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On the geochemistry of gold in Bulgarian coals

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Г. Ескенази — О геохимии золота в болгарских углях. В изученных 10 болгарских угольных месторождениях содержание золота варьирует от 3,8 до 171 ppb в золе и от 0,7 до 33 ppb в угле. Для некоторых из месторождений сорбционная зола является концентратором золота. Угольные литотипы, особенно самостоятельные витреновые линзы, часто обогащены золотом по сравнению с исходными образцами, из которых они выделены. На основе собственных данных и анализа литературных данных предполагается присутствие $Au_{орг}$ (включительно $Au_{био}$) и $Au_{неорг}$. Повышенное содержание золота в углях некоторых месторождений объясняется повышенной золотоносностью Маджаровского рудного поля (для месторождения Вылче-Поле), наличием золотоносных кварцевых жил (для месторождения Меден-Бук), наличием золотоносных россыпей (для Перникского бассейна), влиянием морской трансгрессии (для Бургасского бассейна).

Abstract. In 10 Bulgarian coal deposits studied the content of gold varies from 3.8 to 171 ppb in ash and from 0.7 to 33 ppb in coal. For some of the deposits the sorption ash is a concentrator of gold. The coal lithotypes, and especially the isolated vitrain lenses are often enriched in gold in comparision to the whole coal samples. On the basis of own data, as well as of analysed data from certain published papers the presence of Au_{org} (Au_{bio} included) and Au_{inorg} is assumed. The higher content of gold in coal of some deposits is due to the following gold-bearing source areas: the Madjarovo gold field (for the Vâlče Pole coal deposit), gold-bearing quartz veins (for the Meden Buk deposit), gold-bearing placers (for the Pernik coal basin) and the influence of the marine transgression (for the Burgas basin).

Introduction

The geochemistry of gold in coals is not well studied yet, although some data on its content in coals appear already before the end of the previous century. The most complete review on the occurrence of gold in coal includes 19 papers (Boyle, 1979). A part of them are of historical interest since some of published high concentrations have not been confirmed in later research. Only the paper by Попович (1954) and the very good (though not well known) paper by Китаев, Михайлов (1979) and the paper of Chyi (1982) may be cited as publications concerning strictly the gold in separate coal basins (together with the silver and the platinum group metals). The general lines of the geochemical behaviour of gold in the coal-forming process are briefly assumed in the monographs of Boyle (1979), Юдович et al. (1985) and Клер et al. (1987). On the other hand, in view of the big interest in gold, numerous studies have been made on its occurrence in plants and the mechanisms of its deposition in them, on the content and the mode of occurrence of gold in fluvial waters, sea-waters and underground waters, and on its behaviour in the wea-

Fig. 1. Map of the Bulgarian coal deposits studied: *1* — Elhovo; *2* — Marica-East; *3* — Burgas; *4* — Pernik; *5* — Bobov Dol; *6* — Vâlče Pole; *7* — Meden Buk; *8* — Pčelarovo; *9* — Belogradčik; *10* — Dodrudža

thering process. The relation of gold to the organic matter in waters and to the humic matter in soils is well known, and the interaction of gold with the fulvic and the humic acids has been studied too. That creates the prerequisites for clearing the behaviour of gold in coal-forming processes in accordance with the modern analytical methods for a fast and precise determination.

The purpose of this paper is: 1 — to determine the content of gold in some Bulgarian coal deposits since there are no data on this element up to now; 2 — to study the principal trends of the geochemical behaviour of gold in coals; 3 — to estimate the possible forms of occurrence of gold in Bulgarian coals and to interpret the received results in accordance with the published data on the role of the organic matter in the migration and fixing of gold; 4 — to investigate the relation between the gold content in coal and the source area of each deposit.

The investigation on the geochemical behaviour of gold in Bulgarian coals is based on the analyses of 191 individual samples of coals, coaly shales and mineral interlayers from 10 deposits (Fig. 1) and of some isolated vitrain lenses. The determination of gold was made in the ash. The coals were burned in an open muffle furnace at a gradually increasing temperature up to 500°C. A neutron activation analysis with thermic neutrons, succeeded by a Ge(Li)-spectroscopy has been applied for the determination of gold. Au^{198} was detected on the fifth day after the irradiation.

