CHAPTER 11

GRADE AND TONNAGE MODELS FOR THE ANALYSIS OF NEVADA'S MINERAL RESOURCES

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INTRODUCTION

Mineral deposit grade and tonnage models and numbers-of-undiscovered deposits estimates provide the fundamental means of translating geologists' resource assessments into a language that economists and land planners can use (Singer, 1993a). The models and the estimates allow both assessment of resources that might be discovered under different exploration conditions and the economic analysis of the value of these sources of potential supply. Here I discuss the relative importance of different types of mineral deposits that exist or might exist in Nevada and provide the numeric estimates necessary to those wishing to perform economic analyses. The next sections of this chapter discuss basic considerations of grade and tonnage models. Following this discussion is a section concerned with the application of the grade and tonnage models in Nevada including summary statistics for all deposit types for which number of undiscovered deposits were estimated (table 11-1). Comparisons of the known deposits in Nevada (chapter 10) with the general grade and tonnage models are used to identify models that required modification for proper application in Nevada. Only those models that required modification or have recently been developed or changed for other reasons are discussed here. New grade and tonnage models for sediment-hosted gold and distal disseminated silver-gold deposits are probably the most important of these changes. Finally, a comparison of the grades, tonnages, and contained metal by deposit type possible in Nevada is presented in order to show the relative importance of the types to each other and to other deposit types that are important suppliers of each metal.

WHAT ARE THE KINDS OF GRADE AND TONNAGE MODELS?

There are two main types of grade and tonnage models; those that deal with grades and tonnages of samples or blocks within deposits, and those that use tonnages and average grades of whole deposits as samples (Singer, 1993b). The first type of model is primarily designed for ore reserve and economic analysis within deposits, whereas the second type is designed for analysis and comparison of groups of undiscovered deposits. Here grade and tonnage models that deal with groups of deposits are considered because our purpose is to represent undiscovered deposits; intradeposit grades and tonnages are only considered to the extent that they affect the group models.

Frequency distributions of tonnages and average grades of well-explored deposits of each type are employed as models for grades and tonnages of undiscovered deposits of the same type in geologically similar settings. The recent publication of more than 67 grade and tonnage models (Cox and Singer, 1986; Bliss, 1992) represents the largest collection of models that can be used for resource assessments. These grade and tonnage models are presented as cumulative frequency graphs. For each deposit type these grade and tonnage models help to distinguish a deposit from a mineral occurrence or a weak manifestation of an ore-forming process.

HOW ARE GRADE AND TONNAGE MODELS CONSTRUCTED AND USED?

Construction of grade and tonnage models involves multiple steps, the first of which is the identification of a group of well-explored deposits that are believed by others or the modeler to belong to the mineral deposit type being modeled. A descriptive model is commonly prepared also, and the attributes of each deposit in the group are compared with it to ensure that all are of the same type. These data consist of average grades of each metal or mineral commodity of possible economic interest and tonnages based on the total of production, reserves and resources at the lowest cutoff grade for which data are available. All further references to tonnage follow this definition. These data represent an estimate of the endowment of each known deposit so that the final model can represent the endowment of all undiscovered deposits. In practice, the available grades and tonnages are seldom reported at the same cutoff grade and, in fact, cutoff grades are reported only infrequently.

The second step in the data gathering stage is reviewing the question of what the sampling unit should be. Grade and tonnage data are available to varying degrees for districts, deposits, mines, and parts of mines that are represented by individual mine shafts. It is extremely important that all the data used in the model represent the same sampling unit because mixing data from deposits and districts usually produces bimodal or, at least, non-lognormal frequencies and may introduce correlations among the variables that are artifacts of the mixed sampling units (Singer, 1993b).

The next step is to plot the data. For tonnage and most grade variables, a transformation to logarithms is necessary to remove skewness. Histograms, normal probability plots, cumulative frequency plots, and empirical quantile function plots are all appropriate as is the examination of skewness

Table 11-1. Summary statistics of grade-tonnage models for Nevada [logarithms (base 10) except Fe, which is percent; S. D. = standard deviation, * = new or revised model].

Deposit type	W skarn			W vein			Climax Mo			Zn-Pb skarn and Polymetallic replacement*			Fe skarn			Distal disseminated Ag-Au*			Porphyry Mo, low-F		
	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposit
Tonnage (metric)	6.016	1.025	28	5.748	0.8574	16	8.305	0.5020	9	6.218	0.7031	86	6.858	1.041	168	6.869	0.815	10	7.974	0.6053	33
Fe (pct)	--	--	--	--	--	--	--	--	--	--			49.61	10.28	168	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--				-.5362	‘0.5102	52	--	--	--	--	--	--	--	--	--
Mo (pct)	--			--	--	--	0.7171	0.1363	9	--	--	--	--	--	--	--	--	--	-1.070	.1459	33
W03 (pct)	-.1826	0.2430	28	-.0400	.1408	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	--	--	--	--	--	--	2.125	0.5783				--	1.620	.6651	10	--	--	--
Au (g/t)	--	--	--	--	--	--	--	--	--	-.1600	0.6954	67	- -	- -	--	.0914	.5568	7	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--	.6650	0.4556	85	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--	.6320	0.4297	82	--	--	--	--	--	--	--	--	--

-Deposit type	Porphyry copper			Cyprus massive sulfide			Cu skarn			Comstock epithermal vein			Au skarn*			Epithermal quartz-alunite*			Sierran kuroko massive sulfide*		
	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits
Tonnage (metric)	8.159	0.6864	208	6.105	0.8765	49	5.747	0.9505	64	5.884	0.8379	41	5.017	1.700	39	6.421	0.5220	9	5.496	0.5471	23
Fe (pct)	--	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		
Cu (pct)	-.2690	.1900	208	0.2040	0.3068	--	.2266	.2880	64	-1.816	.7955	18	--	--	--	-1.678	1.554	8	.1521	.4602	23
Mo (pct)	-1.907	.4343	103	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WO3 (pct)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ag (g/t)	.2180	.3646	76	1.109	.6457	15	1.331	.6955	15	2.060	.8156	41	.8379	.6726	29	1.276	.6540	9	1.673	.7862	18
Au (g/t)	-.9077	.7012	81	-.0417	.6893	15	.2496	.6107	16	.8726	.4410	41	.9167	.4792	39	.8080	.3000	9	.0440	.8351	17
Zn (pct)	--	--	--	-.1021	.7085	16	--	--	--	-1.594	1.702	3	--	--	--	--	--	--	.6063	.5144	16
Pb (pct)	--	--	--	-1.333	5774	3	--	--	--	-1.870	.9817	19	--	--	--	--	--	--	-0482	.5833	9

Deposit type	Sediment-hosted Au-Az*			Hot-spring Au-Ag			Comstcck epithermal vein			Sado epithermal vein			Epithermal quartz-alunite*			Sediment-hosted Au-Ag*			Hot-spring? Au-Ag*		
	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits	Mean	S. D.	Number of Deposits
Tonnage (metric)	6.822	0.6709	39	7.114	0.6922	17	5.884	0.8379	41	5.472	0.7876	20	6.421	0.5220	9	6.822	0.6709	39	7.114	0.6922	17
Fe (pct)	--	--	--	--	--	--	--	--	--	--			--	--	--	--	--		--	--	--
Cu (pct)	--	--	--	--	--	--	-1.816	‘.7955	18	-.7200	1.153	9	-1.678	1.554	8	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--	--	--	--	,--	--	--	--	--	--	--	--	--
WO3 (pct)	--	--	--	--	--	--	--	--	--	--	--	--			--			--	--	--	--
Ag (g/t)	.2692	.3617	3	.9818	.8458	10	2.060	.8156	41	1.579	.6647	20	1.276	.6540	9	.2692	.3617		.9818	.8458	10
Au (g/t)	.3653	.3000	39	1928	.2323	17	.8726	.4410	41	.8363	.4007	18	.8080	.3000	9	.3653	.3000	39	1928	.2323	17
Zn (pct)	--	--	--	--	--	--	-1.594	1.702		-.602	--	1	--	--		--	--	--	--	--	--
Pb(pct)	--	--	--	--	--	--	-1.870	.9817	19	-2.372	.2129	2	--	--	--	--	--	--	--	--	--

and kurtosis statistics. Bivariate (scatter) plots of each pair of variables should also be constructed. The purpose of the plots and statistics is to discover if the data contain multiple populations or outliers. Deviations from lognormality, outliers, or subgroups are all cause for reexamination of the data. If any of these conditions exist, the data should be checked for correctness of data entry, data reporting, and lastly, correctness of the geologic reasoning that led to the classification of the individual deposits. If subgroups of data exist, one or more geologic attributes of the subgroups will probably be different which suggests that the descriptive model may need reexamination and possible modification. In most cases, the process of model building is iterative and requires multiple passes. Sources of difficulties include mixed geologic environments, poorly known geology, data-recording errors, incomplete records of production or resources, mixed deposit and district data, and mixed mining methods within the group. Two related reasons for models changing are the use of immature grade and tonnage estimates and the use of data on new or incompletely understood deposit types. As an example, both causes have affected the model for sediment-hosted Au deposits where there have been significant additions to reserves plus the recent recognition of deep sulfide ore in some deposits.

