NUMERIC CODES DOCUMENT CHONDRULE TEXTURES AND CRYSTALLIZATION HISTORY.

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Introduction: Ferromagnesian chondrules, the most abundant compositional variety, consist of essential olivine and/or low-Ca pyroxene crystals embedded in mesostasis[1]. The textures of these minerals and their intergrowths record the cosmic processes to which they have been subjected, and to which they have responded, completely or partially. The textures are a potentially vast source of information on how, or even where and when, chondrules and chondrites formed, and re-formed. Simple numeric codes to document not just the presence/absence of minerals, but also intra-chondrule textures, have been developed, and are being refined and tested [2,3]. A subset of chondrules occurring in the L4 chondrite Saratov continues to form the basis of investigations, using available BSE photos.

Methodology: The numeric codes enhance the most robust textural-mineralogical scheme in use for over 35 years to describe chondrules [4]. The new annotations allow a means of describing and differentiating among intra-chondrule assemblages dominated by bi- or multi-modal crystal-size populations of olivine (O) and pyroxene (P) of remarkably variable habit. These assemblages have previously been lumped together in broad categories that obscured their individual variety, and did not assist systematic comparisons within the categories. Recognizing that the size distribution of minerals and crystals in chondrules can be subdivided into four size ranges -- megacrystic (M), macrocrystic (m), microcrystic(μ), and mesostasis (ms) -- with tags for equant (q), elongate (l), angular (a), and rounded (r), an alphabetic scheme was the precursor of the numeric codes. 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.

Examples:	S9	0000*0760*0000*9999*	PPO
	S13	0060*0764*0000*9999*	PPO
	S14	0000*0760*0000*9999*	PPO
	S16	0000*0740*0000*9999*	PPO

Pyroxene (6,4) and minor relict olivine (7) dominate macrocrystic assemblages in these chondrules. The pyroxene looks to be derived from original olivine, probably by reaction with silica in its surroundings.

S2	0000*1048*0020*9999*	POP
S8	0000*7500*0028*0000*	POP
S17	7500*7500*0028*0000*	POP
S19	0000*1300*0028*9999*	POP

Olivine (7,5,1,3) dominates macrocrystic assemblages with very similar microcrystic pyroxene (2,8).

Discussion: The most common variety of chondrules under the earlier scheme[4], the "porphyritic" ones, constitute 84% of Ordinary Chondrite chondrules. This observation supports the conclusion that all such chondrules formed from melts[1]. While such textures may have the same general origin (variable melting and cooling processes and rates, sub-liquidus and sub-solidus reactions, recrystallization and/or annealing), they are not identical, and they do not record identical events. The ferromagnesian mineral phases are not all phenocrysts and the chondrules are not all porphyries. Some means of sorting and sub-dividing chondrules is required, to allow access to the rich and valuable data their textures contain. The new numeric scheme facilitates, at-a-glance, the subdivision of chondrule textural groups, and records features related to the variability of their heating and cooling histories, for four size ranges for each chondrule. Common size-related features of different chondrules are recognizable, e.g. when chondrules have different megacrysts and/or macrocrysts, but the same microcrysts with the same mineralogy and texture.

Conclusions: The numeric codes are much more useful to understanding the origin of chondrules than schemes and nomenclature that lump them texturally. Assigning the codes requires observers to look more carefully at the intra-chondrule textures and to ponder their origins, recognizing features that may be comparable to igneous and metamorphic Earth rocks affected by changing P, T and X. Considering chondrites as agglomerates and subdividing their chondrules by their preserved textures may help to determine characteristics of chondrule source-regions, and how many such regions have contributed to the plethora of samples available today. Chondrule groupings and subdivisions can be tested for consistency using chemical and isotopic studies.

References: [1] Rubin A. E. and Ma C. (2017) *Chemie Erde-Geochemistry.* [2] Herd R. K. (2017) *LPS XLVIII*, Abstract #2753. [3] Herd R. K. (2017) Workshop on Chondrules and the Protoplanetary Disk, Abstract #2033. [4] Gooding J. L. and Keil K. (1981) *Meteoritics & Planetary Science*, 16:17-43.