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Podiform Chromites in Mantle Peridotites from Indus Ophiolite Belt, Ladakh Himalaya

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Abstract. Peridotites in ophiolites from Ladakh Himalaya occur as disconnected slices within an ophiolite melange exhibiting faulted, sheared and tectonic contacts. Chromite occurs as pods, schlieren banded as accessory ore within dunites. The pods are generally concordant to semi-concordant to the foliation of the host dunites. In places, however, they are discordant to the foliation. The chrome spinels (sensu lato) exhibit bimodal distribution. Those in harzburgite conform to Type I alpine type peridotites. Whereas the ones from dunite are akin to Type III peridotites as classified by Dick and Bullen (1984). The spinels from wehrlites are compositionally similar to those from ophiolite cumulates.

Keywords : Chromite, Indus Ophiolite Belt, Ladakh Himalaya.

INTRODUCTION

A study of chromites and host rock peridotites from the Indus Ophiolite Belt, Ladakh Himalaya has been undertaken. The chromites of the belt are compared with similar occurrences in other parts of Indian subcontinent and eastern Mediterranean. Various hypothesis put forth for the origin of podiform chromites have been briefly reviewed and a genetic model for the Ladakh deposits outlined.

GEOLOGICAL SETTING

The Indus Ophiolite Belt forms a part of the Trans-Himalayan tectonic province. It is delimited in the south by the Suru crystallines, sedimentaries of the Zanskar Tethyan zone, and Tso Morari crystallines, (Srikantia and Razdan, 1985). In the north it is bounded by the Ladakh Granitic Complex. The belt extends in general from WNW-ESE direction from Dras in the west to Hanley in the East over a length of 450 km. The ophiolite belt exhibits a complex tectonic structure. The rocks are thrust, folded, faulted, fractured, brecciated and mylonitised. The ophiolite is therefore, dismembered and consists of chaotically arranged stacks of thrust slices of peridotites and gabbroic rocks (late Cretaceous to early Paleocene) tectonically emplaced within the rocks of Sangeluma Group (Srikantia and Razdan, 1980). This group is equivalent to Dras Volcanic Group (Searle, 1983; Dessai *et al*, 1986) and consists of thick sequence of basalts and andesites (late Cretaceous to Paleocene) together with radiolarian cherts and limestones. Wadia (1937) referred this volcano-sedimentary sequence as "Dras Volcanics".

The ophiolitic rocks of this belt were referred as the "ophiolitic melange" (Ganser, 1974) and as "Shergol melange" (Thakur, 1981). The ophiolites occur as three separate parallel zones confined to the Khalsi, Dras