Although it is not possible to guarantee that a model will never change, a model will probably be stable if: (1) tonnage and grades not significantly different from lognormally distributed (grades of more than 10% are not expected to be lognormally distributed); (2) at least 20 deposits are used; and (3) there are no significant correlations between tonnage and grade. For example, for some deposit types, such as placer Au, a correlation between tonnage and gold grade exists due in part to the effects of different, but inseparable, mining methods having been used. In such cases, the model will have to stand until the effects of mining method can be related to grades and tonnages and the revised model can be linked to geology.

The grade and tonnage models are presented in a graphical format to make it easy to compare deposit types and to display the data. The plots show grade or tonnage on the horizontal axis, whereas the vertical axis is always the cumulative proportion of deposits. Plots of the same commodity or tonnages are presented on the same scale; a logarithmic scale is used for tonnage and most grades. Each circle represents an individual deposit (or, depending on the specific model, a district), cumulated in ascending grade or tonnage. Smoothed curves are plotted through arrays of points, and intercepts for the 90th, 50th, and 10th percentiles are constructed. For tonnage and most grades, the smoothed curves represent percentiles of a lognormal distribution that has the same mean and standard deviation as the observed data. Exceptions are plots where only a small percentage of deposits had reported grades and those grade plots that are presented on an arithmetic scale, such as deposit types with iron or manganese as main commodities, for which the smoothed curve is fitted by eye. The 90th and 10th percentiles are 1.282 standard deviations (in logarithms) from the mean (figs. 11-1, 11-2, and 11-3).

QUALITY OF DATA: MISSING LOWER GRADES AND LOWER TONNAGES

Deposits, or more correctly, occurrences, suspected to be small or having a very low grade are seldom sampled well enough to be characterized in terms of grade and tonnage, thus the sample of many deposit types should in theory be truncated by economics. Because occurrences are typically not thoroughly explored (drilled in three dimensions), they are not included in grade and tonnage models. Effects of economic filtering should be most evident in plots of grade versus tonnage where the combination of low-grade and low-tonnage should be missing. For almost any conceivable distribution of grades and tonnages before economic filtering, the removal of low-grade and low-tonnage deposits due to economics would cause a negative correlation in the remaining data. The uncommonness of significant negative correlations in the 67 published grade and tonnage models suggests economic filtering is not severe. Probably 40% of the deposits used in the models of Bulletin 1693 are, in fact, non-economic today. For example, at least 50% of the 208 deposits used in the grade-tonnage model for porphyry copper have never been developed even though most were explored over 15 years ago. About 90% of the 33 porphyry Mo, low-F deposits have never been developed. The majority of the 435 podiform chromite deposits from California and Oregon were mined only when there was a subsidy. A perusal of the figures in Cox and Singer (1986) and in Bliss (1992) will demonstrate examples of both small deposits and low grade deposits. Explorationists commonly drill out a deposit in the hope that more tonnage or higher grades will be found. These hopes are not always fulfilled.

Potential metal supply is dominated by the very few largest tonnage deposits, as shown by Singer and DeYoung (1980), who also pointed out that inverse correlations between grade and tonnage are surprisingly rare. Therefore, a low-grade deposit will not necessarily be large. This means that most low-grade deposits are not likely to have huge resources and that the omission of a few low-grade or small-tonnage deposits will not seriously degrade the predictions of potential supplies of most commodities (Singer, 1995).

From the preceding discussion, it is clear that most of the published grade and tonnage models include a significant proportion of non-economic deposits and that in most cases the low-grade or low-tonnage deposits (occurrences) that are not included in the models would have negligible effect on any potential supply estimates (Singer, 1995). In the experience of most economic geologists however, low-grade and particularly low-tonnage deposits are underrepresented in the models.

The missing low-grade and small-tonnage deposits suggest that the grade and tonnage models represent a biased sample of the large number of low-grade or small-tonnage occurrences and prospects found by exploration. Grade and tonnage models of mineral deposits focus attention on the distinction between *mineral occurrences* and *mineral deposits* that might, under the most favorable circumstances, be considered to have economic potential. This difference between the population of mineral deposits represented by

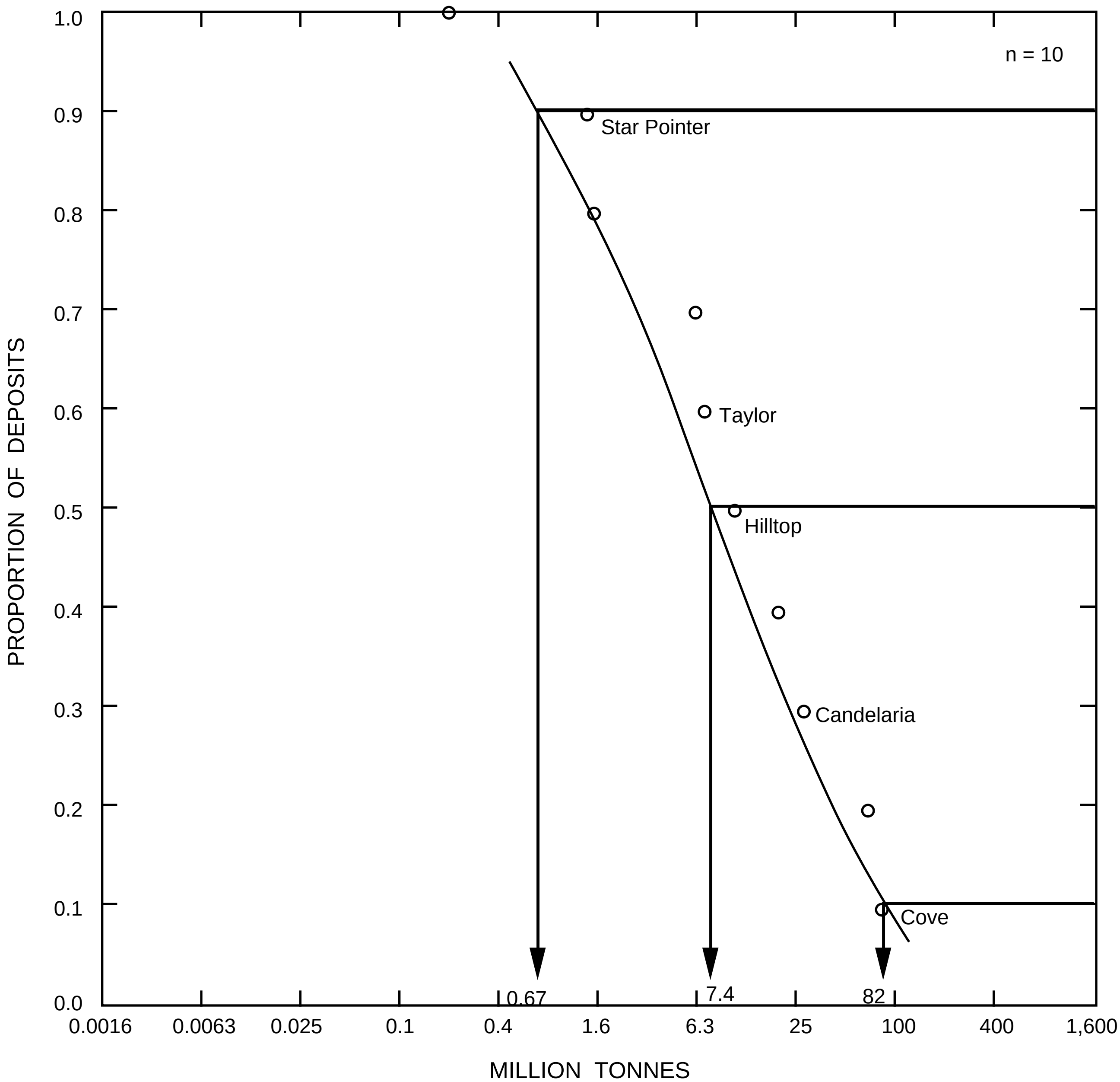

Figure 11-1. Tonnages of distal disseminated silver-gold deposits. Nevada deposits identified.

