Investigating the Effects of Aqueous Alteration on Phase Q using Insoluble Organic Matter from Tagish Lake (C2-ung). M. Riebe[1], H. Busemann[2], C. M. O'D. Alexander[3], C.D.K. Herd[4], C. Maden[1], and R. Wieler[1], [1]Dept. of Earth Sciences, ETH Zürich, CH-8092 Zürich, Switzerland (riebe@erdw.ethz.ch), [2]School of Earth, Atmospheric and Environmental Sciences, University of Manchester, M13 9PL Manchester, UK [3]DTM, Carnegie Institution of Washington, 5241 Broad Branch Road, Washington, DC 20015, USA [4]Dept. of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, T6G 2E3, Canada

Introduction: Noble gases are important tools for studying numerous processes in the early solar system. Primordial noble gases, which are the subject of this study, give us insight into the history of the volatile elements during nebular processing, parent body accretion and alteration. The heavy noble gases (Ar, Kr, Xe) in primitive meteorites are dominated by the Q component. During thermal metamorphism Ar and Kr are more easily lost than Xe from the Q carrier phase, so that Ar/Xe and Kr/Xe decrease with increasing thermal alteration [1,2]. Thermal metamorphism may also have modified the isotopic compositions in Q by incorporation of noble gases released from presolar phases that were destroyed [2]. The effects of aqueous alteration on Q are less well understood. Aqueously altered CM2 chondrites have low Ar/Xe and Kr/Xe ratios, similar to thermally altered ordinary chondrites [1; Fig.1]. On the other hand, CM2 chondrites show the highest He/Ar and Ne/Ar ratios [1; Fig.2], suggesting that light and heavy Q gases may reside in sub-phases with slightly different susceptibilities to thermal and aqueous alteration. Phase Q only contains small amounts of He and Ne compared to other primordial noble gas components in primitive meteorites, making it difficult to analyze He and Ne in Q. The Q gases are lost from a meteorite when it is treated with an oxidizing acid [3]. Because of this, a majority of the work on Q has been done by comparing analyses of insoluble organic matter (IOM) before and after treatment with an oxidizing acid. A more direct way to analyze Q is by Closed System Step Etching (CSSE) [4]. In this technique, the IOM is etched with increasingly harsh (time, temperature) etch conditions in vacuo and the noble gases are analyzed at steps.

The aim of this study is to further constrain the effects of aqueous alteration on phase Q using a unique set of samples from the Tagish Lake meteorite. Tagish Lake is a very primitive meteorite with affinities both to CM and CI chondrites [5]. It is heterogeneous with respect to degree of aqueous alteration, providing a unique opportunity to study IOM from clasts from the same meteorite and with the same general history, but with different degrees of aqueous alteration. Herd et al. [6] found a systematic variation in the IOM H/C ratio and δD that correlated with mineralogical and petrological evidence for the extent of aqueous alteration. We analyzed aliquots of the same IOM residues [6] to investigate the effects of aqueous alteration on Q. We are currently analyzing the most altered of these residues (11v) using CSSE and concentrated HNO_3 as oxidizing agent. Data for this residue and the least altered of the residues [6] will be presented at LPSC.

Material and Methods: The samples and procedures used to make IOM residues are described in [6]. We analyzed He, Ne, Ar, Kr and Xe by a very similar method to the one described in [1]. At the time of writing, 7 steps have been analyzed and about 20% of the expected gas has been released, based on [7].

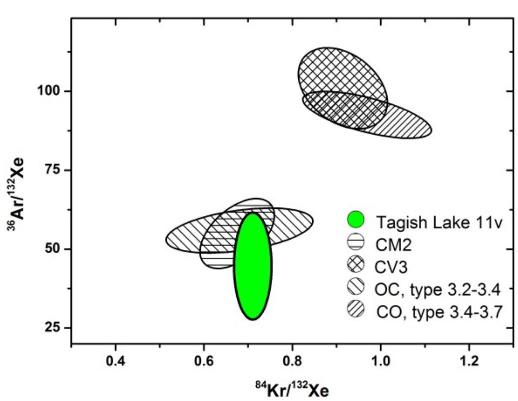

Fig. 1. Heavy Q gas elemental ratios for Tagish Lake measured at time of writing compared with other groups of meteorites previously analyzed with CSSE [1 and references therein]. Fields represent areas where different analyses plot.

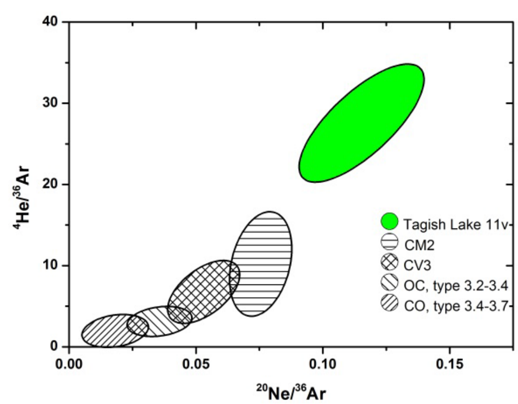

Fig. 2. Light Q gas elemental ratios for Tagish Lake measured at time of writing compared with other groups of meteorites previously analyzed with CSSE [1 and references therein]. Fields represent areas where different analyses plot.

