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Study of the (010) olivine surface by Rutherford backscattering spectrometry in channeling geometry

LAURENCE LEMELLE,[1,*] FRANÇOIS ABEL,[2] CAMILLE COHEN,[2] AND FRANÇOIS GUYOT[3]

[1]Laboratoire de Sciences de la Terre, Ecole Normale Supérieure de Lyon, 46 allée d'Italie, 69007 Lyon, France
[2]Groupe de Physique des Solides, Tour 23, 2-4 place Jussieu, 75251 Paris cedex 5, France
[3]Laboratoire de Minéralogie et Cristallographie de Paris, Tour 26, 2-4 place Jussieu, 75252 Paris cedex 5, France

ABSTRACT

The (010) surfaces of forsterite (Fo_{100}) and natural forsteritic olivine (Fo_{90}) single crystals have been studied by Rutherford backscattering spectrometry (RBS). Spectra were collected either in channeling geometry with the incident beam parallel to the [010] zone axis, or in a random orientation. In both materials, two surface preparations were examined: (1) mechanical polishing and (2) chemical etching by hydrofluoric acid after mechanical polishing. Composition profiles extending to several hundreds of nanometers below the surface were probed by RBS in random mode. Simulations of all the spectra indicated constant major element compositions, equal to the bulk compositions of the crystals. Characteristics of the few top atomic layers were probed by RBS in channeling mode. The crystalline quality of the surface of chemically etched samples has been evaluated quantitatively and is shown to be much better than that of mechanically polished samples. Given the energy resolution, we estimate that the bulk crystalline quality is perturbed for more than 40 nm below the surface in the case of mechanical polishing whereas disorder is limited to a topmost layer thinner than 1 nm in the case of chemical etching. On average, for the chemically etched samples, less than one atom per [010] atomic row is displaced from its mean crystallographic position. The bulk stoichiometry is preserved in the topmost layer of pure forsterite whereas a slightly higher Fe/Mg ratio is detected at the surface of chemically etched Fo_{90}. A method for the quantitative assessment of surface quality of olivine is thus proposed, constituting a useful preliminary step before any study of surface modifications of olivine subjected to various geological conditions.