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Variations in Melting Conditions Along the Xigaze Ophiolite (Tibet): A Transition from Ridge to Arc Setting?

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Geochemical studies of ophiolite ultramafic sequences can provide key information for our understanding of melting in the mantle and melt extraction processes. Such studies may also provide information on the tectonic setting of formation of ophiolite complexes.

The fresh nature of Xigaze ultramafic sequence (<10% serpentinisation) provides an unique opportunity to measure REE abundances on both whole rocks and clinopyroxene separates. The aim of this study is to obtain a better understanding of the mantle processes that lead to the geochemical characteristics of these highly depleted residua and investigate the extent of chemical equilibrium in mantle rocks.

The Xigaze ophiolite crops out on the Yarlung-Zangbo suture zone, ~250 km west of Lhasa (Tibet). The age of formation and emplacement of the ophiolite is estimated at 120Ma and 50Ma respectively (Marcoux et al., 1987). The massif forms a sub-linear continuous belt for over 250 km from East to West with a N-S width ranging from 1-30 km. The ultramafic sequence is 5 km thick and is mainly harzburgitic. The petrological and textural features of the ultramafic rocks have been interpreted as a consequence of a low thermal gradient at the Xigaze palaeo-ridge (Girardeau and Mercier, 1988). This implies that small amount of melt was produced during partial melting and that the ophiolite was formed at a slow spreading ridge (Nicolas et al., 1981). The ultramafic rocks analysed in this study are from the mantle sequence of three sub-massifs: Luqu, Dazhuku and Dazhuka sections. Major element compositions of the Dazhuka and Dazhuku peridotites show a large range with linear correlations between most major elements: CaO and MgO contents vary between 0.68 and 2 wt% and 41.9 and 44.9 wt% respectively. In contrast the Luqu peridotites have very homogenous major element contents with CaO and MgO around 1 wt% and 44.5 wt% respectively. Coupled FeO and MgO variation of the peridotites imply ~14% partial melting for the Dazhuku and Dazhuka sections and ~ 20% for Luqu. The whole rocks from the 3 sections are all characterised by spoon-shape REE patterns. The degree of LREE enrichment increases East to West ($0.04<(Ce/Sm)_N<1.65$) and correlates with a decrease, by a factor of 10, of $(Yb)_N$ abundances.

Of the three sections, the Luqu clinopyroxenes are the most depleted in MREE and HREE with $(Dy)_N$ and $(Yb)_N$ as low as 0.5 and 2.1 respectively. They also record the lowest degree of LREE abundances but have variable LREE enrichment ($(Ce/Sm)_N$ as high as 1).The Dazhuku clinopyroxenes have "spoon-shaped" REE patterns, with a marked inflection at Sm. The REE patterns show sub-parallel HREE and constant MREE depletion but more variable LREE. $(Ce/Sm)_N$ ratios vary between 0.01 and 0.1 and reflect different degrees of LREE addition. In contrast, the Dazhuka clinopyroxenes are characterised solely by LREE depletion. Their MREE and HREE abundances are comparable to clinopyroxenes from abyssal peridotites (Johnson et al., 1990) but the extent of LREE depletion is a factor 10 lower ($(Ce)_N = 0.001$).

The HREE depletion of the Dazhuku and Dazhuka clinopyroxenes is best modelled by 10-15% incremental batch dry melting in the spinel stability field, while the Luqu clinopyroxenes require unrealistic large degree of partial melting (>25%). The observed LREE enrichment of Luqu clinopyroxenes and all whole rocks imply different extent of melt/rock interaction during melt extraction. The Luqu clinopyroxenes in particular, require hydrous melting involving refertilisation of the source (Bizimis et al., 2000). This conclusion is in contradiction with previous studies that argued for a low thermal gradient under the Xigaze paleoridge.

The observed variation in the degree of chemical equilibrium between clinopyroxene and whole rocks correlates with the extent of melt/rock interaction and the degree of partial melting. Such data provides information on the extent of melting required for full chemical homogenisation. Furthermore, the East-West increase in the degree of LREE enrichment, HREE depletion, degree of partial melting and chemical equilibrium between clinopyroxene and whole rocks attest to changes in melting condition and are interpreted as a record of changing tectonic environment: i.e., decreasing distance to a subduction zone. This conclusion is supported by the negative ε_{Nd} values of both clinopyroxenes and whole rocks.

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