



TRIANGULAR GRAPHS
AS AN AID TO METALLOGENIC STUDIES OF
POLYMETALLIC VEIN DEPOSITS

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INTRODUCTION

Triangular graphs are a common means of depicting relative variations of three components of multi-component systems. They are commonly used in petrology and rock classifications, for example, where the components in question generally constitute a large proportion of the system. In geochemistry they may be used to compare trace element ratios for samples from one environment to another. In this latter application it is possible to plot variables that span several orders of magnitude, certainly one of the advantages of this form of graphical representation. One application of triangular diagrams in the field of ore deposits classification concerns porphyry-type deposits (for example, Kesler, 1973; Sinclair, *et al.*, 1982). These authors use triangular diagrams to show variations in metal ratios involving copper, molybdenum, gold, and silver in several groupings. In order to spread plotted points over a reasonable proportion of the triangular field some of these variables had to be multiplied by a constant. For example, in constructing a copper-molybdenum-gold plot Kesler (1973) transformed all variables to the same units and then multiplied copper by 1, molybdenum by 10, and gold by 10 000. These transformed figures were then recalculated to a pseudo 100 per cent for plotting purposes. This multiplication procedure is essential or all plotted points might be confined to a very small field (a point) or to one side of the triangular graph. Nevertheless, it is important to be aware that multiplying some of the components by different and large numbers has the effect of confusing our natural or automatic interpretation of the diagram. For example, in a triangular graph ABC, the line from A to the mid-point of side BC would normally be expected to represent a ratio for B:C of 1:1. If B has been multiplied by 1 000 and A and C have not, then the aforementioned line in reality represents a ratio of approximately 1 000:1. Obviously, such diagrams should contain labelled reference lines for important ratios.

APPLICATION TO POLYMETALLIC VEIN CAMPS

In our studies of vein camps in southern British Columbia (for example, Sinclair and Goldsmith, 1980) we have found triangular diagrams a useful means of comparing production data from various camps. Data available to us at the time of our study were entirely in per cent (for lead and zinc grades) or ounce per ton (for gold and silver grades). Because of this, and because ratios involving precious and base metals commonly used in the exploration industry are in ounces of precious metal per per cent of base metal (ounce per per cent), we adopted the procedure of plotting triangular diagrams as follows: average grade figures were accepted as quoted (per cent or ounce per ton) and for any three figures (for example, lead, zinc, and silver) the figures were recalculated to 100 per cent assuming they were all the same units, that is, 28 ounces silver per ton, 7 per cent lead, and 5 per cent zinc would be recalculated to apparent percentages of 70 per cent silver, 17.5 per cent lead, and 12.5 per cent zinc.

The four vein-mining camps considered here are Ainsworth, Slocan (Sandon), Slocan City, and Trout Lake (Fig. 97). Each contains from 43 to 204 veins that have had at least one ton of production for which grade data are available in existing computer files (Orr and Sinclair, 1971; Read, 1976; Goldsmith and Sinclair, 1983; and MINFILE) that have been updated and edited by the writers.

