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U-Th-Pb in petroleum by LA-ICP-MS: Source rocks-crude oils comparison.

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The U, Th elemental and Pb isotopic ratios in petroleum source rocks have been determined for the first time and compared with crude oils from different regions in the World using a femtosecond laser ablation (high ablation rates) coupled to an ICP-MS and direct analysis of digested samples on ICP-MS.
The advantage of femtosecond compared to nanosecond laser ablation is that it drastically reduces thermal effects, minimizes isotope and elemental fractionation and matrix effects during chemical analysis of solid samples. Fs-Laser Ablation coupled to an ICP-MS is therefore a potentially valuable tool for the determination of trace metals in crude oils as well as in solid samples such as source rocks.
The principal problems encountered arise from the lack of isotopic lead standards in organic matrixes and the heterogeneity of source rocks which contain sulphides with high natural U and Th concentrations. Therefore, to determine exactly the U, Th and Pb contents in source rocks, two analytical techniques have to be compared. In one, the use of the laser ablation allows us to analyze in-situ small parts of the organic materials and to determine the proportions of two end members: pure kerogene and pure sulphides. In the other, the use of the conventional dissolution of the same pellets involves total consumption of the sample and gives an average value of the isotopic lead ratios and U, Th and Pb concentrations of the bulk sample. For the two cases a “sample-standard bracketing” procedure was applied using NIST 612 glass standard for ablation and NIST 981 in aqueous solution for the mineralization. Due to the lack of organic matrix standards, the fs-LA-ICP-MS technique produces only qualitative trace element (U, Th and Pb) and isotopic analysis of source rocks.
Our results obtained on both crude oils and associated source rocks have shown that Th, U, Pb systematics determined using the two analytical methods (mineralization of kerogen directly analyzed on ICP-MS or MC-IC-PMS, and laser ablation coupled with Quad ICPMS or with a MC-ICP-MS for kerogen pellets), provide constraints on the depositional environment, on concentrations and isotopic lead signatures that can be used to date crude oils and to characterize the lead sources (mantle or crustal). This gives innovative new constraints for the modelling of petroleum systems.