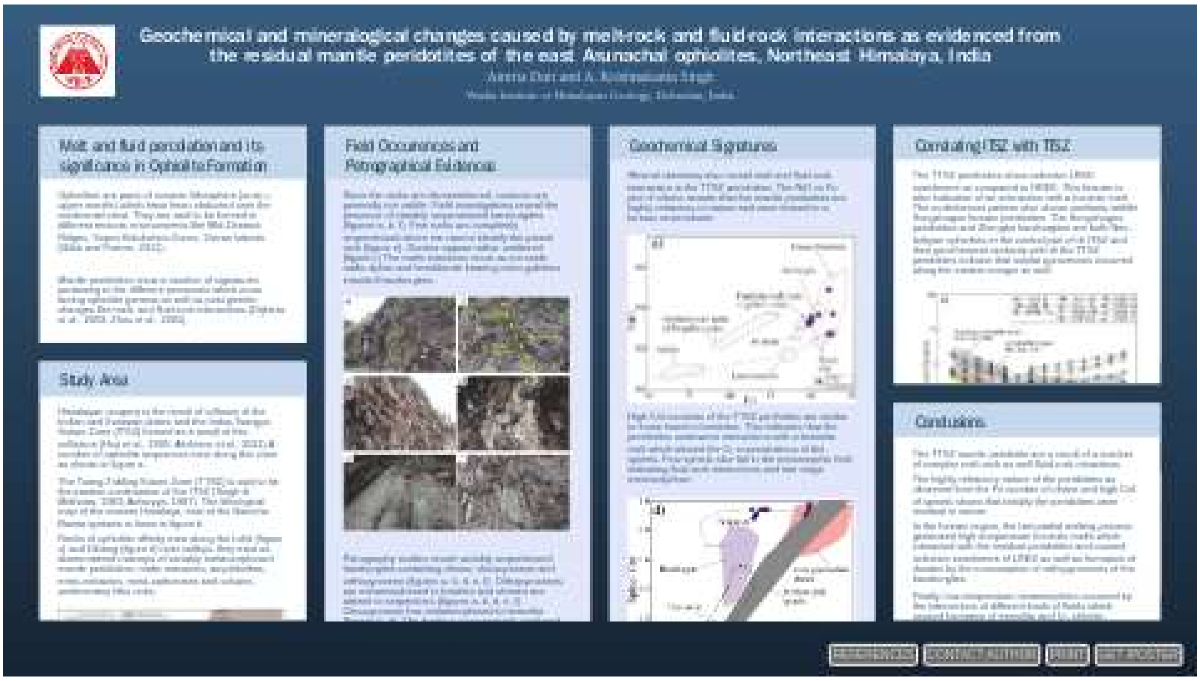
Geochemical and mineralogical changes caused by melt-rock and fluid-rock interactions as evidenced from the residual mantle peridotites of the east Arunachal ophiolites, Northeast Himalaya, India



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MELT AND FLUID PERCOLATION AND ITS SIGNIFICANCE IN OPHIOLITE FORMATION

Ophiolites are parts of oceanic lithosphere (crust + upper mantle) which have been obducted onto the continental crust. They are said to be formed in different tectonic environments like Mid-Oceanic Ridges, Supra Subduction Zones, Ocean Islands (Dilek and Furnes, 2011).

Mantle peridotites show a number of signatures pertaining to the different processes which occur during ophiolite genesis as well as post genetic changes like melt- and fluid-rock interactions (Dijkstra et al., 2003; Zhou et al., 2005).

