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High- and low-value tails of frequency distributions in geochemistry and mineral resource evaluation

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Initially, many frequency distribution models in geoscience were based on the lognormal model. For example, Ahrens' fundamental law of geochemistry published in 1953 stated that elements in the Earth's crust have lognormal concentration value distributions. Logarithmic probability paper was widely used for fitting one or more straight lines representing lognormal distributions not only in geochemistry but in resource evaluation for total amounts and grade of metals in orebodies as well as for the sizes of oil and gas fields. The multiplicative version of the central-limit theorem was used to justify the lognormal approach. More recently, fitting the Pareto distribution to high-value tails of frequency distributions became more widespread, first from an empirical point of view and later in connection with the theory of fractals.

The high-value tail of a Pareto distribution is thicker than a lognormal tail fitted to the same data, and this has important implications especially in resource evaluation. The low-value tail of a Pareto distribution increases in thickness downward, theoretically reaching infinity at zero-value. In reality, low-value tails generally are observed to decrease in thickness tending to zero-density at zero-value. This paper is concerned with frequency distributions that are approximately lognormal in the vicinity of median-value but have high- and low-value tails that are either thicker or thinner than lognormal. A multifractal variant of the monofractal Turcotte model provides thicker than lognormal tails whereas the multifractal model of De Wijs results in thinner tails. Examples are based on computer simulation experiments and published data sets.