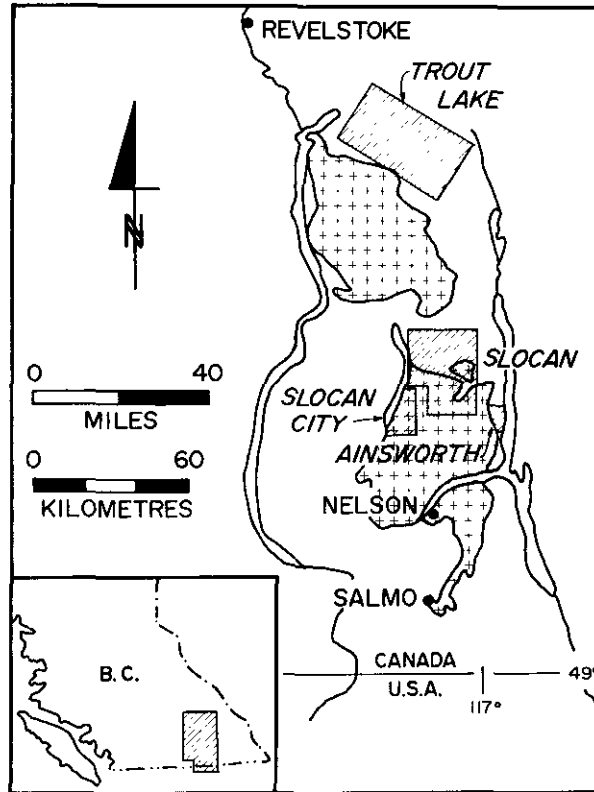


Figure 97. Location of Ainsworth, Slocan (Sandon), Slocan City, and Trout Lake silver-lead-zinc-gold camps, southern British Columbia.

TROUT LAKE CAMP: Triangular plots of average grade data for 43 past-producer vein deposits in Trout Lake mining camp are shown on Figure 98. The greatest spread of data appears in the silver-lead-zinc plot where all deposits for which these elements are available ($n = 38$) plot in about half the field represented by silver(ounce)/lead(per cent) ratios greater than about 0.7. In fact, only five of the 38 deposits have silver(ounce/lead(per cent) ratios less than one. Large tonnage deposits (greater than 600 tons production) are distinguished from moderate to low tonnage deposits by symbols and it is apparent from the plot that no distinction of metal ratio field exists as a function of production tonnage.

The other three plots of Figure 98 seem more effective in separating deposits into meaningful groups. In particular, Figure 98b and 98c clearly separate gold deposits from low to high tonnage silver deposits.

AINSWORTH CAMP: Mean grades of production from 75 veins in Ainsworth camp are shown on triangular plots on Figure 99. The silver-lead-zinc plot is dramatically different from that for Trout Lake camp. Data plot as two clearly defined clusters, one with relatively high silver(ounce)/lead(per cent) ratios (*greater than one*) which is comparable to Trout Lake camp and a second with much lower silver/lead ratios containing most of the deposits in the camp. A second difference from the Trout Lake camp is that a much greater proportion of Ainsworth deposits are zinc rich. Other plots of Figure 99 point to the very low gold content of Ainsworth silver-lead-zinc ores, comparable to the silver-lead-zinc ores of Trout Lake camp.

SLOCAN (SANDON): Average production grades for about 200 deposits from the Slocan (Sandon) camp are plotted as triangular diagrams on Figure 100. On Figure 100a virtually all deposits plot in little more than one-half of the triangular field with silver(ounce)/lead(per cent) ratio of greater than 0.7, comparable to silver-lead-zinc deposits from Trout Lake camp, and to a small subset of deposits from Ainsworth