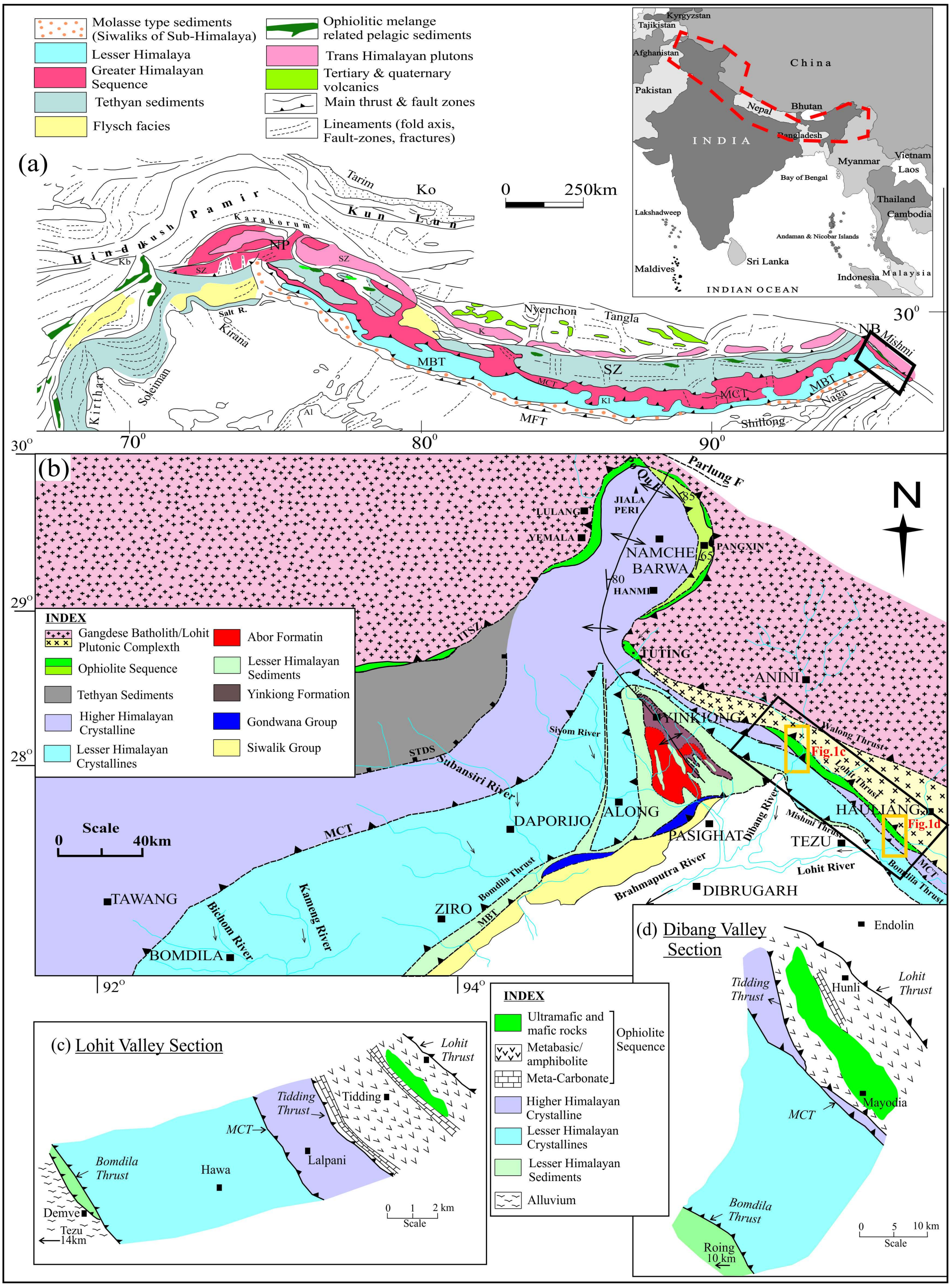
Melting and melt migrations in the mantle are complex processes (Bedard, 1989).Generally the forearc region of a subduction zone is the seat of melt and fluid rock interactions since the mantle wedge below a subduction zone undergoes partial melting and the subducting continental slab undergoes dehydration melting. These processes cause the release of melt and fluids which interact with the depleted peridotites to cause changes in their chemistry.

STUDY AREA

Himalayan orogeny is the result of collision of the Indian and Eurasian plates and the Indus-Tsangpo Suture Zone (ITSZ) formed as a result of this collisison (Hsü et al., 1995; Aitchison et al., 2011) A number of ophiolite sequences exist along this zone as shown in figure a.

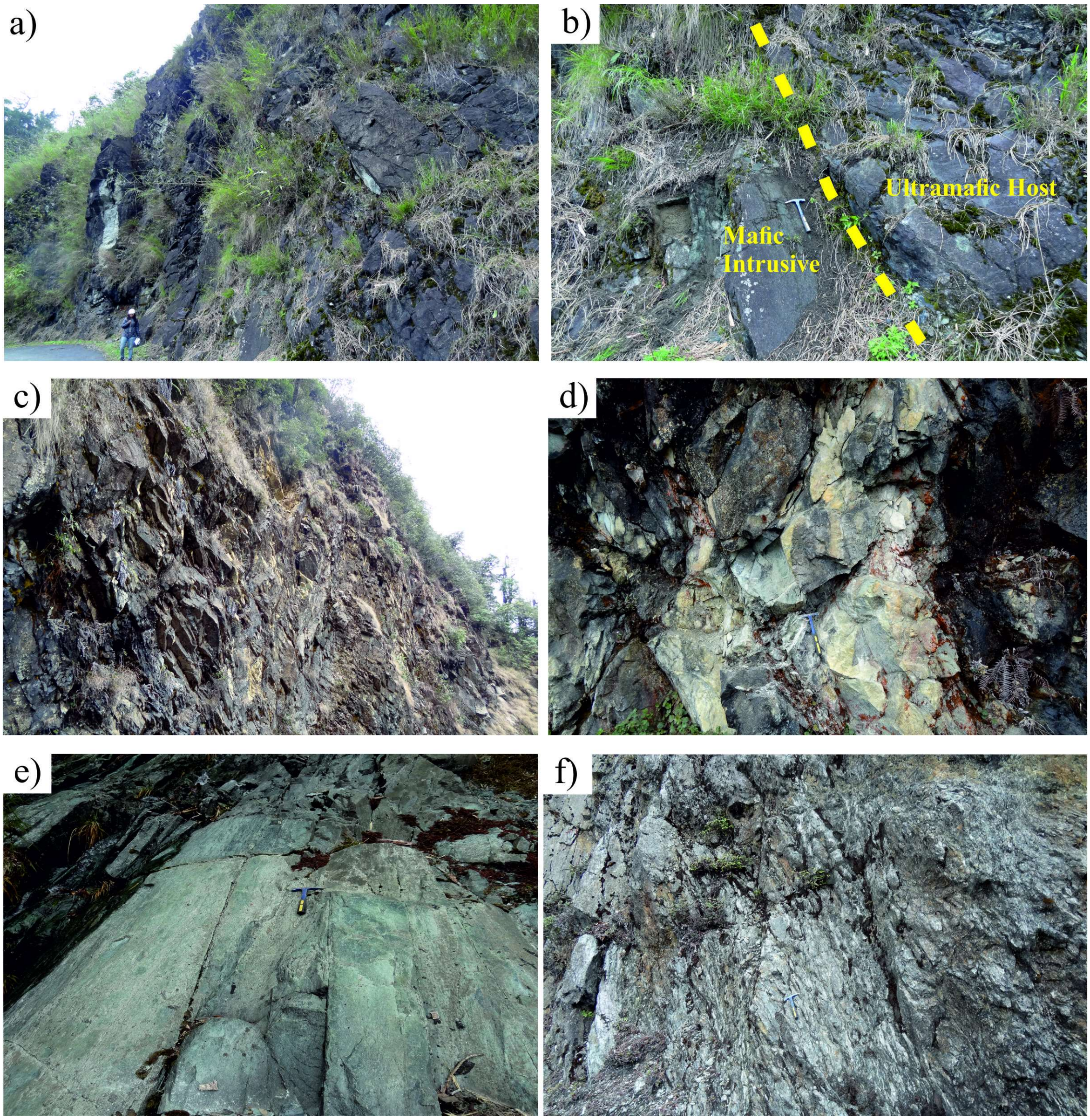
The Tuting-Tidding Suture Zone (TTSZ) is said to be the eastern continuation of the ITSZ (Singh & Malhotra, 1983; Acharyya, 1987). The lithological map of the eastern Himalaya, east of the Namcha Barwa syntaxis is hwon in figure b.