A possible loss of gold during burning is discussed. After Клер, Ненахова (1981), the gold volatilizes during burning the coal, since it was found in the ash on the electrofilters and not in the slag. After the data of Ковалевский (1984), during burning the plants at 500-600°C the loss of gold may vary from 20 to 50%. Virtually, the loss of gold during burning the coal in the power station might be a result of mechanic fly with not burned particles. In order to estimate the eventual losses of gold at 500°C, its content in some samples was determined in parallel both in ash and in coal itself. The results did not show any systematic decrease of the gold content in the ash as compared with the coal. The difference is within the limits of error for determination of the elements in the standard geological sample for ash BS-1. For the recommended value 5.1 ppb the mean content found by 4 parallel determinations is 5.75 ppb, the standard deviation being 2.2 ppb and the relative standard deviation, 38%. The analysis for gold in ash, instead of coal, is an advantage, since the ash is a concentrate from 3-6 g coal. This is of a great importance because of the natural unhomogenity of gold distribution. Besides that, the detection limit of this method applied directly to coal would be insufficient (>1 ppb) for 0.5 g initial sample which is commonly used.

Results and discussion

The mean values of gold content in coals, coaly shales and mineral interlayers are shown in Table 1. The clarke of gold in coal is not yet calculated, so that some published data on gold content in different coals and some mean values for sedimentary rocks

Table 1

Average Au content in the coals, coaly shales and mineral interlayers, ppb

Loaction	N[1]	Ash %	Coals		Coaly shales		Mineral interlayers	
			in ash	in coal	in ash	in coal	in ash	in coal
Elhovo	14	16,6	16[2];0,7[3]	4,0;1,2	3,3	1,2	3,0	2,0
Marica-East	49	14,9	20;1,3	2,4;1,2	14;0,8	6,6;0,7	0,4	0,3
Burgas	15	23,7	19;0,9	3,6;0,7	6,0;0,5	3,0;0,4	2,0	1,7
Pernik	19	15,2	171;1,3	33:1,5	141;1,3	80;1,2	29	28
Bobov Dol	10	17,8	5,1;0,7	1,0;1,2	3,8	2,9	8,0	7,0
Vâlče Pole	27	13,7	40;1,6	2,7;1,7	9,8;0,7	4,6;0,7	1,7	1,6
Meden Buk	9	19,6	60;0,6	11;0,6	4,7	2,3	27	24
Pčelarovo	25	18,6	17;2,8	1,7,1,5	16;1,2	7,8;1,1	4,0;0,7	3,6;0.7
Belogradčik	10	15,9	4,0;0,6	0,9;0,8	7,0;0,4	4,0;0,5	7,0	6,7
Dobrudža	16	21,8	3,8;0,9	0,7;0,9	4,0	2,3	0,5	0,4

[1] number of samples; [2] arithmetic mean; [3] relative standard deviation.

Table 2

Mean Au content of coals and sediments

Locality	Coal rank	Au, ppb in coals	Reference
Cheljabinski, USSR		5—800	Юровский (1968)
Kuznetzki, USSR		50	Юровский (1968)
USSR, average	subbituminous	0,2	Башаркевич et al. (1977)
	bituminous	0,7	
USSR, Far East	subbituminous	1,6—3,3	Китаев & Михайлов (1979)
	bituminous	1,2—5,6	
Kazahstan (19 samples)	subbituminous	3,5—443	Клер et al., 1987
England and Germany (single samples)	bituminous	5,5–138	Goldschmidth & Peters, 1933 (in Гольдшмидт, 1938)
Western U.S.A	bituminous	20	Boyle (1979)
Canada	pyritized lignite	5	Boyle (1979)
Canada	pyritized coal fragments	34	Boyle (1979)
Belgium		10—40	Block & Dams (1975)
Kentucky, U.S.A.	bituminous	0,1	Chyi, 1982
Coals, average		1–3	Юдович и др. (1985)
Shales		n. 10^{-7} %	Beus & Grigorian (1975)
Clarke for sedimentary rocks		1	Виноградов (1962)
Average for sedimentary rocks		5	Никитин & Ясырев (1974)

are shown in Table 2. As it is seen, the earliest data are rather high, as a result of inacurate analytical determinations in some cases, and of samples selected from gold-bearing areas. The mean contents cited by Башаркевич et al. (1977), Китаев, Михайлов (1979) and Chyi (1981) are suggested as reliable, because they have been deduced from a large number of samples and by using modern methods.

