The maintenance and development of a specialised cold curation facility for pristine astromaterials.

14th April 2016

EURO-CARES WP3 Meeting, NHM Vienna

Chris Herd and Nicole Spring*

C. D. K. Herd, R. W. Hilts, A. W. Skelhorne, and D. N. Simkus (2016) Cold curation of pristine astromaterials: Insights from the Tagish Lake meteorite. *Meteoritics & Planetary Science* 51, Nr 3, 499–519.

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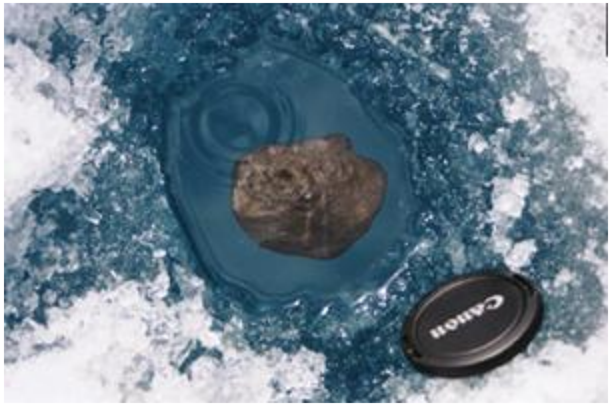
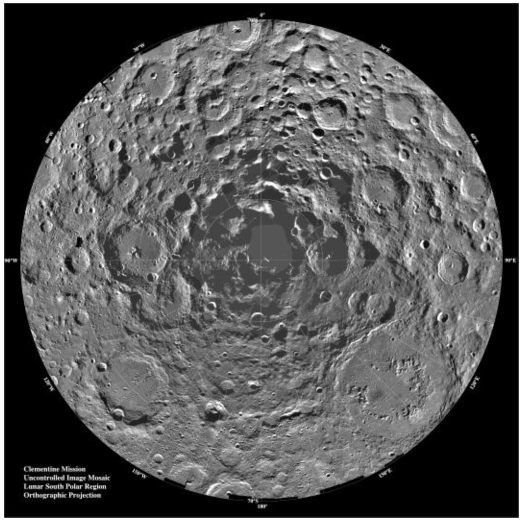
Incentive for a cold curation facility

- The Tagish Lake Meteorite Fall
- Specimens of the meteorite were recovered within a week of the fall and kept frozen and untouched by hand.
- Kept in sub-zero conditions since recovery
- Tagish Lake is an organic -rich, ungrouped type 2 carbonaceous chondrite with affinities to CI and CM meteorites
- Low-temperature storage and handling protocols have almost certainly helped to retain the most volatile, low molecular weight acids and organic compounds. e.g. Napthalene and Formic acid

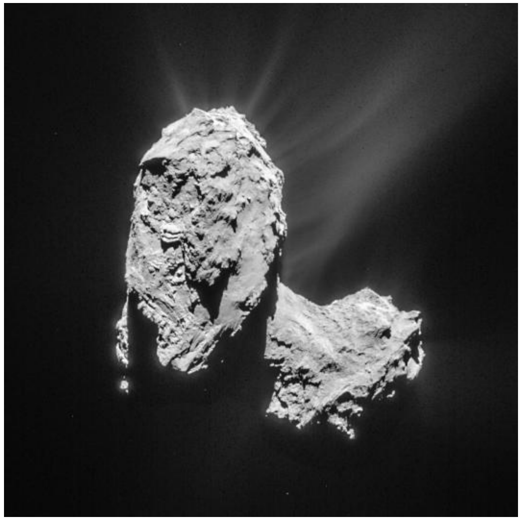


Incentive for a cold curation facility

- Important for future sample return of pristine asteroidal, lunar, martian and cometary samples.
- Whether or not the sample contains ice, a cold environment (along with an inert, dry atmosphere) will further reduce reaction rates e.g. oxidation and hydrolysis.
- Reduces terrestrial contamination from known volatiles released from laboratory building and handling materials
- Reduces/stops bacterial and fungal growth
- Mitigate against accidental exposure to atmospheric moisture.



