

TRACE ELEMENT PARTITIONING BETWEEN TITANITE, DIOPSIDE AND MELT AT 1 ATM. – AN EXPERIMENTAL STUDY OF THE SYSTEM ANORTHITE – DIOPSIDE – TITANITE

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One atmosphere data from crystallisation experiments are presented in the system $\text{CaAl}_2\text{Si}_2\text{O}_8$ (An) – $\text{CaMgSi}_2\text{O}_6$ (Di) – CaTiSiO_2 (Ti). Within this system these minerals form more or less limited solid solutions. The Clinopyroxenes can contain CAT molecules ($\text{CaAl}_2\text{SiO}_6$), MAT molecules ($\text{MgAl}_2\text{SiO}_6$) or Titanpyroxene molecules ($\text{CaTiAl}_2\text{O}_6$). Titanites contain variable amounts of Mg and Al, whereas the Anorthites within this system show extreme limited solid solutions. Such solid solutions are the basis for trace element incorporation (HFSE and REE). In this case, the elements Al, Ti, and Mg act as charge balancing elements for coupled substitutions. For this reason the extent of solid solutions controls the trace element partitioning. The extent of solid solution and of the concentration of selected trace elements was determined by microprobe analysis. The analysed samples represent compositions of the pseudoeutectics from the surrounding binary systems and of the piercing point from the ternary system.

I. Al and Ti in Clinopyroxene:

Ti-free Clinopyroxenes show a partition coefficient for $\text{DAI} = 0.74$. Al-free Clinopyroxenes show $\text{DTi} = 0.15$. The Clinopyroxenes which contain both Ti and Al exhibit changed coefficients of $\text{DAI} = 0.5$ and $\text{DTi} = 0.5$. This change is caused by the Titanpyroxene Molecule – building coupled substitution $\text{Mg} + 2\text{Si} \leftrightarrow \text{Ti} + 2\text{Al}$.

1. Zr in Clinopyroxene:

Al-free Clinopyroxenes contain not measurable amounts of Zr. Whereas Al-bearing Clinopyroxenes contain 1200 ppm ZrO_2 , yielding a partition coefficient of $\text{DZr} = 0.26$. This correlates with an increase of the DAI - and a decrease of the DTi - and DMg -partitioning. Zr incorporation seems to follow the coupled substitution $\text{Mg} + 2\text{Ti} \leftrightarrow \text{Zr} + 2\text{Al}$.

2. Nb and Ta in Clinopyroxene:

The Clinopyroxenes from all systems show Nb and Ta concentrations below the detection limit of microprobes.

