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STATISTICAL DISTRIBUTIONS OF ORE ELEMENTS IN THE RECSK ORE FIELD, HUNGARY

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ABSTRACT

Statistical frequency distributions of the Ag, Au, Cu, Fe, Mo, Pb, S, Se and Zn contents measured in 51000 rock samples taken from 194 diamond boreholes exploring a large porphyry copper and polymetallic skarn ore deposit-complex were analyzed. The distributions were represented by subsets of their common, and extreme values. The characteristic values of the ore components were displayed, and compared across units within three types of objects: spatial parts, rock-formations, and depth-zones of the deposit-complex. Among the deposit-parts, distributions of Ag, Cu, Pb, S and Au revealed significant differences. Except for a few units and those only in terms of several components, rock-formations exhibited a limited specialty in comparison. Statistically, values of the measured elements showed a notable vertical zoning.

Key words: ore deposit, statistical distribution, percentile, base metal, porphyry copper, polymetallic ore

INTRODUCTION

On the Lahóca Hill, near the village of Recsk, northern Hungary, silver and copper mining started in the 1850-s. During the next one hundred plus years several exploration campaigns were conducted in the area, and in the 1960-s a large, complex, porphyry copper and polymetallic, deep-seated ore deposit (Recsk Deep) was discovered. Detailed explorations resulted in 130 deep (>1,000 m) diamond boreholes, two deep shafts (to 1,200 m depth), tunnels and numerous crosscuts at two levels, and a total of 75,000 m of underground drillholes. After decades Recsk Deep still awaits exploitation and is in the state of long-term suspension. More than 150,000 rock samples have been analyzed for varying sets of ore components. Obviously, during this long exploration history, regulations and techniques of sampling and analysis changed a number of times. The most important analytical methods were, for base metals: atomic absorption spectroscopy, and, in the earlier times, classical wet methods; for gold: fire assay/gravimetric analysis (for Au>0.5 ppm).

In the numerous technical reports and published papers produced during the various exploration, development and assessment periods of the ore field, evaluations and models of statistical distributions of the analyzed metals are rare. Those consistent and based on a number of data comparable with the amount of the available analyses are completely absent. Hence, the aim of this paper is to provide a basic and more or less uniform characterization of the statistical distributions of ore elements, incorporating as many data as possible. As in geology generally, by statistical distributions we mean frequency distributions of values.

Statistical distributions can be treated in many ways, starting from calculation of a central tendency value to elaboration of sophisticated numerical models, not to mention analysis of bivariate and multivariate distributions. Here, statistical distributions serve as a mean to understand the structure and genesis of the ore field better, therefore, instead of thoroughly analyzing the distributions themselves, their effective, robust, unambiguously producible, and comparable representation is searched for, and used.

At this level of description of an ore deposit, no matter how asymmetric or complex a distribution is, the first related question to be answered is: which are the common (usual, typical, normal, "background", etc.), and which are the extreme (exceptional, atypical, deviant, "anomalous", etc.) values of a component. In other words, the representation of a distribution is mainly expected to elucidate this binary property of practically any set of values.

GEOLOGICAL SETTING

The study area lies in eastern Central Europe (Fig. 1), in the Carpathian Basin, a wide lowland with a few hilly patches inside. Geologically, this is the Pannonian Basin system, a Neogene-Quaternary sedimentary basin, surrounded by the arc of the Carpathian Mountains in the north, east, and southeast, bounded by the Eastern Alps in the west, and by the Dinaridic belt in the south. The Cenozoic evolution of the region was largely governed by movements and deformations of two continental plate fragments (Csontos 1995), that were squeezed between the colliding African and European Plates. These plate fragments, now forming the basement of the region, were forced to undergo major displacements, rotations, block-faulting, tilting, and thrusting during the prevailing compressional tectonic regime, whereas at their edges subduction processes took place. The geodynamic events were accompanied by episodic but significant magmatic activity both at the peripheries and in the interiors of the plate fragments, resulting in numerous corresponding volcano-magmatic formations throughout the Cenozoic. In the Paleogene, large andesitic stratovolcanic

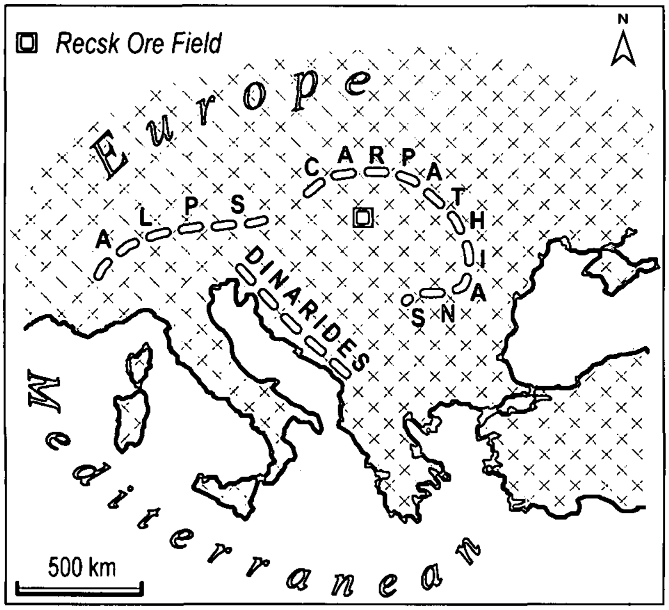

Fig. 1. Location of the Recsk Ore Field.

complexes were formed at several localities in a narrow belt (Csillag et al. 1983) to the north of what is now the Mid-Hungarian fault zone, identified as the boundary of the two plate fragments (Csontos and Nagymarosy 1998). One of these volcanic complexes hosts the Recsk Ore Field, a large mineralized complex, usually divided into Recsk Deep and Lahóca (Fig. 2, and, for certain details, Fig. 3 and Fig. 5).

The pre-volcanic basement of the Recsk area consists of Triassic limestone, quartzite and shales. Due to a post-Triassic uplift, Jurassic and Cretaceous rocks are absent. The Paleogene series starts with Late Eocene shallow-marine limestone and marl, mostly underlying intermediate volcanic rocks. Recent investigations (Less et al. 2005, Földessy et al. 2006) suggest that at least the overwhelming part (if not the whole) of the volcanic complex was formed in the Early Oligocene, as opposed to the traditionally employed Late Eocene age.. The Paleogene volcanic cycle comprises four stages: 1) submarine lavaflows, agglomerates, and peperites (the rocks of this stage do not outcrop on the surface); 2) a stratovolcanic sequence of dacitic character, gradually shifting to volcanites of subaerial environments; 3) a stratovolcanic sequence of biotite-hornblende andesites, their pyroclasts, and reworked andesitic volcanic sediments, with emplaced diorite-porphyry and quartz-diorite intrusions hosting the porphyry copper mineralization; and 4) development of a central explosive caldera in the area linked with the volcanism of stage 3, and formation of pyroxene-andesite dyke-pattern bodies and laccoliths within and around the caldera. Late Oligocene sandstone, clay and marl spread over the area except the central, several sq.km large andesitic horst (Baksa et al. 1988, Gatter et al. 1999, Seres-Hartai et al. 2001).

The deep-seated mineralizations (Recsk Deep) consist of different types of genetically linked ore formations. In the intrusive body, a typical porphyry copper (and subordinate Mo) mineralization with gold developed (Földessy et al. 2004). Along the exo- and endocontacts with the Triassic limestone, a skarn Cu-Zn-Pb-Fe mineralization was formed. In the Triassic limestone metasomatic and vein-type Zn-Pb ores occur. During the alteration of the intrusive body, silicification developed in the central and upper parts. At the top of the intrusion it is associated with an argillic zone containing a quartz-sericite-anhydrite assemblage. The propylitic zone, with albite, chlorite, epidote, anhydrite and calcite, is not continuous, and overlaps with the endoskarn containing diopside, amphibole and phlogopite. The garnet-diopside exoskarn is fringed with a metasomatic zone in which the limestone recrystallized to marble (Csillag 1975).

The porphyry Cu mineralization forms chalcopyrite-pyrite disseminations and stockworks. In the central parts molybdenite occurs in quartz-, and siliceous-anhydrite veins. In the skarn mineralization the basic Cu-bearing mineral is chalcopyrite, accompanied by pyrite, pyrrhotite, magnetite and hematite. Within the skarn polymetallic deposit, sphalerite is essential, associated with pyrite, chalcopyrite, galena and pyrrhotite. In the zones of hydrothermal-metasomatic alterations the polymetallic ore deposits contain sphalerite (dominant), pyrite, galena and chalcopyrite (Csongrádi 1975, Szebényi et al. 1985).

The deep-seated porphyry and skarn Cu deposit (Recsk Deep) has a spatial and, probably, genetic association with the Lahóca epithermal Cu-Au deposits. The Lahóca deposit is located in the NE part in the uppermost zone of the Recsk mineralized complex (Fig. 2). It can be considered as a typical high-sulfidation epithermal system (Földessy 1997, Gatter et al. 1999, Seres-Hartai and Földessy 2000, Seres-Hartai et al. 2001).

