-7	0.35	0.02-0.55 (V)	0.30-0.45	27-32
Chiricel 1-6	0.35-0.70		0.35-0.70	20-25
Wagner-5	0.35-1.00	0.02-0.92 (S)	0.55-1.50	20-25
Coroban-4	0.30-0.50	0.02-0.05 (S)	0.35-0.75	2-8
Irina-3	0.38-0.45	0.02-0.30	0.65 (centru)	8-15
Kalk-2	0.30-1.00	0.01-0.63 (S)	0.30-0.65	40-50 max
Maria-1	0.70-2.00	0.002-0.40 (N)	0.70 (N)	25-50; 10-30
SUBASEMENT				

The largest cuvette (Vasiesti-Darmanesti-Dofteana), both as sediment extension and maximum thickness reached, namely 800m, is divided into three main compartments by big unhooking on the north-south direction, the northern one, the Vasiesti cuvette, being represented on the section in Fig. 1. Here, in the axial zone, the water depth was great during the entire period and, consequently, there are no coal strata.

The great unevenness of the coal strata and the existence of Paleogenic crests are arguments that lead to the assumption that not all the vegetal matter accumulations were transformed into coal. The initial extension of the peat bogs cannot be estimated, but there surely existed emersion zones that did not take part in the coal genesis process, the vegetal matter accumulated here being destroyed.

Apparently, a greater area mobility existed in the Falticeni area, where coal strata are due to a separate block of two faults approximately west-east, south of Falticeni, respectively north of Targu-Neamt (Visarion, 1995). This mobility allowed a smaller subsidence rate installment than in the Comanesti basin.

The foreland deposits have three lithostratigraphic units here, as can be seen in Fig. 1.

The coal-bearing formation of Falticeni-Boroaia, of an Upper Volhynian age, has 22-29 lens, lamines and coal strata (Tibuleac, 1998). On the littoral plain appeared on the border of the Sarmatian Sea, the installment of peat bogs generating coal succeeded several times, depending on the local variations of the withdrawal, under the influence of the tectonic factor and the sea level variations.

There are four strata (A; B; C; D), uneven for the whole area and with variable thickness, as can be seen in Table 2. The results obtained from the F137 Spataresti drilling are important at a regional level. What is remarkable is the fact that, apart from the four main coal strata (A, B, C, D), coal, lamines, clayey coal or coaly clay and impressions of leaves can be found before the D stratum is reached.

Each main stratum is, therefore, divided into three or four beds; the coal is not uniform and the strata thicknesses vary a great deal (see Table 2).

Table 2

Stratum number	Average thickness (m)	Thickness variations	Gangue among strata
A	0.21	0.02-1.21	80-100
B	0.50	0.02-1.67	60; 70-100
C	0.33	0.02-1.60	70-90 about the strata D
D	0.29	0.06-0.80	

The B and C strata are identified at the scale of the entire area; the D stratum is known only in the southern part; in the north, where the section in Fig. 1 is traced, the drillings were stopped at the level of the superjacent deposits, and the A stratum was mostly eroded, being sporadically known from the outcrops.

Among the factors that determine the most important qualities of coal, we could mention the generative paleoflora, the paleotemperatures and the realization of a sinking depth due to the lithostatic pressure exercised throughout geological time, which is proven to lead to an increase in the quality of deeper strata, compared to those closer to the surface.

Table 3

%	Comănești BS		Fălticeni BL	
textinite texto-ulminite ulminite	- - -	- - -	33.5	12.5
cutinite	-	-	-	2
sclerotinite	-	-	-	8
rezinite	-	-	14	-
suberinite	-	-	9	-
fuzinite	-	-	6	-
TOTAL	-	-	62.5	22.5
gelinite	18	4-8	8	-
vitrinite	59.6	50-65	-	-
liptinite	12.1	2-8	-	-
inertinite	2.1	4-7	-	-
	0.8	1-3	-	-
TOTAL	92.6	75-85	8	-
pyrites	3.4	5-8	2	2.25
Clay min.	4	10-20		
Barren gangue	7.4	15-25	27.5	74.25
TOTAL	100 %	100 %	100 %	100 %

a – mean of 5 samples of washed coal; b – samples collected in several periods of time; c – B stratum (I+III); d – B stratum (II+IV)

The quality of coal is reflected directly by its caloric power. The qualitative difference between the two areas is clear. The coaling degree reached by the coal in Falticeni ranks it, according to the classification in Table 3, as being of a lower degree, with a caloric power of 1860-4680 Kcal/Kg (Tibuleac, 1998), namely earthy brown coal and lignite, while in the Comanesti basin the coaling rank is medium, with a caloric power of 5700-7000 Kcal/Kg, dull brown coal and shiny brown coal.

