AN UNIVERSAL METEORITE FORMATION PROCESS.

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Our study of glasses in several types of meteorites show that all glasses have a common source, the solar nebula [1]. Glasses are the remnants of the liquid that facilitated growth of well-ordered crystals from the gas phase by the VLS growth process. The chemical (major and trace element) composition of all glasses have a surprising property: they do not show the signature of crystallization of the minerals they are associated with. Our key observation is that glasses do not have the composition of the residual melt from which the crystals (documented by glass inclusions), or aggregates and chondrules (documented by mesostasis glass), or the whole rock (documented by glasses that fills open spaces in achondrites) were formed [2-3]. These observations led us to develop The Primary Liquid Condensation (PLC) model [4] that utilizes the ability of dust-enriched solar nebular gas to directly condense a silicate liquid [e.g., 6]. Once a stable CMAS liquid nucleus is formed and growth into a droplet, an olivine crystal can nucleate from the liquid. If the quantity of liquid is low, the crystal nucleus will continue growing where it is covered by the liquid. In this way a single crystal can be formed. Increasing the liquid/crystal ratio can create olivine aggregates and droplets of crystal-liquid mush, PO chondrules [7]. If condensation of liquid is faster than nucleation of an olivine crystal, a chondrule-sized droplet is formed, which at a high degree of undercooling will homogeneously or heterogeneously nucleate an olivine crystal. Instantaneously, a plate dendrite can be formed, the barred olivine (BO) texture. We have estimated the composition of the initial liquid droplet for such chondrules to be: SiO_2: 46.1 wt%, MgO: 38.5 wt%, Al_2O_3: 8.4 wt%, CaO: 7.1 wt%. The primary condensate liquid from which BO chondrules could be formed will condense in regions with a dust/gas ratio enhanced over the solar value by ~ 700 x CI dust - at T~ 1700 °C and p ~ 10^{-3} atm [8].Variation in the chemical composition of, e.g., the mesostasis glasses, is achieved by continuing communication of the glass with the cooling nebula that will result in a variety of elemental exchanges. This way an infinite amount of individual chemical compositions for chondrules and other chondrite constituents is created – as it is observed.

A liquid of similar composition and origin also formed the olivine-anorthite intergrowth of angrites [9] and a chemically slightly modified liquid – increased Si/Mg but similar TE abundance – crystallized the eucrites [10].

Also, radiating pyroxene (RP) chondrules could form as droplet liquid condensates directly from a nebular gas [11]. Enstatite becomes a stable liquidus phase in a 800 x CI dust-enriched nebular gas at a p^{tot} of 10^{-3} atm., after about 72 % of the originally present Mg was removed (as forsterite?) from the system.

In conclusion, the PLC model describes an universal process that can create all major chondrule types, PO, BO and RP, omnipresent in all chondrites, in the same region of the solar nebula. In addition, it can also create some common achondrites (e.g., ureilites, angrites, eucrites) directly in the solar nebula and does neither need parent bodies nor re-heating events. The PLC model describes chondritic constituents and their infinite chemical variability as well as the most common achondrites as consequent products of just a single-step cooling solar nebula.

References: [1] Varela and Kurat, 2004, *MAPS 39* Suppl, A109; [2] Varela et al., 2002, *GCA* 66, 1663-1679; [3] Varela et al., 2003, *GCA* 67, 5027-5046; [4] Varela et al., 2005, *Icarus* 178, 553-569; [6] Ebel and Grossman, 2000, GCA 64, 339-366; [7] Kurat et al., 2004, *MAPS 39* Suppl, A57; [8] Varela et al., 2005, Icarus, in press ; [9] Varela et al. (2005) MAPS 40, 409-430; [10] Varela et al. (2005) EGU05-A-07425 ; [11] Ebel et al. 2003, LPS XXXIV, 2059.pdf.