AQUEOUS ALTERATION FINGERPRINTS IN THE MOLECULAR COMPLEXITY OF CARBONACEOUS CHONDRITES AND RYUGU.

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Introduction: The use of High Resolution Mass Spectrometry has yield a remarkable insight on the organic composition of carbonaceous chondrites and extraterrestrial samples [1]–[4]. The capability of counting every single mass in each range came with the description of the sample mixture. In this new data, all the planetary processes affecting the minerals, and the organic matter may have left their fingerprints. As far as carbonaceous chondrites are concerned, the origin and the survivability of organic matter are always interpreted with the asteroidal processes taking place and modifying or creating molecules.

The finding of polymerization patterns in pristine meteorites [5] and laboratory proxies [6] helps understanding the molecular mixture because of chemical selection. As a synthesis pattern can be isolated, any other feature in the chemical complexity can be interpreted as a modification or an alternative synthetic pathway. This way, the effect of UV irradiation has been measured [5] and more recently, the chemical modification due to asteroidal aqueous alteration has been highlighted [7].

The canonical synthesis pattern is a bell-shaped mass distribution due to geometrical growth of the molecules. This pattern is seen in artificial polymers as well as in carbonaceous chondrites. It is described by fitting a model [7], [8] among the measured distributions. One parameter, the broadness of the distributions, is systematically higher in the carbonaceous chondrites and in Ryugu samples. One exception to the typically extraterrestrial broadness has been found in altered part of Tagish Lake [7]. We present here an augmented series of data and its implication in the quantification of the aqueous alteration.

Results: Tagish Lake lithologies known as TL11i and TL5b, respectively the most altered and the most pristine [9] were prepared for Orbitrap analysis following protocol in [7]. Sub-spectra were isolated and fitted with a Wesslau geometrical growth model. On top of these two samples, a large variety of artificial synthetic samples have been treated the same way. Mixtures like in [10] and [11] are standards to monitor aqueously synthesized complex mixtures.

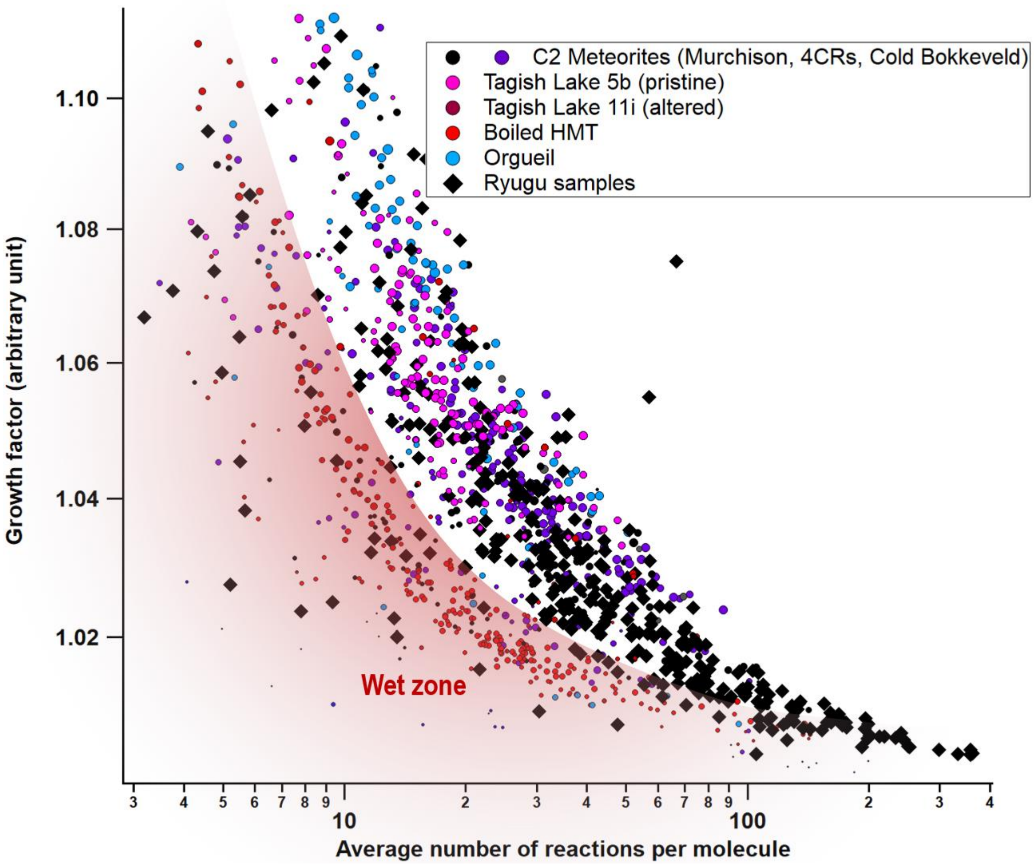

Figure 1: The mass distributions are fitted with a two parameters polymerization model. One parameter is related to a growth factor, the relative mass increment of each polymerization step. The other is related to the average number of steps it took to produce a molecule in each bell-shaped mass distribution. Each point on the graph above is one mass distribution. The difference between the two Tagish Lake

lithologies is key in setting a “wet zone” apart, corresponding to the mass distribution of water-altered and water-synthesized samples. Independently, the mixture resulting from an aqueous alteration of simple molecules (HMT) experiment exhibit mass distributions close to the altered Tagish Lake organics.

The altered parts of Tagish Lake are systematically narrower than the pristine part in good agreement with the lower entropy described in [7]. The artificial samples seem to have the same narrow distributions. This can be interpreted as a common chemical selection process leading to a limitation of the diversity in mass. One remarkable fact is the discrepancy between Orgueil and the most altered part of Tagish Lake. Orgueil seems to be on the canonical pristine trend. This may be paradoxical since Orgeuil is thought to have undergone extensive aqueous alteration.

Ryugu samples are quite like the pristine trend although they clearly exhibit a different mass distribution type with slightly higher average mass. Albeit it is not possible to point out a unique cause for the Ryugu uniqueness, the aqueous alteration is not the main process responsible for the state of the organic matter in the Hayabusa 2 samples.

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