

BOLTYSHKOE OF OIL SHALE DEPOSITS

Boltyshkoe deposits of oil shale is located in the Alexander area Kirovogradskoy area and partly in Kaminski region Cherkassy region, and in conjunction with the Boltyshkoe valley in the crystalline basement, which reaches a depth of 600 meters, diameter of about 25 km.

The field «Boltyshkoe» is located 250 kilometers south of Kiev and is the only country's shale deposit area with production potential, where the total amount of deposits estimated is about 3.8 billion tons.

It is the third major shale deposit in Europe, along with Estonia and Leningrad deposits. Fuel value of the Ukrainian oil shale is estimated in the region of 2000-2500 kcal / kg, which is equal to the potential of the Estonian oil shale.

Power of the productive layer, containing layers of shale oil, reaches 400 m. Generally, it is divided into 5 horizons (horizons numbering upward), composed of laminated clays and dark colored alverites.

Oil shale is found throughout but the IV-th and II-nd horizons represent a practical interest because of their thickness, continuity and quality of formations. The IV-th horizon including the bulk of reserves (82%) has 5 layers: A, B, C1, C2 and D. These layers are more than 2m thick and have minimal combustion heat of 2000 kkal/kg. Two subsurface layers of the 2-nd horizon are spread in the central part of the basin and occur 40-50 m below bottom of formation D. Oil shale layers occur more or less horizontally and only in the peripheral part of the basin they are refracted with 1-40 in the direction of the central part.

Topmost layer A in the soil and the surface has no clear boundaries, and, as a rule, there are gradual transitions in the bituminous clay and alewritte. Characteristic of it is that sub layers of bituminous clay are divided into two almost equal parts. Depth to top reservoir in inclined parts of basin is 60-80 meters; in the center of the structure it is 315 m. The average power in two meter contour accounts of 3.5 m.

Below layer A lies stratum B, which is developed throughout the area of basin and is the most productive. This layer contains 43,8% of total deposits. The power between the layers is 8-10 m. The average thickness within two meter contour is of 4.6 m, depth increases from 20-40m from peripheral parts of basin to 335 m in the central basin. Layer B is characterized by a massive texture, and presence of less productive layers of thin mudstones. The lower part of the reservoir, as a rule, has the best quality and has a clear boundary with the underlying mudstones.

At 4-5 m below the layer of B lie two very similar layer B1 and B2, separated by dense mudstones layers with a power 0,8-1,0 m, which occurs throughout the deposit area and is a marker for these layers. The average thickness in the B1 two meter circuit is 2,5 m, the reservoir B2 -2,9 m Depth of deposited layers from 58 m to 345 m.

Among the green marl clay layer lies G which got development only in the central basin. Power of the deposited layer between the overlaying layer of B2 and D layer is 3-4 m. The average thickness, 2, 6 m, depth ranges from 65 m to 354 m. Layer has a relatively complicated structure. Typically, in the middle part of it is of being said to bituminous clay with a power capacity up to 0,5 m.

Two of the lower layer of horizon II distributed in the central basin lie 40-50 m below the soil layer G. Layers of complex structure, which are made of sub layers of bituminous clays has the average power of 7.2 m, with the deposits at depth 221-398 m.

Most common second upper stratum B, is well developed throughout the basin. The remaining layers occupy much less space. They are seen primarily in the central part of the deposit. Power between layers is about 3-10 m, with gradual decreasing to the periphery up to 2 meters, and the between the layers B1 and B2 are rarely more than 1m.

Table 1

Characteristic	Layer IV Horizon					Total in horizon	II horizon	Total at Deposits
	A	B	C1	C2	D			
Area, km ²	57,2	251,9	11,4	151,4	46,6			
Power, m	3,5	4,6	2,5	2,9	2,6			
Reserves (cat. C2+ P1), billion. tns.	0,28	1,62	0,4	0,61	0,17	3,08	0,71	3,79
Depth of deposits, m								
- from	17	24	70	75	135		150	
- to	300	330	335	340	350		370	
- prevailing	100	120	120	130	140		150	
	240	275	285	290	295		300	

The qualities of all the layers are almost the same. Since the depth indicated little noticeable deterioration in performance. The same is observed in the area of the center cavity to its ends. Key indicators of quality Boltyskhoe shale with on-board heat of combustion 2 000 kcal / kg are shown in Table 2.

