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X-ray high resolution micro-CT of thin sections: A new calibration approach between classical "2D" thin-section studies and "3D" CT analysis

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Micro-CT has been introduced into geosciences since the early eighties, initially mainly as a visualization technique but recently as a more accurate technique which allows to quantify rock constituents, porosity and rock texture. The technical revolution of the last decennia has constantly improved the resolution of the acquired CT-scan images. However, the detailed calibration of micro-CT reconstructed image data in terms of mineralogical quantification, quantification of diagenetic phases and porosity is still a key-issue. Different geological studies calibrate the 3D CT-scanned samples by comparing 2D thin sections or a polished surface of the scanned material with the corresponding (best fit) 2D CT scanned slice (f.e. Van Geet et al., 2001). However, it is often very difficult to find back the corresponding slice in the CT image, especially since the latter not necessarily is plane parallel to the studied thin sections and physically not exactly the same. To reduce the possible mismatch, image analysis might help to define the most likely CT plane that matches the thin section (Kerckhofs et al., 2008). The latter calculations are, however, time-consuming and require important computational power. Moreover, the complex multi-mineral composition of geo-samples often increases the difficulty to carry out and thrust this cross-correlation between physically different samples.

In this study we explore the possibilities and the advantages of scanning two-dimensional thin-sections directly. In this way, calibration is easy, time-effective and straight-forward. Based on pre-scanning computer simulation it is furthermore possible to define the most suitable operating scan parameters to discriminate different mineral and diagenetic phases in complex multi-component geological materials. The following case studies will be discussed:
- diagenetically altered deltaic sandstones, where apart from authigenic kaolinite also ankerite and siderite occur as major diagenetic phases;
- Khuff carbonates, yielding a high oomoldic porosity with different degrees of dolomitisation and anhydrite cementation/replacement;
- hydrothermal dolomites, where an attempt is made to calculate the amount of post –hydrothermal pore occluding calcite to define the original pore distribution before calcite cementation.

The possibility to extrapolate the interpreted 2D thin-section CT image to the 3D rock volume represents a new revolutionary calibration method for CT results. This approach allows a more accurate segmentation of the 3D micro-CT results, which enables to work out a more consistent quantification of rock constituents (detrital and diagenetic mineral phases and porosity). Obviously the resolution of classical thin section microscopy or polished surface microscopic analysis is higher then the resolution acquired by present-day micro-CT. So, this approach can be seen as an important step in the development of an adequate "up-scale" methodology bridging the gap between 2D and 3D petrography each characterized by different scales and resolutions. Additionally, by geostatistical analysis and based on the calibrated 3D results of the scanned samples (after the proposed 2D thin section calibration method), comparison with and up-scaling to medical CT scans (at lower resolution) and finally core log analysis is possible.

Keyword: high resolution micro-CT, thin section, calibration

References

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