Nickel-Chromite Mineralization of Mwetaung Area, Tiddim Township, Chin State

Thidar Win[1*] & Thi Thi Kyaw[2]

Abstract

The study area is bounded by the latitude 23° 22' to 23° 30' N and the longitude 94° 00' to 94° 05' E, in one inch topographic map 84-I/3. It is located about 17 miles (27 km) NW of Kalemyo. Mwetaung hill of the study area lies prominently on the eastern flank of the northern Chin Hills. Nickel-Chromite deposits are widespread in Myanmar, being related to the N-S trending ophiolite belts and are composed of ultramafic igneous rocks associated with serpentenite. At Mwetaung, nickel mineralizations are found as apple green colour garnierite (Nisilicate).The nickel ore occurs in altered serpentinized peridotite, mostly in highly weathered serpentinies derived from peridotites. As a network of criss-crossed veinlets, ribbons, stringers and also as subparallel aggregates were found at Mwetaung. Chromite occurs as small pockets, lenses and pods and is similar to those of Alpine type peridotites. The abundance of volatile-and alkali-rich mineral and fluid inclusions in chromite grains of the Mwetaung indicates relatively high water contents in the parential magmas which, in turn, suggest formation in a supra-subduction zone environment. Ophiolites formed in such environments would be characterized by depleted mantle peridotites produced by high degrees of partial melting.

Key words : Mwetaung hill, ophiolite belt, Alpine type peridotites, supra-subduction zone

Introduction

Location and size

The study area is bounded by the latitude 23° 22' to 23° 30' N and the longitude 94° 00' to 94° 05' E, in one inch topographic map 84-I/3. It is located about 17 miles (27 km) NW of Kalemyo. It is accessible by car from Kalemyo throughout the year. The location map of the area is shown in (Fig1).

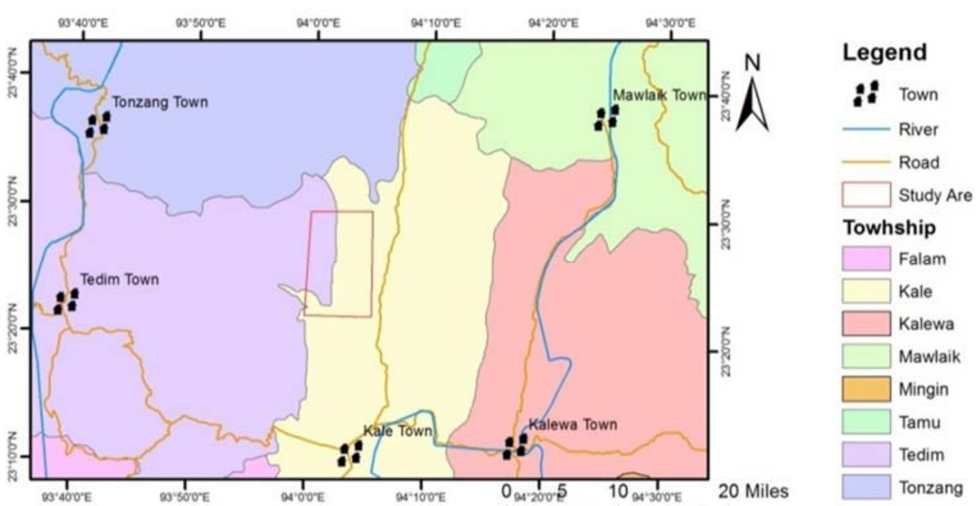

Figure (1). Location map of the study area.