Rocks of ophiolitic affinity exist along the Lohit (figure c) and Dibang (figure d) river valleys. they exist as dismembered outcrops of variably metamorphosed mantle peridotites, mafic intrusives, amphibolites, meta-volcanics, meta-carbonates and volcano-sedimentary litho-units.

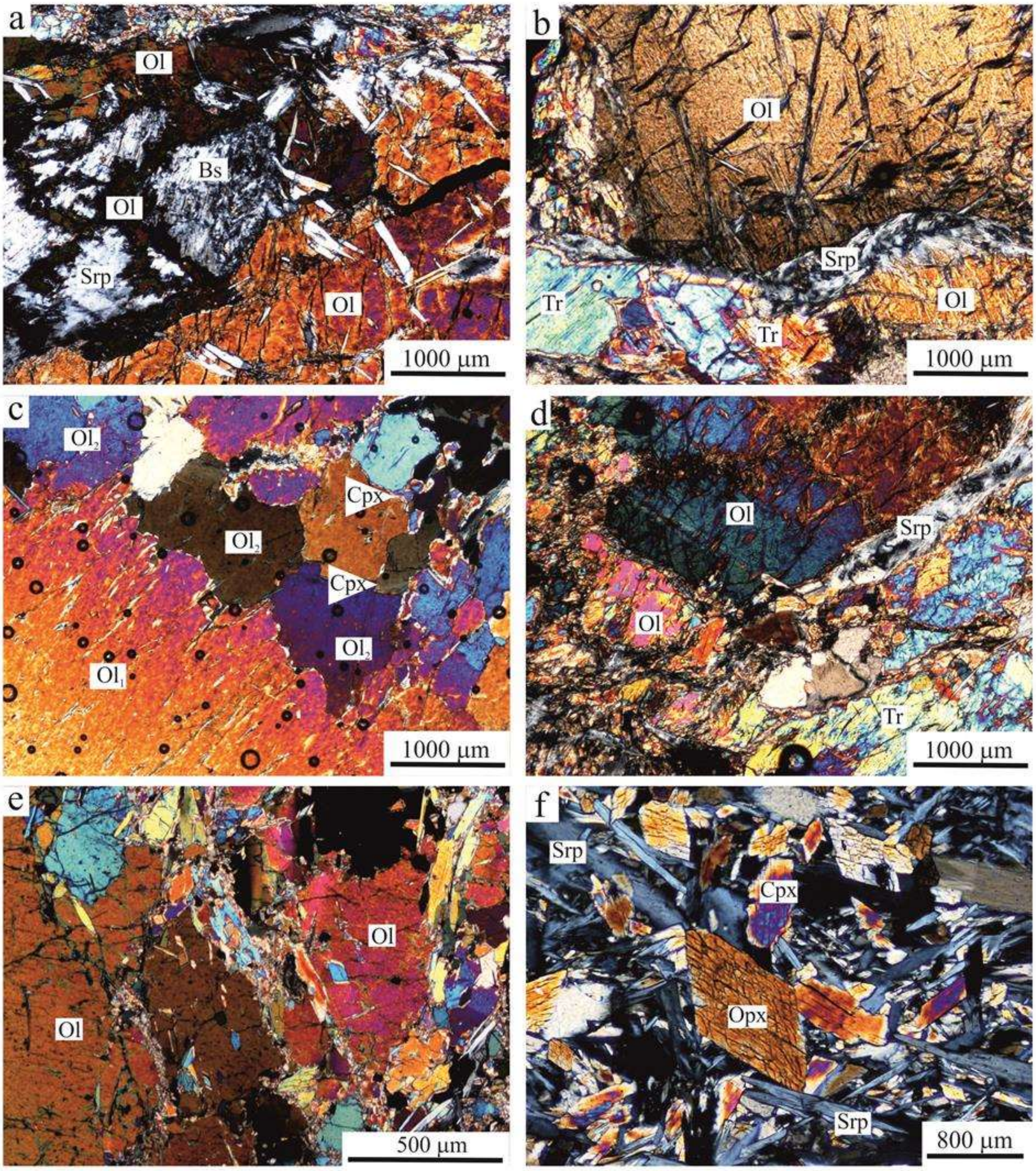


FIELD OCCURRENCES AND PETROGRAPHICAL EVIDENCES

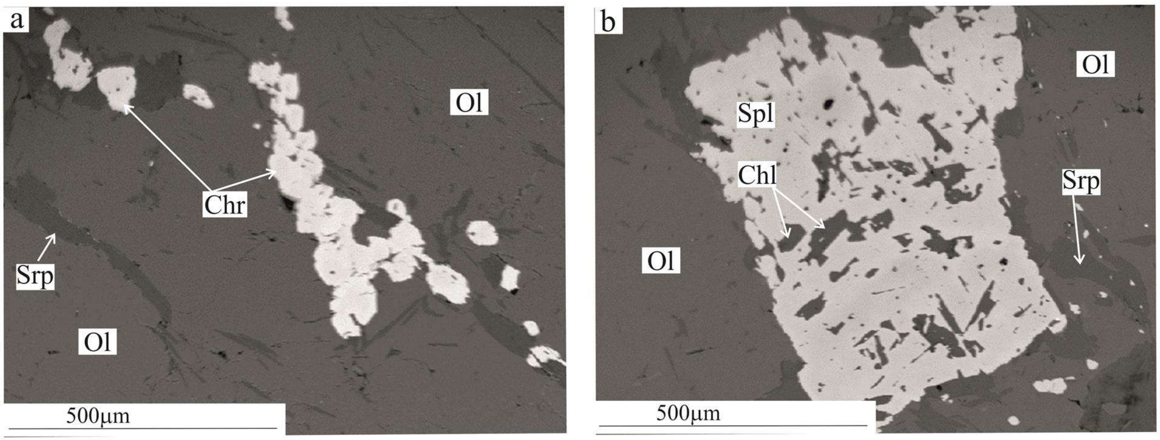
Since the rocks are dismemebered, contacts are generally not visible. Field investigations reveal the presence of variably serpentinized harzburgites (figures a, b, f). Few rocks are completely serpentinized where we cannot identify the parent rock (figure e). Dunites appear rather unaltered (figure c) The mafic intrusives occur as cm scale mafic dykes and hornblende bearing micro-gabbros intruded harzburgites.



