The virtual spot approach: a simple method for in situ U-Pb carbonate geochronology by high-repetition rate LA-ICP-MS.

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Résumé

We present a simple approach to laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) U-Pb dating of carbonate minerals from isotopic maps, made possible by the use of a high repetition rate femtosecond laser ablation system. The isotopic ratio maps are built from 25-μm-height linear scans, at a minimal repetition rate of 100 Hz. The analysis of 238U, 232Th, 208Pb, 207Pb and 206Pb masses by a sector field ICP-MS is set to maximize the number of mass sweeps, and thus of pixels on the produced maps ($\sim$8 to 18 scans s-1). After normalization by sample standard bracketing using NIST614 for 207Pb/206Pb ratio and WC-1 calcite for correction of 238U/206Pb ratios, using the Iolite 4 software, the isotopic maps are discretized into squares using a python script. The squares correspond to virtual spots of chosen side length, for which the mean and its uncertainty are calculated, allowing to calculate ages with commonly used concordia diagrams. Because the ratios can vary strongly at the pixel scale (1.3 μm x 25 μm), the values obtained from the virtual spots display higher uncertainties compared to static spots of similar size. However, their size, and thus the number of virtual spots can be easily adapted. A low size will result in higher uncertainty of individual spots, but their higher number and potentially larger spread along the isochron can result in a more precise age. For a given size, different locations of the discretization grid on the image can also be tested, and corresponding ages calculated. Their comparison helps to assess sample reliability, and the more statistically robust age can be selected. We present examples of the approach, for which in the most favorable cases (U $>$ 1 ppm, 238U/206Pb $>>$ 1, and highly variable U/Pb ratios) an age can be obtained at reasonable uncertainty ($<$ 5-10%) from images as small as 100 μm x 100 μm, i.e. the size of a single spot in common in situ approaches. Although the method has been developed on carbonates, it should be applicable to other minerals suited to U-Pb geochronology.

Mots-Clés: U/Pb, geochronologie, carbonates, calcite, isotopie, LA, ICPMS

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