

FREMDLINGE TYPE OBJECT IN A COSMIC SPHERULE FROM THE INDIAN OCEAN. Rudraswami N. G.^{1,2*} and Shyam Prasad M.¹, ¹National Institute of Oceanography (Council of Scientific and Industrial Research), Dona Paula, Goa, India 403 004 (*Corresponding Author: rudra@nio.org), ²Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, USA.

Introduction:

A predominant majority of ~40,000 tons per annum flux of extraterrestrial matter [1–3] comprises of material in the sub-millimeter size range. These micrometeorites are believed to have been derived from either carbonaceous chondritic based on their bulk compositions or even from cometary bodies based on their textures [4–6]. A small percentage of such spherules also have an achondritic provenance [e.g. 7]. As micrometeorites enter the earth's atmosphere the various degrees of heating they experience results in changes in their mineralogical and chemical compositions [1]. Linking these micrometeorites or cosmic spherules to their original parent bodies is always complicated, since the original identity of the spherules is altered considerably. The platinum group elements (PGE) nugget present in the cosmic spherules have been presented earlier as the result of extreme transformation undergone during atmospheric entry due to heating and oxidation [8–10]. Whereas, PGNs in meteorites have been presented as some of the most primitive, early solar nebular materials or possibly even pre-solar [e.g. 11] and are almost always associated with CAIs and fremdlinge. Such primitive PGNs or fremdlinge have not so far been reported from micrometeorites investigated so far. We present here the discovery of a fremdlinge-type object from the cosmic spherule collection from Indian Ocean which survived atmospheric entry.

Experimental Descriptions:

Cosmic spherules were recovered from a hundred close-spaced locations in the deep sea regions of the Indian Ocean by one of us (MSP). Close to 20,000 spherules of >200 μm diameter are isolated from a total quantity of ~3 tons of sediment collected using grab samplers covering a seafloor carpet area of 25 m^2 . The estimated terrestrial age of the spherules is 0–50,000 years [9,10]. About >1000 spherules from this and an other collection made by one of us (MSP) using magnetic techniques [12] were systematically and sequentially ground and polished for investigations on PGNs. Scanning electron microscope (SEM) JEOL JSM 5800LV attached with OXFORD-INCA energy dispersive spectrometer detector (EDS, ISIS-300) system at National Institute of Oceanography, Goa was used for electron imaging. Electron beam energy of 20 keV was used for back-scattered electron (BSE) images. The suitable high resolution BSE imaging at vary-

ing magnifications was done to identify PGNs in the polished sections, their compositions were subsequently determined by using pure PGE elemental standards.

Results:

During this effort, we have come across a rare type of PGE nugget in one of cosmic spherule AAS26-D-P15 measuring ~150 μm in diameter (Fig. 1a). The nugget exhibits an irregular shape as can be seen in Fig. 1b. The entire nugget (marked as region 1 in Fig. 1b) is enclosed by a Fe–Ni phase (marked as region 2) which is in turn surrounded by a sulfide phase (marked as region 3). This spherule is Ca-rich having bulk che-

