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THERMOELECTRIC PROPERTIES OF PYRITE IN THE SUPRA-ORE LEVEL OF GOLD MINERALIZATION (UKRAINIAN CARPATHIANS)

Abstract: The thermoelectric properties of different-aged generations of pyrite from Lostun (Chyvchyny ore region) Tukalo and Kamin-Kliovka (Лостунь, Тукало, Камінь-Кльовка) (Rakhiv ore region) ore manifestations are investigated.

The research included traditional geological observations with the collection of samples of various hosting ores, together with mineralogical analysis measuring their reflective power and the thermo electro-motive force of pyrite.

Two pyrite generations (pyrite I and pyrite II) have been revealed by the investigation's results. The crystals belonging to the generations differ morphologically quite vividly (pyrite I has the form of a pentagonal dodecahedron, while pyrite II takes the form of a cube) and have different thermoelectrical properties. Pyrite I testifies to the fact that in the direction from the central parts of crystals with a pentagonal-dodecahedron tendency to its surface, the thermoelectrical properties essentially change. In particular, the central parts of pyrite I crystals have electron conductivity while its faces are mainly hole ones. Such essential changes of the pyrite thermoelectrical properties from the central parts of the crystals to their peripheral ones are probably mostly caused by quantitative changes of element admixtures in the crystalline lattice. However, the pyrite II thermoelectrical properties investigation results testify that this mineral has only hole-conductivity.

Thus, in terms of general thermo-e.m.f. (electromagnetic field) as well as selections range, the thermoelectric properties of the pyrite from the Lostun and Tukalo ore manifestations and the Sauliak (Сауляк) auriferous deposit are similar. The comparative character of the pyrite thermoelectric properties from the investigated ore manifestations, the Sauliak deposit and other auriferous deposits testify to the supra-ore level of the gold mineralization in Tukalo and Lostun objects and make it possible to assume that erosion shear of the gold mineralization in Tukalo ore manifestation is similar to the Sauliak deposit erosive shear and is deeper in comparison to the Lostun ore manifestation.

Keywords: pyrite, sulfides, gold, thermoelectroconductivity, ore manifestations

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1. Introduction

The Chyvchyny (Чивчини) and Rakhiv (Рахів) ore regions have some common features in terms of geological structure (structural-tectonic, petrological, lithology-stratigraphic [1–5]. Their structural-metallgenetic position is caused by belonging to the Chyvchyny and Rakhiv outcrops of the Marmarosky massif. The single-type ore-bearing formations are spread within its boundaries.

In the Rakhiv ore region in particular, the following objects are known: the Sauliak auriferous deposit, and the Bilyi Potik (Білий Потік), Kamin-Kliovka, Tukalo, Velykiy Banskiy (Великий Банський), Yaseniv (Ясенів) ore manifestations. Within the Chyvchyny ore region are found the Albin (Альбин), Dobryn (Добрин), Lostun, Mokryn (Мокрин), Perkalab (Перкалаб), Preluchnyi (Прелучний) and Popadynets (Попадинець) ore manifestations.

In our previous scientific papers we presented data concerning the typomorphism of minerals-semiconductors from the Bilyi Potik, Velykiy Banskiy [6, 7] Dobryn and Albin [6, 8] and Kamin-Kliovka ore manifestations [9].

So far as the Tukalo, Lostun and Kamin-Kliovka ore manifestations are similar in terms of their geological formation conditions and mineral composition [10], we considered a more detailed study and comparison of the peculiarities of physical-chemical conditions of mineralization worthwhile.

The thermoelectric properties of different-aged generations of pyrite from Lostun (Chyvchyny ore region), Tukalo and Kamin-Kliovka (Rakhiv ore region) ore manifestations are investigated in this paper.

Data (SR-α_{med}) testifies to the functional connection of the average values (α_{med}) of statistically reliable selections of thermo-e.m.f. (hole or electron conductivity) with ranges of these selections (SR). It provides an opportunity to reflect not only the peculiarities of the thermo-e.m.f. properties of the mineral different generations but also different parts of the separate crystals and (be thermo-e.m.f. vector) evaluate the changes and tendencies acquired during its formation).

The comparative character of the pyrite thermoelectric properties from the investigated ore manifestations, the Sauliak deposit and other auriferous deposits can testify to the supra-ore level of the gold mineralization in the Tukalo, Kamin-Kliovka (Fig. 1) and Lostun objects, and make it possible to assume that the erosion shear of the gold mineralization in the Tukalo ore manifestation are similar to the Sauliak deposit erosive shear and is deeper in comparison to the Lostun ore manifestation.