The mean gold contents in Bulgarian coals vary within the limits of 3 orders of magnitude — from 0.4 to 33 ppb. Excluding the Pernik basin with the uncommonly high gold content, the upper limit of the mean values is much lower — 11.4 ppb. For the most of the deposits the mean contents are comparable with those found by Китаев, Михайлов (1979) and for the Dobrudža basin — with the data of Chyi

(1982) for the Illinois coals. Taking into account the irregular distribution of gold, evidently the number of analysed samples both from the Bulgarian coal deposits and the foreign ones is still rather small for calculating the clarke of gold in coals.

The gold content in coaly shales and mineral interlayers is of the same range in the sedimentary rocks, i. e. from 1 to 5 ppb. Only for the Pernik basin it is higher, and that is in accordance with the high gold content in the coals.

Gold and ash content of coals

The decrease of the gold content with the increase of the ash content is a general tendency of the distribution of gold in coal ash (Fig. 2). For the deposits of Vâlče Pole, Burgas, Marica-East and Pčelarovo the enrichment of the low-ash coals in gold is very intense, and that shows the dominating role of the sorption ash for its concentration. That concerns also the Meden Buk deposit, but there the mineral interlayers are enriched in gold too. Although the maximum of gold content is reached at 20-30% asht in the Elhovo basin the sorption ash is also a concentrator of this element. In the deposit of Goce Delčev, besides the sorption ash, gold is bound to the terrigenous ash. The highest gold content in the Pernik basin is observed at the interval of ash content

