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Deciphering Mantle Source Heterogeneity and Melt Evolution Beneath the South Mid-Atlantic Ridge (~31°S)

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Major and trace element geochemical data of basement rocks recovered during IODP expeditions 390 & 393 along ~31°S crustal flow line were investigated west of the South Mid-Atlantic Ridge (SMAR). The study sites encompass six sites from U1556 to U1559 and spanning an age range of ~61.2 to 6.6 Ma. Trace element patterns reveal a shift from enriched signatures at older sites (U1556 and U1557) to more depleted compositions at younger sites (<49.2 Ma) U1558, U1583, U1560 and U1559. Rare earth element patterns show N-MORB like signatures, showing light REE depletion and small negative Eu anomalies, except at Site U1559 where the Eu anomaly is absent. In the Th/Yb vs Nb/Yb diagram, samples from younger sites plot near the N-MORB field whereas samples from older sites plot near the E-MORB field. These variations indicate a heterogenous mantle source beneath the SMAR.

Whole rock major element trends combined with mineral LA-ICP-MS data reveal early olivine fractionation followed by plagioclase and clinopyroxene crystallization. Olivine phenocrysts (Fo_{88} to Fo_{82}) show high Ni (1048-2220 ppm), Co (147-183 ppm) and Cr (246-454 ppm) contents indicating crystallization from primitive melts. Pyroxenes analysed from the study area are mainly augites ($En_{28.57}Fs_{32.34}Wo_{39.10}$ to $En_{57.14}Fs_{11.54}Wo_{31.32}$). Clinopyroxenes show LREE depleted and nearly flat HREE patterns ($(La/Yb)_N \approx 0.04$-0.11) consistent with derivation from a spinel-lherzolite source. Plagioclase crystals (An_{38} to An_{92}) contains high Sr (75-263 ppm) levels and displays strong positive Eu anomalies ($Eu/Eu^* \approx$ 2.8-13.1) whereas clinopyroxenes show low Sr and weak negative Eu anomalies ($Eu/Eu^* \approx$ 0.7-1.2). This suggests that plagioclase fractionation had already depleted the melt in Sr and Eu before or during clinopyroxene crystallization. Also, plagioclase phenocrysts mainly show oscillatory zoning with few crystals displaying normal and reverse zoning indicating fluctuating physicochemical conditions within the magma.