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Determination of the Parent Salt for the Perchlorate Ion Measured at the Phoenix Mars Lander Site

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In the summer of 2008 the Phoenix Mars mission landed at the northern latitudes of Mars. On board was a Wet Chemistry Laboratory (WCL) that performed a series of wet chemical analysis of the martian soil for a variety of soluble ionic species. In addition to being dominated by calcium/magnesium carbonates, sulfate, and the presence of other minor soluble species, the soil was found to contain almost 1% perchlorate (ClO_4^-). The discovery of perchlorate has broad implications for the geochemistry, planet-wide water cycle, astrobiology, human habitability, and the possible formation of liquid brines on Mars.

Even though the perchlorate ion itself is of major significance, the identity of its parent salt(s) could also have a significant impact on its chemical and physical interaction with other components in its environment. The initial analyses of the soil/solution mixtures in the WCL allowed for Na^+, K^+, Ca^{2+}, and Mg^{2+}, either singly or together, as possible cations. Potassium was deemed to be an unlikely cation since its concentration was orders of magnitude below that required. Even though Na is a possible candidate, its concentration would only account for a portion of the perchlorate as sodium perchlorate. The two remaining species Ca and Mg, were both considered possible perchlorate cations.

Refined analyses of the WCL chemistry data using the dissolution rates of the measured ionic species and conductivity, coupled with more accurate determination of the chemistry and mineralogy of the soil/solution mixture analyzed on Mars, and further chemical equilibrium modeling using the other confirmed chemical and ionic species, has shown that the dominate form of the perchlorate salt in the martian soil is most likely magnesium perchlorate. This chemical form of the perchlorate, with a potential hexahydrated phase of the salt, allows for a significant depression of the melting point when solvated in water and may be a direct participant in the global water equilibrium cycle.