

WILD-2 DÉJÀ-VU: COMPARISON OF WILD-2 PARTICLES TO CHONDRITES AND IDPS

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Wild-2 Olivine and Low-Calcium Pyroxene:

Thanks to the Stardust mission, we can now perform mineralogical and petrographic analyses of particles derived directly from the Jupiter-family Comet Wild-2. Crystalline materials are abundant in Comet Wild-2 and many are “coarse-grained” relative to the submicrometer scales characteristic of many anhydrous IDPs and interstellar dust populations [1]. Of the best studied 26 samples (tracks in aerogel), 8 are dominated by olivine grains, 7 by low-calcium pyroxene, 3 by a fairly equal amount of olivine and pyroxene, and the remaining 8 are dominated by other minerals, mainly Fe-Ni sulfides. Olivine and pyroxene are thus present in the majority of Wild-2 particles, with observed grain size ranging from submicrometer to over 10 μm . Wild-2 olivine has an extremely wide compositional range, from Fo₄₋₁₀₀ (Fig. 1), with a pronounced frequency peak at Fo₉₉. The presence of significant Fe-rich olivine and lack of a peak at equilibrated olivine compositions ($\sim\text{Fo}_{40-60}$) suggests that compositional changes due to capture heating has been insignificant in the coarse-grained component *en masse* [2-5]. Wild 2 olivines include varieties with very elevated MnO, Al₂O₃ and Cr₂O₃ contents, up to 6.45, 0.71 and 1.46 wt%, respectively [6]. About 1/4 of these Mn- and Cr-rich olivines contain $\ll 1\%$ FeO. Olivines with enrichments in these elements have been reported in carbonaceous chondrites, micrometeorites, and chondritic IDPs, though they are rare [7-11]. The wide Mg-Fe compositional range of Wild-2 olivine is similar to anhydrous chondritic IDPs. However, the range of these olivine compositions is also similar to what is found in the matrix of the chondrites Murchison (CM2), and Orgueil (CI1), which have experienced significant-to-pervasive aqueous alteration. Therefore the olivine analyses alone do not demonstrate whether Comet Wild-2 ever hosted liquid water. Particular Wild 2 particles which have the most Mg-rich olivine,

and the most restricted olivine compositions are potentially survivors of localized, partial aqueous alteration.

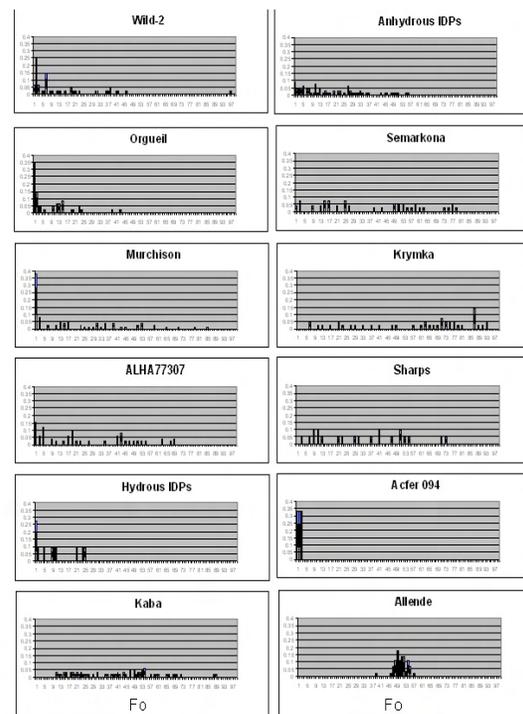


Figure 1. Composition ranges of olivine (Fo) and in grains from 9 Wild-2 particles, compared with those for primitive chondrite matrix olivine from [17-24]. Vertical scale is number of analyses normalized to a total of 1.