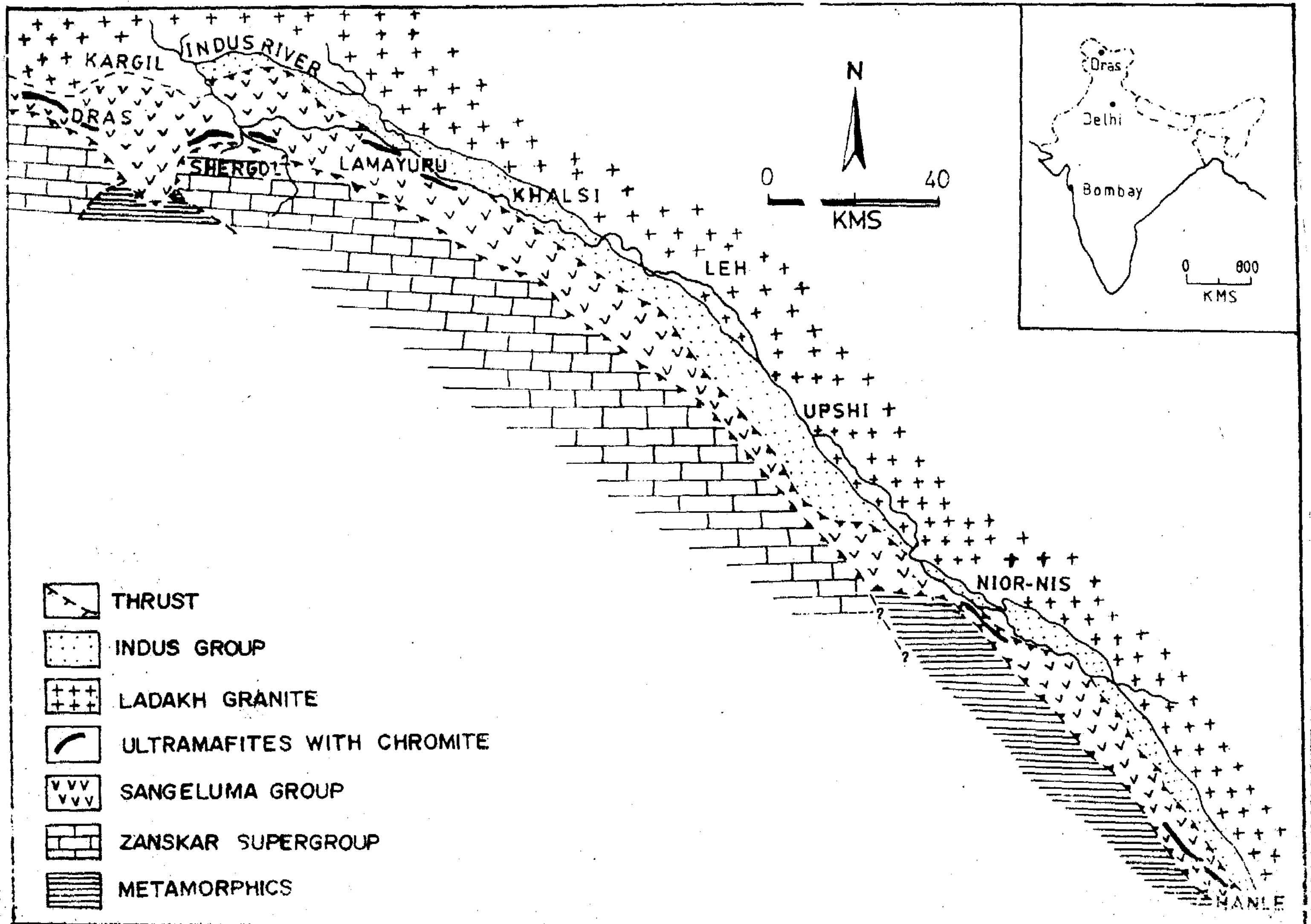

Fig. 1. Geological sketch map of northwestern part ofthe Indus Ophiolite Belt, Ladakh Himalaya (modified after Srikantia and Razdan, 1985)

Volcanic and Shergol Formations of Sangeluma Group (Srikantia and Razdan, 1985). The ophiolites have been examined in the west at Dras followed towards east at Tasgam, Kargil, Pashkhyum, Shergol, Mulbekh, Namika-La, Lamayuru, Nior-Nis and Hanley (Fig. 1). The peridotites which are the host rocks for chromite mineralisation exhibit sheared, faulted and tectonic contacts with no contact metamorphic aureole with the volcanoclastic sediments. They occur as disconnected bodies generally striking WNW-ESE and show dips of 50 to 60° towards NNE. Individual bodies extend for over 2 to 6 km. in length and are 1 to 1.5 km across. The peridotites at the base of the section are represented by harzburgites which progressively grade into dunites by disappearence of orthopyroxene. Pockets of wehrlite occur within dunite. Chromite mineralisation is mainly restricted to the dunites.

MODE OF OCCURRENCE

Chromite concentrations occur predominantly in the form of pods, lenses, pencil-ore, schlieren and streak ore within dunites (Fig. 2). The most common ore forms are the pods which vary from a maximum of 8 m to 25 cm

Fig. 2. Polished slab of dunite showing pods and schlieren of chromite

in the longer dimension and about half meter to 25 cm. across. The pods are in general concordant to the foliation (N 80 W - S 80E) of the host peridotites. They are elongated and stretched parallel to the prominant mineral lineation in the plane of foliation. However, in places, especially at Dras, the pods trend N 20 E-S 20 W with steep dips and in places are even vertical. The ores forming pods and nodules are massive and coarse-grained (2 to 4 mm) with very little interstitial silicates. Most nodules are typically ovoid and massive. In polished microsections the ore exhibits pull-apart structure with fractures transverse to the elongation of the grains (Fig. 3). The fractures are at places filled with silicates. The ores also

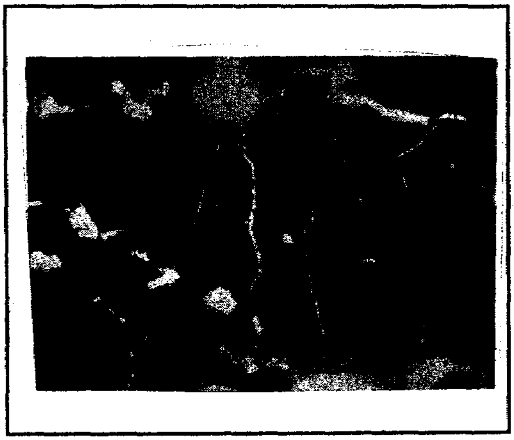

Fig. 3. Pull-apart fractures in chromite (over polariser; scale : Bar = 1mm.)

exhibit chromite net and chain texture and ocluded silicate textures. In some samples the chromites exhibit development of "ferrit-chromite".