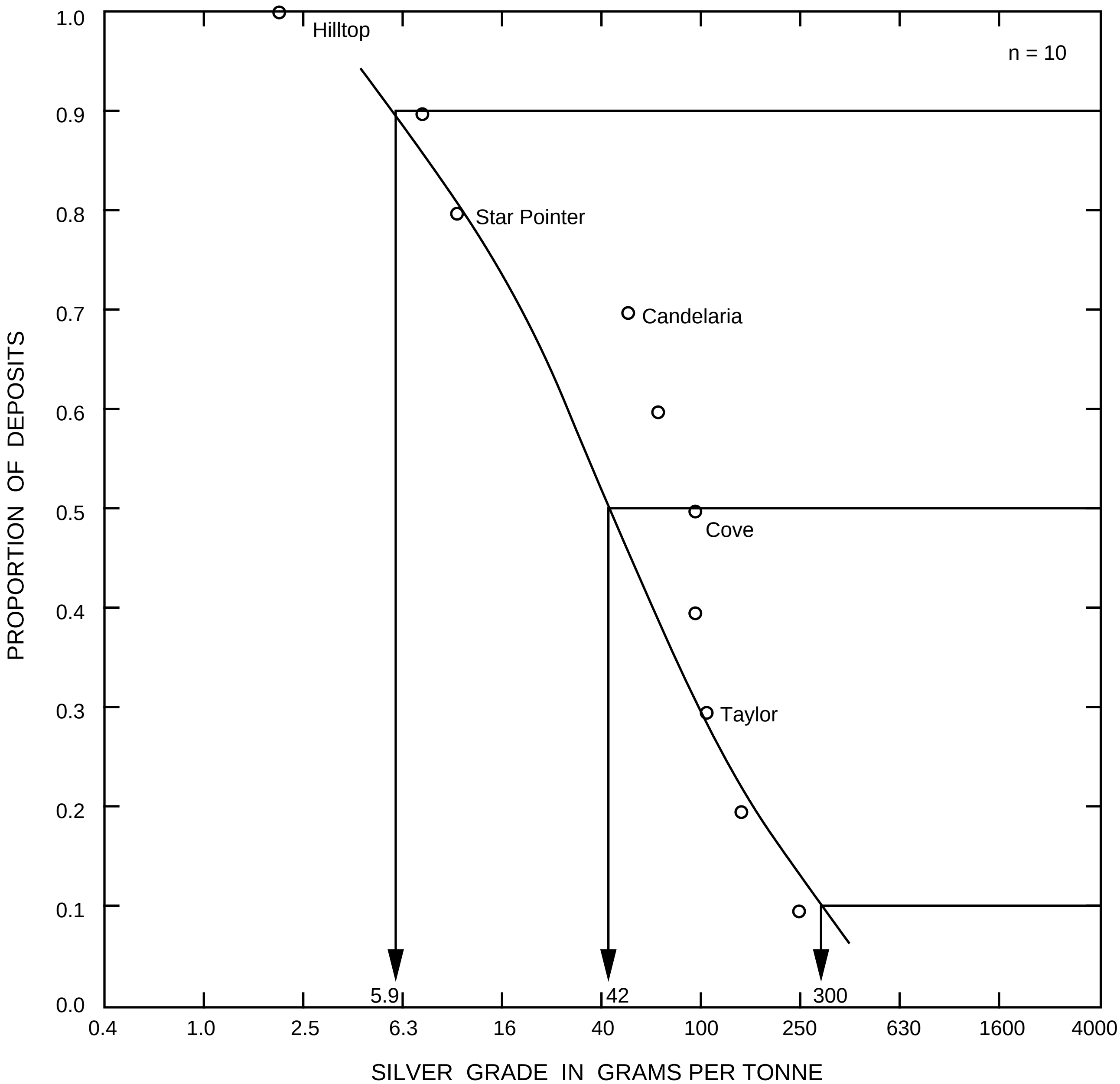

Figure 11-2. Silver grades of distal disseminated silver-gold deposits. Nevada deposits identified.

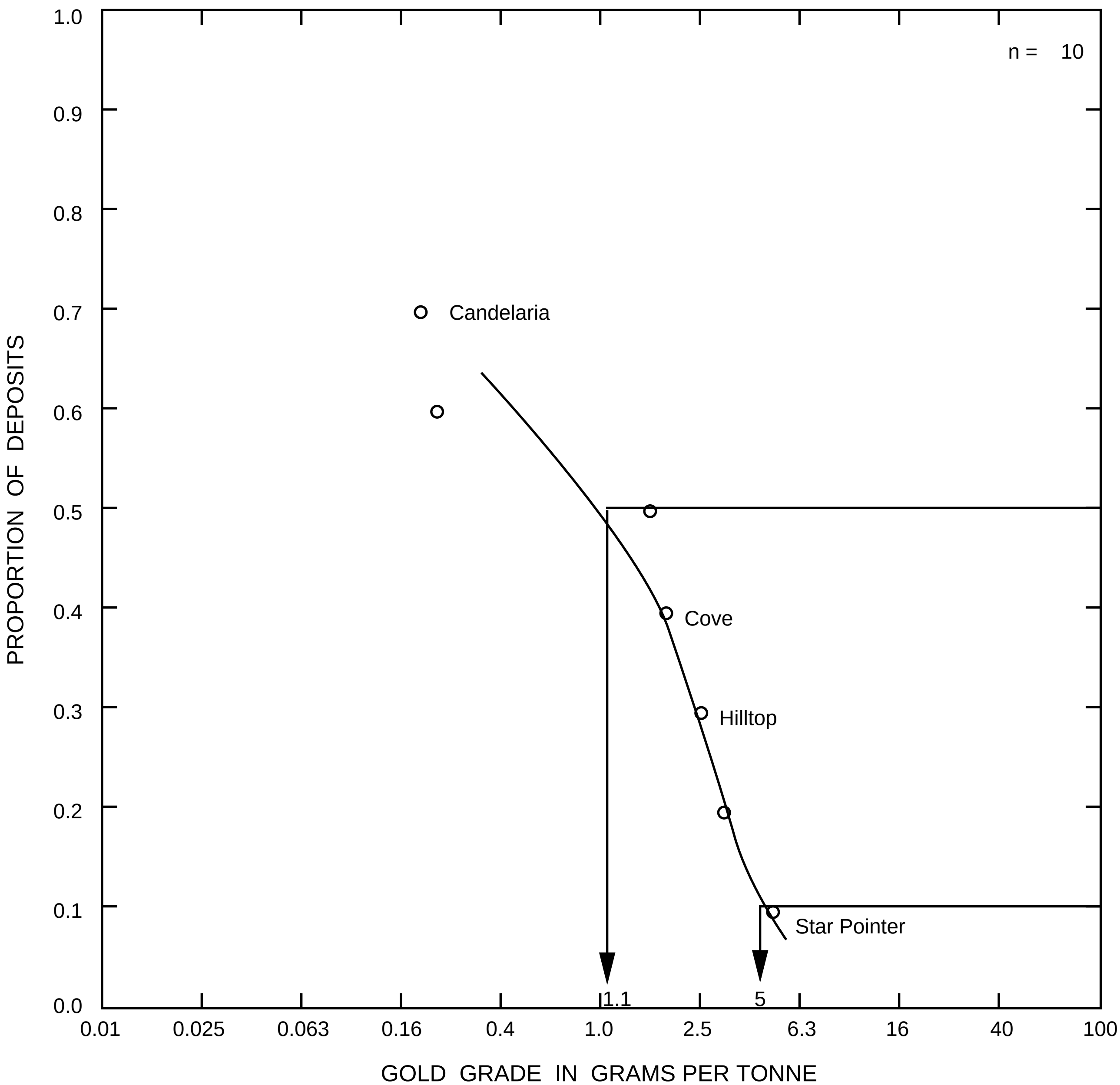

Figure 11-3. Gold grades of distal disseminated silver-gold deposits. Nevada deposits identified.

the grade and tonnage model and the population of occurrences that may exist in the earth must be considered when the number of undiscovered deposits is estimated. The estimators must be certain that their estimates of numbers of deposits are guided by a clear understanding of the corresponding grade and tonnage models (Singer, 1994). For the estimated number of deposits to be consistent with a grade and tonnage model, approximately half of the deposits estimated should have greater than the model's median tonnage or grade; in practice, grade is typically not of concern because even mineral occurrences have sufficient grade. The minimum requirement of half of the estimated deposits being larger than the median solves the most common error of estimating a number of deposits, that is an estimate is incorrectly made of the number of deposits that are larger than the lowest tonnage observed in the tonnage model. Estimates of the number of deposits must be consistent with the population of *mineral deposits* in the grade and tonnage model and not with the population of *mineral occurrences*.

INTRADEPOSIT GRADE VARIATION

The original data used to construct the grade and tonnage models have differing and frequently unknown cutoff grades. In principal, improved price or productivity should lower the cutoff grade, which, in turn, should add new deposits that have average grades above the new cutoff (discussed above) and it should increase the tonnage of those deposits currently under production. Lasky's (1950) analysis of the relationship between cumulative tonnage of mineralized material and the average grade of that material demonstrated that different cutoff grades can significantly change total tonnages and average grades. The close correspondence of Lasky's equation to observed data over the range of grades for which data exist has been shown to be a consequence of the lognormal distributions of grades (Matheron, 1959).