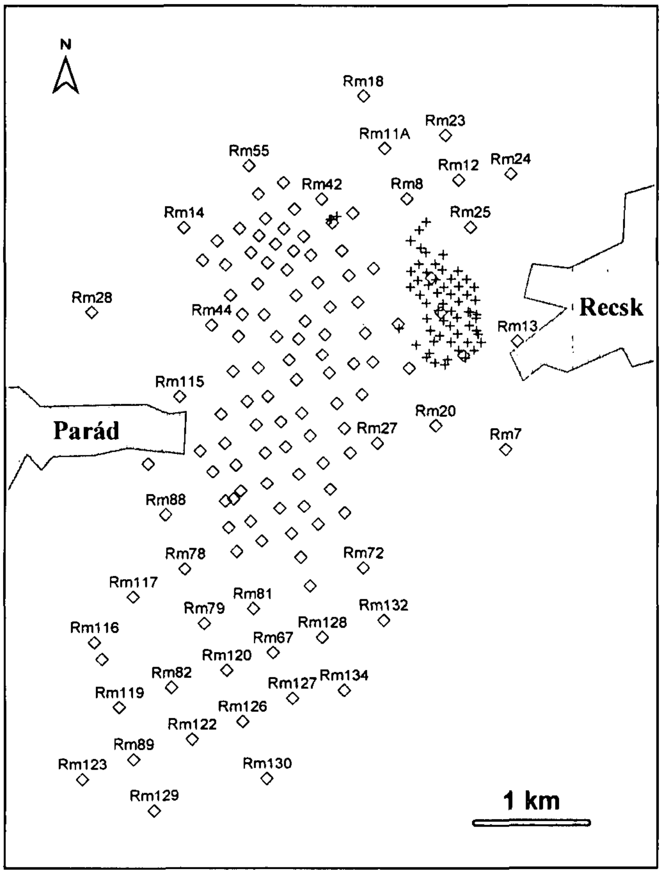

Fig. 3. Map of boreholes used in this study. Diamonds denote deep (1000-1365 m) boreholes, 124 in total, exploring Recsk Deep. For some of them their names are given (e.g. Rm18). Crosses denote shallower (17-400 m) boreholes, 70 in total, exploring Lahóca. Compare with Fig. 5.

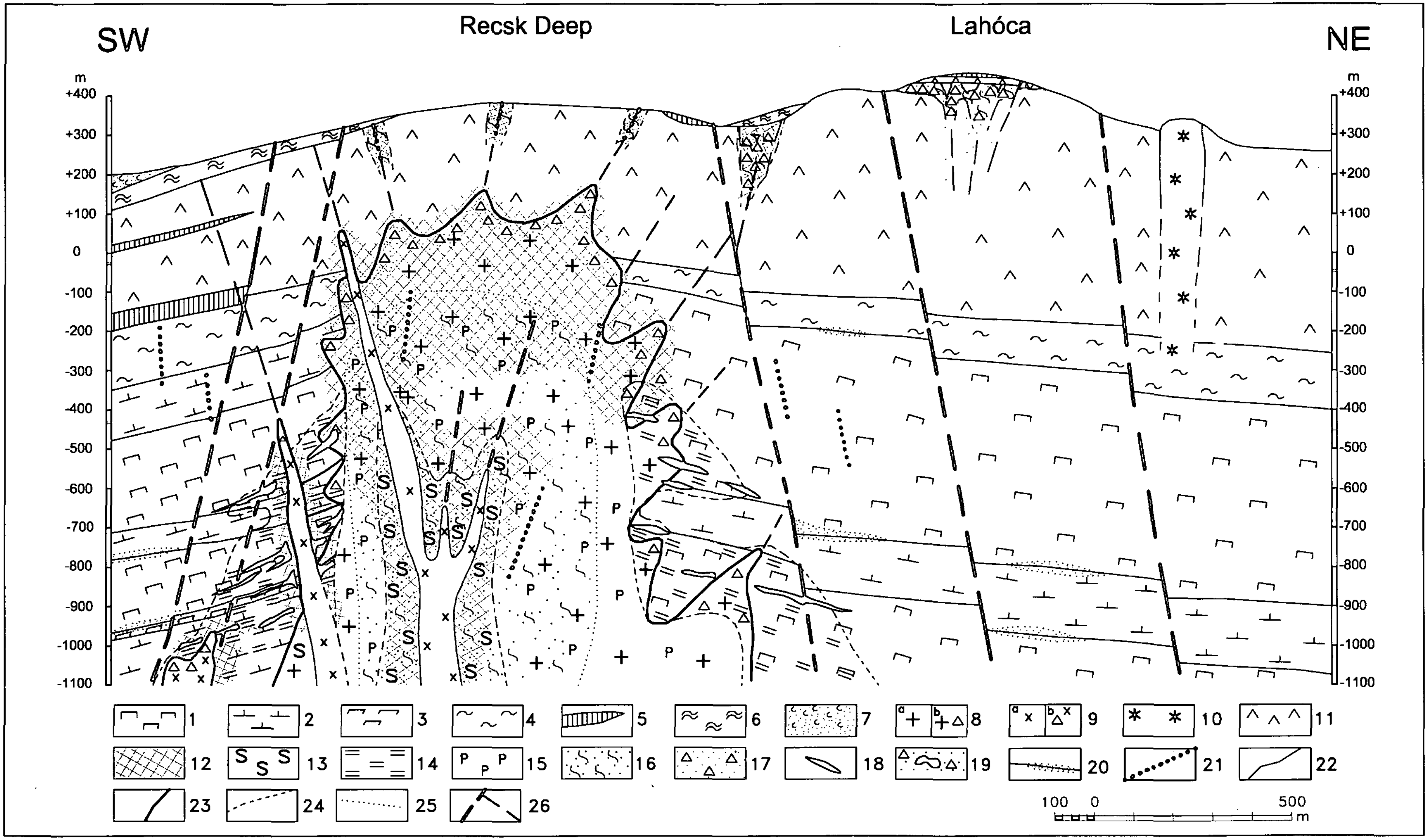

Fig. 2. Schematic geologic section of the Recsk Ore Field (after Zelenka and Szebényi, 2002). 1-limestone (Triassic), 2-quartzite (Triassic), 3-dolomite (Triassic), 4-shale (Triassic), 5-bituminous clay marl, marl, marly limestone, limestone, sandstone, nummulitic limestone (Upper-Eocene), 6-clay marl, sandstone (Oligocene), 7-delivium, alluvium (Quarter), 8a-diorite porphyry (Upper-Eocene–Lower Oligocene), 8b-peripheral breccia of diorite porphyry (Upper Eocene–Lower Oligocene), 9a-quartz-diorite porphyry (Upper-Eocene–Lower Oligocene), 9b-peripheral breccia of quartz-diorite porphyry (Upper-Eocene–Lower Oligocene), 10-post-ore dikes and laccoliths (Upper-Eocene–Lower Oligocene), 11-stratovolcanic andesite and other effusives (Upper-Eocene–Lower Oligocene), 12-quartz-argillic alteration, 13-endoskarn, 14-exoskarn, 15-propylitic alteration, 16-impregnation Cu-Mo or Cu-(Mo) ore (stockwork), 17-brecciated-impregnation Cu-Mo or Cu-(Mo) ore (stockwork), 18-massive-sulphide Cu-Fe or Zn-Fe-Cu-(Pb) ore bodies, 19-impregnation and massive Cu-Au-Ag-As-(Pb-Zn) ore in silicified volcanic breccia, 20-hydrothermal-metasomatic polymetallic (Pb-Zn-Fe) ore, 21-vein-type Pb-Zn-(Fe)-Cu ore, 22-geologic boundaries between main rock types, 23-intrusive boundary, 24-boundaries of alteration zones (fronts), 25-subordinate boundaries of alteration zones, 26-tectonic lines.

DATA SELECTION AND PREPARATION

It is obvious that for geologic objects of similar complexity descriptions may be provided at a great number of both hierarchical and non-hierarchical levels of homogeneity, from the entire ore field down to rock bodies, ore mineral occurrences, etc. In the given study statistical distributions of elements in three sets of units reflecting three different aspects of the geologic object are described: 1) geologically separable parts of the deposit-complex (hereafter deposit-parts), 2) stratigraphically-petrographically meaningful rock-formations, and 3) geologically-economically interesting depth-zones.

In order to reach a coherent characterization of the distributions, the largest possible but consistent subset of the available data is selected. First of all, this means selection of those boreholes from which methodologically and geometrically comparable samples were taken, and in which levels of knowledge about the geological objects and phenomena are similar. Fig. 3 displays the position of the selected boreholes.

From these boreholes, altogether approx. 70,000 analyzed rock/ore samples are available. These are more or less regularly taken and handled, half-core samples. Among them there are close to 11,000 that have a recorded length of 20 cm, otherwise the majority of samples have a length of 1 meter. Every 5 adjacent samples with a 20 cm length were merged, thus yielding more than 1800 'new' 1 meter long samples. As a result, close to 62,000 samples (still not all having the same lengths, see below) were entered into the work database.