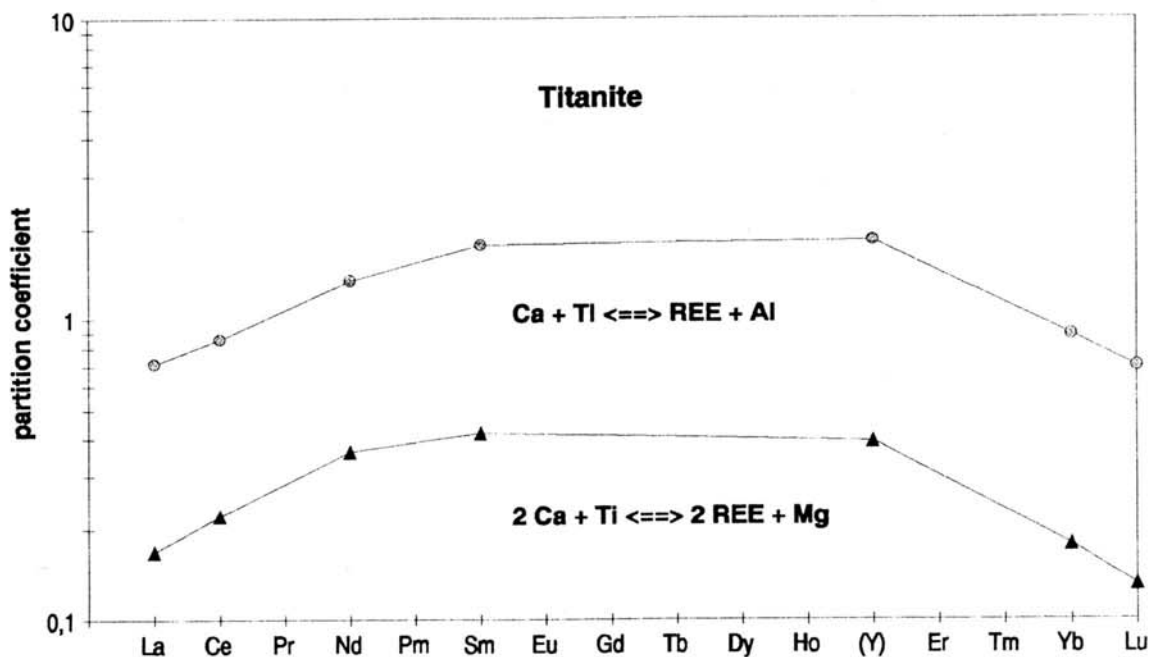


Fig. 1. Titanite spider diagramm

3. REE in Clinopyroxene:

The most incompatible behaviour exhibit the Clinopyroxenes which contain only Ti and no Al. The partition coefficients are generally below 0.03. Clinopyroxenes containing both Al and Ti are less incompatible. The light REE are strongly depleted. La/Sm reaches 0.15. For the heavy REE the partition coefficients lie in the range of 0.19. The least incompatible behaviour show the Ti-free but Al-bearing Clinopyroxenes. La/Sm reaches also 0.15. The partition coefficients for the heavy REE increase to 0.27. All 3 REE patterns run parallel: for this reason it can be stated that the presence of Al favours the incorporation of REE, whereas the presence of Ti hampers the REE distribution.

II. Al and Mg in Titanite:

In Titanites Al and Mg are incorporated only in minor amounts. The concentration of Al is always less 1 Wt%, that of Mg always less 0.5 Wt%. The partition coefficients reach max. values of $DA_{Al} = 0.07$ and $DMg = 0.08$. Nevertheless these elements influence the trace element incorporation.

1. Zr in Titanite:

Al-free Titanites show a partition coefficient for $DZr = 1.54$. This coefficient traces back to the direct substitution $Ti \leftrightarrow Zr$. The presence of Al in Titanites raises the $DZr = 1.66$. Two superposing mechanism can be distinguished: a) $Ti \leftrightarrow Zr$ and b) $Mg + 2 Ti \leftrightarrow Zr + 2 Al$.

2. Nb and Ta in Titanite:

Titanites from the ternary system behave compatible for Nb and Ta ($DNb = 1.24$ and $DTa = 6.0$). Ta is by the factor 5 more compatible than Nb. The incorporation of Nb and Ta takes place by the coupled substitution $2 Ti \leftrightarrow (Nb, Ta) + Al$.

3. REE in Titanite:

Al-free, but Mg-bearing Titanites are depleted by the factor 2.5 in light and heavy REE with respect to the middle REE. The middle REE show max. partition coefficients of 0.4. Titanite bearing both, Al and Mg, exhibit the same shape of the REE pattern. The middle REE are also enriched by the factor 2.5. Nevertheless this REE group behaves compatible in these Titanites. The partition coefficients lie in the range of 1.35 – 1.83. This is an effect of the superposition of two different couples substitutions (Fig.1).

The REE content of the Al-free Titanites can be explained by a substitution mechanism in the form of $2 Ca + Ti \leftrightarrow 2 REE + Mg$. The Al-bearing Titanites which are compatible with respect to the middle REE incorporate these elements by an overlay of a second mechanism in the form of $Ca + Ti \leftrightarrow REE + Al$. The later coupled substitution seems by far more effective for REE incorporation: Al content in Titanites controls the distribution behaviour of the REE.

STEADY STATE FLOW AND RHEOLOGY OF DEFORMED ERZGEBIRGE GRANITOIDS

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Porphyric coarse grained pre-Variscan granite intrusion dated at 490–420 MY, K–Ar Hofmann et al. 1979 and cropping out in the central part of the Erzgebirge mountains was intensely reworked during Variscan westward ductile shearing (Mlčoch and Schulmann 1992). This reworking was heterogeneous producing 1) pervasive S–C granite as the most abundant rock type; 2) low-strain domains elongated in E–W direction, tens to hundreds meters in size and 3) zones of banded quartzofeldspathic mylonites.

The mylonitic flat-lying foliations bear east–west trending stretching lineation marked by elongation of quartz–feldspar aggregates and biotite clusters. Ubiquitous S–C relationships indicate west oriented shearing.

The textural transition from metagranite to banded mylonite during granite deformation is explained using a rheological model for bi- and polyphase material (Jordan 1988, Handy 1990). At the initial stages of granite deformation the strain rate and stress were concentrated into interconnected hard feldspar fraction while quartz was shielded from deformation. Tharp's load carrying framework rheological model operated during this stage.