Petrography studies reveal variably serpentinized harzburgites containing olivine, clinopyroxene and orthopyroxene (figures a, b, d, e, f). Orthopyroxenes are metamorphosed to bastites and olivines are altered to serpentines (figures a, b, d, e, f). Clinopyroxene has metamorphosed to tremolite (figures b, d). The dunite is comparatively unaltered (figure c) and two kinds of olivine are observed. Ol1 is larger in size and shows embayed grain boundaries while Ol2 is smaller in size and surrounds Ol1. Ol2 grain boundaries are straight and show triple junctions with each other.



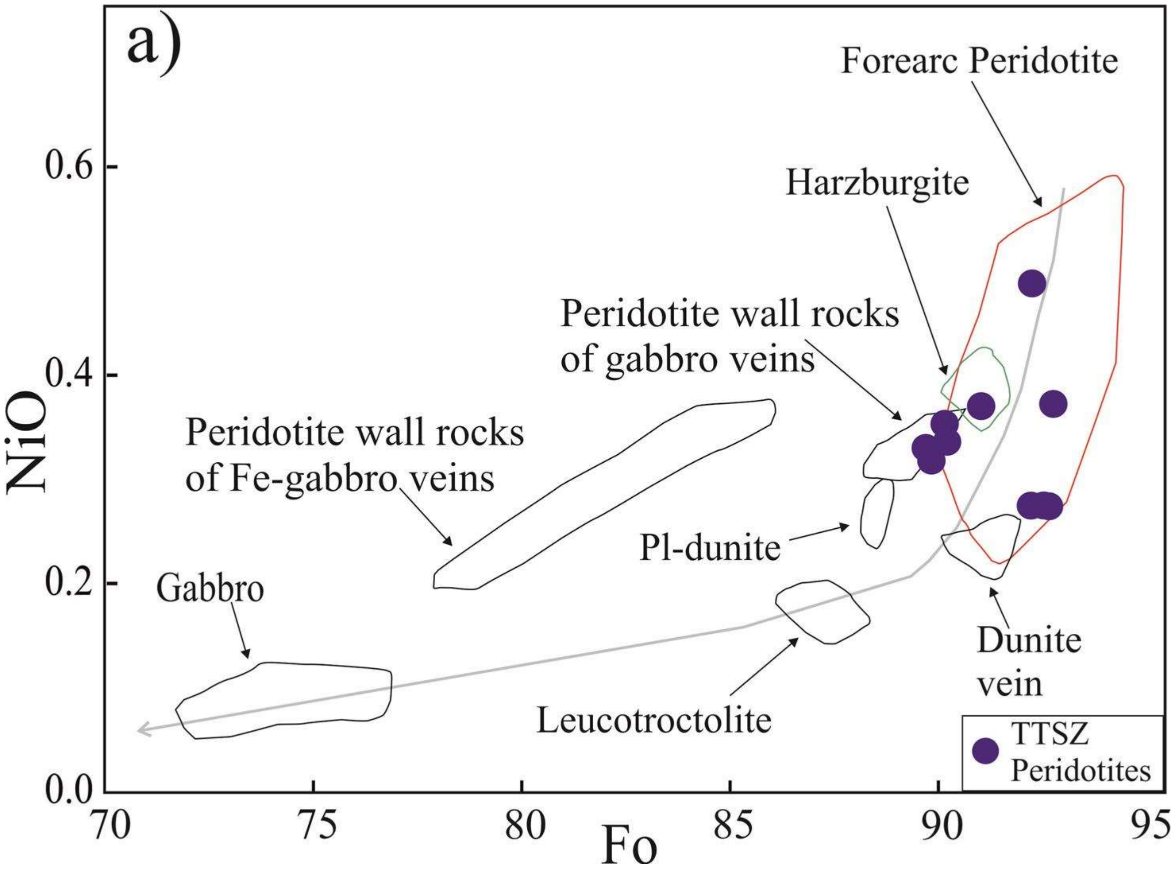
BSE images show the textures of Cr-spinels where Cr- spinels are either surrounded by chlorite or the chlorite exists as inclusions in them.



