SOURCE TO SINK MINERAL ANALYSIS OF AN EAST AFRICAN RIFT DRAINAGE: ANALOG FOR MARS.
L. J. McHenry[1], G. R. L. Kodikara[1], B. M. Hynek[2], and J. K. Njau[3], [1]Dept. of Geosciences, University of Wisconsin-Milwaukee, Milwaukee, WI 53211 (lmchenry@uwm.edu, gayantha@uwm.edu), [2]UC Boulder Laboratory for Atmospheric and Space Physics, 3665 Discovery Drive, Boulder, CO 80303 (Brian.Hynek@lasp.colorado.edu), [3]Dept. of Geological Sciences, Indiana University, Bloomington, IN. (jknjau@indiana.edu).

Introduction: One feature that led to the selection of Jezero crater as the Mars 2020 Perseverance rover landing site was its delta. This delta is interpreted to have been fed by a drainage that pierces the crater rim, bringing in sediments from a broad catchment with diverse lithologies [1]. Based on orbital remote sensing, the delta has mafic minerals, Mg/Fe phyllosilicates, and carbonates (most likely Mg-dominated) [2]. Finding a terrestrial analog, where a modern catchment erodes through these lithologies, is challenging.

The Lake Natron basin of northern Tanzania, East Africa, shows potential as an analog. The closed-basin rift lake is sourced by springs and drainages along its margins, especially to the west where drainages have eroded channels through its steep rift escarpment walls. The headwaters of the larger drainages erode diverse lithologies, including Pleistocene basaltic tuffs and lavas, Mg/Fe phyllosilicate rich saline-alkaline paleolake deposits (Moinik Fm), and more distal Precambrian granitic basement [3]. Smaller drainages are more locally sourced, deriving sediments exclusively from the basalts and paleolake beds.

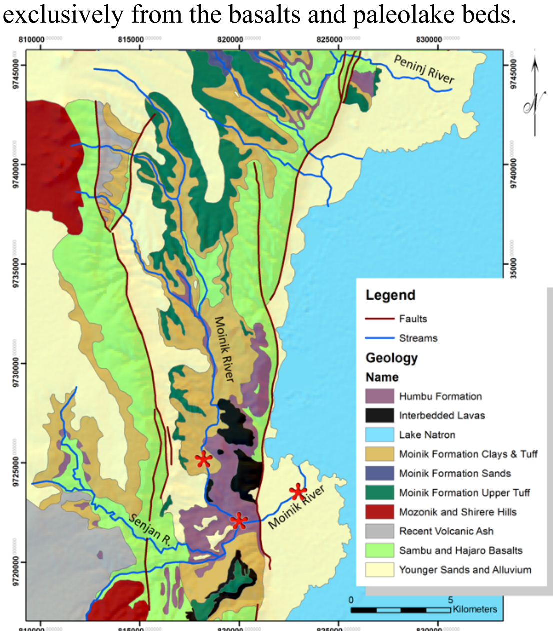

Fig 1: Geologic map of the Moinik River catchment. Red stars = sediment sample areas. Geology based on [4].

The purpose of this study is to conduct a source-to-sink analysis of one of these drainages, focusing on mineral assemblage and grain size, to assess its relevance to Jezero crater.

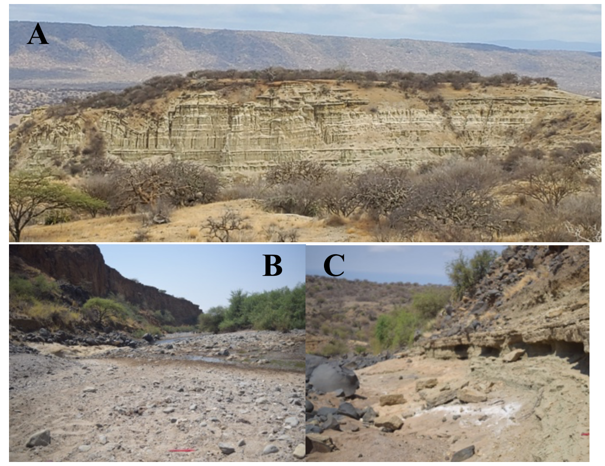

Figure 2 A. Pleistocene Mg/Fe-rich clay lake beds exposed in Moinik catchment. B. Moinik river sediment with cliffs of basaltic tuff and lava. C. Green paleolake clays (sample M05), tuffs, and basaltic lava eroding into Moinik river channel.

Methods: We visited the Lake Natron basin in July 2022 to identify targets for a source-to-sink analysis. The Moinik River drainage was selected since its catchment is dominated by Mg/Fe clay rich paleolake beds and basaltic lavas and tuffs [3,4]. 18 sediment samples were collected in 3 main areas: upstream where the drainage cuts through ancient lakebeds, in a canyon where the river has incised through thick basalt lava and tuff beds, and at the distal end of the fan.

Samples were analyzed using a Bruker D2 XRD (powdered samples) and a Malvern Laser Particle Size Analyzer to determine their mineral assemblages and particle size distributions for the <2mm size fraction.

Results: While the mineral assemblages of the exposed source materials were variable (paleolake sediments rich in smectitic clays, zeolites, and carbonates (magnesite, dolomite, and calcite), tuffs bearing plagioclase, orthoclase, augite, and zeolite), this assemblage was not reflected in the <2mm channel sands of the Moinik river, which was dominated by quartz with minor amounts of basalt or paleolake-derived minerals (e.g. minor feldspar, augite, and analcime). This is reflected in the grain size analysis as well- the finest grain sizes correspond to samples from the green lake beds (clay-silt size particles), while those from the Moinik channel are overall well-sorted and sand sized, even in the distributaries within the delta.