Fig. 4 shows the frequency distribution of sample-length in this database. There are 3 sample-length values (1 m, 5 m, and 10 m) that have very high frequencies (51682, 2140, and 2303, respectively), but a wide range of values occurs. From the long-time experience of exploration geologists it is known that mixing of samples with different geometry may bias the results of a statistical analysis, therefore below only the 1 m samples are used.

REPRESENTATION OF THE STATISTICAL DISTRIBUTIONS

In most of the units gained by divisions of the given huge dataset from three different aspects (see above)

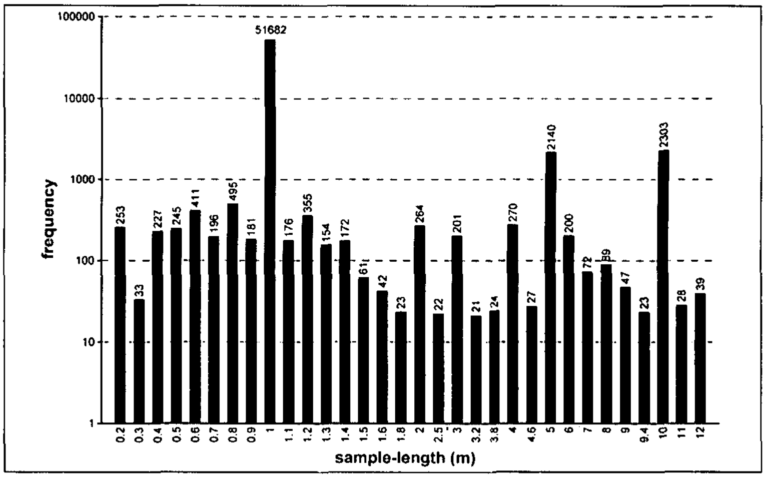

Fig. 4. Frequency distribution of sample-length in the analyzed data set. Only sample-length values with a frequency more than 20 are shown.

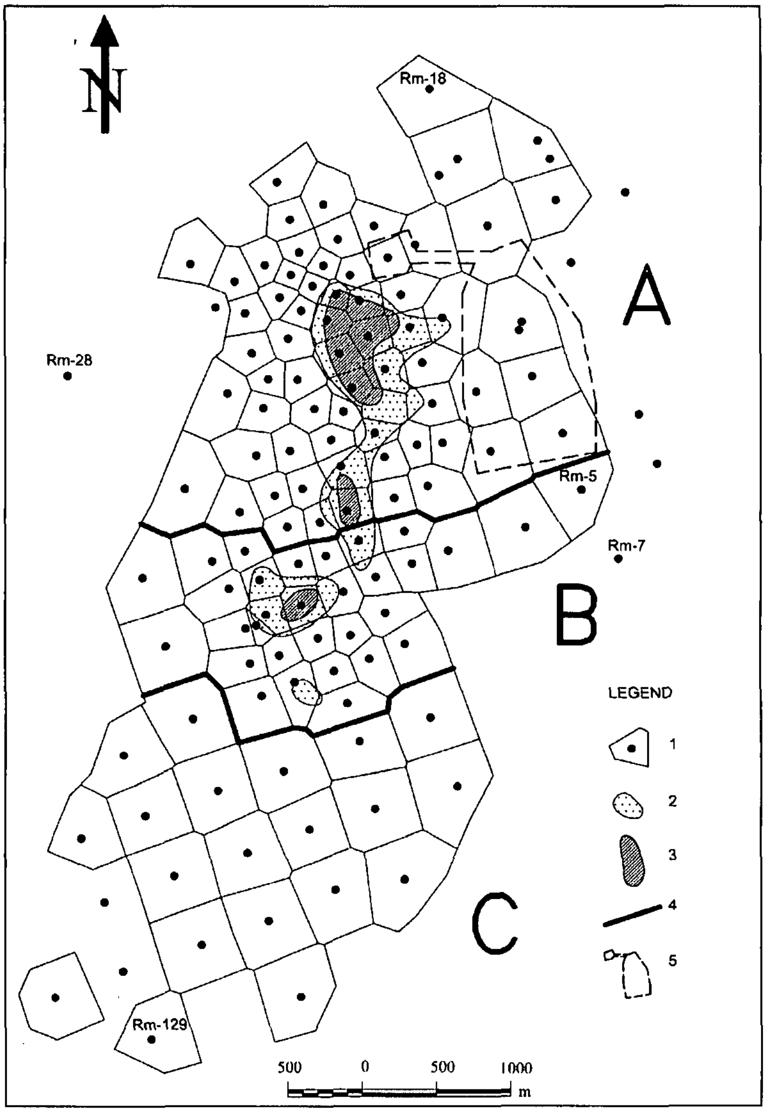

Fig. 5. Map showing the main deposit-parts of the Recsk Ore Field. 1- deep exploration borehole (compare with Figure 3) surrounded by ore reserve estimation polygon, 2-area where the total intersected thickness of porphyry body/bodies exceeds 300 m, 3-area where the total intersected thickness of porphyry body/bodies exceeds 500 m, 4-boundary between the main parts, A, B and C, of Recsk Deep, 5-mining plot of Lahóca. For more explanation see text.

measured values are available for nine chemical elements (Ag, Cu, Mo, Pb, Se, Zn, Fe, S, and Au), which means a great number of distributions are to be analyzed. The distributions are also expected to be compared across the units (within each of the three division schemes). All this requires a simple and efficient representation. From the numerous possible solutions proposed by statistics (e.g. Henley 1981, Marsal 1987, Rock 1988, SPSS 1998a, 1998b) using suitably chosen percentiles seem to be adequate and profitable (for another application of percentiles in geochemistry see Ó.Kovács and Kovács, 2002).

When talking about distribution, in most cases common values are considered those falling somewhere towards the central part of the whole range of values. This is true even when the distribution is asymmetric, multimodal, or unimodal but a result of superimposed processes, etc., which often occurs in a complex ore deposit. Extreme values are those falling towards the (higher) end of the occupied range. Hence, at the given basic level of description, we essentially need a definition of two sub-ranges for each distribution. In an ore exploration context the boundary between these sub-ranges is often called 'anomaly threshold', and there are a lot of methods suggested for its calculation, both parametric and non-parametric. A definition of anomaly should always be target-dependent, and is often conditional and subjective. We keep using the less formalized, intuitive terms 'common' and 'extreme', and separate them at a simple but robust, non-parametric statistics: at the 90th percentile. It should be emphasized that in the given study this definition is not crucial, it could also be the 95th, or the 99th, or probably even the 75th percentile, because we just need to produce sets of comparable representations of frequency distributions, from which plausible sub-ranges of common, and extreme values are immediately seen.

The chosen representation is introduced in Fig. 6 and Fig. 7 (geochemically evaluated in the next section). In Fig. 6, displaying the common values, each thin bar extends from the 10th to the 90th percentile, i.e. the inner 80% of the valid measured values fall into this sub-range. Thick bars portray interquartile ranges (extending from the 25th to the 75th percentiles), i.e. the 'central' 50% of the valid measured values fall into these sub-ranges. Knots on the bars represent the medians (that is the 50th percentiles). In Fig. 7, displaying the extreme values, each thick bar extends from the 90th percentile to the measured maximum, representing the sub-range of the highest values making 10% in number. Horizontal ticks on the bars represent the 95th percentiles, marking the boundary of the upper 5% of the values. N stands for the number of measurements in each particular case. Values above upper detection limits are omitted, luckily there are only a few of them in the whole dataset. Below-detection-limit values are represented by zeros. Sometimes a great proportion of values are such zeros; there, the picture of common values shrinks to that of the median (e.g. Se in Deep-C). Similarly, the range of extreme values may be very limited, e.g. Au in Deep-C. Obviously, these cases are less informative, still they provide a part of the characterization.

Even when a distribution is perceptibly displayed, e.g. any of the Fe distributions in Fig. 6 and Fig. 7, particular values characteristic of the given distribution are usually needed to comprehend it. When the picture is uncertain, e.g. that of Se in Fig. 6, discrete numbers are indispensable. Therefore, for all represented distributions characteristic values are also given. It is obvious, that a distribution comprising a (possibly large) set of values can only be represented with a few numbers at a price of significant simplification, made always from a deliberately, or inherently, chosen aspect. In order to be treatable, the number of characteristic values should also be limited. It has been found that the triplet (see Table 1, evaluated later) of the 25th percentile, the median, and the 75th percentile is very handy, especially when regarded together with the corresponding graphs. Values below detection limits, here too, are replaced by zeros. Hence, if the 25th percentile is zero (S in Deep-B), or the median is also zero (Pb in Deep-C), or the 75th percentile is also zero (Au in Deep-C), we immediately know that at least 25%, or 50%, or 75%, respectively, of the values were below detection limit. In similar cases, further statistics may be greatly influenced by these conditions. Otherwise, median is usually a powerful estimation of the central tendency, while the other two percentiles used mark a range of presumably the most frequent and ordinary, and, hence, characteristic values of the given set.

