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QEMSCAN+LAICPMS: a new tool for petrochronology and sedimentary provenance analysis

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Only a relatively small number of rock-forming minerals contain sufficiently high concentrations of naturally occurring radioactive parent isotopes and sufficiently low background concentrations of the corresponding daughter isotopes to be suitable for geochronology. The first step in most geochronological studies is to extract these datable minerals from the host rock using a combination of magnetic and density separation techniques, a process that is tedious and time consuming. We here present a new method to avoid mineral separation by coupling a QEMSCAN electron microscope to an LA-ICP-MS instrument. Given a polished hand specimen, a petrographic thin section, or a grain mount, the QEMSCAN+LAICPMS method produces chemical and mineralogical maps from which the X-Y coordinates of the datable mineral are extracted. These coordinates are subsequently passed on to the laser ablation system for isotopic and, hence, geochronological analysis. QEMSCAN+LAICPMS can be applied to a wide range of problems in igneous, metamorphic and sedimentary geology, as is illustrated with three case studies. In the first case study, a 3×4 cm slab of polished granite from the L'Erée pluton in Guernsey is scanned for zircon. This yields 23 U-Pb ages resulting in a concordia age of 615 ± 2 Ma. The second case study re-investigates a paragneiss from an ultra-high pressure terrane in the Qaidam Basin (Qinghai, China) that was previously analysed by conventional petrography, electron microscopy and SIMS zircon U-Pb analysis. In this example, the QEMSCAN revealed 107 small (20 μm) metamorphic zircons that were analysed by LA-ICP-MS to constrain the 430 Ma age of peak metamorphism. The third and final case study investigates the mineralogy and geochronology of sedimentary rocks of the Ordovician Sarah Formation (Saudi Arabia). We analysed 44 outcrop samples and a further 35 subsurface samples, resulting in a dataset comprising 10,000 detrital zircon U-Pb ages and 79 heavy mineral compositions and petrographic analyses. Jointly considering this enormous dataset by 3-way multidimensional scaling paints a remarkably simple picture of sandstone compositions that are determined by a combination of provenance and diagenesis. In conclusion, the QEMSCAN+LAICPMS method represents an efficient and cost effective way to obtain chemical and isotopic compositions on the same sample, which improves both the quantity and quality of geological data.