Origin of the Sustut Copper deposit, central British Columbia

by

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ABSTRACT

Sustut copper deposit is in central British Columbia about 370 k northwest of Prince George. Copper concentrations are in the Upper Triassic Savage Mountain formation, mainly in gently dipping tabular zones parallel to bedding and much less abundantly in crosscutting veinlets that occur in local concentrations and with local preferred orientations. Copper-rich zones with economic potential appear to be restricted to a zone of about 200 m within the 700 m-thick, coarse-grained volcaniclastic host, though there are minor occurrences through out . Copper minerals (chalcopyrite, bornite, chalcocite and native copper) and gangue (epidote, quartz and calcite) are common to both veins and tabular zones although proportions of these minerals vary drastically from place to place. Some detailed textural features, especially bornite-chalcopyrite intergrowths, are also common to both veins and tabular zones. Veinlets are predominantly open space filling whereas tabular zones are a combination of open space filling and replacement, commonly with replacement dominant.

Tabular zones and local sets of veinlets appear to have formed an interconnected system permeable to ore fluids, that presumably were derived from below. Comparable veins are reported in underlying Triassic lavas. Thus, veinlets form an integral part of the mineralizing system and become an important evaluation criterion in exploration. Age of mineralization is uncertain but vertical mafic dykes that cut the Savage Mountain formation stratigraphically above the main mineralized zones are premineralization.

Logging of 10,000 feet of diamond drill core representing several cross sections through the main copper-rich zones was done in a thorough and rigorous manner on a coding form designed for input into a computer. This procedure combined with various forms of computer output led to a rapid visual and quantitative evaluation of the data, particularly as regards internal stratigraphy of the volcaniclastic country rock, mineral zoning and the relationship of copper concentrations to wallrock with particular characteristics. In brief, (1) local internal stratigraphy is shown best by layers of sand-sized volcaniclastic rocks, (2) an ideal vertical zoning from margin to core in a tabular zone is pyrite-chalcopyrite-bornite-chalcocite-native copper with much overlap of mineral zones and, in places, the absence of symmetry about the core, and (3) copper minerals statistically are much more prevalent in agglomeratic rocks that are dominantly green (i.e. iron in the reduced state) rather than red.

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Sustut copper deposit, owned by Falconbridge Nickel Mines Ltd., is in central British Columbia about 370 k northwest of Prince George. Copper concentrations are in the Upper Triassic Moosevale formation (figure 1), mainly in gently dipping tabular zones essentially parallel to bedding and much less abundantly in steeply-dipping veinlets that occur in local concentrations and with local preferred orientations. Copper-rich zones with economic potential appear to be restricted to a zone of about 100 m within the 600 m-thick, coarse-grained volcaniclastic host, though there are minor occurrences throughout the Moosevale formation. Copper minerals (chalcopyrite, bornite, chalcocite and native copper) and gangue (epidote, quartz, calcite, prehnite and pumpellyite) are common to both veins and tabular zones although proportions of these minerals vary drastically from place to place. Some detailed textural features, especially bornite-chalcopyrite intergrowths, are also common to both veins and tabular zones. Veinlets are predominantly open space filling whereas tabular zones are a combination of open space filling and replacement, commonly with replacement dominant.

Detailed logging of 10,000 feet of diamond drill core representing several cross sections through the main copper-rich zones was done in a

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rigorous manner on a coding form designed for input into a computer. The coding system used was modified from the GEOLOG system of Blanchet and Godwin (1972). This procedure combined with various forms of computer output led to a rapid visual and quantitative evaluation of various aspects of the mineral deposits and enclosing rocks, particularly as regards mineral zoning and relationship of copper concentrations to various attributes of the country rocks. In brief, (1) local internal stratigraphy is shown best by layers of sand-sized volcaniclastic rocks, (2) an ideal vertical zoning from margin to core in a tabular zone is pyrite-chalcopyrite-bornite-chalcocite-native copper with much overlap of mineral zones and, in places, the absence of symmetry about the core, (3) copper minerals statistically are much more prevalent in agglomeratic rocks that are dominantly green (i.e. iron in the reduced state) rather than red, and (4) specific textural parameters of the host rock can be shown to have been particularly amenable to the occurrence of copper minerals.