2. Methods

Thermo-e.m.f. was determined with the help of apparatus assembled in an applied thermobarogeochemistry laboratory. The main measuring instrument was a V7-21 microvoltmeter. Also employed were electrodes-needles that made it possible to thermically excite every area of the surface of the investigated samples. The tension directed to a hot electrode was stabilized with the help of a VIP-10 feeding block. The precision and stability of measurements was checked by the periodic measurement of standard thermo-e.m.f. (a constantans plate produced from a copper-constant thermocouple) and by supporting the constant difference value between the working surfaces of the hot and cold electrodes (100°C) with a help of potentiometric control. Therefore the possible systematic error of thermo-e.m.f. measurement was minimized. The measured potential difference between the excited and unexcited parts of the investigated mineral-semiconductor was divided into the difference of temperature between the working surfaces of the hot and cold electrodes. The coefficient of thermoelectric potential α of investigated sample were brought to 1 degree (mcV/deg) and were plotted onto corresponding diagrams. Grouping intervals of thermo-e.m.f. values were picked out in conformity with known empiric stredges Formula (1):

$$\alpha = \frac{(\alpha_{max} - \alpha_{min})}{1 + 3.332 \log n} \tag{1}$$

where:

$\alpha_{max} - \alpha_{min}$ – selection range,

n – quantity of measurements.

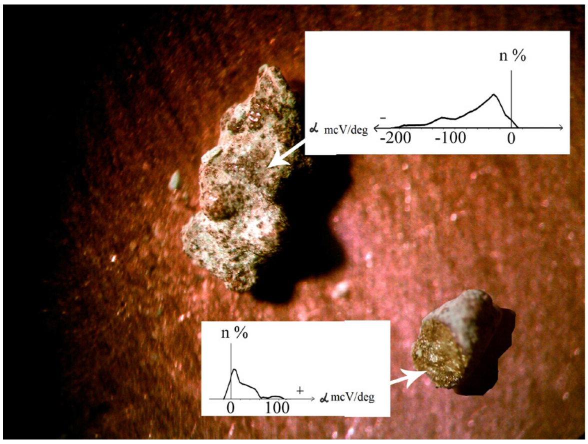

Fig. 1. Method for the determination of power thermo-e.m.f. 50 measurements of thermo-e.m.f. value were realized in both the central part of pyrite grains and on its surfaces or separate faces (ore manifestation Kamin-Kliovka, magnification power 12.5 ×)

Every investigated crystal or mineral grain was tested 50 times; only very fine grains in separate cases were studied by fewer measurements. 50 measurements of thermo-e.m.f. values were realized in both the central part of crystals, the grains and on its surfaces or separate faces (Fig. 1).

3. Results

3.1. Lostun ore manifestation

The Lostun ore manifestation is situated 600 m to the south-east of the Lostun mount within the Chyvchyny ore region and occurs in chlorite-quartz(SiO_2) and sericite-chlorite-quartz shists that form the core of the anticline fold of the north-western strike. The rocks are greatly folded and complicated by forms of a superior order.

According to Matkovsky's data [5], lead-zinc mineralization within this ore manifestation is connected with brecciate rocks consisted of fragments of sericite-quartz and sericite-chlorite slates, sometimes with barite, barite-quartz and quartz-barite-carbonate veined formations.

The main minerals of the ore manifestation (Tab. 1) form the following mineral associations: chlorite-quartz, sericite-quartz, sericite-chlorite-quartz, pyrite-quartz, pyrite-galenite-sphalerite, pyrrhotite-chalcopyrite-quartz, quartz-carbonate-barite.

The main ore mineral of this ore manifestation is galenite, in close association with sphalerite, pyrite and chalcopyrite. As a rule, these minerals form fine impregnations, small (to 5 mm) bunches and thin streaks of different sizes (from 0.1 to 2.5–3.5 mm).

In disintegrated rocks, blocks within the ore manifestation boundaries were observed as fragments of ore bodies, where some galenite separations reach 5–7 sm (centimeters) in size, while chalcopyrite – 3–4 sm and pyrite – 2–3 sm.

Table 1. Main minerals of the Lostun ore manifestation

Non-metalliferous	Ore
Quartz I, II, III	pyrite I, II
Chlorite	pyrrhotite
Sericite	chalcopyrite
Barite	galenite
Carbonate I, II	sphalerite

The pyrite is widespread, not only in the ore bodies but also in enclosed rocks and was studied in detail. In particular, these mineral forms separations in enclosed rocks in the form of separate crystalline individuals (to 7 mm in size) and separations of an irregular form (10–15 mm in size). In the quartz streaks, pyrite has a tendency be connected with its selvage parts but may occur in the quartz in the form of impregnations, thin streaks and irregular separations. The general selection of the pyrite thermo-e.m.f. values in the Lostun ore manifestation are presented in Figure 2b.

