A protocol for determining provenance of quartz grains in sandstones using the hot-cathode cathodoluminscence (CL) microscope

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Determining the source of sedimentary detritus to 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 colours 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 Appalachians 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, volcanic, undivided igneous, vein, medium-high grade metamorphic, and low grade metamorphic quartz.

Once a grain has been irradiated, the CL properties cannot be reproduced. A protocol has been developed that ensures that each part of a thin section is only irradiated once. Colours are captured by digital photography at 3 and 12 seconds after irradiation commences. The origin of individual detrital quartz grains is then interpreted from the CL photomicrographs, and petrographic features.

A test sample of 890 quartz grains from the Logan Canyon Formation in the Peskowesk A-99 well contained 32.6% plutonic, 31.7% low grade metamorphic, 25.4% vein, 4.27% volcanic, 3.20% medium-high grade metamorphic, and 2.90% undivided igneous quartz. Sand-sized lithic clasts from the same sample, determined by standard petrographic microscope, comprise 17.7% polycrystalline quartz of igneous origin, 12.7% polycrystalline quartz of metamorphic origin, 16.5% deformed (metamorphic) polycrystalline quartz from mylonite, 45.6% igneous rocks (both plutonic and volcanic), and 2.50% metamorphic rocks. No vein quartz was recorded, as sand-sized vein quartz would normally be indistinguishable from monocrystalline quartz of other origins. The lithic clast data thus tends to overestimate the overall supply from igneous rocks, probably because igneous quartz tends to be coarser grained than metamorphic quartz. The proportion of volcanic quartz by CL is reasonably consistent with the proportion estimated from detrital zircon geochronology: 11% of dated zircons are volcanic, but there was probably a bias towards dating nice-looking euhedral volcanic zircon grains. The developed protocol has since been employed to determine provenance or quartz grains in sandstones from various depths in wells Alma K-85, Venture B-13, and Thebaud I93. 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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