Bluewing 001: A new eucrite with extremely unequilibrated pyroxene, cognate (?) eucritic xenoliths, and Stannern-like geochemistry

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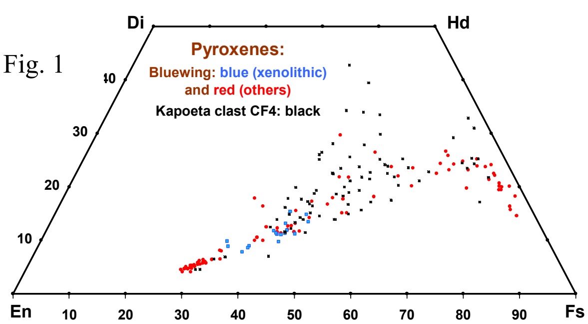
We report the first data and description for a eucrite found by one of the authors (PG) on 14 June 2000 as a single stone of 6.1 g, in the Bluewing Flat area of Pershing County, Nevada. The name Bluewing 001 has been approved by the Nomenclature Committee of the Meteoritical Society. A 0.46 g sawn end piece was used to produce a 9×9 mm thin section. A 0.174 g fragment was powdered for bulk analysis by INAA and fused bead electron-probe analysis [1].

The texture is subophitic and fine-grained. Pyroxene lengths are up to 2 mm, but mostly under 1 mm. Plagioclase tends to be smaller by a factor of about one-half. The meteorite's pyroxenes are extremely unequilibrated, with zoning as extensive as any yet discovered among HED meteorites: On the pyroxene quadrilateral (Fig. 1), zonation starts from ~$En_{67.6}Wo_{4.7}$ and extends almost linearly toward En_6Wo_{25}, and then abruptly turns toward En_3Wo_{15} (the most extremely Fe-rich compositions may actually be pyroxferroite). The sampled pyroxenes are not random: extremes, especially near the maximum En, have been more extensively analyzed.

Fig. 1



The nearest precedent among eucrites is the main lithology of the polymict eucrite Pasamonte. However, the most ferroan composition among 122 Pasamonte pyroxene analyses [2,3] is $En_{15}Wo_{27}$. Also, a plot of Mg/(Mg+Fe) vs. TiO_2 (Fig. 2) shows that Bluewing's pyroxenes are systematically more Ti-rich. For example, at the start of the zoning (*mg* = 70 mol%) Bluewing's pyroxene contains ~0.22 wt% TiO_2; Pasamonte's otherwise similar pyroxene contains only about 0.12 wt%.

Two additional unequilibrated lithologies have been previously described from polymict HED meteorites: clast CF4 from the Kapoeta howardite [4]; and a set of clasts from the Y-75011 polymict eucrite [5,6]. The pyroxenes of CF4 are also systematically Ti-rich relative to Pasamonte.

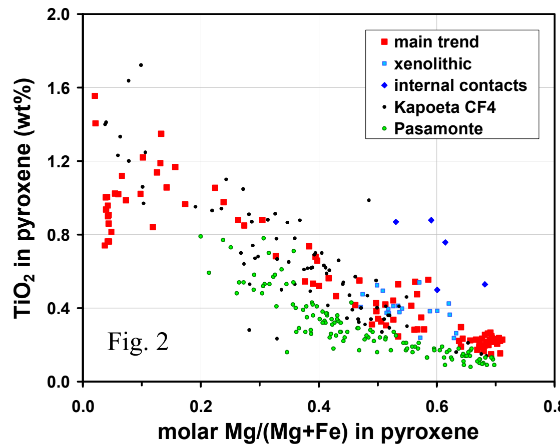


Fig. 2

Plagioclase is zoned from An_{89} (but only one analysis shows $An_{>84.3}$) to An_{75}, and averages An_{82}. Other phases present include minor silica and ilmenite (MgO <0.2 wt%), and traces of phosphate, fayalite (Fa_{98}), K-feldspar (or K-rich felsic glass; the composition is $K_{81}Ca_{16}Na_3$), troilite and Fe-metal. BSE images (Fig. 3) show many of these phases (plus ?pyroxferroite) in symplectic intergrowths.