Table 1. Common values within deposit-parts

	Ag	Cu	Mo	Pb	Se	Zn	Fe	S	Au
	ppm	%	%	%	%	%	%	%	ppm
	0	0.03	0.001	0	0	0	2.7	5.9	0
Deep-A	1.2	0.08	0.005	0	0	0.01	4.0	11.6	0
	2.9	0.23	0.012	0	0	0.13	5.9	19.6	0.1
	0	0.01	0	0	0	0	2.4	0	0
Deep-B	2.1	0.03	0.004	0	0	0.01	3.4	1.3	0
	7.4	0.09	0.008	0	0	0.05	4.8	3.9	0.1
	3.3	0.01	0	0	0	0	2.0		0
Deep-C	10.5	0.03	0.001	0	0	0.02	3.2		0
	21.2	0.08	0.008	0.09	0	0.24	4.2		0
	0	0.005							0.016
Lahóca	0	0.009							0.139
	3.0	0.023							0.460
	0	0.01	0	0	0	0	2.6	5.7	0
ALL	1.0	0.05	0.005	0	0	0.01	3.7	10.7	0.09
	3.1	0.14	0.010	0.01	0	0.11	5.4	19.5	0.30

Each triplet represents the 25th percentile, the median, and the 75th percentile.
ALL stands for the entire deposit.

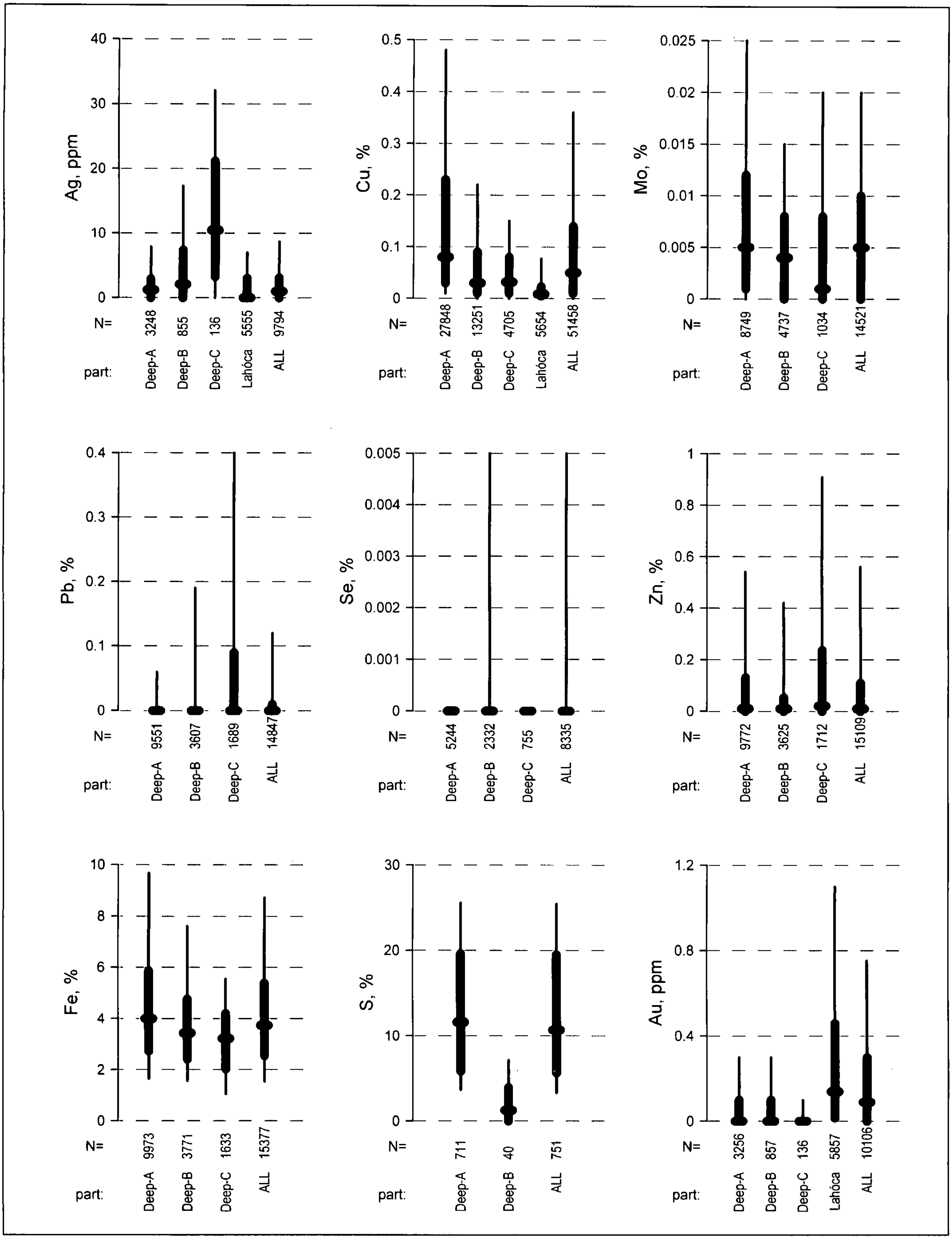

Fig. 6. Common values of ore components within deposit-parts. Thin bars extend from the 10th to the 90th percentiles. Thick bars represent interquartile ranges. Knots on the bars represent the medians. N denotes the number of valid values. ALL stands for the entire deposit.

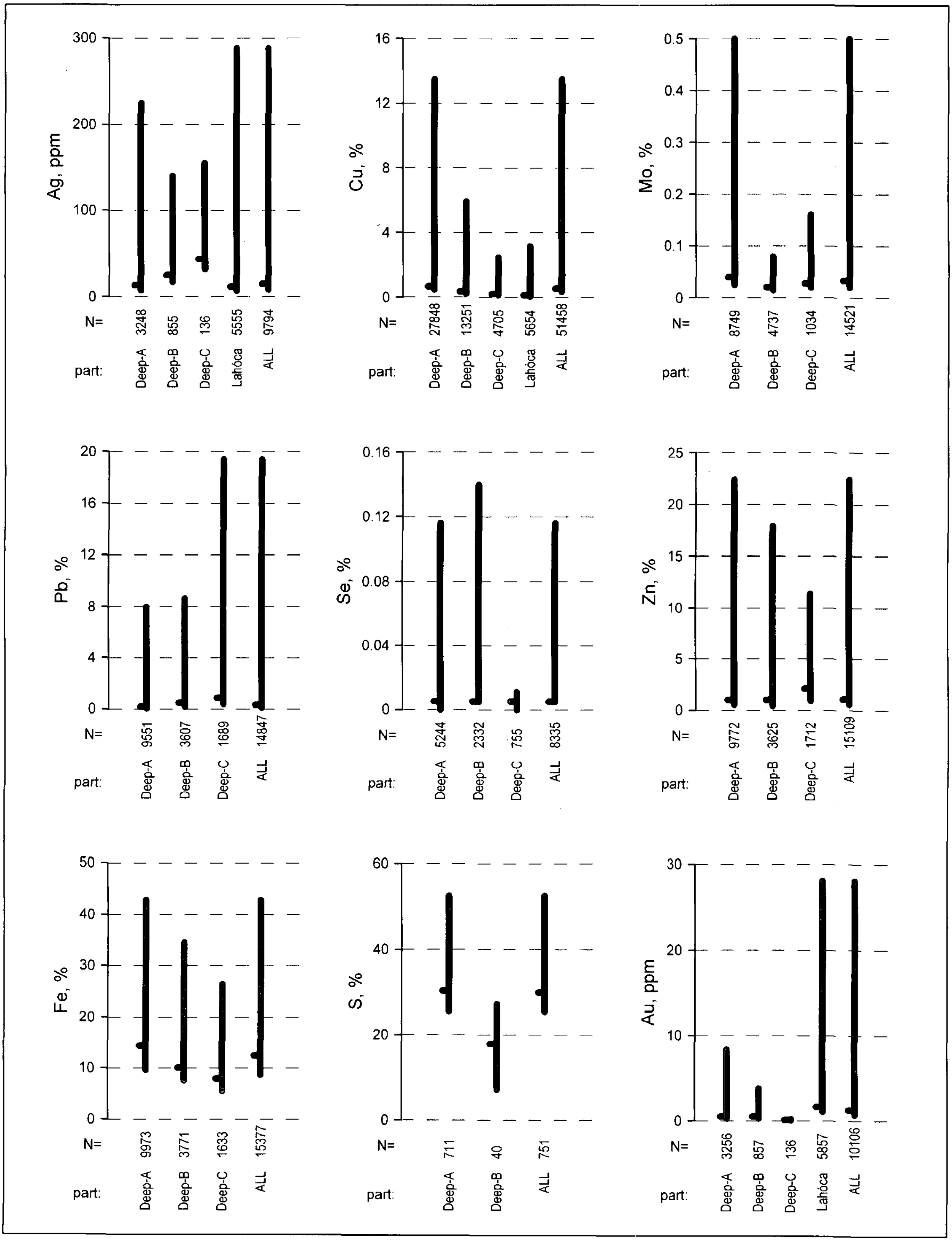

Fig. 7. Extreme values of ore components within deposit-parts. Thick bars extend from the 90th percentiles to the measured maxima. Horizontal ticks on the bars represent the 95th percentiles. N denotes the number of valid values. ALL stands for the entire deposit.