[1,2]Department of Geology, Kalay University

Regional Geologic Setting

The Myanmar can be subdivided into six N-S trending major tectonic domains. From west to east are: (1) Rakhine Coastal Strip as an ensimaticforedeep, (2) Indoburman Ranges as an outer arc or forearc, (3) Western Innerburman Tertiary Basin as an interarc basin, (4) Central Volcanic Belt (Central Volcanic Line) as an inner magmatic volcanic arc, (5) Eastern Innerburman Tertiary Basin as backarc basin and (6) ShanTaninthayi massif as ensialic Sinoburman Ranges (Bender, 1983, Khin Zaw, 1990). The Indoburman Ranges (Western Ranges) of Myanmar, consisting of the Naga Hills, Chin Hills and Rakhine Yoma, are underlain by thick, mildly deformed, slightly folded, and weakly metamorphosed (Fig 2). Mesozoic and early Tertiary flysch type deposits, locally associated with ophiolites and metamorphic tectonites believed to have been deposited in a trench (Win Swe, 1981). The study area occupies the boundary between western margin of the Innerburman Tertiary Basin and at the foot of eastern Indoburman Ranges. Mwetaung hill 3379 ft (1030 m) is located in the northeastern corner of map sheet 84-I-3 of the Chin Hills. Mwetaung hill of the study area lies prominently on the eastern flank of the northern Chin Hills. It is almost entirely made up of ultramafic igneous rocks with nickel-chromite mineralization.

Purpose of Study

This research is to focus to describe the stratigraphy and related mineralization, the distribution of minerals deposits of the area and establishing the petrogenesis of the nickel-chromite in the area.

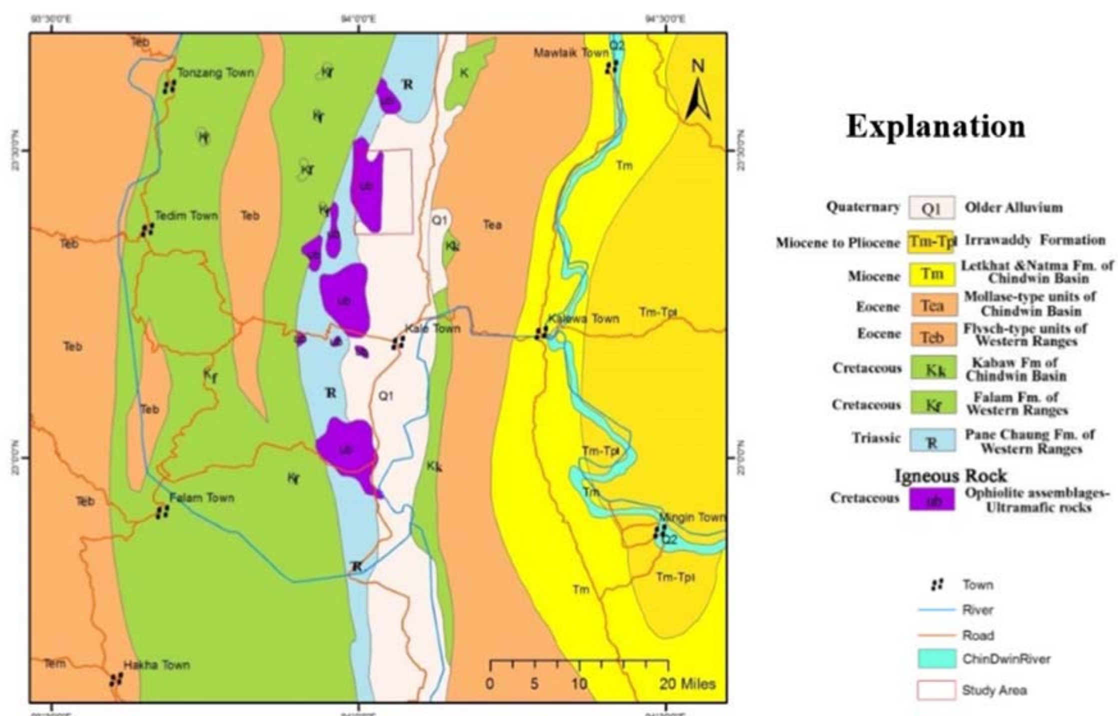

Figure (2). Regional Geological Map showing the study area (After Myanmar Geosciences Society: 2014).

Stratigraphy

The study area is underlain by the Pane Chaung Group and Ultramafic rocks. Nickel-chromite mineralization mainly occurs in ultramafic rocks of the study area. Stratigraphic sequence of the study area is shown in Table (1). Geological map of the area is also presented in (Fig. 3).

