Extinct radioactivities in presolar silicon carbide grains of type X

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Introduction

Silicon carbide (SiC) is the best studied presolar mineral phase [1,2]. While most of the SiC grains are believed to originate from asymptotic giant branch (AGB) stars the rare SiC X grains most likely formed in the ejecta of Type II supernova (SN) explosions. The X grains are characterized by enrichments (relative to solar isotopic abundances) in ^{12}C (most grains), ^{15}N, and ^{28}Si. Other important features of X grains are the imprints of extinct radioactivity. Large isotopic overabundances are observed for ^{26}Mg, ^{44}Ca, and ^{49}Ti which can be attributed to the decay of radioactive ^{26}Al ($T_{1/2}$ = 0.7 My), ^{44}Ti ($T_{1/2}$ = 60 y), and ^{49}V ($T_{1/2}$ = 330 d), respectively.

Aluminum-26

Most of the SiC X grains carry radiogenic ^{26}Mg. Inferred initial $^{26}Al/^{27}Al$ ratios are 0.01-0.6 [3,4]. High $^{26}Al/^{27}Al$ ratios are expected from H burning in the outer layers of Type II SN (HeN zone) [5] and the grain data imply contributions from this zone to the SiC condensation site in the SN ejecta.

Titanium-44

About 20-30% of the X grains carry radiogenic ^{44}Ca. Inferred initial $^{44}Ti/^{48}Ti$ ratios are in the range of 0.01-0.5 [3,4,6]. Radiogenic ^{44}Ca is homogeneously distributed within X grains, except for one grain in which it is concentrated in a small subregion [6]. The presence of radiogenic ^{44}Ca is of particular importance in identifying the stellar sources of X grains because its precursor ^{44}Ti can be produced only in SN. In Type II SN ^{44}Ti is produced in the innermost zones (Ni, SiS) [5]. The X grain data thus imply mixing of matter in SN ejecta over large scales.

Vanadium-49

Many X grains show enhanced $^{49}Ti/^{48}Ti$ ratios of up to 2x the solar ratio [3,7]. Enrichments in ^{49}Ti may be the result of n-capture reactions and/or may be due to the decay of radioactive ^{49}V which is produced in the innermost zones of Type II SN [5]. The observed correlation of $^{49}Ti/^{48}Ti$ ratios with V/Ti is best explained if radioactive ^{49}V contributed to the ^{49}Ti budget and if ^{49}V was incorporated live into X grains, i.e., grain formation must have occurred on a time scale of several months [7].

References

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The role of mixing in the evolution of andesites at Ngauruhoe Volcano, New Zealand: constraints from analyses of crystal growth zones

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The use of whole-rock geochemical data can result in an incomplete characterization of true chemical and isotopic variability present in arc magmas. This is because these magmas may have had extensive opportunity to interact with the crust, and may be heterogeneous mixtures of phases with different evolutionary histories. Juxtaposition of these components in an erupted magma may occur relatively late in the magma's evolution.

Detailed study of magmatic histories as recorded in plagioclases, (similar to Tepley et al., 1999), from recently erupted andesites at Ngauruhoe Volcano, near the southern margin of the Taupo Volcanic Zone (TVZ), New Zealand indicates that open-system processes are important to magma evolution in this system.

Some of the plagioclases have disequilibrium textures, typified by highly resorbed crystal cores with more euhedral overgrowths. Significant chemical and isotopic disequilibrium between early and late stage growth of these crystals suggests that there was an abrupt change in chemistry and/or temperature during growth, rather than a protracted episode of incremental magma modification. Therefore, these resorbtion horizons can be interpreted as significant unconformities in the crystal record. Extreme chemical disequilibrium between resorbed calcic cores of plagioclase crystals (some having An > 85) and host groundmass glass, which is rhyodacitic in composition, indicates that a large fraction of the plagioclases present are xenocrystic.

Whole-rock chemical compositions for these lavas can be interpreted as being mixtures of crystals, which grew in a basaltic melt, and liquids of more evolved composition. This may be consistent with remobilisation and disaggregation of crystal-rich basalt or previously formed basaltic cumulate (with minimal re-melting) by crystal-poor rhyodacitic magma. Admixture of xenocrysts and re-mobilization of basaltic crust could be an important process, complementary to AFC, whereby magmas of intermediate composition are generated at the andesite-dominated margins of the rhyolite-dominated TVZ.

References

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