OSMIUM ISOTOPES AT THE ONSET OF YOUNGER DRYAS USING THE GRIP ICE CORE. Ji-Hye Seo[1], Changhee Han[2,3], J. P. Steffensen[4], Sungmin Hong[2], and Mukul Sharma[1], [1]Department of Earth Sciences, Dartmouth College, Hanover, NH 03755, [2]Department of Ocean Sciences, Inha University, Incheon, South Korea, [3]Korea Polar Research Institute, Incheon, South Korea, [4]Centre for Ice and Climate, Univerisity of Copenhagen, Denmark.

Introduction: The Younger Dryas (YD) was an abrupt cooling period during the last deglaciation between 12.9-11.7 ka and is well recorded in the Greenland ice cores [1-2]. The main mechanism behind the short-term cooling is a temporary slowdown of North Atlantic thermohaline circulation due to catastrophic release of meltwater from proglacial Lake Agassiz during the integral retreat of the Laurentide Ice Sheet [3]. An alternative hypothesis states that the cooling was directly/indirectly initiated by one or more cosmic airbursts/impacts, resulting in destabilization of the ice sheet [4]. In support of the hypothesis, the evidence of the extraterrestrial impact, including microspherules, nanodiamonds, magnetic grains, and glass-like carbon, has been documented [5-9]. However, this hypothesis remains controversial as there has been no evidence associated with the impact markers and no YD-age impact crater found [10-13].

Petaev et al. [14] discovered an unusually high Pt/Ir ratio of ~1200 associated with high Pt of ~82 ppt in a Greenland ice core (GISP-2) at the onset of YD. The observed Pt/Ir ratio is much higher than average chondrites (= 2.0) and average continental crust (= 23). Petaev et al. [14] inferred that this high ratio resulted from the impact of Sikhote-Alin type iron meteorite, which has a Pt/Ir ratio of >108. Using the estimated Pt fluence, Petaev et al. [14] assessed the diameter of the YD impactor to be ~0.8 km.

Here, we report Os concentration and isotopic composition from Greenland ice core (GRIP) spanning the period through YD. The key issue we seek to address is whether Os concentration and isotope composition ($^{187}Os/^{188}Os$ ratio) in Greenland ice cores provides an independent confirmation of the inferred meteorite impact. The $^{187}Os/^{188}Os$ ratio of meteorite/cosmic dust is ~0.13 and quite distinct from that of the upper continental crust (=1.26). This distinction has allowed Os isotopes to be used as a robust tracer of meteorite impacts, to evaluate the size of the impactor, and also to assess the temporal variations in the cosmic dust flux (see [15] and references therein).

GRIP ice core sampling: We examined GRIP ice core from a depth of 1659.35 m through 1664.30 m (~12811-12937 years old) curated at the Centre for Ice and Climate, University of Copenhagen, Denmark. During the drilling operations and core handling processes, the surface of an ice core is heavily contaminated and requires decontamination. The decontamination of GRIP segments includes removal by chiseling of each layer of ice with ceramic knives, which were precleaned in 10% HCl. The decontamination was performed in a cold laboratory (-15 ºC) at the Korea Polar Research Institute (KOPRI). The laboratory is equipped with a class 10 clean bench under laminar flow conditions in a class 1000 clean room.

Nine ice core sections each with lengths of ~55 cm and areas of 3 cm by 4 cm were decontaminated and cut into ~6 cm legths, providing 54 samples with ~2-3 years of time resolution. The ice core sections were decontaminated from the outer contaminated part to inner most part of the ice, producing total of three outer veneer layers and one inner-most core. The obtained inner core, ~50 g, was melted and stored in 125-mL wide mouth Teflon bottles at room temperature. The Teflon bottles were pre-cleaned in concentrated HNO_3, HCl, HBr, and high purity water following procedures given in Sharma et al. [16]. The decontaminated melt-water samples were then aliquoted to measure 1) Os isotopes at the Radiogenic Isotope Laboratory, Dartmouth College and 2) trace elements at the KOPRI using Inductively Coupled Plasma Sector Field Mass Spectrometry (Element-2).

