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TIMESCALES OF MAGMATIC FRACTIONATION DOCUMENTED BY PALEOSECULAR VARIATION IN BASALT DRILL CORE, SNAKE RIVER PLAIN VOLCANIC PROVINCE

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The timescales over which fractional crystallization and recharge work in mafic volcano-plutonic sequences is subject to great uncertainty. Currently modeled processes are subject to the scale of measurement: monogenetic basalt fields accumulate over hundreds of thousand years, consistent with U-Th-Ra isotope variations that imply 50% crystallization of basic magmas that indicate timescales of 100,000 years, whereas crystal diffusion modeling implies phenocryst residence times of circa 1 to 1000 years.

Monogenetic basalts of Snake River Plain in southern Idaho post-date passage over the Yellowstone-Snake River Plain hotspot up to 2 km thick. Detailed lithologic and geophysical logging of core from deep drill holes, along with chemical stratigraphy and paleomagnetic inclinations, document individual eruptive units, compound lava flows, and flow groups that accumulated over 1-6 Ma. Hiatuses, commonly marked by loess or fluvial interbeds, vary from ~0.1 and 20 meters thick. Radiometric (40Ar-39Ar, detrital zircon U-Pb) and paleomagnetic timescale ages show the deepest hole (Kimama drill hole, 1912 m TD) accumulated over ~6 Ma. Cycles of fractional crystallization and recharge are recognized in the chemical stratigraphy as up-section shifts in major and trace elements, with fractionation cycles that commonly represent 40-50% fractionation. Individual fractionation cycles may comprise 20-40 eruptive units (8-17 lava flows) with little to no change in magnetic inclination (0-2º), whereas adjacent cycles may differ by several degrees from one another or reflect changes in polarity.

Rates of paleosecular variation in Holocene lavas and sediments dated using 14C document significant shifts in magnetic inclination over short time scales, ranging from about 0.5º/century to 2º/decade, with an average of about 0.5º/decade or 5º/century. This implies that fractionation cycles with <1º to 2º variation in magnetic inclination formed on timescales of a few decades up to a few centuries. This implies that the lavas collectively represent only a few thousand years of eruptive activity, with major flow groups separated in time by 10s-100s of ka. We suggest that crystal diffusion modeling captures the timescale of individual flow units or lava flows; in contrast, paleosecular variation captures the timescales of magma chamber evolution.