Some examples of the types of information that can be retrieved rapidly from a computer processible file are illustrated in figures 2 to 4. Figure 2 shows relative abundance of the various rock types that were coded and allows a quantitative statement as to the predominance of green or red colouration to the rocks because this information is contained in symbols for the abundant rocks types. Figures 3 and 4 are examples of the proportion of 5-foot samples with various physical characteristics, that are mineralized. These and many other comparisons illustrate the correlation of copper minerals and volcaniclastic rocks that have sedimentary features that indicate a high porosity and probably a high permeability prior to mineralization.

A general model for the development of the Sustut copper deposits can be proposed based on traditional geological investigations aided by results of the computer-oriented study of detailed drill log data. Tabular copper zones and local sets of veinlets appear to have formed an interconnected system permeable to ore fluids, that presumably were derived from below (Comparable veins are reported in underlying Triassic lavas). Thus, veinlets form a integral part of the mineralizing system and become an important evaluation criterion in exploration. Age of mineralization is uncertain but vertical mafic dykes that cut the Moosevale formation stratigraphically above the main mineralized zones are premineralization.

In concert with Harper (1977) we speculate that the ore fluid and copper were derived from below, perhaps in part by dehydration metamorphic reactions in underlying basaltic and andesitic flow rocks (figure 5). The upward flow of the hot solutions within a structural zone defined now by swarms of Cu-bearing veinlets produced a confined geothermal high that resulted in a local node of prehnite-pumpellyite facies metamorphism with associated copper minerals. Copper minerals and non-metallic metamorphic minerals were precipitated from the same solutions, both in veins and relatively porous tabular zones, at temperatures near or somewhat above 300°C.

Mineral deposition was apparently affected variably by rock-fluid reactions: some tabular zones have undergone extensive replacement, especially epidotization, whereas others formed by infilling of interstics among grains; some zones contain concentrations of copper minerals with economic potential, others are essentially devoid of copper minerals.

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Monger, J.W.H. & Church, B.N., 1977, Revised Stratigraphy of the Takla Group North-Central British Columbia, C.J.E.S., V. 14 pp. 318-326.

