

## Anions F-Cl-Br-I

### Anions: F-Cl-Br-I

The elements Fluorine (F), Chlorine (Cl), Bromine (Br) and Iodine (I) are halides which form salts and sulfo-salts, and they are included in the mineral structure of a wide variety of hydrous minerals. They make useful indicators of mineralization and hydrothermal alteration, and are very mobile as anions in both primary and secondary

environments. As noted by Sudov et al (1994, Erlich Translation), "Halogens... play an important role in the process of forming endogenous ore: they are main factors in mobilizing and transferring metals in magmatic melts and post-magmatic hydrothermal solutions. The main recent hypothesis of endogenous ore formation suggests that halogens play an active role in the transfer of metals and in their precipitation in the form of ore deposits. Many hypotheses accept the role of halogens in the process of formation of ore deposits as decisive." In a primary ore setting these anions segregate into a late gaseous stage from alkalic magma and form complexes with metals assisting in mobility, such as the mobility of gold as the complex  $AuCl$ . Anion chemistry results in many of the specific conditions of mineral deposition. The presence of fluorite enrichments above molybdenum porphyries and in pegmatites are the tracers of such activity. In a secondary alteration setting they are present in the volatiles expressed upwards and distal from mineralization and hydrothermal alteration (Figure 3), or evidenced by minerals such as the secondary copper mineral Atacamite,  $Cu_2Cl(OH)_3$ .

Halide minerals include all salts, and minerals with a dominant halide anion (F, Cl, Br and I). In addition to the two most common minerals Halite and Fluorite, F-Cl-Br attach themselves within a variety of minerals such as apatite,  $Ca_5(PO_4)_3(F,Cl,OH)$ ; biotite,  $K(Mg,Fe^{2+})(Al,Fe^{3+})Si_3O_{10}(OH,F)_2$ ; and similar hydrated minerals.

The commercially important halide minerals are halite (NaCl) and fluorite ( $CaF_2$ ). The highly mobile nature of  $F^-$ ,  $Cl^-$  and their complexes make them useful as acids (HCl, HF) that aid in the dissolution of minerals. The Latin word *fluo* means to flow, a tribute to this mobility.

Fluorite is an isometric mineral with cubic habit, common twinning and strong cleavage. Fluorite is strongly fluorescent, a name derived from the mineral's property. It is transparent with variable colour in both natural and fluorescent light. Element substitutions for Ca include U and REE.

Analytical methods for F-Cl-Br-I include total instrumental methods such as Neutron Activation and Ion Selective Electrode or XRF methods after fusion digestion. Br and I may be determined from some multi-element ICP-MS methods. These methods may be affected by unusual sample matrix, such as samples with extremely high Fe, Si, Mg, or phosphates. The purpose of the analytical program and types of samples should be discussed with an analyst. Analytical laboratories use the HCl and HF acids for sample digestion, so potential contamination must be carefully managed.



Figure 1: Halite Salt (Na (Cl-Br-I))  
[www.wikipedia.com](http://www.wikipedia.com)



Figure 2: Fluorite ( $CaF_2$ )  
<http://www.electric-lady-land.com/>

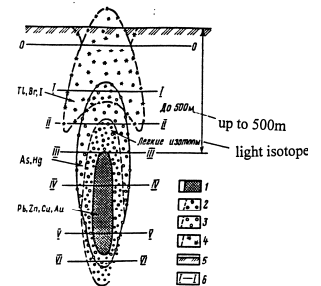


Figure 3: Outward halide halo in primary ore deposits (Solovov et al, 1994).

Fig. 3. Generalized scheme of primary halo of hydrothermal ore body (after A.P. Solovov): 1 - ore body; 2 - lead halo; 3 - mercury halo; 4 - iodine halo; 5 - recent Earth's surface; 6 - levels of haloes' cross-sections

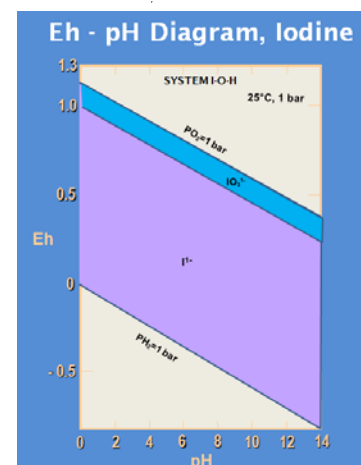


Figure 4: Redox Diagram for I, 25C, 1Bar (Brookins, p 15).



## Anions F-Cl-Br-I

An abundance of naturally occurring chlorides, fluorides, iodides and bromides occur in the surficial environment. These elements are also extremely mobile (Figure 4), contributing to their effectiveness as pathfinder elements. Most are soluble in water, and are concentrated in evaporite deposits.

F-Cl-Br-I Anions: Analytical Methods Available At ALS Minerals

Method	Description	Range	ALS Code
Trace	F, Cl by Fusion, Ion Chromatography	20 ppm - 1% F 50 ppm - 1% Cl	(F,Cl)-IC881
	F, Cl by Fusion, Ion Selective Electrode	5 ppm - 1% F 50 ppm - 2% Cl	(F,Cl)-ELE81a
Assay	F by Fusion, Ion Selective Electrode	0.01% - 100% F	F-ELE82
	Cl by Fusion XRF	10 ppm - 4% Cl	Cl-XRF11
	Cl by Acid Digestion, Titrimetric Finish	0.01% - 80% Cl	Cl-VOL66
Instrumental Total	Br by Neutron Activation	0.5 ppm - 1% Br	Br-NAA05
	Cl by Neutron Activation	100 ppm - 1% Cl	Cl-NAA06
	Cl by Neutron Activation	0.01% - 50% Cl	Cl-NAA07
	I by Neutron Activation	0.5 ppm - 1% I	I-NAA07
Super-trace Soil/Regolith Multi-element	Ionic Leach - selective leach Sodium cyanide and chelating agents to pH 8.5, 60 elements by ICP-MS	50 ppb - 0.1% Br 10 ppb - 0.1% I	ME-MS23
	Mn-oxide - selective leach Hydroxylamine-HCl, 63 elements determined by ICP-MS and final leach pH	2 ppm - 2% Br 100 ppb - 5% I	ME-MS05
	Fe-oxide - selective leach Hydroxylamine-HCl, 63 elements determined by ICP-MS and final leach pH	2 ppm - 2% Br 100 ppb - 5% I	ME-MS06

February, 2012

RIGHT SOLUTIONS RIGHT PARTNER

www.alsglobal.com