Table 2. Rock-formations examined in this study

Symbol	Age	Description / Traditional name	Thickness
O	Oligocene	claystone, marl	250-430 m
a1	Late Eocene – Early Oligocene	upper member of the stratovolcanic series (with that in Lahóca)	0-100 m
a1q	Late Eocene – Early Oligocene	middle member of the stratovolcanic series	120-250 m
a2	Late Eocene – Early Oligocene	lower member of the stratovolcanic series	50-200 m
a3	Late Eocene – Early Oligocene	intrusive complex, altered, partly with ore mineralization	0-863 m, mean: 400 m
ERC	Late Eocene – Early Oligocene	rock essentially composed of sulphide ore (mainly pyrite)	0-28 m
Sk	Late Eocene – Early Oligocene	skarn	0-162 m
Ap1/Kv1	Mesozoic	'upper shale'/'upper quartzite' group	120-600 m, mean: 180 m
Mk1	Mesozoic	'upper limestone' group	120-557 m, mean: 236 m
Kv2	Mesozoic	'middle quartzite' group	40-260 m, mean: 103 m
Mk2	Mesozoic	'lower limestone' group	100-290 m, mean: 122 m
Ap2/Kv3	Mesozoic	'lower shale'/'lower quartzite' group	0-78 m, mean: 49 m
üa	uncertain	fresh, cutting intrusive rocks (dyke, laccolith)	0-80 m

As pointed out by Földessy et al. (2004), among the Au determinations from Recsk Deep there are seriously biased assay series. Since in these cases the actual concentrations of Au are systematically underestimated, i.e. the nature of the bias is known, the related statistical observations may still be of use, provided this uncertainty is kept in mind.

DISTRIBUTIONS WITHIN DEPOSIT-PARTS

Along with the history of mining and exploration in the area, mainly thanks to increasing the density of the surface drilling network and to an extensive underground exploration (Szebényi 2000), structural model of the deposit has significantly developed in the sense that it has become more and more detailed and accurate. The applied here subdividing of the complex into deposit-parts (Fig. 5) is based on 1) the total known thickness of intrusive formations (Cseh Németh et al. 1984), 2) spatial distribution of ore mineralizations in Recsk Deep (Cseh Németh 1975), and 3) the map of copper ore reserve estimation from surface boreholes (Cseh Németh et al. 1984, Cseh Németh 1988), and partly explained also in Gagyi Pálffy Sr. et al. (1971) and Baksa et al. (1988).

Deposit-part Deep-A has the largest mass of intrusive rock and connected porphyry copper. Also significant is the amount of skarn copper and zinc ore. In Deep-B the known total thickness of intrusive rocks is smaller, the proportion of skarn ores is higher relative to porphyry copper, and in the composition of skarn ores polymetallic ores are more important than in Deep-A. Deep-A and Deep-B together make the Recsk Deep copper-ore deposit. Deep-C, called also Recsk-South, or the Recsk Deep polymetallic ore deposit, only contains polymetallic ores with subordinate and low-value copper, and has a limited amount of intrusives. Within the Recsk Ore Field, Recsk Deep may be defined as a domain below the depth of 500 m with the joint area of Deep-A, Deep-B and Deep-C. A distinct, near-surface mineralization with enargite, luzonite and Au-pyrite, treated as the fourth part, is Lahóca, developed at the eastern edge of Deep-A. Below, these parts are compared in terms of statistical distributions of ore components.

Regarding the common values (Fig. 6, Table 1), some of the components reveal significant dissimilarities among the deposit-parts. For example, Lahóca is the richest in Au, and the poorest in Cu. Deep-A has significantly higher S values than Deep-B. In Deep-C, bulk of the Ag values are higher than elsewhere, whereas Au is very low. On the other hand, regarding the Mo, the Zn, and the Fe contents, the three parts of Deep are not very different.

The extreme values (Fig. 7) may reflect similar relationships, as in the case of Cu, Pb, S, Au, and especially Fe, the most 'regular' component, in terms of consistency of its plots. For other elements, these values do not repeat the picture of the common values, e.g. for Zn. It should be stressed that extreme values are not necessarily expected to plot similarly to the common values, as they are often extreme just because they do not belong to the same natural population of values. Hence, their plots may be better for displaying their sub-ranges than reflecting the general relative levels of the components.

DISTRIBUTIONS WITHIN ROCK-FORMATIONS

As this ore field extends to a large geologic space with a number of structural and stratigraphic elements, a characterization of distributions within the main rock-formations (Table 2) should not be omitted. Within the research project supporting also the given paper the main geologic formations defined are obviously based on previously described and accepted, by local geologists, models (e.g. Baksa et al. 1980, Földessy 1975, Földessy-Járányi 1975, Komlóssy et al. 2000). Therefore, the symbols figuring here are similar to those used in earlier studies.

Generally speaking, the common values of the analyzed ore components (Fig. 8 and Table 3) reveal a limited specialty for most of the formations. In other words, the statistical distributions are not drastically different from one formation to another. Exceptions, at least in terms of a few components, may be ERC (high Fe and Cu), a1 (high Se and Au, low Zn), and a1q (high Ag, Pb, Se and Au). The Oligocene clayey marls (O) are very poor in Ag, Cu and Au, expectedly.

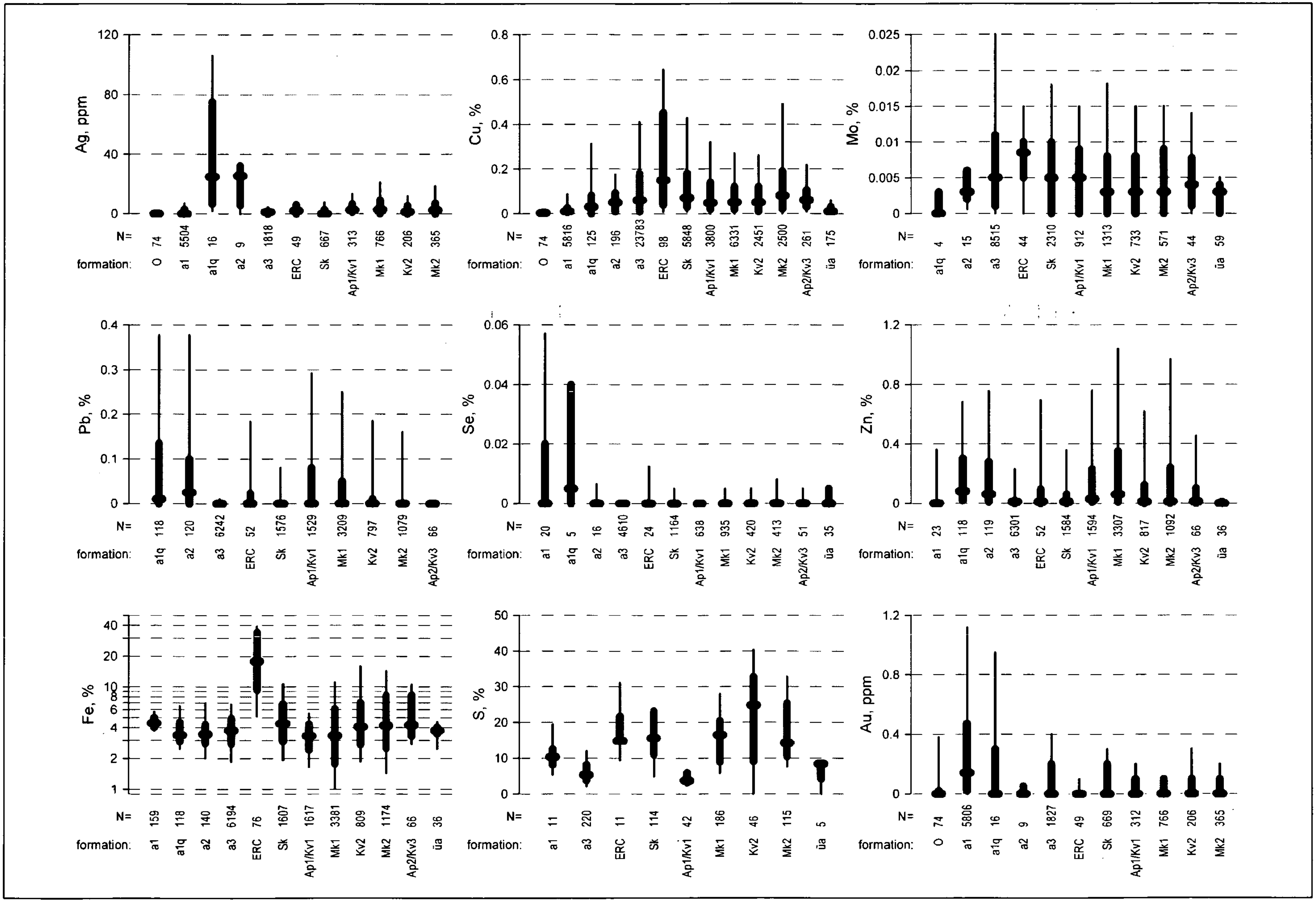

Fig. 8. Common values of ore components within rock-formations. Thin bars extend from the 10th to the 90th percentiles. Thick bars represent interquartile ranges. Knots on the bars represent the medians. N stands for the number of valid values.