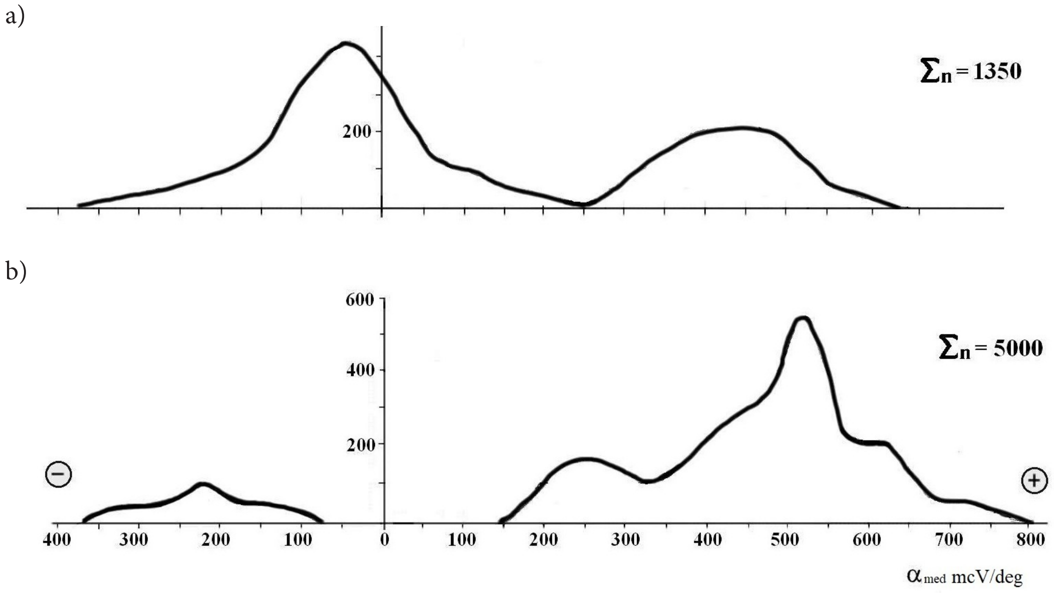

Fig. 2. General selections of thermo-e.m.f. values of pyrite from the Sauliak deposit (a) – upper part [10] and Lostun (b) – lower part; Σn – measurements quantity

Two pyrite generations (pyrite I and pyrite II) have been revealed by the investigation. The crystals belonging to the generations differ morphologically quite vividly (pyrite I has the form of a pentagonal dodecahedron, while pyrite II takes the form of a cube) and have different thermoelectrical properties.

3.2. Tukalo ore manifestation

The Tukalo ore manifestation is situated 700 m above the Tukalo stream junction (a left tributary of the Tysa (Тиса)) on the outskirts of Dilove (Ділове) village in the Rakhiv ore region. The main minerals of the ore manifestation (Tab. 2) form the following mineral associations: chlorite-quartz, sericite-quartz, pyrite-quartz, pyrite-galenite-sphalerite). Gold mineralization is spatially connected with an intensive schist formation zone. A ferruginated and intensive silificated gold-bearing zone is situated among the chlorite-sericite-quartz slates. Numerous mainly fine quartz streaks with a thickness to the first centimeters (except quartz and carbonate) and contain galenite, pyrite, chalcopyrite and native gold. These minerals are also super posited onto enclosed rocks forming its impregnated or streaky-impregnated texture.

Table 2. Main minerals of the Tukalo ore manifestation

Non-metalliferous	Ore
Quartz I, II, III	pyrite I, II
Chlorite	galenite
Sericite	sphalerite
Carbonate I, II	chalcopyrite

A general selection of the pyrite thermo-e.m.f. values in the Tukalo ore manifestation are presented in Figure 3b.

Two pyrite generations (pyrite I and pyrite II) were revealed by the investigation. The crystals belonging to the generations differ morphologically quite vividly (pyrite I has the form of an octahedron, while pyriteI-Itakes the form of a cube) and have different thermoelectrical properties.

3.3. Kamin-Kliovka ore manifestation

The Kamin-Kliovka ore manifestation is situated 300 m from the Kamin-Kliovka mountain on the outskirts of the city of Rakhiv. The main minerals of the ore manifestations (Tab. 3) form the following mineral associations: chlorite-quartz, sericite-quartz, quartz-barite-carbonate, pyrite-quartz, pyrite-galenite-sphalerite).