Taylor (1985) combined the theoretical aspects of the lognormal distribution with actual examples and economic analysis to show how cutoff grades can, in practice, affect grades and tonnages. He concluded that the cutoff grade must be near the median of the population to recover a reasonable proportion of the metal content in a tonnage fraction that is sufficiently large to have spatial continuity and be minable. He also observed that many cutoff grades of mines are located at or near the population medians. Thus, although wide variability in tonnages and average grades may result from changes in cutoff grades, in practice, operators are limited to a rather narrow range of cutoff grades by economics, spatial continuity of mineralized rock, and by the consequences of dealing with the lognormal distribution. Exceptions may exist, however, due to differences in mining methods that significantly affect operating costs such as the very low costs of dredge mining and heap leaching for gold. Although further work clearly needs to be done on this subject, the effect of cutoff grades on the grade and tonnage models may not be as important as suspected as long as the mining method is the same.

GRADES AND TONNAGES OF DEPOSITS IN NEVADA

We presume that the undiscovered deposits in Nevada can be represented by certain grade and tonnage models, but it is critical to test the appropriateness of the models to Nevada. A reasonable test is to compare the grades and tonnages of the deposits from Nevada that were used in the construction of each model with grades and tonnages from elsewhere (Singer, 1993b).

Pluton-related Deposits

The seven deposits from Nevada in the copper skarn model (Jones and Menzie, 1986) are significantly lower in tonnage and higher in copper grade than the other deposits in the model. However, because the Nevada deposits in the model are all located in the same general area near Yerington, and because we believe that undiscovered copper skarn deposits are, for the most part, located elsewhere in Nevada (chapter 12), we have decided to rely on the original unmodified model.

Because of the difficulty of separating Zn-Pb skarn and polymetallic replacement in the delineation process (chapter 12), these two deposit types are combined here. The individual models are similar and the combined types have unimodal distributions of tonnage and grades. No information is lost in the assessment by combining these types.

Careful analysis of the original group of sediment-hosted Au deposits led to a new deposit type (Cox, 1992; chapter 10 in this report) in which disseminated Ag and Au occur mainly in sedimentary rocks distal to porphyry Cu, base metal skarns, and polymetallic vein and replacement deposits. A grade and tonnage model (figs. 11-1, 11-2, and 11-3) for the new type was also constructed (Cox and Singer, 1992). This model is similar to sediment-hosted Au, but has significantly higher Ag grades.

The grade and tonnage model for the gold skarn deposit type presented here is based on the data provided by Theodore and others (1991, figs. 1c and 2c). The distribution of tonnages in this model has a very large standard deviation (table 11-1) which suggests that there are severe problems with mixed data. The data represent mixed sampling units (for example, districts, mines, and incompletely explored adits) which means the model is unlikely to be representative of grades and tonnages of undiscovered deposits (Singer, 1994). It is worth noting that the grades and tonnages of many deposits now called Au skarn are similar to those in the published models of Cu skarn (Jones and Menzie, 1986) and Zn-Pb skarn (Mosier, 1986).

Epithermal and Sediment-hosted Gold Deposits

The tonnages of Comstock epithermal vein districts (Mosier and others, 1986a) in Nevada are not significantly clustered in the high or low tonnage end of the global tonnage plot (fig. 11-4) and gold grades are not clustered (fig. 11-5). This model was therefore used for the number of district estimates of regular Comstock epithermal vein districts (chapter 12).

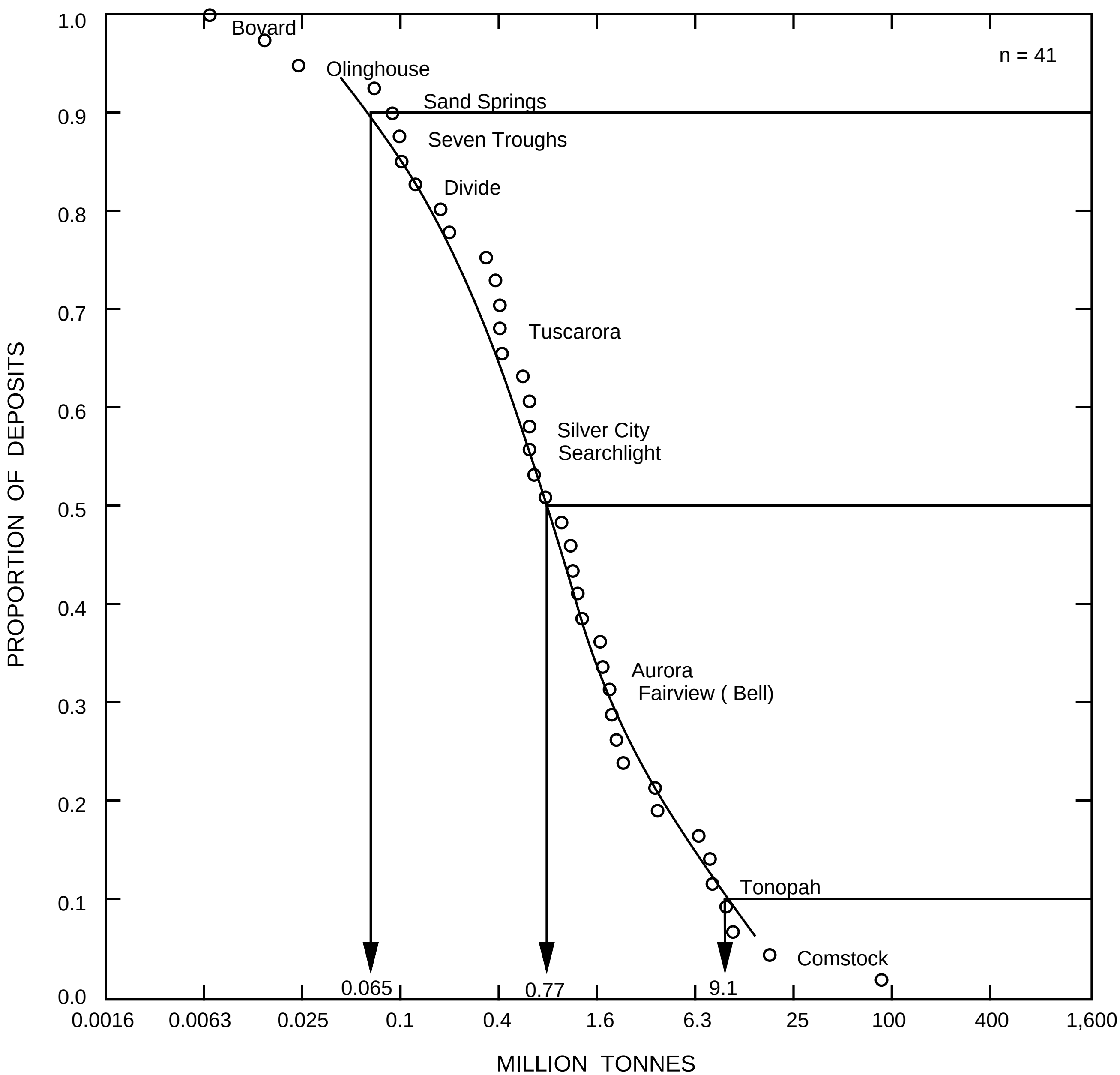

Figure 11-4. Tonnages of Comstock epithermal gold-silver deposits. Nevada deposits identified.

