A DETAILED INVESTIGATION OF THE MINERALOGY AND TEXTURES OF THE L4 ORDINARY CHONDRITE SARATOV. L. Dixon[1], R. K. Herd[1,2], C. Samson[1], P. A. Hunt[2], [1]Department of Earth Sciences, Carleton University, Ottawa, Ontario K1S 5B6 (ldixon@connect.carleton.ca), (claire_samson@carleton.ca), [2]Natural Resources Canada, Ottawa, Ontario K1A 0E8 (herd@nrcan.gc.ca), (phunt@nrcan.gc.ca).

Introduction: We argue that in order to classify and thoroughly investigate the formation, history and provenance of chondrules, exhaustive and systematic textual and mineralogical observations are required. While we acknowledge that long-standing mineralogical-textural classifications for chondrules exist, they obscure relevant data. For example, many workers would class a chondrule with radiating spinifex textured olivine and pyroxene (Figure 1A) identically to another with coarse subhedral olivine and skeletal pyroxene[1] (Figure 1B). This conventional approach homogenizes two vastly different textures. Moreover, these schemes overlook micron-scale features, such as mesostasis crystals and zoned pyroxene that may provide invaluable insight into chondrule history.

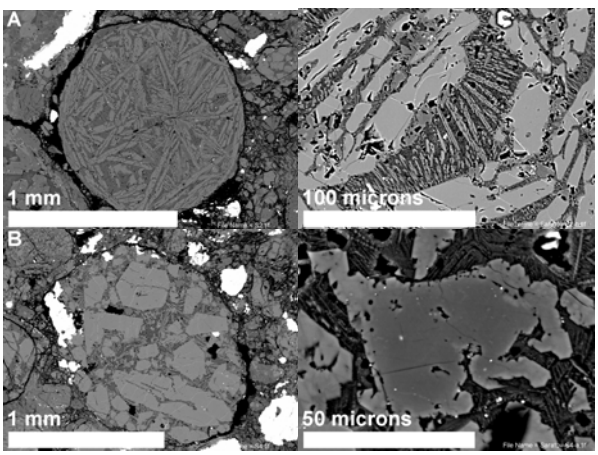

Figure 1: BSE images of Saratov chondrules S2 and S4. A) S2 displays spinifex texture (left). Fine pyroxene crystals are set in dark mesostasis between larger light grey olivines (right) B) S4 contains coarse subhedral olivine and skeletal pyroxene (left). Pyroxene is zoned from an orthopyroxene core to a low-Ca pyroxene rim (right). By current classifications, both are porphyritic olivine-pyroxene (POP) type.

Herd et al.[2] identified and described 19 chondrules (denoted S1 to S19) with archetypal and atypical textures using a polished thin section of the L4 ordinary chondrite Saratov. Saratov was selected for their study because of the abundance and variety of representative chondrules[2]. The objective of our follow-up project is to further contribute to the development of a new comprehensive classification scheme for chondrules based on mineralogy and textures.

Methods: Currently, we are investigating chondrule mineralogy and textures by polished thin section analysis using a scanning electron microscope (SEM). The SEM is an important tool for our research since most chondrule features are at the micron-scale and may be overlooked with a petrographic microscope. Due to time constraints, we restricted our study to chondrules greater than 100 µm in diameter.

Herd et al.[2] used back-scatter electron (BSE) images to generate a photomosaic of the entire Saratov thin section. From this photomosaic, we have created a 2.5 mm^2 grid coordinate system of the thin section in order to map specific chondrules. Additionally, we have identified numerous textures and mineral phases with the aid of BSE images, energy dispersive spectrometry (EDS) and cathodoluminescence.

Discussion: Our preliminary results indicate that chondrule textures are akin to those of igneous and metamorphic rocks[3]. For instance, chondrule S2 (Figure 1A) displays spectacular radiating olivine laths reminiscent of the spinifex quench texture observed in komatiites[4]. Additionally, komatiites often contain elongate pyroxene set between the larger olivine crystals similar to those seen in chondrule S2[4].

Chondrule S4 (Figure 1B) may have experienced a different cooling history. Coarse subhedral olivines suggest slower initial cooling, while zoned pyroxene and fine dendritic mesostasis crystals may indicate a final quenching stage[5]. Zoning and dendritic crystal forms suggest that equilibrium was not achieved - consistent with the rapid cooling often seen in volcanic material[5].