Comparing the extreme values (Fig. 9) with the common ones (Fig. 8) demonstrates, in a way, a strength of the given representation of distributions, namely, an ability to reveal possible significant differences in the relative magnitude of values. For example, a1 has the highest extremes in Ag, whereas its common values are low. Or, although Ap1/Kv1 has a few (9, actually) high Se values, the bulk of the analyses yielded a value below detection limit. Similarly, a large part of the Cu values in ERC are high, the highest values in the dataset, however, belong to other formations (Mk2, Mk1 and a1). On the other hand, there are cases when the extreme values suggest the same conclusion, e.g. Zn exhibits similar sets of ranges, regarding both the extreme and the common subsets. Or, in both subsets it is probably S the most variable across the formations (which, otherwise, may partly be due to the low number of analyses).

DISTRIBUTIONS WITHIN DEPTH-ZONES

No matter how important tectonic processes have taken place since the Paleogene in the surrounding areas, the structure of the deposit in terms of position of rock bodies has not been changed significantly. Hence, vertical zoning detectable in the main characteristics of statistical distributions is expected to hint on some basic features of the ore-forming process. This expectation may also be justified by the fact that considering only the main ore minerals, the following very rough vertical distribution can be outlined: down to the depth of +100m a.s.l. association of (epithermal) enargite-luzonite-pyrite-Au; between -300m and -900m (porphyry-related, mesothermal) chalcopyrite-molybdenite(sphalerite)-pyrite; between -500m and -1100m (skarn-metasomatic, mesothermal) chalcopyrite-sphalerite-pyrite; and in several depth intervals, importantly close to the surface and at +100m, (mesothermal) galena-sphalerite-gray copper-pyrite. This is a very generalized picture but can be derived from the related studies, e.g. Gagyi Pálffy Sr. et al. (1971) and Gatter et al. (1999). In the present work, vertical intervals with a thickness of 200 m were chosen, and distribution plots produced for each.

Table 3. Common values within rock-formations.

	Ag ppm	Cu %	Mo %	Pb %	Se %	Zn %	Fe %	S %	Au ppm
O	0	0.0024							0
	0	0.0027							0
	0	0.0037							0.021
a1	0	0.005			0	0	4.0	8.2	0.02
	0	0.009			0	0	4.4	10.3	0.14
	3.0	0.026			0.02	0	5.0	12.5	0.47
a1q	6.8	0	0	0	0	0.02	2.9		0
	24.9	0.03	0	0.010	0.005	0.08	3.4		0
	75.2	0.08	0.003	0.135	0.040	0.30	4.5		0.3
a2	5.9	0.01	0.002	0	0	0.01	2.8		0
	25.6	0.05	0.003	0.025	0	0.06	3.4		0
	32.1	0.09	0.006	0.100	0	0.28	4.3		0.05
a3	0	0.01	0.001	0	0	0	2.8	3.8	0
	1.2	0.06	0.005	0	0	0.01	3.8	5.3	0
	2.1	0.18	0.011	0	0	0.02	4.9	8.2	0.2
ERC	0	0.04	0.005	0	0	0	9.4	14.8	0
	2.1	0.15	0.009	0	0	0.010	17.8	14.8	0
	6.0	0.45	0.010	0.023	0	0.095	34.0	21.7	0
Sk	0	0.03	0	0	0	0	3.0	11.1	0
	0	0.07	0.005	0	0	0.01	4.4	15.6	0
	2.8	0.18	0.010	0	0	0.06	6.8	23.2	0.2
Ap1/Kv1	1.1	0.02	0	0	0	0.01	2.4	3.2	0
	2.5	0.05	0.005	0	0	0.03	3.3	3.7	0
	6.5	0.14	0.009	0.08	0	0.23	4.3	5.9	0.1
Mk1	0	0.02	0	0	0	0.01	1.8	8.9	0
	2.7	0.05	0.003	0	0	0.06	3.3	16.5	0
	9.0	0.12	0.008	0.05	0	0.35	6.1	20.4	0.1
Kv2	0	0.01	0	0	0	0	2.7	9.1	0
	1.2	0.05	0.003	0	0	0.01	4.1	24.8	0
	5.4	0.12	0.008	0.01	0	0.12	7.0	32.7	0.1
Mk2	0	0.02	0	0	0	0	2.5	10.5	0
	2.5	0.08	0.003	0	0	0.01	4.2	14.3	0
	7.2	0.19	0.009	0	0	0.24	8.2	25.4	0.1
Ap2/Kv3		0.03	0.001	0	0	0	3.3		
		0.06	0.004	0	0	0.01	4.2		
		0.11	0.008	0	0	0.1	8.3		
üa		0.01	0		0	0	3.5	4.2	
		0.01	0.003		0	0	3.8	8.5	
		0.03	0.004		0.005	0.01	4.0	8.5	

Each triplet represents the 25th percentile, the median, and the 75th percentile.

And indeed, all charts of distributions of the common values (Fig. 10), together with the tabulated data (Table 4), reveal some kind of vertical zoning. Ag, Pb, and Zn show a general decrease towards the depth. Mo exhibits an opposite tendency, and Fe, too, except for the uppermost zone where it also has slightly elevated values. Although with some differences in the relative magnitudes, Cu, S, and Au show a nice wavy change: first decrease, then grow, and, at the end—in the deepest zones—decrease again. The detection limit for Se was obviously too low, it has a few elevated common values however in the uppermost zone.

Just as with the deposit-parts and rock-formations, here too, the extreme values (Fig. 11) do not unequivocally correlate with the common values. Behavior of the two sets of distribution ranges is identical in the case of S, similar, maybe with some disturbances, at Ag, Cu, Mo and Au, notably different at Se, and Fe, and essentially opposite at Pb and Zn. One might pick up zones where the range of extreme

