ROLE OF JIU VALLEY HARD COAL DEPOSITS BETWEEN EASTERN AND WESTERN EUROPEAN ENERGETIC CONSTRAINTS

Grigore BUIA[1], *Professor Ph.D. eng., at University of Petrosani, Mining Faculty, Management, Environmental Engineering and Geology Department, Universitatii Street, No. 20, 32006, Petrosani, Romania, grigbuia@yahoo.com*
Csaba LORINȚ[2], *Lecturer Ph.D. eng., at University of Petrosani, Mining Faculty, Management, Environmental Engineering and Geology Department, Universitatii Street, No. 20, 332006, Petrosani, Romania, csabigeo@yahoo.com*
Ciprian NIMARĂ[3], *Assistant PhD, at University of Petrosani, Mining Faculty, Management, Environmental Engineering and Geology Department, Universitatii Street, No. 20, 332006, Petrosani, Romania, cikgeogra@yahoo.com*
Radu LUPULEAC[4], *PhD Student, University of Petrosani, l.radu.f@gmail.com*

ABSTRACT: *As a result of being part of European organizations, Romania took responsibility to produce until 2020 about 24% of its energy from renewable sources. Energy wise nowadays, hard coal gives 5-7% of the electrical energy produced in Romania. Based on this fact, but given the context of East-European conflict which can rewrite local and regional energy scenario, this paper analysis the opportunities of coal valorization, framed by the wider perspective of mineral production technologies, energy factors and geological reserves.*

KEYWORDS: *energy balance, Jiu Valley, hard coal deposit, geological reserves*

1. INTRODUCTION

The motivation of this paper appeared in the new geo-economic context created by the geopolitical changes in Europe and in particular in South-East Europe, Romania as well. In connection with this, we can highlight the following issues: the contribution of natural gas in the energy balance of the region in question is quite uncertain, due to the policy of Russia. Other sources, Turkmenistan, Iran, Iraq, which represent the replacement of one of the main supplier from this region (Russia) are in part difficult to become viable, due to the lack of transport infrastructure, and socio-political situation in the region and on the other hand, the policy of protectionist and intimidation promoted by Gazprom and Rosneft. In the same context, we noted that for the near future, the exploitation of shale gas in Southeastern Europe may not be a certainty. Taking into account the stated role of hard coal, even at that rate of 5-7%, it becomes important and a viable alternative in any geopolitical and more as geo-economic circumstances.

Currently, the mining activities in the Jiu Valley are carried out under the coordination of "Societatea Naţionala de Închideri Mine Valea Jiului" (the National Society of Mining Decomissioning Jiu Valley), within the perimeters of the mining sectors Petrila, Paroşeni and Uricani and also under the coordination of the entity known as "Complexul Energetic Hunedoara S.A" (Energy Complex Hunedoara). "Complexul Energetic Hunedoara S.A" was created by the unification of several commercial entities, namely "Electrocentrala Deva S.A.", "Electrocentrala Paroşeni S.A." and "Societatea Naţională a Huilei S.A."; its main role consists of electricity generation using hard coal sourced from the mining perimeters Lonea, Livezeni, Vulcan and Lupeni, Figure 1. (CEH Portal, 2014)