Table (1). Stratigraphic sequence of the study area

Rock Unit	**Age**
Alluvium	Holocene
Terrace Laterite	Pleistocene
Ophiolites (ultramafics, mafics, dykes volcanics)	Cretaceous-Eocene
Pane Chaung Group	Pre-Cretaceous Triassic

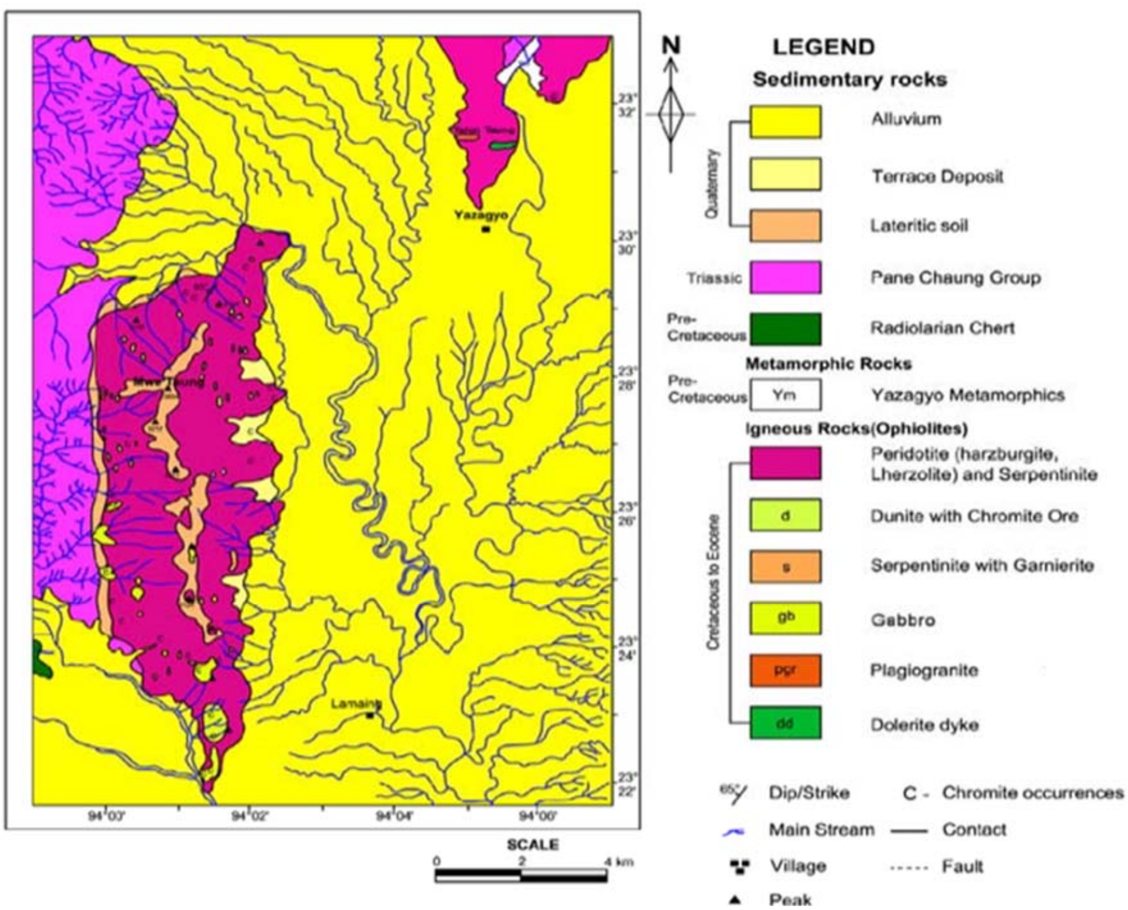

Figure (3). Geological map of the Mwetaung area (Thidar Win 2014).

Nickel-chromite Mineralization

General Statement

The present area lies within the Rakhine-Naga Region (Brown, 1924) or the chromite, nickel and platinum province or the Rakhine -Chin nickel- chromium- platinum-copper-iron province. The geology of Mwetaung complex has long been recognized as favourable for nickelchromite mineralization. Field work has revealed the relationships of these mineral deposits to the country rocks or to the adjacent igneous rocks. Nickel mineralization can be found in ophiolite suites of the area. The nickel ore occurs in altered serpentinized peridotites, mostly on the highly weathered serpentines derived from peridotites. The main ore mineralization of the area is chromite deposits. In tropical climates, where leaching is especially effective only the most insoluble oxides remain at the surface. Therefore the chromite deposits of Mwetaung are primary magmatic segregations. Chromite floats have been found only in the soil covering the ultramafic bodies and representing residual chromites. Generally nickel-chromite mineralizations are connected with ophiolite ultramafic rocks.