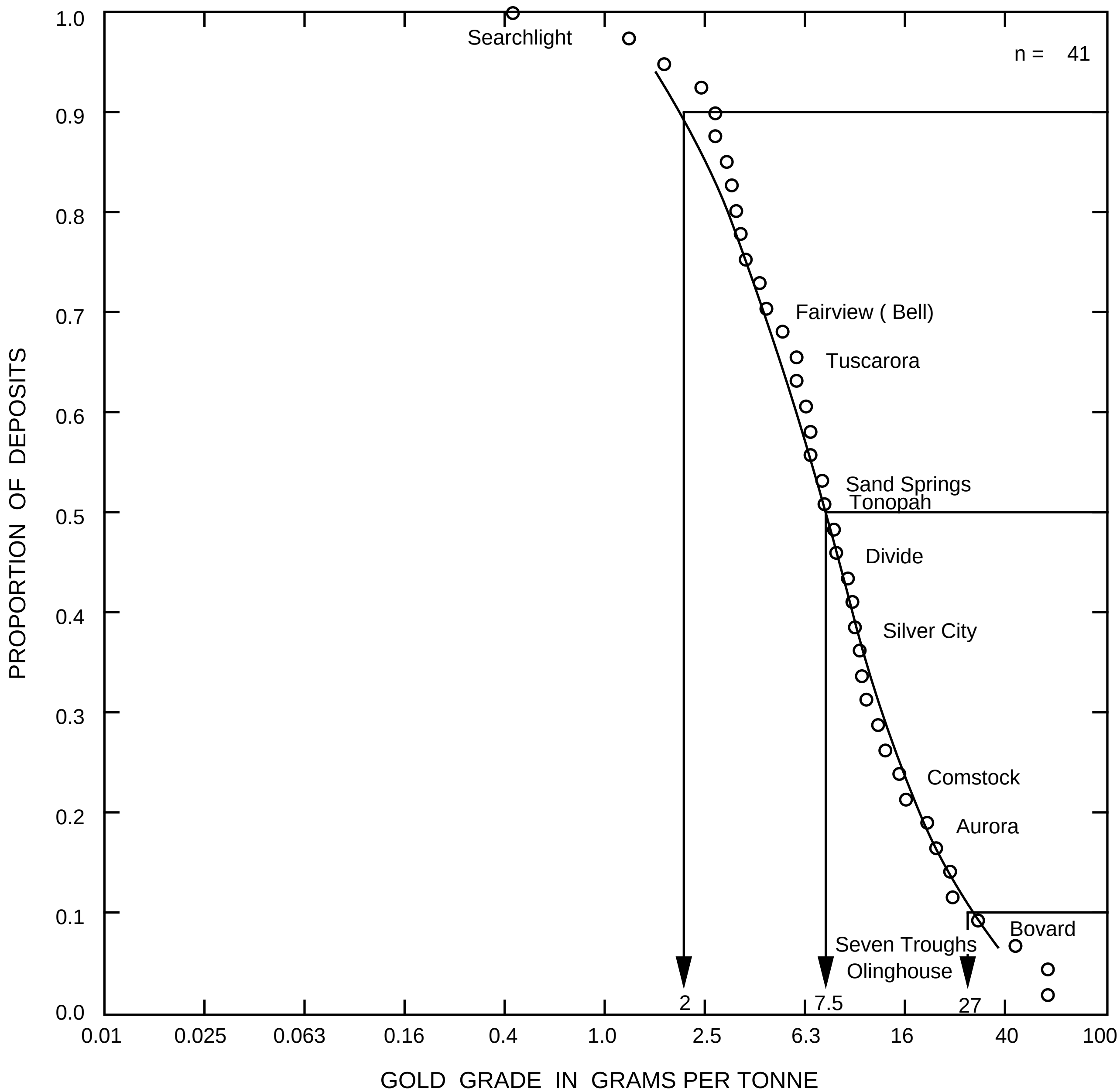

Figure 11-5. Gold grades of Comstock epithermal gold-silver depsosits. Nevada deposits identified.

However, a number of Comstock epithermal districts, such as Bullfrog, have in recent years been found to have large low-grade zones that are inconsistent with the grade and tonnage model for Comstock epithermal districts. Although not all of these deposits can be shown to be the hot-spring gold type, the hot-spring gold grade and tonnage model appears to fit the known deposits and is used in this report for these low-grade deposits.

In addition to modifying the polymetallic replacement and lead-zinc skarn models for Nevada, three other models were revised to reflect additional information that was unavailable when the original models were constructed. The epithermal quartz-alunite model was changed slightly by the addition of one deposit and seven deposits were added to the hot-spring Au-Ag model (Berger and Singer, 1992).

Major changes were recently made to the grade and tonnage model for sediment-hosted gold deposits (Mosier and others, 1992). This model applies to the descriptive model for carbonate-hosted Au-Ag (Berger, 1986) and supersedes the grade and tonnage model for that deposit type (Bagby and others, 1986). The change in the model name reflects the discovery of many deposits in siliceous shale and other noncarbonate host-rocks and the reassignment of some silver-rich deposits to a new model discussed above, the distal disseminated Ag-Au type. Deposits where mineralization is known to be within 500 meters were combined, which increased the tonnage of many deposits (figs. 11-6 and 11-7). For many sediment-hosted Au deposits, there have been significant additions to reserves after initial mining estimates and the recent recognition of deep sulfide ore in some deposits. The distribution of tonnage shows evidence of skewness. The skewness is a result of the very large tonnage of two deposits (Gold Quarry-Maggie Creek and Post-Betze-Genesis). Our experience with the frequencies of tonnage of over 67 mineral deposit types, suggests that the lognormal distribution is an appropriate model for tonnage and that departures from lognormality are typically due to mixing data of different types. After a careful literature search and discussions with mining geologists familiar with these deposits, we have been unable to find any geologic reason that explains why the two deposits stand apart. The best explanation appears to be that they have been more thoroughly explored than many of the other deposits. This explanation suggests that many of the other known deposits will eventually have significant additions to reserves through lateral extension and grouping of adjacent deposits and through discovery of deep sulfide ore beneath deposits. Additions to reserves needed to remove the skewness of the tonnage distribution and have the two largest deposits unchanged amount to approximately a doubling the total tonnage of ore and gold metal in the known deposits.

A new grade and tonnage model that applies to Nevada is associated with the descriptive model for kuroko massive sulfide deposits (Singer, 1986); however, only kuroko deposits of Triassic or Jurassic age in North America were used to construct this subset. Because many of the deposits lie in the western foothills of the Sierra Nevada in California, the name Sierran kuroko is given to the group. These deposits are significantly lower in tonnage than the worldwide kuroko group (Singer, 1992).

Comparisons of Deposit Types

Summary statistics for each of the 21 grade and tonnage models relevant for Nevada including the above mentioned deposit models are provided below in Table 1. Grade and tonnage models for which numbers of deposit estimates have been made (chapter 12) are included in this table. Models for other, mostly small, deposit types that may be present in Nevada can be found in the summary statistics table in Cox and Singer (1986). The primary value of this table is its use with the number of undiscovered deposits estimates (chapter 12) in simulations to determine the conditions under which the undiscovered mineral deposits might be economic to mine. Proper simulations require information about the relationships among the variables. The correlations among grades within a deposit type are provided in Cox and Singer (1986) and Bliss (1992). Typically, grades are not correlated with tonnages.

In order to show one way to examine the relative importance of different deposit types that may exist in Nevada, five figures are presented (figs 11-8 through 11-12) in which grades and tonnages are compared by deposit type. Some of these elephant diagrams mix deposits and districts. Median grades and tonnages are the centers of ellipses that represent one standard deviation limits of average grades and tonnages of each deposit type. Shown by arrows from the deposit medians to elephant icons are the median grade and tonnage of the five deposits that have the most metal of the deposit type. Also shown are diagonal lines of constant contained metal. Each of these figures contains one deposit type not suspected to occur in Nevada but that is a major source of the metal worldwide. From the standpoint of national or world supply, deposit types that could be significant sources of a metal can be identified by viewing the location of types and their "elephants" with respect to the constant metal lines. Deposit types having high grades can be mined by a wider variety of methods, whereas lower grade deposits are limited to bulk mining methods. However, most deposits contain more than one metal, so examination of an individual figure does not tell the whole story about a deposit type.

The diagram for gold (fig 11-8) shows the relatively high grades of Comstock epithermal vein districts compared to porphyry copper deposits which, for those deposits with reported gold, contain more gold because of the very large tonnages. Quartz pebble conglomerate gold districts from South Africa (Witwatersrand) are included in the figure to provide perspective—the world's biggest gold producer had both high gold grades and very large tonnages. High silver grades of Comstock epithermal districts (fig. 11-9) explain Nevada's domination of silver production in years past. Contained silver in the largest Comstock epithermal districts rivals the silver content of polymetallic replacement districts and sediment-hosted copper deposits. In recent years, Nevada's silver production has come predominantly from the lower-grade distal disseminated Ag-Au deposits. The figure for copper (fig. 11-10) contains the major copper source,