Two pyrite generations (pyrite I and pyrite II) have been revealed by the investigation. The crystals belonging to the generations differ morphologically quite vividly (pyrite I has the form of an octahedron, while pyrite II takes the form of a cube) and have different thermoelectrical properties.

Table 3. Main minerals of the Kamin-Kliovka ore manifestation

Non-metalliferous	Ore
Quartz I, II	pyrite I, II
Carbonate II	pyrite I, II
Quartz II	sphalerite

As a rule, pyrite I thermo-e.m.f. values fluctuate from −500 to +980 change from 120 to 480 mcV/deg (Tab. 4).

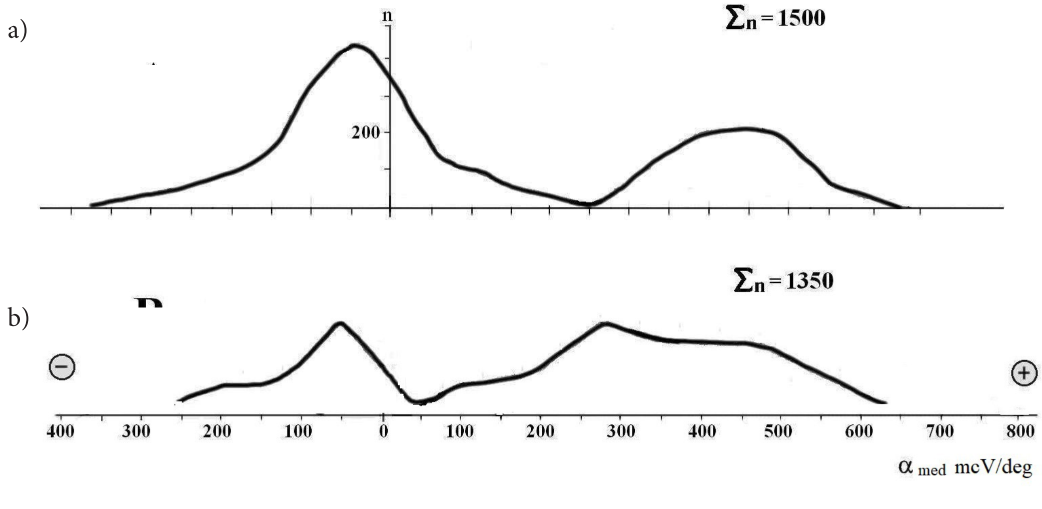

Fig. 3. General selections of thermo-e.m.f. values of pyrite from Sauliak deposit (a) – upper part [10] and Tukalo (b) – lower part); Σn – measurements quantity

Table 4. Pyrite I and II thermo-e.m.f. values for the Lostun ore manifestation in the inner parts of crystals (a) and their faces (b)

Crystal number	Simple forms that determine crystal habit	Pyrite generations	α [mcV/deg]			Selection range [mcV/deg]
			max.	min.	average	
1 (a)	cube	II	+580	+270	+444	310
1 (b)	cube	II	+670	+270	+460	400
2 (a)	cube	II	+590	+250	+402	340
2 (b)	cube	II	+600	+370	+508	230
3 (a)	cube	II	+610	+320	+435	290
3 (b)	cube	II	+1000	+690	+829	310
4 (a)	pentagonal dodecahedron	I	−390	−100	−235	290
4 (b)	pentagonal dodecahedron	I	+790	+510	+620	280
5 (a)	cube	II	+460	+170	+304	290
5 (b)	cube	II	+750	+470	+594	280
6 (a)	pentagonal dodecahedron	I	+580	+100	+277	480
6 (b)	pentagonal dodecahedron	I	+760	+400	+622	360
7 (a)	cube	II	+600	+320	+476	280
7 (b)	cube	II	+600	+390	+515	210
8 (a)	cube	II	+680	+280	+437	400
8 (b)	cube	II	+810	+410	+610	400
9 (a)	cube	II	+590	+320	+460	270
9 (b)	cube	II	+560	+220	+356	340
10 (a)	pentagonal dodecahedron	I	−500	−150	−315	350
10 (b)	pentagonal dodecahedron	I	+790	+380	+588	410
11 (a)	cube	II	+520	+200	+382	320
11 (b)	cube	II	+620	+370	+514	250
12 (a)	cube	II	+560	+260	+268	300
12 (b)	cube	II	+640	+440	+525	200
13 (a)	cube	II	+590	+280	+465	310
13 (b)	cube	II	+620	+390	+538	230
14 (a)	pentagonal dodecahedron	I	−170	−50	−109	120
14 (b)	pentagonal dodecahedron	I	+380	+180	+280	200
15 (a)	cube	II	+450	+210	+323	240
15 (b)	cube	II	+630	+420	+531	210
16 (a)	cube	II	+640	+280	+438	360
16 (b)	cube	II	+660	+370	+514	290
17 (a)	cube	II	+610	+150	+399	460
17 (b)	cube	II	+780	+500	+632	280
18 (a)	pentagonal dodecahedron	I	+600	+200	+415	400
18 (b)	pentagonal dodecahedron	I	+980	+600	+710	380
19 (a)	cube	II	+350	+140	+229	210
19 (b)	cube	II	+610	+370	+504	240
20 (a)	pentagonal dodecahedron	I	−500	−150	−282	350
20 (b)	pentagonal dodecahedron	I	+640	+320	+454	320
21 (a)	pentagonal dodecahedron	I	+630	+370	+542	260
21 (b)	pentagonal dodecahedron	I	+650	+480	+587	170
22 (a)	cube	II	+300	+100	+206	200
22 (b)	cube	II	+560	+200	+420	360
23 (a)	cube	II	+350	+140	+238	210
23 (b)	cube	II	+610	+370	+524	240
24 (a)	pentagonal dodecahedron	I	−320	−100	−229	220
24 (b)	pentagonal dodecahedron	I	+730	+350	+551	380

