Mineral Chemistry: Modern Techniques and Applications to Exploration

W.L. Griffin, N.J. Pearson, E.A. Belousova, S.Y. O'Reilly

GEMOC Key Centre, Dept. Earth and Planetary Sciences, Macquarie University, NSW 2109, Australia

Introduction: Why in-situ methods? Very short overview of developments

Analytical Methods -- Overview

1. Major and minor elements: EMP (routine since 1970s)
    - Principles
        - WDS vs EDS: advantages, drawbacks

2. Trace elements
    - Ion Microprobe (since mid-1980s)
        - Principles: advantages and disadvantages, COST
    - Proton Microprobe (since mid-1980s)
        - Principles
        - Advantages, limitations, MDL, etc
        - Scanning PMP/pixel mapping: fluid inclusions as example
    - LAM-ICPMS (since mid-1990s)
        - ICPMS principles
        - Quadrupole vs sector instruments
        - Time-resolved software: essential
        - Lasers: types, pros and cons
    - Summary- cost-effectiveness, speed, reliability: LAM-ICPMS

3. Isotopic Analysis
    - Ion Probe: U/Pb, stable isotopes
    - LAM-ICPMS: U/Pb, Pb isotopes
        - Compare ion probe re data quality, speed, spatial resolution, COST
    - LAM-MC-ICPMS
        - Principles
        - U-Pb vs quadrupole etc
        - Other radiogenic systems: Lu-Hf, Re-Os, Rb-Sr, Sm-Nd
            - Brief overview of limitations and possibilities
    - Summary: comparisons

Examples of applications -- "indicator mineral" approach

Basics: anything can be an "indicator": must know your system, what to look for, use imagination + technology. Empirical "fingerprints" can work, or not; need to understand your target.

1. Trace element applications: Diamond exploration as example
   - G10 discriminant: originally purely empirical, failed in several instances
   - Improvement: add information on critical genetic factors
     - Ni thermometry on garnets, trace element signatures: understand depth distribution of sampling relative to diamond window, redox etc
     - → improved discrimination of good and bad targets
   - Slave Craton example: best indicator = kyanite-eclogite garnet (from DI studies), not G10 garnets (from graphite stability field)
2. Trace elements: Examples of ther potential "indicators"
   - Zircon: kimberlitic vs crustal; signatures of hydrothermal systems
   - Apatite
   - Tourmaline
   - Cpx: use Ni-related Cr-diopsides as example?

3. Isotopic "indicators"
   - Zircon: Age determinations ± Hf isotopes -- looking for specific rock types/settings -- cross-reference talk in main conference
   - Cu-Fe isotopes in sulfides: vectors toward ore (examples)
   - Potential fingerprints: Sr isotopes in apatite, titanite, cpx, feldspar, etc