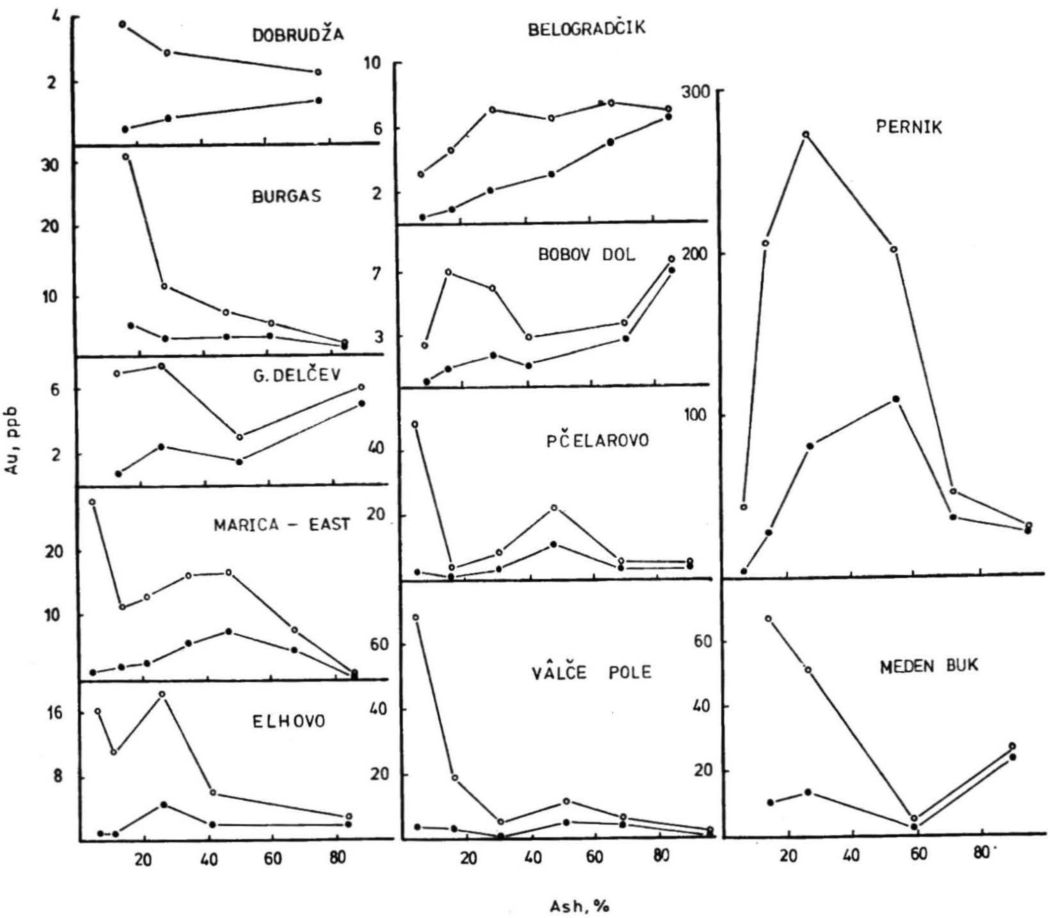

Fig. 2. Average Au content versus average ash content
○ — in ash; ● — in coal

20-60%, which is probably due to the transportation of gold with the terrigenous materials. Only for the deposit of Belogradčik the sorption ash is a carrier of gold and the terrigenous ash is a concentrator for it.

The distribution of gold in coal itself as related to the ash content is rather various. In the Burgas basin even in the coal itself the gold content decreases with the increase of the ash content, thus confirming the dominating role of the sorption ash for fixing this element. In the deposits of Vâlče Pole and Pčelarovo the gold content in coals varies slowly with increase of the ash content, because the sorption ash is a strong concentrator of the element. In the deposits of Dobrudža, Belogradčik, Goce Delčev, Bobov Dol and Elhovo the content of gold in coals increases with the increase of the ash content, thus the terrigenous ash in these deposits is a carrier of gold.

Gold in the lithotypes of coals

Till now there is no data on the distribution of gold in coal lithotypes. A number of determination of gold in lithotype are shown in Table 3. The distribution of gold within the vitrain and the whole coal samples is rather various. In the Marica-East ba-

Table 3

Au content in whole coal samples and in selected lithotypes, ppb

Sample	Ash, %	Au		Sample	Ash, %	Au	
		in ash	in coal			in ash	in coal
				Elhovo			
26	24,1	27	6	26x	4,9	31	15
70	22,7	14	3	70x	10,5	15	1,6
				Marica-East			
166	30,2	18	5,4	166l	8,4	46	4
952	49,5	25	10	952l	6,1	4	0,2
1152	52,0	4	2	1152l	3,0	19	0,6
				1152g	19,9	43	9
596	46,7	17	7,5	596l	3,7	34	1,0
278	37,7	20	8	278x	5,0	140	7
280	36,6	14	5	280x	3,8	27	1
1191	20,0	32	6	1191x	5,2	25	1
1499	16,7	2	0,3	1499x	4,5	41	1,8
126	37,4	24	9•	126v	7,0	17	1
142	86,5	0,1	0,09	142v	12,5	3	0,4
1790	45,2	6	3	1790v	12,6	22	3
701	69,9	16	10	701f	44,5	39	17
715	52,4	13	7	715f	44,1	18	8
				Goce Delčev			
6	89,2	6	5	6v	8,3	0,1	0,008
				Vâlce Pole			
39	35,7	8	0,3	39v	7,5	218	20
				Pčelarovo			
115	19,0	1	0,09	115v	3,9	0,1	0,004
116	31,5	11	3,4	116v	8,0	0,1	0,008
129	33,2	20	6,6	129v	12,6	6	0,8
233	49,0	45	22	233v	17,9	10	1,8

l — lyptain; x — xylain; g — gelinite; v — vitrain; f — fusain.

sin the humovitrain is usually considerably enriched in gold against the whole samples. Uncommon high gold content was found in some vitrains from the deposit of Vâlče Pole: in the vitrain from sample 39 the gold content is 2.5 times higher than it is in the whole sample. On the contrary, in the vitrain from the Pčelarovo deposit the gold content is usually lower than in the corresponding whole coal samples. The same is valid for the sample studied from the Goce Delčev deposit.