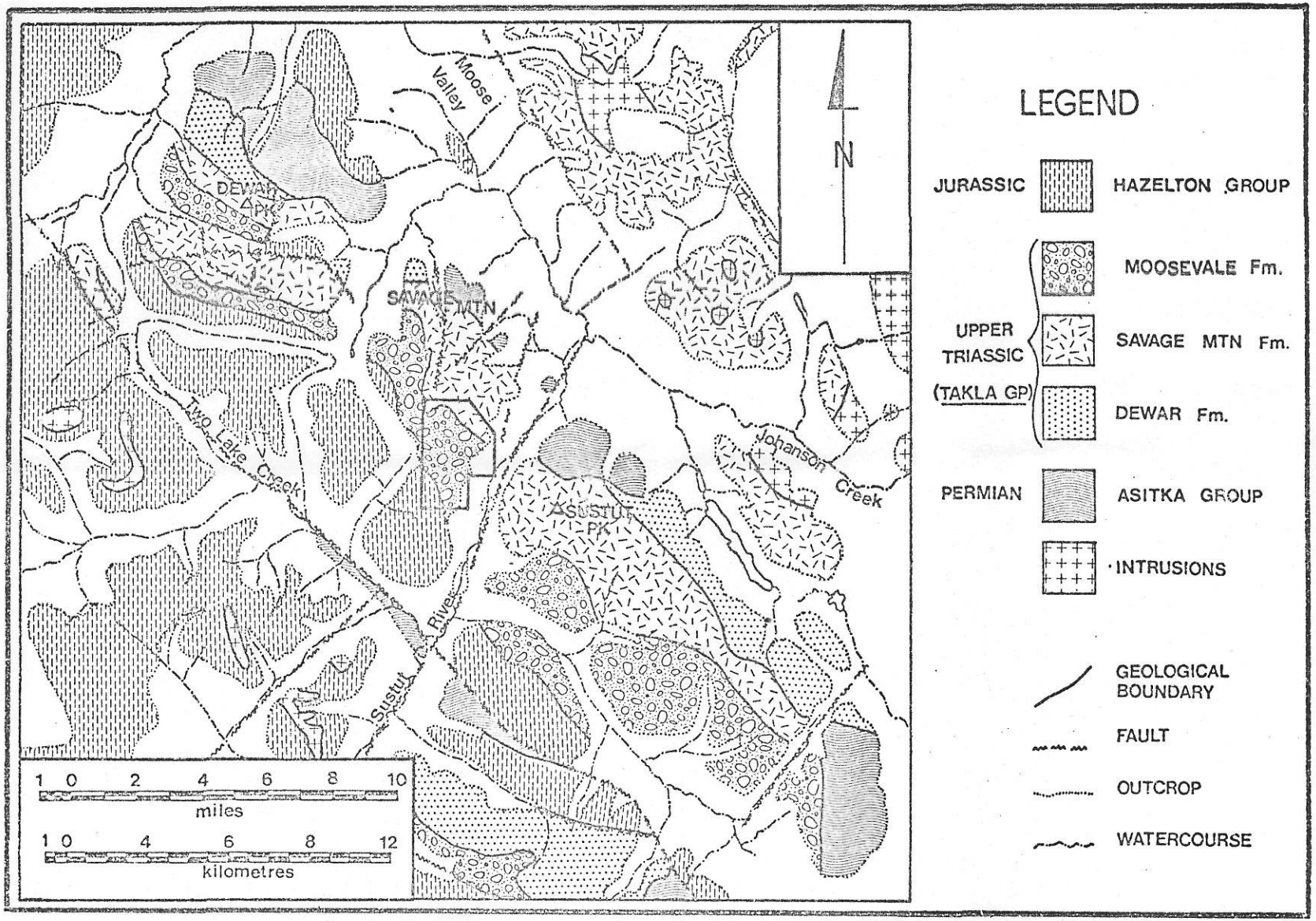

Fig. 1: General geology of an area centred on Sustut Copper deposit, central British Columbia. Modified from Monger and Church, 1977. The outlined area in the centre of the figure is the Sustut Copper property of Falconbridge Nickel Mines.