Both low- and high-calcium pyroxenes are present among the Wild 2 grains, with the former being dominant. In some cases Synchrotron X-ray Diffraction (SXRD) or Selected Area Electron Diffraction (SAED) patterns reveal low-calcium pyroxenes to be orthoenstatite, requiring slow cooling, but in the majority of cases we have only EDX analyses and are not certain whether we have ortho- or clinopyroxene. The com-

positional range displayed by the low-calcium pyroxene is also very extensive, from En_{52-100} , with a significant frequency peak centered at En_{95} (Fig. 2). Low-calcium pyroxene usually coexists with olivine, but the Mg/Fe ratios for coexisting phases are not always similar. Track 17 contains olivine in the range Fo_{55-69} , while associated low-calcium pyroxene is En_{52-96} . Flash heating during sample collection may account for this disparity, as olivine equilibrates faster than orthopyroxene under identical circumstances [12]. The extreme compositional range of low-Ca pyroxene is again similar to the anhydrous chondritic IDPs, and significantly broader than what is observed for most chondrites, including Murchison and Orgueil (Fig. 2).

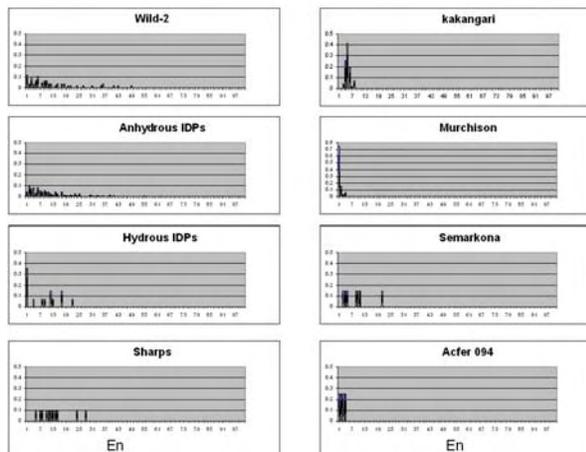


Figure 2. Composition ranges of low-Ca pyroxene (En) and in grains from Wild-2 particles, compared with those for IDPs and primitive chondrite matrix pyroxene, from the same references as Fig. 1.

Sulfides: Fe-Ni sulfides are also ubiquitous in the Wild 2 grains, and practically all unmelted ones have compositions close to that of FeS, with less than 2 atom % Ni [6]. Only a few pentlandite grains have been found, but these are intriguing since this phase can be an indicator of metamorphism under oxidizing conditions, and/or aqueous alteration [13]. Ni-rich sulfides are not found in anhydrous chondritic IDPs, but are found in hydrous IDPs, and are abundant in aqueously altered carbonaceous chondrites.

Caveats: In the course of making comparisons to chondrite matrix and IDP silicates, we have been reminded that there are still very few good olivine and pyroxene analyses from the Wild-2 samples, especially as regards minor elements. Also, most of the few available analyses of chondrite matrix olivine or pyroxene derive from microprobe analyses of matrix which is generally too fine-grained to support such analyses. For some major meteorite types matrix analyses are not even available. The problem is probably most acute for the ordinary-, enstatite-, E-, and R

chondrites. We need chondrite matrix mineral analyses based upon TEM analyses. How about our assumption that chondrite matrix is the material to which we should be making comparisons rather than microchondrules, or amoeboid olivine aggregates, or fine-grained chondrule rims? Comparisons to micrometeorites should be made, but the majority of these are highly heated and equilibrated by atmospheric entry. Even the comparison to the IDPs is to some degree questionable. Although the most extensive database of olivine and pyroxene analyses [14] indicates that anhydrous chondritic IDPs have no significant compositional peak at forsterite, bulk analyses of anhydrous chondritic IDPs indicate a high Mg/Fe ratio [15&16]. Obviously some new analyses of IDPs are also required. The dearth of minor element analyses of matrix, micrometeorite and IDP silicates is also a problem. A hallmark of the sudden availability of a new sample type is that critical discrepancies in our understanding of existing samples are always uncovered.

Summary: Olivine and pyroxene from Wild-2 have the same range of Mg, Fe, Mn and Cr compositions as those in anhydrous chondritic IDPs (Figs. 1&2), while olivine is also very similar to that in the matrix of Murchison and Orgueil. However, the anhydrous chondritic IDPs lack the Fo peak (but see the caveat section) observed for Wild-2. The apparent lack of hydrous phases among the Wild 2 samples appears to preclude a common origin with type 1 or 2 carbonaceous chondrites, but the presence of some Ni-rich sulfides suggests otherwise. The resemblance to Wild-2 olivine to CI and CM chondrite matrix olivine, with pronounced forsterite peaks, suggests that a more detailed search for possible aqueous alteration products should be undertaken.

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