TEXTURE OF PERIDOTITES

The peridotites are tectonites that exhibit textures characteristic of plastic deformation and recrystallisation (Dessai *et al.*, 1986). The basal harzburgites exhibit mylonitisation leading to sub-microscopic matrix which is partly serpentinised. Higher up, the texture is transitional between protogranular and porphyroclastic. The porphyloclasts of orthopyroxene (4 to 6 mm) are elongated,

Fig. 4. Kink controlled clinopyroxene in a stretched and bent porphyroclast of enstatite (BXN; scale : Bar = 2mm.)

Fig. 6. Symplectic exsolutions of spinel in enstatite. (BXN; scale : Bar = 2 mm.)

Fig. 5. Enstatite porphyroclast with diopside exsolution lamellae. (BXN; scale : Bar = 2mm.)

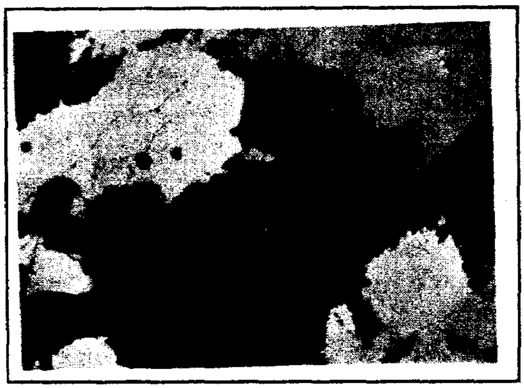

Fig. 7. Xenoblastic granular texture in dunite. (BXN; scale : Bar = 2 mm.)

stretched, bent and kinked. Along the kink, exsolution of clinopyroxene is commonly seen (Fig. 4). Diopside in harzburgite occurs as lamellae in orthopyroxene (Fig. 5) indicating its exsolution during partial melting (Dick, 1977). Orthopyroxene also exhibits spinel symplectites (Fig. 6) which coalesce to larger patches. The myrmekitic, interstitial and poikilitic nature of spinel and its association with orthopyroxene suggests incongruent melting. The textures of harzburgite suggest that deformation and partial fusion were simultaneous. The occurrence of this spinel is typically different from spinel in rocks from layered intrusions. The orthopyroxene neoblasts are strain-free, polygonal and 0.5 to 1.5 mm. in size (Karmalkar *et al.*, 1989).

The above texture grades into xenoblastic granular texture in dunites in which the olivines have interlocking and mutually interfering grain boundaries (Fig. 7). The olivines are stretched, elongated, kinked and show poor recovery. The grain size is coarse (4 to 6 mm). The spinel is chromian, euhedral to subhedral, dark brown and nearly opaque. This texture grades into equigranular texture in which two subtypes are recognised. One is a 'Dreiser Weiher' texture which shows preferred orientation of longer axis of olivine. The other texture is mosaic equigranular texture in which olivines are equant, they have straight boundaries which meet in 120° at triple points (Fig. 8). The triple points and grain boundaries are invariably occupied by euhedral chromites. The wehrlite is hypidiomorphic granular and exhibits cumulate texture. It is predominantly constituted of olivine and clinopyroxene with accessory chromite.