Variational curves of the distribution of the thermo-e.m.v. values for the greater part of the investigated crystals are bimodal. Such a peculiarity can be explained by the probable later growth of the peripheral parts of some of the mineral crystals from a later fluid portion. The pyrite I diagram (SR-α_{med}) (Fig. 4) testifies to the fact that in the direction from the central parts of crystals of a pentagonal-dodecahedron habit to their surface, the thermoelectrical properties essentially change. In particular, the central parts of pyrite I crystals have electron conductivity while its faces are mainly hole ones. Such essential changes to the thermoelectrical properties of the pyrite from the central parts of crystals to their peripheral ones are probably caused by quantitative changes in the element admixtures in the crystalline lattice. Data (SR-α_{med}) testifies to the functional connection of the average values (α_{med}) of statistically reliable selections of thermo-e.m.f. (hole or electron conductivity) with ranges of these selections (SR). It provides the opportunity to not only reflect on the peculiarities of the thermo-e.m.f. properties of the mineral different generations, but also different parts of the separate crystals and (be thermo-e.m.f. vector) evaluate the changes in the tendencies acquired during its formation).

The pyrite II thermoelectrical properties results testify to the fact that this mineral has only hole-conductivity. All thermo-e.m.f. values fluctuate from +200 to +600 mcV/deg. The selection range of the pyrite II thermo-e.m.f. values are about +210 to −4600 mcV/deg. Variational curves of the general selections of thermo-e.m.f. values for many pyrite crystals (especially crystals with intensive striation of the faces) have bimodal similarity with scarcely noted excesses that are probably caused by initial and later growth of this pyrite generation from different “waves” of the same fluids.

Diagram (SR-α_{med}) of the pyrite II (Fig. 5) testifies to the fact that in the direction from the central parts of the cubic habit crystals to their surface, the thermoelectrical properties change from low meanings of the hole conductivity to superior ones, that is in this case one can only see quantitative changes to the thermo-e.m.f. values.

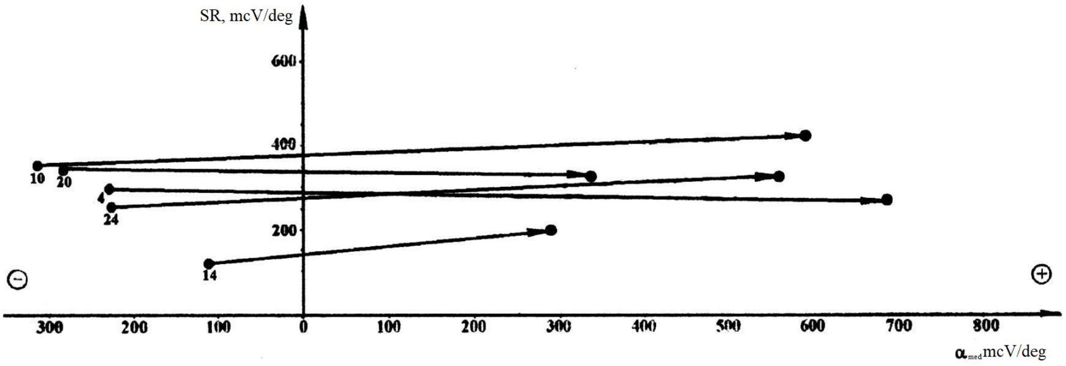

Fig. 4. Thermo-e.m.f. vectors of the pyrite I thermo-e.m.f. average values alterations (vectors of the crystals growth) in direction from central parts of crystals with a pentagonal dodecahedral habit to their surface (Lostun, Chyvchyny ore manifestation)