The coaling degree reached is reflected by the petrographic constituents of the coal, which are different in the two areas, as can be seen in Table 4.

Table 4

Kcal/Kg	Internal classification 1992			Romania	Comanesti	Falticeni
3500 5700 6100 7200	Lignite	C B A	Low rank	Peat b.c. Lignite c.b. mat 5700-6700	5700	1860 4680 Sup. Caloric power
7750	Bituminous	D	Medium rank	Shiny b.c.6000- 7200	7000	
8450		C				
				pitcoal		
		B				
		A				
	Anthracite	C	High rank			
		B				
		A				

x – superior caloric power in relation to combustible matter (Kcal/Kg)

In the Comanesti basin, the autochthony is proven by the existence of coniferous roots. The coal strata were petrographically proven and studied by Razesu and Bitoianu (1970), who showed the predominant role of vitrain (50-60%), as can be seen in Table 4, to which other macerals are added, depending on the type of coal-generating vegetation: cutinite subrinite in leafy trees and resinite in conifers. On the whole, the majority are macerals of superior coal.

In Falticeni, the higher areas on the side of the depression are characterized by a treelike vegetation of conifers that generated the xilitic lithotype, while in the south-central area the water was deeper, the vegetation predominantly grassy and, consequently, the generated lithotype is the detritic one.

The macerals signaled by Tibuleac (1998) are characteristic to inferior coal: textinite and ulminite are predominant, while suberinite, cutinite, sclerotinite and resinite appear subordinately.

By analyzing the contribution of the qualitative factors, we will establish the aspects presented below.

The generating flora

While referring to the Comanesti basin, Givulescu underlined in 1996 the fact that the paleofloristic association presented by Micu et al. represents a typical swampy forest association with Osmuda, Glyptostrobus, Byttneriophyllum and Alnus, which characterize the biotope without any age signification for coal-bearing formations dated on a mollusk basis.

This association is present in the western part of the country, but on younger, Pontian and Dacian formations.

The same author emphasizes the fact that, although Glyptostrobus and, to a lesser degree, Taxodium are well represented macroscopically, the leafy trees of the Alnus type, not the conifers, had a predominant role in the swampy forest being the coal-generating mass. The autochthony is confirmed by the presence of the conifer roots.

The paleoflora identified by Tibuleac (1998) in the Falticeni-Sasca-Raucesti area consists of small vegetation samples, but we can notice the predominance of angiosperms in relation to conifers, represented here by the Glyptostrobus and Pinus species.

Parallel to the situation between the Nistru and the Prut (Stefarta, 1997), Tibuleac (1998) notices the presence of a tropical-subtropical type paleoflora for the Lower Sarmatian at Rasca and of an Arcto-Tertian one, with Acer, Corylinus Carpinus, Betula and Vitis, which settles down in the Middle Sarmatian, similar to the eastern Prut area identified both in Rasca and in the Falticeni-Sasca-Raucesti area.

The paleotemperatures

Taking into account the thermic flux map of Eastern Europe (Cermak and Hurting, 1972; from Negut, 1982), the Falticeni area ranks within lower values than 40mW/mx, while the Comanesti basin ranks within higher values, namely 60mW/mx. This is normal because platform areas are generally characterized by a low thermic flux.

Without being able to appreciate which is the significance of these different geological factors, we notice that in the case of geothermic gradients the same differences are recorded. Taking into account the temperature data measured at hydrocarbon drillings, V. Negoita, 1970, established the following: for the Comanesti basin – 2.3°C/100 m Dofteana, 2.45 °C/100 m Moinesti, and 2.4°C/100 m Lucacesti; for the Falticeni area the nearest values are: Tg. Neamt 2, 05°C/100 m, Bodesti 1.85°C /100 m. At Horodniceni, the geothermic gradient value is 2.29°C/100 m (Cirimpei C., 2002), but it was determined by taking into consideration a single temperature measurement.

We shall notice that, given the fact that the temperatures were not measured in all drillings at the same depth and under the same conditions, the gradient values measured should not be considered exact. However, the tendency illustrated by them is obvious.

According to Tissot and Welte (1984), the transition from inferior to superior coal takes place at a vitrain Ro 0.5% reflectance, occuring at temperatures of 60-80 °C, or, in other words, when the temperature reaches the value which gives the diagenesis and chartagenesis limit.