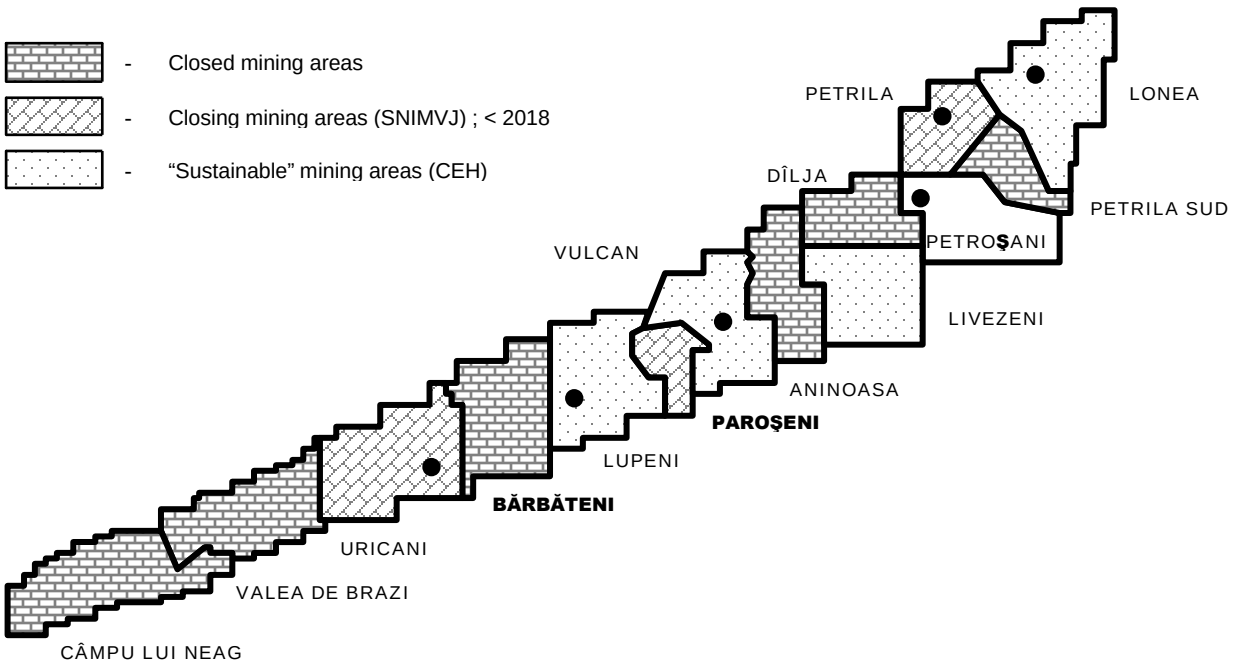

Figure 1. Spatial distribution and status of mining perimeters in the Jiu Valley

2. GEOLOGY OF THE STUDY AREA

The Jiu Valley (Valea Jiului) / Petroşani basin (Figure 2) is an asymmetrical synclinal structure formed during the Alpine orogeny, and sliced by transverse faults (Figure 2). The Jiu Valley basin, with a SW–NE orientation, is 48-km long and 10-km wide on the eastern side and 2-km wide on the western side; the coal mines are distributed along the center of the valley, following the western and eastern tributaries of the Jiu River (Figure 2).

The Jiu Valley basin (Figure 2) is underlain by a crystalline basement, filled with molasse sedimentary deposits. On the basin rims, rocks of Danubian and Getic ages crop out; these rocks are represented by Neoproterozoic, Paleozoic, and Mesozoic sedimentary, volcanic and magmatic formations, presenting different degrees of metamorphism (Burchfiel, 1976; Pop, 1993; Preda, 1994; Petrescu et al., 1987; Iancu et al., 2005). The Getic crystalline rocks crop out in the north-eastern side of the basin and partially on the southern rim, consisting of gneisses, mica-schists, quartzites, and amphibolites. The overlying sedimentary deposits are of Jurassic, Cretaceous, Paleogene, and Neogene age, mostly covered by Quaternary formations. The oldest sedimentary rocks in the basin are Cretaceous, consisting mostly of flysch deposits, located on the northern and southern rims. The Cretaceous deposits are represented by conglomerates, green-grey sandstones, red marls, and minor limestones. From an economic perspective, the Oligocene deposits are the most important, as these formations contain all the coal layers, of Rupelian and Chattian ages. The Rupelian overlying the metamorphic sediments of the bedrock and the Cretaceous deposits crops out as discontinuous layers on both rims of the basin. The Rupelian deposits, 200 m to 600 m thick, consist of sandstones and green and red conglomerates with ferruginous and limestone clasts. Dîlja–Uricani Formation, of Chattian-age, also known as the „productive horizon", contains coal seams and crops out on the southern rim of the basin, as well as in the northeastern, central, and western rims (Figure 2). The thickness of these paralic deposits ranges from 270-m to west to 350-m to east (Baron, 1998). Twenty-two layers of coal have been identified in the Chattian-age rocks, numbered as beds 0 to 21, from the bottom to the top. Beds 3, 4, 5, 7, 8/9, 12, 13, 14, 15, and 17/18 are economically feasible for extraction, bed 3 being the most productive. The thickness of these beds varies from several meters up to several tens of meters (bed 3); the estimated percentage of the Jiu Valley reserves are as follows: bed 3-48 percent, bed 5-16 percent; bed 13-10 percent; beds 4, 6, 7, 8, 9, 12, 15, 17, and 18 are thin, discontinuous and each contributes about 1-3 percent; beds 1, 2, 10, 11, 14, 16, 19, and 20 are very thin, representing a small fraction of the reserves (Pop, 1993; Preda, 1994; Petrescu et al., 1987; Fodor et al., 2000; Fodor and Plesa, 2006; Belkin et al., 2010; Buia and Lorinţ, 2010). The Miocene deposits are between 300 m and 550 m thick, formed of grey sandstones, marls, clays, sands, and coarse conglomerate. The Quaternary consists of alluvial and pro-luvial deposits.

