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THE TENNANTITE-TETRAHEDRITE SERIES IN PERMIAN FORMATIONS OF THE WESTERN CARPATHIANS

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Abstract: Analyses of 191 samples of the tennantite-tetrahedrite series from different associations of minerals in the mineral deposit in Permian rocks of the Western Carpathians by EMA method show in formula unit variability if Cu^{1+} from 9.5 to 11.6 atoms, total Me^{2+} (Fe + Zn + Hg) from 0.3 to 2.8 atoms, $Me^{1+} + Me^{2+}$ from 9.5 to 12.3 atoms, complete substitution of As and Sb (Me^{3+} from 3.5 to 4.3 atoms) and from 12.4 to 13.4 atoms of S. The contents of Ag, Pb, Bi, Te and Se are increased by up to 2.4 atomic % in the same type of deposits. The variability of the physical properties of the tennantite-tetrahedrite series reflects different chemical compositions: unit cell (a_0) from 1.0204 to 1.0369 nm, microhardness ($VHN_{50\,g}$) from 275 to 361, reflectivity ($R_{546\,nm}$) from 26.7 to 31.2 %.

Key words: tennantite, tetrahedrite, electron microprobe analysis, unite cell, reflectance, microhardness, correlation.

Introduction

The geologico-tectonic development in the Late Paleozoic and Mesozoic of the Western Carpathians (collected in Vozárová & Vozár 1988; Soták 1992; Putiš 1992) conditioned the variety of ore forming processes in the Permian complexes. Various genetic types of ore deposits, with variable mineral associations, chiefly minerals of copper and uranium originated here. These are above all (Fig. 1):

A - Stratiform Copper Sandstones - SCS
B - Disseminated and Stockwork Copper Mineralization - DSCM
C - Uranium Stratiform and Stratabound Ores - USSO
D - Vein Copper Mineralization - VCM.

Minerals of the tennantite-tetrahedrite series (further tn-td) are among the characteristic typomorphic minerals in each of the types of deposits mentioned.

The geological position, mineral association and paragenesis

A - Stratiform Cu-mineralization occurs in two horizons of sandstones of the lower and upper formations of the north Gemeric Permian (Novotný & Mihál' 1987), in the wider area of Markušovce and Novoveská Huta (Šafárka, Vojtechova osada and Strážanský kopec localities). Disseminated Cu-sulphides, especially tennantite, bornite, chalcopyrite and poor uranium mineralization are found in lenticular layers of sandstones (1 - 10 m thick) with subordinate limestones, often with significant cross-bedding and silicified remnants of flora (Háber et al. 1986). Tennantite forms impregnations (grains 1 - 2 mm in size) in the cement of the sandstones, often enclosing clastic grains, and occasionally accumulations after bedding and veinlets. It is especially abundant in sandstones with an increased representation of carbonates, where its grains are up to several millimetres in size. It is frequently replaced by bornite, chalcocite and covelline.

B - Disseminated and stockwork Cu-mineralization in complexes of Permian rocks is typically developed in deposits in the area of the Špania dolina Valley - Piesky - Staré Hory Mts. and Ľubietová.

Copper mineralization in Špania dolina Valley is developed in a stripe 4 km long and 1.5 km wide, with a N - S direction. The vein impregnated with ore mineralization forms a 100 m thick zone of small veinlets and veins with a N - S direction and an inclination to the west, and impregnation with tetrahedrite and chalcopyrite in Permian greywackes, conglomerates and arcoses. Apart from these main minerals, pyrite, marcasite and others are described in association with siderite, dolomite and quartz. Siderite veins with similar Cu mineralization are younger. The ore mineralization is considered polygennic, with the disseminated and veinlet mineralization connected with Permian volcanism, and the younger vein is the product of remobilization during the Alpine orogeny (Ilavský & Sattran 1976; Čillík 1982).

In the Ľubietová area, Cu-mineralization occurs in three deposits: Podlipa, Svätodušná and Kolba. They have an impregnated veinlet and vein character, with a quartz-chalcopyrite-tetrahedrite-tennantite-carbonate filling (Čillík 1978). While quartz, dolomite, chalcopyrite, tetrahedrite and tennantite are the dominant minerals, arsenopyrite, gersdorffite, skutterudite, cobaltine, pyrite, galenite and hammarite are also described in the deposits. Tetrahedrite and tennantite (often of unhomogeneous composition) form veinlets, aggregates and accumulations with chalcopyrite and hammarite in carbonates and quartz (Fig. 2).

Cu-mineralization in Permian basic volcanites is found in cavities and cracks of the basalts and andesites. Sulphidic minerals fill the amygdale and veinlets of the carbonates. Chalcopyrite, bornite, chalcocite, pyrite, tetrahedrite and tennantite are especially found in the form of impregnations in the volcanites, as also in barite veins. The form Cu-mineralization in amygdaloid cavities and cracks in the basalts, points to their origin from residual solutions of the Permian basic volcanism.

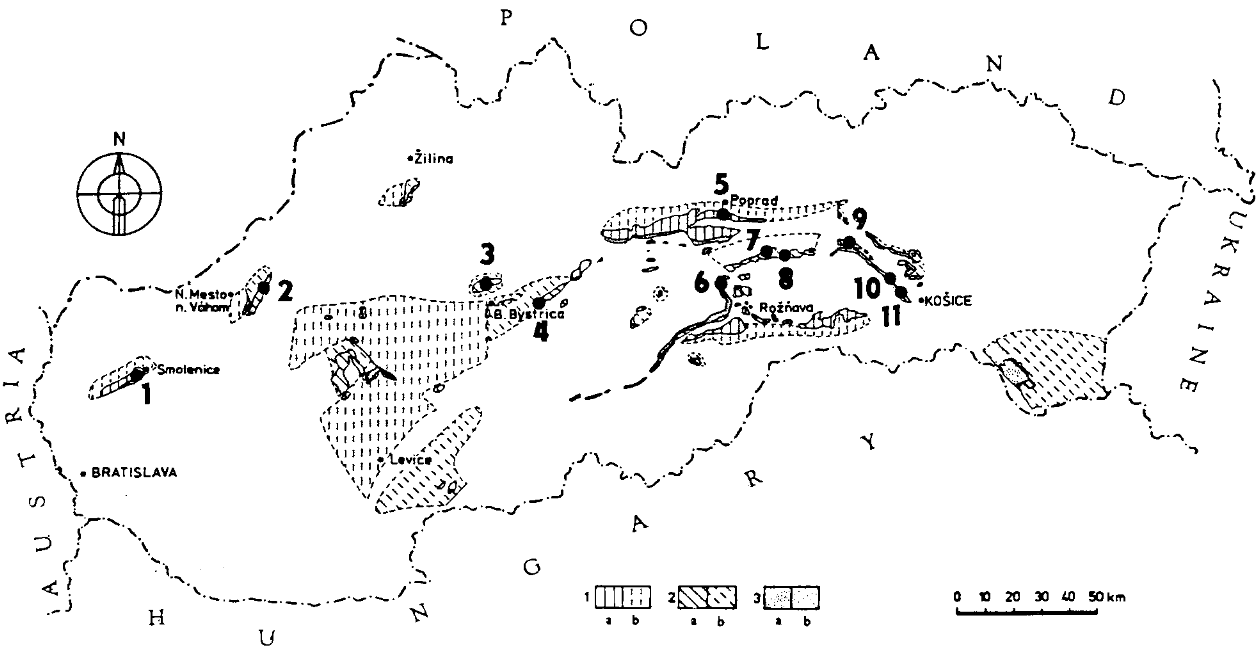

Fig. 1. Localization of the analyzed tetrahedrites and tennantites from mineral deposits and occurrences in the Permian of the Western Carpathians (the source of map - Vozárová & Vozár 1988).
Legend: 1 - Thuringian - Saxonien - Autunian (conglomerates, sandstones, silts, gypsum, carbonates, basalts, andesites, volcanoclastics); 2a - Thuringian - Saxonian (conglomerates, sandstones, arkoses, silts, evaporites, carbonates, rhyolites, dacites, volcanoclastics); 3a - Autunian - Stephanian C (1b, 2b, 3b - represents the area where the unit is covered with younger formations): 1 - Lošonec (SCS), 2 - Kálnica (DSCM), 3 - Špania dolina Valley (DSCM), 4 - Ľubietová (DSCM), 5 - Vikartovce (USSO), 6 - Dobšiná (VCM), 7 - Novoveská Huta (SCS, DSCM, USSO, VCM), 8 - Markušovce (SCS), 9 - Petrova hora (USSO), 10 - Košická Belá (VCM), 11 - Jahodná (USSO).

C - Stratiform and stratabound uranium mineralization in the Permian of the Western Carpathians often shows a spatial relationship to Permian acidic volcanism. The most important U-Mo ore mineralization is found in the Slovenské Rudohorie Mts. in the northern Gemeric Permian, in the surroundings of Novoveská Huta, Rudňany, Petrová Hora, Jahodná near Košice, and in Považský Inovec Mts. near Kálnica and Selec. The ore bodies form lenses mostly concordantly with the surrounding rocks. Intensive alteration changes are characteristic of the ore rocks. Uraninite, molybdenite, pyrite, chalcopyrite, tennantite, galenite, sphalerite and arsenopyrite represent the primary association of ore minerals (Rojkovič 1968, 1980; Rojkovič & Mihál' 1991). Minerals of the tn-td series belong to the youngest minerals of ore mineralization. They often surround or replace minerals (Figs. 3 and 4). The homogenization temperatures of the fluid inclusions in the carbonates accompanying this mineralization give 110 - 120 °C, and the decrepitation temperatures vary from 120 to 160 °C.

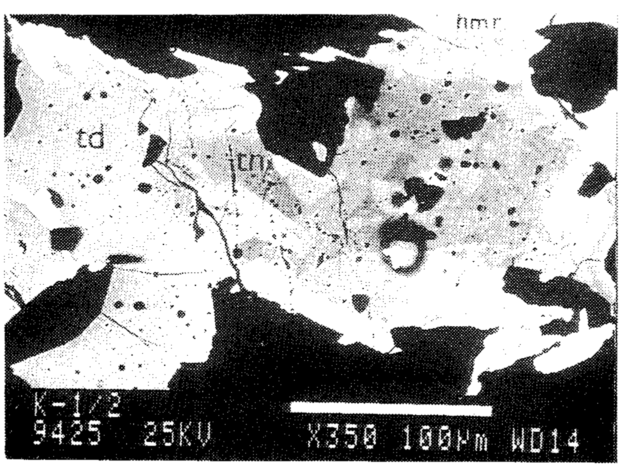

Fig. 2. Needle-like crystals of hammarite (hmr) in tetrahedrite and tennantite aggregate with different shades of grey due to the different Sb and As content. Ľubietová (disseminated and stockwork Cu-mineralization). SEM - BEI.

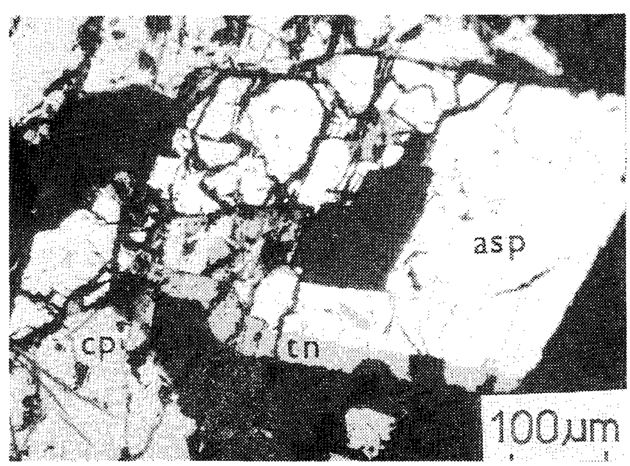

Fig. 3. Replacement of an idiomorphic crystal of arsenopyrite (asp) with a border of tennantite (tn) and chalcopyrite (cp). Petrova Hora (U-Mo-Cu-stratiform ores). Reflected light.

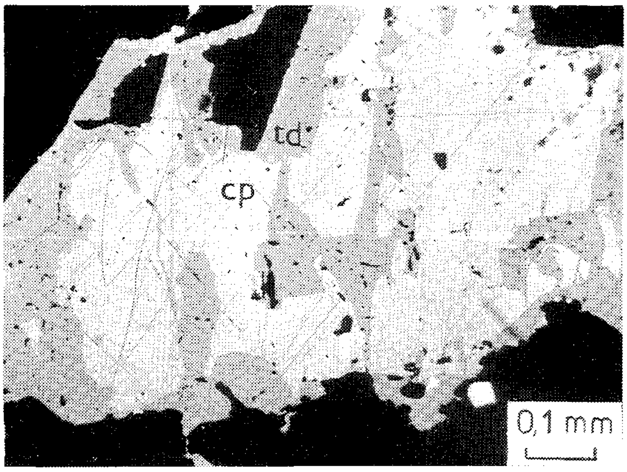

Fig. 4. Replacement of chalcopyrite by tetrahedrite. Novoveská Huta (U-Mo-Cu-stratiform ores). Reflected light.