In the lyptain, xylain and fusian from the Marica-East basin the gold content is usually higher than in the whole samples. The distribution of gold is irregular in the separate lithotypes. Tne mean content of gold in ash decreases in the following succession: xylain (39 ppb) — fusain (24 ppb) — lyptain (22 ppb) — humovitrain (8.2 ppb). In the Elhovo basin the gold content in the ash of the xylain is 15 ppb and in the ash of the fusain is 39 ppb.

From all the above cited data we may conclude that the lithotypes of coals, especially the isolated vitrain lenses are often enriched in gold. Such a high gold concentrations were found earlier in isolated coal fragments in some other deposits (B o y l e, 1979).

Forms of occurrence of gold in coals

Based on published data and own research, Boyle (1979) assumes various forms of occurence of gold in coals: 1 — macroscopic and microscopic forms; 2 — gold probably associated with the coaly substance of coal and may be bound as an organometallic complex; 3 — gold that may be adsorbed to the coaly substances; 4 — much gold is present in or associated with pyrite and some gold is generally observed in the small amounts of galena, chalcopyrite and other sulphides that are found in coal basin; 5 — in the weathered part of coal seams gold may occur in jarosites and iron oxides.

К и т а е в, М и х а й л о в (1979) have established that the content of gold is higher in low-ash coals and fractions and they suppose that it occurs as an unit phase. Such a phase may be presented by autogenic minerals or by different forms sorbed to the organic matter. C h y i (1982) considers that the limited data do not permit to discuss the mode of occurrence of gold in the coal studied by him, nevertheless he supposes that it occurs mainly in inorganic form. During the study of the distribution of gold within fractions with different density from brown coals the maximum gold concentration has been found in the fractions with an intermediate density (1.70-1.95) (К л е р et al., 1987). In the same fractions a maximum amount of quartz was established, so that the authors consider gold to be bound not only to the organic matter, but also to the quartz grains.

Direct data on the presence of Au_{inorg} were listed by F i n k e l m a n (1980). By means of the electron microprobe he established several lames of native gold (with a size of 10 μm) and one particle of gold telluride in different coals. Some of the lames contain also silver.

The role of the organic matter for binding, transportation and concentration of gold in nature has been an object of study for 60 years and that continues in the present day. The main conclusions from these researches may be summarized as follows: 1 — Au (I) and Au (III) from many organometallic compounds and chelates (B o y l e, 1979; V i a s s o p o u l o s et al., 1990). 2 — Gold interacts with solutions of natural organic compounds, mainly humic and fulvic acids (F r e i z e, 1931; B a k e r, 1978; B e r g e r o n, H a r r i s o n, 1980). 3 — The complexes of Au (III) with the fulvic acids are more stable than those with the humic acids. That fact was established by Ф и ш е р et al. (1974) by means of model experiments, and also by В а р ш а л et al. (1984) — for the fulvic acids in natural waters. In the soils the preferencial relation of gold to the fulvic acids is characteristic too (Р о с л я к о в, Ц и м б а л и с т, 1988). In the secondary halos of dispersion up to 67.4% of the total content of gold is bound to the fulvic acids and only 5.6% — to the humic acids (Б е л о г о л о в а et al., 1989). 4 — The organic substance can reduce inorganic complexes of gold (for example $AuCl_4$) to elementary colloidal gold (O n g, S w a n s o n, 1969; Ф е д о с е е в а et al., 1985; G a t e l l i e r, D i s n a r, 1987; B e r g e r o n, H a r r i s o n, 1989). 5 — A bind of gold with the organic substance in soils, in sea sediments etc. was established. C u r t i n et al. (1987) have found a positive correlation between gold and the organic compounds in the water leachates from forest humus layers. After П а ш к о в а et al. (1987, 1989), up to 15.7% of the total amount of gold in sea sediments enter into the composition of the separated humic acids and from 25 to 93% of this amount is directly bound to the nuclides of their macromolecules. 6 — Gold can migrate in natural waters as lames of submicroscopic size, or as inorganic anions, or as particles of elementary gold included or sorbed to suspended inorganic compounds (Р а з и н, Р о ж к о в, 1966; C r o c k e t, 1972). The fulvate and humate complexes have a special importance.

