

Cations and anions II: Some geochemical realities

One fact of geochemistry is that many "elements", such as Na, K, Mg, Ca, F, and Cl, exist on Earth only in charged form, and thus as ions. The reason for putting "elements" in quotation marks in the previous sentence is to emphasize that Earth scientists *never* encounter


these entities in nature in their elemental uncharged form (i.e., with a number of electrons equal to their number of protons). Those particular numbers of electrons are not stable in the electron shells and orbitals that nature makes available. Thus the things we call Na, K, Mg, and Ca atoms travel through Earth's geo-oceano-bio-chemical cycles with fewer electrons than protons, and are the cations Na^+ , K^+ , Mg^{2+} , and Ca^{2+} . Likewise, the things we call F and Cl travel through those cycles with more electrons than protons, and thus as the anions F^- and Cl^- .

These statements have probably been true for all of geologic time. It's probably not correct to say that "Na and K have lost electrons and become cations" because, in any reasonable geologic context of time, Na and K (and Li and Mg and Ca and Sr, etc.) have never had the full set of electrons that would equal in number the number of their protons.

If we move in from the left side of the periodic table, the same is true of *almost* all Al and Si. We *almost* inevitably find Al and Si as the charged entities Al^{3+} and Si^{4+} – but we have found *tiny* amounts of those elements in elemental form, in rocks deep in Earth's crust.

Moving in from the other side of the periodic table, most of the O we encounter is anionic O^{2-} in the oxide and oxysalt minerals of Earth's crust. Here, however, time matters: oxygenic photosynthesis has produced so much elemental O, as O_2 , that we Phanerozoic animals consider elemental O a common entity in our atmosphere. With that said, one should remember that an Earth without life engaged in oxygenic photosynthesis would have essentially no elemental O, and O would join F and Cl in the ranks of things known only as anions.

Li^+	Be^{2+}	B^{3+}	C	N^{3-}	O^{2-}	F^-
Na^+	Mg^{2+}	Al^{3+}	Si^{4+}	P	S^{2-}	Cl^-
K^+	Ca^{2+}	Sc^{3+}	Ti^{4+}	V	Cr^{2-}	Br^-
Rb^+	Sr^{2+}	Y^{3+}	Zr^{4+}	Nb	Mo^{2-}	I^-
Cs^+	Ba^{2+}	La^{3+}	Hf^{4+}	Ta	W^{2-}	At^-
Fr^+	Ra^{2+}	Ac^{3+}	Th^{4+}	Pa	U^{2-}	

 Not known in nature on Earth in elemental form