Occurrence of Nickel Silicate Ore

The nickel silicate deposits are found to be concentrated in the highly decomposed serpentinized zones of the ultramafic rocks. Deposits of nickel silicate are associated with chromite as cement in brecciated serpentine. The nickel ore occurs in altered serpentinized peridotite, mostly in highly weathered serpentinies derived from peridotites. As a network of criss-crossed veinlets, ribbons, stringers and also as sub-parallel aggregates were found at Mwetaung. They are mainly found in all primary mafic rocks but the major concentrations are confined to the weathered and altered peridotites, mainly serpentines derived from the latter. Chalcedony-garnierite veins with box-work structures are filling the fractures and joints in altered peridotites and also in weathered and unweathered other ultramafic rocks (Fig 4).

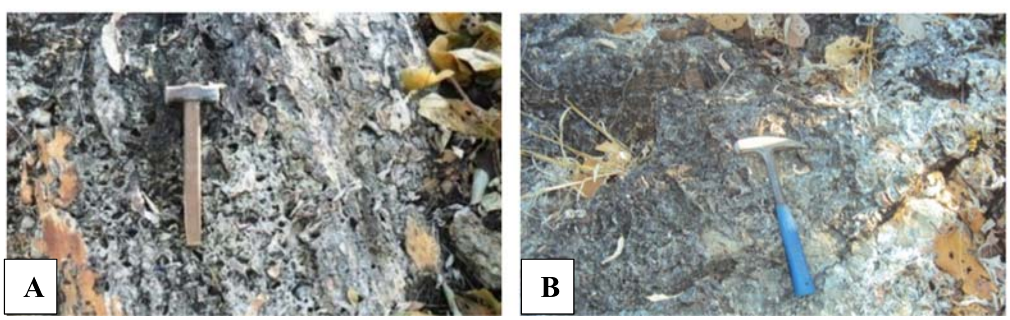

Figure (4). (A)The boxwork structure along the outcrop vein of chrysoprase, (B) the boxwork structureon the surface of serpentinized peridotite in the southern part of Mwetaung (23° 22′14″N, 94° 1′ 37″E).

Formation of Nickel Ore

Nickel occurrences at Mwetaung are mostly as supergene enrichment under tropical weathering. Generally a gradual transition was observed from the uppermost products of weathering to the primary ultramafic rocks of serpentinite, peridotite and dunite. The nickel ore of the study area is found in the form of nickel silicate, a secondary or a residual mineral. The nickel silicates in solution penetrate into the rocks of serpentinized mafic rocks which are highly fractured and brecciated. The mobile seepage water, the tropical climate and morphological conditions are responsible for the formation of the deposit.

Origin of Nickel Silicate Ore

As mentioned earlier, the nickel ores were formed from the weathering of nickel bearing peridotite that was originally composed of olivine and enstatite. Mwetaung peridotite is the source of nickel to form of nickel silicate. The nickel silicate that forms veins on joint in the peridotites is elearly supergene mineral. Nickel deposits at Mwetaung Hill which contain antigorite, talc etc are supergene in origin. It is generally believed that the peridotite is the original source of nickel and the metal has been concentrated during the course of weathering. This shows that hydrothermal influence is also partly responsible for the formation of nickel silicates. In the process of weathering, serpentine is broken down into its constituents. The first element to be leached out is magnesium, followed by more magnesium with iron and nickel. The last element to be decomposed is the silica matrix. All these are dissolved by water which seeps into the underlying rocks through cracks, fissures and pores. Nickel is carried in solution more deeply than the bulk of iron and starts to precipitate as nickel silicate in the pores, fissures and cracks of serpentine.

Surface Indication of Nickel Silicate

Deposits of garnierite occur mostly in mafic and ultramafic rocks and the following characteristic features are used in prospecting for them.

1. Presence of dark brown ochres, green clays and leached serpentines on the surface of mafic rocks.

2. Fragments of deep green veins of opal and chalcedony, and exposures of a dense white magnesite, which form the root of weathering.

