AUSTRALIS: a new microanalytical tool for trace element and isotope analyses

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A microanalytical system, based on a 3 MeV Tandetron Accelerator, has been developed at the Heavy Ion Analytical Facility (HIAF) of CSIRO Exploration and Mining. The development commenced in 1994, and first isotope measurements were performed in April 1997. The instrument, known as AUSTRALIS (**A**MS for **U**ltra **S**ensitive **Tra**ce Element and **I**sotope **S**tudies) is based on the principles of accelerator mass spectrometry (AMS) which in contrast to conventional ion microprobes (e.g. Compston *et al.* 1982) virtually eliminates all molecular interferences by accelerating the secondary ions released from the sample in the accelerator where the chemical bonds are broken. Consequently, high resolution *in situ* analyses of isotopes and trace elements can be performed in a wide range of different mineral matrices. Routine applications within the framework of geochronology and other geochemical studies are expected for 1998.

Method

The instrument (Fig. 1) is basically a double mass spectrometer separated by the accelerator, with the low energy side operating as an ion microprobe (cf. Niklaus *et al.* 1997, Sie *et al.* 1997). It features a modified HICONEX source producing a focused primary Cs beam of currently 30 µm diameter. The negatively charged secondary beam is directed towards the particle accelerator via an electrostatic analyser (ESA) and the injection magnet. This first mass spectrometer has a mass resolution M/ΔM of ~850 that enables a range of geochemical investigations, if only at the reconnaissance level. After passing the injector magnet, the selected ion beam (e.g. PbS^- for Pb and S analyses in galena) is accelerated to MeV energies in a tandem accelerator. Interaction with the stripper gas causes breakdown of the molecular bonds and thus production of positively charged atomic components, free of mass overlaps (e.g. $^{208}Pb^{32}S$ *vs* $^{207}Pb^{32}SH$). For example, PbS^- is transformed into positive Pb and S ions that can be analysed, after passing the second magnet/ESA combination, in a Faraday cup, a gas counter or an ion counter at the end of the beamline. Consequently, very moderate mass resolution at the

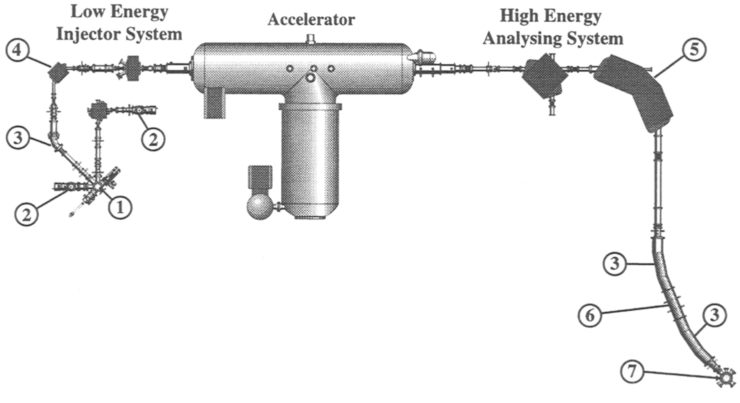

FIG. 1. A schematic layout of the AUSTRALIS system, showing the sample chamber (1), ion sources (2), ESA (3) and injection magnet (4) as parts of the low energy injector system and the high energy analysing system, comprising the analysing magnet (5), ESA's (3), quadrupole lens (6) and detector chamber (7). The entire beam line is about 25 m long.

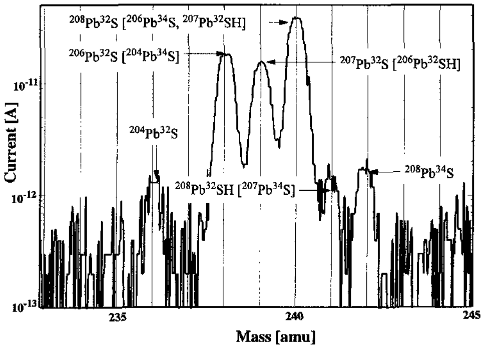

FIG. 2. Mass spectrum of a galena sample, analysed at the low energy end of the instrument, virtually comparable to a normal ion microprobe. The spectrum shows the $Pb^{32}S^-$ ions at masses 236, 238, 239 and 240, corresponding to ^{204}Pb, ^{206}Pb, ^{207}Pb and ^{208}Pb. The spectrum also displays the $^{208}Pb^{34}S^-$ peak, indicating the interference of the $^{206}Pb^{34}S^-$ and $^{208}Pb^{32}S^-$ peaks (from Sie *et al.* 1998).

high energy system is sufficient to completely resolve molecular interferences (Fig. 2, 3; from Sie *et al.* 1998), particularly those by hydrides in hydrous phases other than zircon. The ability to select from a great range of molecular ions can be used to alleviate or completely exclude the influence of isobaric interferences. For example, in the Rb/Sr system, selection of Sr hydride ions causes suppression of interfering Rb isotopes. Additionally, the elimination of mass interferences is coupled with a significant background reduction, thus enabling trace element analyses in the sub-ppm range.

Applications

Pb and S isotopes from sulphides are now readily obtainable at a precision <1 %. Work currently concentrates on the effect of instrumental mass fractionation of light isotopes and reduction of the isotope switching period, ultimately to sub-milliseconds, which will further improve the precision by eliminating the effect of source instabilities. This will bring it to the permil range predicted from counting statistics, which is required for many applications in geochemistry and geochronology. AUSTRALIS will be used for a variety of different applications (cf. Sie and Suter 1994). These are for example geochronological studies of U/Pb isotopes on minerals other than zircons, particularly in hydrous phases (e.g. apatite). Due to the above mentioned suppression of interfering Rb ions, the use of Sr isotopes will enable

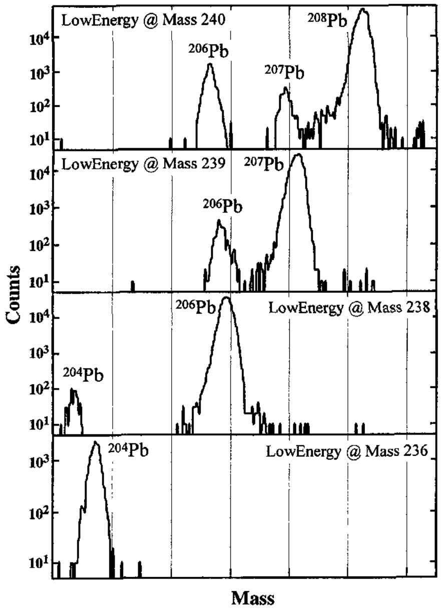

FIG. 3. Mass spectrum of Galena, measured at the high energy end, following acceleration and charge change in the accelerator, causing disintegration of the molecular bonds. If mass 240 is injected, the $^{208}Pb^{4+}$ ions are completely separated from the $^{206}Pb^{4+}$ in the $Pb^{34}S^-$ as well as from the $^{207}Pb^{4+}$ in the $^{207}Pb^{32}SH^-$. The other spectra demonstrate injection of masses 239, 238 and 236, respectively (from Sie *et al.* 1998).

tracer studies and dating in high Rb phases. For the Re/Os system, natural suppression of Re^- ions will enable *in situ* measurements of Os isotopes in phases that concentrate PGE such as molybdenite. Accurate microanalysis of sulphur isotopes will serve as a tracer for fluid flows and their pathways and contribute to geothermometric studies.

References

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