

Quantitative evaluation of the distribution of a variable within a solid by a method using constitution and distribution heterogeneities of P. Gy, application to textural study of ores.

Luc Barbanson, Stanislas Sizaret

▶ **To cite this version:**

Luc Barbanson, Stanislas Sizaret. Quantitative evaluation of the distribution of a variable within a solid by a method using constitution and distribution heterogeneities of P. Gy, application to textural study of ores.. Congrès SEM /SFMC: hydrothermalisme, solution aqueuses et minéralogie, 2005, Biarritz, France. hal-00090355

HAL Id: hal-00090355
https://insu.hal.science/hal-00090355

Submitted on 8 Sep 2006

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Congrès SEM /SFMC: hydrothermalisme, solution aqueuses et minéralogie, 03/11-04/11, Biarritz.

Quantitative evaluation of the distribution of a variable within a solid by a method using constitution and distribution heterogeneities of P. Gy, application to textural study of ores.

Barbanson L. and S. Sizaret, (**2005**).

Luc Barbanson and Stanislas Sizaret
ISTO Université d'Orléans,Bâtiment Géosciences, Rue de St Amand BP 6759, 45067 Orléans Cedex2, Luc.Barbanson@univ-orleans.fr

The textural description of a solid can be seen as a two stages job. The first one consists in determining the mineralogical composition and the size of the components. Information collected during this step will be named Granularity Parameter (GP). The second stage is a study of the spatial distribution of the components, called below Distribution Parameter (DP). The proposed method quantifies GP and DP by respectively constitution heterogeneity (HC) and distribution heterogeneity (HD). HC and HD are functions defined by P. Gy, 1982 and 1988 in his "Theory of particule material sampling".
The characterisation of a texture generally requires the use of several variables. For example, the Folk and Land classification of limestone involves at least two parameters: the size of the matrix components and the clasts relations. Let be first consider a way to quantify the distribution of one variable.
The first step is to split up the "real solid" into elementary units (EU), the set of EU makes up the "model solid". A given real solid can be resolved in different model solids according to the definition of the EU. In this way, EU in a mineralized breccia can be defined as mono crystalline grains or as elements and cement. The studied variable must be measurable within each EU. For instance, if an ore is split up into mono crystalline grains and if the studied variable is the valuable mineral content, his measure, at the EU scale, is 1 if the EU is a grain of valuable mineral and 0 if the EU is a gangue mineral.
The contribution of an EU i to the heterogeneity of the model solid with respect to a variable ϕ can be evaluated (Gy, 1988) by: $h_{\phi,i} = \left(\frac{a_{\phi,i} - a_\phi}{a_\phi}\right) \cdot \left(\frac{V_i}{\overline{V}}\right) = n \cdot \left(\frac{a_{\phi,i} - a_\phi}{a_\phi}\right) \cdot v_i$; where n is the number of EU; V_i the volume of the EU i; $V_\Sigma = \sum_{i=1}^{n} V_i$ the volume of the solid; $v_i = V_i / V_\Sigma$ the relative volume of i; $\overline{V} = (1/n) \cdot \sum_{i=1}^{n} V_i = V_\Sigma / n$ average of V_i; $a_{\phi,i}$ the measure of ϕ in i; $a_\phi = \sum_{i=1}^{n} (a_{\phi,i} \cdot v_i)$ the value of ϕ in the solid.
According to Gy, 1988, the heterogeneity of constitution of the solid (HC_ϕ) with respect to the variable ϕ is the variance of $h_{\phi,i}$: $HC_\phi = \mathrm{var}(h_{\phi,i})$. HC_ϕ is an intrinsic characteristic of the solid taking into account the magnitude of ϕ in the solid and the size of components; therefore HC_ϕ can work as an estimate of GP.
HC_ϕ is independent of the distribution of ϕ in the solid. To account for this factor, let consider a network devoted to gather information on the spatial distribution of ϕ. This network would