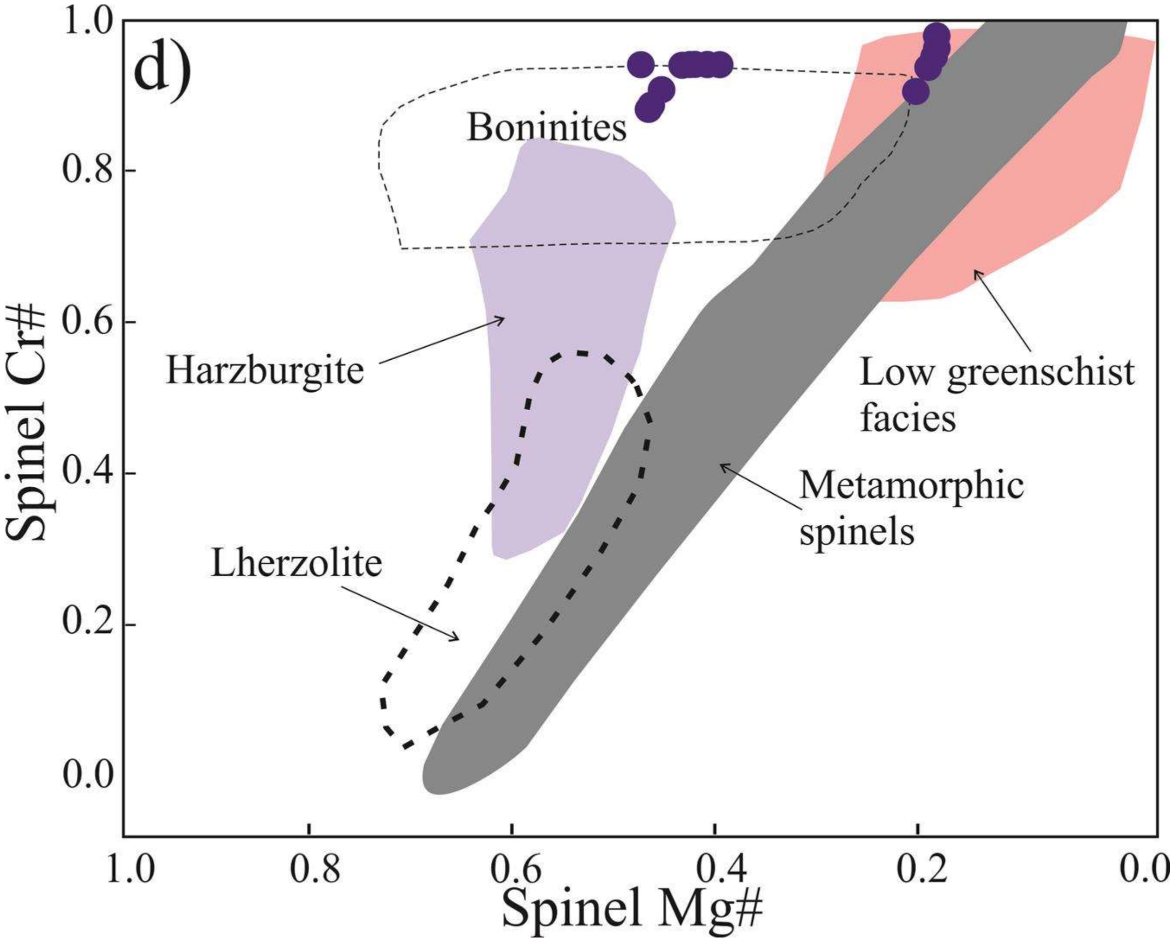
The petrographic evidences like occurrence of two kinds of olivines indicate that the harzburgites interacted with an olivine saturated melt which caused the formation of the second type of olivine at the expense of orthopyoxene. Presence of tremolite and chlorites indicate interactions with different kinds of subduction related fluids.