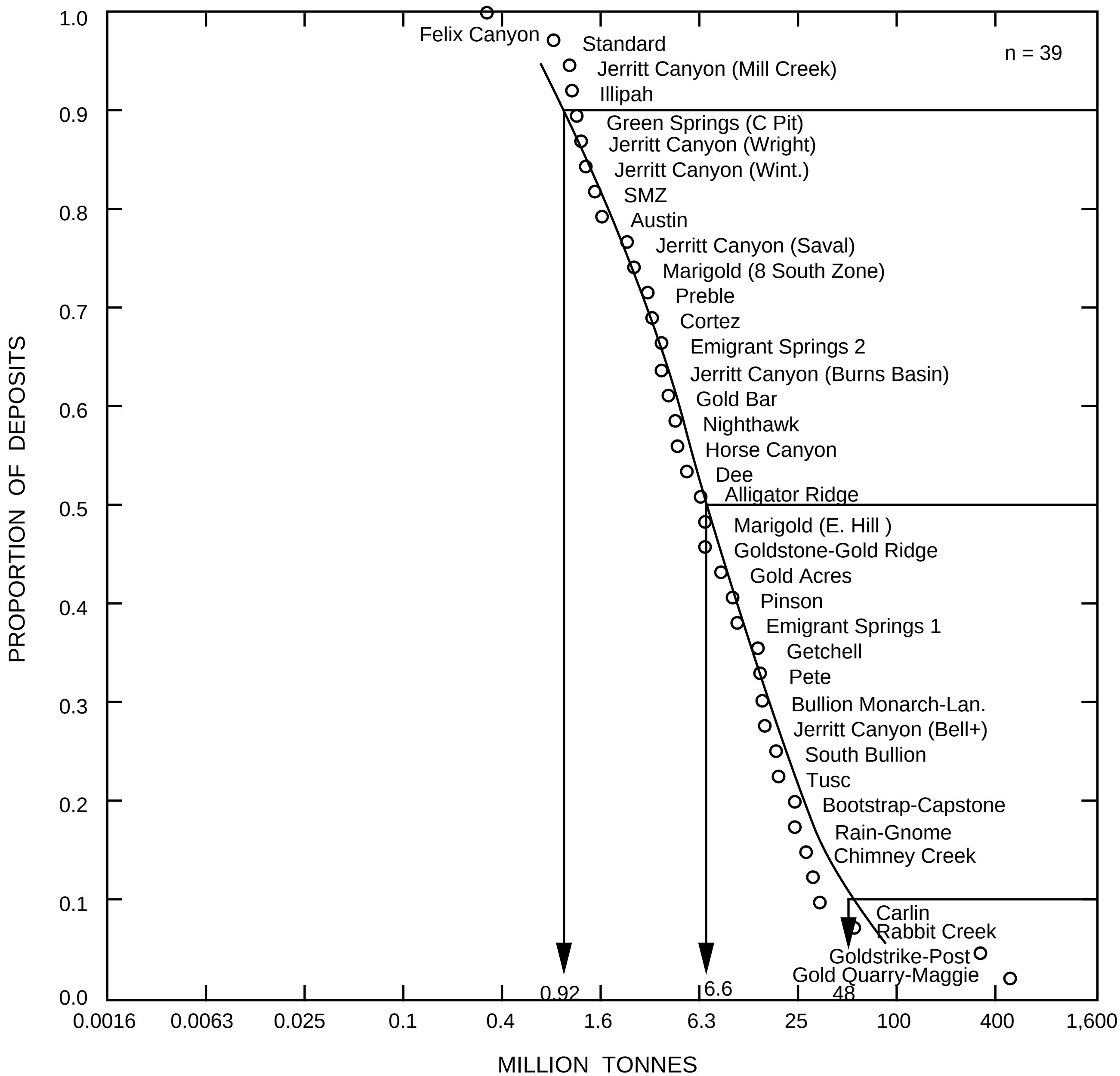

Figure 11-6. Tonnages of sediment-hosted gold deposits. Nevada deposits identified.

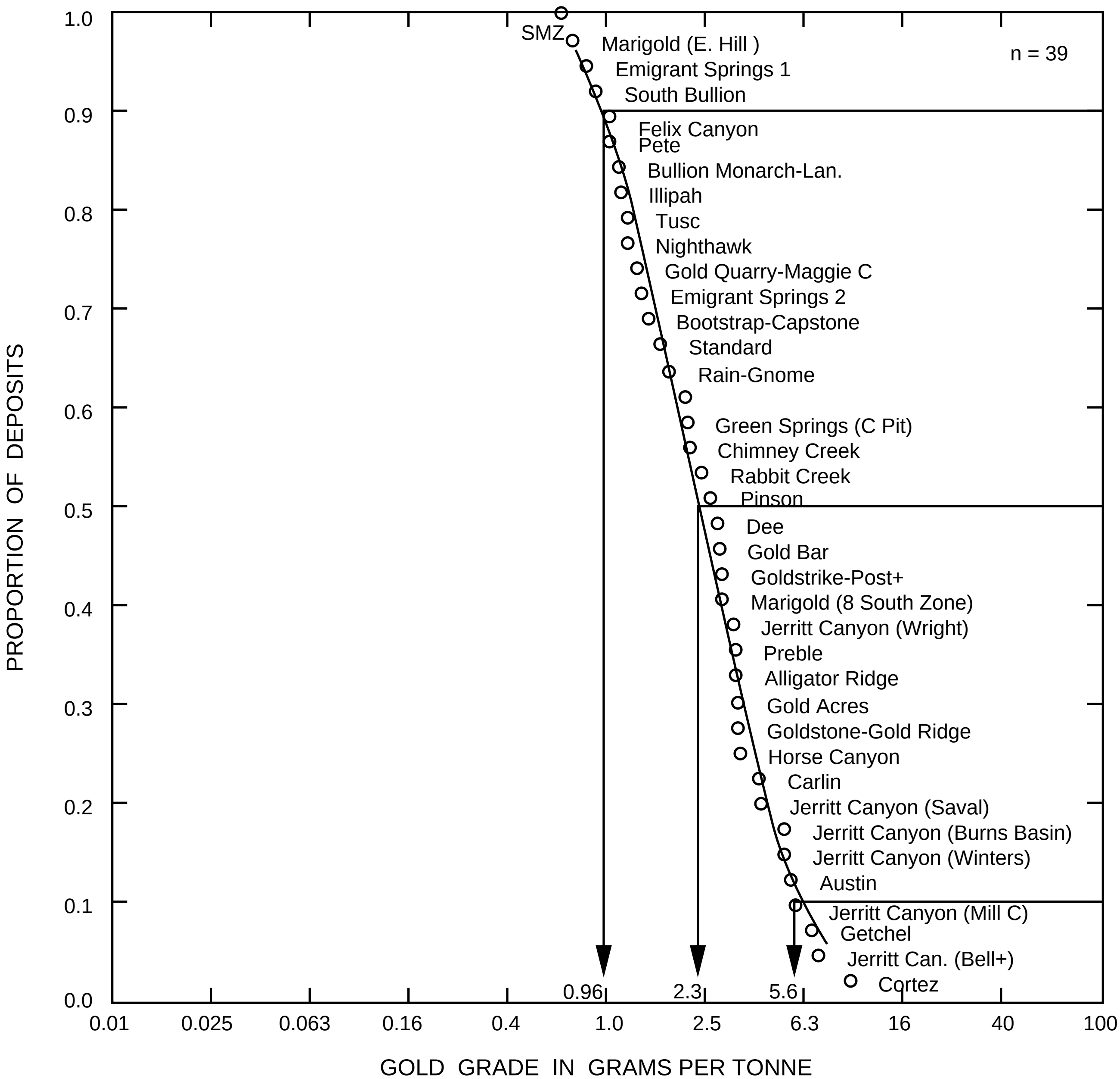

Figure 11-7. Gold grades of sediment-hosted gold deposits. Nevada deposits identified.

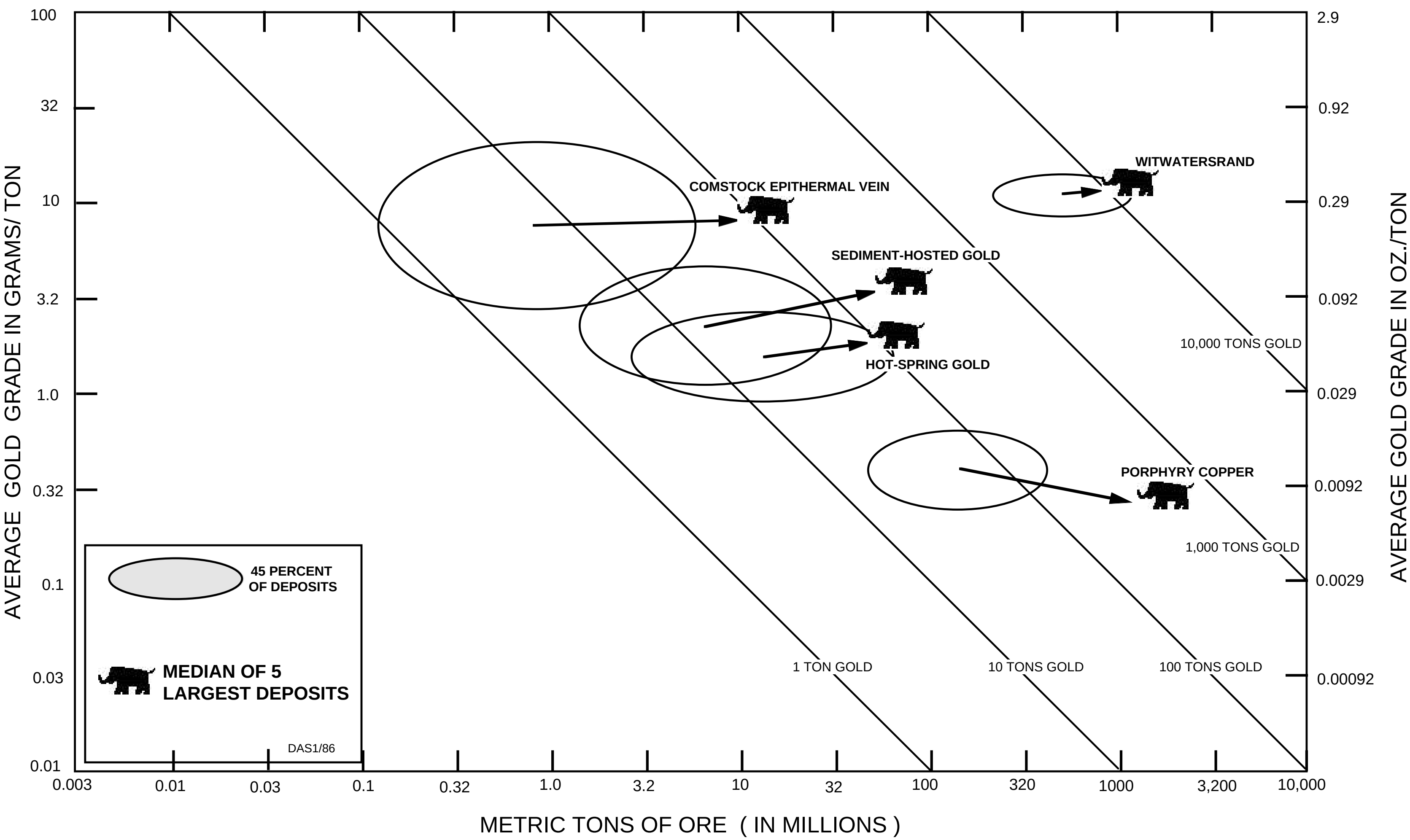

Figure 11-8. Gold grades and tonnages by deposit type. Median grade and tonnage of each type located at center of ellipse.