TABLE I

Microprobe analyses of chromites from ophiolite peridotites, Ladakh Himalaya

Analysis No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Constituents	C	M	C	M	C	M	C	M	C	M	C	M	C	M	C	M	C	M
TiO_2	0.23	0.28	0.23	0.20	0.11	0.11	0.26	0.25	0.29	0.25	0.33	0.28	0.60	0.60	—	0.03	0.06	0.06
Al_2O_3	13.12	12.76	14.41	11.83	10.89	11.44	13.11	13.09	12.12	11.95	19.97	20.22	53.58	53.54	44.17	41.71	32.14	34.53
Cr_2O_3	57.37	56.73	57.67	59.42	62.02	62.57	56.39	58.41	55.45	55.36	42.34	42.50	—	16.21	24.35	28.15	37.66	35.06
Fe_2O_3	3.37	4.10	1.99	3.49	2.57	1.72	4.64	2.64	4.80	4.30	7.87	6.76	—	—	1.34	0.46	0.80	01.59
FeO	11.59	12.61	11.21	10.19	8.87	9.02	10.75	11.18	16.95	16.49	20.01	20:42	10.23	10.62	13.36	12.54	13.44	13.75
MgO	14.70	14.09	15.17	15.55	16.30	16.45	15.25	15.03	11.20	11.22	9.87	9.44	20.05	19.68	16.56	16.87	15.19	15.56
ZnO	0.06	—	—	0.10	—	—	—	—	0.20	0.14	—	—	—	—	0.23	0.23	0.19	0.07
Total	100.44	100.40	100.82	100.72	100.84	101.34	100.27	100.66	100.82	99.56	99.98	99.34	101.27	100.75	100.19	100.12	99.71	100.77
Cations recalculated to stoichiometry with 24 cations per 32 oxygens																		
Ti	0.0438	0.0531	0.0433	0.0377	0.0210	0.0209	0.0497	0.0466	0.0577	0.0485	0.0622	0.0535	0.0936	0.0942	—	0.0054	0.0113	0.0110
Al	3.8875	3.8070	4.2223	3.4950	3.2119	3.3508	3.8733	3.8640	3.6781	3.6688	5.9476	6.0684	11.1252	13.1933	11.5177	10.9562	8.8703	9.3443
Cr	11.3997	11.3321	11.3317	11.7774	12.2701	12.2923	11.1711	11.5620	11.2849	11.4007	8.4554	8.5521	2.7519	2.6779	4.2583	4.9587	6.9685	6.3619
Fe^{+3}	0.6373	0.7804	0.3737	0.6598	0.4842	0.3225	0.8765	0.4996	0.9311	0.8421	1.4968	1.2938	—	—	0.2223	0.0776	0.1407	0.2759
Fe^{+2}	2.4361	2.6645	2.3476	2.1361	1.8571	1.8755	2.2529	2.3417	3.6487	3.5921	4.2277	4.3464	1.7780	1.8564	2.4721	2.3374	2.6318	2.6402
Mg	5.5065	5.3062	5.6181	5.8104	6.0794	6.0924	5.6955	5.6094	4.2968	4.3559	3.7161	3.5802	6.2092	6.1307	5.4585	5.6013	5.2988	5.3232
Mn	—	—	—	—	—	—	—	—	—	—	—	—	0.0100	0.0176	0.0322	0.0241	0.0450	0.0290
Zn	0.0106	—	—	0.0181	—	—	—	—	0.0387	0.0266	—	—	—	—	0.0372	0.0375	0.0324	0.0124

1—2 : Chromite from massive chromite pod in dunite, Dras
3—6 : Chromite from massive chromite pod in dunite, Hanley
7—8 : Chromite from schlieren chromite in dunite, Dras
9—10 : Disseminated chromite in dunite, Dras
11—12 : Disseminated chromite in wehrlite, Dras
13—14 : Accessory chrome spinel in harzburgite, Dras
15—16 : Accessory chrome spinel in harzburgite, Lamayuru

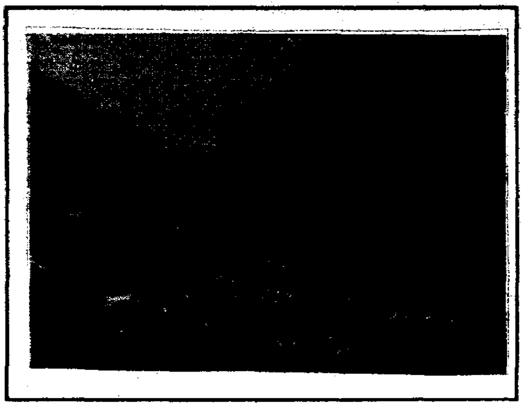

Fig. 8. Mosaic equigranular texture in dunite. (BXN; scale : Bar = 400 u.)

CHEMISTRY

The massive and schlieren chromites as a group display large variation in Cr_2O_3 wt. percentage (50-62%) and (Cr + Al) between samples (Table I) a feature typical of ophiolite chromites (Thayer, 1964). The former is sympathetic with modal chromite percentage. TiO_2 in these chromites is less than 0.3% and it does not show correlation with any of the major elements. The chromites are more magnesian ($MgO>Al_2O_3$) than stratiform chromites and contain less than 16 wt% total iron (as FeO) when Cr_2O_3 is 45%. Fe^{+2}/Mg ratio (0.3 to 0.5) has a very small range (in comparison with stratiform chromites) whereas Cr/Al ratio (2.5 to 3.8) has a larger range. These features are typical of podiform chromites which are residual after partial fusion. The $Mg/(Mg + Fe^{+2})$ ratio has higher value and broader range (0.5 to 0.76). The Cr/(Cr + Al) ratio is more than 0.6 (between 0.72 and 0.79) which is similar to spinels in Type III peridotites of Dick and Bullen (1984). Cr/(Cr + Al) exhibits reciprocal behaviour with Al/(Cr + Al) implying that Cr is preferentially incorporated in Al-spinel lattice.