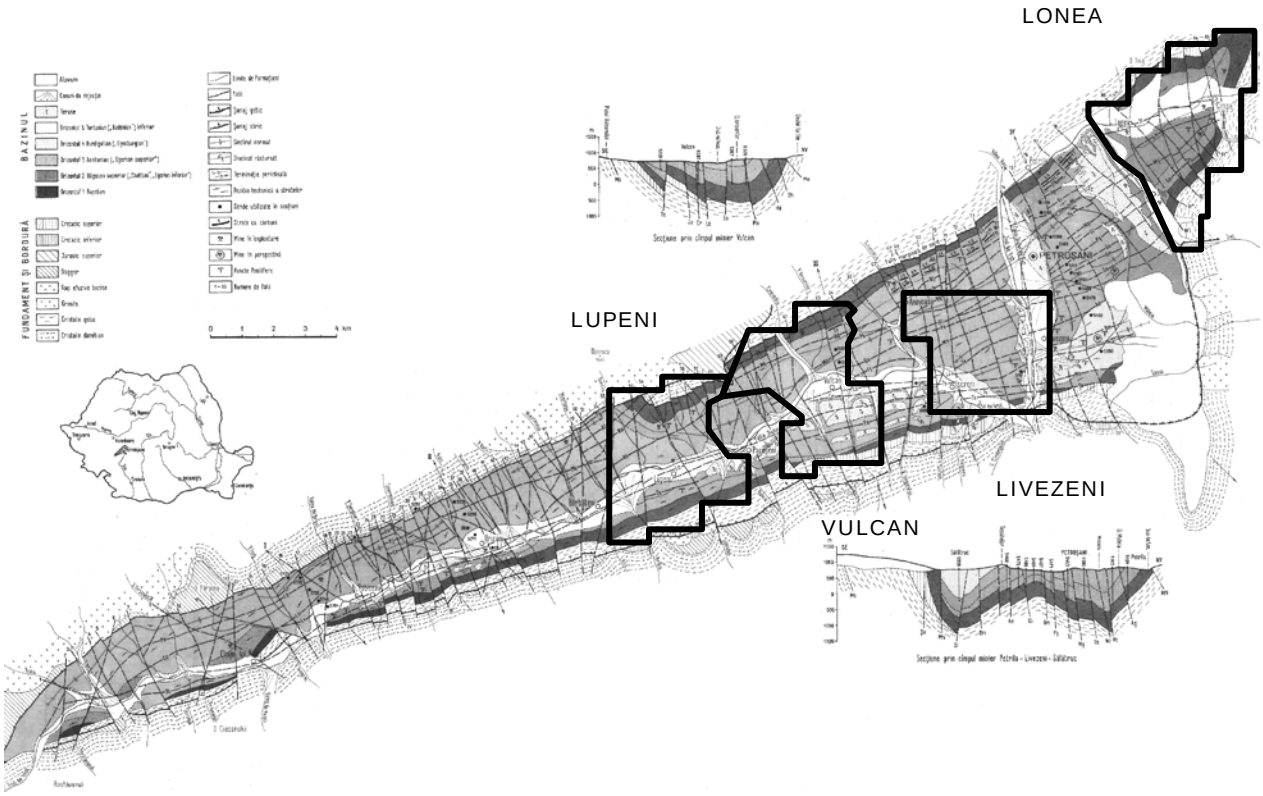

Figure 2. Geo-tectonic map of Jiu Valley / Petroşani basin study area showing the regional geology, the major synclinal axis, tectonic units and few sections in major point of interest
Modified from Pop E.I. (1988)

3. TECHNICAL PROPERTIES AND STATISTICS OF HARD COAL RESERVES IN THE JIU VALLEY

This section describes the main characteristics of the hard coal in the Jiu Valley. From a valorization potential perspective, the classification falls into three categories, depending on the current state of the mining perimeters, as follows; Closed (decommissioned) mining Perimeters (Table 1), Closing mining perimeters (Tables 2 and 4) and Sustainable mining perimeters (Tables 3 and 4).

Table 1. Statistics of the reserves pertaining to the closed mining perimeters (thousands of tonnes at the closing date)

Group/Category	Lonea Pilier	Petrila Sud	Dâlja	Aninoasa	Valea de Brazi	Câmpul lui Neag
Ab	0	269	746	90	710	54
Bb	0	769	0	72	393	0
C1b	52,660	48,484	56,710	0	59,128	716
C2b	0	10,332	2,657	0	9,766	0
Total recoverable, (proven) geological reserves	**52,660**	**59,854**	**60,113**	**162**	**69,997**	**770**
Aaf.b	0	98	5	461	232	0
Baf.b	0	0	0	632	209	0
C1af.b	41,693	17,783	14,869	75,109	12,270	199
C2af.b	0	9,328	9,380	23,485	5,644	779
Total probable geological reserves	**41,693**	**27,209**	**24,254**	**99,678**	**18,355**	**978**
Total geological reserves/perimeter	**94,353**	**87,063**	**84,367**	**99,849**	**88,352**	**1,748**
