# Geochemistry and Sm–Nd dating of a Stannern-group eucrite, Northwest Africa 7188

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Basaltic eucrites are generally considered to have formed at, or near, the surface of the eucrite parent body (EPB). Most basaltic eucrites have experienced various degrees of thermal metamorphism and/or impact events on the EPB. To constrain the early thermal history of the EPB, unweathered meteorites, which display relatively small degrees of brecciation, need to be investigated. NWA 7188 is one such eucrite. However, to date relatively little petrological or geochemical information has been obtained for this important sample. Here we study geochemistry, petrology, and Sm-Nd chronology of NWA 7188, with the aim of understanding the origin of this meteorite and more generally, the thermal history of the EPB's crust.

A polished thick section of NWA 7188 was examined using an EPMA at Tokyo Tech for the mineralogical observations. Oxygen isotope analysis was carried out using an infrared laser fluorination system at the Open University. The major (Fe, Mg, Ti) and trace element (REEs) bulk rock abundances of NWA 7188 were measured by a Q-pole ICP-MS at Tokyo Tech. In addition, we revised the previously obtained $^{147, 146}$Sm–$^{143, 142}$Nd ages of NWA 7188 (Kagami et al., 2017) by additionally measuring fractions of magnetic and non-magnetic minerals of which the grain size was $< 45\ \mu$m.

The $\Delta^{17}$O value of NWA 7188 is −0.245 ±0.017‰ (2SD). This is similar to the average HED value ($\Delta^{17}$O = −0.240; Greenwood et al., 2017). In addition, we previously reported that NWA 7188 has a similar Fe/Mn ratio in pyroxenes to that of other eucrites (Kagami et al., 2017). These results indicate that this meteorite is a normal member of HED suite.

The CI chondrite-normalized REE pattern of the bulk NWA 7188 sample is characterized by the elevated REE abundances (~20 ×CI) with a prominent Eu negative anomaly ($Eu/Eu^* = 0.57$) and a relative depletion of HREEs (Fig. 1). In addition, the sample has elevated La and $TiO_2$ abundances at a given FeO/MgO ratio compared to main-group and Nuevo Laredo-group eucrites. These chemical characteristics suggest that NWA 7188 should be classified as a member of the Stannern-group eucrites. The EPMA observation of the thick section shows remnant Ca-zoning of augite with thicker lamellae near the rim than those near the core, which corresponds to a type 4 metamorphic grade (Takeda and Graham, 1991; Yamaguchi et al., 1996).

The $^{147}$Sm–$^{143}$Nd and $^{146}$Sm–$^{142}$Nd ages updated in this study yields 4582 ±190 Ma and 4553 $^{+17}/_{-20}$ Ma, respectively. To identify the thermal event that corresponds to the $^{146}$Sm–$^{142}$Nd age, the Sm–Nd closure temperature ($T_c$) of plagioclase is estimated because it potentially has a lower $T_c$ than the other major minerals used in the Sm–Nd dating. The $T_c$ for Nd in plagioclase is obtained to 925–1070 ˚C (Fig. 2), which is equal to or slightly lower than the solidus temperature of basaltic eucrites (~1060 ˚C; Stolper, 1977). The $^{146}$Sm–$^{142}$Nd age of NWA 7188 obtained here is the oldest among the Sm-Nd ages of basaltic eucrites reported previously, indicating that this meteorite did not suffer significant resetting during later impact events. However, the age is substantially younger than the crystallization age of the main-group eucrite Juvinas that was estimated from the $^{53}$Mn–$^{53}$Cr mineral isochron (4562.5 ±1.0 Ma; Lugmair and Shukolyukov, 1998). Rather, the $^{146}$Sm–$^{142}$Nd age of NWA 7188 coincides with the Pb–Pb age of zircons

 

in the basaltic eucrite Agoult (4554.4 ±1.7 Ma; Iizuka et al., 2015) that most likely indicates the timing of global crustal metamorphism. Therefore, the age obtained from NWA 7188 suggests that either the timing of crystallization for the Stannern-group eucrites postdated by ~10 Myrs the formation of the EPB's crust, or that the crystallization age of NWA 7188 was reset by the global metamorphism that occurred at 4554 Ma. If the latter is the case, the peak temperature of the global metamorphism was near the solidus of basaltic eucrites and so was high enough to disturb the Sm-Nd isotope systematics of plagioclase in NWA 7188.

Keywords: basaltic eucrites, Sm-Nd chronology, Stannern-group, Vesta, oxygen isotope

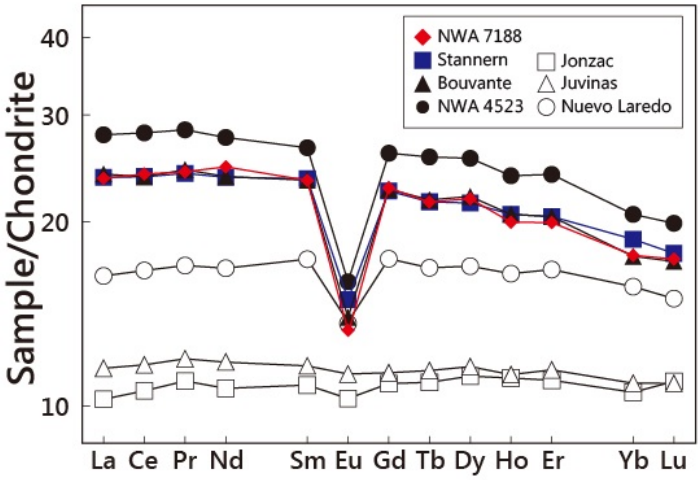


**Fig. 1** *CI chondrite-normalized REE patterns of NWA 7188 (this study) and the other basaltic eucrites (Barrat et al., 2000;2007). The CI chondrite data are from Anders and Grevesse (1989).*

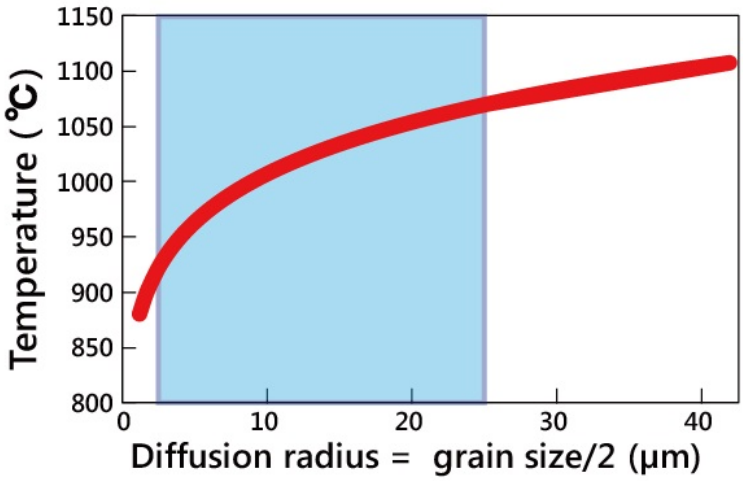


**Fig. 2** *Closure temperature for Nd in plagioclase. Blue area represents typical size of plagioclase.*

 