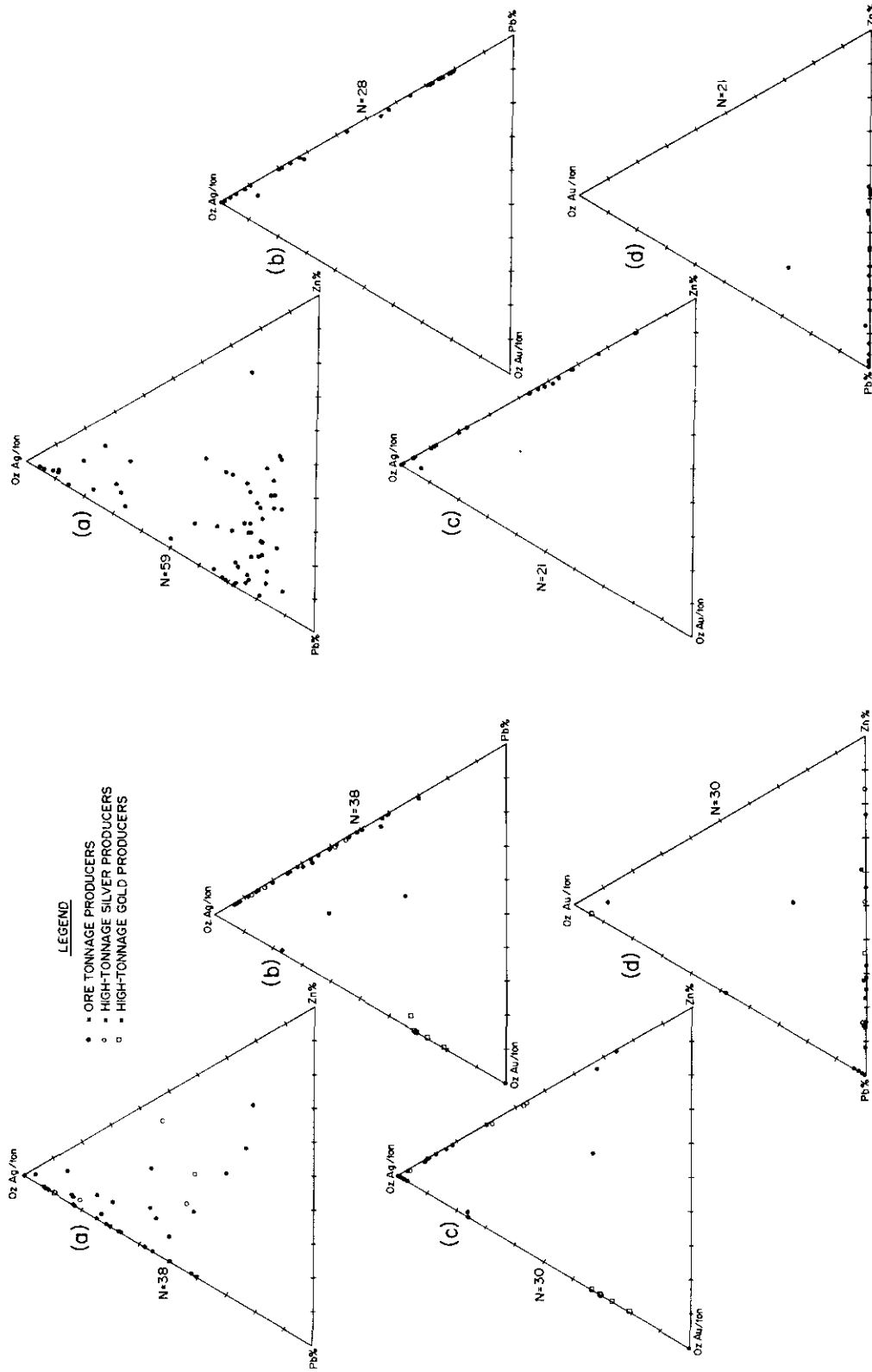


Figure 98. Triangular plots of average production grades for veins of Trout Lake mining camp.

Figure 99. Triangular plots of average production grades for veins, Ainsworth mining camp.

