EVIDENCE THAT ^{26}AL DECAY DID NOT MELT ASTEROIDS.

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Introduction: Chondrites contain too little 730-ka ^{26}Al to produce appreciable melt fractions in their parent asteroids; the maximum ^{26}Al/^{27}Al ratios available for heating are the lowest well-determined ratios in chondrules, 5E-6 in LL Semarkona [1], 4E-6 in CO Yamato 81020 [2].

Nonetheless, there are numerous papers stating that ^{26}Al was the heat source that melted the asteroids parental to the differentiated meteorites (e.g., [3, 4]). In fact, isochrons measured on basaltic meteorites such as eucrites, angrites and Asuka 881394 are implausibly low if the parental rock had a ^{26}Al/^{27}Al ratio close to the canonical ratio of 5.2E-5 and in most cases, are too low to be consistent with the minimum ratio that can produce 20% melt fractions ~1E-5.. In fractured asteroids melt migrates rapidly compared to the ^{26}Al half life; magma flowing through a dike 10 cm thick can move from its point of origin to its solidification point within ~30 years. Thus the ^{26}Al/^{27}Al ratio at the time the melt started to migrate is recorded in ^{26}Al-^{26}Mg isochrons for differentiated meteorites; the observed low initial ratios imply that ^{26}Al did not provide most of the heat that resulted in the melt formation, and that impacts were a major source of this heat.

Discussion: Heating from the decay of ^{26}Al occurs slowly; half the available energy is deposited in one half-life, 94% in four half-lives. If, four half-lives (about 2.9 Ma) after the formation of asteroids, melt segregation has not yet begun, it will probably not occur at all because the cooling of the body will have reached a steady state with heat introduction resulting from the decay of the remaining ^{26}Al. In contrast, impact heating occurs very rapidly. If the amount of heat deposited is sufficient to produce melting, the buoyant separation of melt from solids and silicate melts from metallic melts starts immediately. Kilometer-scale melting by impacts is sufficient to produce differentiated meteorites; global melting is not required.

It is useful to compare heating by two initial ^{26}Al/^{27}Al ratios, the <u>canonical</u> CAI ratio of 5.2E-5 and a <u>minimum</u> ratio of 1E-5 that can melt a well-insulated body with a moderately high (CO-chondrite-like) concentration of Al (14 mg/g) (based on calculations reported in [2]). This is a best estimate for the lowest ratio consistent with melting produced entirely by the decay of ^{26}Al; lower Al contents or weaker insulation required higher ratios.

The reported ^{26}Al/^{27}Al ratios inferred from Al-Mg isochrons in eucrites are 7E-7 in Piplia Kalan [6] and Asuka 881467 [3]; still lower ratios were observed in the Asuka 87272 and Asuka 881388 eucrites [3]. These ratios are much too low to be consistent with melting of materials that initially had a canonical CAI ^{26}Al/^{27}Al ratio, but 7E-7 is marginally within the range expected by melting with minimum ratios.

^{26}Al-^{26}Mg isochrons for the angrites SAH 99555 and D'Orbigny yielded initial ratios of 4E-7 to 5E-7 [3, 5]; these are far too low for a canonical ratio in the parental materials, and slightly too low for the minimum ratio. They are thus inconsistent with ^{26}Al being the only heat source.

Al-Mg isochrons reported for the basaltic meteorite Asuka 881394 [3, 7] yielded ^{26}Al/^{27}Al ratios of 1.2E-6, consistent with melting by minimum ratio amounts of ^{26}Al, but inconsistent with melting by canonical ratios.

Conclusions: Published initial ^{26}Al/^{27}Al ratios in angrites are too low to be consistent with ^{26}Al as the only heat source responsible for their melting; the ratios in eucrites and the anomalous meteorite Asuka 881394 are consistent with ^{26}Al as the only heat source, but with an initial asteroidal ratio several times lower than the canonical CAI ratio. These data thus offer little evidence that ^{26}Al was the only heat source responsible for melting differentiated asteroids. They do support the previous conclusion, based on the lowest well-determined ^{26}Al/^{27}Al ratios in chondrules, that the differentiated meteorites (like the Moon and the terrestrial planets) were mainly melted by impacts. Although ^{26}Al was alive when the silicate melts formed and segregated, the low observed ^{26}Al/^{27}Al ratios indicate that impact heating played a major role in producing these melts.

References:

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