be designed in a way insuring homogeneity during collection of data. This could be done with a cubic periodic lattice characterised by: the volume V_{MO} of the cell and the scale of observation ($\alpha = V_\Sigma / V_{MO}$). Unbiased condition is realized if the lattice strictly fit the solid. The contribution of a cell j to the heterogeneity of ϕ in the model solid can be evaluated by: $h_{\phi,\alpha,j} = \left(\frac{a_{\phi,\alpha,j} - a_\phi}{a_\phi}\right) \cdot \left(\frac{U_j}{\overline{U}}\right)$; where $a_{\phi,\alpha,j}$ is the measure of ϕ in the cell j belonging to a lattice of scale α; U_j the volume of matter assigned to the cell j; $\overline{U}$ average of U_j. To distinguish between an aggregate of EU identical in nature and one EU of the same composition displaying a volume equal to that of the aggregate, the following rule is adopted: all EU which barycentre belong to the cell j are assigned to j. As a result of this rule, U_j can be greater than V_{MO} and some cells can be empty. Let $\beta(\alpha)$ the number of cell devoid of matter. According to Gy, 1988, at the scale α, the heterogeneity of distribution of the solid with respect to the variable ϕ (= $HD_{\phi,\alpha}$) is the variance of $h_{\phi,\alpha,j}$:

$$HD_{\phi,\alpha} = \mathrm{var}(h_{\phi,\alpha,j}) = (\alpha - \beta(\alpha)) \cdot \sum_{j=1}^{\alpha-\beta(\alpha)} \left[\left(\frac{a_{\phi,\alpha,j} - a_\phi}{a_\alpha}\right) \cdot u_j\right]^2;$$

where $u_j = U_j / V_\Sigma$ is the relative volume of matter assigned to the cell j. $HD_{\phi,\alpha}$ is a function of: (1) the scale α of the lattice, (2) the spatial distribution of ϕ. This function display two useful properties:

(i) If $V_{MO} = V_\Sigma \Rightarrow \alpha = 1 \Rightarrow HD_{\phi,\alpha} = 0$.

(ii) There is a value α_c such as $\forall j, n_j = 0 \text{ or } 1 \Rightarrow$ for $\alpha \geq \alpha_c$ $HD_{\phi,\alpha} = HC_\phi$, where n_j is the number of EU assigned to the cell j.

Therefore diagram $HD_{\phi,\alpha}/HC_\phi$ versus α can be used to compare distributions of ϕ in distinct solids and, for a given solid, the integral $A_\phi = \int_1^{\alpha^*} \frac{HD_{\phi,\alpha}}{HC_\phi} \cdot d\alpha$ is defined without ambiguity. So, A_ϕ can work as an estimate of DP.

Among the parameters defined above, some, as α_c and $\beta(\alpha)$, characterise the geometry of the EU; some, as $HC\phi$ and $A\phi$, can be used to assess the "texture" of a variable ϕ. $\beta(\alpha)$ is a function of: α, V_i, size distribution of V_i, morphology and orientation of EU. So, a diagram $\beta(\alpha)$ versus α can give granularity information on the model solid. A textural description involves generally several variables. Let consider a texture characterised by K variables. At least, two graphical representations of such texture can be done: either a spider like diagram $HD_{\phi_k,\alpha}/HC_{\phi_k}$ (k=1 to K) versus α, where $HD_{\phi_k,\alpha}/HC_{\phi_k}$ contour lines delineated a landscape accounting for the texture; or a HC_{ϕ_k} versus $A\phi$ diagram where the set of K points represent the texture. A textural change, in the first case appears as a relief evolution, in the second case as K different translations working on the initial K points.

In the line of the work of Martin et al., 2005 on classification of soils, studies in process deal with an interpretation of $A\phi$ and $HC\phi$ as relative entropy through the Shannon theory of information.

References

Gy P., 1982 – Sampling of particulate materials. Elsevier, Amsterdam, 431p.
Gy P., 1988 – Hétérogénéité, Echantillonnage, Homogénéisation. Masson, Paris, 607p.
Martin M.A., Rey J.M. & Taguas F.J., 2005 – An entropy-based heterogeneity index for mass-size distributions in Earth science. Ecological Modelling, 182, 221-228.