As was proven in other cases, superiors ranks are reached when the geothermic gradients have high values due to magmatic intrusions. The Neogene East Carpathian volcanism increased the temperature in the nearby areas, and the secondary products, such as gases, reached the phreatic waters in Slanic-Moldova, mineralizing them.

In conclusion, the inner temperature in the Comanesti Basin, on Carpathian Orogen and a western volcanic chain, is higher than in the Falticeni area, on a stable sedimentary platform with a thick sedimentary stack.

The lithostatic pressure exercised through the thickness of the sedimentary stack mentioned above has a minor role. It is comparable in the two cases, as can be seen in Fig.1, and the present coal afloration is due to erosion in both cases.

The effect of the lithostatic pressure on the peat stratum is physical and it determines the compactness and the elimination of water, and some of the chemical transformations are linked to the water eliminated from the peat.

An increase in coal quality is not signaled either at Comanesti or at Falticeni.

By analyzing the most important qualitative and quantitative factors that were quantified in the two areas in order to see which of them determined the main difference in the attained coalification degree, we will conclude the following: the Comanesti shiny brown coal has a high caloric power (5700-7000 Kcal/Kg) and, petrographically, the superior coal macerals predominate, respectively vitrain (Table 3 and Table 4), while the pit brown coal and the Falticeni lignite have a low caloric power (1860-4680 Kcal/Kg), and the main macerals are those characteristic to inferior coal, textinite and ulminite.

The age of coal-bearing formations is not very different, Upper Volhynian at Falticeni (12-13m.y.) and Upper Bessarabian-Chersonian at Comanesti (10-11m.y.)

The burying depth of these formations (Fig. 1) is not the cause of their different degree of coalification, which is close, and in both cases erosion made the two formations aflorate.

The generating paleoflora, which is arborical, generally is characteristic to forestrial peat bogs, unimportant from the point of view of the age, being known both in the Sarmatian between Prut and Nistru (Stefarta, 1997) and in younger, Pontian and Dacian peat bogs in the west. (Givulescu, 1996).

The only major differences are those derived from the different tectonizing degree and the most important one is that given by the geothermic parameters which are unlike in the two areas.

From a tectonizing point of view, in accordance with the pattern suggested by Grasu et al., 2002, the ground listric faults have an active role in the formation of the basin. Here, the cuvette was shaped through a former erosion, therefore the paleography is not the principal factor which maintained and further increased the water depth, which in some cases was greater than the necessary one in the formation of peat bogs; subsidence played an important role, and the sedimentation was detritic.

As Tibuleac, 1988, noticed, the ground faults were reactivated at Falticeni as well, but in this case the tectonic factor is less important and it is illustrated by the simple tectonics of coal-bearing formations.

It is acknowledged that the tectonic factor firstly controls the coal strata thickness, so it has a quantitative aspect; yet, through the exercised pressures, others than the lithostatic one, which is given by the coal sinking depth, it can have positive influences over the rise of the coalification degree.

The most important role in the increase in coal quality through the attaining of a high coalification degree is given by the rise in temperature.

The Neogene volcanism in the west of the Comanesti Basin determined a rise in the temperature of the nearby areas, quantified in high values of the thermic flux and geothermic gradient, which permitted the increase of the coalification degree; the coals in this area are qualitatively superior to those in Falticeni and in other basins close geological ages throughout the country.

References

Givulescu, R., 1996. Turbăriile fosile din Terțiarul României. Ed. Carpatica, Cluj-Napoca, 1996

Grasu, C. et al., 2004. Geologia Bazinului Comănești. Ed. Tehnică, 2004

Micu, M., Țicleanu, N. et al.,1985. Geologia Bazinului Comănești. D.S. I.G.G. LXIX/1982

Panaitescu, Cornelia, Predeanu, Georgeta, 1999. Atlas carbopetrografic. Ed. Acad. Române, București, 1999

Petrescu, I. et al., 1987. Geologia zăcămintelor de cărbuni. Vol. 2, Ed. Tehnică, București

Preda, et al., 1994. Geologia zăcămintelor de cărbuni. Ed. Univ. București.

Țibuleac, P., 1998. Studiul geologic al depozitelor sarmațiene din zona Fălticeni - Sasca - Răucești, cu privire generală asupra stratelor de cărbuni (teză de doctorat, Iași, 1998).

Harta geologică, 1: 50.000 - foaia 63d Comănești.

Harta cu izobatele fundamentului paleogen, anexa 6 - Raport geologic 1981, Tema III/2 I.P.G.G. - București