

Integrated geochronology of intrusion-related gold systems: Examples from Yukon & Alaska

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Establishing the age relationships of complex ore-bearing magmatic-hydrothermal systems requires the integration of several geochronological methods.

SHRIMP zircon U-Pb, mica Ar-Ar, molybdenite Re-Os, and existing TIMS U-Pb data are used to establish the timing of magmatism and mineralization, and the duration of magmatic-hydrothermal systems within intrusion-related gold systems of the Tintina Gold Province, in Yukon and Alaska. Evidence, including thermal modeling, indicates that the plutons and their associated magmatic-hydrothermal systems cooled to below the Ar-mica closure temperature (~250°C) within 0.3 to 1.0 m.y. Establishing genetic relationships between mineralization and magmatism requires that the timing of these events be proven to within this time-frame.

TIMS U-Pb dating indicates that most plutons hosting mineralization were emplaced circa 91.5±1 Ma. However, much of the zircon U-Pb data (and zircon SEM imagery) show evidence of ancient inheritance and Pb-loss, which cast doubt on the accuracy of the individual dates. SHRIMP dating of zircon was employed to avoid Pb-loss and inheritance. Resulting dates are up to 3 m.y. older than the TIMS dates which likely have notable, though inconspicuous Pb-loss, even from abraded fractions.

Ar-Ar dates for magmatic biotite and hornblende indicate that most of these plutons cooled quickly as the dates are within one million years of the U-Pb dates. Ar-Ar dates on hydrothermal biotite and muscovite from mineralization within or adjacent to the plutons are in agreement and within the ±1 m.y. uncertainty of the SHRIMP dates. Re-Os molybdenite dates are also in agreement, and within the uncertainty of the SHRIMP dates for the host plutons.

An integrated approach to documenting a magmatic-hydrothermal history seems valid, but many complicating factors conspire to make resolution of individual events within a one million year time-frame difficult, if not impossible. In addition to the within-system problems, uncertainties in the decay constants, and the compounding of decay constant errors across isotopic systems further increase the uncertainties. Until these problems are reduced and calibrations between methods are improved, the *slotting-in* of events within a one million year window is best done as a process of relativity from within a single isotopic system.

The chemography of diamonds: A review of recent ion microprobe data

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The use of the ion microprobe or SIMS technique has made it possible to determine chemical compositions for the individual growth zones shown by diamonds, and therefore use chemographic relationships (spatially coordinated variations in chemical composition) to unravel diamond formation histories. Ion microprobe measurements on a wide variety of diamonds have been made for carbon isotope ratios, nitrogen abundance and more rarely nitrogen isotope ratios with a spatial resolution of <25 µms (see references).

In all cases there is a close correlation between growth zones (as shown by CL images) and the abundance of N. Wide variations in N_{ppm} are common in closely spaced sets of concordant growth zones. These results urge caution with respect to the common application of the infra-red transmission technique (FTIR) for determining N abundances and diamond mantle residence times, since the FTIR analyses may sample many zones of widely varying N content (and possibly N aggregation state). They also urge caution in using bulk data to erect correlations between N_{ppm} and $\delta^{13}\text{C}$ (e.g. Cartigny et al., 2001).

Where the growth structure indicates a continuous phase of growth (either cuboid or octahedral) the variation in $\delta^{13}\text{C}$ is typically <4‰ even though major variations in N_{ppm} may occur during the phase of growth. In sectorial growth cuboid and octahedral domains show differences of <2‰. These relationships within single diamonds do not support suggestions that differentiation during growth causes a regular trend of $\delta^{13}\text{C}$ and N_{ppm} values (Cartigny et al., 2001); nor do they suggest that fractionation during growth from a source of limited composition gives rise to the variation of diamond $\delta^{13}\text{C}$ values from ca. 0 to -30‰ (Galimov, 1991).

Where changes in $\delta^{13}\text{C}$ in single diamonds are found they are typically in situations where the growth patterns indicate separate episodes of growth. This suggests that major variations in $\delta^{13}\text{C}$ are associated with discreet major changes in the compositions of the C-O-H-N fluid or melt source for the diamonds. Present evidence shows that the change of $\delta^{13}\text{C}$ source composition is usually from one of low values to more normal (nearer -5‰) mantle composition. Such data may be interpreted as implying a change from a subducted source (with organic carbon) to an intrinsic mantle source.

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