VANADIUM-RICH REFRACTORY PLATINUM METAL NUGGETS FROM A FLUFFY TYPE A INCLUSION IN ALLENDE; J.M. Paque, Center for Materials Research and Geology Department, Stanford University, Stanford, CA 94305-4045.

The existence of micron sized nuggets in Ca-Al-rich inclusions from carbonaceous chondrites that are rich in refractory metals (W, Mo, Re) and noble, or platinum, metals (Ru, Os, Ir, Pt, Rh) has been known and documented by many workers (e.g., 1-3). The Allende Ca-Al-rich inclusion A-WP1 had previously been found to contain an unusually high concentration of vanadium in the oxide phases (4). Recent work has revealed the presence of vanadium bearing refractory platinum metal nuggets (V-RPM) within A-WP1. The occurrence of vanadium both as a metal and an oxide in the same inclusion may allow constraints to be placed on the conditions of formation of this particular CAI, particularly with respect to the oxygen fugacity. Thorough study of all components of A-WP1 is crucial to deciphering the history of this object and others similar to it.

Description. A-WP1 is similar to "fluffy Type A" inclusions as defined by (5). It consists mainly of gehlenitic melilite (MEL, Ak 6-15) and its alteration products (sodalite, nepheline, grossular, and anorthite), V-rich spinel (SP), and hibonite (HIB). Minor perovskite, corundum, the "unknown phase" (6), and unidentified V-rich aluminates are also present, in addition to the micron sized RPM nuggets that are the focus of this paper. SP enclosed within MEL are low in Fe and contain significant V (1-3 wt.% V_2O_3; referred to as V-SP) while SP in altered areas of the inclusion can contain up to 26 wt.% FeO and 12 wt.% V_2O_3. RPM nuggets are scattered throughout the inclusion and have been divided into three major associations: 1) within MEL; 2) associated with SP; and 3) in altered areas.

Analytical Methods. All RPM nuggets in A-WP1 are only about a micron in size and present unique analytical problems. Wavelength dispersive analyses were undertaken using a 20 kV accelerating voltage and a 20 nA beam current as measured on the Faraday cup. The analytical volume under these conditions is larger than the size of the nugget. For some analyses Si, Mg, Al, and Ca were analyzed in addition to the elements listed in Table 1, and calculated as oxides. In these cases the analytical totals were near 100 wt.%, suggesting that significant quantities of other elements are not present. For all grains, the RPM elements (plus V) were recalculated to 100 %. Due to the analytical uncertainties these results must be considered in a semi-quantitative manner.

Analyses of RPM nuggets in contact with spinel pose additional problems. Both the spinel and the nuggets contain V and Fe. I have not determined the contribution of these two elements to the RPM analyses and instead have chosen to look carefully at analyses of RPM nuggets that are enclosed within MEL, eliminating one source of analytical uncertainty. However, representative analyses of RPM grains from all associations have been included in Table 1.

Results. Examining only the RPM nuggets that occur within MEL indicate that the V content is inversely correlated with both Pt and Fe+Ni, and that many of the elements are present in approximately cosmic proportions (e.g., Figure 1). Previous study (7) of correlations between elements in RPM grains found three compositional groupings: 1) Pt, Mo, W; 2) Os, Ir, Ru; and 3) Fe, Ni. In this inclusion V correlates with Os+Ir+Ru and strong negative correlations exist with the other two groups (Fig. 2). The majority of the variation in composition of V-RPM in MEL can be expressed by the ratio of Pt+Mo+W : Os+Ir+Ru+V, with Fe+Ni relatively constant.

Implications for the origin of A-WP1. (8) calculated that V metal would be stable with a gas of solar composition at T>1770K ($P=10^{-3}$ bar). This would allow for the condensation of V metal along with the other elements in V-RPM. As T decreases and V_2O_3 becomes the stable phase in the solar gas it could condense into SP. Here the assumption is made that RPM do not react with the solar gas to lose V. Condensation of gehlenitic melilite is calculated to occurs at ~1625K (9) and could have the effect of isolating both the V-RPM grains and the V-SP from further compositional changes. V-RPM would be unlikely to oxidize from these grains and enter MEL since the MEL structure would not accept the V cation. As the temperature decreases Fe enters into the SP (wherever the SP grains were not isolated by the MEL from the gas) and alteration of the MEL occurs. The RPM grains in these areas also reacted with the gas, increasing their Fe and Ni contents (analyses R13 and R19 in Table 1). It has not been determined why some of the V-RPM grains that are in contact with V-SP were able to retain their V-rich compositions. Further analyses of the coexisting metal and oxides may resolve this dilemma.