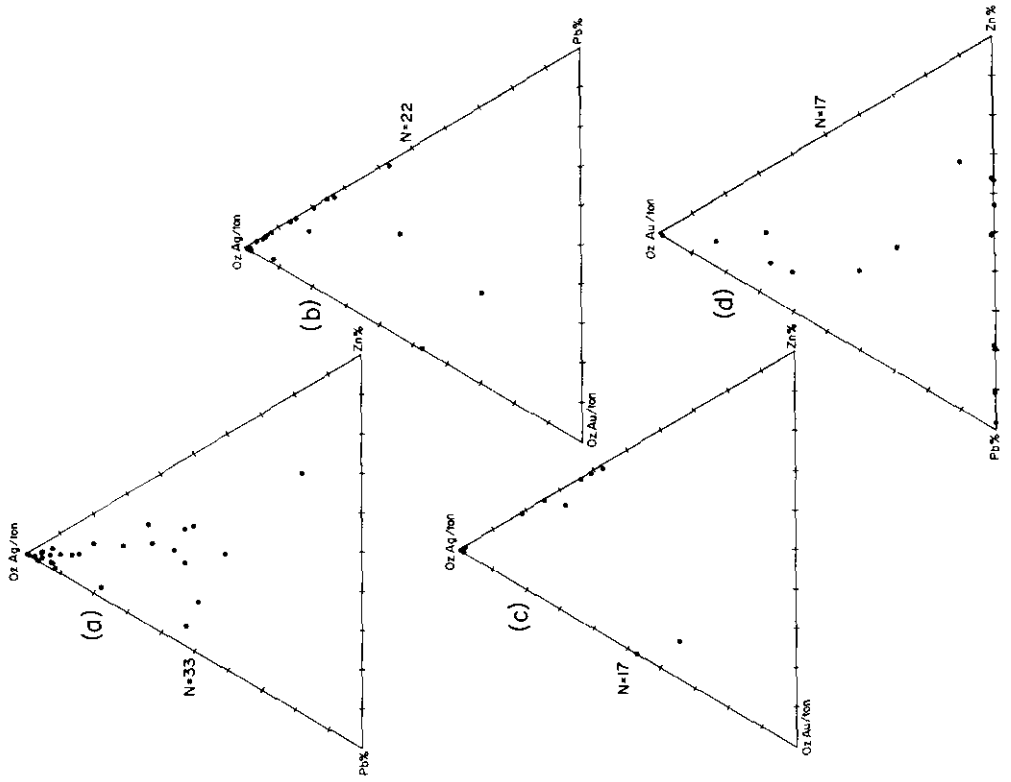


Figure 101. Triangular plots of average production grades for veins, Slocan City mining camp.

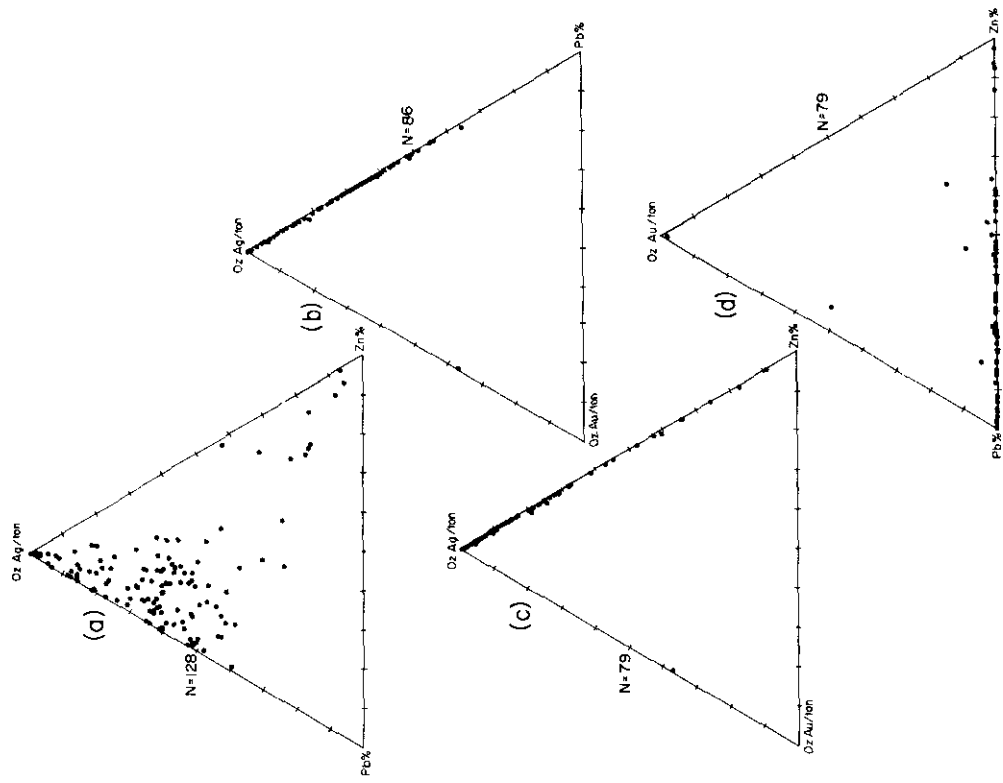


Figure 100. Triangular plots of average production grades for veins, Slocan (Sandon) mining camp.

camp. Slocan ores differ slightly from the other two groups in that a significant group of zinc-rich deposits occurs and seems to form a separate grouping within the high silver(ounce)/lead(per cent) field.