In comparison with the chromites described above, the accessory chromites in wehrlites contain less than 43% Cr_2O_3 and total iron (as

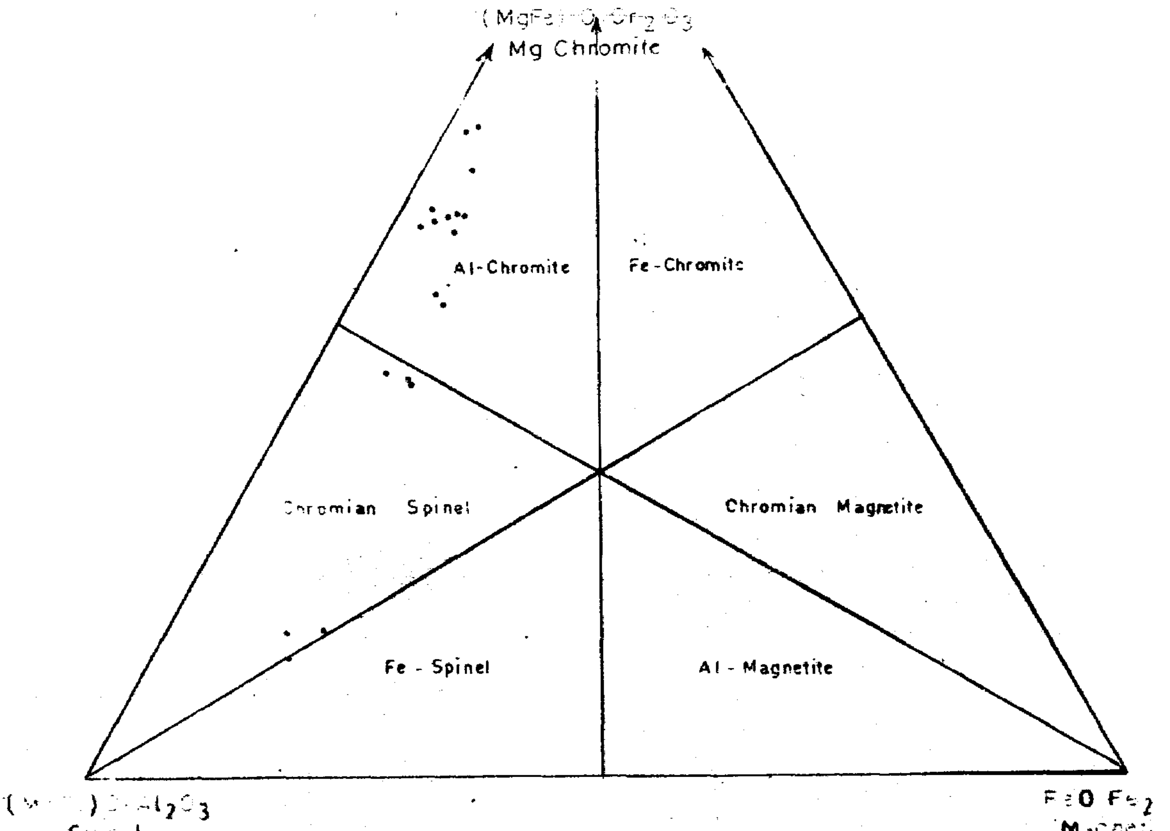

Fig. 9. Plots of Ladakh chromites in the spinel compositional prism (Stevens, 1944).

FeO) in them exceeds 24%. They have low Cr/Al (1.3 to 2.5) and Mg/(Mg + Fe^{+2}) ratios (0.45 to 0.47) characteristic of cumulus chromites from ophiolites.

The accessory chrome spinels in harzburgite contain 16 to 37% Cr_2O_3, between 32 and 53% Al_2O_3, negligible TiO_2, (except one sample from Dras, analysis 13 & 14 Table I) comparatively restricted range of Mg/(Mg + Fe^{+2}) ratio (0.66 to 0.76) which shows negative correlation with Cr/(Cr + Al). In these respects these chrome spinels are similar to those in abyssal spinel peridotites of Dick and Bullen (1984).

In the spinel compositional prism (Stevens, 1944) majority of chromites lie in the Al-chromite field (Fig. 9) except 6 analyses which occupy the chromian spinel field. In the 100 Mg/(Mg + Fe^{+2}) versus 100 Cr/(Cr + Al) face of the spinel prism (Irvine, 1967) a linear trend is observed in the plots of accessory chrome spinels in harzburgite and those of massive and schlieren ore in dunite (Fig. 10). This evolutionary trend indicates progressive increase in Cr/(Cr + Al) and a consequent decrease in Mg/(Mg + Fe^{+2}) from harzburgite spinels to chromite ore. It is characteristic of alpine type peridotites and is observed in different complexes such as those of Antalya,