Table 2.

Indicators	Units	In the numerator are extreme values (from -- to) Reciprocally there is a mean value for the areal reserve estimate					
		IV –th horizon					
		A			A	G	
Ash content (Ad)	%	47.4-70.0 66.4	Ash content (Ad)	%	47.4-70.0 66.4	Ash content (Ad)	%
Moisture of fuel as received (Wtr)	%	33	Moisture of fuel as received (Wtr)	%	33	Moisture of fuel as received (Wtr)	%
Specific heat (Qsdaf)	kkal kg	2000-4150 2280	Specific heat (Qsdaf)	kkal kg	2000-4150 2280	Specific heat (Qsdaf)	kkal kg
Oil yield (Tsk)	%	6,0-27,2 12,2	Oil yield (Tsk)	%	6,0-27,2 12,2	Oil yield (Tsk)	%
Sulphur content (Std)	%	0,5-3,5 1,5	Sulphur content (Std)	%	0,5-3,5 1,5	Sulphur content (Std)	%

In geological terms Boltyskhoe field development can be done by two methods - open pit in the periphery where the deposits are till depth of 15 - 160 m and underground method in the central part. The industrial development of the field can give economic benefit only if the complex, waste processing of oil shale using their organic and mineral parts is done.

Odessa Regional Office Center development and economic reconstruction of the Cabinet of Ministers of Ukraine has developed a program involving the exploitation of Boltyskhoe field, whose goal is to develop and justify a comprehensive system of waste processing oil shale, which provides the following major areas of use of mineral resources:

- The direct combustion of oil shale in the furnace of power units;
- Energo-chemical processing of oil shale;
- Processing of liquid shale products;
- Processing polluted water;
- Processing of gas shale products;
- Processing of the mineral part of oil shale;
- Environmental protection.

In a world of modern technology different methods are implemented for combustion and energo-chemical processing of low-potential energy commodities that can be subjected to refinement and improvement and can become a technological basis for an integrated system of waste processing of oil shale.

Center performed testing the possibility of obtaining synthetic oil from shale with a yield up to 170 kg per ton of oil shale with the subsequent processing of the remaining part of the mineral by cold Ceramic wall building blocks.

Attractive side of the site, apart from the huge reserves of oil shale is, high presence of resin liquid fraction from which you can receive up to 20% gasoline and 37% diesel fuel. This field can be considered as a possible alternative source of liquid fuel to Ukraine.

Over the years since the exploration work, it became apparent that the deposit belongs Boltyskhoe not I, but to II - group of industrial classification. According to «The instructions for the application of the classification of reserves to deposits of coal and oil shale» exploration network density and the degree of knowledge Boltyskhoe field, in general, corresponds to the stage of prospecting and evaluation work. Calculation of Energy oil shale is made in two versions: with a minimum calorific value 2000 kcal / kg / layers A, B, B1, B2 and D horizon IV and II of the horizon / and 2500 kcal / kg / layers B, B1, B2 and D IV horizon.

The minimum area of the reservoir to calculate the reserves in accordance with the recommendations «UkrNIIproekt» / 1966., 1998 / accepted by 2,0 m. The value of the volumetric weight calorific value 2000 kcal / kg 1,40 t/m³ adopted, at 2500 kcal / kg - 1,35 t/m³. Moisture of working fuel - 33%.

The reserves calculated by figures (larger blocks) using the formula:

$$Q_e = S \times m \times q$$

Where:

S - square shape (the block).

m - mean thickness of the block.

Q - volumetric weight.

Category reserves C2 + P2 + P1

Boltyskoe shale was studied, mainly as energetic raw material, ie burned in dry lumps form for the thermal plants.