GEOCHEMICAL SIGNATURES

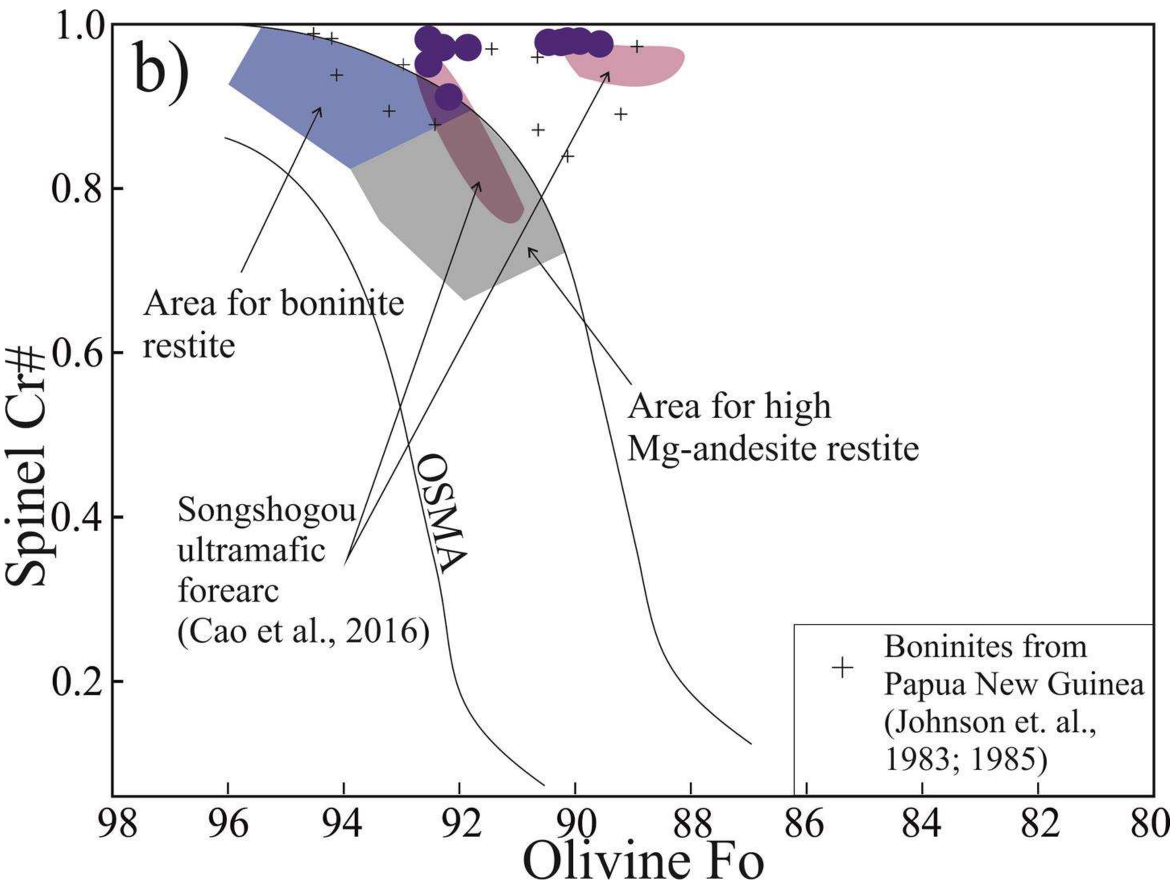
Mineral chemistry also reveal melt and fluid-rock interaction in the TTSZ peridotites. The NiO vs Fo plot of olivine reveals that the mantle peridotites are highly refractory in nature and were formed in a forearc environment.



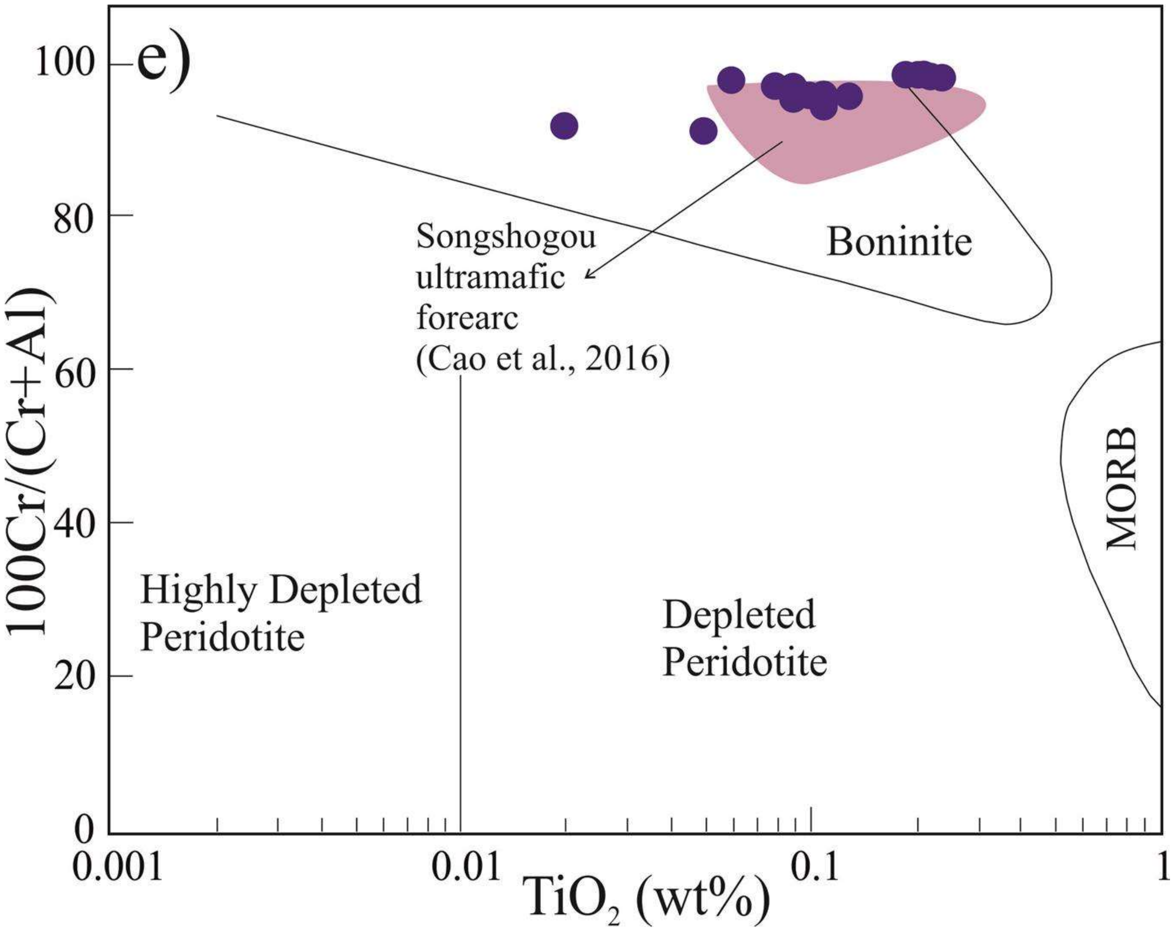
High Cr# contents of the TTSZ perifotites are similar to those found in boninites. This indicates that the peridotites underwent interactions with a boninitic melt which altered the Cr concentrations of the spinels. Few spinels also fall in the metamorphic field indicating fluid-rock intearctions and late stage metamorphism.



