

CHAIN PERIODICITY FAULTS IN PYROXFerroITE FROM LUNAR BASALT 12021.

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Introduction

Chain periodicity faults (CPFs) have been discovered recently in various natural and synthetic pyroxenoids (1 to 7). Pyroxenoids are chain silicates of the general formula $M_p[Si_pO_{3p}]$, with chain periodicities $p = 3, 5, 7, 9, \dots$. The kind and frequency of CPFs in pyroxenoid crystals are correlated with their chemical composition, in particular with the radii of their cations on the one side and with thermal and baric history on the other (2). In natural terrestrial rhodonites ($p=5$) as well as pyroxmangites ($p=7$) the CPF concentrations are relatively low and no significant differences between crystals from different localities have been found (2). In comparison, in synthetic pyroxenoids the CPF concentration varies considerably (1,3,5,6,7). Crystals of synthetic rhodonite ($Mn_5[Si_5O_{15}], p=5$) and ferrosilite III $Fe_9[Si_9O_{27}]$, ($p=9$), which were grown at P, T conditions within the stability field of these phases were almost free of CPFs (5,6,7). However, crystals grown outside of the stability field, or in a very short time, show a higher CPF concentration. The CPF concentration can be diminished by tempering the crystals within the stability field (6,7). Therefore, we assume that, at least in the case of pure one-cation pyroxenoids such as $MnSiO_3$ and $FeSiO_3$, the presence of CPFs indicate a short annealing period which, in a crystallizing magma, is equivalent to rapid cooling.

Since for the pyroxferroite-bearing lunar basalt 12021 relatively rapid cooling has been established (8) and since pyroxmangite and pyroxferroite differ considerably in their chemical composition a search for CPFs in lunar pyroxferroite was undertaken.

Experimental

15 hand-picked pyroxferroite crystals ($\sim 100 \mu$ in size; sample number: 12021,252) were available for our studies. To obtain a general view of the structural imperfections, all crystals were examined by X-ray precession methods. Since in general CPFs are planar faults parallel (001), it is important for the EM study to prepare the crystals in such an orientation that (001) lattice imaging can be obtained. Therefore, 5 crystals were prepared by grinding to fine powder, which was deposited on a carbon supporting film. Some of the grains could then be oriented in the right way.

An energy-dispersive analysing unit on the EM was used for qualitative chemical analyses.

Results

For all 15 crystals the chain periodicity $p=7$ has been confirmed by X-ray diffraction. No diffuseness parallel c^* of reflections was observed on any of the single crystal X-ray diagrams. That means, that no high CPF concentration could be expected. In fact, from the EM-studies a CPF concentration of $\sim 0.5\%$ was detected. Most of the CPFs observed had $\Delta p = p' - p = +2$, i.e. they consisted of chain units with 9 tetrahedra ($p'=9$) which are interspersed into the regular sequence of siebener chain units ($p=7$) of the pyroxferroite crystals (Fig. 1). Although CPFs with $p'=9$ were the most abundant, other CPFs having $\Delta p = -2, +4$ and $+6$ have been observed. Note, that within the same crystal grain CPFs with $\Delta p = -2$ as well as with $\Delta p = +2$ occur (Fig. 1). Only one non-planar CPF was observed.

In Fig. 2 the frequency distribution of the various CPFs is presented as obtained by counting the lattice fringes observed. All together, crystal grains with ca. 280000 \AA in length parallel [001] were surveyed.

The qualitative chemical analyses of a representative part of one crystal grain is given in Fig. 3. It seems that the pyroxferroites we studied contain

Czank M. et al.

more Mg and Mn but significantly less Al than the starting glasses used by Grove and Lindsley (9) in attempts to crystallize pyroxferroite.

