Petrologic type 7: Necessary or not?

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Ordinary chondrites are classified into petrologic types 3 to 6. Some chondrites seem to have experienced a higher degree of thermal metamorphism than type 6. Dodd et al. (1975) proposed petrologic type 7 for such chondrites, and suggested the criteria include rare relict chondrules, Ca-rich low-Ca pyroxene, and coarse-grained plagioclase, based on the observations of the Shaw meteorite. Takeda et al. (1984) also suggested that Y-74160 is an LL7. However, Taylor et al. (1979) argued that Shaw is an impact melt breccia. Mittlefehldt and Lindstrom (2001) suggested that Y-74160 is not type 7, because of impact melting. On the other hand, LEW 88663 is an L7, not having evidence for partly melted (Mittlefehldt and Lindstrom, 2001). Tait et al. (2014) studied the Watson 012 chondrite in detail, and proposed that type 7 is defined as a partially melted rock.

Thus, the classification and criteria for type 7 is a controversial problem. Brearley and Jones (1998) suggested that type 7 is not generally accepted. Nevertheless, 109 chondrites are reported as type 7 in the Meteoritical Bulletin database, as of September 2017. In order to evaluate whether type 7 is necessary for classification of chondrites or not, and to improve the classification criteria for chondrite petrologic type, we studied 13 chondrites, by using FE-SEM and EPMA. All meteorites studied have been classified as type 7 or type 6/7.

The Y-790446 L chondrite shows recrystallized texture with abundant relict chondrules, and is reclassified as L6. Five other samples, EET 92016, Uden, Y-74160, Y-790120, and Y-791067 show not only brecciated texture, but well recrystallized features. These must be called recrystallized breccias.

On the other hand, the other 7 chondrites show well-recrystallized texture, without brecciated features. Equigranular texture with triple junctions is predominant in all of them. Additionally they all contain relict chondrules. However, the number density of chondrules is lower than 0.06 per mm^2. The constituent minerals, olivine, pyroxene, and plagioclase, are homogeneous in composition. Average CaO contents of low-Ca pyroxenes are 0.7-1.9 wt.%. These features are nearly consistent with the criteria by Dodd et al. (1975). However, Y-75008 is enriched in opaque minerals in its modal composition and is a melt rock, similar to some partially melted primitive achondrites (McCoy et al., 1997). The other 6 chondrites have modal compositions that are consistent with those of ordinary chondrites. One of them, Y-82067 preserves a chondritic chemical composition, in spite of a highly recrystallized texture (Friedrich et al., 2014).

From these observations, we propose new criteria for classification of type 7 as follows; 1) The texture is predominantly equigranular with triple junctions between minerals. 2) Relict chondrule abundance is lower than 0.06 per mm^2 (~2-3 in a normal thin section of 1 inch diameter). 3) Modal composition is consistent with that of ordinary chondrites. 4) No brecciated and melted features are observed, although such features often become ambiguous by later thermal events. We exclude recrystallized and melt breccias from type 7. These chondrites of type 7 are clearly distinguished from type 6, especially by the criteria 1) and 2), and we suggest that type 7 is necessary to petrologic classification of ordinary chondrites. Type 7 chondrites experienced higher temperatures or longer durations of metamorphism than type 6, but the temperatures did not exceed the solidus temperature. Our new criteria are simple and convenient, especially for the many organizations classifying great numbers of meteorite samples, because only optical microscopy and EPMA are needed.

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