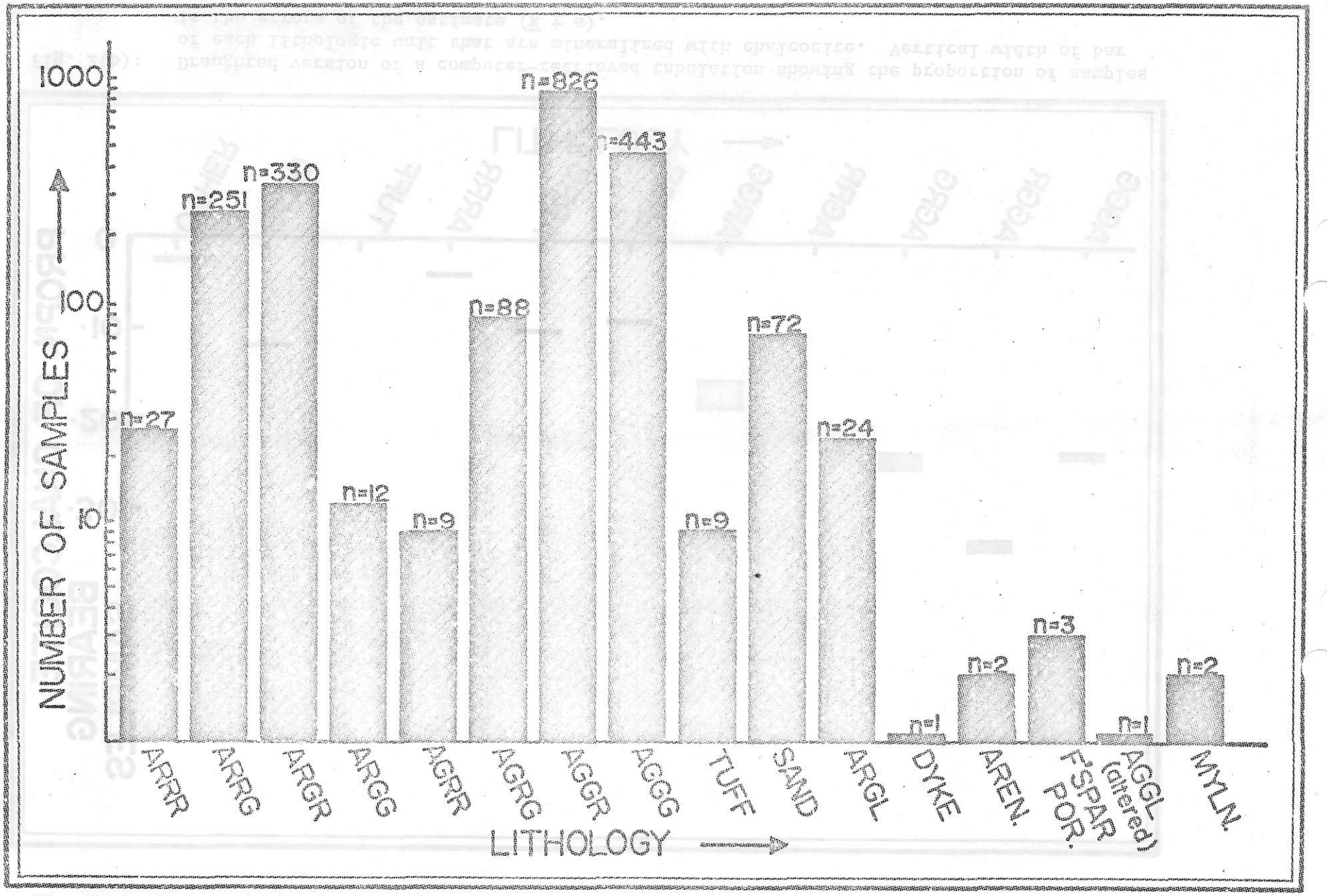

Fig. 2(a): Bar graph showing relative abundances of rock types. Note the log scale for frequency. For a symbol such as AGRG the first A indicates agglomerate, G is green matrix, and the second R before G means coarse red fragments are more abundant than coarse green fragments.