Os Chemical separation and mass spectrometry: The Os isotope determinations in polar ice cores are technically challenging due to extremely low Os concentrations (~10^{-15} g/g or 1 fg/g). Approximately 50 g of melt-water sample was combined with pre-weighed ^{190}Os spike and frozen at -20 ºC in a quartz-glass ampoule. A mixture of 2.5mL of purified HNO_3 and 1.5mL of H_2O_2 was then added and the sample was sealed at 100 bars and heated to 300°C in a High Pressure Asher for 16 hours. This process allows all Os species to be oxidized to OsO_4. The sample was then taken out from the HPA and the resulting OsO_4 was extracted using distillation and trapping with ice chilled HBr. The trapped Os in form of hexabromoosmate was further purified using microdistillatoin and dried to a small drop ~0.2uL. The sample was then loaded on to a pre-cleaned Pt filament and covered with an emitter solution, containing $Ba(OH)_2$ and NaOH. Prior to loading the sample, the filament was outgassed at 1480 ºC for 20 minutes and its surface cleaned with HBr and water. Os concentrations and isotopic compositions were determined at Dartmouth (Triton with a secondary electron multiplier). The OsO_3^- ion beams were obtained using highly sensitive and reproducible face-to-face filament geometry. The Os reagent blank concentration of 2.70 fg and the $^{187}Os/^{188}Os$ ratio of 0.15 are used as blank correction.

Results: We have so far obtained data on 12 samples. All but one of these ice samples show unradiogenic Os isotope ratios but are associated with low concentrations (Fig 1). While the $^{187}Os/^{188}Os$ ratio in Sikhote-Alin meteorite is ~0.13, its Os concentration is abnormally low (=19 ng/g) [17]. If Os from this impactor were globally distributed over the surface of the Earth it would provide an Os fluence of only 10 pg/cm^2. After decontamination, the expected Os concentration at the anomalous Pt peak should be ~600 fg/g. If the peak is present in a sample, Os concentrations should be distinct among the background concentrations in ice. However, no such concentration and isotopic composition has been observed in these samples.

The sample at depth 1662.56m, near the YD boundary, the $^{187}Os/^{188}Os$ ratio is 0.31, suggesting a mixing of unradiogenic dust source. If it is a mixture of meteorite and continental sources, 85% of Os should come from the meteorite. However, Os concentration is quite low (=2.8 fg/g). So far, Os isotopes suggest contributions from cosmic dust. In addition, the sample at depth of 1663.29m near the Laacher See volcanic eruption has $^{187}Os/^{188}Os$ ratio of 0.34 with the concentration of 0.98 fg/g. This indicate the volcanic signal, which has an isotope ratio of 2.1 and the concentration of 16 pg/g [8], is absent in the GRIP ice core.

The Ni/Co ratio of continental crust (=2.2) and Sikhote-Alin (=13; [18]) are quite distinct. We find that at depths of 1659.90m and 1662.01m the Ni/Co ratios are 17 and 19, respectively. However, the Os concentrations and the $^{187}Os/^{188}Os$ ratio do not show any correlation with Ni/Co ratio. Additional measurements are underway to search for the impact near the YD boundary.

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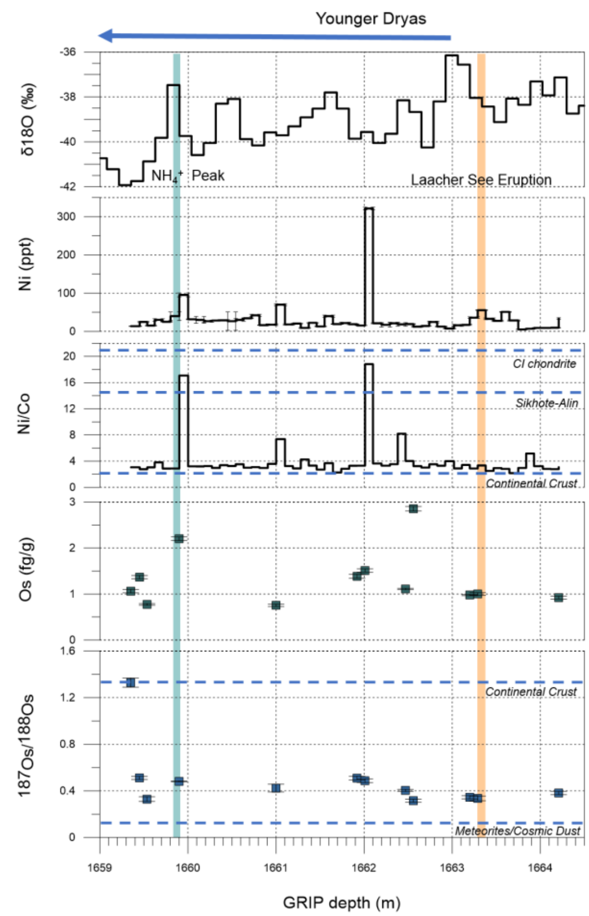

Fig. 1. $\delta^{18}O$, Ni, Ni/Co, Os, $^{187}Os/^{188}Os$ ratios in the GRIP ice core as a function of the GRIP depth. Blue arrow at the top of the $\delta^{18}O$ graph provides the depth of onset of Younger Dryas. The green line indicates observed NH_4^+ anomaly in the GRIP ice core. The orange shade indicates Laacher See eruption based on the ECM peak observed in the GRIP ice core.