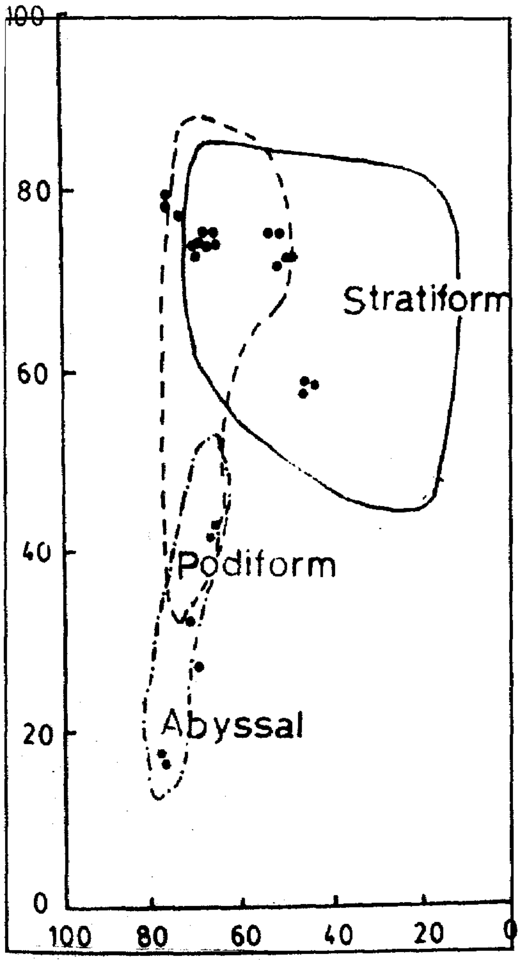

Fig. 10. Plots of Ladakh chromites in the 100 Mg/(Mg + Fe^{+2}) versus 100 Cr/(Cr + Al) diagram (after Irvine, 1967; Leblanc *et al*, 1980; Dick and Bullen, 1984).

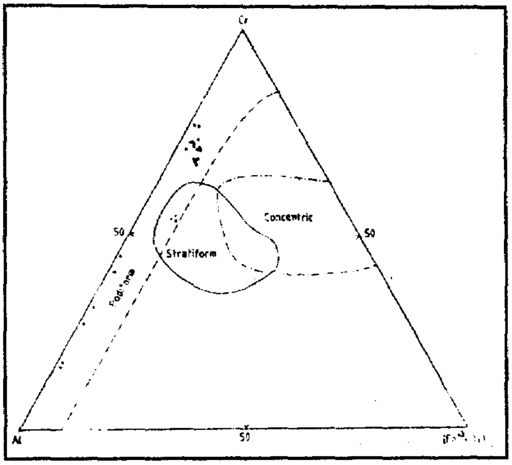

Fig. 11. Plots of Ladakh chromites in the Cr-Al-(Fe + Ti) ternary diagram (after Dickey, 1975; Bird and Clark, 1976).

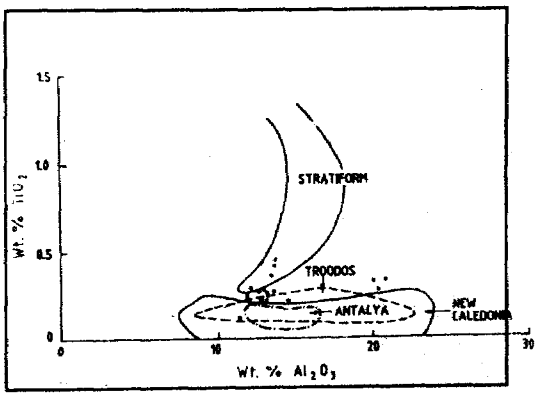

Fig. 12. Plots of Ladakh chromites in the TiO_2 versus Al_2O_3 diagram showing fields of ophiolite and stratiform chromite

Troodos, New Caledonia. The chromites from wehrlite plot in the field of stratiform chromites separated from others. In the Cr-Al-(Fe^{+3} + Ti) ternary diagram (Fig. 11) all analyses except those from wehrlite, lie in the field of podiform chromites and display progressive enrichment in chromium. The chrome spinels in this diagram too plot within the field of chrome spinel peridotites (Dick and Bullen, 1984). In the TiO_2 versus Al_2O_3 diagram (Dickey, 1975) (fig. 12) all the analyses except three, plot in the field of chromites from Antalya, Troodos and New Caledonia, again indicating their podiform nature.