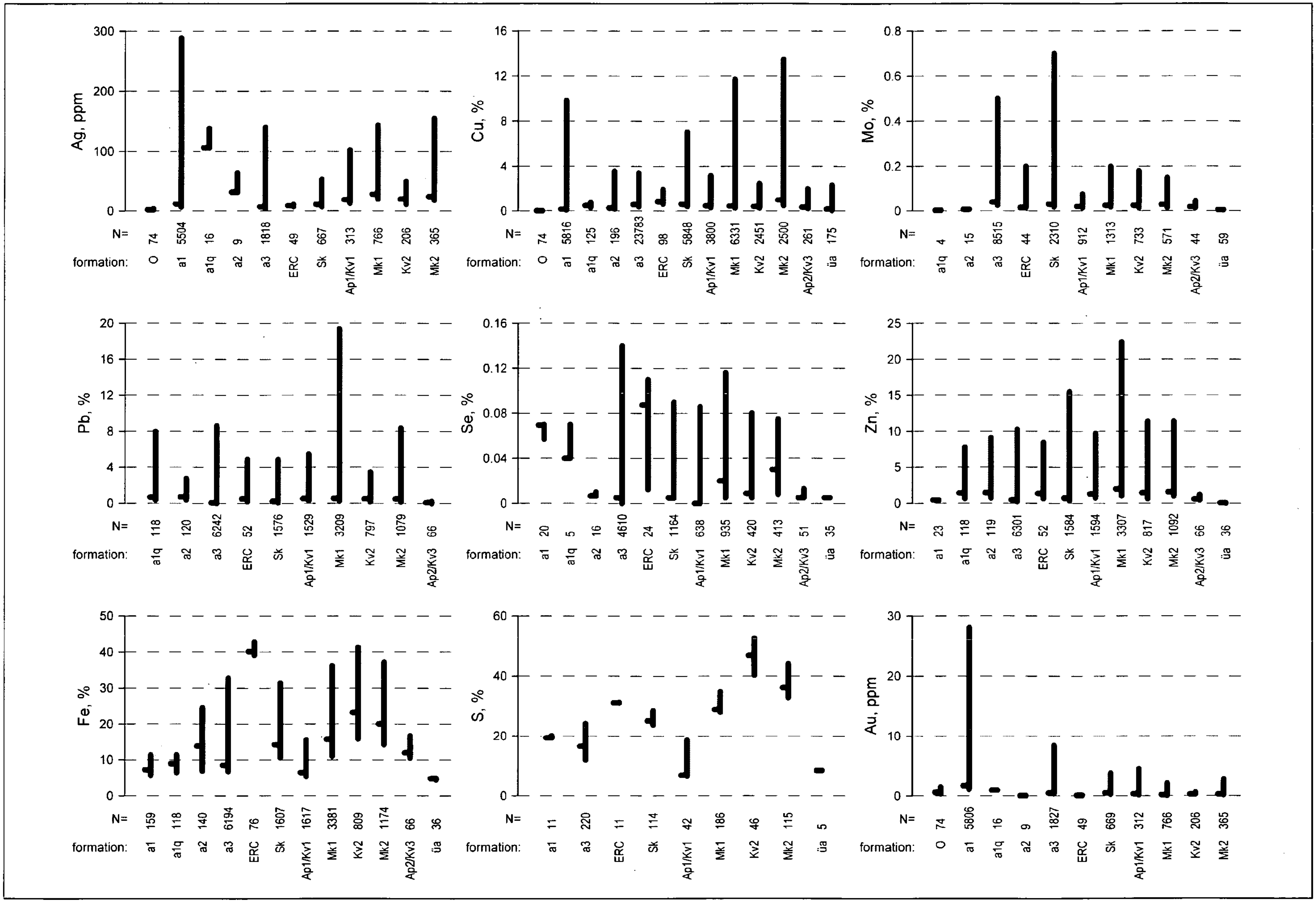

Fig. 9. Extreme values of ore components within rock-formations. Thick bars extend from the 90th percentiles to the measured maxima. Horizontal ticks on the bars represent the 95th percentiles. N stands for the number of valid values.

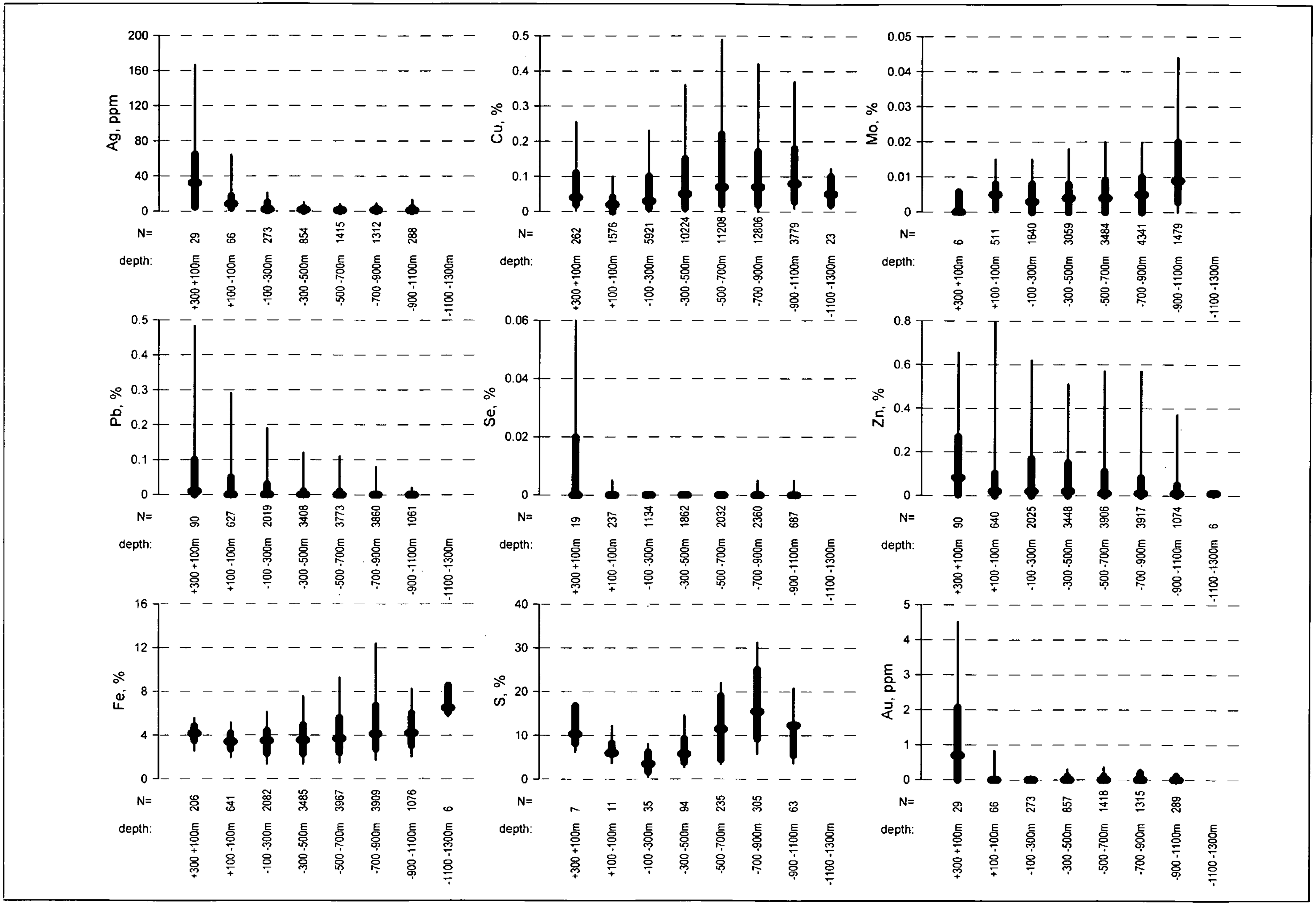

Fig. 10. Common values of ore components within depth-zones. Thin bars extend from the 10th to the 90th percentiles. Thick bars represent interquartile ranges. Knots on the bars represent the medians. N stands for the number of valid values.

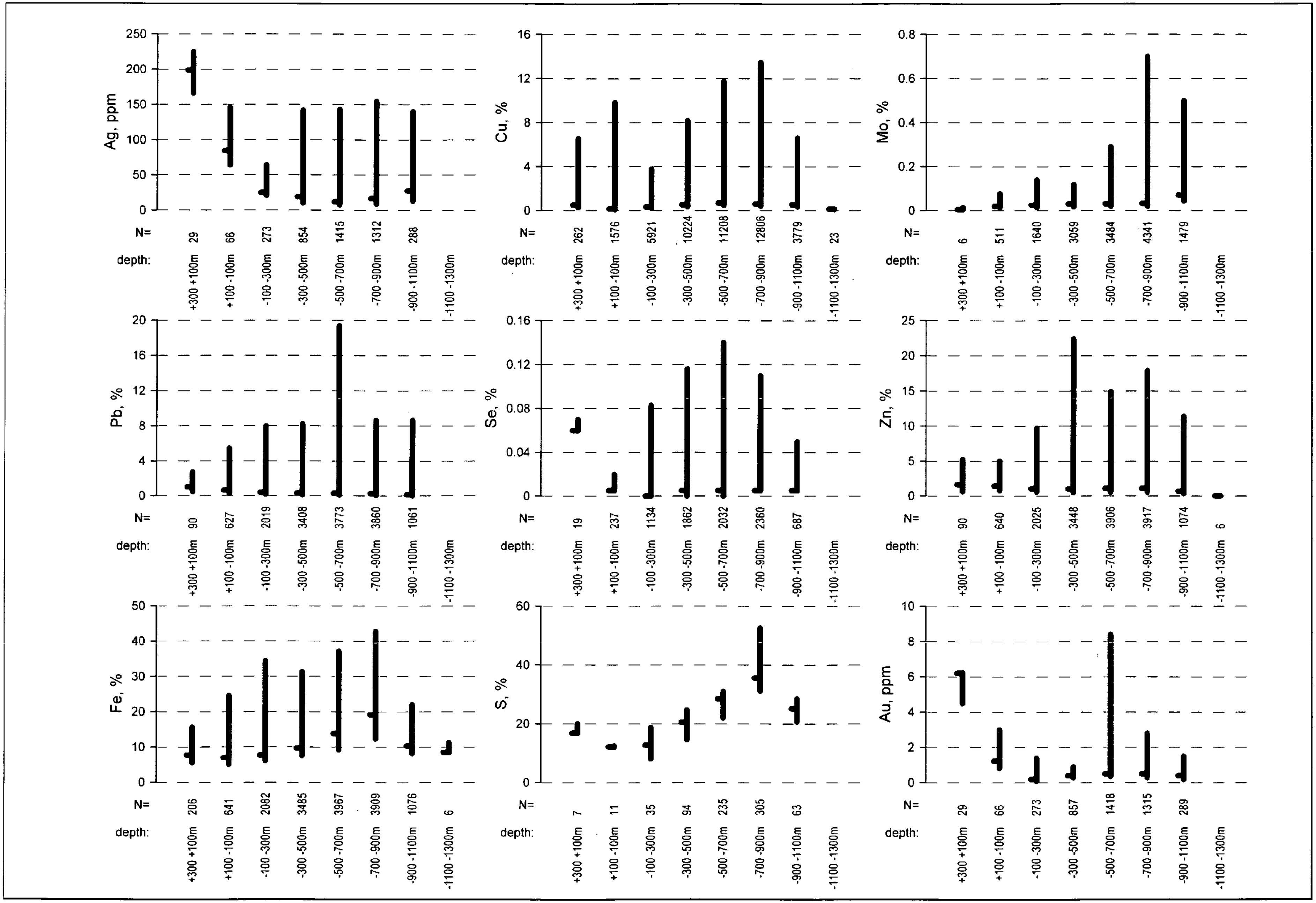

Fig. 11. Extreme values of ore components within depth-zones. Thick bars extend from the 90th percentiles to the measured maxima. Horizontal ticks on the bars represent the 95th percentiles. N stands for the number of valid values.

values in one or two components has a spectacularly high upper limit. Clear examples are Zone "+300 +100m" regarding Ag, and Zone "-500 -700m" with Pb and Au. Taking into consideration the relatively large number of data, the above quantitative features surely have a certain economic relevance.

