Mineralogy and Texture Descriptions to Help Understand Chondrule Origins

R. K. Herd[1]. [1]Curator, National Meteorite Collection of Canada (Retired) herdrk@gmail.com

Introduction: Attempts to understand chondrule origins almost always involve chemical and isotopic approaches before, or in place of, other observations. Chondrules are tiny rocks, produced by cosmic processes and containing, therefore, some evidence within themselves of their origin, preserved in their mineralogy and textures. Simple, mnemonic and alpha-numeric codes to describe these fundamental features have been developed and are now being refined [1,2,3,4,5].

Methodology: The codes allow an at-a-glance means of recording mineralogy and textures dominated by bi- or multi-modal crystal-size populations of olivine (O) and pyroxene (P) of variable habit. Chondrule images, (e. g. BSE grey-scale) may be annotated with letters that compile into number sequences that convey essential detailed and comparative classification information. They resemble ISBNs, Bar Codes, or Credit/Debit Card numbers, a familiar format in this digital age.

Potential: Alpha-numeric codes or tags allow researchers: to document and label intra-chondrule textures in each chondrule, from relatively coarse- to fine-grained; to map out the distribution of similar or dissimilar chondrules in any chondrite; to compare the kinds of chondrules present in different chondrites; and to teach observers to ponder the processes that may have affected chondrule formation. The discipline of having to assign an alpha-numeric label to each chondrule leads to detailed textural observations that might not otherwise have been made, e.g. of melting, annealing, and reaction textures at different scales. Robust, evidence-based constraints and ideas on chondrule origins should result, that need to be considered along with others from e.g. cosmochemical approaches.

Description schemes: The most robust textural-mineralogical scheme used by meteoriticists [6] to describe (intra)chondrule textures has been in successful use for 35 years and is firmly entrenched. It tends to lump, rather than split and for detailed studies is not ideal. Recognizing that the size distribution of minerals and crystals in chondrules can be subdivided into four size ranges for each and every chondrule -- megacrystic (M), macrocrystic (m), microcrystic(µ), and mesostasis (*ms*) -- with tags for equant (q), elongate (l), angular (a), and rounded (r), an alphabetic scheme that splits rather than lumps yields many details [1,2,3]. For example, two chondrules from the ordinary chondrite Saratov (L4) labelled S2 and S4, respectively, are classified as follows under the alphabetic system:

S2:	POP	mµ*ms*	mOla, Plr, Pqr / µPla / meso
S4:	POP	mµ*ms*	mOqa/ µPla, Pqa / meso

Both chondrules are POP [6]. Neither contain megacrysts. S2 contains macrocrysts of angular elongate olivine, elongate rounded pyroxene, and equant rounded pyroxene; and microcrysts of elongate angular pyroxene. S4 contains macrocrysts of equant angular olivine; and microcrysts of elongate angular pyroxene, and equant angular pyroxene. Both show (unresolvable) mesostasis. They therefore have different detailed mineralogy and textures, but this is still not readily grasped at-a-glance.

The new system: The most up-to-date and improved version of the new system substitutes numbers for the letters, arranged in 4 sequential fields with 5 slots each:1=Ola, 3=Olr, 5=Oqa, 7=Oqr, 2=Pla, 4=Plr, 6=Pqa, 8=Pqr , 9=unresolvable, 0=not present. *spaces are for notes on the immediately preceding size ranges.

S2 becomes:	0000*1048*0020*9999*	(cf. mOla, Plr, Pqr / µPla / meso)
S4 becomes:	0000*5000*0026*9999*	(cf. mOqa/ µPla, Pqa / meso)

The first five digit spaces are for M. At each scale the left 2 spaces are assigned to O, the right 2 spaces to P. As above, odd numbers describe olivine, even numbers pyroxene, except for 9 and 0. The next five digit spaces are for m, the next for µ, and the last for *ms.*

Results: The chondrules are clearly different at-a-glance in the numeric system.

References: [1] Dixon, L. et al. 2009. Abstract #1465. 40th Lunar & Planetary Science Conference. [2] Herd R.K. et al. 2010. Abstract #2026. 41st Lunar & Planetary Science Conference. [3] Herd, R.K. 2014. *Meteoritics & Planetary Science* 49: Supplement: Abstract #5416. [4] Herd, R.K. 2015. Abstract #2824. 46th Lunar & Planetary Science Conference. [5] Herd, R. K. 2016. *LPI Contribution* No. 1921: Abstract #6236. [6] Gooding, J.L. & Keil, K. 1981. *Meteoritics & Planetary Science* 16: pp. 17-43.