NOT ALL EUCRITES ARE MONOMICT BRECCIAS. A. Yamaguchi, G. J. Taylor, and K. Keil, Hawaii Institute of Geophysics and Planetology, SOEST, University of Hawaii at Manoa, Honolulu HI 96822, USA.

Sioux County is an important eucrite because some authors have assumed it represents a primary melt, although its texture and mineralogy have not been studied in detail. We have made a petrologic study of two PTSs of this meteorites and conclude that it is a typical fragmental polymict breccia, composed of coarse- to very fine-grained basaltic clasts, breccia clasts, and mineral fragments. Compositions of pyroxene vary significantly [mg#=mg/(mg+fe) of low-Ca pyroxenes range from 0.34-0.48, among clasts, but pyroxenes in each clast are very homogeneous]. Three types of pigeonite (type 4, 5, and 6), plus (primary?) orthopyroxene, and augite are present. One clast contains large (1.1 x 0.8 mm) orthopyroxene grains (mg# = 0.44) with blebby augites, which might be a fragment of a cumulate eucrite. We did not find any diogenitic and other exotic components. This suggests that Sioux County is a mixture of several kinds of equilibrated eucritic components. We conclude that this polymict eucrite experienced both metamorphism and multistage impact events. The lesson from Sioux County is that almost all eucrites are metamorphic rocks and/or breccias, and the pristinity of eucrites should be reexamined carefully before using them as a representative magma type.

Since the classic studies of eucrites [e.g., 1], it has been widely believed that these meteorites are monomict breccias, mainly because compositional homogeneity of the pyroxenes. BVSP [2] examined several eucrites and concluded that the textural variability within these eucrites might be explained by these rocks being mixtures of rocks from a single lava flow or intrusion. On the other hand, Delaney et al. [3] suggested that some eucrites may be metamorphosed polymict breccias and that similar pyroxene compositions among clasts are the result of metamorphism Yamaguchi et al. [4] argued that Millbillillie could be a metamorphosed polymict eucrite. Detailed petrologic studies of a typical eucrite, Juvinas, reveal that this rock is a mixture of several lithologies; Juvinas might be a genomict breccia [5, 6]. Metzler et al. [5] reclassified Pasamonte as a polymict breccia. Clearly, these facts are critical for the petrogenesis of eucrites, and therefore it is important to examine the petrology of the eucrites in detail. One of the most important eucrites is Sioux County, which is believed to represent a primary melt [7]. We have investigated the petrology of individual clast and matrix components in Sioux County.

Two PTSs (AMNH4133-2 and UNM621) of Sioux County were examined using EPMA, SEM and optical microscopy. We find that this rock is a fragmental breccia, composed of a wide range of clast types and sizes (up to ~4 mm). Most clasts are angular in shape, set in a porous, clastic matrix. The PTSs contain abundant mafic clasts of several textural types: fine- (<100 µm) to medium-grained (~a few mm) subophitic basalts, coarse-grained (a few mm in size) pyroxene and plagioclase clasts, recrystallized breccia clasts, a feldspathic clast, and granular clasts. This rock also contains mineral clasts dominantly of pyroxene and plagioclase ranging in size from a few µm to 3.3 mm. We also observed a variety of pyroxene crystals. The most dominant type is a pigeonite with closely spaced thin (<a few mµ) (001) augite lamellae (type 5, [8]) and a pigeonite with remnant Ca-zoning (type 4). These pyroxene types are commonly observed in the basaltic clasts and mineral fragments. Two basaltic clasts contain partly inverted pigeonites (type 6) with (100) augite and orthopyroxene lamellae between thicker (001) augite lamellae. The fourth type of pyroxene is (primary?) orthopyroxene, with mainly (100) augite lamellae, which are rare components in basaltic eucrites. This pyroxene occurs only as mineral fragments. Other types include complexly recrystallized pyroxenes (low- and high-Ca pyroxene). We found a unique clast containing large orthopyroxenes (1.1 x 0.8 mm in size). The orthopyroxene grains are relatively magnesian ($Wo_{2.2}En_{43.1}$) and contain thick (<200 µm thick) irregular to blebby augites ($Wo_{42.8}En_{33.7}$). This pyroxene is similar to those found in cumulate eucrites (e.g., Binda-type; [9]), although the coexisting plagioclase is more enriched in the albite component ($Or_{5.3}Ab_{25.5}$-$Or_{0.7}Ab_{14.8}$) than those in cumulate eucrites. Many pyroxenes have a cloudy appearance due to presence of tiny inclusions, and other pyroxenes (especially recrystallized grains) are clear. Pyroxenes often contain thin (<10 µm) veins of fayalitic olivines (~Fa_{70-75}).

