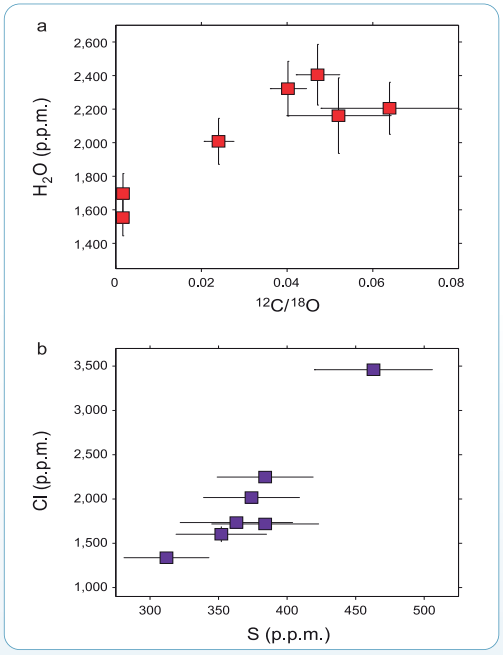
Cosmochemistry Applications of the IMS 7f-GEO Ion Microprobe

Measurement of Volatile Elements

Lunar Apatite with Terrestrial Volatile Abundances

The Moon is thought to be depleted relative to the Earth in volatile elements such as H, Cl and the alkalis. Determination of volatile contents in lunar samples is important for understanding lunar origin and evolution. This study reports quantitative Secondary Ion Mass Spectrometry (SIMS) measurements of late-stage apatite from lunar basalt 14053 using the **IMS 7f-GEO**. The key result of this study is the observation that H, Cl and S contents of apatite from the lunar basalt are essentially indistinguishable from apatites grown from terrestrial magmas. One possible implication is that portions of the lunar mantle or crust are more volatile-rich than previously thought.

The **IMS 7f-GEO** is well suited for measurement of volatile species (C, H, F, S and Cl) in mineral samples. High quality data and low detection limits are obtained using spot analysis mode due to its high-density Cs^+ primary beam, optical and electronic gating to eliminate contribution from crater edges, and high mass resolution capabilities for eliminating mass interferences (e.g. $^{16}O^1H^-$ / $^{17}O^-$, $^{32}S^-$/ $^{31}P^1H^-$ and $^{35}Cl^-$ / $^{19}F^{16}O^-$).



Plots of H_2O versus C (a) and Cl versus S (b), for SIMS analyses of 14053 apatite. All concentrations are reported by weight, with hydrogen reported as H_2O and sulfur reported as S.

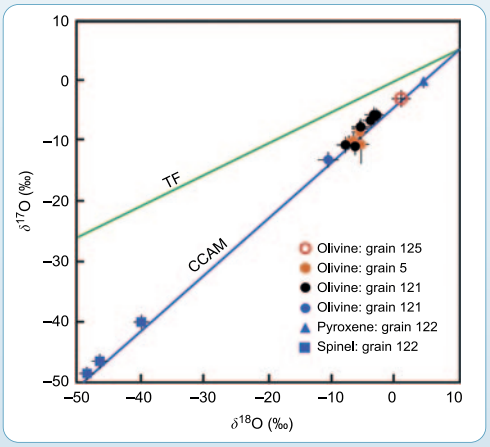
Data collected on IMS 7f-GEO at Caltech (USA). From J. W. Boyce et al., NATURE 466, 466-469 (2010).

Oxygen Three-Isotope Analysis

Evidence for the Extraterrestrial Origin of the Rock Containing a Natural Quasicrystal

The discovery of a natural quasicrystal, icosahedrite ($Al_{63}Cu_{24}Fe_{13}$), accompanied by khatyrkite ($CuAl_2$) and cupalite (CuAl) in the Khatyrka meteorite has posed a mystery as to what extraterrestrial processes led to the formation and preservation of these metal alloys in the oldest rocks (~4.5 billion years) of the solar system. In this study, the extraterrestrial origin is inferred from the $^{18}O/^{16}O$ and $^{17}O/^{16}O$ isotopic data obtained on different grains of the Khatyrka meteorite using the **IMS 7f-GEO**.

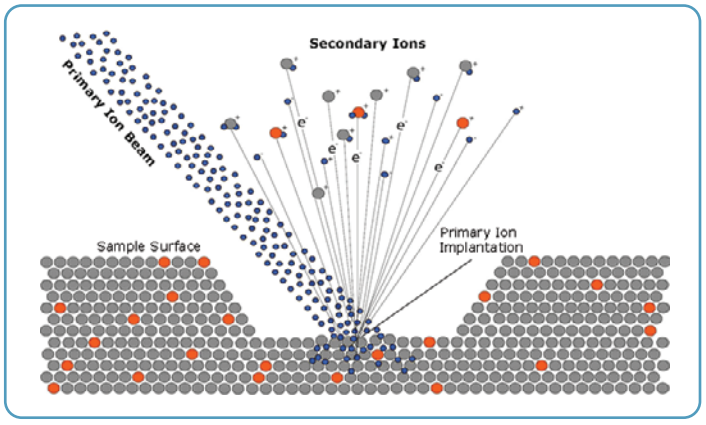
High precision isotope measurements are performed using the **IMS 7f-GEO**'s specific detection system with two low-noise Faraday cups and one discrete-dynode Electron multiplier. In this study, secondary ions were collected by peak-jumping into either a Faraday cup (^{16}O-) or Electron multiplier (^{17}O- and ^{18}O-) at a mass resolving power of ~6,500, which easily resolves the ^{16}OH- interference on ^{17}O-. A measurement precision of ~1-1.3 ‰ (1σ) was achieved for both $\delta^{17}O$ and $\delta^{18}O$.