Lunar south pole



Comet 67P-CG

Cold Curation Facility at Uni of Alberta

- Purified Ar-atmosphere glove box – H_2O and O_2 < 0.1 ppm
- Class 1000 clean room and walk-in freezer.
- Also houses the meteorite collection (1100 specimens of 175 meteorites)
- Tagish Lake samples kept in a separate freezer at -30C...
- Facility differs significantly from similar facilities elsewhere, and from previous cold curation testbeds (e.g., Fletcher et al. 2008a, 2008b) due to the enclosure of the glove box within a low-temperature environmental chamber (Model C811 from Conviron, Inc.).
- Designed to maintain T within 1C.

Meteorite storage in clean room

Chris Herd at the facility

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Clean Room

Class 1000 cleanroom (Lasco Services, Inc.) acts as room T ante-room.

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Walk-in Freezer

Freezer can maintain $-30<T<-10^{\circ}$ C

Designed to maintain T within 1C.

Defrost cycle twice a day

Glove Box

Purified Ar-circulated glovebox (MBraun, Inc.) is enclosed within the freezer

The box has main (operating) and secondary (storage) boxes

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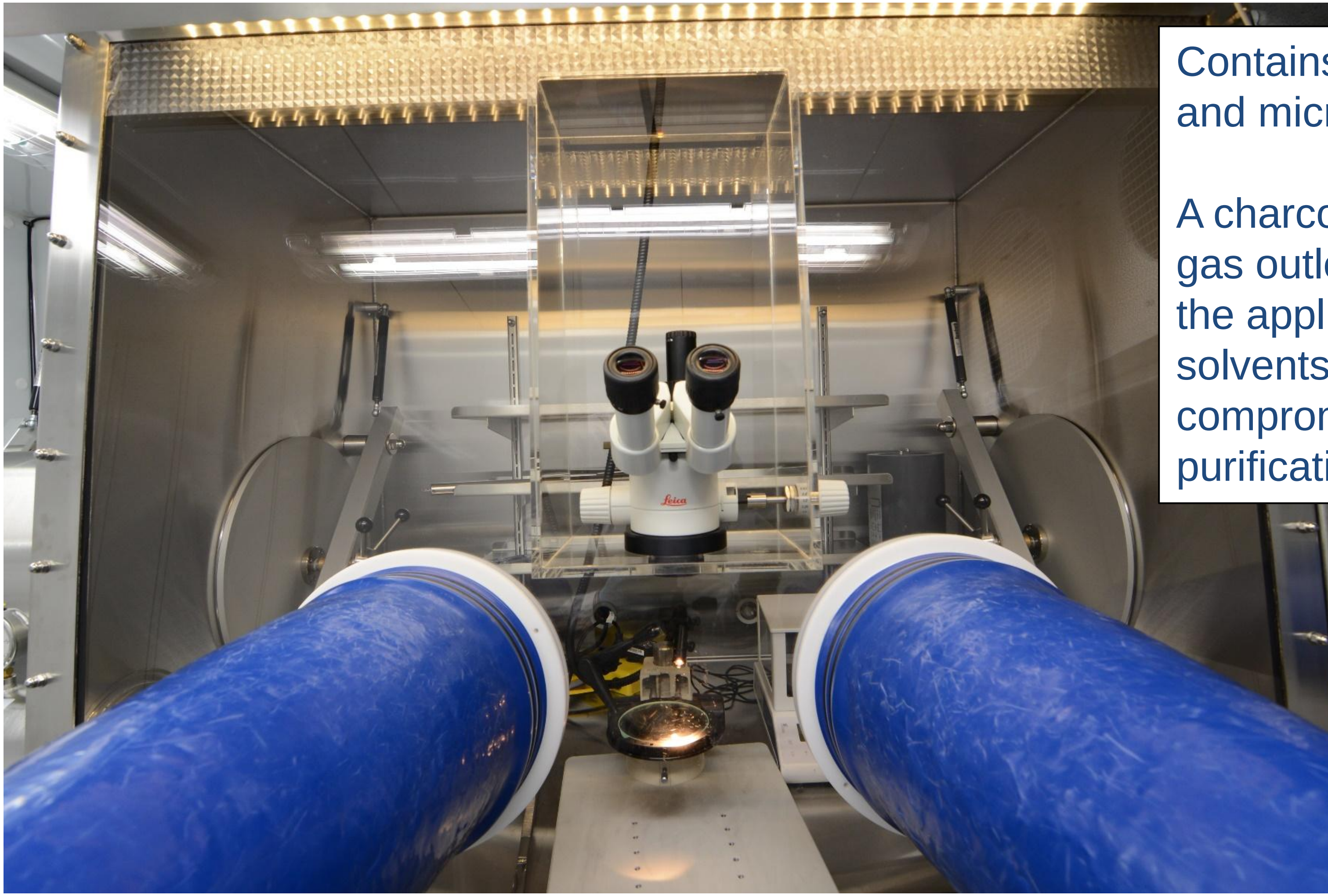
Anti-chambers