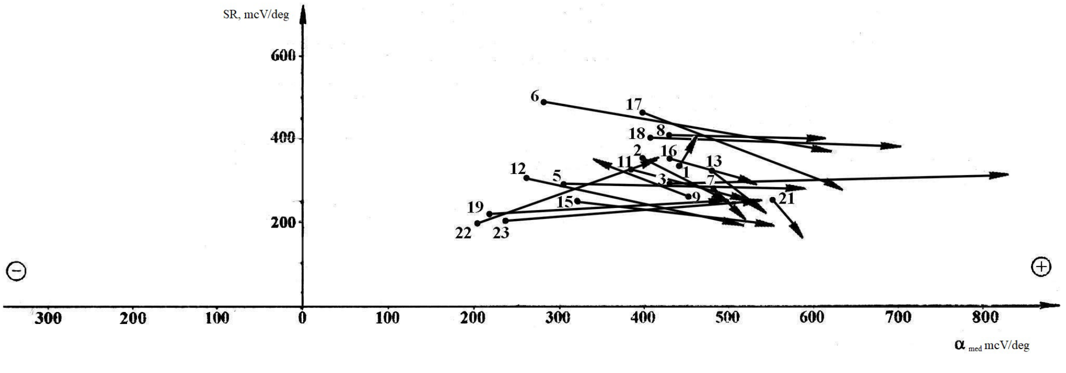

Fig. 5. Thermo-e.m.f. vectors of the pyrite II thermo-e.m.f. average values alternations (vectors of the crystals grown in direction from the central parts of the cubic habit crystals to their surface (Lostun, Chyvchyny ore manifestation)

With the Tukalo and Kamin-Kliovka manifestations, the thermoelectrical pyrite properties from quartz streaks in enclosed rocks were investigated in detail (Tab. 5).

A general selection of pyrite thermo-e.m.f. values from the Tukalo ore manifestation are presented in Figure 3. According to their morphology and size, the pyrite crystals from this ore manifestation are scarcely distinguished so far as their habit is mainly determined by cube and octahedron combination. At the same time, the results of investigations of the thermoelectric properties of pyrite crystalline samples the opportunity to assume that its generation, growth and later growth took place in a different manner. In particular, the general selection of thermo-e.m.f. values testifies to the presence of an obvious bimodal distribution of these parameters while thermo-e.m.f. vectors in SR-α_{med} diagram are oriented in a different manner: in one case, in direction from electron conductivity to hole conductivity (or from low values of hole conductivity to higher ones): in another case – from higher values of hole conductivity to lower (or to the electron meanings) (Fig. 6).

Thus, by general thermo-e.m.f. as well as selections range, the thermoelectric properties of the pyrite from Lostun, Kamin-Kliovka, and Tukalo ore manifestations and the Sauliak auriferous deposit (Tab. 6) are similar (in particular, by statistically reliable selections of thermo-e.m.f. values investigated crystals posses electron, hole or mixed conductivity; at the same time these meanings are clearly grouped into two massifs that can testify to two acts of pyrite formation).

Within the peculiarities of the pyrite thermoelectric properties from the Tukalo ore manifestation it was possible to distinguish two pyrite generations (pyrite I and pyrite II).

The pyrite thermoelectric properties data indicate one of the criteria for revealing pyrite generations (pyrite I and pyrite II) [11].

The thermo-e.m.f. and selection range of thermoelectric properties of the pyrite from the Kamin-Kliovka ore manifestation has its own characteristics (Tab. 7).

Table 5. Thermoelectrical properties of the pyrite crystals from the Tukalo ore manifestation (on its faces and inner parts)