Total geological reserves Closed perimeters	**455,732**					
Heating value/perimeter Q (kal/kg)	**5,788**	**5,566**	**5,434**	**5,539**	**5,343**	**4,776**
Average heat content Q (kal/kg)	**5,535**					

Table 2. Reserves Statistics - Closing mining perimeters (thousands of tonnes)

Group/Category	Petrila		Paroşeni		Uricani		TOTAL	
	Quantity	Aanh (%)	Quantity	Aanh (%)	Quantity	Aanh (%)	Quantity	Aanh (%)
Ab	337	22.05	538	19.74	48	24.43	**923**	**20.83**
Bb	810	22.73	0	0.00	406	30.25	**1,216**	**25.24**
Ab+Bb	1,147	22.53	538	19.74	454	29.63	**2,139**	**23.34**
C1b	16,109	19.42	20,683	21.77	38,980	24.76	**75,772**	**22.81**
A+B+C1	**17,256**	**19.63**	**21,221**	**21.72**	**39,434**	**24.82**	**77,911**	**22.82**
C2b	1,481	32.56	1,213	24.88	8,411	23.37	**11,105**	**24.76**
Total recoverable (proven) geological reserves	**18,737**	**20.65**	**22,434**	**21.89**	**47,845**	**24.56**	**89,016**	**23.06**
Aaf.b	343	22.72	315	23.60	354	26.46	**1,012**	**24.30**
Baf.b	81	29.00	83	20.66	595	30.92	**759**	**29.59**
C1af.b	55,761	18.64	13,216	21.95	50,589	21.47	**119,566**	**20.20**
C2af.b	13,535	18.18	5,425	23.14	11,386	21.74	**30,346**	**20.40**
Total probable geological reserves	**69,720**	**18.58**	**19,039**	**22.31**	**62,924**	**21.64**	**151,683**	**20.32**
Total geological reserves Closing perimeters	**88,457**	**19.02**	**41,473**	**22.08**	**110,769**	**22.90**	**240,699**	**21.33**