GENESIS

Prasad and Singh (1981) and Varadarajan (1985) have concluded that chromite mineralisation in Ladakh is the consequence of fractional crystallisation by gravity differentiation. Varadarajan has described two types: a zoned ultrabasic complex and discrete dunite bodies. According to him chromites in the latter were emplaced as crystal mush while those in the former crystallised *in situ* under disturbed magmatic conditions. Our observations, however, are not in conformity with the above observations. Different sections along the ophiolite belt at Dras, Tasgam, Shergol, Lamayuru, Nior-Nis and Hanley have been studied. The peridotites are represented dominantly by harzburgites and dunites which as at Dras and Tasgam contain pockets of wehrlite. The harzburgites and dunites are texturally and mineralogically gradational. This is best seen at Dras and Lamayuru. The gradational textures from photogranular/porphyroclastic to equigranular indicate high temperature deformation and recrystallisation. They are characteristic of transition zone of ophiolite (Mercier and Nicolas, 1975; Nicolas *et al.*, 1980). The morphology of spinel as symplectites or as automorphic grains, its chromian composition and its intimate association with aluminous orthopyroxene (Karmalkar *et al.*, 1989) has been shown to be the result of incongruent melting of orthopyroxene (Leblanc *et al.*, 1980; Nicolas and Prinzhofer, 1983) in the transition zone which represents the site of extensive partial melting (Nicolas *et al.*, 1980). This is also supported by (i) restricted compositional variation of associated silicates, olivines and orthopyroxene and (ii) scarcity and at places complete absence of diopside which may have been removed during partial melting (Dick, 1977).

The podiform chromites occurring within the alpine-type mantle peridotites have been suggested to have originated by various mechanisms, the important among them being (i) settling and rolling of crystals in a magma due to liquid immiscibility (ii) snowballing of chromites in a turbulant magma (iii) boudinage by deformation and remobilisation (iv) winnowing as magma percolates through a system (v) hydrothermal process of formation. The first and last of these hypothesis are discarded (Pavlov *et al.* 1977; Johan and Le Bel, 1978) as they lack experimental support. The other possibility that chromite pods originate in a magma chamber and were subsequently inserted in the tectonite peridotite (Greenbaum, 1977; Dickey, 1975) has been disproved by Prinzhofer *et al.*, (1980) and Cassard *et al.*, (1981). The model proposed by Lago *et al.*, (1982) seem more workable, in that chromites originate in the fractures traversing the mantle peridotites during upward migration of magma, produced by partial fusion. During this process the orthopyroxene from the peridotites melts incongruently with exsolution of chrome spinel. The spinel reacts with the percolating magma and become more chromian as seen from decrease in Al/Cr ratio from core to margin. Sinking and segregation brings about densification and accompanying growth (Golding, 1975) by annealing of grains (Spry, 1969).

CONCLUSIONS

The podiform chromites from Indus ophiolite are confined to residual mantle peridotites. The peridotites in general could e categorised as Type II peridotites of Dick nd Bullen (1984). The harzburgites, howver, belong to Type I alpine type peridotites, vhereas the dunites with chromite nineralisation are akin to Type III peridotites of Dick and Bullen, (1984). The wehrlites epresent impregnated dunites, showing texural and mineralogical similarity to peridottes from ophiolite cumulates.

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References

BIRD, M.L. and CLARK, A.L., (1976) Microprobe study of olivines chromites of the Goodnews Bay Ultramafic complex, Alaska and the occurrence of platinum, U.S. Geol. Surv. Jour. Research, 4, pp. 717-25.

CASSARD, D., NICOLAS, A., RABINOWITCH, M., MOUTTE, J., LEBLANC, M., and PRINZHOFER, A., (1981), Structural classification of chromite pods in southern New Caledonis, Econ. Geol., v. 76; pp. 805-831.

DESSAI, A.G. PARDESHI, R.G., KARMALKAR, N.R. and POWAR, K.B., (1986) Petrology of the mafic and ultramafic rocks of the Indus Ophiolite Belt, Ladakh Himalayan in Ghose, N.C. and Varadarajan, S. (Eds) Ophiolites and Indian Plate Margin, Sumna Pub. Patna, pp. 63-73.

DICK, H.J.B., (1977), Partial melting in the Josephine peridotite I: The effect of mineral composition and its consequence for geobarometry and geothermometry, Amer. Jour. Sci., v. 277, pp. 801-832.

— and BULLEN, T., (1984), Chromian spinel as a petrogenetic indicator in abyssal and alpine-type peridotites and spatially associated lavas, Contr. Miner. Petrol v. 86, pp. 54-76.

DICKEY, J.S. Jr., (1975), A hypothesis of origin for podiform chromite deposits, Geochim. Cosmochim. Acta, v. 39, pp. 1061-1074.

GANSSER, A., (1974), The ophiolitic mélange, a wold wide problem on Tethyan examples, Ecol. Geol. (Helv)., v. 67, pp. 479-507.

GOLDING, H.G., (1975), Relict textures of chromites from New South Wales, Geol. Soc. Austr. Jour., v. 22, pp. 397-412.

GREENBAUM, D., (1977), The chromiferous rocks of the Troodos ophiolite complex, Cyprus, Econ. Geol., v. 22, pp. 1175-1194.