Crystal number	Selection	Investigated simple firms that determine crystal habit	α [mcV/deg]			Selection range [mcV/deg]
			max.	min.	average	
1	b	cube and octahedron combination	+470	+200	+275	270
	a	crystal inner parts	+70	−50	−15	120
2	b	on the cube faces	+300	+10	+215	290
	a	crystal inner parts	+70	−110	+1	180
3	a	on the octahedron faces	−20	−110	−60	90
	c	cube and octahedron combination	−20	−100	−50	80
	b	crystal inner parts	+70	−70	−5	140
4	b	cube and octahedron combination	−20	−110	−60	90
	a	crystal inner parts	+70	−200	−57	270
5	b	cube and octahedron combination	+630	+380	+460	250
	a	crystal inner parts	+470	+220	+360	250
6	b	cube and octahedron combination	+250	+20	+80	230
	a	crystal inner parts	+480	+210	+345	270
	d	cube and octahedron combination	+110	−60	+15	170
	c	crystal inner parts	+390	+100	+245	290
7	b	cube and octahedron combination	−20	−260	−145	240
	a	crystal inner parts	+570	+100	+336	470
8	b	cube with a striation on the faces	+690	+400	+490	290
	a	crystal inner parts	+720	+430	+565	290
9	a	cube	−50	−260	−240	210
	b	octahedron	−200	−280	−240	80

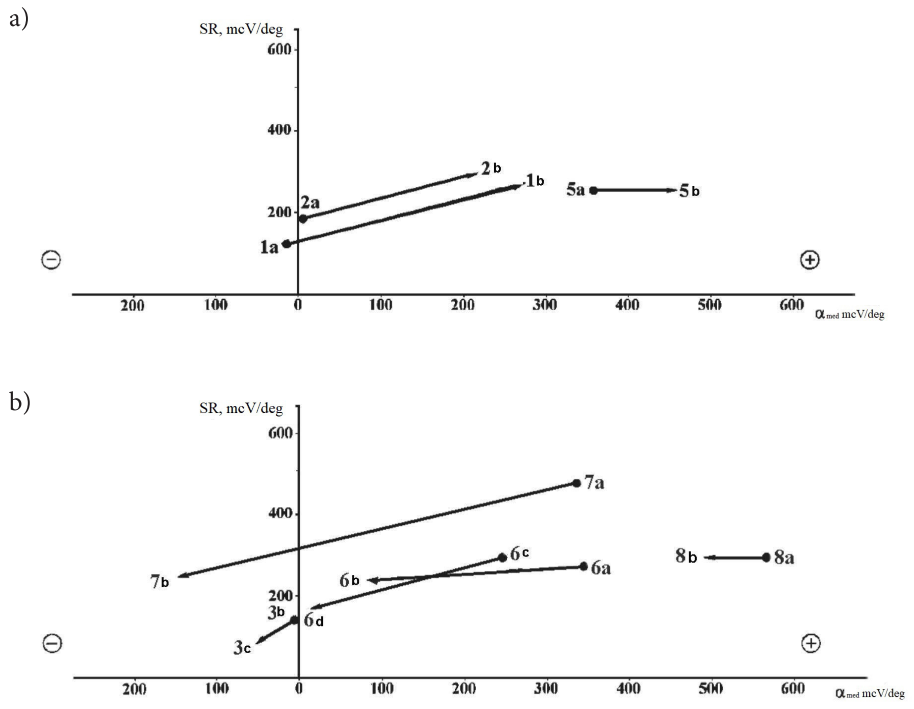

Fig. 6. Vectors of thermo-e.m.f. average values alterations and selections range of the pyrite I (a) and pyrite II (b) crystal growth vectors from the central parts of crystals to their surface (Tukalo ore manifestation, Rakhiv region)

Table 6. Thermoelectric properties (in faces and inner parts) of the pyrite crystals from the Sauliak deposit

Crystal number	Selection	Investigated simple firms that determine crystal habit	α_{med} [V/deg]			Selection range [mcV/deg]
			max.	min.	α_{med}	
1	2	3	4	5	6	7
1/8	a	pentagonal dodecahedron	+400	+20	+165	380
	c	inner part	–20	–280	–140	260
	b	octahedron	+460	+200	+325	260
1	a	cube + octahedron	–20	–200	–60	180
	b	inner part	+90	–90	–25	180
6	a	cube with striation	–210	–460	–290	250
	c	inner part	–20	–220	–80	200
	b	octahedron	–6	–110	–45	105
38	a	cube with striation	–35	–280	–185	245
	b	octahedron	–20	–110	–90	90
	c	inner part	+90	–100	–25	190
40	a	cube	–20	–220	–80	200
	b	octahedron	+260	+20	+80	240
	c	inner part	+8	–250	–60	242
41	a	cube	+210	–90	+25	300
	b	inner part	+330	–70	+80	400
42	a	cube + octahedron +pentagonal dodecahedron	–20	–110	–70	90
43	a	cube with striation	+490	+340	+450	150
	b	inner part	+690	+210	+452	480
44	a	pentagonal dodecahedron	+680	+400	+540	280
	b	octahedron	+490	+240	+410	250
	c	inner part	+490	+200	+356	290
45	a	pentagonal dodecahedron	+660	+350	+535	310
	b	octahedron	+490	+260	+410	230
	c	inner part	+460	+280	+380	180

