UPDATE ON THE EXOGENIC MINERLAOGY OF PICA (CHILE) IMPACT GLASSES: IMPLICATIONS FOR IMPACTOR IDENTIFICATION AND SHOCK DYNAMICS IN AN AIRBURST.

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Introduction: Melt glasses found across the Atacama Desert (near Pica, Chile) were first suspected to be the result of an airburst but only recently confirmed [1,2]. One of the key observations is the discovery of meteoritic debris trapped in melt glass [3, 4]. Multiple fireballs about 12 ka generated intense radiant and convective heating that melted fine-grained sediments and combined to form folded and rolled melt masses. After melting, trailing meteoritic dust (entrained in air and degassing volatile-rich phases) was injected into the resulting glass and trapped in vesicles.

Previous Results: Initially the exogenic component seemed to fall into three groups: 1) an iron-like component represented by Fe-Ni, Fe-Ni sulfides, buchwaldite, and schreibersite; 2) a primitive carbonaceous component represented by CAI-like particles and AOIs; and 3) a mafic silicate component represented by enstatite, diopside, Ca-rich plagioclase, and halogen-rich albite, all usually associated with iron sulfides and/or chlorapatite. This was merely an effort to sort the variety of clasts that are identified in the glass and does not account for every phase. However, based on the expectation that an airburst would more easily result from a collision with a weak, volatile-rich fragmental body, this scheme was consistent with the working hypothesis that the bolide was similar to a body such as Bennu.

Updated Results: A breakthrough occurred in understanding the Pica bolide when the abundant iron-sulfide/iron-nickel sulfide/iron-copper-nickel sulfide assemblages that coat the walls of many vesicles (Fig 1.) were compared to work by Berger et al. [5,6] to understand aqueous alteration on comets, represented by the Stardust samples returned from 81P/Wild and the CI primitive chondrite Orgueil. The Pica sulfides not only are very similar in chemistry and morphology to those reported in CIs and cometary material, the entire suite of exogenic minerals can be compared quite well with CIs, or a combination of CIs and CVs. As a result, a comet is the most likely candidate to have been the Pica impactor.

Airburst Shocks: If the sulfide assemblages were identical to CI sulfides prior to the airburst event over Chile, what changes were imparted by the impact with Earth's atmosphere?

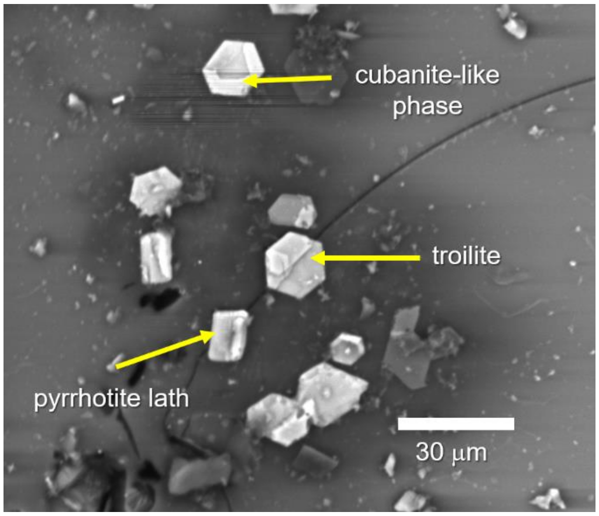

Figure 1. Electron backscattered (BSE) photomicrograph of Fe-Ni-Cu sulfide grains on the wall of a vesicle in Pica glass. The assemblage is very similar to sulfide assemblages documented in CI meteorites [7], and the Cu-rich overgrowths are the same as those discussed by Berger et al. [5,6] that occur from aqueous alteration on comets.

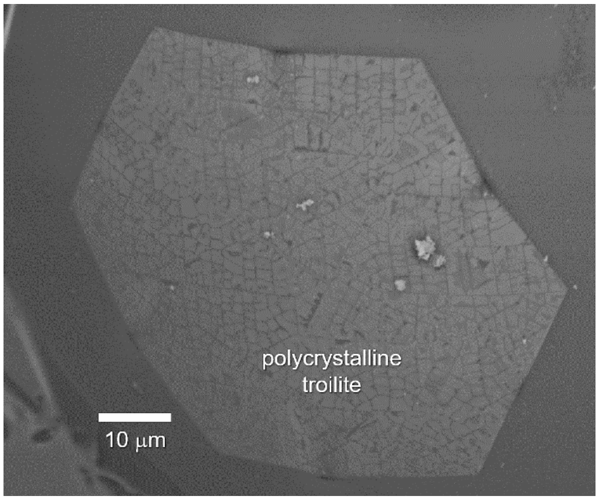

Figure 2. Electron backscattered (BSE) photomicrograph of troilite grain in Pica glass. The grain has developed polycrystallinity likely due to shock metamorphism. The planar fractures follow the crystallography of each subgrain.

First, there is some evidence that nickel was mobilized out of some grains at temperatures exceeding 2000ºC. Second, most of the sulfide platelets exhibit pervasive planar fracturing, due to rapid mechanical or thermal shock. But some rare grains show clear evidence of metamorphism by a transient high-pressure shock wave (Fig. 2). According to Bennett and McSween [8], polycrystallinity develops most commonly starting at shock stage 4, corresponding to approximately 30 GPa. The grain shown in Figure 2 has developed polycrystallinity, and the planar fracturing subsequently has followed the crystallographic control of each oriented domain. Further investigations will examine the possibility that such grains may inform models for the shock wave generated in a large airburst.

Implications: It appears that the assemblage of exogenic grains trapped in the Pica impact melt glass is most consistent with an origin on an aqueously altered carbonaceous body similar to CI meteorites or a comet such as 81P/Wild. These clasts also are large enough to allow detailed petrologic study. That work is continuing in an effort to understand the nature of the early solar system and to assess the future risk of an airburst the scale of that that occurred in Chile at the end of the Pleistocene.

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