IRVINE, T.N., (1967), Chromian spinel as a petrogenetic indicator, Part II; Petrologic applications, Can. J. Earth Sci. v. 4, pp. 71-103.

JOHAN, Z., and LE-BEL, L., (1978). Sur la genese de couche et podes de chromit dans les complexes ophiolitiques, Resume des principaux resultants, Sci. et Tech. Serv. Geol. Nat. B.R.G.M., v. 96, pp. 1-9.

KARMALKAR, N.R., DESSAI, A.G., and LEBLANC, M., (1989) SEM morphology and geochemistry of podiform chromite from ultramafites of Indus Ophiolite Belt, Ladakh Himalaya in Ghose, N.C. (Ed.) Phanerozoic Ophiolites of India, Sumna Pub. Patna, pp. 119-132.

LAGO, B.L., RABINOWITCH, M., and NICOLAS, A., (1982), Podiform chromite ore bodies; a genetic model, Jour. Petrology v. 23, pp. 103-125.

LEBLANC, M., DUPEY, C., CASSARD, D., MOUTTE, J., NICOLAS, A., PRINZHOFER, A., RABINOWITCH, M., and ROUTHIER, P., 1980, Essai sur la guissement de corps podiformes de chromitites dans les peridotites ophiolitiques, Etude de chromites de Nouvelle-Caledonie et comparaison avec celles de Mediterrane orientale, in, Ophiolites Proc. Intern. Ophiolite Symp. Cyprus. Geol. Surv. Dept., pp. 691-701.

MERCIER, J.C.C., and NICOLAS, A., (1975), Textures and fabrics of upper mantle peridotites as illustrated by xenoliths from basalts, Jour. Petrology, v. 16, pp. 454-487.

NICOLAS, A., BOUDIER, F., and BOUCHEZ, J.L., (1980). Interpretation of peridotite structures from ophiolitic and oceanic environments, Amer. Jour. Sci. 230A, pp. 192-210.

— and PRINZHOFER, A., (1983), Cumulative or residual origin for the transition zone in ophiolites: Structural evidence, Jour. Petrology, v. 24, pp. 188-206.

PAVLOV, N.V. GRIGORYEVA, I.T., and TSEPIN, A.L., (1977), Chromite nodules as an indicator of liquidation of a magmatic melt, Intern. Geol. Rev. v. 19, pp. 43-56.

PRASAD, U., and SINGH, B., (1981) Geochemical studies of dunite with reference to chromite mineralisation in Indus Ophiolite Belt, Ladakh, J and K state, Rec. Geo. Surv. Ind., v. 112, pp. 118-125.

PRINZHOFER, A., NICOLAS, A., CASSARD, D., MOUTTE, J., LEBLANC, M., PARIS, J.P., and RABINOWITCH, H., (1980), Structures in the New Caledonian peridotite-gabbro: implications for oceanic mantle and crust, Tectonophysics, v. 69, pp. 85-112.

SEARLE, M.P., (1983), Stratigraphy, structure and evolution of the Tibetan Tethys Zone in the Zanskar and the Indus Suture Zone in the Ladakh Himalaya, Trans. R. Soc. Edin. Earth Sci., 73, 205-219.

SPRY, A., (1969), Metamorphic textures, Pergamon Press, New York, 350.

SRIKANTIA, S.V., and RAZDAN, M.L., (1980) Geology of part of Central Ladakh Himalaya with particular reference to Indus Tectonic Zone, Jour. Geol. Soc. Ind., v. 21, pp. 523-545.

— and — (1985) Indus Tectonic Belt of the Ladakh Himalaya: Its geology tectonics and ophiolite occurence. Rec. Geol. Surv. Ind. v. 115, pp. 61-92.

STEVENS, R.E., (1944) Compositions of some chromites of the western hemisphere. Amer. Mineral, v. 29, pp. 1-34.

THAKUR, V.C., (1981) Regional frame-work and geodynamic evolution of the Indus Suture Zone, Trans. R. Sec. Edin. Earth Sci., v. 72, pp. 89-97.

THAYER, T.P., (1964) Principal features and origin of podiform chromites and some observations on the Guleman-Soridag district, Turkey, Econ. Geol., v. 59, pp. 1497-1524.

VARADARAJAN, S., (1985) Chromite mineralisation of Ladakh Himalaya in Gallagher, M.J., Tyer, R.A., Neary, C.R., and Prichard, H.M. (Eds) Metallogeny of Basic and Ultrabasic rocks, pp. 249-261.

WADIA, D.N., (1937). The Cretaceous volcanic series of Astor-Deosai, Kashmir and its intrusions, Rec. Geol. Surv. Ind., v. 72, pp. 151-61.

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