In terms of the use of oil shale to produce motor fuels, the main problem today, almost no research was conducted. As a preliminary assessment of analytical studies, Boltyskoe shale's are promising for thermal processing.

Options for estimating reserves of oil shale in mine fields

Mine field	Characteristic	Layers IV Horizon(total), at:			Layers IV Horizon(total), at						Layers IV Horizon(total), at			
		Qmin=1200 kcal/kg Tsk min=6,0% Admax=77, %	Qmin=1500 kcal/kg Tsk min=8,0% Admax=74,0 %	Qmin=1800 kcal/kg Tsk min=10,0 % Admax=71,0%	Qmin=2000 kcal/kg		Tsk min=12,0%		Admax=69,9 %		Qmin=2500 kcal/kg	Tsk min=15,0 %	Admax =65%	Total IV horizon
					A	B	C1	C2	D1	Total IV horizon				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
№ 1	Reserves th. tons	1428000	8781120	649100	101527	228887	61199	84220	47193	523026	78563	37665	51155	167383
	mcp, м	33,0	20,4	15,2	3,6	5,1	2,5	2,6	2,6	16,4	2,8	2,3	2,5	7,6
	Tsk, %	10,9	13,0	14,6	12,2	14,2	15,3	15,6	12,3	14,0	19,8	18,0	18,2	18,7
	Ad, %	70,0	67,5	66,0	65,1	63,2	61,5	61,6	67,1	63,7	57,1	59,8	59,5	58,8
	Qds, kcal/kg	1950	2200	2400	2271	2664	2850	2812	2099	2539	3223	2967	3000	3063
№ 2	Reserves th. tons	1751631	1003800	798021	19049	272576	75152	119512	9152	495441	92400	13752	48756	154908
	mcp, м	34,9	60,0	15,9	2,7	5,3	2,4	2,9	2,5	15,8	2,8	2,3	2,6	7,7
	Tsk, %	10,8	12,9	14,0	12,2	14,2	15,3	15,6	12,3	14,6	19,2	17,8	16,9	18,0
	Ad, %	70,0	67,4	66,0	65,8	64,2	62,3	63,0	66,6	63,7	57,9	60,2	61,3	59,8
	Qds, kcal/kg	1950	2200	2400	2210	2508	2661	2556	2051	2397	3142	2923	2807	2957
№ 3	Reserves th. tons	1810900	1058680	877887	28316	309139	103608	103422	-	544485	73390	12939	42452	128781
	mcp, м	26,0	15,2	12,7	3,0	4,2	2,6	2,8	-	12,6	2,9	2,3	2,6	7,8
	Tsk, %	10,3	12,8	14,0	12,2	14,2	15,3	15,6	-	14,6	19,2	17,4	17,6	18,1
	Ad, %	70,8	67,5	66,0	67,7	64,3	63,6	63,7	-	64,8	57,9	60,6	60,3	59,6
	Qds, kcal/kg	1900	2200	2400	2140	2527	2543	2612	-	2456	3002	2871	2904	2926

