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Mineralogy of a crystalline meteorite from a metamorphosed earliest crust with live 53Mn and 26Al

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Antarctic meteorite, Asuka 881394 is a unique crystalline differentiated meteorite with very high clacic plagioclase (ca. An98) [1]. It is a volatile-depleted eucrite with low Ga/Al and Na/Al ratios like angrites, but Fe/Mn=34 is typical for eucrites. Nyquist et al. [2] reported a conventional 87Rb-87Sr age younger than the canonical 4560 Ma age of eucrites, but excesses of 53Cr and 26Mg correspond to the initial solar system abundances of the parent nuclides, 53Mn and 26Al. They give a 53Mn-53Cr age of 4564 Ma, and a 26Al-26Mg age of 4562 Ma relative to 4566 Ma for Allende CAI [2].

Asuka 881394 is a coarse-grained rock composed of subequal amounts of mm-sized plagioclase and pyroxene crystals. A composite mineral distribution map of PTS, A881394,52-2 has been derived from elemental distribution maps of Si, Mg, Al, and Cr by EPMA. Modal abundances (vol. %) of minerals obtained from this figure are: pyroxene 49%, plagioclase 45%, silica 5.3%, and chromite 0.5%. A881394 pyroxenes are Mg-rich like those of cumulate eucrites (e. g., Moama), but its granulitic texture is unlike their adcumulate texture. Exsolved augite lamellae on (001) up to 10 micron wide are set in the host low-Ca pyroxene with a bulk composition of Ca 13 Mg 50 Fe 37. Because the host pyroxene has not inverted to orthopyroxene, the cooling history differs from that of cumulate eucrites of this composition. White plagioclase regions up to 2 mm in longest dimension fill the interstices, and are composed of rounded, smaller crystals typically ca.0.1-0.4 mm in diameter. Grains of a silica mineral up to 0.9 mm in length are distributed among plagioclase and pyroxene. A large (0.55x0.30 mm) chromite poikilitically encloses plagioclase, evidence of thermal metamorphism.

Textural and mineralogical evidence favors the idea that the last incremental heating of asteroid 4 Vesta was supplied by the accretion of its outermost layers [3] in addition to heating by 26Al. If we accept the proposal that a chondritic partial melt is rich in albite and diopside components, the unusually low Na abundance in A881394 suggests that Na may have been lost during crystallization to produce silica, magnesian pyroxene and anorthite. Yamaguchi et al. [4] performed shock experiments on hot eucrites and found that Na loss may take place from the melted eucrites. This Na loss is consistent with the presence of calcic plagioclase and abundant silica mineral in A881394. If radiogenic 26Mg* cations stayed at the tetrahedral sites of the plagioclase framework structure following 26Al decay, their diffusion rate would be slow in comparison to cations located outside of the framework. Crystallization of very large plagioclase grains, followed by recrystallization to smaller granulitic grains, would retard diffusion of 26Mg out of the entire assemblage. An early-formed, thin, outer scarf-like crust might have experienced prolonged heating from the magma beneath it, kept hot by late-stage accretion after 26Al had decayed. Impacts into such crust on a magma ocean would be a favorable environment for thermal metamorphism and Na volatilization, thus accounting for the unusually calcic plagioclase in A881394. Very early formation of such an outer crust would account for generation of radiogenic 26Mg* within it.

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References: [1] H. Takeda et al. (1997) Antarct. Met. Res., 10, 401-413. [2] L. E. Nyquist, Y. Reese, H. Wiesmann, C.-Y. Shih, H. Takeda, Meteoritics and Plant. Sci, 36, A151 (2001). [3] H. Takeda, Meteoritics & Planet. Sci., 32, 841-853, 1997. [4] A. Yamaguchi, T. Sekine, H. Mori (2002) Shock experiments on a preheated basaltic eucrite, Shock Chemistry and Meteoritic Applications, Springer-Verlag in press.