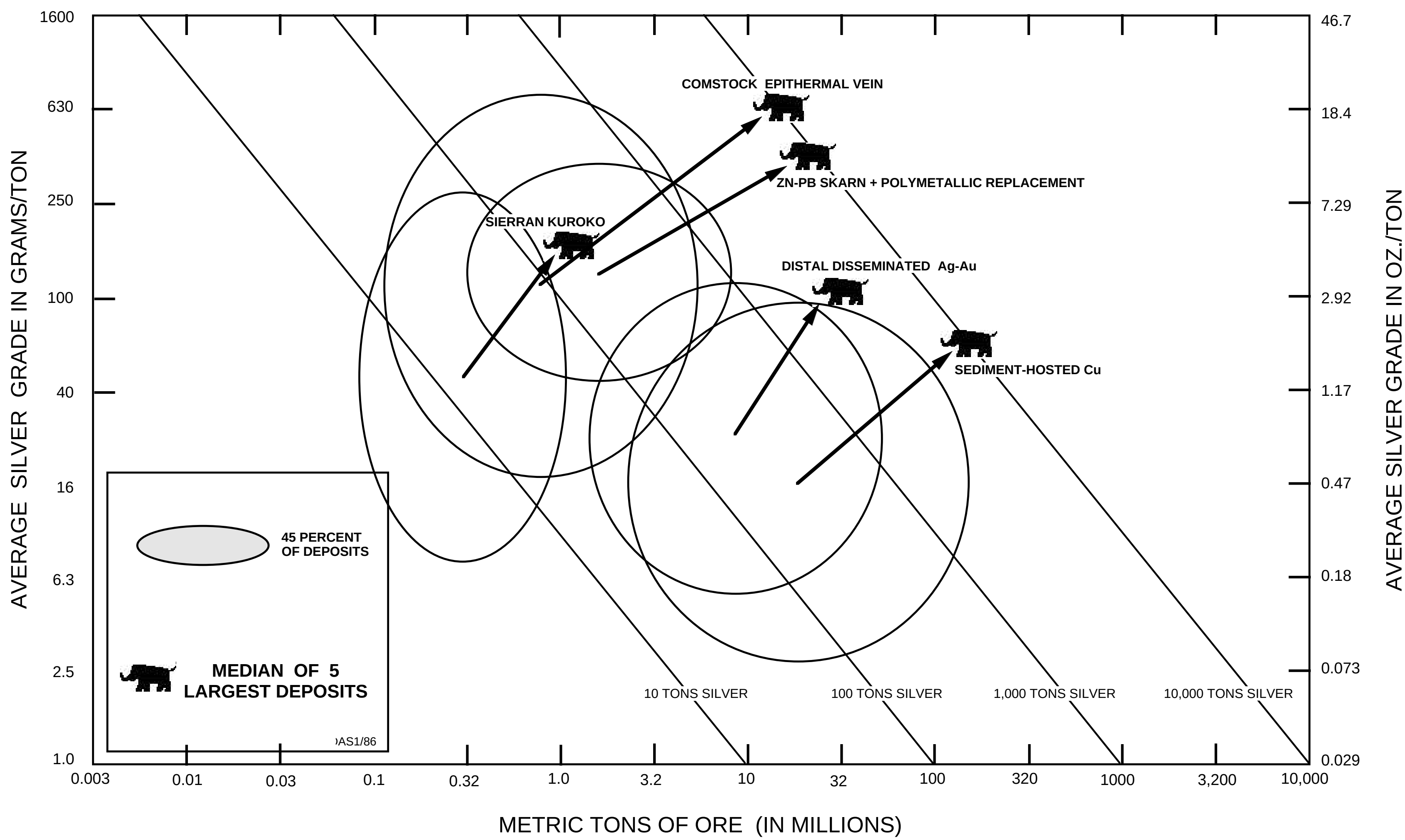

Figure 11-9. Silver grades and tonnages by deposit type. Median grade and tonnage of each type located at center of ellipse.

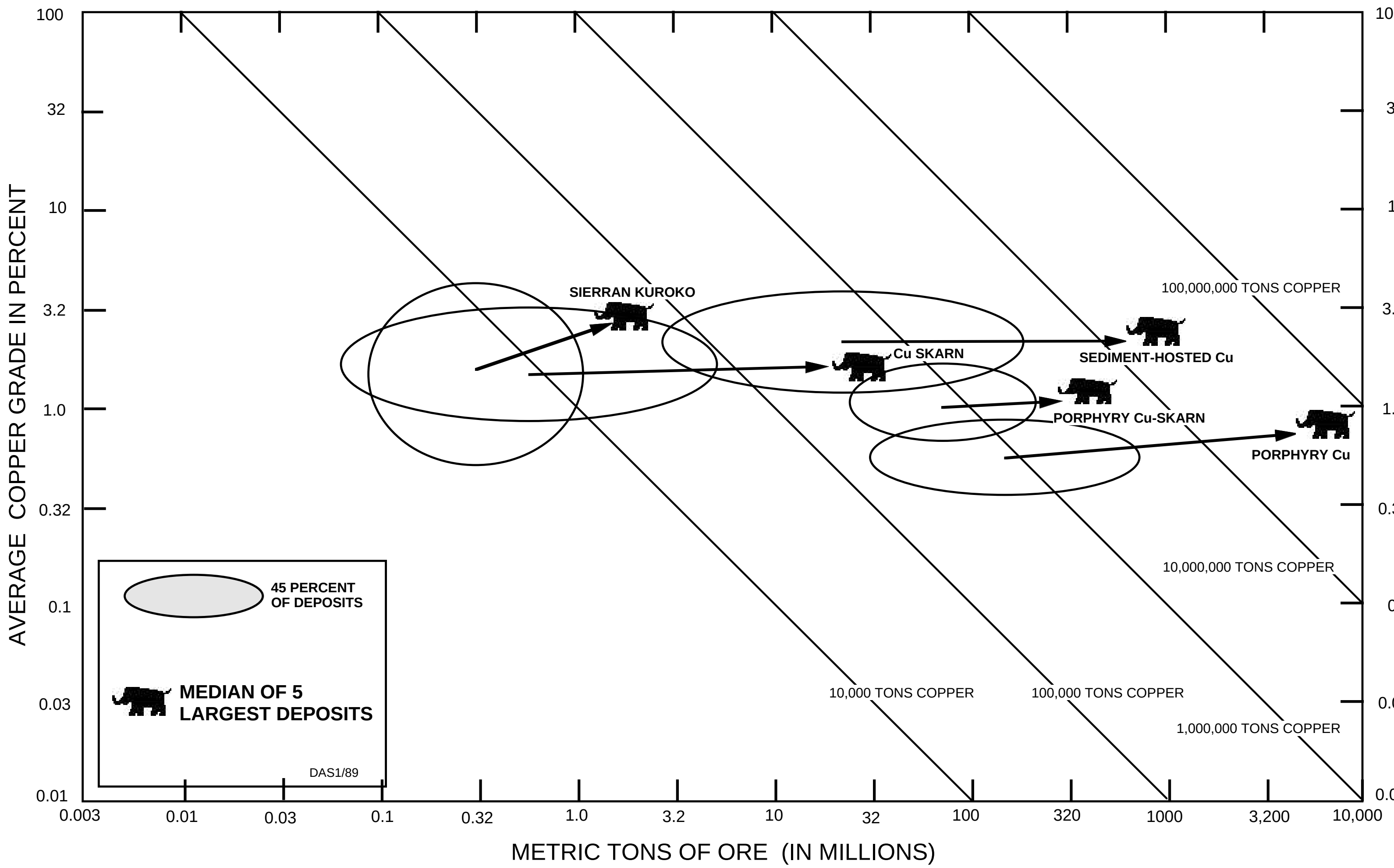

Figure 11-10. Copper grades and tonnages by deposit type. Median grade and tonnage of each type located at center of ellipse.