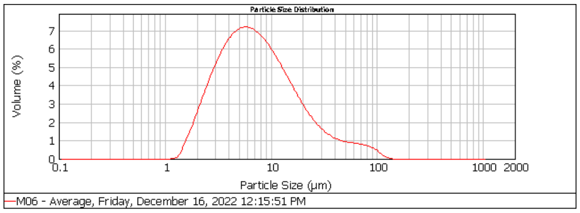

Fig 3A: Particle size distribution for green paleolake sample (M05), dominated by clay-silt sized grains.

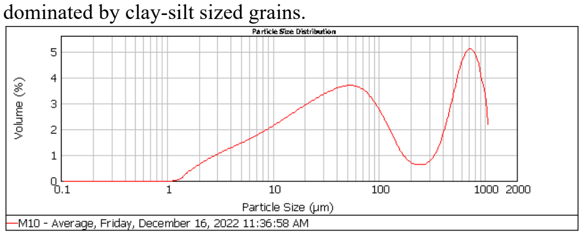

Fig 3B: Particle sizes for sample M10 from Moinik channel where coarse channel sands are mixing with locally eroding finer paleolake materials.

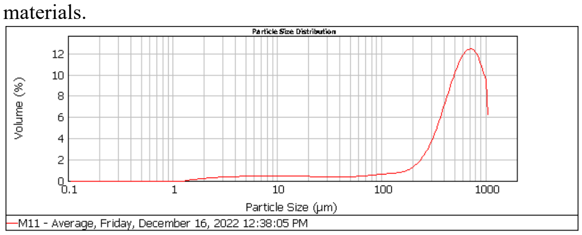

Fig 3C: Particle sizes for sample (M11) from distal distributary, dominated by sand.

While the source rocks exposed along the course of the Moinik drainage that were being actively eroded into the sediment were mostly basaltic lavas and tephra or Pleistocene clay-dominated lake beds, the <2mm size fraction of the channel sediments was dominated by quartz sand, presumably from minor sandy layers in the fluvio-lacustrine Moinik Formation sediments upstream or from aeolian input from the plains to the west.

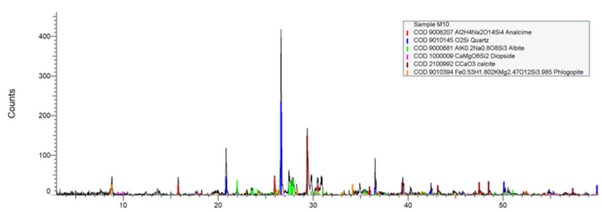

Fig 4A: XRD pattern for M11 (distributary) sample, dominated by quartz with minor feldspar, calcite, analcime, and other phases.

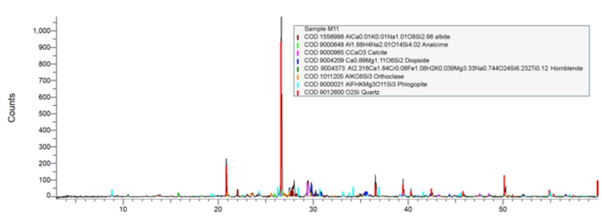

Fig 4B: XRD plot for mixed sediment sample (M10) from Moinik channel. Dominated by quartz, with smectitic clay, calcite, analcime, feldspar, and augite.

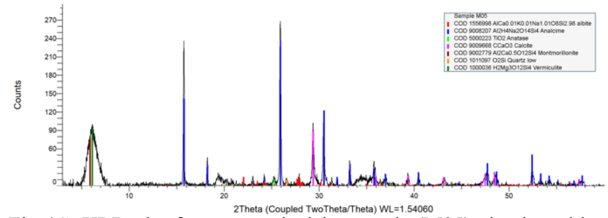

Fig 4C: XRD plot for green paleolake sample (M05), dominated by smectitic clay, analcime, and calcite.

Discussion: The ubiquity of quartz in the <2mm size fraction of the Moinik river channel sediments, despite its rarity in the lithologies through which drainage erodes, illustrates how more resistant sediments end up dominating the fluvial record. The clays so prevalent in the catchment are transported further into the lake and only locally contribute to channel or delta sediments. Basalts dominate the cobble to boulder sized sediments and locally contribute plagioclase and pyroxene clasts.

While the Jezero catchment is certainly more mafic (and quartz free), the grain size observations are relevant. Despite the abundance of clay in the headwaters, they are not observed in the delta and channel sediments of the Moinik river, which are dominated by coarser sediments. The quest to find biosignature-bearing fine phyllosilicates at Jezero might be similarly limited by lack of preservation in the lithologies encountered.

Future work: We plan VNIR-SWIR spectroscopic and clay mineral separations and XRD studies on existing samples, and a return visit with drones (including one with a multispectral camera) to better constrain the mineralogy of the Moinik catchment. We will also expand our survey to smaller catchments to the north that are more dominated by basalt with less contamination by quartz. We will also characterize carbonate-rich beds within the paleolakes, which contain abundant magnesite.

Acknowledgments: This work was supported by NASA SSW grant NNH20ZDA001N. Permission to conduct research in Tanzania provided by COSTECH.

References: [1] Goudge T.A. et al. (2015) *JGR 120*, 775-808, [2] Horgan B.H.N. et al. (2020) *Icarus 339*, 113526. [3] Luque L., Alcalá L., and Domínguez-Rodrigo M. (2009). A Research Project on Human Origins 1995-2005. Oxbow Books, Oxford. 15-48. [4] Isaac G.L. (1965) *Quaternaria 7,* 101–130.