Cathodoluminescence and trace element distribution in authigenic quartz in sandstones

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The differentiation of diagenetic quartz overgrowths from detrital quartz grains is easily done by cathodoluminescence (CL) observations as shown in the 1960's (Smith and Stenstrom, 1965, Sippel, 1968). Cathodoluminescence and backscattered electron image analysis techniques were used to quantify detrital and authigenic quartz as well as pore volumes (Evans et al., 1994, Demars et al., 1994). However, the causes of the CL variations are only partially understood and it is still impossible to interpret the CL in terms of diagenetic conditions. In a first publication (Demars et al., 1996), we have shown that combination of CL image and spectra with secondary ion mass spectrometry (SIMS) analyses help to better understand the relation between the trace element content and the CL signal. In the case of the Triassic sandstones from the Paris basin, the main CL emission band at 330-340 nm is related to the Al and Li content of diagenetic quartz.

A systematic study of authigenic quartz occurring as overgrowths on detrital quartz grains in sandstones is in progress. There cathodoluminescence (CL) properties are investigated with a system consisting of a parabolic mirror, a silica window allowing the passage of UV emissions, a grating spectrometer and a photomultiplier in order to record CL spectra between 200 and 900 nm (Blanc et al., 1994). Quantitative in-situ trace element determination in the ppm range is realized using secondary ion mass spectrometry. The Al content is also determined by electron microprobe analysis.

The following data are presented and discussed:

(1) The trace element content (Al, Li, Na, K, Ti, Mn) of diagenetic quartz overgrowths is variable in a quartz overgrowth, in different overgrowths from the same sample and in different sedimentary formations.

(2) The Al content of some quartz overgrowths reaches up to 3000 ppm (Triassic sandstones from the Paris basin and the Ardeche paleomargin). In some oil field reservoir studies, the Al content is generally lower than 400 ppm. With the increase of the Al content, there is also an increase of the Li content. There are Al zonations related to growth patterns.

(3) The CL spectra obtained on different quartz overgrowths are highly variable. The intensity of the 330-340 nm emission band is correlated to the Al content of quartz. At the present stage of the study, this is the only obvious relation between the trace element content and the CL emission bands. However, the low content

of other trace elements does not facilitate the correlation. In this case, data must be obtained on synthetic doped crystals.
(4) The intensity of the 330-340 nm emission band is increased by alpha irradiation as observed in samples from the Oklo uranium deposit (Gabon) where the Al content reaches up to 1400 ppm.

In summary, the conclusion of Demars et al (1996) on the Triassic sandstones from the Paris Basin is generalized. The emission band at 330-340 nm is related to Al and Li content of quartz but it is still difficult to definitively conclude on the cause of the CL emission.

The variation of trace element content in quartz overgrowths opens a new avenue of research and a correlation with in-situ oxygen isotopes data is needed.

In sandstones, the combined use of cathodoluminescence with trace element analysis, fluid inclusions studies, oxygen isotopes determination on quartz could give important informations on several topics : origin of the detrital quartz, silicification stages, dissolution, microfracturation, relative time of hydrocarbon migration,...

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