Modern high resolution ICP-MS (HR-ICP-MS) instruments offer a number of performance advantages compared to more widely used quadrupole ICP-MS instruments, including increased sensitivity, superior detection limits and faster scan speeds. For laser ablation acquisition, rapid peak scanning is a distinct advantage, as it allows for increased temporal resolution of time-resolved data. The advantage of single-collector ICP-MS over multi-collector ICP-MS, is that a wider mass range can be scanned in a single analysis. This means that a range of elemental concentrations can be determined, as well as precise isotope ratios.

Laser ablation sampling coupled to measurement via ICP-MS is an increasingly used tool within earth science, and can be used for determining quantitative trace element concentrations of materials, as well as for isotopic dating of minerals in particular within U-Pb geochronology. Here, we report the use of the Nu AttoM for determining U-Th-Pb isotopes in zircon and monazite crystals, and demonstrate the ability to combine these isotope ratio measurements with other trace element concentrations using the wide mass range available in rapid peak-scanning mode.

![Figure 1: 20µm diameter ablation pits in Moacyr monazite.](image)

**Discussion**

Using typical ablation parameters (20 to 35 µm spot @ 1.5-2.5 J/cm²), the Nu Attom is capable of measuring 207Pb/206Pb, 206Pb/238U, 206Pb/232Th, 207Pb/232Th ratios with an external reproducibility of <3% (2SD) after normalisation to a standard, these ratios are accurate to <2% (2SD) (figure 2). This makes the Attom ideal for U-Th-Pb geochronology of U-bearing accessory minerals such as zircon and monazite; although not shown, dating of other minerals such as titanite, allanite and apatite is feasible.

To gain the most from U-Th-Pb geochronology it is commonly useful to determine trace element concentrations of the dated minerals. For example, REE patterns in zircon can aid the determination of the co-precipitating mineralogy, and thus whether the dated growth-zone within the zircon represents a magmatic or metamorphic event. Ideally, trace element concentrations will relate to the individual growth zone that has been dated. This can be done using one ablation for a U-Th-Pb measurement, and a separate ablation for a trace element measurement; however, this assumes that the same zone has been analysed each time. For consumption of less material and allowing a greater spatial resolution, a preferred approach is to analyse U-Th-Pb isotopes and trace elements in one ablation. The large mass range of the Nu Attom allows for certain trace elements to be simultaneously determined along with precise U-Th-Pb isotopic ratios. Experiment 3 shows that 207Pb/206Pb and 206Pb/232Th ratios can be precisely and accurately measured along with determination of the heavy REE content; whilst experiment 4 shows that a complete REE pattern can be determined along with precise and accurate 207Pb/206Pb age determinations (figure 2).

**Conclusions**

The Nu Attom ICP-MS allows for rapid peak-scanning across a wide mass range. The ability to determine precise and accurate U-Th-Pb isotope ratios, whilst at the same time determining concentrations of other trace elements makes it an ideal tool for geochronological dating of a range of natural materials.
Figure 2: (A) U-Pb concordia diagram for GJ-1 zircon normalised to 91500 (ellipses are 2σ). (B) Th/Pb vs. U/Pb isochron for Moacyr monazite normalised to Stern monazite (error bars are 2σ). (C) U-Pb Concordia for GJ-1 zircon normalised to 91500, and (D) weighted mean Pb-Pb age of 91500 zircon normalised to Plesovice. (E) Chondrite normalised HREE pattern, and (F) chondrite normalised REE pattern.

Table 1: Measured masses and dwell times for each of the four experiments.