Spinel Cr# vs olivine Fo plot reveals that the TTSZ peridotites bearboninitc signature and similar to the Sonshugou peridotites (Cao et al 2015) which also underwent different melt- and fluid-rock interactions.

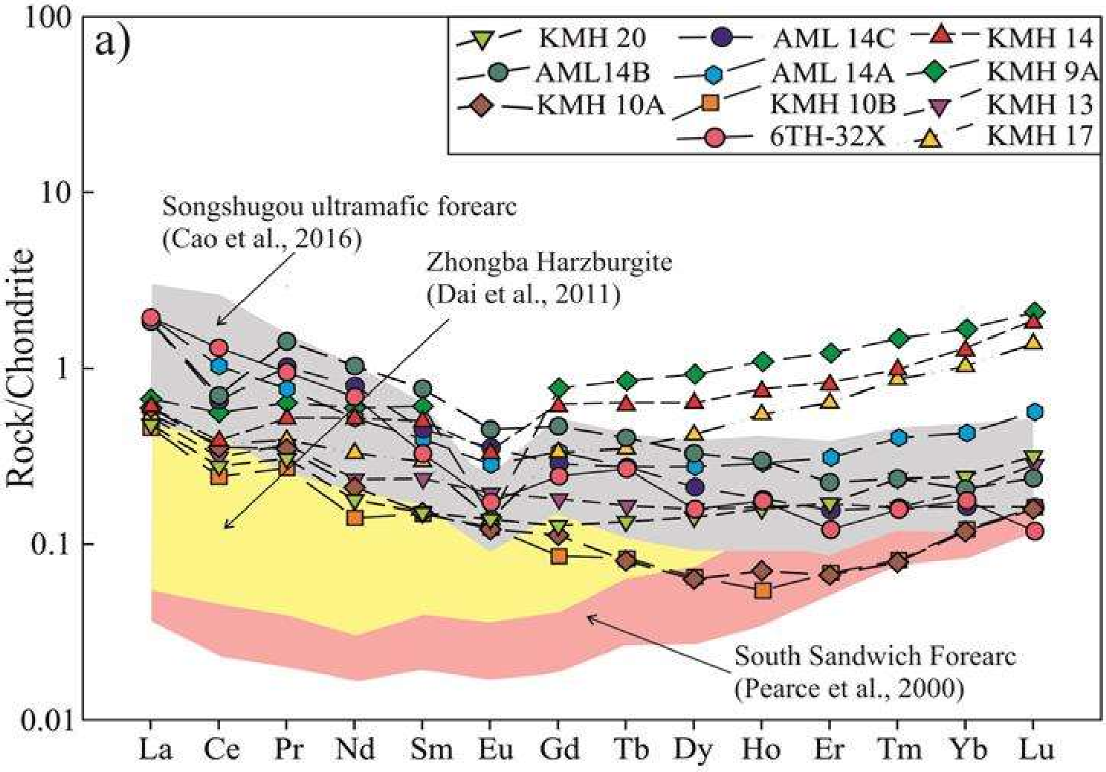


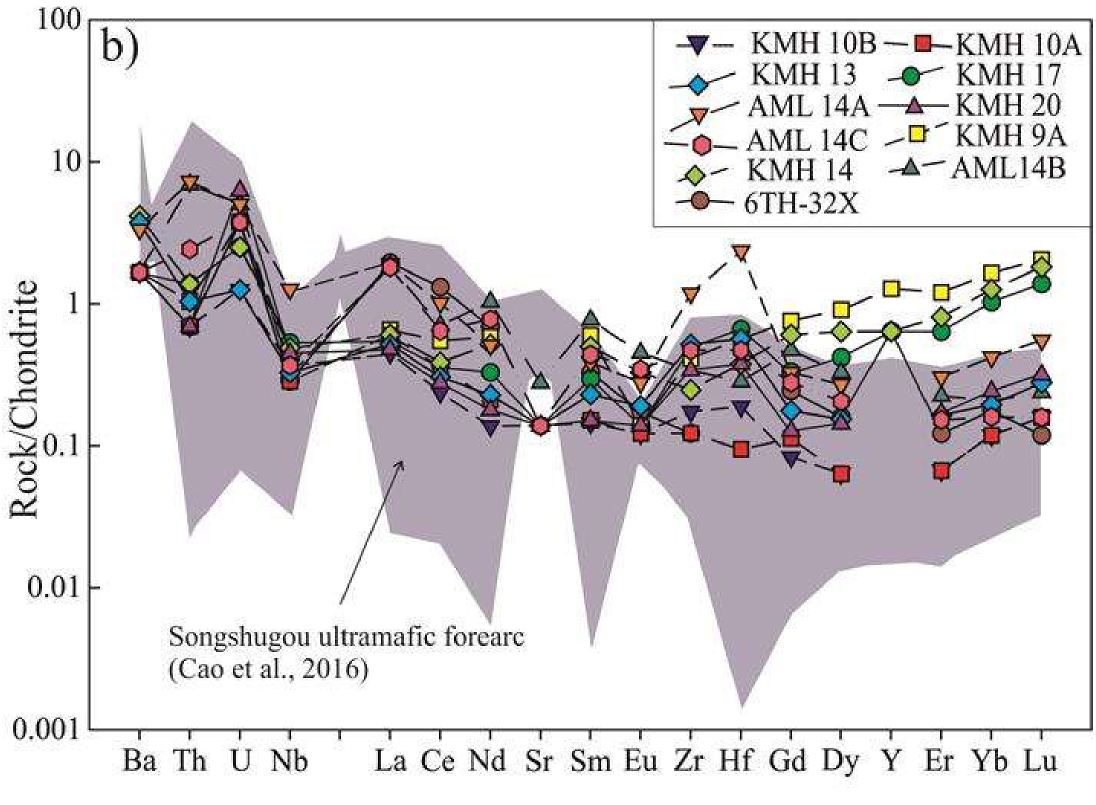
Spinel Cr# vs TiO_2 plot also gives a similar interpreation for the genesis of TTSZ peridotites.


e)
100
80
60
40
20
0
100Cr/(Cr+Al)
0.001
0.01
0.1
1
TiO2 (wt%)
Songshogou
ultramafic
forearc
(Cao et al., 2016)
Boninite
MORB
Highly Depleted
Peridotite
Depleted
Peridotite

CORRELATING ITSZ WITH TTSZ

The TTSZ peridotites show selective LREE enrichment as compared to HREE. This feautre is also indicative of an interaction with a boninitc melt. The multielement pattern also shows similarity withtht Songshugou forearc peridotites. The Songshugou peridotites and Zhongba harzburgites are both Neo-tethyan ophiolites in the central part of th ITSZ and their geochemical similarity with th the TTSZ peridotites indicate that similar pprocesses occurred along the eastern margin as well.





CONCLUSIONS

The TTSZ mantle peridotite are a result of a number of complex melt-rock as well fluid-rock intractions .

The highly refractory nature of the peridotites as observed from the Fo number of olivine and high Cr# of spinels shows that initially the peridotites were residual in nature.

In the forearc region, the last partial melting process generated high-temperature boninitic melts which interacted with the residual peridotites and caused selective enrichment of LREE as well as formation of dunites by the consumption of orthopyroxenes of the harzburgites.

Finally, low-temperature metamorphism occurred by the interactions of different kinds of fluids which caused formation of tremolite and Cr- chlorite.