Mine field	Characteristic	Layers IV Horizon(total), at:			Layers IV Horizon(total), at						Layers IV Horizon(total), at			
		Qmin=1200 kcal/kg Tsk min=6,0% Admax=77, %	Qmin=1500 kcal/kg Tsk min=8,0% Admax=74,0 %	Qmin=1800 kcal/kg Tsk min=10,0 % Admax=71,0%	Qmin=2000 kcal/kg		Tsk min=12,0%		Admax=69,9 %		Qmin=2500 kcal/kg	Tsk min=15,0 %	Admax =65%	
		A	B	C1	C2	D1	Total IV horizon	B	C1	C2	Total IV horizon			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
№ 4	Reserves th. tons	2442895	1614795	1291874	128106	441334	108910	216142	98106	99599	172793	77586	170934	421313
	mcp, м	29,5	19,5	16,7	3,6	5,1	2,4	2,8	2,7	16,6	2,9	2,4	2,7	8,0
	Tsk, %	11,2	13,0	14,5	12,2	14,2	15,3	15,6	12,3	14,2	19,2	17,6	18,0	18,3
	Ad, %	69,3	67,5	66,0	65,3	63,3	61,3	61,2	66,1	63,4	57,9	60,3	59,7	59,3
	Qds, kcal/kg	2000	2200	2400	2300	2659	2851	2926	2108	2569	3139	2908	2966	3004
№ 5	Reserves th. tons	582750	441000	343350	-	149246	10937	62010	9641	231834	44341	4208	40775	89324
	mcp, м	18,5	14,0	10,9	-	4,7	2,4	2,8	2,3	12,2	2,8	2,5	2,7	8,0
	Tsk, %	11,0	13,0	14,1	-	14,2	15,3	15,6	12,3	14,5	18,6	17,2	18,3	18,0
	Ad, %	70,0	67,5	66,0	-	63,8	61,0	61,0	67,1	63,2	58,8	61,0	59,3	59,7
	Qds, kcal/kg	1950	2200	2400	-	2571	2872	2856	2100	2600	3056	2842	3005	2968
№ 6	Reserves th. tons	8016176	4996395	3960232	276998	1401182	359806	585307	164092	2783385	461487	146150	354072	961709
	mcp, м	28,7	18,0	16,5	3,5	4,9	2,4	2,9	2,6	16,3	2,8	2,4	2,6	7,8
	Tsk, %	11,0	12,8	14,2	12,2	14,2	15,3	15,6	12,3	14,3	19,2	17,6	17,8	18,2
	Ad, %	70,0	67,5	66,0	65,9	63,7	61,9	62,1	66,7	64,0	57,9	60,4	60,0	59,4
	Qds, kcal/kg	1950	2200	2400	2236	2587	2755	2735	2090	2512	3112	2902	2936	2983

Projected resources of tar shale in II shale horizon of mine fields

Mine field	Characteristic	The reserves and quality, with on-board tar shale				
		6 %	8 %	10 %	12 %	15 %
№ 1	Reserves thousand tons	688860	410030	228780	137745	-
	mcp, M	23,5	14,2	8,3	6,9	-
	Tsk, %	9,3	11,2	11,8	12,5	-
	Ad, %	72,4	40,3	68,5	67,2	-
	Qds, kcal/kg	1710	1920	2090	2201	-
№ 2	Reserves thousand tons	1785000	790500	446250	181272	-
	mcp, M	50,0	23,9	15,0	7,9	-
	Tsk, %	8,6	11,4	12,2	12,5	-
	Ad, %	72,4	70,3	68,5	67,2	-
	Qds, kcal/kg	1710	1920	2090	2154	-
№ 3	Reserves thousand tons	520620	183400	82950	-	-
	mcp, M	17,5	8,0	7,9	-	-
	Tsk, %	8,1	10,0	11,0	-	-
	Ad, %	72,4	70,3	68,5	-	-
	Qds, kcal/kg	1710	1920	2090	-	-
№ 4	Reserves thousand tons	1327370	696140	435360	335079	-
	mcp, M	20,5	12,0	9,3	7,0	-
	Tsk, %	9,5	11,2	12,1	12,5	-
	Ad, %	72,4	70,3	68,9	68,7	-
	Qds, kcal/kg	1710	1920	2090	2095	-
№ 5	Reserves thousand tons	55120	31540	-	-	-
	mcp, M	7,0	5,3	-	-	-
	Tsk, %	8,4	8,9	-	-	-
	Ad, %	72,4	70,3	-	-	-
	Qds, kcal/kg	1710	1920	-	-	-
Total:						
	Reserves thousand tons	4376970	2111610	1193340	654096	-
	mcp, M	26,3	14,2	10,4	7,0	-
	Tsk, %	8,9	11,0	12,3	12,5	-
	Ad, %	72,4	70,3	68,5	67,8	-
	Qds, kcal/kg	1710	1920	2090	2150	-

