1.3.12

LA-ICPMS common Pb corrected U-Th-Pb dating of titanite

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Laser ablation (LA) coupled to ICP-MS is now an accepted technique for in-situ micro-scale studies of mineral chemistry and isotope systematics. Recent advances have allowed accurate and precise U-Pb age determinations in zircon [1,2] to be competitive with established Ion Microprobe (IMP) techniques. In this study we extend established U-Pb techniques by LA-ICPMS (quadrupole) to titanite. Titanite is an extremely useful phase for U-Pb dating since it is relatively more abundant than zircon and generally forms larger crystals, occurs in numerous geologic environments, is sensitive to P-T-t-x variations and has a high closure temperature for the U-Th-Pb system. However, it readily incorporates up to ppm levels of (common)Pb into its lattice alongside U and Th during crystallisation, making the necessity for common Pb correction paramount. Several approaches exist for making such corrections: 1) A 2D mathematical correction in the U(Th)-Pb system assuming U-Pb concordancy (known as a $^{207(208)}$Pb-correction and popular with IMP users), 2) A 3D mathematical correction in the U-Th-Pb system requiring an estimate of age of Pb-loss (designed specifically for LA-ICPMS users not reporting accurate ^{204}Pb data [3]), 3) A correction based upon measurement of the stable ^{204}Pb isotope to assess the amount of common Pb in the analysis, requiring an independent measurement or estimate of the common Pb composition to be corrected for (herein termed a TIMS-style correction).

In this study we demonstrate that accurate and precise U-Th-Pb measurements can be determined from small areas within titanite by LA-ICPMS and we go on to demonstrate that we are able to apply an accurate common Pb correction both by mathematical based ^{207}Pb-correction and the far more robust TIMS-style correction. We also demonstrate that, in one pilot study from the Kiruna Magnetite-Apatite ore body, Sweden, the co-precipitated titanites are extremely enriched in radiogenic Pb to such a degree that a common Pb correction is unecessary and that two concordant U-Pb ages can be resolved in-situ in one crystal. Thus, our study has allowed insight into U-Th-Pb systematics of titanite from a range of environments and has shown that we are able to deal with a number of different analytical challenges by application of different protocols and data handling.

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1.3.13

A new tool for in situ isotopic analysis of small samples: Multiple Ion Counting –ICPMS and -TIMS

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Laser Ablation in combination with MC-ICPMS has evolved to become a useful analytical technique for precise in situ isotopic analysis. The same is true for multicollector TIMS instruments coupled with the micro-drilling technique to extract the sample volume from a small scale. However, todays multicollector instruments are still using Faraday detectors and for small sample sizes the attainable precision is limited by the noise level of the Faraday detectors and the stability of the background. Ion counting overcomes the noise limit and high mass resolution is the key to discriminate against molecular spectral interferences and to clear up the background. Both features open the door to expand the analytical power of these instruments to smaller sample sizes.

We have developed a special setup of miniaturized Multiple-Ion-Counters (MIC), which are identical in size to, and interchangeable with, the standard Faraday detectors of the multi-collectors of both instruments, the Finnigan NEPTUNE multicollector ICPMS and the Finnigan TRITON multicollector TIMS. In total, 9 Faraday cups plus 8 MIC channels can be installed simultaneously at any position in the collector array. The mass dispersion of the variable multicollector array is large enough to measure U isotopes on the high mass side and all Pb isotopes and Hg on the low mass side at unit mass separation. This makes the Finnigan NEPTUNE a powerful tool for in-situ analyses of zircons using multiple ion counting detectors and laser ablation [1]. An overview of other possible applications like Hf isotope systematics in old garnets [2], paleoclimate studies using Sr isotope variations in minerals [3], disequilibrium studies by precise determination of ^{234}U/^{235}U and ^{230}Th/^{232}Th on ng-sample sizes and forensic investigations of nuclear material [4]. If proper cross calibration of the ion counters is ensured during the measurements precisions of 1‰ can be achieved.

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