The various information on the interaction of gold with humic substances was critically appraised by В а р ш а л et al. (1990). They consider the complex formation between gold and humic compounds to be one of the most important processes for its migration and concentration in the hypergenic processes. The interaction of gold with the fulvic acids mainly leads to the formation of soluble complexes of the type $Au(OH)_2$ fulv. ac. and to the increase of the migration ability of gold, since the interaction with humic acids is favorable for sedimentation, i. e. for concentration of gold. The chemical bind of gold with humic acids is confirmed.

On the basis of all above mentioned data it can be assumed that in the coal-forming process, in a reducing medium, at low pH and in the presence of coagulating organic compounds, favor conditions are created for fixing gold in several ways: capture of colloidal elementary gold, adsorption to a coagulating organic substance, formation of chelates and organo-metallic compounds.

It can be supposed that a part of Au_{org} is presented as Au_{bio}. There are still many data on the content of gold in plants. According to the review (till 1971) by C r o c k e t (1972), the average gold contents in earth plants are from 8 to 62 ppb in dry substance (after the data on 241 samples). It must be taken into account that in many cases the plants investigated come from gold-bearing areas as it has been established by Т а й с а е в (1988). The most detailed research was made by Р а з и н, Р о ж к о в (1966), it included 497 samples from 79 plant species of 31 families from the area of gold deposits in Yakutia. They have found that about 62% of these samples contain $\sim$1 ppb gold. The roots of the plants directly extract gold from soils, rocks and natural waters. Usually the gold content is proportional to its content in soils. Both perennial and annual plants can concentrate gold up to 100 ppb, its distribution being irregular in the different organs of plants — increasing from the branches to the steams and reaching the maximum in the roots. The adsorption of gold by plants is also studied in details by S h a c k l e t t e s et al. (1970). It is not yet clear what amount of gold occurring in the plants would be preserved.

On the basis of the published data and of own data the Bulgarian coal deposits studied it can be concluded that gold occurs as Au_{org} and Au_{inorg}. The organic affinity of gold is proven by its higher content in the ash of low-ash coals and by the decrease of gold content with increase of the ash content (Fig. 2). This conclusion is even more categorically confirmed by the distribution of gold within specific gravity fractions of coal — the content of gold in the ash of the fractions decreases with the increase of the ash content. This tendency is valid even for the gold content in coal itself, i. e. for not burnt fractions from the most of the samples studied (Fig. 3). The straight organic affinity of gold is proven also by the relation Au_{inorg}/Au_{org}, which is lower than 1 for a large interval of ash content (Table 4).

In the low-ash lithotypes of coals the gold content is often high. For example a liptain sample from the Marica-East basin contains 28 ppb of gold, the ash con-