Reserves of oil shale and volume of waste material in mine fields
($Q_{\min.} = 2000 \text{ kcal./kg}$, $T_{sk} = 12 \%$, $Ad_{\max} = 69 \%$)

Mine fields	Layers IV Horizon				Layers IV & II Horizons			
	Geological reserves. Thousand tons	stripping, th. m3 (raw)		Kv	Geological reserves. Thousand tons	stripping, th. m3 (raw)		Kv
		total	Vol between the layers			total	Vol between the layers	
1	523026	7698470	633600	14,7	660771	8394040	695570	12,7
2	495441	9829660	376050	19,8	676713	10523500	693840	15,6
3	544485	10988610	327050	20,2	544485	10988610	327050	20,2
4	992599	14747310	812660	14,9	1327678	15943820	2009170	12,0
5	231834	3042620	111240	13,1	231834	3042620	111240	13,1
Total:	2787385	46306670	2260600	16,6	3441481	48892590	3836870	14,2

The sulphur content in shale oil of Boltyskoe deposits belong to the medium - 1-2%. The content of organic matter in the shale layers is 36-45%. Semi coking of shale layers in a rotating retort showed output products: resin 15-20%, 67-72% semi coke, Pyrogenic water 4-6%, gas 5,5-7,0%. The group and fractional composition of oil shale resin layers are identical resin layers, namely:

Yield by weight %	Layer	Layer	Layer	Layer	Layer A1	Layer A1	Layer B1	Layer B1
					Mine field			
					1	2	1	2
Phenols	2,3	2,3	1,6	1,5	2,3	2,4	2,0	1,8
Base	2,4	2,6	2,8	3,3	2,3	1,9	3,2	2,5
Paraffins	8,4	5,1	7,6	3,3	5,1	7,0	4,5	5,0

NK - 200° Celsius (gasoline fraction)	17,5-19,0% vol.
200 - 300° Celsius (diesel fraction)	38,0-40,0% vol.
330° Celsius	40,0-44,5% volume.

Group composition of gasoline fractions in weight %:

naphthenic and paraffin hydrocarbons	42
Unsaturated	42
Aromatic	10
Neutral oxygen compounds	6

Group of the diesel fraction of the weight %:

paraffin and naphthenic	35
Unsaturated	40
Aromatic	7
Neutral oxygen compounds	18

Gasoline fraction consists mostly of paraffin and olefin hydrocarbons of normal structure. The content of organic bases in the gasoline fraction is 1.1% and in the diesel fraction 3.3%.

Bases of diesel fractions were tested as anti-corrosive additives and showed a good degree of protection in hydrochloric and sulfuric acids.

Shale is characterized by high resin content of paraffin (8%). In fractions if boiled above 300° Celsius higher paraffin content of 15% can be obtained.

Mineral ash portion has silica-alumina composition, which can be suitable for the production of a number of construction materials.

Boltyshkoe oil shale deposits can be used in energy sector or in energo-chemical directions to the get electricity and various chemical products: benzene, toluene, ethylene, propylene, cleaning substances, oils for wood, etc.

When processing 12 million tons of shale a year for Power and energo-chemical schemes ENIN may receive the following products:

№	Derived products	As per energo-chemical schemes. Thousand Tons	As per energo-technical schemes. Thousand Tons
1	Heavy fuel oil	1279 ton	1680 ton
2	Aromatic carbohydrates (benzene, toluene)	22 ton	3,5 ton
3	Unsaturated carbohydrates (ethylene, propylene)	100 ton	16 ton

In the future, should continue to study the products semi-coking shale with a view to identifying opportunities for electrode coke, drugs to combat soil erosion, nitrogen compounds. Mining and geological conditions of oil shale deposits Boltyshskogo allow the use of both open and underground development.

The Future Company can produce and process fuel oil shale, which will enable the company to sell its product not only in Ukrainian market but a potential exporter to European Union as well. There are various other by-products which can be derived from the oil shale like production of electricity, building material, semi coked gas etc.

Possession of such strategic object in the European region will be of high value not only from economical point of view but a excellent opportunity for investment in the future project with positive growth.