

## BRECCIATION OF ORDINARY CHONDRITES - SURVEY OF 2248 METEORITES

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**Introduction:** Meteorites are affected by shock metamorphism. Impacts on meteorite parent bodies can cause brecciation and among all groups of meteorites abundant brecciated rocks were recognized (e.g. [1]). Ordinary chondrites are shocked to various degree [2] and are often heavily brecciated (e.g. [3,4]). In 1967 Binns [5] studied 361 ordinary chondrites and registered ~66% LL chondrites as breccias as well as ~33% and ~20% as H and L chondrite breccias, respectively.

**Results:** In this study thin sections (PTS) of 994 H, 736 L, and 115 LL chondrites and hand specimen of 202 H and 201 L chondrites at the Institut für Planetologie were studied in order to obtain the abundance of brecciated rocks among these chondrites (Table 1). Data on the LL chondrites were published earlier [6].

*H chondrites:* We have studied 1196 H chondrites and 154 are brecciated. The 13% of brecciated H chondrites are significantly lower than the 33% registered by [5]. Most of these breccias are complex breccias containing fragments of various petrologic types (H3-6).

*L chondrites:* A brecciated texture was found in 126 of the 937 studied L chondrites. This makes about 13% and is somewhat lower than the value obtained by [5].

*LL chondrites:* 91 of the investigated 115 chondrites are brecciated (~79%). This percentage is somewhat higher than the value earlier estimated by [5] (~66%). In addition, 48 of the 115 examined LL chondrites contain shock veins. 44 of these 48 chondrites are brecciated rocks. Many of the LL5, LL5-6, and LL6 breccias experienced thermal metamorphism and recrystallization after brecciation and relithification.

*Shock veins:* About 27% of the ordinary chondrites contain shock veins (Table 1). The number of ordinary chondrites with shock veins increases with the petrological type. In most cases shock veins cross-cut different fragments of the entire thin section. In other cases the shock veins are restricted to individual clasts indicating that these veins were formed in an earlier setting, prior to brecciation, mixing of fragments, and shock-relithification [7] to form the current breccia.

**Discussion:** The LL chondrites are by far the most heavily brecciated class among the ordinary chondrites. This fundamental result is consistent with earlier studies by [5], who stated that H and L chondrites are less often brecciated (~33% and ~20%, respectively). However, Binns [5] registered a higher percentage of brecciated H and L chondrites than the results of this study show. Most of the samples studied here are hot desert finds which are not corrected for pairing [8]. However, the effect of pairing is very small since similar data were obtained for the samples not related to the desert meteorites from dense collection areas (compare values in brackets of Table 1). Breccias with a huge variety of xenolithic clasts like Kaidun and Almahata Sitta were not encountered [9-12].

**References:** [1] Bischoff A. et al. (2006) Meteorites and the Early Solar System II (eds. D.S. Lauretta and H.Y. McSween Jr.), 679-712, Univ. of Arizona, Tucson. [2] Stöffler D. et al. (1991) *Geochim. Cosmochim. Acta* 55:3845-3867. [3] Bischoff A. et al. (1993) *Meteoritics* 28:570-578. [4] Metzler K. et al. (2011) *Meteoritics & Planetary Science* 46:652-680. [5] Binns R.A. (1967) *Earth Planet. Sci. Lett.* 2:23-28. [6] Schleiting M. (2014) Bachelor-Thesis, Inst. Planet., WWU Münster, Germany 1-54; [7] Bischoff A. et al. (1983) *Earth Planet. Sci. Lett.* 66:1-10. [8] Bischoff A. and Geiger T. (1995) *Meteoritics* 30:113-122. [9] Zolensky M. and Ivanov A. (2003) *Chem. Erde-Geochem.* 63:185-246. [10] Horstmann M. and Bischoff A. (2014) *Chem. Erde-Geochem.* 74:149-183. [11] Bischoff A. et al. (2010) *Meteoritics & Planetary Science* 45:1638-1656. [12] Goodrich C. et al. (2014) *Elements* 10:31-37.

Table 1: Brecciation among 2248 studied ordinary chondrites. Samples in brackets exclude desert chondrites from dense collection areas.

		H	L	LL
Number of samples	PTS	994(187)	736(179)	115(21)
	Hand specimen	202	201	0
Brecciated chondrites	Total number	154(29)	126(20)	91(14)
	Breccias in %	13(16)	13(11)	79(67)
	Binns [5] in %	33	20	66
Chondrites with shock veins	Total number in %	21	33	42
	location of shock veins* in %	78/14/8	91/4/5	53/45/2

\*) indicates the occurrence (location) of shock veins within the meteorites. Example: (78/14/8) = in 78% of the chondrites with shock veins, the veins cross-cut the entire meteorite, in 14% of the cases shock veins are restricted to individual fragments, and in 8% of the cases shock veins were not found in our samples, but described in the literature.