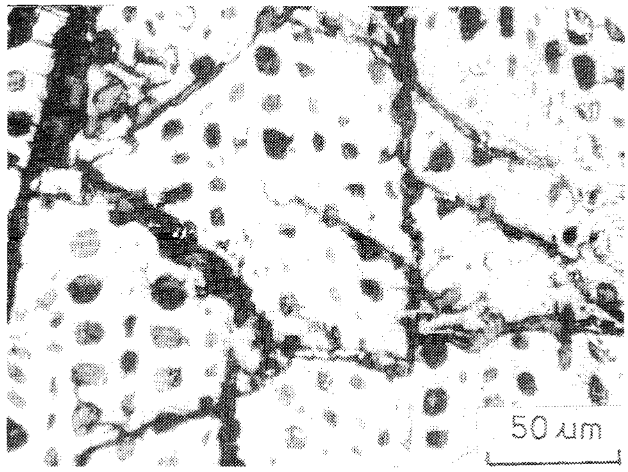

Fig. 6. Chalcopyrite (white) and tennantite (gray) in the voids and fissures of the fusinitic plant tissue. Vikartovce (uranium stratiform ore). Reflected light.

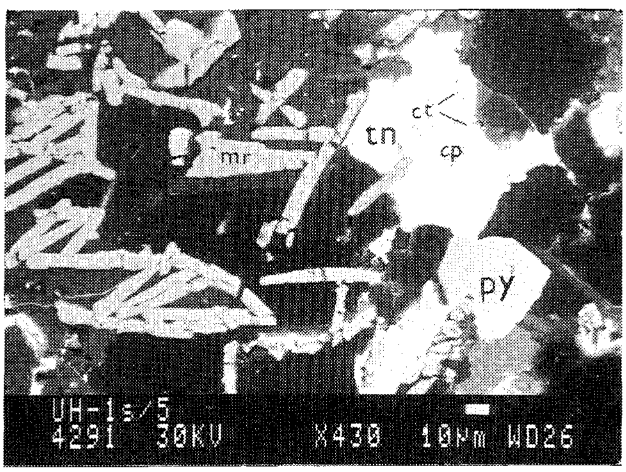

Fig. 5. Replacement of chalcopyrite (cp) and pyrite (py) by tennantite with inclusions of clausthalite (cl). Bladed crystals of montroseite (mr). Novoveská Huta (U-Mo-Cu-stockwork ores). SEM - BEI.

Fig. 7. Locally recrystallized originally submicroscopic aggregates of pyrite, chalcopyrite and Sb-tennantite. Novoveská Huta (vein Cu-mineralization). SEM - BEI.

Rich uranium and accompanying mineralization are more rarely found on faults, cutting horizons with U-Mo mineralization. The ore mineralization has a disseminated veinlet character. Uraninite and coffinite accompany molybdenite, chalcopyrite, tennantite, galenite, U-Ti oxides, montroseite, marcasite, sphalerite, clausthalite, graphite, quartz and Fe-dolomite (Fig. 5).

The isotopic data allow us to suppose a mixing of meteoric solutions with fluids of volcanic origin, and are also a reflection of their complex origin. Dating the age of the uranium ore mineralization by the U/Pb isotopic method gives two age groups in Novoveská Huta (Kolektiv 1984) According to the U/Pb method, the stratiform concentration of poor uranium ores are 240 ± 30 Ma old. The highest concentration of uranium ores, in proximity to fault tectonics give an Alpine age of 130 ± 20 Ma. Similarly, in Považský Inovec Mts., at Kálnica and Selec, two groups of ages of 240 ± 30 Ma and 100 ± 20 Ma were found (Kolektiv l.c.). Alpine tectonometamorphic processes created structures, in which hydrothermal solutions could circulate. The main source of ore elements was the surrounding Permian rocks. This remobilization was superimposed on the older poor mineralization.

The stratiform uranium mineralization in sandstones of the Permian Choč Nappe in the Kozie Chrbty Mts. (localities Kravany and Vikartovce) is associated with arcose sandstones with abundant detritus of carbonised plant remnants (Novotný & Badár 1971). Quartz-carbonate-sulphide mineralization often fills the voids of fusinite (inertinite), as well as secondary fissures cutting the original plant structure, or dividing broken fragments of coal (Rojkovič et al. 1992). It is demonstrably younger than the sorption of uranium by organic substances. The voids are filled with quartz, carbonates and sulphides, especially chalcopyrite and tennantite (Fig. 6). Chalcopyrite, bornite, pyrite, chalcocite and tennantite represent the Cu-mineralization, mostly in dolomite-quartz veinlets. The younger uranium mineralization is represented by uraninite. The low thermal hydrothermal solutions caused partial remobilization of the uranium and the origin of the younger uraninite-sulphide mineralization.

The geochronological dating of the mineralization of $^{238}U/^{206}Pb$ gave an age of 263 Ma. Gas-liquid inclusions in the carbonates from Vikartovce and Kravany showed temperatures of homogenization in the range from 86 °C to 140 °C.

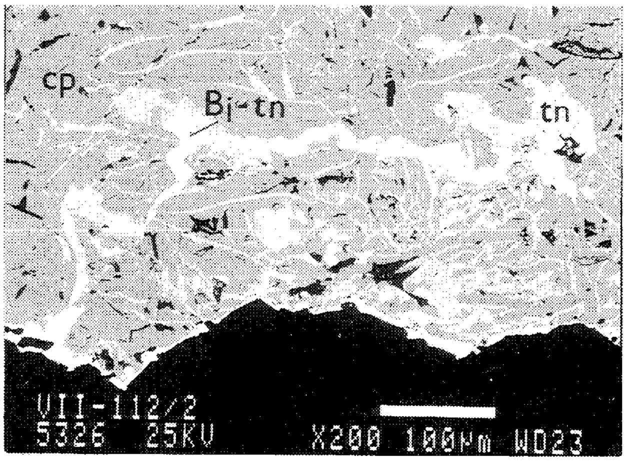

Fig. 8. Myrmekite-like intergrowths of tennantite (tn)-Bi-tennantite (Bi-tn) with chalcopyrite (cp) in Fe-dolomite. Novoveská Huta (vein Cu-mineralization). SEM - BEI.

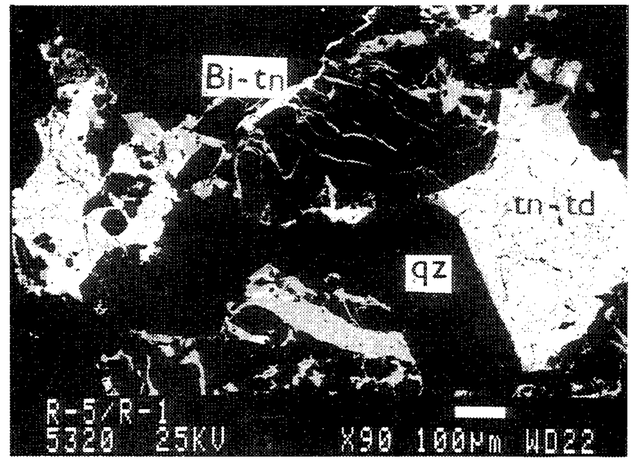

Fig. 10. Veinlets and grains of tennantite and tetrahedrite (tn-td) in Fe-dolomite. To the right zoned crystal: dark zones correspond to As-rich zones and light zones correspond to Sb-rich zones. Grains of Bi-tennantite (Bi-tn) are in the middle. Idiomorphic crystal is quartz (qz). Novoveská Huta (vein Cu-mineralization). SEM - BEI.

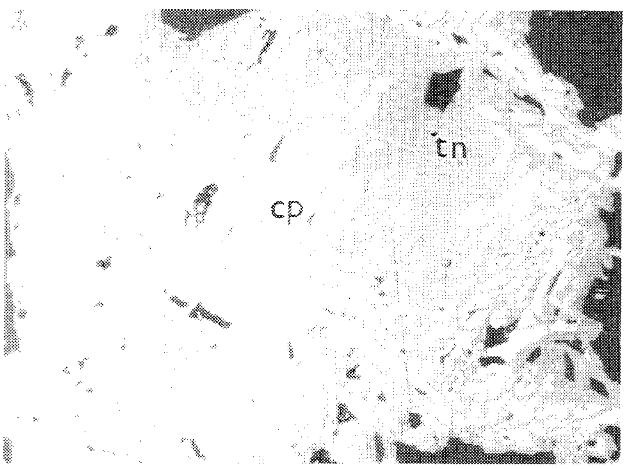

Fig. 9. Myrmekite-like intergrowths of tennantite (tn) with chalcopyrite (cp) in Fe-dolomite. Novoveská Huta (vein Cu-mineralization). Reflected light.

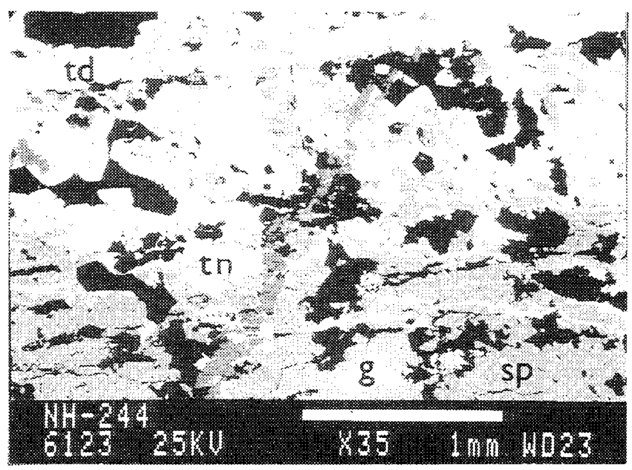

Fig. 11. Replacement of sphalerite (sp) and galena (g) by tennantite (tn). Veinlet of tetrahedrite (td) at the top of the photograph. Novoveská Huta (vein Cu-mineralization). SEM - BEI.

D - Vein Fe-dolomite-copper mineralization creates a significant swarm of mineralized fissures, in the form of true veins and veinlets with a predominance of Cu-ore, in the complexes of rocks of the Permian Krompachy Group from Dobšiná through Novoveská Huta to Košice. The most complex is studied in the Novoveská Huta ore field. The deposit is formed by a series of parallel veins with a general E - W direction, 1 - 8 km in length, inclined depth 0.5 - 1.2 km, thickness 0.3 - 2.5 m and an inclination of 25 - 60° to the S.

The chief minerals of the vein filling are Fe-dolomite, chalcopyrite, pyrite, locally in some veins and at deeper levels quartz, minerals of the tn-td series and siderite (for more details see Háber 1983).

The mineralization was formed in two stages of mineralization: siderite and Fe-dolomite-quartz-sulphide. The main mineralization occurred in the second stage of mineralization, in the framework of which 5 mineralization periods have been distinguished: quartz, Fe-dolomite, chalcopyrite, siderite-sulphide and a mobilized one. The periods are divided by intermineralization tectonic. They are distinguished by the character and temperature of the solutions from which they originated.

Deposits of carbonates, silicites, evaporites, albitites, haematitic shales and conglomerates, U-Mo-Cu ores and Cu-sandstones occurring in the Permian sequences participated in the formation of the veins in the northern Gemeric. All these complexes found their reflection in the hydrothermal filling of the veins, which cut them (Háber l.c.). The results of isotopic research confirm that in the hydrothermal process, solutions from a well homogenized deep source participated, as well as from the Permian and probably also Early Paleozoic and Carboniferous rocks. It is suggested by the enrichment of vein and remobilized sulphides with a light isotope of sulphur, with $\delta^{34}S$ in tn-td reaching values from -15.37 to -18.81 ‰ (Rojkovič et al. 1993; Zhukov 1978). The Permian rocks were weakly metamorphosed, and the temperature of anchimetamorphosis of the northern Gemeric Permian reaches 200 to 250 °C (Šucha & Eberl 1992).

The vein filling originated from ascending low to medium thermal solutions. The higher temperature of the solutions, from which the main vein filling was formed, showed T_{hom} and T_{decr}, Fe-dolomite (250 °C) and quartz (180 °C and 250 °C). These solutions were also less concentrated (7 % material equi-

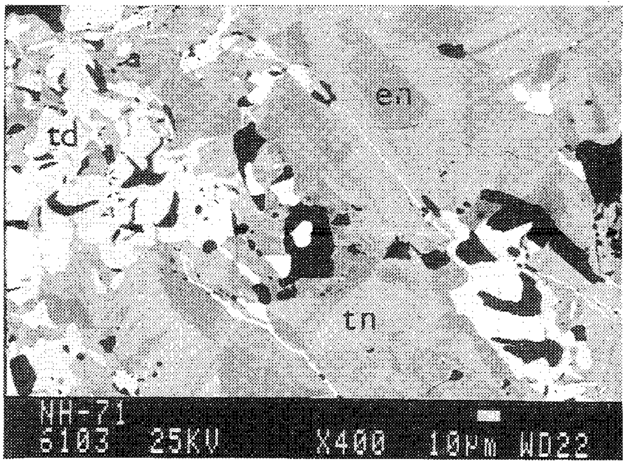

Fig. 12. Replacement of enargite (en) by tennantite (tn) and younger tetrahedrite (td). Novoveská Huta (vein Cu-mineralization). SEM - BEI.

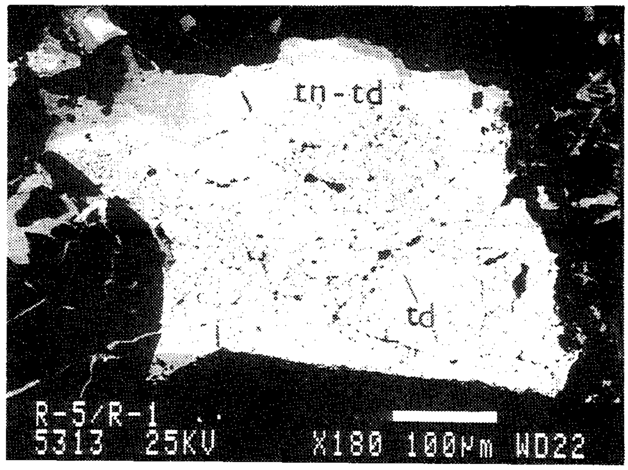

Fig. 14. Zoned crystal of tn-td in Fe-dolomite: dark zones correspond to Sb-rich zones and light zones correspond to Sb-rich zones cut veinlet of younger tetrahedrite. Novoveská Huta (vein Cu-mineralization). SEM - BEI.

