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## 镁橄榄石相变长大率与水含量的关系及亚稳态橄榄石的存在深度

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Relationship between the growth rate of forsterite phase transformation and its water content and the existing depth of metastable olivine

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摘要

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**摘要** 通过分析镁橄榄石相变长大率方程的指前系数和亥姆霍兹活化能在不同含水条件下的实验拟合值, 本文研究了橄榄石相变长大率与水含量的关系. 结果表明含水量较高的镁橄榄石在相变过程中对应较低的亥姆霍兹活化能, 而长大率方程中的指前系数几乎是一个与含水量无关的常数. 这个常数的数值在晶界控制长大的晶体相变动力学经典理论中相应于晶界是一层或几层分子的厚度. 亥姆霍兹活化能随水含量的增加而降低的结果既和利用淬火实验得到的结论相一致, 也和流变学实验研究的结论相一致. 应用以上结果, 我们估算了含水量对亚稳态橄榄石存在深度的影响. 镁橄榄石的亚稳性受到水的影响很大, 具体表现是橄榄石到其高压相瓦士利石的动力学相变界面从下压了几十公里到一直下压到660 km间断面附近. 地幔橄榄石与镁橄榄石的亚稳性存在差异. 名义上干的地幔橄榄石实验结果显示地幔橄榄石具有更小的亚稳性, 相变完成10%的深度比镁橄榄石浅了20 km左右. 以上结果仍然支持在冷的俯冲带中存在可探测的亚稳态橄榄石楔但很难达到660 km间断面深度的结论.

**关键词:** 橄榄石 相变 长大率 含水量 深源地震 俯冲带

**Abstract:** We investigate the relationship between water content and the parameters in the growth kinetics of forsterite phase transformation, i.e., the pre-exponential factor and the Helmholtz free energy of activation, by analyzing the growth parameters of forsterite separately for water content varying from about 0.08 to 0.5 per cent in weight. Results show that increase of water content only decreases the Helmholtz free energy of activation for growth, while the pre-exponential factor of classical growth rate equation has weak dependence on the water content and is nearly a constant, of which the value corresponds to an interphase boundary with the thickness of one or a few layers of molecules. This fact is consistent with the observation of quench experiments on olivine and rheological studies. Accordingly, taking this fact as a constraint, we predict the survival depth of metastable forsterite with different water contents. The dynamic phase boundary of forsterite changes from several kilometers below the equilibrium boundary of forsterite phase transformation to almost the 660 km discontinuity. Different from forsterite, mantle olivine has smaller metastability. Under a nominal dry condition, the dynamic phase boundary of mantle olivine is 20 km shallower than that of forsterite. The current result agrees that there might exist detectable extent of metastable olivine in subduction zones although it is difficult to reach the 660-discontinuity.

**Keywords:** Olivine Phase transformation Growth rate Water content Deep earthquake Subduction zone

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