Oxygen 3-isotope composition, to discriminate terrestrial (TF = terrestrial fractionation) and extraterrestrial (CCAM = carbonaceous chondrite anhydrous minerals) sources. The plot displays data for olivine, pyroxene, and spinel coexisting with a natural quasicrystal in the Khatyrka meteorite. Terrestrial minerals fall along the TF line (green line) with a slope of ~0.5; the oxygen isotope compositions measured for these samples lie along the CCAM line with a slope of ~1.

Data collected on IMS 7f-GEO at Caltech (USA). From L. S. Hollister et al., Nature Communications 5, 4040 (2014).

The Technology Behind



Dynamic SIMS

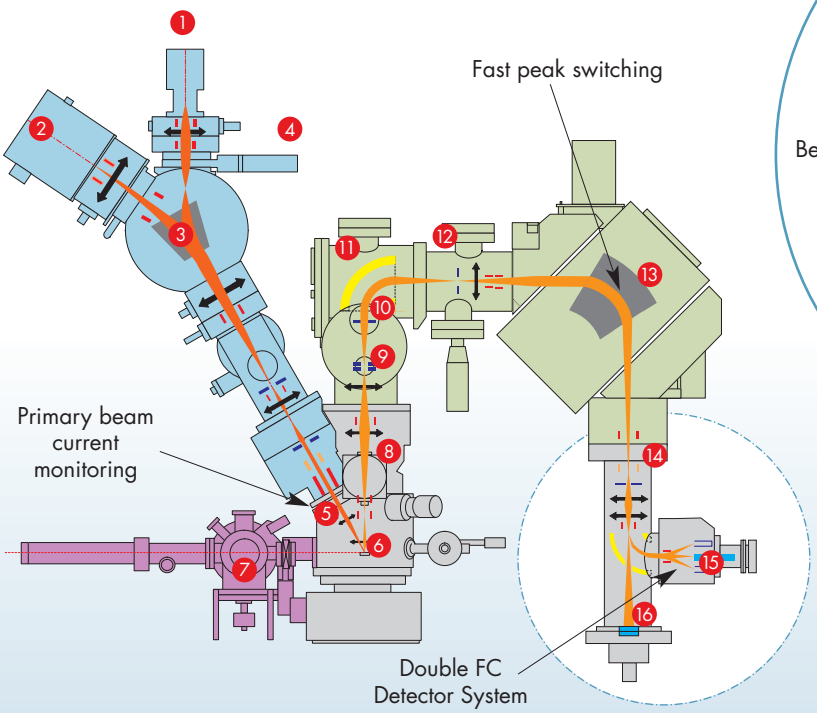
When a solid sample is sputtered by primary ions of few keV energy, a fraction of the particles emitted from the target is ionized. Secondary Ion Mass Spectrometry consists of analyzing these secondary ions with a mass spectrometer.

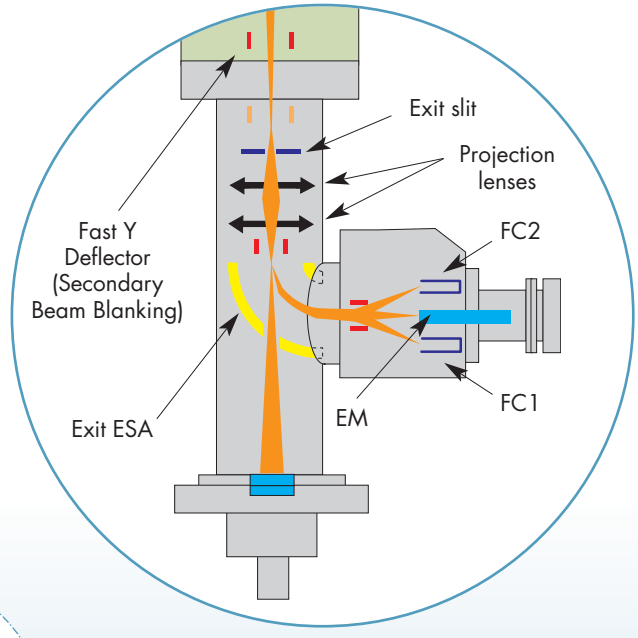
The SIMS technique is "destructive" by its nature (sputtering of material). It can be applied to any type of flat, solid material that can be kept under vacuum.

In dynamic SIMS, bulk composition and in-depth distribution of trace elements are investigated with a depth resolution ranging from sub-nm to tens of nm. SIMS is recognized as the most sensitive elemental and isotopic surface analysis technique.

CAMECA IMS 7f-GEO

The IMS 7f-GEO is a mono-collection SIMS model that combines the well-proven features of the IMS 7f with a specific detection system including two Faraday cups and one Electron Multiplier.





1 Microbeam Cesium ion source
2 Duoplasmatron ion source
3 Primary Beam Mass Filter (PBMF)
4 Cesium source isolation option
5 Primary Faraday cup
Motor driven primary column aperture
6 Sample (-10kV to +10kV) (Z axis in option)
7 UHV airlock system (Sample storage chamber in option)
8 Normal incidence Electron Gun (NEG)
9 Motor driven contrast aperture and entrance slit
10 Motor driven field aperture
11 Electrostatic Analyzer (ESA)
12 Motor driven energy slit
13 Fast laminated magnet
14 Motor driven exit slit
15 Electron Multiplier and double FC detectors
16 Ion image detector

For more information please visit www.cameca.com/products/sims/ims7f-geo

Ref. AP 7f-geo-cosmochemistry upd 2023