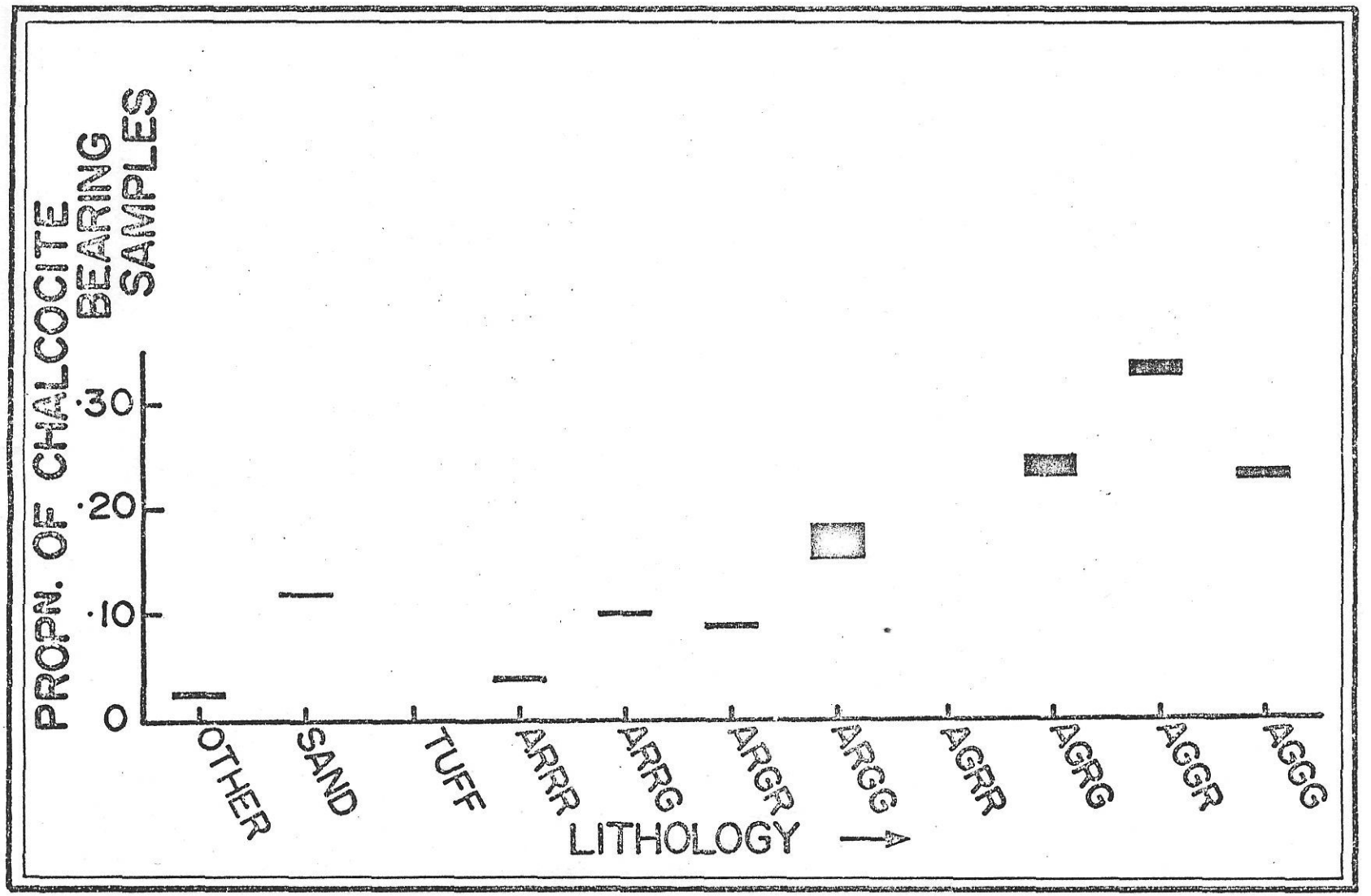

Fig. 2(b): Draughted version of a computer-retrieved tabulation showing the proportion of samples of each lithologic unit that are mineralized with chalcocite. Vertical width of bar is the errors of the estimate ($\bar{x} \pm s$).