Two antechambers for moving materials in and out.

Typically this involves cycling between box gas and vacuum three times.

Main source of leaks into glove box.

Glove Box

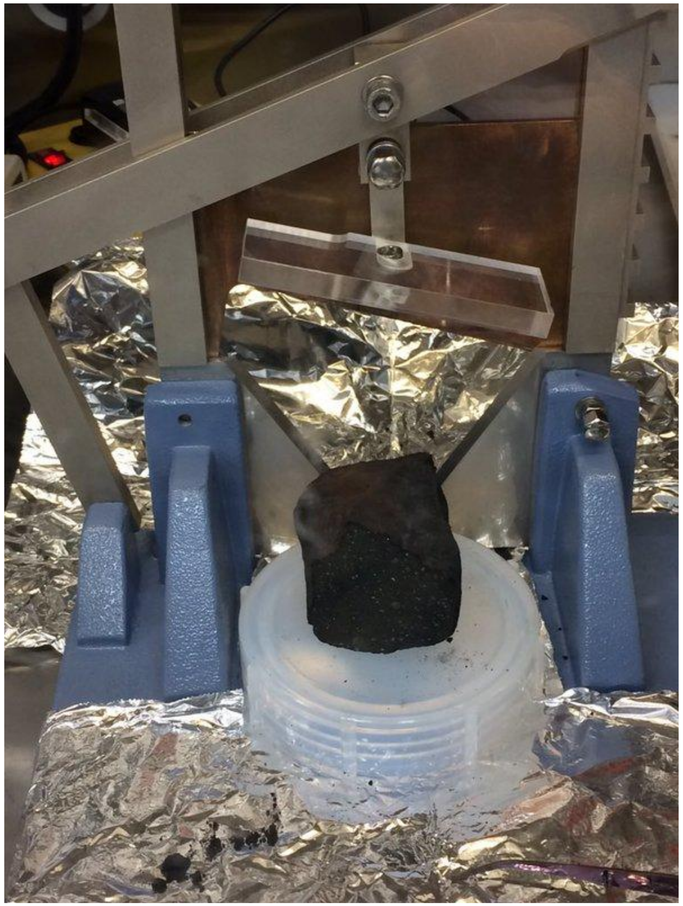


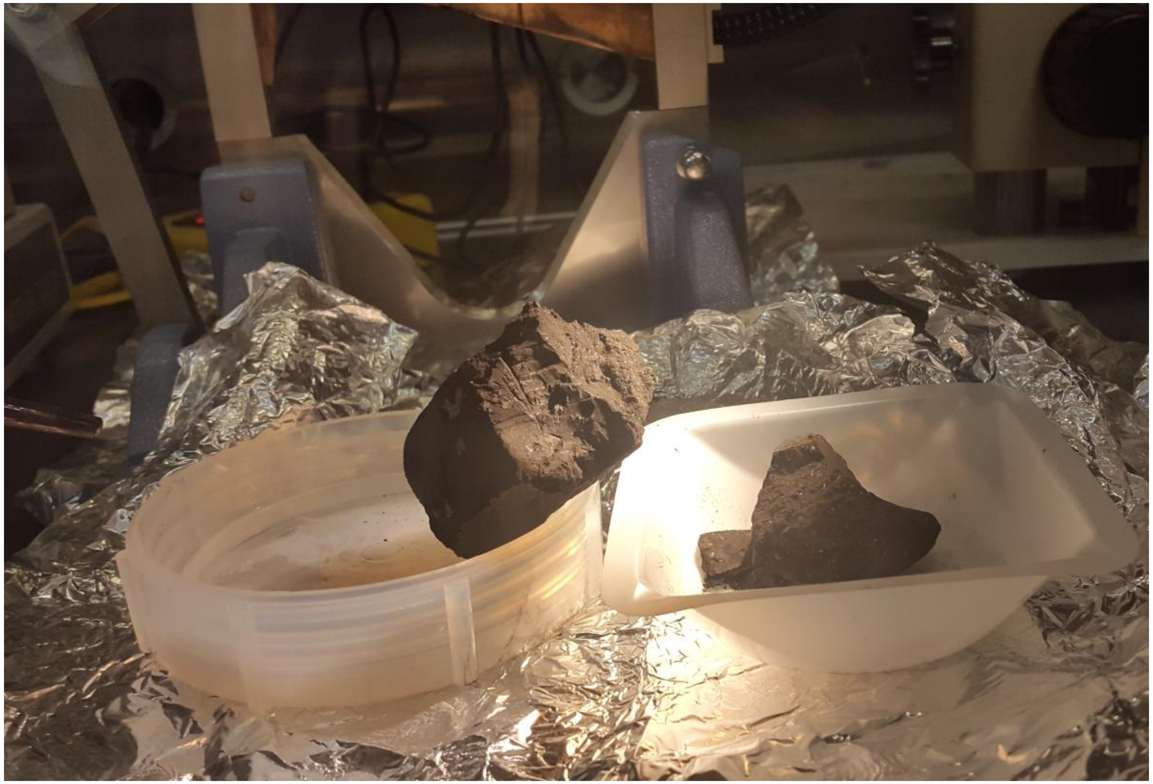
Contains a microscope and micro-balance.

A charcoal filter on the gas outlet enables the application of solvents without compromising the purification system.