Table 7. Thermoelectric properties of the pyrite grains from the Kamin-Kliovka deposit

No.	Samples	∝ min.	∝max.	∝ average	Selection range [mcV/deg]
1	1.	250	620	428.6	370
2	2	150	520	335.6	370
3	3	260	440	379.2	180
4	97/10 a	130	400	280.4	270
5	97/10 b	170	450	347	280
6	97/25 a	140	420	253.4	280
7	97/25 b	220	410	195.9	388
8	97/25 p/3	150	300	165.1	285
9	97/p/3 a	–290	–370	135.2	341
10	97/25 p/4	140	340	251.4	200
11	97/25p/5	40	380	266.4	340
12	97/25 p/6	40	350	210.4	310
13	97/25 p/7	–14	-450	265.8	436

4. Discussion

The Lostun ore manifestation presents two pyrite generations (pyrite I and pyrite II) as revealed by this investigation. The crystals belonging to the generations differ morphologically quite vividly (pyrite I has the form of a pentagonal dodecahedron, while pyriteII takes the form of a cube) and have different thermoelectrical properties. Pyrite I is widespread in ore bodies and enclosed rocks and is one of the earliest sulfides. In comparison, the spread of pyrite II is more restricted yet occurs more often than other sulfides (in particular galenite and chalcopyrite). This mineral mainly occurs in the form of monocrystalling formations that are often crushed and etched by later pyrite II separations. The main habit form of its crystals is that of a pentagonal dodecahedron which is sometimes partially ferruginated. Pyrite II has a classic yellow and sometimes light yellow color. Its crystals are sometimes ferruginated. With pyrite II separations, mono crystals predominate over other forms, with the occurrence of growth, aggregates and streaks of different forms and sizes (from 0.2 to 1.5 mm). It must be noted that pyrite II cubic crystals have vividly expressed stinting on their faces in the quartz-carbonate streaks. Their generations, in association with galenite or chalcopyrite in some sections, take the form of thin streaks or separations of an irregular form. The pyrite II thermoelectrical properties results testify to the fact that this mineral has only hole-conductivity.

With the Tukalo and Kamin-Kliovka ore manifestations, pyrite I has a habitual form which is mainly determined by octahedron faces as well as combination of cubes and octahedrons. As a rule, the octahedron faces of the investigated crystals almost always have flat shimming surface. Poikilitic enclosures of chalcopyrite, galenite and sphalerite sometimes occur in pyrite 1 connected with crossing fissures that corrode pyrite I crystals. The presence of these minerals and native gold were ascertained by the growth zones of pyrite I. This mineral is mainly spread throughout enclosed rocks (with a thin noncontinuous ferruginization film) but also occur in compositions of quartz and quartz-carbonate veins and streaks. The habitual form of pyrite II crystals are determined by a combination of cubes and octahedrons. Pyrite II crystals aspire to selvages of the quartz and quartz-carbonate veins and streaks. The sizes of its crystals are mainly 0.2–2.0 mm; they also have a flat surface, sometimes with a blocky structure or uneven striation of the surface of the faces.

5. Conclusions

The Chyvchyny and Rakhiv ore regions have some common features of geological structure (structural-tectonic, petrological, lithology-stratigraphic [1–5]. Their structural-metallgenetic position is caused by belonging to the Chyvchyny and Rakhiv outcrops of the Marmarosky massif. The single-type ore-bearing formations are spread within its boundaries.

Thus, in terms of the general thermo-e.m.f. as well as a selection range of the thermoelectric properties of the pyrite from the Lostun, Kamin-Kliovka, and Tukalo ore manifestations and the Sauliak auriferous deposit are similar (in particular, by statistically reliable selections of thermo-e.m.f. values investigated crystals possess electron, hole or mixed conductivity; at the same time, these meanings are clearly grouped into two massifs that testifies to two acts of pyrite formation).

The comparative character of the thermoelectric properties of the pyrite from the investigated ore manifestations, the Sauliak deposit (see Figs. 2–4) and other auriferous deposits [12–14] testify to the supra-ore level of gold mineralization in the Tukalo and Lostun objects and make it possible to assume that the erosion shear of the gold mineralization in the Tukalo ore manifestation is similar to the Sauliak deposit erosive shear and is deeper in comparison with the Lostun ore manifestation; at the same time, a more reliable estimation of the deep horizons of the investigated ore manifestations can be realized after a detailed thermobarogeochemical study of the productive complexes of the minerals within these ore manifestations.

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