DISCUSSION

We never feel the number of data is optimal. Because, especially when dealing with mineral deposits, if the amount of numerical data is very low, the conclusions seem to contain too much interpretation; if there are a lot of quantitative data, nothings seems 100% true as we always have contradicting values. Statistics obviously helps, although if we are honest, the way we use statistics is always charged with some subjectivity. Nevertheless, the need for conclusions requires a purposeful evaluation. Below, a few points are discussed, helping to more appropriately treat the observations presented in the given study.

In Fig. 6 distributions are given also for the entire deposit ('ALL'). Although numerically its plots are correct, their mainly descriptive character should be emphasized, be-cause they merge otherwise separable populations. For example, Cu is very different in Deep-A and in Lahóca which is masked in ALL. In addition, significant differences in the size of subsets may cause a 'loss' of one of them when combined, as with S. Nonetheless, if someone is interested in the most common values of ore components in the ore field, these charts together with Table 1 may be used.

Understandably, the set of distributions of the common values within the formations (Fig. 8) and that within the depth-zones (Fig. 10) show visually perceptible elements of correlation. Ag, Se and Au have elevated common values in units located in higher spatial position. Cu is characterized with slightly elevated common values in units representing intermediate depths of the sampled space domain. While there is consi-derable overlapping in the distributions across the units for most components, S tends to reveal somewhat more specialized units in this sense.

Table 4. Common values within depth-zones

	Ag ppm	Cu %	Mo %	Pb %	Se %	Zn %	Fe %	S %	Au ppm
+300 +100m	4.9	0.02	0	0	0	0.004	3.5	8.2	0
	32.1	0.04	0	0.01	0	0.082	4.2	10.3	0.7
	64.7	0.11	0.006	0.10	0.02	0.270	4.8	16.8	2.1
+100 −100m	3.7	0	0.001	0	0	0	2.8	5.8	0
	8.2	0.02	0.005	0	0	0.02	3.4	6.0	0
	17.3	0.04	0.008	0.05	0	0.10	4.2	8.2	0
−100 −300m	0.3	0.01	0	0	0	0	2.3	1.7	0
	2.0	0.03	0.003	0	0	0.02	3.5	3.6	0
	9.9	0.10	0.008	0.03	0	0.17	4.4	6.2	0
−300 −500m	0	0.01	0	0	0	0	2.3	3.9	0
	1.6	0.05	0.004	0	0	0.02	3.6	5.8	0
	3.6	0.15	0.008	0.01	0	0.15	4.9	9.2	0.1
−500 −700m	0	0.02	0	0	0	0	2.4	4.6	0
	1.1	0.07	0.004	0	0	0.01	3.7	11.5	0
	2.9	0.22	0.009	0.01	0	0.11	5.6	19.0	0.1
−700 −900m	0	0.02	0	0	0	0	2.8	9.4	0
	1.4	0.07	0.005	0	0	0.01	4.1	15.5	0
	4.0	0.17	0.010	0	0	0.08	6.7	25.0	0.2
−900 −1100m	0	0.03	0.003	0	0	0	3.1	5.6	0
	1.2	0.08	0.009	0	0	0.01	4.2	12.4	0
	4.1	0.18	0.020	0	0	0.05	6.0	12.5	0.1
−1100 −1300m		0.02				0.008	6.1		
		0.05				0.010	6.5		
		0.10				0.010	8.5		

Each triplet represents the 25th percentile, the median, and the 75th percentile.

Concerning all the given distributions, in principle, when the common values and extreme values represent two distinct populations, a limit between them could easily be defined. This may be a rare case anyway, but at the given basic level of description it is not necessary. However, the goodness of the chosen separation (at the 90^{th} percentile) may indirectly be confirmed considering the fact that the relative behavior of the common and extreme values is realistic: in cases similar, in other cases different, or even reverse, corresponding to the properties and relative importance of the ore-forming processes. In such a complex geologic object this is what may intuitively be expected.

This huge dataset may (and hopefully will) be a basis of more sophisticated statistical analyses. Here, the representation and evaluation of the data are deliberately kept as unfussy as possible, because these basic descriptive statistics, calculated for the given data for the first time, are meant also for comparisons with analogous deposits.

The investigated subdividing schemes may seem formalized or generalized (and the others analyzed in the project but not presented here, too). Indeed, from the point of view of ore mineralizations, for example, the cleverest subdivision would be that one where each type of the occurring ore mineralizations is individually represented. And as was indicated, there are quite a number of different types present, in cases with a distinct structural character (strata-bound, depth-controlled, cutting, etc.). The problem is, in this particular case, that the analyzed rock/ore samples were not (and could not be) regularly classified in a corresponding way during the exploration. And this is true more generally as well: we can only deal with subdivisions for which the pertinent information is registered in, or can be generated from, the database, or at least the technical documentation.

At the end, we have to remember again, that this is statistics, i.e. it may mask many details, be too general from certain points of view, nevertheless, the features it reveals are numerically established observations.

CONCLUSIONS

Appropriately selected sets of percentiles, either shown on a purposeful graph, or suitably tabulated, serve as a concise and informative representation of statistical frequency distributions of diverse—in cases very large—amounts of values. Graphs made separately for the common, and for the extreme values are effective even in the case of complex distributions. The relative levels of the common, and those of the extreme values within a particular set of the analyzed units (deposit-parts, rock-formations, or depth-zones) may, or may not correlate. The latter case may obviously occur when the two types of values do not belong to the same natural population.

Comparing the deposit-parts, Ag, Cu, Pb, S and Au expose major differences among them—mainly in terms of the common values. Regarding Mo, Zn, and Fe, the three parts of Recsk Deep are not very different. The richest in Au is Lahóca (with common values between 0.02 and 0.46 ppm, and extremes close to 30 ppm), whilst in Cu it is Deep-A (common values between 0.03-0.23%, extremes over 10%).

For most of the rock-formations, distributions of the common values of the analyzed ore components are not peculiar relative to each other. Exceptions are: sulphide ore ('ERC') with high Fe (9.4-34.0%) and Cu (0.04-0.45%); upper member of the Paleogene stratovolcanic series ('a1') with high Se (up to 0.02%) and Au (0.02-0.47 ppm), and low Zn (virtually nil); and middle member of the stratovolcanic series ('a1q') with high Ag (6.8-75.2 ppm), Pb (up to 0.14%), Se (up to 0.04%) and Au (up to 0.3 ppm). Regarding the extreme values, partly different specialties should be noted. Namely, the highest extremes in Ag (close to 300 ppm) belong to the upper member of the Paleogene stratovolcanic series ('a1'); all the detectable Se values in the Paleogene intrusive complex ('a3') and in the Triassic upper shale group ('Ap1/Kv1') are remarkably high (up to 0.14% and 0.08%, respectively); and the highest Cu values are measured in the Triassic lower limestone ('Mk2', up to about 14%), the Triassic upper limestone ('Mk1', up to 12%) and the upper member of the Paleogene stratovolcanic series ('a1', up to 10%). On the other hand, the common and extreme values of Zn result in similar patterns of ranges.

In spite of the fact that the analyzed set of depth-zones is more or less arbitrary, distributions of the common values expose a notable vertical zoning. Towards the depth, Ag, Pb, and Zn show a general decrease, while Mo and Fe exhibit an opposite tendency. Cu, S, and Au display a nice wavy change: first decrease, then grow, and in the deepest zones decrease again. Based on the extreme values, zones can be named where one or two components have a spectacularly high upper limit: Zone "+300 +100m" with Ag nearing 250 ppm, and Zone "-500 -700m" with Pb of up to 20% and Au exceeding 8 ppm.

At last, a few general remarks follow. Within each of the three analyzed sets of units, S is the most variable component in the sense that it reveals the most conspicuous differences across the units. Fe can be regarded as the most regular component in terms of consistency of its plots, and by the undisturbed two-tailed shape of its presumable frequency distribution curves. Although its elevated values in the dataset are noteworthy, the detection limit for Se was obviously too low to provide a representative picture of its distributions.

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