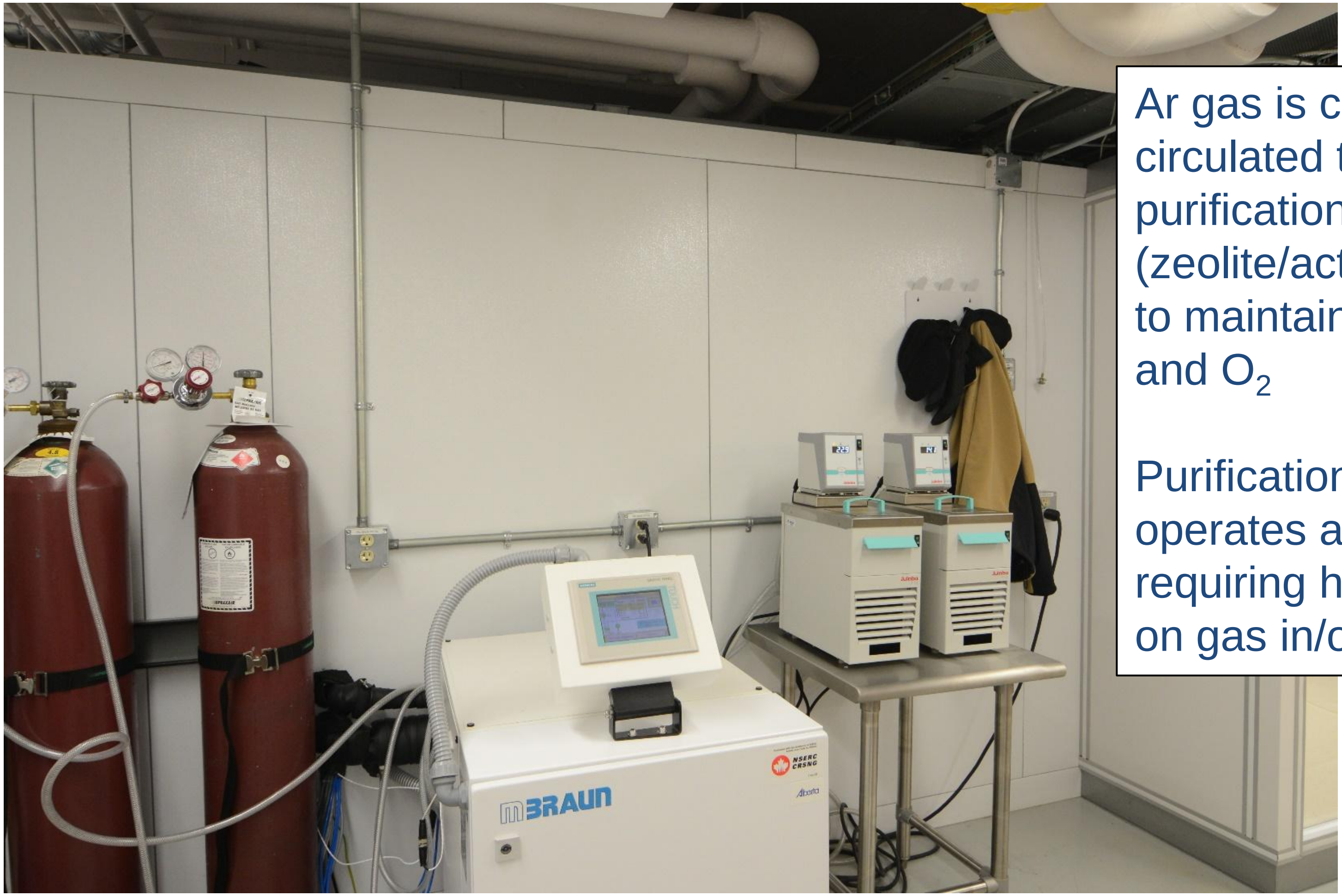
Glove box interior

Glove box now features a guillotine – very effective for cutting friable Tagish Lake!





Purification System



Ar gas is continually circulated through a purification system (zeolite/activated charcoal) to maintain < 0.1 ppm H_2O and O_2

Purification system operates at T > 10° C, requiring heat exchangers on gas in/out of box.

Glove box atmosphere – Ar vs N_2

N_2 routinely used at NASA JSC curation facilities

Ar used in glove box at UofA.

- Ar is denser than air - an asset in instances where the glove box springs a leak and air gets into the interior of the glove box – mixes with air much more slowly.

- Argon is completely inert in typical lab conditions

  - Studies over the last 20 yr that have shown that N_2 forms numerous compounds with early transition metals, including most significantly iron (Fryzuk 2003; Hazari 2010; Anderson et al. 2013), which runs counter to the view that N_2 is unreactive.

Particle filtration

Anti-room clean room provides clean air to the freezer chamber, but there is no particle filtration in the freezer – HEPA filters would frost up. Therefore freezer does not permanently qualify as class 1000 (can be cleaned, however).

Insights from other facilities: Montana State University Sub-Zero facility– HEPA filtration built above the freezer is effective. Looking into adapting facility at UoA.

Class 1000 (ISO Class 6) Cold Cleanroom - MSU

***(-20˚C to +10˚C)*: Germ-free space for decontaminating and processing ice core samples and conducting microbial experiments.**

Reduction of contamination