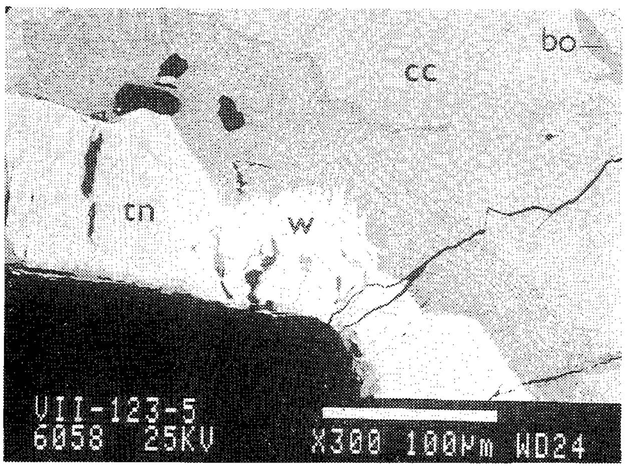

Fig. 13. Chalcocite (cc) and bornite (bo) aggregate with skeletal wittichenite (w) is rimmed by tennantite. Novoveská Huta (vein mineralization). SEM - BEI.

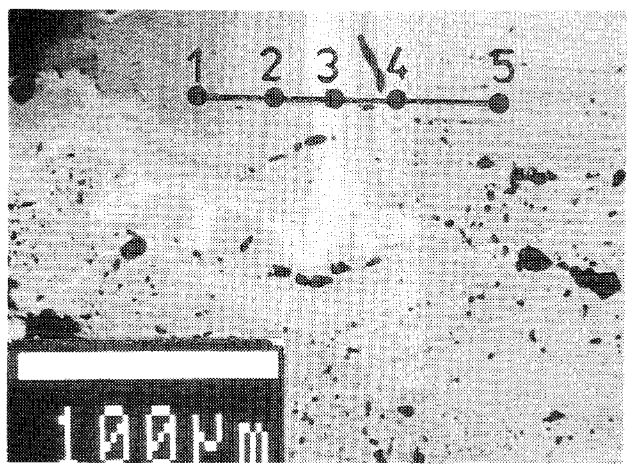

Fig. 15. Detail of Fig. 14 (1 - 5: localization of electron microprobe analyses and measurements of VHN_{10} and R_{546nm}). SEM - BEI.

valent NaCl). The T_{decr} of sulphides, including td-tn (95 to 120 °C) as well as T_{homog} of Fe-dolomite (105 °C) show the lower temperature of the solutions and their higher concentration. The origin of the mineralization studied is connected with the younger phases of the Alpine orogeny, as the model age of the Pb from galenite - 115 - 70 Ma also confirms (Rojkovič et al. l.c.)

The oldest tetrahedrite in the deposit was found in association with siderite, barite, haematite, chalcopyrite and pyrite, in the form of veinlets and small accumulations in siderite.

The tennantite of the main vein filling originated together with chalcopyrite and pyrite from a high concentration colloidal solution. Pyrite with tennantite, or chalcopyrite with tennantite, and more rarely all three minerals crystallized together (Fig. 7). The results of this are colloform, later recrystallized aggregates and myrmekite intergrowing of chalcopyrite with tennantite and enargite (Figs. 8 and 9).

The youngest tennantite forms independent veinlets in Fe-dolomite (Fig. 10), sphalerite (Fig. 11) and enargite (Fig. 12). It also replaces bornite, chalcocite, wittichenite and haematite (Fig. 13). The conditions of crystallization and the chemical composition of the solutions often changed, causing heterogeneity of individual grains and aggregates (rhythmic zonality or polygonal grains) of minerals of the tn-td series (Figs. 12, 14 and 15).

The variability of the above mentioned origin of the minerals of the tn-td series caused a significant variability of their chemical composition, and crystallochemical, optic and mechanical properties.

Methods of research

Electron-probe microanalysis. The minerals of the tn-td series were analysed in the laboratory of the Geological Institute of D. Štúr in Bratislava (analysts J. Krištín, F. Caňo, P. Siman) on the electron microanalyser JXA-733. The analytic data were controlled by the KEVEX (Sesame). Conditions of analysis: acceleration potential 15 and 20 kV and probe current 10 and 25 nA. The contents of Cu, Ag, Zn, Fe, Hg, Pb, Ni, Co, Sb, As, Bi, Te, Au, S, Se were determined. Pyrite (for Fe, S), chalcopyrite (for Cu), stibnite (for Sb), galium arsenide (for As), arsenopyrite (for As), galena (for Pb), cinnabarite (for Hg) and pure metals for selenium, tellurium, silver, gold, bismuth and zinc. The analysis was done in at least three, and at most ten points. According to the test for homogeneity the results averaged or separately evaluated into summary tables. The analytic accuracy was evaluated according to the relationship (√N/N; N = number of elements) derived from Poison statistic of pulses. For S, Zn, Fe and Ag it was 8%, for Sb 0.7 %, for Cu 0.4 % and for Hg and Bi 1.2 %. The homogeneity of the standards was 96 %.

X-ray analysis. The powder Debye-Scherrer method with the Micrometa - Chirana instrument, diameter of chamber 57 mm, Straumaniss position of film, anticathode Co, filter Fe, screen 1 mm, 23 kV, 32 mA, internal standard NaCl, exposure 8 hours, was used for calculating the lattice constant (a_0) 43 samples of the tn-td series. The lattice parametres were calculated with 6 diffraction lines (analyst J. Ševc, Science Faculty of Commenius University).

Reflectivity (R) was determined for 42 grains of the tn-td series in air, at 20 nm between wave lengths 420 and 680 with the spectrophotometer Leitz MPV Compactphotometer, on the microscope Ortoplan obj. 50 x, measured area 25 μm^2, standard SiC NPL No. 477 (C. Zeiss, Oberkochen). P. Kašpar calculated (according to Kašpar 1988) the colour coordinates x and y, brightness Y (%), wave length of spectral colour (nm) and purity of colour P_e (%), for members of the tn-td series, from the values measured for reflectivity.

Microhardness (VHN) was measured at the points of measurement of reflectivity with the help of a microhardness device PMT-3 with a 50 g weight for a period of 10 sec. When local changes in the properties of minerals of the tn-td series were found, a 10 g weight was used for the same time.

Discussion of the analytic results

1 - The chemical composition and physical properties of the tetrahedrites related to the empirical formula: $(Cu^{1+}, Ag)_{10}(Fe, Zn, Cu^{2+}, Hg, Cd)_2(Sb, As)_4S_{13}$ (Charlat & Lévy 1974, 1975, 1976), and to the structural formula for tn-td according to Wuensch (1964, 1966): ${}^{IV}M1_6{}^{III}M2_6({}^{II}X{}^{I}Y_3)_4{}^{VI}Z$, where M1 represents Cu and Ag, M2 - Cu, Fe, Zn, Hg, and Cd, X - Sb, As, Bi and Te, Y - Se, and Z - S. The set of analyses were statistically evaluated and standardized to 29 atoms. The programme CLEOM divided the analyses of minerals of the tn-td series into groups (SCS, DSCM, USSO, VCM), in accordance with the preceeding text. An overview of the minimum and maximum atomic proportions of the most important elements is given in Tab. 1. The set of analyses were processed into graphic form (Figs. 16 - 22).

Table 1: Atomic proportions based on 29 total atoms per formula unit of tennantite-tetrahedrite series minerals.

	SCS-type (13 anal.)	DSCM-type (30 anal.)	USSO-type (13 anal.)	VCM-type (135 anal.)
Cu	9.25 - 10.64	10.03 - 11.31	9.59 - 10.38	9.69 - 11.62
Ag	0.00 - 0.08	0.00 - 0.08	0.00 -0.03	0.00 - 0.44
Zn	0.02 - 1.07	0.07 - 1.67	0.02 - 1.65	0.01 - 1.77
Fe	0.14 - 1.83	0.37 - 2.00	0.10 - 1.93	0.06 - 1.74
Hg	0.00 - 1.40	0.00 - 0.12	0.00 - 1.00	0.00 - 0.42
Sb	0.00 - 1.38	0.11 - 3.18	0.08 - 3.93	0.00 - 4.09
As	2.76 - 4.19	1.00 - 3.75	0.28 - 3.64	0.03 - 4.12
Bi	0.00 - 0.20	0.00 - 0.43	0.01 - 0.03	0.00 - 0.59
Te				0.00 - 0.10
Se		0.00 - 0.04		0.00 - 0.04
S	12.96 - 13.10	12.82 - 13.08	12.75 - 13.12	12.50 - 13.20

Substitution of Se for S, Bi and Te for As and Sb, and also irregular mixtures of Au, Co, Mn, Ni and Pb were found in the analysed minerals of the tn-td series.

2 - In the **stratiform copper sandstones**, tennantite is the dominant mineral (Fig. 17). It has a wider dispersion, but a relatively lower Cu content (Fig. 18), a raised content of Fe, and locally also raised Hg contents (4.8 wt.%).

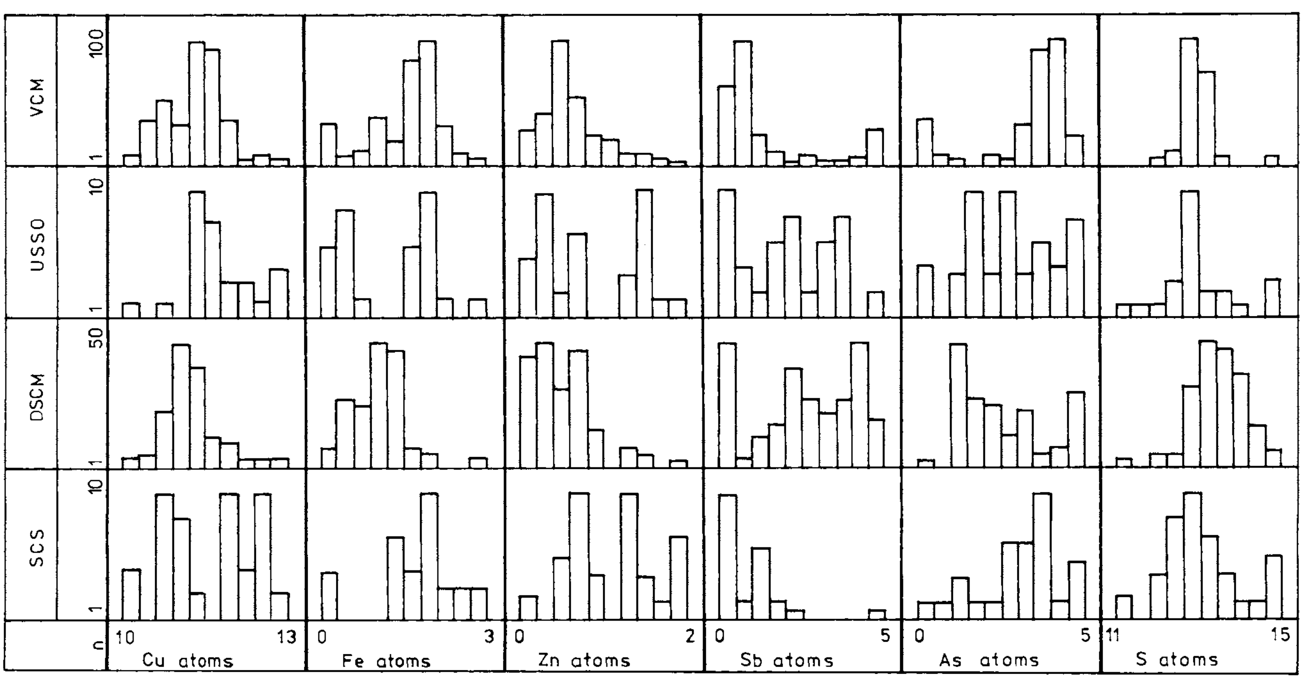

Fig. 16. Distribution of elements in analysed minerals of tn-td series.

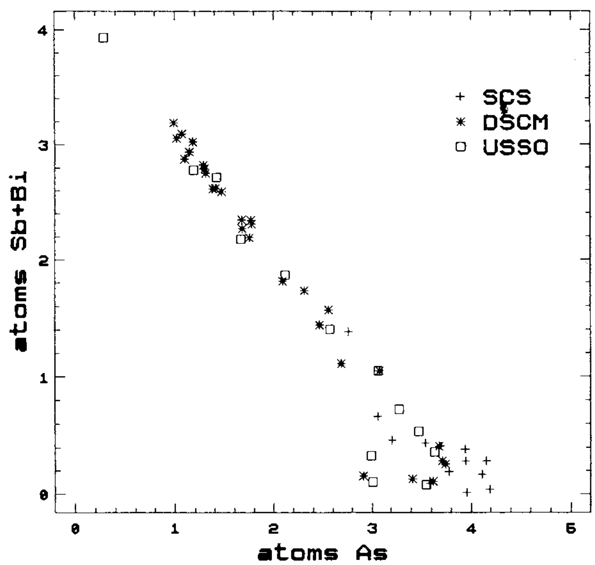

Fig. 17. Number of As atoms *versus* number of Sb+Bi atoms for samples of td-tn serie for SCS, DSCM and USSO types.