Table 3. Reserves statistics – Sustainable mining perimeters (thousands of tonnes)

Group/ Category	Lonea		Livezeni		Vulcan		Lupeni		TOTAL	
	Quant.	Aanh (%)	Quant.	Aanh (%)	Quant.	Aanh (%)	Quant.	Aanh (%)	Quant.	Aanh (%)
Ab	785	19.23	113	22.47	251	24.75	1,117	27.82	**2,266**	**24.24**
Bb	362	18.25	1,246	29.78	308	27.26	1180	26.87	**3,096**	**27.07**
Ab+Bb	1,147	18.92	1,359	29.17	559	26.13	2,297	27.33	**5,362**	**25.87**
C1b	21,501	18.79	70,176	23.74	22,997	21.36	29,379	24.48	**144,053**	**22.77**
A+B+C1	**22,648**	**18.80**	**71,535**	**23.84**	**23,556**	**21.47**	**31,676**	**24.69**	**149,415**	**22.88**
C2b	0	0.00	4949	20.18	13	26.47	0	0.00	**4962**	**20.20**
Total recoverable (proven) geological reserves	**22,648**	**18.80**	**76,484**	**23.61**	**23,569**	**21.48**	**31,676**	**24.69**	**154,377**	**22.80**
Aaf.b	59	15.00	1,390	27.08	288	29.61	471	30.41	**2,208**	**27.80**
Baf.b	317	13.81	1,710	29.72	288	17.73	756	26.27	**3,071**	**26.10**
C1af.b	39,769	17.16	53,225	20.81	24,389	21.42	34,304	22.05	**151,687**	**20.23**
C2af.b	4,280	19.12	36,875	22.74	8605	20.66	16	27.40	**49,776**	**22.07**
Total probable geological reserves	**44,425**	**17.32**	**93,200**	**21.83**	**33,570**	**21.26**	**35,547**	**22.25**	**206,742**	**20.84**
Total geological reserves Sustainable perimeters	**67,073**	**17.82**	**169,684**	**22.63**	**57,139**	**21.35**	**67,223**	**23.40**	**361,119**	**21.68**

Based on the data presented in Tables 1, 2 and 3, the reserves of hard coal are as follows: **455.732** millions of tonnes in the closed mining perimeters Lonea Pilier, Petrila Sud, Dâlja, Aninoasa, Valea de Brazi, Câmpul lui Neag, **240.699** millions of tonnes in the closing mining perimeters Petrila, Paroşeni, Uricani and **361.119** millions of tonnes in the sustainable mining perimeters Livezeni, Vulcan, Lupeni –leading to a total of **1,057.550** million tonnes.

Of the total reserves, only the recoverable (proven) reserves are available for valorization, as follows: **243.556** million tonnes in the closed mining perimeters, **89.016** million tonnes in the closing mining perimeters and **154.377** million tonnes in the Sustainable perimeters, totalling to **486.949** million tonnes. To note that within the closed mining perimeters, the recoverable (proven) reserves belong over 90 percent to category C1 of reserves.

As it can be observed from table 4, the reserves from the active mining perimeters, including the closing and sustainable perimeters, amount to **94.189** million tonnes which are currently available.

Table 4. Statistics of proven and probable reserves in the active mining perimeters (thousands of tonnes)

