# NORTHWEST AFRICA 11351 (LL3-6): A CASE STUDY FOR A SHOCK-INDUCED PETROFABRIC.

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**Introduction:** Chondrites often show petrofabrics that were created by shock deformation [1-3]. Northwest Africa (NWA) 11351 is a strongly shocked (primarily shock stage S4) LL genomict breccia that we studied with microCT for 3D particle shapes of opaques (metal and troilite), and with EBSD for crystallographic features in an oriented thin section. Our goals were to: 1) see whether EBSD fabric data for metal, troilite, and olivine could be related to microCT fabric data, and 2) better understand the ways in which chondrite fabrics were established by shock deformation. Our assessment is that the two techniques provide consistent and complementary fabric information and that NWA 11351 could provide a case study for how chondrite petrofabrics were established.

**NWA 11351:** The meteorite contains 3 lithologies: Lith A, Type 3/4 with excellent cluster texture; Lith B, Type 3/4 with very poor cluster texture and which is fragmental; and Lith C which is a breccia with Type 5 and 6 clasts. Lith A forms a lenticular unit between the other two lithologies. Troilite forms coarse aggregates in Lith A that partly engulf chondrules and that are elongated subparallel to the Lith A-B-C contact. All three lithologies were sampled by microCT in one hand specimen 3.0 x 2.2 x 1.3 cm across, and Lith A and B were studied in a thin section that was created from one cut face of this specimen.

**3D shapes of opaques via micro-CT:** Opaque minerals in all three lithologies show the same strong foliation of long grain axes roughly parallel to the Lith A-B-C contacts. Short grain axes in all lithologies form nearly the same lineation normal to this. This indicates that the fabrics for all lithologies were established in one shock event after the individual lithologies formed. The data can be explained by compression perpendicular to the lithology contacts. Further, the lenticular shape of Lithology A, and the elongation of coarse troilite aggregates within it, can be explained by compression and attendant flattening.

**Crystallography via EBSD:** One large area map (LAM) covering much of the section, two regional "mini-LAMs", and several targeted maps (TMs) of metal and troilite were obtained. Most metal indexes as bcc phase, which could be kamacite or martensite. Some maps for both Lith A and B show clear evidence for a shape-preferred orientation (SPO) of olivine, bcc metal, and troilite, with the trace of long grain axes oriented subparallel to the A-B contact, consistent with the microCT data. Other maps lack good evidence for SPO of one or more of these phases. Bcc metal is heavily deformed and extensively twinned, with <111> twin lamellae in Lith A grains having preferred orientations at an angle to the Lith A-B contact (Fig. 1, left). This suggests a shear origin for the twins produced during compression. Troilite is also heavily deformed, partly recrystallized, and has <$\bar{1}\bar{1}$20> twins. Recrystallized troilite grains form bands that cross-cut non-recrystallized grains, suggestive of shear-induced recrystallization. Troilite {0001} is lineated at a high angle to the plane of the thin section and has a weaker foliation subparallel to the Lith A-B contact (Fig.1, right). The troilite {0001} lineation and foliation are roughly normal to the inferred compression direction, which is unexpected as previous work indicated that {0001} poles would orient parallel to the maximum compressive impact stress [4]. This could indicate mobilization of troilite *along* confined and compressing layers between constituents in the rock.

**References:** [1] Sneyd D.S. et al. (1988) *Meteoritics* 23: 139-149. [2] Krzesińska A. et al. (2015) *Meteoritics & Planetary Science* 50: 401-417. [3] Hanna R. et al. (2015) *Geochimica et Cosmochimica Acta* 171: 256-282. [4] Ruzicka A.M. and Hugo R.C. (2018) *Geochimica et Cosmochimca Acta* 234: 115-147.

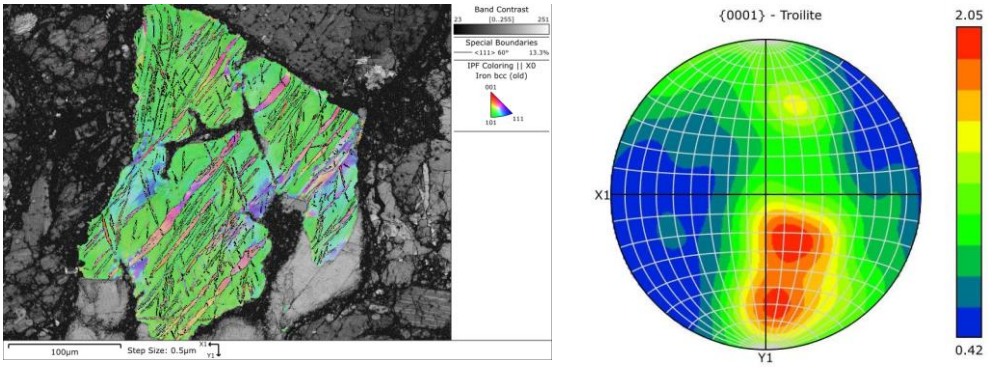


*Figure 1*. EBSD images (Lithology A) with inferred compression direction left-right (x direction). Left: bcc metal grain that has twin lamellae, colors indicate IPFx orientations. Right: pole figure plot of troilite {0001}, 1 point per grain, colors indicate MUD values.