Provenance identification of detrital quartz using the hot-cathode cathodoluminscence (CL) microscope: a study of quartz sandstones of the Scotian Basin

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Determining the source of sedimentary detritus of the Lower Cretaceous deltas of the Scotian Basin is important for understanding the distribution of reservoir sandstones and their subsequent diagenesis. It thus contributes to both exploration models and to understanding reservoir quality. Quartz is the principal mineral in reservoir sandstones, but most quartz grains have few characteristics that are diagnostic of provenance. The technique of hot-cathode cathodoluminescence (CL) provides a method of identifying quartz from different sorts of igneous, hydrothermal, and metamorphic rocks.

Quartz of different origins shows different colors after the first few seconds of exposure to the CL beam and after the color shift has completed. Representative bedrock samples of possible source rocks from the Appalachian orogen were collected and the CL characteristics of quartz of known origin were determined. CL criteria were established for the following six types of quartz: plutonic and hypabyssal, volcanic, aplite and vein, low-grade metamorphic, medium-high-grade metamorphic and high-pressure metamorphic quartz. Once quartz grains have been exposed to the electron beam, the initial CL color cannot be reproduced. We have developed a protocol that records which areas of thin sections have been exposed to the CL beam in order to ensure that true initial CL colors are captured in photomicrographs. Colours are captured by digital photography at three and twelve seconds exposure to the CL beam. The origin of individual detrital quartz grains is then interpreted from the CL photomicrographs, and petrographic features.

In order to test the developed protocol for determining quartz provenance, 890 quartz grains from a sample of the Logan Canyon Formation in the Peskowesk A-99 well were analyzed. Provenance results using this method were reasonably consistent with results of provenance studies involving the same samples using both lithic clast and zircon geochronology, although some important differences were noted. Provenance data collected using lithic clasts reported no vein quartz and a higher abundance of igneous quartz. This is probably because sand-sized vein quartz would normally be indistinguishable from monocrystalline quartz of other origins and because the lithic clast data tend to overestimate the overall supply from igneous rocks since igneous quartz tends to be coarser grained than metamorphic quartz. Also, the reported proportion of volcanic quartz by CL is slightly lower than from detrital zircon geochronology. It is probable that there was a bias towards dating nice-looking euhedral volcanic zircon grains which explains this discrepancy. The developed protocol has since been employed to determine provenance of quartz grains in sandstones from various depths in wells Alma K-85, Venture B-13, and Thebaud I93. Our results so far thus suggest that hot-cathode CL imaging is a powerful method for determining the provenance of quartz grains in Scotian Basin sandstones.

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