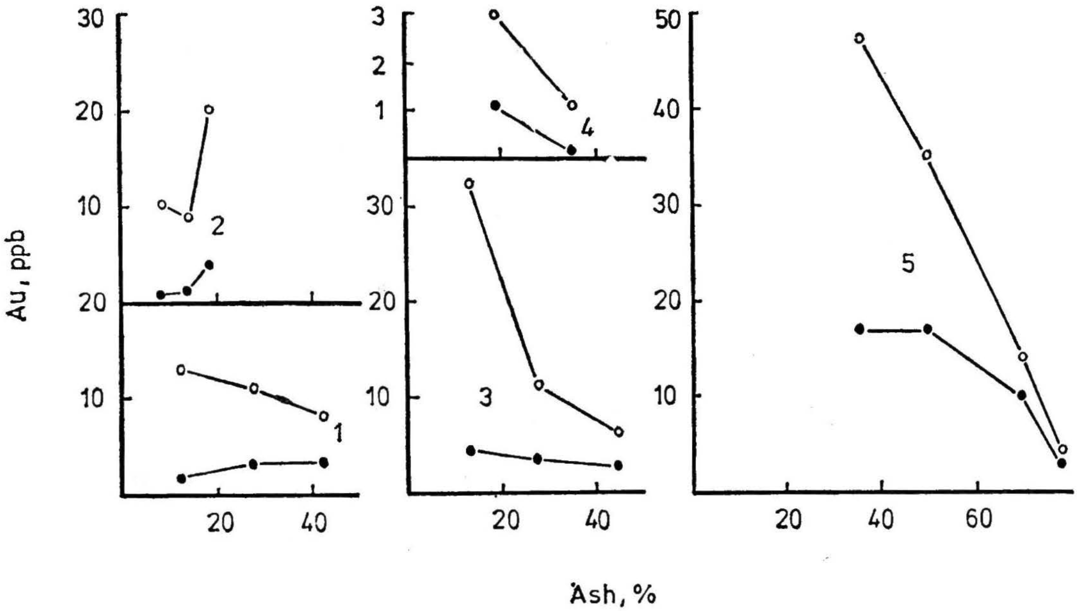

Fig. 3. Distribution of Au in specific gravity fractions from different samples:
○ — in ash; ● — in coal; *1* — Bobov Dol 169; *2* — Marica-East 963; *3* — Marica-East 5824; *4* — Elhovo 32; *5* — Pčelarovo 194

tent being 2.4%, which corresponds to the biogenic ash. This can be explained by the inheritance of gold from the plants (Au_{bio}).

The high content of gold in the mineral interlayers in the deposits of Goce Delčev and Meden Buk is an indication of a presence of Au_{inorg}. In the Belogradčik deposit Au_{inorg} seams to be a dominating form of occurrence of gold — both in ash and in coal itself there is a straight positive correlation between the gold content and the ash content (Fig. 2), and there is a rather high relation Au_{inorg}/Au_{org} even for the low-ash coals (Table 4). Besides the elementary gold the Au_{inorg} may be also presented as gold bound to the clay minerals. The research made by Федосеева

Table 4

Au_{inorg}/Au_{org} ratio for the coals, coaly shales and mineral interlayers

Ash, %	0—10	10—20	20—40	40—60	60—80	80—100
Elhovo	0,1	0,3	0,7	2,2	—	10
Marica-East	0,01	0,05	0,1	0,3	0,6	1,8
Goce Delčev	—	0,8	2,0	5,1	—	45
Burgas	—	0,08	0,2	0,4	0,6	2,2
Pernik	0,6	1,5	3,3	10	22	189
Bobov Dol	1,4	2,8	6,1	10	36	87
Vâlče Pole	0,02	0,08	0,2	0,4	0,9	9,9
Meden Buk	-	0,4	0,9	3,5	—	22
Pčelarovo	0,1	0,4	0,8	1,7	4,2	18
Belogradčik	2,3	5,6	11	25	53	531
Dobrudža	—	0,3	0,5	—	2,6	16

— = no samples.

(1988) shows that at pH=6, in the presence of Al_2O_3, 98% of gold, which occurs in solution as $AuCl_2(OH)_2^-$ or $AuCl_3^-$, may be adsorbed.

In pyrite from coals studied the content of gold has not been determined, and in the pyrite from underlaying clays in the Elhovo basin no gold gas been found the detection limit being 1 ppb.

Conditions for accumulation of gold

The accumulation of gold is breafly discussed by A v e r i t t (1969). After his opinion gold may occur in "any coal deposit that is formed near a denudated source of gold". During the accumulation of plant materials gold is carried in the basin in three ways: 1 — by a mechanical transportation of fine dispersed gold; 2 — in a soluble state; 3 — by plants. К л е р et al. (1987) consider that theoretically two ways of carrying gold in coal-bearing complexes are possible: mechanical and chemical migration.

In the most of the Bulgarian coal deposits gold is to a considerable extent bound of the organic matter, which indicates not only and not mainly a mechanical transportation but also a chemical interaction. The same conclusion follows from the distribution of gold in the vitrain lense (sample 34) from Valče Pole deposit (Table 5). Its gold content decreases from outside to inside, which indicates the penetration of gold-bearing solutions in this direction. Furthermore, the mineralized crust around the lense contains less gold than the periphery of the lense does, thus indicating the bind of gold to the organic matter. The core of the vitrain lenses from the village of Pastrogor area is enriched in gold too in comparison to the mineralized crust (Table 5).