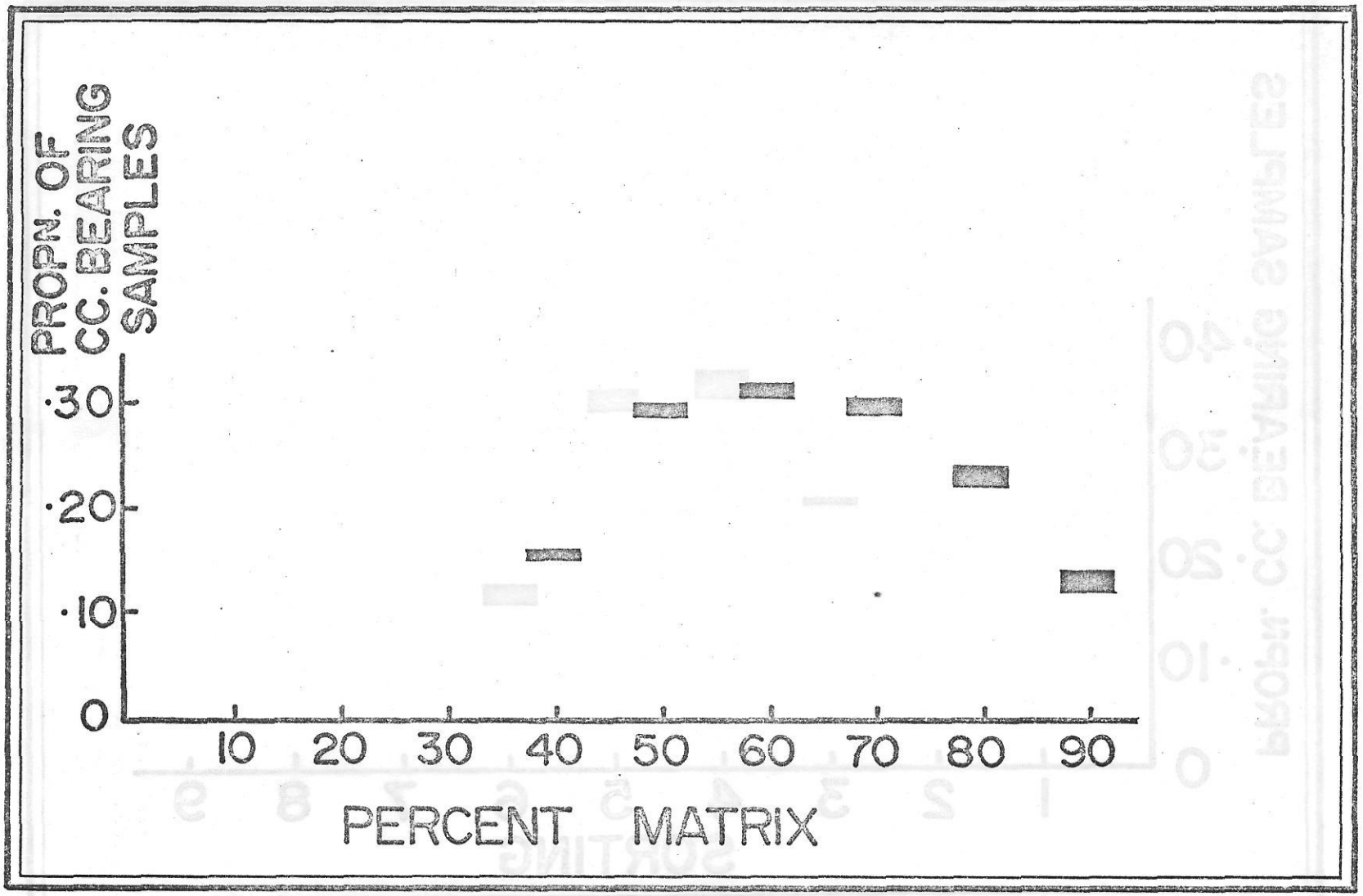

Fig. 3: Draughted version of a computer retrieved tabulation showing the extent (proportion) to which rocks with various percentages of fine to medium grained matrix are mineralized with chalcocite. Vertical widths of black bars are errors of the estimates ($\bar{x} \pm s$).