Mining Perimeter	Coal Bed	Characteristics of the coal bed	Proven			Probable			Total		
			Quantity	Aanh (%)	Q (kal/kg)	Quantity	Aanh (%)	Q (kal/kg)	Quantity	Aanh (%)	Q (kal/kg)
Lonea	3	block II - III level 200, block VII, level 380	1,389	40.40	3,861	12,042	41.90	3,739	13,431	41.74	3,752
	5	block II - III level100	127	27.80	4,881	344	32.60	4,492	471	31.31	4,597
	Total		**1,516**	**39.34**	**3,946**	**12,386**	**41.64**	**3,760**	**13,902**	**41.39**	**3,781**
Petrila	3	block II level -300, eastern side block II -200 - 250	1,352	40.25	3,922	7,194	45.10	3,537	8,546	44.33	3,598
	Total		**1,352**	**40.25**	**3,922**	**7,194**	**45.10**	**3,537**	**8,546**	**44.33**	**3,598**
Livezeni	3	block VI, VIA, III, VII and VIII to level 150	1,563	47.21	3,332	12,085	50.30	3,088	13,648	49.95	3,116
	5	block VII				3,159	39.07	3,974	3,159	39.07	3,974
	13	block X-VIII Iscroni, between level 50 and 200	197	40.16	3,888	1,121	23.24	5,223	1,318	25.77	5,023
	Total		**1,760**	**46.42**	**3,394**	**16,365**	**46.28**	**3,405**	**18,125**	**46.29**	**3,404**
Vulcan	3	block VI, VII, VIII and IX to level 260	656	44.7	3,837	5,412	36.31	4,532	6,068	37.22	4,457
	5	block VII to level 250, block VIII-IX	55	49.52	3,437	1,247	45.78	3,747	1,302	45.94	3,734
	Total		**711**	**45.07**	**3,806**	**6,659**	**38.1**	**4,385**	**7,370**	**38.76**	**4,329**
Paroşeni	3	block 0 - VI between 350 and 200			7,545	11,032	47.68	3,590	11,032	47.68	3,590
	5	block 0, I and II between level 200 and 400	763	42.95	3,982	1,356	39.94	4,232	2,119	41.02	4,142
	Total		**763**	**42.95**	**3,982**	**12,388**	**46.83**	**3,660**	**13,151**	**46.61**	**3,679**
Lupeni	3	block II to 200, block II N, IV,V and VI	2,881	44.12	3,957	13,032	45.10	3,876	15,913	44.92	3,890
	5	block VI level 300-350				744	49.32	3,524	744	49.32	3,524
	Total		**2,881**	**44.12**	**3,957**	**13,776**	**45.33**	**3,857**	**16,657**	**45.12**	**3,874**
Uricani	3	block IIIN, IV, V and VI between level 350 and 250	545	46.61	3,778	13,454	46.92	3,753	13,999	46.91	3,754
	5	block IIIN, IV, V and VI between level 400 and 250	57	38.02	4,483	2,382	33.45	4,859	2,439	33.56	4,850
	Total		**602**	**45.80**	3845	**15,836**	**44.89**	**3,919**	**16,438**	**44.93**	**3,916**
TOTAL	**3**		**8,386**	**43.66**	**3,798**	**74,251**	**45.50**	**3,676**	**82,637**	**45.31**	**3,688**
	5		**1,002**	**41.11**	**4,095**	**9,232**	**39.24**	**4,193**	**10,234**	**39.42**	**4,183**
	13		**197**	**40.16**	**3,888**	**1,121**	**23.24**	**5,223**	**1,318**	**25.77**	**5,023**
	Total		**9,585**	**43.32**	**3,831**	**84,604**	**44.52**	**3,753**	**94,189**	**44.40**	**3,761**

- closing mining perimeters

4. CONCLUSION

Based on the current organizational structure of the coal system, the 2013 coal production from the active mining perimeters, respectively closing perimeters Petrila, Paroşeni and Uricani and sustainable perimeters Lonea, Livezeni, Vulcan and Lupeni amounted to 1.5 million tonnes (0.4 million tonnes, respectively 1.1 million tonnes), with a heating value of 3,600 kal/kg; this resulted in 2,700 GWh/year, for combustion factors representative of the current technology of 3.6 Gkal/t hard coal of Jiu Valley and 2 Gkal/Mw), representing about 5-7 percent of the electric energy produced in Romania, this being 54,358 GWh/year.

Given the energy balance, 94 million tonnes of hard coal from the currently proven reserves in the active mining perimeters can sustain the coal consumption for the next 60 years.

The recoverable reserves from the closed and closing mining perimeter can also be valorized through alternative methods, such as internal combustion.

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