Mg# of the low-Ca pyroxenes vary significantly from 0.34-0.48, although the pyroxene compositions of individual clasts are very homogeneous. The orthopyroxene represents the most magnesian end (see above) and the Fe-rich end is pigeonite in the coarse pyroxene-plagioclase clast. Basaltic clasts tend to be slightly ferroan. This suggests that Sioux County is composed of several equilibrated components.

Pyroxene compositions of fragments in the clastic matrix show a similar range as the clasts, suggesting that those are mainly fragments of the clasts described above. The equilibration temperature of low- and high Ca-pyroxene [10] varies from 750-890°C, a range similar to many equilibrated eucrites [11]. Most plagioclase grains in the clasts are compositionally zoned. As a whole, plagioclase chemistry varies extensively from ~$Ab_{5.5-30}$.

The variability of the texture and the pyroxene composition suggests that this rock is a fragmental polymict breccia; it is unlikely this rock could have been produced by mixing of a single lava flow unit. The presence of the recrystallized breccia clasts suggests that it is a polymict breccia formed by multistage impact events. We confirm that the "primary melt composition" of Sioux County is just a coincidence, as suggested by Warren and Kallemeyn [12].

Eucrites, including Sioux County, have previously been classified as monomict breccias. However, detailed textural examinations suggest that these rocks may be genomict or possibly polymict breccias. The textural complexity commonly observed in eucrites [5, 11] may be explained in two ways. First, eucrites may be metamorphosed polymict breccias. Since the bulk compositions of eucrites are similar to one another, it is difficult to recognize a Pasamonte-like rock as a polymict breccia with low abundance of exotic components [5, 9], if it were metamorphosed. Second, eucrites may be multistage impact breccias formed by mixing and annealing [5, 11]. For example, one impact event may have produced the clastic matrix and another vent produced the impact melt pockets, overprinted by metamorphism, which may produce a wide variety of textures. A typical example of a metamorphosed polymict breccia is Millbillillie [4] which contains lithologies with slightly but significantly different mg#. Juvinas is a heterogeneous rock containing clastic and impact melt matrix, and shows evidence of multistage impact, but mg# in low Ca-pyroxenes in different lithologies is very homogeneous [5, 6]. Takeda and Yamaguchi [6] suggested that this rock could be a multistage cataclastic breccia (or genomict breccia), but it also may be an impact melt breccia. Delaney et al. [3] described partly homogenized polymict breccias, EETA79004 and 79011. During the secondary processes, basaltic eucrite-like compositions might have been retained. However, if the breccias are contaminated by cumulate eucrites, the interpretation of these igneous histories is seriously affected [12]. Except for some eucrites (e.g., Ibitira and Caldera) that have been classified as unbrecciated eucrites (but they are metamorphic rocks), almost all eucrites are breccias. Like Sioux County and Pasamonte, some eucrites might be more properly classified as polymict breccias. Failure to recognize these metamorphic and brecciation effects could lead to serious misinterpretation of chemical data obtained from many eucrites. It is essential that studies of eucrites recognize these effects and characterize them before discussing the igneous evolution of eucrites.

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