The remaining triangular plots of Figure 100 demonstrate that, like silver-lead-zinc ores from both Ainsworth and Trout Lake camps, Slocan (Sandon) ores are low in gold. Furthermore, the presence of a high zinc population is emphasized by the presence of some plotted points near the zinc vertex of Figure 100c.

SLOCAN CITY: Average grade data for Slocan City polymetallic vein deposits are shown on Figure 101. The silver-lead-zinc plot is clearly comparable to the equivalent diagram for Slocan (Sandon) camp.

The remaining diagrams are based on sparse data sets but one in particular, the lead-zinc-gold plot of Figure 101d, shows that a large proportion (more than 40 per cent) of the plotted deposits are scattered throughout the triangular field rather than plotting along or very near the lead-zinc side. In this respect, Slocan City deposits differ clearly from Ainsworth and Trout Lake ores, and significantly, but to a lesser extent, from Slocan (Sandon) ores. This difference reflects the proportionately greater gold content of many Slocan City veins in comparison with veins from the other three camps considered.

DISCUSSION

Triangular graphs are a practical means of utilizing quantitative chemical information (average grades of recorded production) as a basis for comparing or contrasting polymetallic mineral deposits in vein camps. They probably have a comparable use for portraying other types of polymetallic deposits. The examples studied here involved four polymetallic vein camps with quantitative production data for silver, gold, lead, and zinc. We found advantages in preparing all four possible combinations of the three metals as triangular plots, that is, silver-lead-zinc, silver-gold-lead, silver-gold-zinc, and gold-lead-zinc. Such plots can be obtained rapidly and cheaply as computer-generated plots from computer-based mineral deposit files.

Clustering of points is evident in some cases and differences from one camp to another become readily apparent. Of course, these differences represent relative proportions of various metals and give no indication of differences in absolute amounts.

One of the principal features that we observe is the common occurrence of a silver-rich group of deposits in all four camps, as shown by the occurrence of clusters towards the silver apex on the silver-lead-zinc plots. On this same plot Ainsworth stands out as being fundamentally different in terms of metal ratios because most deposits cluster in a low-silver field towards the lead vertex.

The other major contrast that we note is that Slocan City camp differs from the others in having a much higher proportion of deposits that are relatively enriched in gold.

From a metallogenic point of view the conclusions are of some interest. Slocan (Sandon) and Slocan City camps are clearly related in origin (LeCouteur, 1972) but are surrounded by totally different country rock. Slates, fine-grained quartzites, and tuffs occur in Slocan (Sandon) camp but plutonic rocks of the Nelson batholith predominate in Slocan City camp. It seems likely that country rock has exerted some control on metal content possibly due to: (1) changes in the fluid composition during transport through changing T-P conditions, or (2) local wallrock reaction at depositional sites.

The preponderance of low silver (ounce)/lead (per cent) values for Ainsworth deposits and the clear indication of relatively higher zinc values accentuates their differences from the other three camps examined. The difference is particularly striking in the case of Ainsworth versus Trout Lake because both camps occur in the same lower Paleozoic sequence (Lardeau Group); albeit rocks in the Ainsworth camp have undergone

much higher grade regional metamorphism compared with the Trout Lake camp. Goldsmith and Sinclair (1983) suggested that in Ainsworth camp sulphides first accumulated as seafloor exhalites and subsequently were remobilized locally to form the numerous veins now known, a suggestion supported by lead-isotope data (Andrew, 1982). No clear-cut genetic model has emerged for Trout Lake deposits nor for deposits in the other two camps, although deposits in all camps are clearly epigenetic veins. Differences in metal ratios may reflect fundamentally different origins of the Ainsworth deposits.

Some degree of quantitative information can be retained in triangular graphs by using different symbols for different categories of deposits. We illustrate this for Trout Lake camp (Fig. 98) where three categories of deposits are distinguished by symbols; large tonnage gold deposits, large tonnage silver-lead-zinc deposits; and medium-to-small tonnage silver-lead-zinc deposits. An alternative practical approach might be to represent by one symbol all those deposits that exceed criteria for a minimum exploration target and to code all other deposits by a second symbol.

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