Conclusion

From the results at date the following suggestions can be made. (i) The almost complete absence of non-planar CPFs indicates that the crystals have not been exposed to considerable stress. (ii) The fact that the large majority of chain units have $p=7$ and that within the same crystal grain CPFs with $\Delta p \geq +2$ as well as with $\Delta p = -2$ have been observed indicates that the pyroxferroite crystals were formed rather rapidly right in the stability field of pyroxferroite ($p=7$). (iii) It can be assumed that the crystals have been cooled rather rapidly since the CPFs, in particular those with $\Delta p = -2$ and with $\Delta p \geq +4$, have not disappeared due to equilibration.

References

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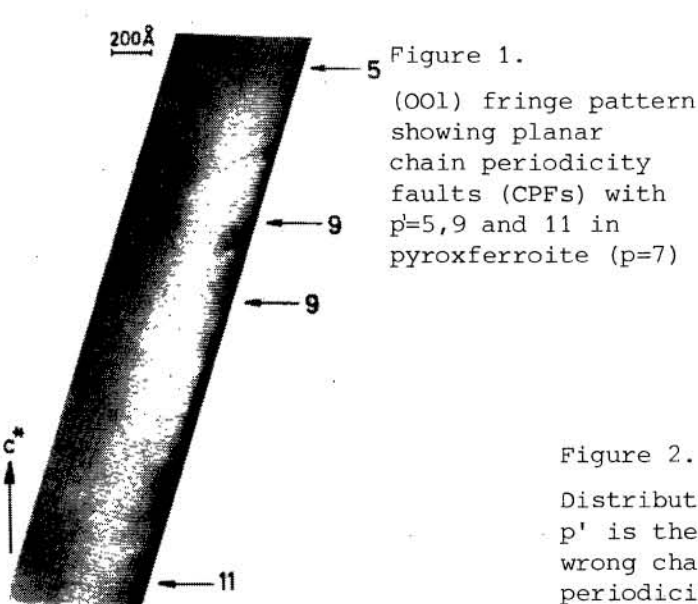


Figure 1.
(001) fringe pattern showing planar chain periodicity faults (CPF) with $p=5, 9$ and 11 in pyroxferroite ($p=7$)

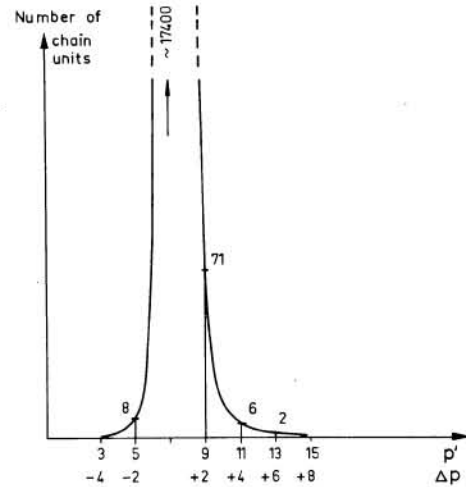


Figure 2.
Distribution of CPFs in pyroxferroite. p' is the number of tetrahedra of a wrong chain unit within a chain of ideal periodicity p . $\Delta p = p' - p$.

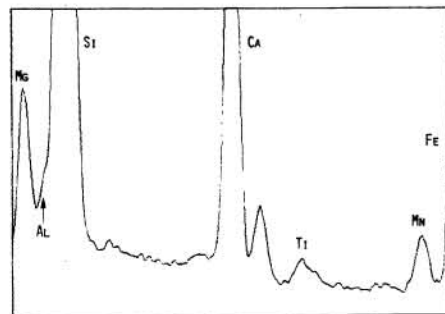
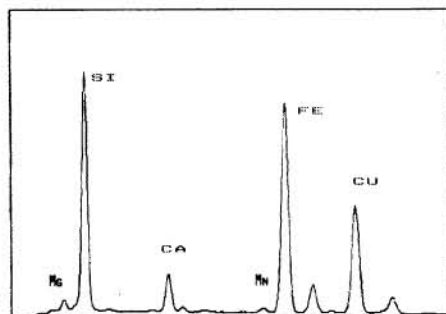


Figure 3a

3b

EDS spectrum from a pyroxferroite crystal grain. b) is an enlarged part of a). (Cu comes from supporting grid.)