A SPECULATIVE "FIEFDOM" MODEL FOR CHONDRITE ORIGINS.

H. J. Melosh[1], P. A. Bland[2], G. S. Collins[3] and B. C. Johnson[4]. [1]EAPS Department, Purdue University, 550 Stadium Mall Drive, West Lafayette, Indiana, 47906, USA, jmelosh@purdue.edu. [2]Dept. Applied Geology, Curtin University, GPO Box U1987, Perth, Weatern Australia, 6845, Australia, P.Bland@curtin.edu.au. [3]IARC, Dept. of Earth Science & Engng, Imperial College, London, SW7 2AZ, UK, g.collins@imperial.ac.uk. [4]Dept. Earth, Environmental and Planetary Sciences, Brown University, Providence, Rhode Island, 02912, USA, brandon_johnson@brown.edu.

Introduction: The ultimate origin of the many classes of chondrite meteorites has been a vexing problem since they were first recognized more than 150 years ago. Three years ago Johnson et al. [1] proposed an impact jetting origin for chondrules. That model was criticized on the grounds that it did not provide a basis for compositional complementarity between chondrules and matrix materials, a problem that has recently been exacerbated by the discovery of complementary matrix/chondrule W isotopic abundances [2]. Connelly et al.'s [3] finding that individual chondrules in the same chondrite may differ in age by millions of years further complicated this issue.

Model: We believe that we can resolve these difficulties with a model inspired by the ALMA observations of dust bands in protoplanetary disks such as HL Tau and TW Hya [4,5] . Although these dust bands are observed only at great distances from their host stars (10 to 100 AU), we hypothesize that in the (currently unresolvable) inner disk, dynamical processes led to a similar radial separation of dusty domains separated by gas-dominated zones, a separation perhaps enforced by interaction with growing planetary embryos aided by dust-gas interactions. We call these dusty domains "fiefdoms" after feudal estates whose self-sufficient economies required only minimal interactions with their neighbors. In a similar way, we propose that each individual dust band was the birthplace of a distinct class of chondrite. Impacts (or other nebular processes: This proposal is independent of any specific chondrule-forming mechanism) among Moon-size and larger protoplanets within each dust band (fiefdom) created chondrules which then, along with undifferentiated dust, gradually accreted into locally-sourced asteroid parent bodies over the ca. 3 Myr lifetime of the nebular gas, perhaps dominated by pebble-accretion processes. Each band thus preserved a distinctive chemical and isotopic signature inherited from its original location in the nebula. When the gas dissipated, gravitational interactions among now-massive protoplanets destabilized their orbits and led to a final stage of violent collisions and growth of a small number of bodies to final planetary dimension, a process that may have been aided by a "grand tack" migration of one or more giant planets [6], leaving behind the solar system as we currently find it. Although no currently investigated dynamical mechanism predicts the formation of such separate dusty domains, we believe that the facts of chondrite ages and compositions demand such a structure during the gas-rich phase of the early solar nebula.

References: [1] B.C. Johnson, D.A. Minton, H.J. Melosh, M.T. Zuber (2015), Nature. 517, 339–341. doi:10.1038/nature14105. [2] G. Budde, T. Kleine, T.S. Kruijer, C. Burkhardt, K. Metzler (2016) Proceedings of the National Academy of Sciences of the United States of America. 201524980–6. doi:10.1073/pnas.1524980113. [3] J.N. Connelly, M. Bizzarro, A.N. Krot, A. Nordlund, D. Wielandt, M.A. Ivanova (2012) Science 338 651–655. doi:10.1126/science.1226919. [4] S.M. Andrews, D.J. Wilner, Z. Zhu, T. Birnstiel, J.M. Carpenter, L.M. Pérez, et al. (2016), ApJ. 820 1–5. doi:10.3847/2041-8205/820/2/L40. [5] K. Zhang, E.A. Bergin, G.A. Blake, L.I. Cleeves, M. Hogerheijde, V. Salinas, et al. (2016), ApJ. 818 1–7. doi:10.3847/2041-8205/818/1/L16. [6] K.J. Walsh, A. Morbidelli, S.N. Raymond, D.P. O'Brien, A.M. Mandell (2011) Nature 475 206–209. doi:10.1038/nature10201.

Brief Description: Distinct chondrite classes, complementarity of chondrules and matrix, and chondrule ages together argue for the existence of long-lasting, distinct domains ("fiefdoms") in the protoplanetary nebula during the chondrule-forming era.