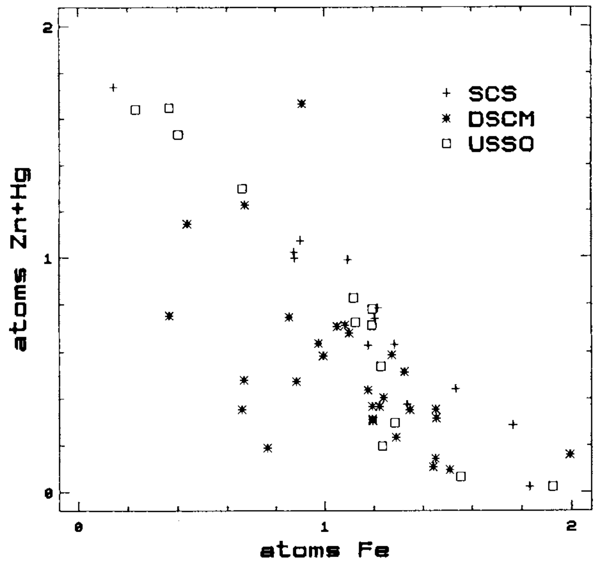

Fig. 19. Number of Fe atoms *versus* number of Zn+Hg atoms for samples of tn-td serie for SCS, DSCM and USSO types.

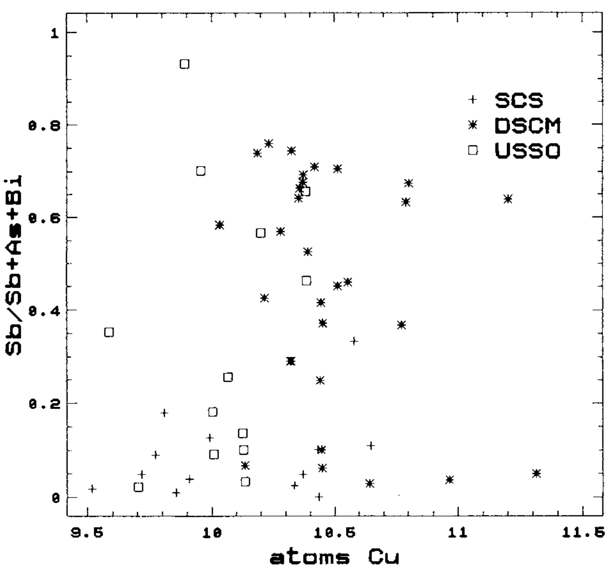

Fig. 18. Number of Cu atoms *versus* Sb/Sb+As+Bi for samples of tn-td serie for SCS, DSCM and USSO types.

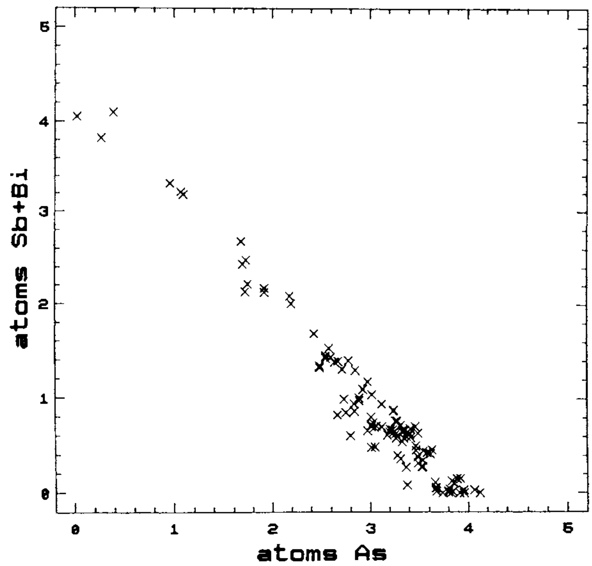

Fig. 20. Number of As atoms *versus* number of Sb+Bi atoms for samples of tn-td serie for VCM type.

3 - In **disseminated and stockwork copper mineralization**, As-tetrahedrite dominates over Sb-tennantite, while the marginal members of the isomorphic series were not found (Fig. 17). The raised Cu^{1+} content compensates for the shortage of bivalent elements (Fig. 19). Locally, in Ľubietová, a high content of Fe (up to 7.5 wt.%) was found, and in samples in association with Pb-Bi-Sb sulpho-salts (hammarite and others) and Bi (up to 5.4 wt.%).

4 - In **stratiform and stratabound uranium ores**, Sb-tennantite dominates over As-tetrahedrite (Fig. 17). This confirms a positive correlation of Fe against As. Fe-tetrahedrite, transitional Fe-Zn tn-td and Zn tennantite were identified (Fig. 19). A dependence of the Zn content in tennantite, on the presence of coexisting sphalerite was found. The raised Hg contents (up to 5.8 wt.%) at Novoveská Huta indicate its deep source (Steiner et al. 1980).

5 - In **vein copper mineralization**, tennantite and Sb-tennantite dominate over tetrahedrite (Fig. 20). Numerous transitional members of the isomorphic series of minerals of the tn-td series, even in the framework of single grains (Fig. 15) was found, which is also expressed in the wide dispersal of the Cu^{1+} content (Fig. 21). The lower Me^{2+} (Fe + Zn + Hg) contents are compensated for in the structure by the Cu^{2+} content. In the Me^{2+} contents, a negative correlation of Fe against Zn+Hg was found (Fig. 22). Locally, a raised Zn content (7.5 wt.%) was found in tennantite in close association with sphalerite, probably as a result of the replacement of sphalerite with tennantite within the vein (Fig. 12). Tennantite in close genetic association with wittichenite, bornite and chalcocite (Fig. 11) has a raised content of Bi (7.8 wt.%). A raised Ag content (2.99 wt.%) was found only in the sample from Dobšiná (Gápeľ). Raised contents of selenium (max. 0.15 wt.%, on average 190 ppm), and locally also tellurium are characteristic of the tn-td vein mineralization in Novoveská Huta.

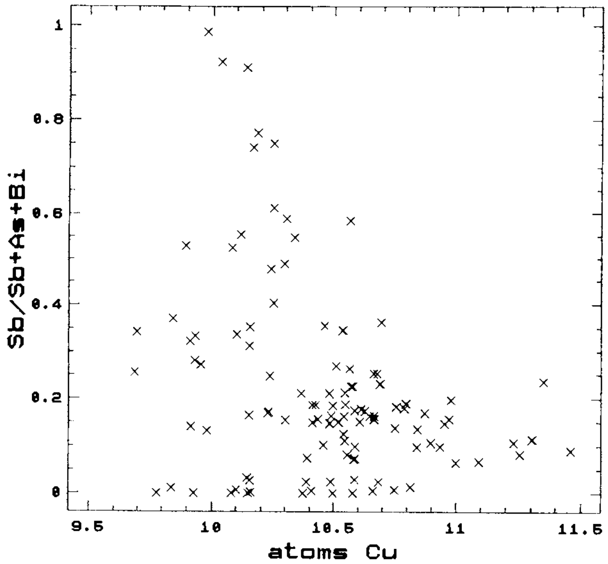

Fig. 21. Number of Cu atoms *versus* Sb/Sb+As+Bi for samples of tn-td serie for VCM type.

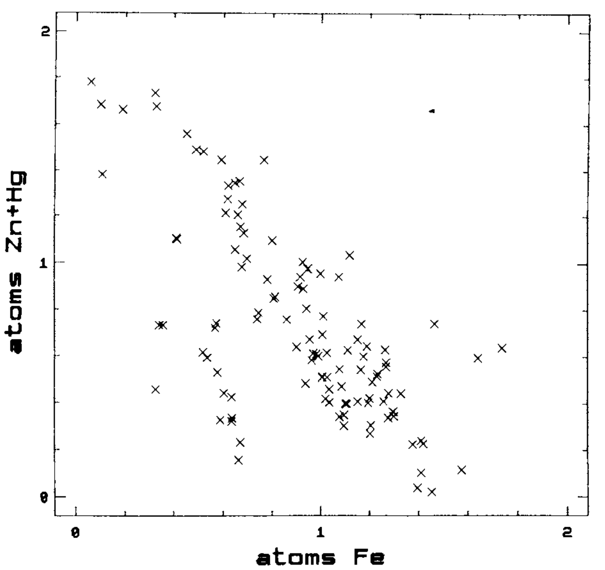

Fig. 22. Number of Fe atoms *versus* number of Zn+Hg atoms for samples of tn-td serie for VCM type.

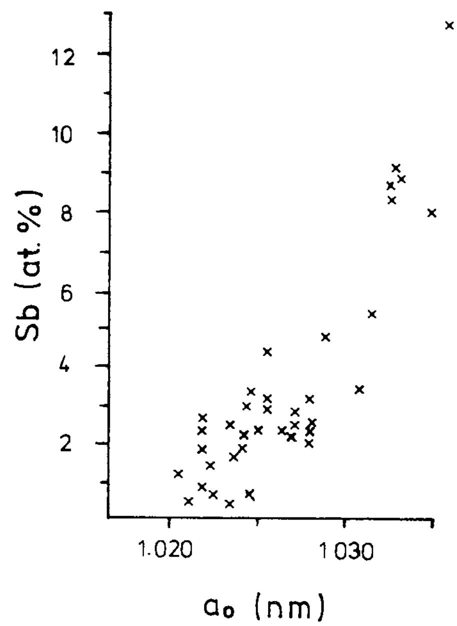

Fig. 23. Atomic % of Sb *versus* a_0 for tn-td serie.

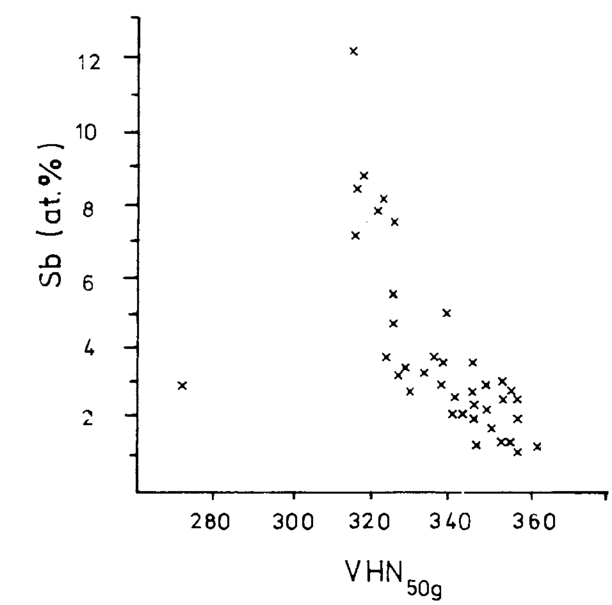

Fig. 24. Atomic % of Sb *versus* $VHN_{50\,g}$ for tn-td serie.

6 - The dependence of the lattice constant - a_0 of minerals of the tn-td series (43 analyses) on changes in their chemical composition was confirmed. A positive correlation of a_0 against Sb (atoms %) is documented in Fig. 23. The minimum value of a_0 = 1.0204 nm corresponds to tennantite with a content of 17.51 wt.% As, the maximum value of a_0 = 1.0369 nm corresponds to tetrahedrite with a content of 28.94 wt.% Sb. The influence of other elements (Ag, Hg) on the change of the lattice constant of a_0 was not found, because of their generally low contents in the structure of the minerals studies. The problem is complicated by the inhomogeneity, already described above, of the youngest grains of minerals of the tn-td series in the deposit, since the authors did not have the opportunity for micro-separation of individual grains, or measurement by the local micro-diffraction method.

7 - The values of microhardness of the minerals studied of the tn-td series ($VHN_{50\,g}$) measured on 42 samples varied in the range 275 - 361. The negative correlation between microhardness and Sb is documented on Fig. 24 (atoms %). The Te-As tetrahedrite from Novoveská Huta (1.1 wt.% Te), the VHN value of which is 275, corresponds to the values for Te- tetrahedrite to goldfieldite (see the lowest values on Fig. 24), is an exception. The Fe contents only have an insignificant influence on the raised VHN values (cca 340), while on the other hand the Zn-tennantites have reduced values of VHN (310 - 330).

8 - The measurement of the reflectivity (Fig. 25) of the minerals studied of the tn-td series confirmed agreement with values and the dispersion curves published (Tschvilova et al. 1988; Araya et al. 1977). A bend of the curve into the blue area and its level maximum in the green-yellow area of the spectrum, is characteristic for tetrahedrite. A maximum of the curve in the

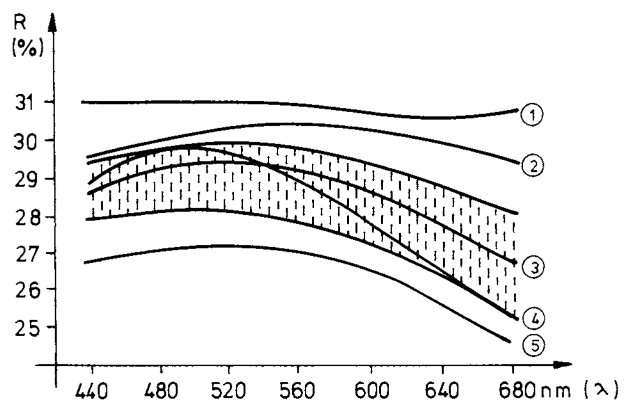

Fig. 25. Reflectance curves in air for the tn-td serie:
1 - Te-As tetrahedrite (1.1 wt.% Te), Novoveská Huta (VCM); 2 - tetrahedrite (28.95 wt.% Sb, 0.13 wt% As, 1.7 wt.% Hg), Novoveská Huta (VCM); 3 - As-tetrahedrite (8.3 wt.% As, Špania dolina Valley (DSCM); 4 - Sb-tennantite (5.1 wt.% Sb, 0.15 wt.% Au), Novoveská Huta (VCM); 5 - tennantite (0.7 wt. % Sb, 6 wt.% Fe), Košická Belá (VCM); 6 - vertical lines show the variation of 37 reflectance curves for the tn-td series of the compositional range from As-tetrahedrite to Sb-tennantite.