Sources of volatile contaminants in clean rooms and glove boxes are reasonably well known:

- filters, sealants, O-rings, paints, adhesives, tiles, and packaging material, as well as laboratory consumables, such as garments, gloves, tape, cleaners, and reagents (Sun et al. 2003; Calaway et al. 2014).

Herd et al. 2016:

- **The activity of terrestrial volatile species may be reduced by low-temperature operation of the glove box,** in addition to the typical decrease in volatile species over time as a result of continued off-gassing and removal by the purification system.

Challenges of sub-zero T

Typical operating T is -10C

Florescent lights didn't work – replaced with LEDs.

Gloves also needed to be replaced (hypalon → polyurethane – greater elasticity at sub-zero T)

At -20C, new problems encountered:

The current micro-balance does not function

Gloves extremely difficult to use

Door on the anti-chamber contracts too much at -20C → poor seal (had to warm it up in the anteroom)

Challenges of sub-zero T

Attire: Winter coat, balaclava, scarf/snood and thin, insulating gloves.

However, User comfort rapidly decreases at -20C → 5 to 10 mins max (for preservation of fingers) – although warming again up in the anti-room only takes a minute or two.

In the case of a sudden leak or atmospheric contamination event **rapid mitigation of the problem can be hampered by the cold, especially if the user has already been working in that environment before the problem is noticed.**