The Burgas basin differs from all the rest by the decrease of gold content as in ash so in coal with the increase of the ash content. This event can be caused by a transgression of the sea water during the formation of this deposit (supposed by В ъ л ч е в а, Ш и ш к о в, 1986). The offshore sea water contains 0.13 ppb of gold, while in the water of the central part of the ocean the gold content is on a range lower — 0.011 ppb (C r o c k e t, 1972). Furthermore a considerable part of gold in the sea water occur in a soluble state (П е щ е в и ц к и й et al., 1965; C r o c k e t, 1972), that favorises the interaction of gold with the organic substance. The complex of basic volcanic rocks of the Burgas Sinclinorium, which is in a paragenetic relation with the gold-sulfide mineralization in this area (К у й к и н, 1974), might be another source of gold in the coals of the Burgas basin.

The maximum gold content is found in the coals of the Pernik basin. The gold-bearing places around the Vitosha-Mountain, known long ago and described by Д и м и т р о в (1960), might be a source of gold in this basin. For the present it is not clear if the region of Kraishte may be attributed to the source area of the Pernik basin,

Table 5

Au content in vitrain lenses, ppb in ash

Location Sample, No Zone	Vâlče Pole							Pčelarovo	Pâstrogor		Pleven	
	34				35			37	280[1]		gagate	
	a	b	c	d	a	d	p		a	d	c	d
Ash, %	4,1	3,5	4,5	63,7	6,0	33,3	67,7	7,8	3,9	35,3	15,9	84,3
Au	0,8	35	113	18	0,8	22	2	13	12	4,3	18	4

a — core; b — middle zone; c — periphery; d — shell of the lenses; p — pyritized vitrain; 1 — average of 4 samples.

since it is considered that the present position of the basin does not correspond to its earlier position during the coal-forming process (Ž. I v a n o v, oral communication). So far as the gold-bearing quatrz veins in the Kraishte area could be a source of gold, their intensive tectonic destruction (Т о н е в, 1964) would fasilitate their erosion and the removal of gold. Whichever was the source area for the Pernik basin, the transportation of gold seams to be mechanical, since the coaly shales, as well the coals have a high content of gold (Fig. 1).

The high gold content in the coal manifestations in the Vâlče Pole deposit is considered to be caused by the high gold content of the Madžarovo ore field, attributed to the quartz-gold-polymetallic formation (Б р е с к о в с к а, Г е р г е л ч е в, 1988). It is worth noting that the peripheric veins, barren quartz veins included, which are the most neighbouring to the Vâlče Pole molasse, have the highest gold content. The subsinchronism of the ore-forming and coal-forming processes is a base to consider that the source of gold was common.

In the area of the deposit of Meden Buk there is gold-bearing quartz veins of not economic significance, which are older than the coals are, and which have been submitted to erosion (after unpublished data of T. T o d o r o v). May be they are a source of the high gold content in coals in this deposit.

The reasons expressed about the relation of gold to a definite ore mineralization have a preventive character and they need to be confirmed by purposeful studies. Thus some of the facts that seem to be contradictory could be explained. For example, why the gold content in the coals of the Pčelarovo deposit is 2.7 times lower than in the Vâlče Pole deposit, though the first is on the territory of the Spahievo ore field, which appartains to the same gold-bearing formation. Since the coals of the Meden Buk deposit are enriched in gold because of their proximity to the quartz-gold-sheelite veins, why the content of tungstein in the coals is unexpectedly low.

The relation of gold to the organic matter is expressed by means of the value of K_{typ} — the ratio of the gold contents in the ash of the low ash coals and the mineral interlayers. On the basis of this coefficient gold may be considered as high-typomorphic element for the coals from following deposits: Vâlče Pole (40), Burgas (16), Pčelarovo (12), Marica-East (6.9), Elhovo (5.4), and as typomorphic for the coals from the deposits of Dobrudža (4.0) and Meden Buk (2.5)

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