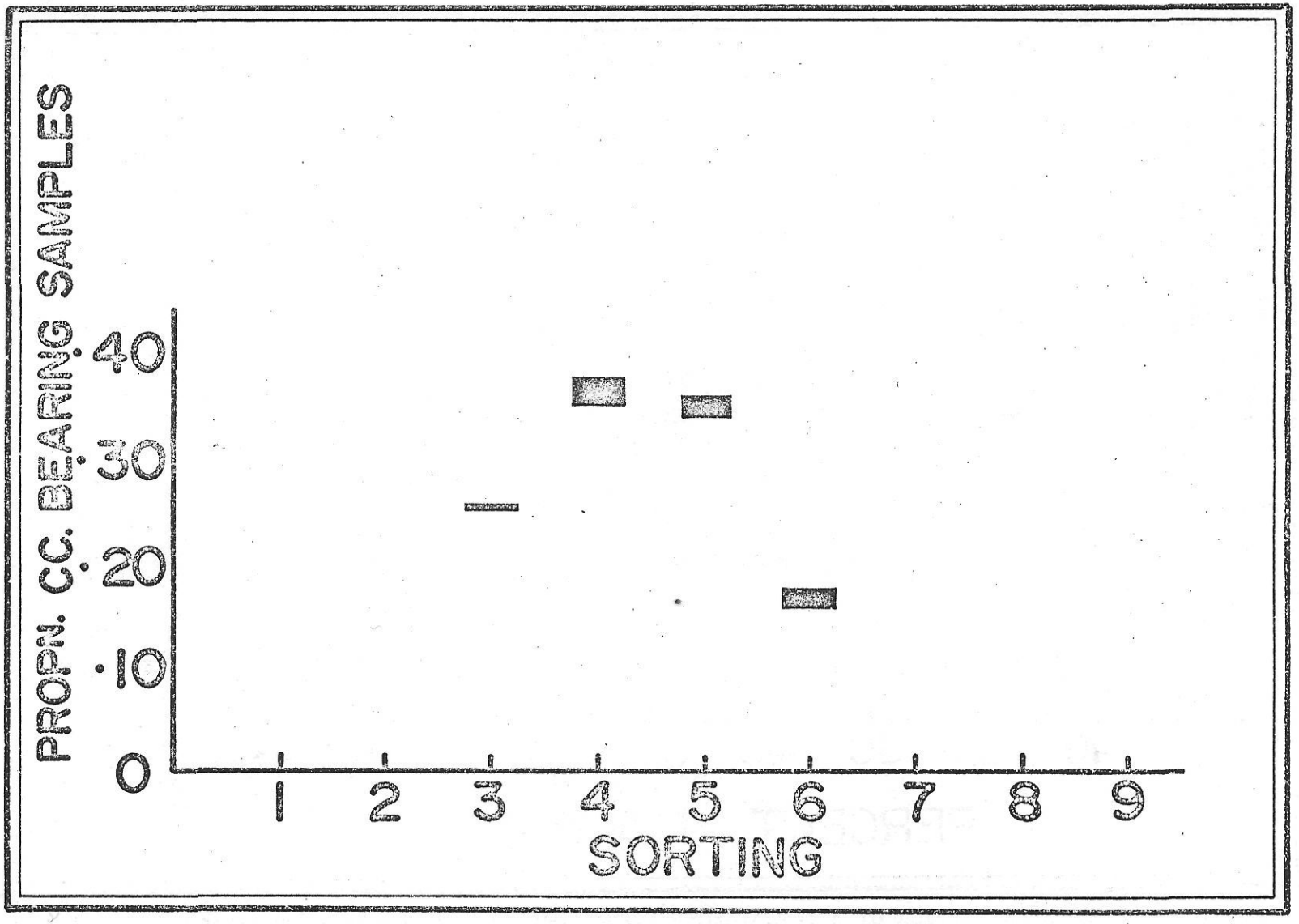

Fig. 4: Draughted version of a computer-retrieved tabulation showing the extent (proportion) to which rocks with various sorting characteristics are mineralized with chalcocite. Vertical widths of black bars represent two standard deviations centred on the mean estimated proportion. It is apparent that rocks with sorting values of 4 and 5 are mineralized to a greater extent than rocks with other sorting values.