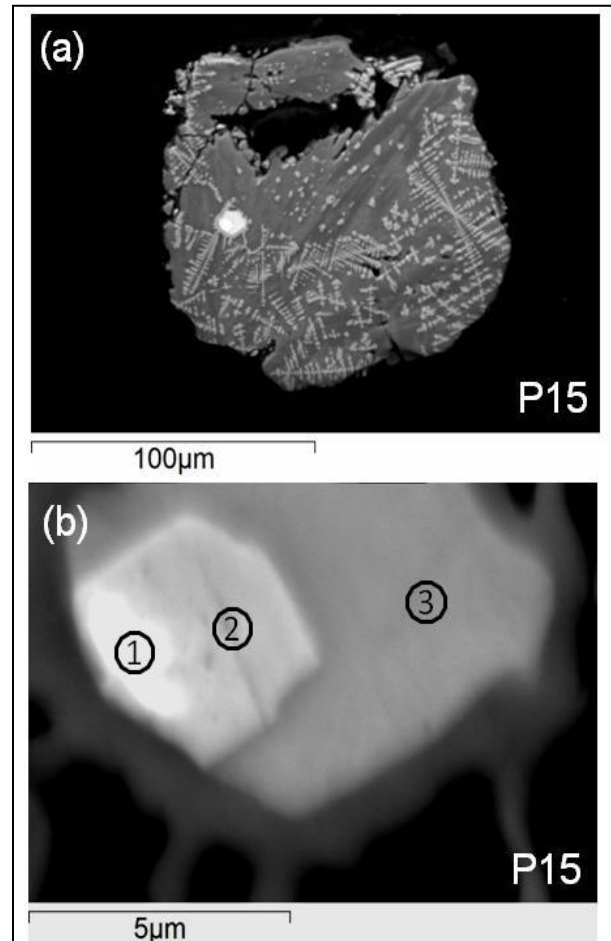


Fig. 1. (a) The SEM image of the AAS26-D-P15 with PGE nugget. (b) The enlarged view of the nugget portion. Marked region 1 are PGE nugget enclosed in region 2 which is Fe–Ni phase. The whole is surrounded by sulfide phase marked as region 3.

-mical composition: CaO ~17 wt%, MgO~16 wt%, Al₂O₃~2.3 wt%, SiO₂~32.1 wt% and FeO~ 31.2 wt%. The more refractory PGE like Os, Ir and Pt are more enriched when compared with Ru and Pd (Fig 2). The fremdlinge is also devoid of elements such as W and Mo.

Discussion:

The spherule AAS26-D-P15 does not fit into the routine classification scheme of cosmic spherules or micrometeorites [13]. The spherule is a Ca-rich object with bulk CaO as high as ~17 wt%. With the presence of the nugget, the spherule has petrological features similar to those of CAIs from carbonaceous chondrites. The complex nature of the nugget assembly bears close resemblance to fremdlinge usually found in CAIs and is multifaceted and complex in nature as can be seen in Fig. 1. This complex spherule with a PGE nugget appears to be an early solar system condensate i.e., a CAI [14, 15]. And the presence of the irregular shaped fremdlinge indicates that the nugget did not experience any major chemical modification or alteration during atmospheric entry. Therefore, its chemistry is representative of early nebular environment and of the parent meteorite of which this spherule was a part.

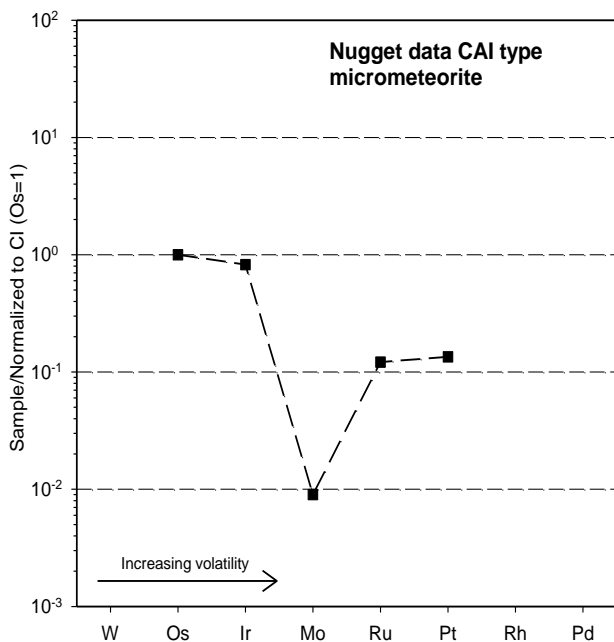


Fig 2. The CI and Os normalized PGE of the nugget from the micrometeorite AAS26-D-P15. Depletion of Pt and Rh when compared with chondritic ratios is visible.

All the PGE concentration of the nugget also does not fall on the normalized CI values as can be seen in

Fig. 2. The nugget does not have any known concentration of W and Mo suggesting that both the elements were been lost in oxidizing either during the entry of atmosphere or in the nebular environment. The depletion of the W and Mo are commonly observed in many CAIs of Allende, Grosnaja, Leoville and Ornans due to high temperature oxidation at high oxygen fugacities [e.g. 14, 15]. There is also no presence of Pd in the nugget. In addition the high concentration of the Fe and Ni in nugget suggest some kind of alteration has taken place. Similar variations in fremdlinge were earlier suggested to be due to processes of oxidation and sulfidation [16]. We believe that the alteration in the nugget of AAS26-D-P15 has taken place in the nebular environment and the precursor of AAS26-D-P15 seems to have a genetic link to CAIs.

While CAIs constitute ~5% of carbonaceous chondrites [17], there is no unequivocal CAI or fremdlinge reported among the micrometeorites so far, in all probability the fremdlinge component is vaporized during entry contributing to the meteoric smoke observed in the troposphere. Further, the survival of this particle implies a low velocity and high zenith angle entry.

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