REFERENCES

Dilek, Y. and Furnes, H., 2011. Ophiolite genesis and global tectonics: Geochemical and tectonic fingerprinting of ancient oceanic lithosphere. Bulletin, 123(3-4), pp.387-411.

Dijkstra, A.H., Barth, M.G., Drury, M.R., Mason, P.R. and Vissers, R.L., 2003. Diffuse porous melt flow and melt-rock reaction in the mantle lithosphere at a slow-spreading ridge: A structural petrology and LA-ICP-MS study of the Othris Peridotite Massif (Greece). Geochemistry, Geophysics, Geosystems, 4(8).

Zhou, M.F., Robinson, P.T., Malpas, J., Edwards, S.J. and Qi, L., 2005. REE and PGE geochemical constraints on the formation of dunites in the Luobusa ophiolite, Southern Tibet. Journal of petrology, 46(3), pp.615-639.

Bédard, J.H., 1989. Disequilibrium mantle melting. Earth and planetary science letters, 91(3-4), pp.359-366.

Hsü, K.J., Guitang, P. and Sengör, A.M.C., 1995. Tectonic evolution of the Tibetan Plateau: A working hypothesis based on the archipelago model of orogenesis. International Geology Review, 37(6), pp.473-508.

Aitchison, J.C., Xia, X., Baxter, A.T. and Ali, J.R., 2011. Detrital zircon U–Pb ages along the Yarlung-Tsangpo suture zone, Tibet: implications for oblique convergence and collision between India and Asia. Gondwana Research, 20(4), pp.691-709.

SINGH, S. and MALHOTRA, G., 1983. Tectonic set-up of Yang Sang Chu Valley, West Siang, Arunachal Himalaya. Himalayan shears, p.107.

Acharyya, S.K., 1987. Limits of greater Indian plate during Gondwana time.

Cao, Y., Song, S., Su, L., Jung, H. and Niu, Y., 2016. Highly refractory peridotites in Songshugou, Qinling orogen: insights into partial melting and melt/fluid–rock reactions in forearc mantle. Lithos, 252, pp.234-254.