The Cryosphere Discussions

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Comment on tc-2022-91

Jonathan Toner (Referee)

Referee comment on "Brief communication: The hidden labyrinth: deep groundwater in Wright Valley, Antarctica" by Hilary A. Dugan et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-91-RC2, 2022

I read the paper with interest and have just a few suggestions that the authors may or may not want to include depending on scope. I don't have expertise in the resistivity analysis, so I have no comments on that.

-The article talks a lot about the connectivity between DJP and Vanda, but an equally intriguing question is the ultimate origin of the DJP brine. This is mentioned in passing, but worth emphasizing more. Harris and Cartwright hypothesized that the brine is ultimately sourced from beneath the East Antarctic Ice Sheet i.e. west of DJP and through the Labyrinth. Is there any evidence for this from the resistivity data? A related question is if the DJP brine extends beneath the 'rock glacier'. It looks like west of DJP there is a low resistivity band at depth extending under the 'rock glacier', and very low values at the extreme that look like a numerical artifact.

-The DJP transect also shows an interesting, vertical low conductivity feature to the E of DJP. E of DJP the elevation along the valley floor rises and then plateaus along a series of small basins. The first basin you encounter holds VXE-6 pond, which is typically dry at the surface but shallow groundwater occurs. This pond has a high $CaCl_2$ content like Lake Vanda, but also high nitrate indicating considerable surface inputs. None of the other ponds have $CaCl_2$. Cartwright and Harris analyzed this pond, and we recently analyzed it in Toner et al. 2022 (also discusses the mixing between NO_3-rich and $CaCl_2$-rich endmembers). I suspect that wind alone can't explain the $CaCl_2$ in this pond; otherwise, why aren't other ponds similarly enriched? The resistivity data seems to suggest a connection between DJP and VXE-6, which would make sense. This would also put the DJP brine on the right path to connecting Lake Vanda, although the data can't show this. Too bad the flight line didn't extend to Lake Vanda!

-We recently published a paper on DJP and surrounding soils and groundwaters (https://www.sciencedirect.com/science/article/abs/pii/S0012821X22002187). One of the findings of the paper was that $CaCl_2$ brine/salts like DJP infuse the Dolerite bedrock up to 200 m above the pond surface. The argument is that salt composition of the dolerite

bedrock is so DJP like and different from surrounding soils, that inputs from wind alone can’t explain the chemistry (you’d get mixing from nitrate-rich soils if deposited from wind), it must be primary. This supports a much stronger association between the DJP brine and the Ferrar Dolerite than previously thought. This suggests that you might "follow the Dolerite" to understand where the DJP groundwater is going. Might be interesting to include discussion about where the Dolerite is going, perhaps infered from the strike/dip of the unit.

-Line 90: The conductivity of salt solutions depends on concentration and composition, and the conductivity decreases at very high concentrations for CaCl2. Could the low conductivity be explained in this way? Also, is the conductivity of CaCl2 different from equivalent ionic strenth NaCl solutions. Would the porosity of the sediments and groundwater affect the result? Just wondering if the relatively low conductivity in DJP could be explained more easily.

~Jonathan Toner