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Mono-energetic Micro-computed tomography(μCT) A reliable potential alternative to mineral Investigation of formation rock

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Traditional mineral investigation techniques are normally destructive and although they provide very useful information, they come with disadvantages and limitations some of which cannot be ignored. A case in point is the mechanical damage in the preparation process of SEM scanning during which artifacts will be introduced to the results. Micro-computed tomography (μCT) in combination with Finite Element Analysis (FEA) based simulation provides a unique opportunity to develop a non-destructive analysis tool. The workflow is as follows:
First, the μCT provides a voxel-based image. Using the already commercial software, this image can be translated into a 3D digital version, meaning that the pore-throat network and the grain structure are modeled and mapped digitally. At this point, porosity, permeability, pore size distribution, capillary pressure and etc are the deliverables. To Apply a structural analysis, a mesh can be created using the geometry of the sample. This mesh can then be used by a finite elements simulator to simulate mechanical properties like strength. The Application of Random field theory is necessary to count for the heterogeneity of the sample.
As for mineral detection,here we have used monoenergetic μCT. The novelty of the technique is to scan some reference materials alongside the sample. There are some subtle points to consider in the choice of the reference material, for example, the density of the reference materials should be distributed alongside the histogram.
Since the density(ρ) of the reference materials is known, the intensity(⊠) and the pertaining standard deviation can be easily calculated which will be used to correlate a particular density to intensity. Using the histogram, the count for the calculated intensity is the volume of the related density. This volume can again be converted to weight percentage using density.
Important to note is that before applying this technique a database must be created that includes the mineral phases/groups we are expecting. Here, this was done by scanning and analyzing three samples. The minerals in the fourth sample then was predicted using the μCT and was compared afterward with the XRD results. A good similarity is found.
The Differences could be owing to the presence of different mineral groups with similar densities. This problem can be addressed by considering more elements (for example topological factors) into consideration. Moreover, we can increase the accuracy of the (⊠, ⊠) function by using more reference materials.
Conclusion
As a proof of concept, a simple yet relatively accurate method is described here to confirm that minerals can be identified by mono-energetic μCT. To do so, an initial database was necessary. Using four reference materials with known densities, a regression model was used to correlate the pixel intensity with the density of the reference materials in the first step and with the density of minerals in the second step. Afterward, by using the frequency (counts in the histogram), the minerals abundance was quantitatively calculated for a new sample that was not used for the development of the model.

Participation

In-Person

References

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