Are high magma supply mid-ocean ridge magma chambers open or closed-system?

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Mid ocean ridge (MOR) volcanism at high magma supply is often thought of as a near steady-state process, with frequent magma supply from below and relatively frequent eruptions. Repeat eruptions at several MOR sites over the past several decades allow one to probe this assumption using radioactive disequilibrium between 210Pb and 226Ra, which is governed by a 22 year half-life. There are multiple possible causes of 210Pb-226Ra radioactive disequilibria in magmas, but in magnesian (>7 wt o/o MgO) tholeiites, this is thought to be produced primarily by mantle melting, followed by decay during melt transport and pre-eruptive storage. Petrological, geochemical and U-series data on four mapped eruption sequences at two sites on the East Pacific Rise (at 9.8 deg N in 1991-92 and 2005-06, and at 17.5 deg S in ca 1990 and ca 1980) demonstrate that successive eruptions separated by 10-20 yrs were fed by the same mantle-derived magma batches that had resided in the crust and lost 210Pb-226Ra radioactive disequilibria by decay, under nominally closed-system conditions. All of the erupted magmas were >7 wt o/o MgO and only sparsely plagioclase phyric. At both sites, crustal magma residence timescales must be very short for the component of the melt that caries live Pb-Ra disequilibrium to be preserved in erupted magmas. On the N-EPR, the two eruptions produced lava flows with only small amounts of compositional variability, but the magmas of the later eruptions were more differentiated (by ca 1wt o/o MgO). On the S-EPR, two eruptions of chemically heterogeneous magmas have variable but indistinguishable ranges of 210Pb-226Ra, MgO, Pb isotopic characteristics, and other geochemical tracers, indicating that they both probably represent mixes of the same two distinct magma batches in the crust. Several things are learned from this study: (a) Erupted magmas resided in the crust for no more than several decades, but longer than the 1-2 decade repose interval at both sites; (b) Erupted magmas are mixtures of melts that act as closed-systems during the repose period, only one of which needs to carry Pb-Ra disequilibrium (the other could be in secular equilibrium); (c) not every MOR eruption at high magma supply ridges requires new magma input from the mantle; (d) mush zone interactions did not induce 210Pb excesses, and (e) crustal melts can differentiate along a range of P-T paths over these short time intervals. Magma chamber thermal modeling indicates that to continually supply heat to observed high temperature hydrothermal systems, magma chambers need to be replenished on decadal timescales if hydrothermal systems are driven by heat from only the small shallow melt lenses detected seismically at ridges. Resupply of magma to these lenses from deeper melt segregations or a crystal mush zone during the repose interval can supply the heat and still allow for the apparent U-series closed-system behavior if the same mantle-derived magma batches are involved.