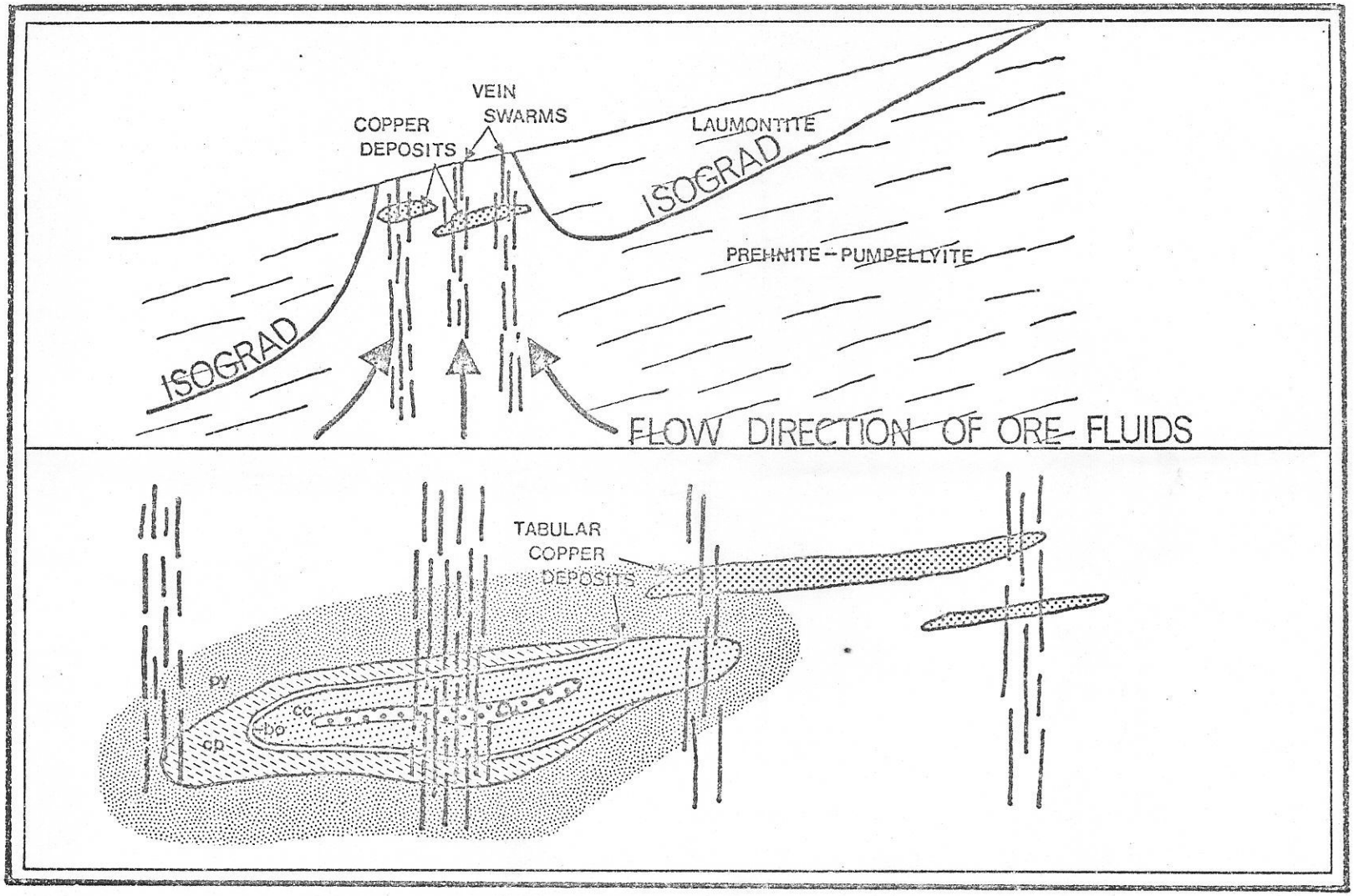

Fig. 5: Conceptual model for genesis of Sustut Copper deposit. The upper diagram shows the deposit localized in a structurally controlled thermal high that caused a node-like irregularity in the regional metamorphic isograds. The lower diagram is a highly idealized illustration of copper mineral and pyrite zoning within a mineralized tabular zone. In reality, zones overlap extensively.