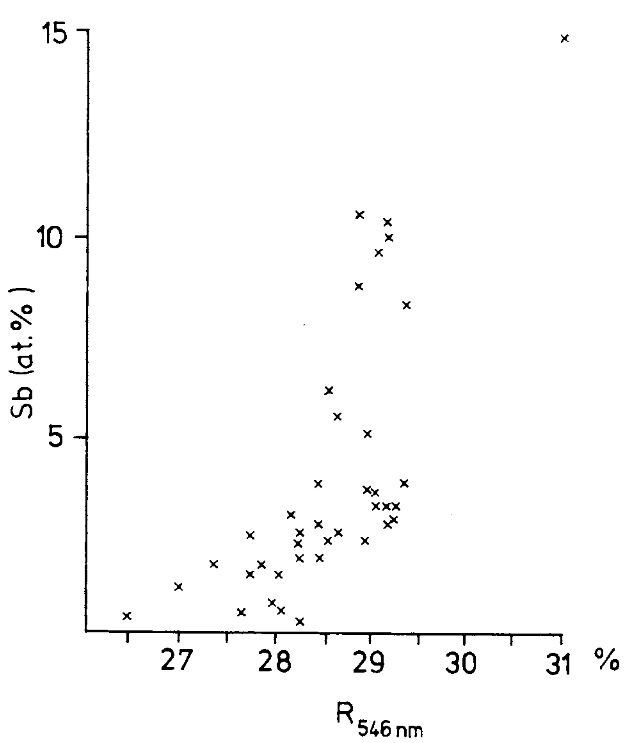

Fig. 26. Atomic % of Sb *versus* $R_{546\,nm}$ for tn-td series.

blue and green, and an essentially reduced reflectivity in the red area of the spectrum is characteristic for tennantite. The reflectivity curves of the transitional members of the tn-td series, fill the field between the curves of the marginal members, and it is not possible only on their basis to identify the predominance of the As or Sb components. Te-As tetrahedrite, with typical leveling of the course of the curve in the area of R around 31 %, which correlates well with the character of the curves of goldfieldite, is an exception (Tschvilova et al. 1988). The gold content (0.15 wt.%) causes a striking maximum of the curve in the blue area of the spectrum of tennantite (curve No. 4).

Kašpar (1992 - oral report) determined indexes of the colours of minerals of the tn-td series from the reflectivity curves measured. For tetrahedrite, values of x = 0.318, y = 0.318, Y = 29.14 %, $_D$ = 499 nm and P_e = 0.81 %, for tennantite values of x = 0.298, y = 0.311, Y = 31.06 %, $_D$ = 485.5 nm, P_e = 4.88 %, were found.

The dependence of reflectivity ($R_{546\,nm}$ from 26.6 to 31.1 %) on the Sb content (atoms %) in the 42 points of the analysed samples of tn-td showed their positive correlation (Fig. 26).

9 - The local changes found in the chemistry of tn-td grains were also expressed in local changes of their physical and optical properties. The variation of the changes in chemical composition are rhythmically zonal (Figs. 10, 14), or irregular and polygonal (Fig. 13). It is documented by the crystal of tetrahedrite-tennantite composition in the vein at Novoveská Huta (Fig. 15). The optically homogeneous grain, identified in polished section as tennantite with the lattice constant a_0= 1.0269 nm, is not homogeneous in SEM-BEI. In Tab. 2 we give the contents of Sb, As, Fe, Zn, the values of $R_{546\,nm}$ and $VHN_{10\,g}$ determined at 5 points of the line profile indicated on Fig. 15.

Table 2: Local changes of chemistry, reflectivity and micro- hardness of rhythmically zoned grains of tetrahedrite- tennantite (line profile on sample 1300 R5/R1 from Novoveská Huta).

Points	(wt.) (%)				R_{546nm} (%)	VHN10
	Sb	As	Fe	Zn		
1	0.88	19.32	2.32	5.67	27.6	370
2	11.15	12.46	4.41	1.97	28.0	330
3	24.07	4.94	2.10	4.46	29.1	305
4	15.48	10.44	4.36	1.74	28.2	338
5	1.02	19.03	1.92	6.32	27.5	375

We consider that the inhomogeneity in the youngest generation of tn-td series was caused by sudden changes in the temperatures of the solutions and the concentrations of elements, above all Sb and As, in the solutions. For the older generations, it is also necessary to consider the replacement processes within veins. Similar conclusions were published from studies of the minerals of the tennantite-tetrahedrite series by Shunzo (1971). For the El Teniente deposit, Araya et al. (1977) described similar inhomogeneity of the small crystals of the tn-td series, with sudden changes in genetic conditions during hydrothermal brecciation.

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Appendix 1a: Analysis of tennantites-tetrahedrites series (wt.%).

Sample No.	Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
A-type'SCS'											
32/86 /avg	45.537	0.070	3.178	4.620	0.430	0.030	20.345	0.103	27.728	0.028	100.27
297/91 /avg	40.800	0.000	3.700	4.000	1.600	5.300	15.000	0.000	28.100	0.000	98.50
298/91 /avg	42.200	0.000	1.700	4.600	2.900	1.500	18.150	0.000	26.150	0.000	101.49
300/91 /avg	41.900	0.000	2.200	4.100	1.100	10.500	12.900	0.000	24.900	0.000	99.99
301/91 /avg	37.600	0.000	1.300	0.467	16.633	3.333	14.233	0.000	25.567	0.000	99.13
302/91 /avg	43.900	0.000	1.600	4.850	0.000	3.450	17.200	0.000	26.350	0.000	99.99
303/91 /avg	41.630	0.000	4.360	3.280	0.000	3.150	19.780	0.000	28.010	0.000	100.21
304/91 /avg	40.070	0.000	4.420	3.230	0.000	0.660	20.620	2.840	27.930	0.000	99.77
305/91 /avg	42.300	0.000	3.443	4.563	0.000	1.380	20.687	0.000	27.593	0.000	99.97
306/91 /avg	44.590	0.000	1.270	6.700	0.000	0.760	18.230	0.000	28.160	0.000	99.71
307/91 /avg	42.700	0.000	0.100	6.980	0.000	0.350	21.400	0.000	28.160	0.000	99.69
308/91 /avg	40.790	0.535	1.915	5.670	0.000	1.665	19.540	1.080	27.515	0.000	98.71
311/91 /avg	42.667	0.000	4.500	3.233	0.000	3.267	17.833	0.000	25.767	0.000	99.98
B-type'DSCM'											
531/82 /avg	43.115	0.095	1.025	5.345	1.015	8.850	13.250	0.075	27.530	0.000	100.30
65/85 /avg	39.383	0.545	1.948	4.510	0.290	22.740	4.878	0.228	24.715	0.200	99.44
61/85 /avg	39.690	0.190	2.598	3.580	0.658	23.600	4.530	0.153	24.938	0.105	100.04
62/85 /avg	44.785	0.153	0.308	5.698	0.325	2.070	18.933	0.083	27.855	0.073	100.28
63/85 /avg	40.885	0.103	2.860	3.790	0.155	17.823	8.295	0.023	25.613	0.080	99.63
64/85 /avg	44.613	0.008	1.463	5.065	0.265	3.370	18.533	0.005	27.413	0.068	100.80
66/85 /avg	43.013	0.000	2.640	3.525	0.163	8.145	14.950	0.258	26.528	0.098	99.32
67/85 /avg	40.388	0.053	2.880	2.920	0.333	21.695	5.387	1.455	25.058	0.087	100.26
68/85 /avg	41.633	0.050	2.815	3.945	0.118	13.438	11.095	0.180	26.400	0.030	99.70
127/83 /avg	41.673	0.128	1.855	2.263	0.165	19.003	6.683	0.278	25.268	0.000	99.97
46/85 /avg	40.588	0.000	1.585	4.263	0.120	15.520	7.748	2.515	25.618	0.000	99.97
133/83 /avg	43.153	0.113	0.720	2.587	0.100	18.980	6.403	0.563	24.870	0.000	99.98
134/83 /avg	40.173	0.120	4.453	1.463	0.157	21.077	5.153	0.710	24.653	0.000	99.66
533/82 /avg	41.500	0.125	2.320	3.480	0.210	21.495	5.145	0.765	26.105	0.000	101.15
547/82 /avg	40.725	0.260	0.900	4.470	0.125	19.305	6.400	0.660	25.975	0.000	98.82
548/82 /avg	40.595	0.175	1.195	4.120	0.190	20.175	6.040	0.785	25.805	0.000	99.08
549/82 /avg	40.765	0.190	1.195	4.135	0.085	20.925	5.945	0.575	25.770	0.000	99.59
45/85 /avg	41.845	0.060	1.750	4.143	0.148	12.468	9.858	2.480	26.218	0.000	98.97
128/83 /avg	41.520	0.107	1.367	2.230	0.097	20.297	5.873	0.457	25.327	0.000	99.97
47/85 /avg	44.823	0.000	0.583	5.370	0.123	0.880	17.978	0.008	27.505	0.000	99.95
48/85 /avg	41.010	0.063	1.400	4.100	0.215	13.298	8.080	5.250	25.358	0.000	98.77
49/85 /avg	40.463	0.050	1.360	4.120	0.260	13.785	8.032	5.453	24.480	0.000	98.00
51/85 /avg	43.243	0.118	0.400	5.085	0.110	11.060	11.648	0.023	25.745	0.000	97.43
52/85 /avg	40.318	0.063	4.880	2.303	0.140	22.653	4.678	0.340	25.005	0.000	100.38
367/86 /avg	42.558	0.025	2.418	4.555	0.128	11.988	12.265	0.450	25.675	0.075	100.14
371/86 /avg	43.323	0.070	0.655	7.473	0.130	2.203	18.703	0.230	27.363	0.013	100.16
144/91 /avg	47.340	0.090	3.260	1.390	0.250	1.080	17.370	0.000	28.970	0.000	99.75
145/91 /avg	49.160	0.040	2.120	3.370	0.010	1.290	14.920	0.050	29.040	0.000	100.00
155/91 /avg	43.120	0.100	1.030	5.340	1.520	8.850	13.250	0.070	27.530	0.000	100.81
309/91 /avg	41.300	0.000	7.050	3.300	0.000	18.300	8.300	0.000	25.700	0.000	99.98

Sample No.	Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
C-type'USSO'											
50/85 /avg	42.370	0.000	1.177	4.616	0.205	14.390	10.173	0.337	26.722	0.000	99.99
287/91 /avg	45.200	0.000	0.300	6.100	0.000	0.900	15.800	0.000	31.800	0.000	100.10
288/91 /avg	44.800	0.000	0.900	4.800	0.000	2.800	15.600	0.000	31.500	0.000	100.40
289/91 /avg	43.600	0.000	0.100	7.600	0.000	0.700	18.800	0.000	31.100	0.000	101.90
290/91 /avg	41.000	0.100	1.900	4.400	1.100	8.200	14.700	0.000	26.800	0.000	98.20
291/91 /avg	42.456	0.050	6.576	1.449	0.338	2.950	18.187	0.000	27.950	0.000	100.00
293/91 /avg	41.900	0.000	3.300	4.400	0.200	5.800	16.200	0.000	27.500	0.000	99.30
294/91 /avg	35.700	0.200	1.100	2.100	11.400	27.200	1.200	0.000	23.500	0.000	102.40
295/91 /avg	38.500	0.100	1.400	3.800	5.800	20.600	5.400	0.000	25.600	0.000	101.20
296/91 /avg	44.000	0.100	3.200	4.300	0.100	4.500	17.800	0.000	28.500	0.000	99.98
299/91 /avg	40.250	0.050	3.050	4.400	0.050	11.300	12.700	0.000	28.700	0.000	100.50
310/91 /avg	40.300	0.000	6.667	0.800	0.000	16.300	7.867	0.000	26.033	0.000	100.02
312/91 /avg	40.626	0.000	6.634	1.257	0.000	20.334	6.551	0.000	24.598	0.000	100.06
D-type'VCM'											
312/85 /avg	36.713	0.403	1.985	3.465	4.828	26.483	1.163	0.525	23.550	0.028	99.14
419/85 /avg	43.742	0.098	2.138	3.173	3.485	3.298	17.853	0.030	27.053	0.120	100.99
441/85 /avg	38.655	0.098	3.715	3.353	0.148	29.888	1.755	0.070	23.790	0.060	101.53
529/82 /avg	45.005	0.165	0.490	5.230	1.470	3.860	14.890	0.060	27.530	0.000	98.70
530/82 /avg	45.590	0.075	0.315	5.915	0.575	0.680	17.010	0.000	28.170	0.000	98.33
556/82 /avg	38.690	0.200	2.630	3.090	3.315	16.115	7.920	0.200	25.100	0.000	99.99
21/86 /avg	45.095	0.023	1.668	3.805	0.478	5.248	16.655	0.153	27.458	0.025	100.61
22/86 /avg	45.108	0.030	1.358	4.015	0.383	5.303	16.743	0.038	27.368	0.023	100.37
23/86 /avg	43.923	0.023	2.028	3.678	0.450	7.278	15.305	0.328	26.760	0.030	99.80
24/86 /avg	44.725	0.020	2.478	3.708	0.470	4.913	17.100	0.213	27.430	0.045	101.10
25/86 /avg	45.425	0.018	1.888	3.913	0.425	4.905	17.040	0.035	27.820	0.038	101.51
26/86 /avg	43.590	0.015	3.063	3.445	1.198	5.923	15.990	0.245	26.545	0.058	100.07
27/86 /avg	44.528	0.015	1.623	4.445	0.385	6.130	16.350	0.078	27.205	0.030	100.79
28/86 /avg	44.140	0.030	1.658	4.295	0.370	6.085	16.358	0.095	27.660	0.020	100.71
29/86 /avg	44.183	0.035	2.585	3.810	0.243	4.748	16.990	0.005	27.275	0.035	99.91
527/82 /avg	45.775	0.130	1.435	4.825	0.465	3.855	15.205	0.160	27.520	0.000	99.37
528/82 /avg	47.260	0.070	3.120	2.100	0.170	6.590	13.120	0.000	26.890	0.000	99.32
534/82 /avg	37.465	0.540	3.225	3.125	1.700	28.945	0.125	0.320	24.495	0.000	99.94
535/82 /avg	44.760	0.110	0.775	5.125	0.605	5.280	15.200	0.585	27.775	0.000	100.22
536/82 /avg	44.524	0.095	1.233	4.777	0.760	4.720	15.102	1.644	27.132	0.000	99.98
538/82 /avg	43.540	0.075	2.085	3.510	1.590	7.745	13.315	0.115	27.235	0.000	99.21
539/82 /avg	43.535	0.080	2.760	3.475	0.325	10.450	12.140	0.045	27.005	0.000	99.82
541/82 /avg	45.970	0.175	0.055	5.435	0.095	0.395	18.380	0.070	27.795	0.000	98.37
543/82 /avg	44.590	0.115	2.015	3.530	1.515	6.840	14.000	0.110	27.390	0.000	100.11
544/82 /avg	45.325	0.145	1.225	4.035	0.265	2.875	16.345	0.045	27.500	0.000	99.96
551/82 /avg	43.115	0.150	1.680	3.720	1.465	6.345	14.630	0.000	27.240	0.000	98.35
553/82 /avg	45.030	0.190	1.710	4.405	0.315	5.655	14.845	0.110	26.945	0.000	99.21
546/82 /avg	44.395	0.135	1.585	3.405	1.395	5.495	15.195	0.040	26.985	0.000	98.63
550/82 /avg	44.400	0.140	4.545	1.530	0.595	2.235	17.430	0.000	27.640	0.000	98.52
554/82 /avg	45.215	0.075	1.410	4.005	0.275	3.130	16.050	0.030	27.120	0.000	99.97
558/82 /avg	45.250	0.490	2.550	3.330	0.635	5.240	14.730	0.120	27.390	0.000	99.74