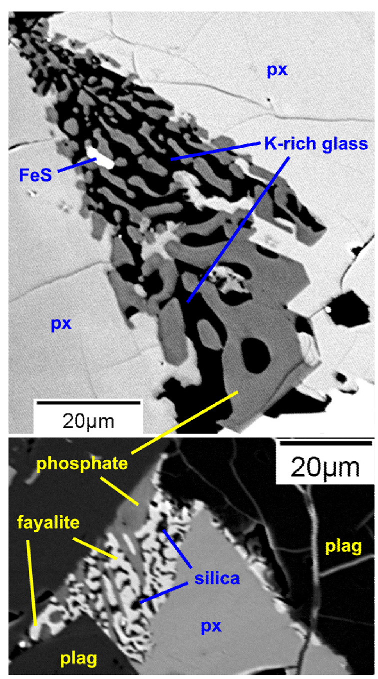


Fig. 3

Another distinctive feature of Bluewing is the presence of relatively iron-rich cores (shown in blue in Figs. 1 and 2) within many of the larger, and most extensively zoned, pyroxene grains. These pyroxene-core enclaves (e.g., Fig. 4) are usually polyphase (i.e., apparently xenolithic), as they include plagioclase (extensively zoned) and tiny grains of other phases (FeS, Fe-metal). The enclaves are in all cases immediately surrounded by extremely primitive (En_{68}) pyroxene. Apart from within a few µm of the enclave outer margin (where *mg* jumps to 70 mol%), the pyroxenes within the enclaves show only limited, possibly reverse (increasing *mg* outward) zonation. Overall compositional variation is mainly enclave-to-enclave rather than intra-grain.

Pyroxene minor element trends suggest that these enclaves may be cognate xenoliths. Pyroxene Ti content, for example, generally shows the same relationship with *mg* as in the rest of the meteorite. The internal contacts between the xenolithic pyroxene cores and the surrounding pyroxene seem to feature anomalously high Ti, however. Also, at moderate-high *mg*, pyroxenes both within and apart from the core enclaves tend to have higher Cr than similarly magnesian Pasamonte pyroxenes.

The meteorite is mildly weathered (trace of carbonate, some alteration of troilite), but its metals and phosphates appear completely unaltered. The numerous tiny metal grains (5 of which were analyzed) are extremely Ni poor (<0.12 wt%) with ~0.2 wt% Co. These Ni-poor compositions are typical of monomict/unbrecciated eucrites, and suggest that despite the presence of the xenolithic pyroxene cores, the meteorite is probably not an impact melt.

As one possible mechanism by which such cognate xenoliths may have formed, we suggest that the flow of the low-viscosity parent lava over the rugged surface of its asteroid (Vesta?) resulted in turbulent mixing of solid crusted parts of the flow back into the hot, molten interior of the flow. For this model to be viable, we must further assume that the solid crusted parts of the flow had managed to extensively crystallize (as opposed to quench into mostly glass), and that fractional crystallization within the pores of the these crust materials had yielded zonation, in terms of *mg*, Ca, Ti, etc. within pyroxenes, and in terms of Na/Ca within plagioclases. After re-entering the hot interior of the flow, these former crust materials were almost entirely remelted, but a small proportion of solids remained and acted as nuclei for the first (En_{68} pyroxene) crystals of the ultimate crystallization sequence.

Bluewing's bulk composition [1] is also distinctively enriched in incompatible elements (e.g., Sm = 3.9 µg/g), despite a moderately high *mg* of 40 mol%. In other words, Bluewing shows a geochemical resemblance to Stannern and Bouvante. Further implications of this extraordinary eucrite are discussed in a companion abstract [1].

References: [1] Warren P. H. and Kallemeyn G. W. (2001) This volume. [2] BVSP (1981) *Basaltic Volcanism on the Terrestrial Planets*, Appendix A-8. [3] Miyamoto M. et al. (1985) *PLPSC 15*, C629. [4] Warren P. H. and Taylor G. J. (1982) *Meteoritics 17*, 293. [5] Takeda H. et al. (1994) *EPSL 122*, 183. [6] Nyquist L. E. et al. (1986) *JGR* 91, 8137.

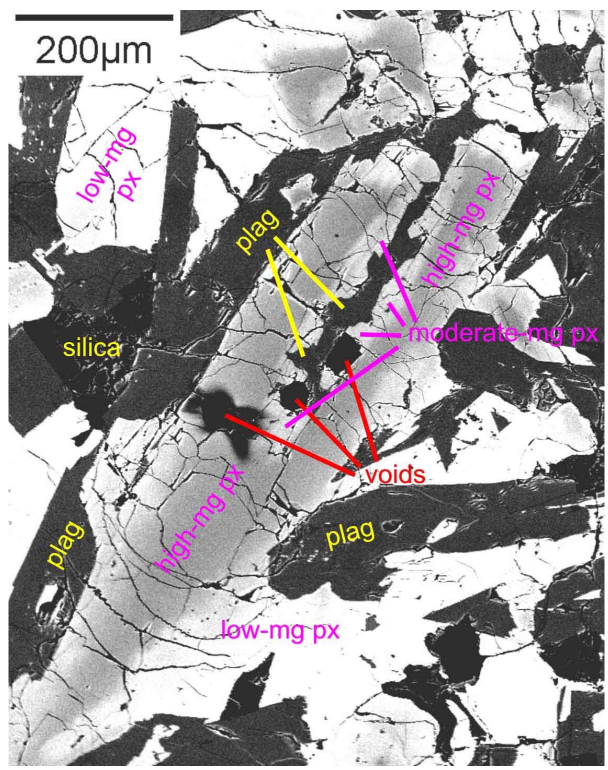


Fig. 4