Chapter 16

ANALYSES OF GEOLOGICAL MATERIALS FOR BORON BY SECONDARY ION MASS SPECTROMETRY

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INTRODUCTION

The purpose of this chapter is to describe the usefulness of the secondary ion mass spectrometer (SIMS, or ion microprobe) in quantitative determination of boron in minerals and glasses. SIMS has broad analytical uses in the earth sciences, and its use for the analysis of boron represents one of its earliest applications (e.g. Blanchard et al., 1972; Hinthorne and Ribbe, 1974; Steele et al., 1980; Jones and Smith, 1984). We present a short description of the instrumentation, discuss some properties of boron secondary ions, and show how SIMS can generate quantitative microanalyses for B from several wt % down to sub-ppm levels. Being a mass spectrometric technique, SIMS allows the analyst an opportunity to obtain precise $^{11}B/^{10}B$ measurements on selected phases in polished thin sections. SIMS can also provide qualitative images of the micro-distribution of boron in complex mineral assemblages.

ANALYTICAL TECHNIQUES

Instrumentation

Most SIMS analyses for B have come from three types of instruments. The ARL ion microprobe mass analyzer (IMMA), the AEI (Banner and Stimpson, 1975), and the Cameca 3f-6f series (Lepareur, 1980). Because very few AEI and ARL machines are still operative, I will describe only the design of the Cameca. Another commercially available SIMS is constructed by ANUTECH (known as the SHRIMP; Clement et al., 1977). The SHRIMP is best known for its application to microanalyses of zircon for dating purposes (e.g. Froude et al., 1983). These analyses are possible because of the very large radius magnet (~1m) in the SHRIMP (compared to ~10× smaller in the Cameca 3f-6f instruments). The SHRIMP has also been successfully applied to S isotope work (Eldridge et al., 1989; McKibben and Eldridge, 1989) and can also be used for micro- and isotopic analyses for boron. Cameca also manufactures a SIMS with a magnet having a size similar to the SHRIMP. This model (the 1270) has only been commissioned in one lab as of 1995, and so will not be discussed, but experience with the 3f-6f series should be broadly applicable to this instrument, except that significant improvements in transmission of ions through the mass spectrometer at high mass resolving power is expected.

General description of analysis conditions

In the Cameca design (see Fig. 1), a beam of primary ions at an impact energy of ~3 to 20 keV is focused to a spot and directed at a sample. Each incoming ion leads to multiple collisions with the atoms in the near-surface environment (known as a collision cascade), and from 1 to ~12 atoms are ejected, or sputtered, from the top few monolayers of the

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