Sample No.	Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
443/85 /avg	45.353	0.048	1.685	4.193	0.250	4.075	17.603	0.055	28.093	0.033	101.39
445/85 /avg	44.958	0.023	1.920	4.047	0.430	5.448	16.020	0.018	27.470	0.035	100.37
446/85 /avg	44.738	0.013	2.230	4.323	0.375	5.755	16.485	0.030	26.820	0.033	100.80
61/91 /avg	44.700	0.030	1.000	4.490	0.540	5.230	16.700	0.000	27.800	0.000	100.49
62/91 /avg	43.820	0.030	1.040	4.460	0.880	5.060	16.860	0.000	27.580	0.000	99.73
63/91 /avg	42.450	0.040	1.970	4.410	0.660	11.150	12.460	0.000	26.070	0.000	99.21
64/91 /avg	42.860	0.050	5.340	2.300	0.610	5.420	17.020	0.100	27.380	0.000	101.08
65/91 /avg	40.040	0.060	4.660	2.100	0.670	24.070	4.940	0.000	24.900	0.000	101.44
66/91 /avg	40.920	0.060	3.800	2.460	1.200	20.450	7.940	0.080	25.490	0.000	102.40
67/91 /avg	41.220	0.000	1.740	4.360	1.190	15.480	10.440	0.000	26.010	0.000	100.44
68/91 /avg	41.590	0.060	4.750	2.430	0.320	11.010	12.330	0.290	26.920	0.000	99.70
69/91 /avg	42.530	0.020	6.420	1.650	0.760	5.600	16.980	0.010	26.430	0.000	100.40
70/91 /avg	39.320	0.050	4.460	2.250	0.990	24.440	4.400	0.090	24.680	0.000	100.68
71/91 /avg	39.990	0.040	4.220	2.380	1.030	23.960	5.090	0.100	25.270	0.000	102.08
72/91 /avg	41.380	0.000	2.910	4.280	0.790	11.160	13.690	0.000	27.270	0.000	101.48
73/91 /avg	41.780	0.030	1.720	4.390	1.100	10.230	13.860	0.000	26.950	0.000	100.06
74/91 /avg	43.080	0.000	5.670	2.320	0.450	0.880	19.320	0.000	27.640	0.000	99.36
75/91 /avg	43.280	0.020	5.720	2.450	0.240	2.160	16.570	0.000	27.200	0.000	99.99
76/91 /avg	41.470	0.000	5.660	2.380	0.310	8.740	14.410	0.000	27.370	0.000	100.34
77/91 /avg	41.080	0.000	6.080	2.170	0.420	12.200	12.730	0.000	27.380	0.000	102.06
78/91 /avg	42.670	0.000	6.320	1.920	0.290	1.020	19.030	0.000	27.360	0.000	98.61
79/91 /avg	41.360	0.040	2.570	4.090	0.700	12.850	11.590	0.320	26.050	0.000	99.57
80/91 /avg	40.000	0.020	2.270	4.610	0.270	8.200	14.730	0.030	27.960	0.000	98.09
81/91 /avg	40.580	0.110	2.300	4.160	0.570	16.410	9.160	0.000	26.540	0.000	99.83
82/91 /avg	40.540	0.030	3.450	3.350	0.960	17.030	9.320	0.000	27.250	0.000	101.93
83/91 /avg	45.440	0.110	2.660	3.720	0.160	3.660	18.000	0.000	27.910	0.000	101.66
84/91 /avg	44.180	0.030	2.590	3.810	0.240	4.750	16.990	0.000	27.280	0.040	99.61
85/91 /avg	45.350	0.050	1.680	4.150	0.250	3.140	17.600	0.050	28.090	0.030	100.39
86/91 /avg	44.000	0.010	1.800	4.760	0.370	4.620	16.280	0.080	27.750	0.000	99.67
87/91 /avg	45.350	0.090	1.200	4.650	0.740	4.600	14.700	1.600	26.410	0.000	99.34
88/91 /avg	44.760	0.110	0.770	5.120	0.600	5.280	15.200	0.580	27.770	0.000	100.19
90/91 /avg	43.590	0.020	3.060	3.440	1.200	5.920	15.990	0.240	26.540	0.060	100.06
91/91 /avg	43.930	0.020	2.030	3.680	0.500	7.280	15.300	0.330	26.730	0.030	99.83
92/91 /avg	45.360	0.100	1.610	3.880	0.500	5.120	16.950	0.180	27.420	0.000	101.12
93/91 /avg	44.730	0.020	2.480	3.700	0.470	4.910	17.100	0.210	27.410	0.050	101.08
94/91 /avg	45.110	0.030	1.360	4.010	0.380	5.300	16.740	0.040	27.370	0.020	100.36
95/91 /avg	45.030	0.190	1.710	4.410	0.320	5.660	14.850	0.120	26.940	0.000	99.23
96/91 /avg	44.530	0.020	1.620	4.440	0.380	6.130	16.350	0.080	27.200	0.030	100.78
97/91 /avg	45.420	0.020	1.890	3.910	0.420	4.900	17.040	0.040	27.820	0.040	101.50
98/91 /avg	44.140	0.030	1.660	4.290	0.370	6.090	16.360	0.100	27.660	0.190	100.89
99/91 /avg	47.500	0.360	1.610	2.320	0.610	2.770	17.300	0.000	26.220	0.000	98.69
100/91 /avg	48.950	0.250	1.200	2.370	0.590	0.470	18.350	0.000	27.190	0.000	99.37
101/91 /avg	48.810	0.100	1.270	2.360	0.540	0.140	18.200	0.010	26.910	0.000	98.34
102/91 /avg	48.440	0.150	1.350	2.230	0.270	2.590	17.710	0.040	28.230	0.000	101.01
103/91 /avg	41.950	0.020	1.750	1.150	0.350	18.750	8.130	0.200	26.890	0.000	99.19
104/91 /avg	45.250	0.490	2.550	3.330	0.630	5.240	14.730	0.120	27.390	0.000	99.73
105/91 /avg	44.390	0.140	1.590	3.410	1.400	5.490	15.190	0.040	26.990	0.000	98.64

Sample No.	Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
106/91 /avg	41.760	0.070	2.610	6.400	0.420	3.810	13.630	5.180	27.490	0.000	101.37
107/91 /avg	42.170	0.000	2.480	5.850	0.000	0.140	13.400	7.850	26.460	0.000	98.35
108/91 /avg	45.530	0.030	0.440	5.260	0.000	0.240	20.280	0.000	27.020	0.000	98.80
109/91 /avg	44.790	0.020	3.220	2.750	0.280	0.000	20.560	0.000	27.350	0.000	98.97
110/91 /avg	43.370	0.090	3.850	2.840	0.340	8.560	14.280	0.170	26.510	0.000	100.01
111/91 /avg	43.650	0.030	3.610	2.980	0.210	0.800	19.280	0.720	26.780	0.000	98.06
112/91 /avg	42.850	0.020	4.260	2.330	0.500	6.830	15.570	0.000	25.860	0.000	98.22
113/91 /avg	44.160	0.030	3.330	2.740	0.200	2.670	17.910	1.710	27.060	0.000	99.81
114/91 /avg	43.700	0.030	3.610	2.990	0.210	0.800	19.290	0.720	27.400	0.000	98.75
115/91 /avg	43.080	0.110	4.200	2.480	0.000	6.920	15.890	0.000	26.930	0.000	99.61
116/91 /avg	46.000	0.030	0.160	5.290	0.000	0.170	19.310	0.000	28.490	0.000	99.45
117/91 /avg	45.200	0.000	1.050	5.300	0.000	0.910	18.460	0.000	27.980	0.000	98.90
118/91 /avg	44.750	0.070	3.090	3.820	0.000	0.020	19.020	0.000	28.670	0.000	99.44
119/91 /avg	44.420	0.000	1.700	4.690	0.230	0.000	19.540	0.010	27.570	0.000	98.16
120/91 /avg	44.610	2.990	2.998	1.230	0.170	2.020	15.210	4.870	25.990	0.000	100.08
121/91 /avg	46.000	0.100	3.040	1.310	0.230	2.090	15.990	5.010	26.990	0.000	100.76
122/91 /avg	40.720	0.290	2.610	3.150	3.220	15.900	8.020	0.280	25.710	0.000	99.90
123/91 /avg	44.400	0.140	4.570	1.520	0.590	2.230	17.510	0.000	27.640	0.000	98.60
124/91 /avg	46.350	0.180	1.240	4.130	0.266	2.945	16.707	0.050	28.119	0.000	99.97
125/91 /avg	43.120	0.100	1.680	3.720	1.470	6.350	14.630	0.000	27.240	0.000	98.31
126/91 /avg	37.460	0.540	3.220	3.130	1.700	28.940	0.120	0.320	24.500	0.000	99.93
127/91 /avg	43.540	0.080	2.080	3.510	1.600	7.740	13.320	0.120	27.230	0.000	99.22
128/91 /avg	37.470	0.540	3.230	3.130	1.700	28.950	0.130	0.320	24.500	0.000	99.97
129/91 /avg	47.260	0.070	3.120	2.100	0.170	6.590	13.120	0.000	26.890	0.000	99.32
130/91 /avg	43.020	0.040	2.700	4.400	0.240	7.530	14.080	0.080	27.850	0.000	99.94
131/91 /avg	42.100	0.000	6.360	2.870	0.030	0.350	19.250	0.000	28.270	0.000	99.23
132/91 /avg	41.950	0.030	4.490	4.170	0.060	4.410	16.640	0.000	27.840	0.000	99.59
134/91 /avg	42.720	0.030	3.180	5.640	0.480	0.020	19.720	0.000	29.040	0.000	100.83
135/91 /avg	41.630	0.050	4.260	3.430	0.250	10.450	13.480	0.090	27.800	0.000	101.44
136/91 /avg	40.730	0.020	5.390	2.510	0.040	11.130	13.100	0.000	28.290	0.000	101.21
137/91 /avg	41.640	0.060	3.280	3.670	0.000	10.850	13.020	0.290	27.090	0.000	99.90
138/91 /avg	43.670	0.060	2.780	4.790	0.000	0.000	19.290	0.050	28.540	0.000	99.18
139/91 /avg	43.540	0.060	2.490	4.820	0.180	0.020	20.160	0.000	28.560	0.000	99.83
140/91 /avg	43.540	0.080	2.760	3.470	0.330	10.450	12.140	0.270	27.000	0.000	100.04
141/91 /avg	47.930	0.000	0.580	2.490	0.300	3.510	18.010	0.000	27.850	0.000	100.67
142/91 /avg	41.490	0.020	2.000	3.820	0.810	16.110	10.380	0.020	26.040	0.000	100.69
143/91 /avg	41.330	0.030	4.610	2.930	0.220	9.320	14.650	0.090	27.310	0.000	100.49
146/91 /avg	45.970	0.170	0.050	5.440	0.090	0.390	18.380	0.070	27.790	0.000	98.35
147/91 /avg	44.590	0.120	2.010	3.530	1.520	6.840	14.000	0.110	27.390	0.000	100.11
148/91 /avg	44.960	0.020	1.920	4.050	0.430	5.450	16.020	0.020	27.470	0.040	100.38
149/91 /avg	44.740	0.010	2.230	4.320	0.380	5.760	16.490	0.030	26.820	0.030	100.81
150/91 /avg	43.350	0.000	5.920	0.400	0.170	5.130	17.340	0.000	27.630	0.000	99.94
151/91 /avg	43.650	0.000	7.230	0.700	0.200	5.480	16.280	0.000	27.730	0.000	101.27
152/91 /avg	42.660	0.060	7.170	1.220	0.220	0.070	19.040	0.100	27.470	0.000	98.01
153/91 /avg	41.880	0.180	7.500	1.200	0.070	0.000	19.690	0.000	27.740	0.000	98.26
154/91 /avg	42.660	0.130	6.420	1.820	0.170	0.240	19.690	0.000	27.520	0.000	98.65
156/91 /avg	43.520	0.100	6.990	0.360	0.240	7.770	13.920	0.260	26.030	0.000	99.12