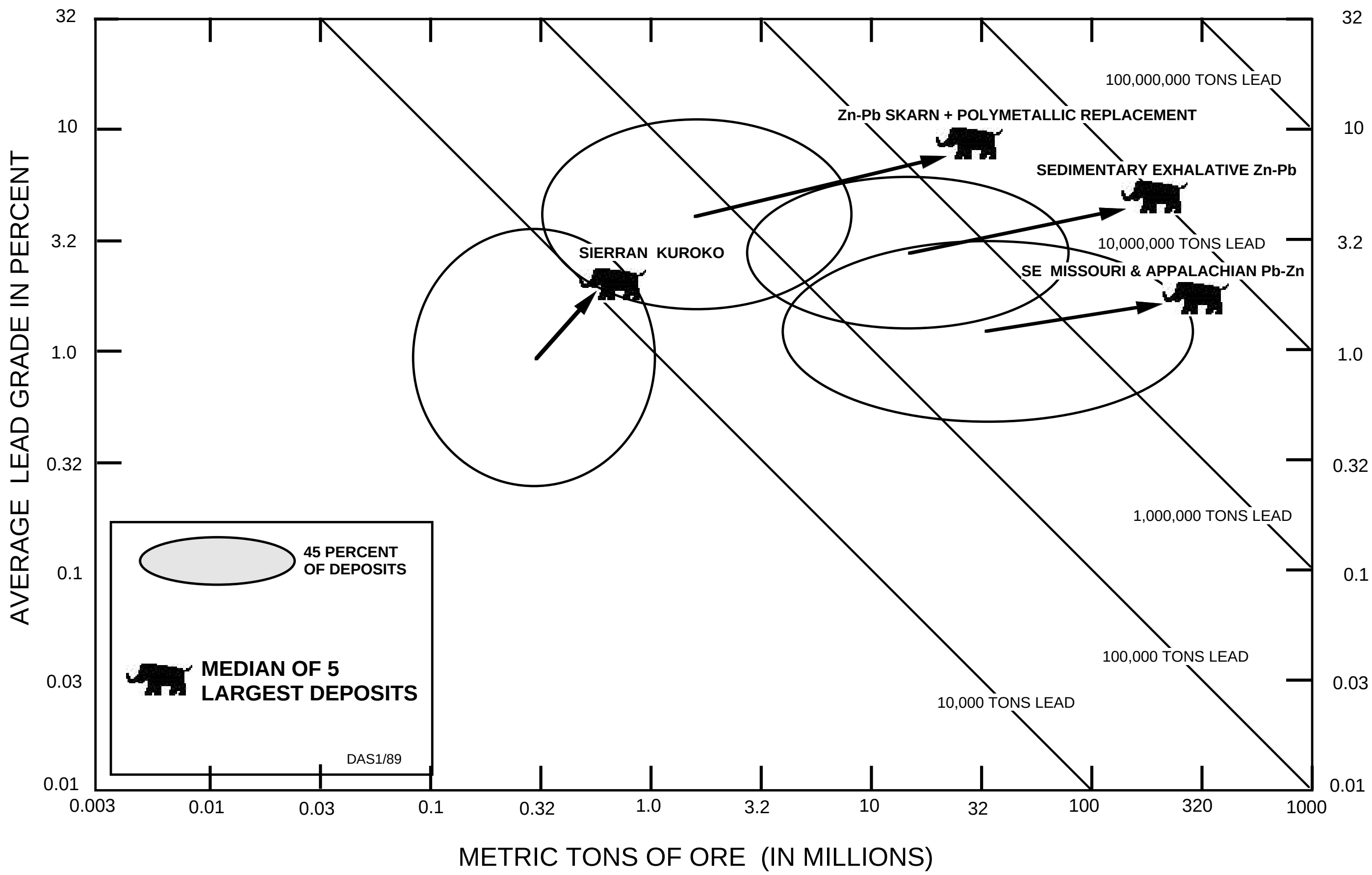

Figure 11-11. Lead grades and tonnages by deposit type. Median grade and tonnage of each type loacted at center of ellipse.

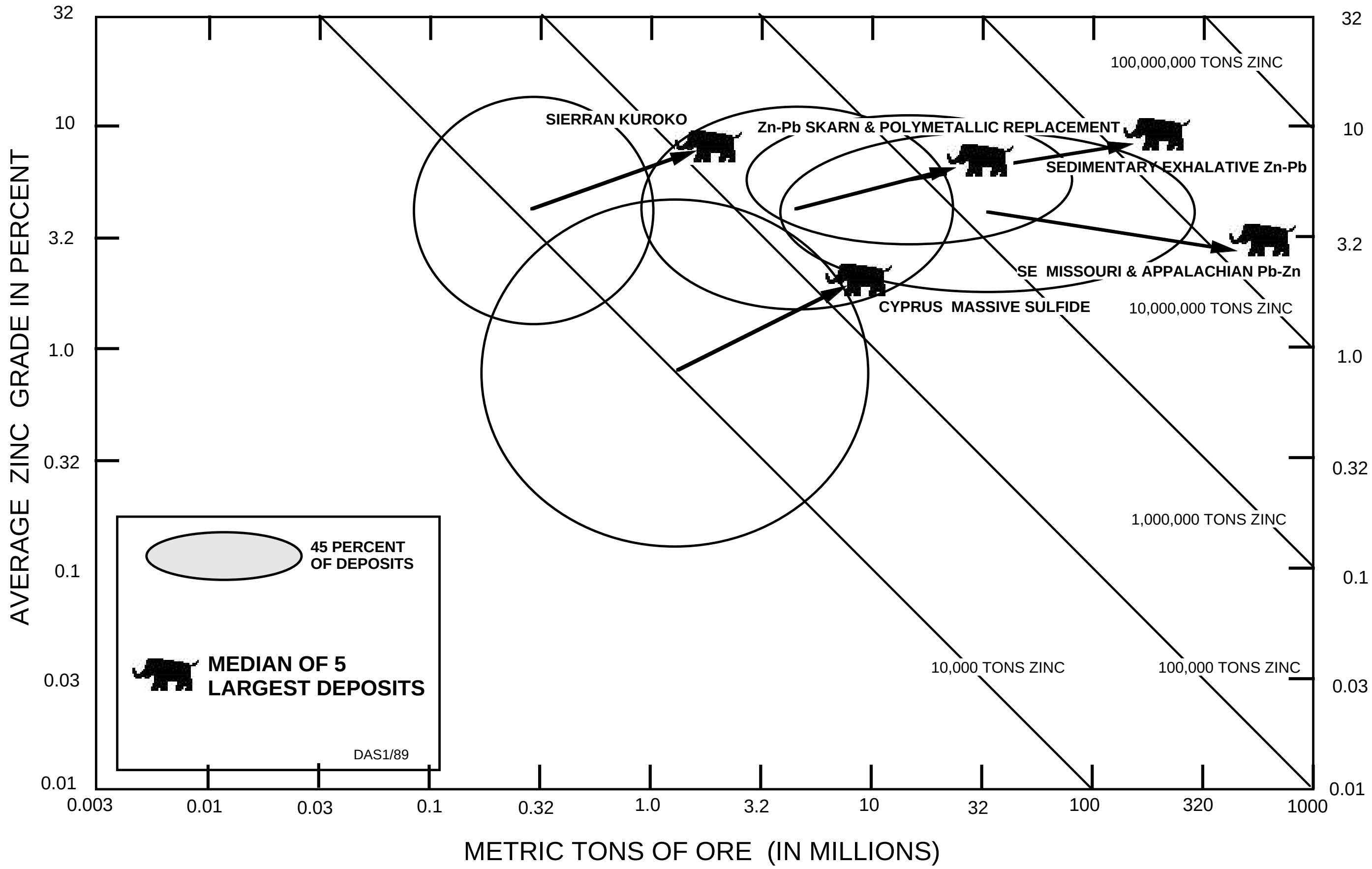

Figure 11-12. Zinc grades and tonnages by deposit type. Median grade and tonnage of each type located at center of ellipse.

sediment-hosted Cu (Mosier and others, 1986b), for perspective. Undiscovered copper skarn districts, porphyry copper deposits, and Sierran kuroko deposits probably exist in Nevada (chapter 12). Southeast Missouri and Appalachian lead-zinc districts (Mosier and Briskey, 1986) are included in the lead (fig. 11-11) and zinc (fig. 11-12) plots. The deposit types that occur in Nevada have relatively high grades, and tonnages that are noticeably lower than the Southeast Missouri and Appalachian deposits. Notable in this regard are Zn-Pb skarn and polymetallic replacement districts which contain high grades for multiple metals and for which undiscovered districts are believed to be present in Nevada (chapter 12).

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