Similarly, S15 (Figure 2A) exhibits pronounced zoning at the chondrule scale, implying that it is not in equilibrium and therefore may have crystallized very rapidly[5]. It is predominantly composed of tightly spaced strands of radiating pyroxene with the main phases consisting of relatively Fe-rich orthopyroxene (dark grey) and low Ca-clinopyroxene (light grey). The radiating texture of the elongate pyroxenes also strongly suggests quenching[4]. Furthermore, the chondrule rim shows evidence of a sieve texture. This texture can occur when melt is included in rapidly growing crystals due to significant undercooling of the liquid [5].

In contrast, chondrule S3 (Figure 2B) appears to have progressed toward equilibrium since the number of mineral phases and the grain size range seem to be reduced[5]. The predominant minerals are elongate forsteritic olivines with sodic plagioclase as mesostasis. Moreover, the olivine laths suggest movement to equilibrium since they have rounded boundaries and are angled at 110º to 120º to each other[5]. Hence, this chondrule seems to exhibit an annealed texture similar to thermally evolved metamorphic rocks[5].

Other metamorphic or plutonic textures are evident in chondrules such as S6 (Figure 2C). This chondrule has concentric mineral rings that resemble the corona texture observed in high temperature and pressure rocks[5]. Anhedral olivine is at the core while plagioclase, pyroxene and olivine form successive layers outward to the pyroxene rim. Within the rim there is partial replacement or intergrowth of at least three pyroxene phases - Ca-clinopyroxene (light grey) between high-Al enstatite or orthopyroxene (both dark grey). This pattern resembles the symplectite or mesh texture often associated with metamorphic coronas[5].

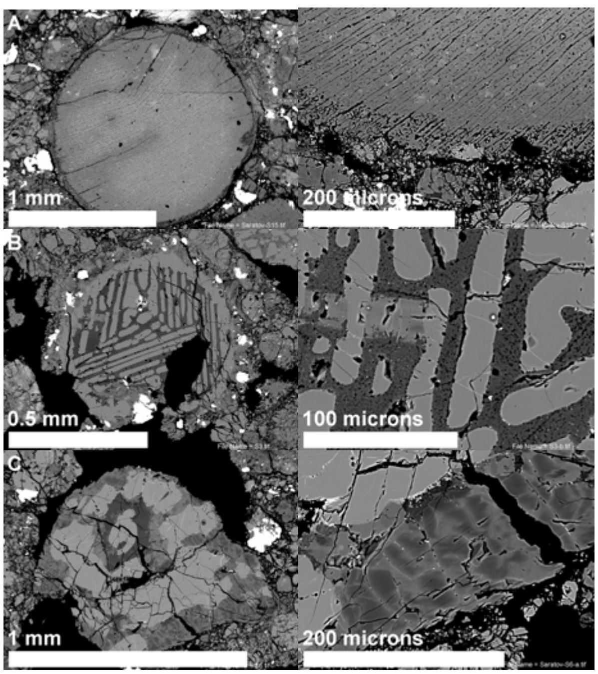

Figure 2: BSE images of Saratov chondrules S15, S3 and S6. A) S15: pyroxene zoning visible at the chondrule scale (left). Rim displays sieve texture (right). B) S3 contains olivine laths and sodic plagioclase as the dominant phases (left). Olivine has rounded grain boundaries and exhibits evidence of annealing (right). C) S6 contains mineral rings that resemble corona texture (left). The mottled appearance of the rim is similar to symplectite or mesh texture (right).

Work in Progress: Our mineralogical and textural observations suggest chondrules have experienced a variety of crystallization and recrystallization conditions. Our aim is to identify several categories around these cooling and pressure-temperature conditions and classify chondrules accordingly. With this approach, we should also be able to make critical distinctions between chemically similar chondrules - much like geological classifications that differentiate terrestrial rocks, such as gabbro and basalt or limestone and marble.

We will construct these categories to reflect mineralogy, cooling rates and stages, degrees of subsequent heating and pressure, grain size and morphology, etc. Modifiers may also be necessary to account for relict grains, inclusions and fractures. Once the classification scheme is complete, we will categorize the Saratov chondrules and plot their mineralogical and textural features on the photomosaic map.

To date, we have documented and mapped the size, sorting and packing of 370 chondrules in the Saratov polished thin section.

References: [1]Jones R.H. et al. (2005) *ASP, 341*, 251-285. [2]Herd R.K. et al. (2004) *LPSC XXXV*, Abstract # 2070. [3]Herd R.K. et al. (2005) *LPSC XXXVI*, Abstract # 2241. [4]Fowler A.D. et al. (2002) *Precambrian Research, 115*, 331-338. [5]Shelly D. (1993), *Igneous and metamorphic rocks under the microscope*, London, UK.