Sample No.	Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
157/91 /avg	44.038	0.123	7.514	0.215	0.112	7.708	14.075	0.000	26.212	0.000	99.99
158/91 /avg	47.110	0.000	1.800	2.290	0.470	3.150	17.730	0.000	28.580	0.000	101.13
160/91 /avg	46.420	0.000	1.990	2.140	0.960	6.030	15.140	0.000	28.020	0.000	100.70
164/91 /avg	47.490	0.030	0.690	2.480	0.910	3.570	17.180	0.100	27.280	0.000	99.73
168/91 /avg	44.170	0.030	2.860	2.060	0.640	11.460	12.430	0.020	27.110	0.000	100.78
169/91 /avg	46.130	0.000	2.400	2.000	0.550	5.280	16.020	0.000	28.150	0.000	100.53
170/91 /avg	46.620	0.030	2.440	1.940	0.780	4.710	16.830	0.000	27.870	0.000	101.22
171/91 /avg	45.780	0.130	1.430	4.820	0.460	3.860	15.200	0.160	27.520	0.000	99.36
172/91 /avg	43.710	0.020	1.680	4.870	0.640	5.020	15.900	0.080	27.050	0.000	98.97
292/91 /avg	41.100	0.000	1.700	3.900	2.700	18.600	8.000	0.000	25.800	0.000	101.80

Appendix 1b: Analysis of tennantites-tetrahedrites series (29 atm.).

	Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
A-type'SCS'											
32/86 /avg	10.433	0.009	0.708	1.205	0.031	0.004	3.954	0.007	12.590	0.005	28.95
297/91 /avg	9.808	0.000	0.865	1.094	0.122	0.665	3.058	0.000	13.388	0.000	29.00
298/91 /avg	10.370	0.000	0.406	1.286	0.226	0.192	3.783	0.000	12.736	0.000	29.00
300/91 /avg	10.582	0.000	0.540	1.178	0.088	1.384	2.763	0.000	12.464	0.000	29.00
301/91 /avg	9.991	0.000	0.336	0.141	1.400	0.462	3.207	0.000	13.463	0.000	29.00
302/91 /avg	10.646	0.000	0.377	1.338	0.000	0.437	3.538	0.000	12.664	0.000	29.00
303/91 /avg	9.773	0.000	0.995	0.876	0.000	0.386	3.938	0.000	13.032	0.000	29.00
304/91 /avg	9.518	0.000	1.021	0.873	0.000	0.082	4.154	0.205	13.148	0.000	29.00
305/91 /avg	9.909	0.000	0.785	1.216	0.000	0.170	4.109	0.000	12.811	0.000	29.00
306/91 /avg	10.335	0.000	0.286	1.767	0.000	0.092	3.584	0.000	12.936	0.000	29.00
307/91 /avg	9.857	0.000	0.022	1.833	0.000	0.042	4.190	0.000	12.883	0.000	28.83
308/91 /avg	9.717	0.075	0.443	1.538	0.000	0.208	3.948	0.079	12.993	0.000	29.00
311/91 /avg	10.430	0.000	1.069	0.900	0.000	0.417	3.697	0.000	12.488	0.000	29.00
B-type'DSCM'											
531/82 /avg	10.324	0.013	0.239	1.456	0.077	1.106	2.691	0.005	13.065	0.000	28.98
65/85 /avg	10.188	0.083	0.490	1.327	0.024	3.072	1.069	0.018	12.671	0.042	28.98
61/85 /avg	10.232	0.029	0.651	1.050	0.054	3.176	0.990	0.012	12.742	0.022	28.96
62/85 /avg	10.447	0.021	0.070	1.512	0.024	0.252	3.746	0.006	12.878	0.014	28.97
63/85 /avg	10.279	0.015	0.699	1.084	0.012	2.339	1.768	0.002	12.762	0.016	28.98
64/85 /avg	10.445	0.001	0.333	1.349	0.020	0.412	3.680	0.000	12.719	0.013	28.97
66/85 /avg	10.440	0.000	0.623	0.974	0.013	1.032	3.078	0.019	12.760	0.019	28.96
67/85 /avg	10.373	0.008	0.719	0.854	0.027	2.908	1.174	0.114	12.754	0.018	28.95
68/85 /avg	10.215	0.007	0.671	1.101	0.009	1.721	2.309	0.013	12.836	0.006	28.89
127/83 /avg	10.793	0.019	0.467	0.667	0.014	2.568	1.468	0.022	12.969	0.000	28.99
46/85 /avg	10.390	0.000	0.394	1.241	0.010	2.074	1.682	0.196	12.994	0.000	28.98
133/83 /avg	11.202	0.017	0.182	0.764	0.008	2.572	1.410	0.044	12.797	0.000	29.00
134/83 /avg	10.513	0.019	1.133	0.436	0.013	2.879	1.144	0.056	12.786	0.000	28.98
533/82 /avg	10.417	0.018	0.566	0.994	0.017	2.816	1.095	0.058	12.986	0.000	28.97
547/82 /avg	10.353	0.039	0.223	1.293	0.010	2.563	1.380	0.051	13.086	0.000	29.00
548/82 /avg	10.357	0.026	0.296	1.196	0.015	2.688	1.305	0.061	13.047	0.000	28.99
549/82 /avg	10.370	0.028	0.296	1.197	0.007	2.779	1.282	0.045	12.992	0.000	29.00
45/85 /avg	10.443	0.009	0.425	1.176	0.012	1.624	2.087	0.188	12.966	0.000	28.93

Sample No.		Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
128/83	/avg	10.803	0.016	0.346	0.660	0.008	2.756	1.296	0.036	13.057	0.000	28.98
47/85	/avg	10.641	0.000	0.134	1.451	0.009	0.109	3.620	0.001	12.941	0.000	28.91
48/85	/avg	10.513	0.009	0.349	1.196	0.018	1.779	1.757	0.409	12.883	0.000	28.91
49/85	/avg	10.556	0.008	0.345	1.223	0.021	1.877	1.778	0.433	12.657	0.000	28.90
51/85	/avg	10.775	0.017	0.097	1.442	0.009	1.438	2.462	0.002	12.711	0.000	28.95
52/85	/avg	10.324	0.009	1.215	0.671	0.011	3.028	1.016	0.026	12.690	0.000	28.99
367/86	/avg	10.451	0.004	0.577	1.273	0.010	1.536	2.555	0.034	12.496	0.015	28.95
371/86	/avg	10.134	0.010	0.149	1.996	0.010	0.269	3.711	0.016	12.685	0.002	28.98
144/91	/avg	10.967	0.012	0.734	0.366	0.018	0.131	3.413	0.000	13.301	0.000	28.94
145/91	/avg	11.316	0.005	0.474	0.883	0.001	0.155	2.913	0.004	13.248	0.000	29.00
155/91	/avg	10.318	0.014	0.240	1.454	0.115	1.105	2.689	0.005	13.055	0.000	28.99
C-type'USSO'												
309/91	/avg	10.033	0.000	1.664	0.907	0.000	2.344	1.677	0.000	12.375	0.000	29.00
50/85	/avg	10.385	0.000	0.280	1.287	0.016	1.841	2.114	0.026	12.980	0.000	28.93
287/91	/avg	10.136	0.000	0.065	1.556	0.000	0.105	3.005	0.000	14.132	0.000	29.00
288/91	/avg	10.130	0.000	0.198	1.235	0.000	0.330	2.992	0.000	14.115	0.000	29.00
289/91	/avg	9.704	0.000	0.022	1.925	0.000	0.081	3.549	0.000	13.719	0.000	29.00
290/91	/avg	10.066	0.014	0.453	1.229	0.086	1.051	3.061	0.000	13.040	0.000	29.00
291/91	/avg	10.007	0.007	1.507	0.402	0.025	0.363	3.635	0.000	13.055	0.000	29.00
293/91	/avg	10.005	0.000	0.766	1.196	0.015	0.723	3.281	0.000	13.014	0.000	29.00
294/91	/avg	9.891	0.033	0.296	0.662	1.001	3.933	0.282	0.000	12.903	0.000	29.00
295/91	/avg	9.956	0.015	0.352	1.118	0.475	2.780	1.184	0.000	13.119	0.000	29.00
296/91	/avg	10.125	0.014	0.716	1.126	0.007	0.540	3.474	0.000	12.998	0.000	29.00
299/91	/avg	9.587	0.007	0.707	1.193	0.004	1.404	2.569	0.000	13.530	0.000	29.00
310/91	/avg	10.200	0.000	1.641	0.229	0.000	2.175	1.667	0.000	13.087	0.000	29.00
312/91	/avg	10.381	0.000	1.647	0.366	0.000	2.716	1.419	0.000	12.472	0.000	29.00
D-type'VCM'												
312/85	/avg	10.035	0.065	0.527	1.078	0.418	3.778	0.269	0.044	12.757	0.006	28.98
419/85	/avg	10.459	0.014	0.497	0.863	0.264	0.412	3.620	0.002	12.819	0.023	28.97
441/85	/avg	10.138	0.015	0.947	1.001	0.012	4.092	0.390	0.006	12.366	0.013	28.98
529/82	/avg	10.751	0.023	0.114	1.421	0.111	0.481	3.017	0.004	13.032	0.000	28.95
530/82	/avg	10.684	0.010	0.072	1.577	0.043	0.083	3.381	0.000	13.084	0.000	28.93
556/82	/avg	10.118	0.031	0.669	0.919	0.275	2.200	1.757	0.016	13.008	0.000	28.99
21/86	/avg	10.646	0.003	0.383	1.022	0.036	0.647	3.334	0.011	12.847	0.005	28.93
22/86	/avg	10.666	0.004	0.312	1.080	0.029	0.655	3.358	0.003	12.825	0.004	28.94
23/86	/avg	10.571	0.003	0.474	1.007	0.034	0.916	3.123	0.024	12.767	0.006	28.93
24/86	/avg	10.517	0.003	0.567	0.991	0.035	0.604	3.409	0.015	12.784	0.008	28.93
25/86	/avg	10.608	0.002	0.429	1.039	0.031	0.598	3.375	0.002	12.875	0.007	28.97
26/86	/avg	10.497	0.002	0.716	0.944	0.091	0.744	3.266	0.018	12.666	0.011	28.96
27/86	/avg	10.547	0.002	0.374	1.198	0.029	0.758	3.285	0.006	12.770	0.006	28.97
28/86	/avg	10.424	0.004	0.381	1.154	0.028	0.750	3.277	0.007	12.947	0.004	28.97
29/86	/avg	10.484	0.005	0.597	1.028	0.018	0.588	3.419	0.000	12.827	0.007	28.97
527/82	/avg	10.841	0.018	0.330	1.300	0.035	0.476	3.055	0.012	12.916	0.000	28.98
528/82	/avg	11.353	0.010	0.729	0.574	0.013	0.826	2.673	0.000	12.802	0.000	28.98
534/82	/avg	9.978	0.085	0.835	0.947	0.143	4.024	0.028	0.026	12.926	0.000	28.99
535/82	/avg	10.585	0.015	0.178	1.379	0.045	0.652	3.049	0.042	13.017	0.000	28.96
536/82	/avg	10.664	0.014	0.287	1.302	0.058	0.590	3.068	0.120	12.877	0.000	28.98
538/82	/avg	10.564	0.011	0.492	0.969	0.122	0.981	2.740	0.009	13.095	0.000	28.98