Table 1. Representative analyses of RPM nuggets from A-WP1.*

Sample / Assoc.**	R2 MEL	R5 MEL	R10 MEL	R15 MEL	R1 SP	R3 SP	R13 ALT	R19 ALT
V	25.68	4.91	14.49	11.11	4.00	33.00	0.20	0.20
W	2.11	1.50	1.61	1.80	0.70	1.42	0.00	0.00
Re	0.70	0.20	0.60	n.a.	0.90	0.30	0.10	n.a.
Os	7.15	4.61	12.37	8.31	13.90	5.16	0.00	0.10
Ir	6.55	5.72	13.28	8.21	13.80	10.02	1.10	6.19
Mo	22.26	20.06	10.16	13.11	7.40	13.26	2.90	4.30
Ru	9.67	14.54	13.38	14.81	17.70	8.60	0.00	0.70
Rh	2.22	4.11	1.91	5.01	2.90	1.72	0.00	1.00
Fe	5.24	9.63	5.94	7.91	10.60	11.03	44.14	26.47
Ni	0.70	2.31	1.21	1.40	5.10	0.61	47.65	31.47
Pt	17.72	32.40	25.05	28.33	23.00	14.88	3.90	29.57

*All analyses are normalized to 100 wt. %. n.a.-not analyzed.
**Mineralogical association of RPM nugget, MEL-melilite, SP-spinel, ALT-alteration.

References. (1) Wark D.A. and Lovering J.F. (1976) LSC VII, 912-914. (2) Palme H. and Wlotzka F. (1976) EPSL 33, 45-60. (3) El Goresy A., *et al.* (1978) Proc. 9th LPSC, 1279-1303. (4) Paque J.M. (1985) LPSC XVI, 651-652. (5) MacPherson G.J. and Grossman L. (1984) GCA 48, 29-46. (6) Paque J.M., *et al.* (1986) LPSC XVII, 646-647. (7) Wark D.A. (1983) Ph.D. thesis, U. of Melbourne. (8) Blum J.D., *et al.* (1988) Nature 331, 405-409. (9) Grossman L. and Clark S.P., Jr (1973) GCA 37, 635-649.

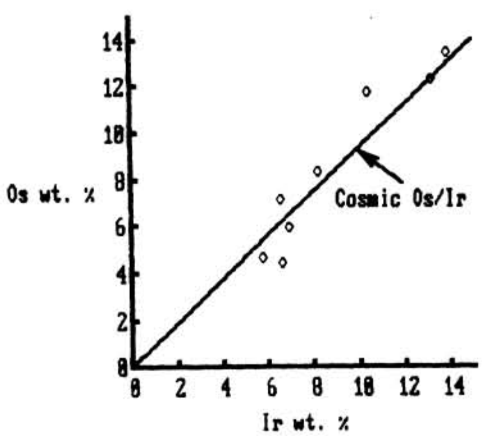

Figure 1. Os vs. Ir (wt. %) from RPM grains enclosed within melilite in A-WP1. The cosmic Os/Ir ratio is shown for comparison.

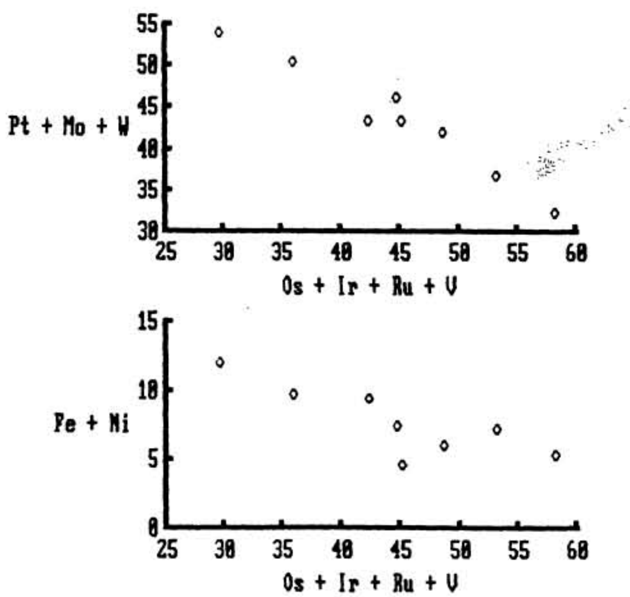

Figure 2. Compositions of RPM nuggets enclosed within melilite from A-WP1.