Results and Discussion: The He isotopic ratio is fairly constant in the steps analyzed so far, ^{3}He/^{4}He ranges between 1.52-1.88×10^{-4}. These values are somewhat higher than the lowest value for Q of 1.23 ×10^{-4}, probably due to some contribution of cosmogenic ^{3}He.

The Ne is mainly a mixture of Ne-Q and Ne-E (Fig. 3). Ne-E is a component of nearly monoisotopic ^{22}Ne that resides in presolar grains [8], and it is known to be released with Q during CSSE of IOM residues with HNO_3 [1]. However, here Ne-E is released much earlier and the relative contribution to the Ne is among the highest measured during CSSE of IOM with HNO_3 [1] - steps 4, 5 and 7 contain about 50% ^{22}Ne-E. Previous studies of Tagish Lake have shown that the meteorite is rich in presolar grains, and contains high concentrations of Ne-E [7,9]. Based on [7], 17% of the total Ne-E expected to be present in the residue has been released so far. Ne-E is carried by both SiC and graphite, but we expect the graphite to be more susceptible to etching with HNO_3. Presolar graphite comes in many different forms, some of which are only poorly crystallized, and might be at least partly affected by the etching [10]. Presolar graphite is known to carry S-process Kr anomalies, but so far the Kr isotopic pattern is very close to Kr-Q. The Xe isotopes are affected by atmospheric Xe in the first steps, but are very similar to all previous analysis of Q [1] in the later steps.

Sample 11v has high ^{4}He/^{36}Ar and ^{20}Ne/^{36}Ar ratios compared to previous measurements of Q (Fig. 2). Previously, the highest ^{4}He/^{36}Ar and ^{20}Ne/^{36}Ar ratios in Q have been observed in CM2 chondrites. This adds to the general picture that aqueous alteration does not result in a loss of ^{4}He and ^{20}Ne. Thus, and because of distinct element ratios released in early and late steps from CM2 Cold Bokkeveld, Busemann et al. [1] suggested that there might be two carrier phases Q_1 and Q_2. Phase Q_1 would be richer in He and Ne and less susceptible to aqueous alteration, while the less He-Ne-rich Q_2 would be susceptible to aqueous alteration. Both phases are susceptible to thermal alteration, hence resulting in lower Kr/Xe and Ar/Xe ratios as a result of both aqueous and thermal alteration within a meteorite class. Tagish Lake fits well into this hypothesis, it is aqueously altered, but has experienced comparably little thermal alteration [5] and has low Ar/Xe and Kr/Xe ratios (Fig. 1), but high He/Ar and Ne/Ar ratios (Fig. 2).

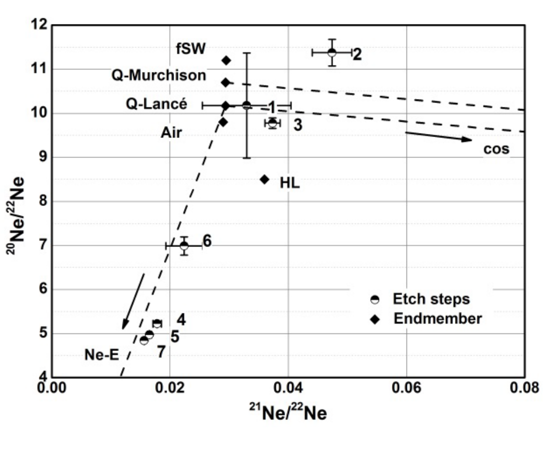

Fig. 3. Ne three isotope plot of the etch steps in Tagish Lake IOM 11v at time of writing.

Presolar graphite contains ^{20}Ne, ^{4}He and minor amounts of ^{21}Ne in addition to the ^{22}Ne; single grain analyses of graphite give an inferred bulk ^{20}Ne/^{22}Ne of 1.07 and ^{4}He/^{20}Ne of 28 [11]. We use these values to investigate if the high ^{4}He/^{36}Ar and ^{20}Ne/^{36}Ar ratios are due to the release of light noble gases from presolar graphite. For the most Ne-E-rich steps, this gives a maximum correction for ^{4}He and ^{20}Ne of 1% and 10%, respectively, which does not change the observed high ratios significantly.

Conclusions: Phase Q in Tagish Lake (C2-ung) has the highest ^{4}He/^{36}Ar and ^{20}Ne/^{36}Ar measured with CSSE so far. Tagish Lake is aqueously altered, but has experienced little or no thermal metamorphism [5]. We can therefore conclude that aqueous alteration does not result in a loss of light noble gases from Q. However, Ar/Xe and Kr/Xe ratios are low compared to CV3 and CO3 chondrites, which probably reflects a loss of Ar and Kr, relative to Xe, during aqueous alteration. Our data therefore supports the hypothesis that there are two sub-phases of Q, one that is enriched in He and Ne and is not affected by aqueous alteration, and one that is depleted in He and Ne and is susceptible to aqueous alteration [1]. Alternatively, Q could have incorporated different elemental ratios in different regions of the presolar nebula. The data from the least altered IOM sample [6] will allow us to further constrain these hypotheses.

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