Sample No.	Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
539/82 /avg	10.539	0.011	0.649	0.957	0.025	1.321	2.492	0.003	12.956	0.000	28.95
541/82 /avg	10.814	0.024	0.013	1.455	0.007	0.048	3.667	0.005	12.958	0.000	28.98
543/82 /avg	10.691	0.016	0.469	0.963	0.115	0.856	2.847	0.008	13.014	0.000	28.98
544/82 /avg	10.841	0.020	0.284	1.098	0.020	0.359	3.316	0.003	13.034	0.000	28.98
551/82 /avg	10.481	0.021	0.397	1.029	0.113	0.805	3.016	0.000	13.123	0.000	28.99
553/82 /avg	10.796	0.027	0.399	1.202	0.024	0.708	3.018	0.008	12.802	0.000	28.98
546/82 /avg	10.757	0.019	0.375	0.939	0.107	0.699	3.121	0.003	12.960	0.000	28.98
550/82 /avg	10.588	0.020	1.053	0.415	0.045	0.279	3.525	0.000	13.063	0.000	28.99
554/82 /avg	10.897	0.011	0.330	1.098	0.021	0.394	3.281	0.002	12.952	0.000	28.99
558/82 /avg	10.789	0.069	0.593	0.903	0.048	0.652	2.979	0.009	12.943	0.000	28.98
443/85 /avg	10.541	0.007	0.380	1.109	0.018	0.495	3.469	0.004	12.940	0.006	28.97
445/85 /avg	10.628	0.003	0.441	1.088	0.032	0.673	3.209	0.001	12.867	0.007	28.95
446/85 /avg	10.612	0.002	0.514	1.167	0.028	0.713	3.317	0.002	12.607	0.006	28.97
61/91 /avg	10.543	0.004	0.229	1.205	0.040	0.644	3.341	0.000	12.994	0.000	29.00
62/91 /avg	10.433	0.004	0.241	1.208	0.066	0.629	3.405	0.000	13.014	0.000	29.00
63/91 /avg	10.462	0.006	0.472	1.237	0.052	1.434	2.605	0.000	12.733	0.000	29.00
64/91 /avg	10.151	0.007	1.229	0.620	0.046	0.670	3.419	0.007	12.851	0.000	29.00
65/91 /avg	10.248	0.009	1.159	0.612	0.054	3.215	1.072	0.000	12.630	0.000	29.00
66/91 /avg	10.250	0.009	0.925	0.701	0.095	2.674	1.687	0.006	12.654	0.000	29.00
67/91 /avg	10.240	0.000	0.420	1.232	0.094	2.007	2.200	0.000	12.806	0.000	29.00
68/91 /avg	10.156	0.009	1.128	0.675	0.025	1.403	2.554	0.022	13.029	0.000	29.00
69/91 /avg	10.226	0.003	1.501	0.451	0.058	0.703	3.463	0.001	12.595	0.000	29.00
70/91 /avg	10.182	0.008	1.123	0.663	0.081	3.303	0.966	0.007	12.666	0.000	29.00
71/91 /avg	10.165	0.006	1.043	0.688	0.083	3.179	1.097	0.008	12.731	0.000	29.00
72/91 /avg	9.933	0.000	0.679	1.169	0.060	1.398	2.787	0.000	12.973	0.000	29.00
73/91 /avg	10.154	0.004	0.406	1.214	0.085	1.298	2.857	0.000	12.981	0.000	29.00
74/91 /avg	10.156	0.000	1.299	0.622	0.034	0.108	3.863	0.000	12.913	0.000	29.00
75/91 /avg	10.389	0.003	1.335	0.669	0.018	0.271	3.374	0.000	12.940	0.000	29.00
76/91 /avg	9.955	0.000	1.321	0.650	0.024	1.095	2.934	0.000	13.021	0.000	29.00
77/91 /avg	9.844	0.000	1.416	0.592	0.032	1.526	2.587	0.000	13.003	0.000	29.00
78/91 /avg	10.144	0.000	1.461	0.519	0.022	0.127	3.837	0.000	12.891	0.000	29.00
79/91 /avg	10.250	0.006	0.619	1.153	0.055	1.662	2.436	0.024	12.794	0.000	29.00
80/91 /avg	9.687	0.003	0.534	1.270	0.021	1.037	3.026	0.002	13.420	0.000	29.00
81/91 /avg	10.082	0.016	0.555	1.176	0.045	2.128	1.930	0.000	13.068	0.000	29.00
82/91 /avg	9.894	0.004	0.818	0.930	0.074	2.169	1.929	0.000	13.180	0.000	29.00
83/91 /avg	10.545	0.015	0.600	0.982	0.012	0.443	3.543	0.000	12.837	0.000	28.98
84/91 /avg	10.483	0.004	0.597	1.029	0.018	0.588	3.419	0.000	12.829	0.008	28.98
85/91 /avg	10.587	0.007	0.381	1.102	0.018	0.383	3.485	0.004	12.997	0.006	28.97
86/91 /avg	10.411	0.001	0.414	1.282	0.028	0.571	3.267	0.006	13.013	0.000	28.99
87/91 /avg	10.971	0.013	0.282	1.280	0.057	0.581	3.016	0.118	12.662	0.000	28.98
88/91 /avg	10.586	0.015	0.177	1.378	0.045	0.652	3.049	0.042	13.016	0.000	28.96
90/91 /avg	10.497	0.003	0.716	0.943	0.092	0.744	3.266	0.018	12.666	0.012	28.96
91/91 /avg	10.578	0.003	0.475	1.008	0.038	0.915	3.125	0.024	12.756	0.006	28.93
92/91 /avg	10.668	0.014	0.368	1.038	0.037	0.628	3.381	0.013	12.780	0.000	28.93
93/91 /avg	10.521	0.003	0.567	0.990	0.035	0.603	3.411	0.015	12.777	0.009	28.93
94/91 /avg	10.666	0.004	0.313	1.079	0.028	0.654	3.357	0.003	12.826	0.004	28.93
95/91 /avg	10.794	0.027	0.398	1.203	0.024	0.708	3.019	0.009	12.799	0.000	28.98
96/91 /avg	10.547	0.003	0.373	1.197	0.029	0.758	3.285	0.006	12.768	0.006	28.97

Sample No.		Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
97/91	/avg	10.606	0.003	0.429	1.039	0.031	0.597	3.375	0.003	12.875	0.008	28.96
98/91	/avg	10.412	0.004	0.381	1.152	0.028	0.750	3.273	0.007	12.931	0.036	28.97
99/91	/avg	11.461	0.051	0.378	0.637	0.047	0.349	3.540	0.000	12.538	0.000	29.00
100/91	/avg	11.556	0.035	0.275	0.637	0.044	0.058	3.674	0.000	12.721	0.000	29.00
101/91	/avg	11.621	0.014	0.294	0.639	0.041	0.017	3.675	0.001	12.698	0.000	29.00
102/91	/avg	11.256	0.021	0.305	0.590	0.020	0.314	3.491	0.003	13.001	0.000	29.00
103/91	/avg	10.565	0.003	0.428	0.330	0.028	2.465	1.737	0.015	13.421	0.000	28.99
104/91	/avg	10.789	0.069	0.591	0.903	0.048	0.652	2.979	0.009	12.943	0.000	28.98
105/91	/avg	10.756	0.020	0.375	0.940	0.107	0.694	3.122	0.003	12.961	0.000	28.98
106/91	/avg	9.979	0.010	0.606	1.740	0.032	0.475	2.762	0.376	13.019	0.000	29.00
107/91	/avg	10.408	0.000	0.595	1.643	0.000	0.018	2.805	0.589	12.942	0.000	29.00
108/91	/avg	10.749	0.004	0.101	1.413	0.000	0.030	4.061	0.000	12.642	0.000	29.00
109/91	/avg	10.577	0.003	0.739	0.739	0.021	0.000	4.118	0.000	12.800	0.000	29.00
110/91	/avg	10.510	0.013	0.907	0.783	0.026	1.083	2.935	0.013	12.731	0.000	29.00
111/91	/avg	10.488	0.004	0.843	0.815	0.016	0.100	3.929	0.053	12.752	0.000	29.00
112/91	/avg	10.546	0.003	1.019	0.652	0.039	0.877	3.250	0.000	12.613	0.000	29.00
113/91	/avg	10.555	0.004	0.774	0.745	0.015	0.333	3.631	0.124	12.818	0.000	29.00
114/91	/avg	10.388	0.004	0.834	0.809	0.016	0.099	3.889	0.052	12.908	0.000	29.00
115/91	/avg	10.367	0.016	0.983	0.679	0.000	0.869	3.243	0.000	12.843	0.000	29.00
116/91	/avg	10.662	0.004	0.036	1.395	0.000	0.021	3.796	0.000	13.087	0.000	29.00
117/91	/avg	10.585	0.000	0.239	1.412	0.000	0.111	3.667	0.000	12.986	0.000	29.00
118/91	/avg	10.373	0.010	0.696	1.008	0.000	0.002	3.739	0.000	13.170	0.000	29.00
119/91	/avg	10.498	0.000	0.391	1.261	0.017	0.000	3.917	0.001	12.913	0.000	29.00
120/91	/avg	10.998	0.435	0.718	0.345	0.014	0.248	3.180	0.365	12.698	0.000	29.00
121/91	/avg	11.094	0.014	0.713	0.360	0.018	0.263	3.271	0.367	12.901	0.000	29.00
122/91	/avg	10.338	0.043	0.644	0.910	0.259	2.107	1.727	0.022	12.936	0.000,	28.99
123/91	/avg	10.581	0.020	1.059	0.412	0.045	0.277	3.539	0.000	13.054	0.000	28.99
124/91	/avg	10.839	0.025	0.284	1.099	0.020	0.359	3.314	0.004	13.032	0.000	28.98
125/91	/avg	10.483	0.014	0.397	1.029	0.113	0.806	3.017	0.000	13.125	0.000	28.98
126/91	/avg	9.977	0.085	0.834	0.949	0.143	4.023	0.027	0.026	12.932	0.000	28.99
127/91	/avg	10.564	0.011	0.491	0.969	0.123	0.980	2.741	0.009	13.094	0.000	28.98
128/91	/avg	9.976	0.085	0.836	0.948	0.143	4.023	0.029	0.026	12.928	0.000	28.99
129/91	/avg	11.352	0.010	0.729	0.574	0.013	0.826	2.673	0.000	12.801	0.000	28.98
130/91	/avg	10.236	0.006	0.625	1.191	0.018	0.935	2.842	0.006	13.133	0.000	28.99
131/91	/avg	9.838	0.000	1.445	0.763	0.002	0.043	3.816	0.000	13.093	0.000	29.00
132/91	/avg	9.916	0.004	1.032	1.122	0.004	0.544	3.336	0.000	13.042	0.000	29.00
134/91	/avg	9.779	0.004	0.708	1.469	0.035	0.002	3.829	0.000	13.174	0.000	29.00
135/91	/avg	9.912	0.007	0.986	0.929	0.019	1.299	2.722	0.007	13.119	0.000	29.00
136/91	/avg	9.695	0.003	1.247	0.680	0.003	1.383	2.645	0.000	13.345	0.000	29.00
137/91	/avg	10.103	0.009	0.774	1.013	0.000	1.374	2.679	0.021	13.027	0.000	29.00
138/91	/avg	10.148	0.008	0.628	1.267	0.000	0.000	3.802	0.004	13.144	0.000	29.00
139/91	/avg	10.081	0.008	0.560	1.270	0.013	0.002	3.959	0.000	13.106	0.000	29.00
140/91	/avg	10.534	0.011	0.649	0.955	0.025	1.320	2.491	0.020	12.947	0.000	28.95
141/91	/avg	11.234	0.000	0.132	0.664	0.022	0.429	3.580	0.000	12.937	0.000	29.00
142/91	/avg	10.295	0.003	0.482	1.079	0.064	2.086	2.185	0.002	12.805	0.000	29.00
143/91	/avg	9.932	0.004	1.077	0.801	0.017	1.169	2.986	0.007	13.007	0.000	29.00
146/91	/avg	10.815	0.024	0.011	1.456	0.007	0.048	3.667	0.005	12.957	0.000	28.99
147/91	/avg	10.690	0.017	0.468	0.963	0.115	0.856	2.847	0.008	13.014	0.000	28.98

Sample No.		Cu	Ag	Zn	Fe	Hg	Sb	As	Bi	S	Se	Total
148/91	/avg	10.626	0.003	0.441	1.089	0.032	0.672	3.211	0.001	12.867	0.008	28.95
149/91	/avg	10.613	0.001	0.514	1.166	0.029	0.713	3.318	0.002	12.609	0.006	28.97
150/91	/avg	10.302	0.000	1.368	0.108	0.013	0.636	3.495	0.000	13.013	0.000	28.93
151/91	/avg	10.232	0.000	1.648	0.187	0.015	0.670	3.237	0.000	12.883	0.000	28.87
152/91	/avg	10.159	0.008	1.660	0.331	0.017	0.009	3.846	0.007	12.964	0.000	29.00
153/91	/avg	9.927	0.025	1.728	0.324	0.005	0.000	3.959	0.000	13.032	0.000	29.00
154/91	/avg	10.101	0.018	1.478	0.490	0.013	0.030	3.954	0.000	12.914	0.000	29.00
156/91	/avg	10.663	0.014	1.665	0.100	0.019	0.985	2.893	0.019	12.639	0.000	29.00
157/91	/avg	10.678	0.018	1.771	0.059	0.009	0.976	2.894	0.000	12.596	0.000	29.00
158/91	/avg	10.935	0.000	0.406	0.605	0.035	0.382	3.491	0.000	13.147	0.000	29.00
160/91	/avg	10.979	0.000	0.458	0.576	0.072	0.744	3.037	0.000	13.134	0.000	29.00
164/91	/avg	11.305	0.004	0.160	0.672	0.069	0.444	3.469	0.007	12.871	0.000	29.00
168/91	/avg	10.695	0.004	0.673	0.568	0.049	1.448	2.553	0.001	13.009	0.000	29.00
169/91	/avg	10.872	0.000	0.550	0.536	0.041	0.650	3.202	0.000	13.149	0.000	29.00
170/91	/avg	10.953	0.004	0.557	0.519	0.058	0.578	3.354	0.000	12.977	0.000	29.00
171/91	/avg	10.843	0.018	0.329	1.299	0.035	0.477	3.054	0.012	12.918	0.000	28.98
172/91	/avg	10.490	0.003	0.392	1.330	0.049	0.629	3.236	0.006	12.865	0.000	29.00
292/91	/avg	10.304	0.000	0.414	1.113	0.214	2.434	1.701	0.000	12.819	0.000	29.00

Localization of samples is at authors.

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