TWO SHATTER-CONED NWA METEORITES. J. F. McHone[1], C. Shoemaker[2], M. Killgore[3], and K. Killgore[3] [1]Planetary Geology Group, Arizona State Univ.,Tempe AZ 85287-1404 (jmchone@hotmail.com), [2]U.S.Geological Survey, Astrogeology Science Center, Flastaff AZ 86001, [3]Southwest Meteorite Lab, PO Box 95, Payson AZ 85547

Introduction: Shatter cones are well known in target rocks as diagnostic indicators of meteoritic impact. We report here the first known occurrences of shatter cones in meteorites.

Shatter Cones; history and significance: A distinct, striated conical rock failure occurs at many terrestrial impact structures. Conical limestone fragments with radiating surface grooves were first reported by Branco and Frass [1] at Steinheim Basin, Germany in 1905. They ascribed the 4 km wide depression to deeply buried explosive magma which failed to reach the surface during a 'crypto volcanic' event. Kranz [2] in 1924 suggested rocks at Steinheim became brittle by absorbing pressurized gases, then broke into delicately grooved cones which he termed 'strahlenkalk' or striated limestone. Walter Bucher in 1931 began studying cryptovolcanic structures in North America and soon found strahlenkalken at Wells Creek, Tennessee. In his report [3] he coined the term shatter cones; the name now used worldwide. By 1933 Shrock and Malott [4] reported shatter cones at Kentland, Indiana. And in 1934 Rohleder [5] described 'Druckstructuren', or pressure structures, at Lake Bosumtwi which he compared to Steinheim rock fractures. In his 1936 summary of United States crytovolcanic structures, Bucher [6] included the association of shatter cones as indicators of an underlying blast event. In 1947 Dietz [7] demonstrated that shatter cone apices point toward the source of an advancing shock pulse, and at Kentland the majority pointed upward. Since the explosive force came from above, not below, he suggested the Kentland disturbance was due to explosion of a meteorite rather than a hidden volcano. Shatter cones were next found in 1954 at Crooked Creek, Missouri by Hendriks [8] who suggested an impact origin for the circular disturbance. In 1959 Dietz [9] introduced the genetically neutral term 'cryptoexplosion' rather than cryptovolcanic. By 1960 Dietz [10] had found shatter cones at Sierra Madera, Texas; Serpent Mound, Ohio; and Flynn Creek, Tennessee, and he proposed shatter cones as a field criterion of meteoritic impact. Today, properly identified shatter cones are widely accepted as reliable and diagnostic impact indicators [11]. The search continues with considerable success and shatter cones are now confirmed in target rocks at more than 70, of about 180, documented terrestrial impact structures [12,13].

NWA Meteorites: In the last few decades, nomadic Saharans have been encouraged to collect dark, dense stones for unregulated markets in Morocco. As a result, large numbers of loose meteorites are now available to the international meteorite trade. The majority are transported in bulk lots of unclassified stones from unknown or deliberately obscured locations. The tradional convention of naming individual or grouped meteorites after nearby settlements or prominent geographic features is not practical. The Meteoritical Society has developed nomenclature guidelines [14] with special instructions for those from Moroccan markets. All are assigned the name NWA (Northwest Africa) and then a sequential number if it is reliably classified and found to be of interest. At the turn of this decade, large numbers of brecciated chondrites from an undisclosed strewn field began appearing in Morroco and more than two tons of material were eventually distributed worldwide. By 2006, samples from this source were designated NWA 869 [15]. Both meteorites in this report were retrieved from a 40 kilogram bulk lot shipped from Erfoud, Morroco in the year 2000.

Shatter-Coned NWA Meteorites: The first meteorite is a 1.74 kg ordinary chondrite. Overall size is about 15 x 9 x 9 cm and subangular in shape. An exploratory corner 'window' cut reveals metallic flecks densely and evenly distributed in a dark matrix (H4-5, W1-2). The mass is magnetic and one flattened face displays fusion crust 1-2 mm thick with flow rills and well-developed regmaglypts (thumbprint depressions). Desert patina is prominent overall. About 20 percent of the surface is covered with the distinct, horse-tail fabric of shatter cones (Fig.1). Rounded ridges separated by sharp grooves radiate from several points in fan-like conical splays. Additional shatter cone sets appear to penetrate into the main body, and possible weather-welded fissures cut across the exploratory window cut.

The second meteorite is a 0.851 kg ordinary chondrite measuring about 2 x 4 x 4.5 cm and is subtabular. A polished corner reveals numerous shock veins, dispersed metal flecks and occasional vesicles indicative of lost metal (L5, S 5-6, W3-4). Thin open fissures are possible internal shatter cone surfaces. A broad convex side forms an ogive with subdued, but distinct, radiating shatter cone ridges (Fig.2) which extend into the interior. Additional sets of negative shatter cone surfaces occur on the opposite and roughly concave side. The mass contains healed fractures and a partial fusion crust along one edge covers underlying shatter cone ridges. Spatial distribution of shock veins and a possible fusion crust suggest the meteorite was shatter-coned after earlier shock events and prior to entering Earth's atmosphere.

Figure 1. Shatter-coned 1.74 kg NWA meteorite.

Figure 2. Shatter-coned 851 gram NWA meteorite.

Conclusions: Shatter cones have been recognised for more than a century. Dietz in 1966 [16] reported striated fracture surfaces on meteorites which were possibly related to, but not verified as shatter cones. Until now they have been found only in terrestrial target rocks. Their positive identification indicates these meteorites fragmented from larger parent bodies during violent collisions, either with other meteorites in space or with Earth. Shatter cones are still the only reliable megascopic evidence of an impact shock history for a solid body.

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