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Scaling laws for the distribution of natural resources

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If scaling laws can be established for the distribution of natural resources, they would have important economic consequences. For example, they can be used to estimate total resources, they can dictate exploration strategies, and they can also point to processes by which natural resources form. A scaling law for the spatial distribution of natural resources can be proposed as:

$$\mathrm{M(r)} \sim \mathrm{r}^{-D}$$

where M(r) is the mass of resource within a circle of radius r. If the mass of individual occurrences of resources is unity, this law describes the Mass Dimension D of the resource, commonly analysed by the number-in-circle method. In this case D is simply interpreted as a measure of the clustering of the resource distribution. Space filling or random distributions have D = 2: lower values indicate a decrease in density with distance. If the mass of resource varies at each occurrence (as typical in nature), then $\mathrm{M(r)} \sim \mathrm{r}^{-D}$ is a general scaling law, with an exponent that is referred to here as the Mass-Radius scaling exponent. This exponent can have values greater than 2.

Mass Dimensions and Mass-Radius scaling exponents have been determined in this study for Archean gold deposits in Zimbabwe, direct use of geothermal energy in Oregon, geothermal energy use in New Zealand and conventional and unconventional gas production in Pennsylvania. Mass Dimensions vary between 0.4 and 2, reflecting the variable clustering of the data sets. The highest values are from conventional gas production, while unconventional gas production and geothermal energy have lower values. In general Mass Dimensions and Mass-Radius scaling exponents are similar in any data sets. An interesting consequence is that an approximate value for the Mass-Radius scaling exponent can be given by the Mass Dimension. It is commonly hard to measure the Mass-Radius scaling exponent because accurate data for mass is difficult to obtain. The similarity of the two exponents suggests that substituting the Mass Dimension for the Mass-Radius scaling exponent can solve this problem to some limit of accuracy, but the generality of this relationship needs testing on more data sets.