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The Pore3D software library applied to the quantitative morphological and textural analysis of three-dimensional images in geosciences

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Imaging techniques play an important role in several research fields of the geosciences. As an example, the well-known scanning electron microscopy (SEM) technique is a widely adopted tool for the investigation of the texture of volcanic rock samples. X-ray based techniques are also of particular interest and, for instance, X-ray microradiography has proved to be useful for the monitoring of the heavy-metal accumulation in vegetal tissues.

In recent years great interest has been posed in tomographic techniques like X-ray computed microtomography (μ-CT) and the micro-scale magnetic resonance imaging (μ-MRI) as they produce three-dimensional (3D) images of the internal structure of objects. In fact, investigations performed directly in the 3D domain overcome the limitations of stereological methods usually applied on SEM-based analysis. Moreover, μ-CT and μ-MRI techniques enable to get 3D images of the internal core of a sample in a non destructive way and with a spatial resolution in the micro-meter scale more suitable for further quantitative analysis. An intriguing challenge lies on the extraction of quantitative measures and indices directly from these kinds of images. Porosity and specific surface area as well as anisotropy, connectivity and tortuosity are interesting descriptors of a 3D model. However, accurate image processing and analysis methods for an effective assessment of these parameters are still an open issue in several applications.

The present work illustrates the *Pore3D* software library developed by the SYRMEP research group of the Elettra Synchrotron Light Laboratory in Trieste (Italy). Although any kind of 2D image and 3D dataset is a valid input, *Pore3D* has been conceived for the handling of X-ray μ-CT images. In fact, the particular case of high-resolution μ-CT images requires *ad hoc* software tools able to manage large 3D dataset in an easy way. Several commercial software and public available libraries as well as research codes have been developed in recent years for 2D and 3D image analysis. Within this framework the Pore3D project merges many of the features implemented in existing software tools, customizing in some cases their characteristics or adding new tools, on the basis of the specific know-how acquired inside the SYRMEP collaboration. Moreover, a custom developed software assures a complete control of the algorithm implementation and permits different strategies of analysis as a function of the specific scientific application. The current version of *Pore3D* consists in a library of state-of-the-art functions and procedures for filtering, segmentation and quantitative analysis of images. It is also under study the deployment of *Pore3D* according to the *software-as-a-service* paradigm.

In this work we present several applications of the *Pore3D* software to the extraction of quantitative information from μ-CT images of geomaterials. In particular, some results obtained in the characterization of texture and 3D shape orientation distribution of crystals and vesicles in volcanic products will be illustrated.