3. Presence of a net-work of apple green garnierite veinlets in the heavily fractured serpentines and other altered peridotites.

4. Presence of serpentine chalcedony-opal breccias cemented with apple green to whitish garnierite stringers. Boxwork structures are common.

Garnierite

Nickel silicate as garnierite is found in the ultramafic rocks of the study area. Garnierite is a green nickel ore that develops in veins within serpentinized ultramafic rocks (Fig.5). Nickel silicate (garnierite) derived from the supergene enrichment of olivine and pyroxene, occurs as greenish yellow fracture-filling veinlets, stringers, encrustations and impregnations in a highly serpentinized harzburgite. Garnierite occurs as sub-parallel aggregate, stringers, ribbons or veinlets, almost in all primary mafic rocks but the major concentrations are found in the altered mafic rock of Mwetaung which, in turn, suggest formation in a supra-subduction zone environment. It is similar to those of Alpine type in their mode of occurrence, physical and chemical characters. Nickel grain of the Mwetaung indicates relatively high water contents in the parential magmas.

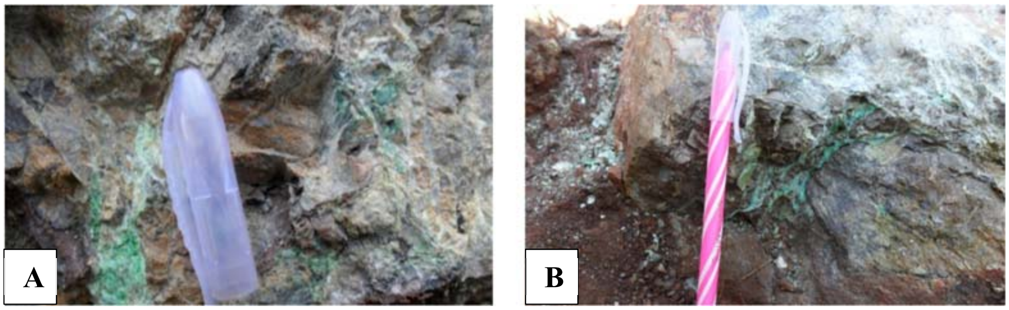

Figure (5). (A) Garnierite with the boxwork structure on the surface (B) garnierite veins on the surface of the serpentinized dunite (23° 23′39″N, 94° 1′ 61″E).

Faulting enabled the seepage waters to move downward, thus aiding in intense weathering. In this way, garnierite occurs as cement in serpentine breccias along fracture zones. The chief characteristic feature of garnierite from Mwetaung hill is that it gives an olivine green colour when fresh but on exposure, it is easily leached and the olive green colour is faded away into white.

Garnierite Deposit in Mwetaung Hill

Nickel occurs as garnierite in the weathering zone of the peridotite/dunite and is contained in the lateritic soil of the summit area. Garnierite is always found accompanying the chromite deposit in this area. They are seen as highly weathered and disseminated residual patches. The thickness of garnierite deposits depends on many factors, including lithology, depth of watertable, annual rainfall and temperature, tectonics and morphological conditions. Geomorphological features are the main control of nickel mineralization, while the structure and rock alteration (serpentinization) remain subsidiary. The garnierite derived from the supergene enrichment of olivine and pyroxene occurs as greenish-yellow veinlets or stringers. They are mostly found in the depressed saddles formed as a result of tectonic disturbance like faulting. The garnierite ore is mainly exposed on the surface but in some areas the ore body is covered with dark brown soil.

Chromite Mineralization

Chromite Occurrences

Chromite occurs at Mwetaung as small pockets, lenses and pods and it is similar to those of Alpine type in their mode of occurrence, physical and chemical characters. They are associated with the ultramafic units of the ophiolite suite. The host rocks are harzburgite, dunite, and serpentinite or combination of these. Physically the chromite is of massive, granular, nodular and podiform types. Besides, chromite is disseminated in dunite and peridotite in which it occurs as highly fractured within serpentine. Chromite pebbles up to 12 inches (30 cm) in diameter are exposed on gentle slopes of the south and southeast of Mwetaung (Fig.4)

Figure (4a). Outcrop showing the disseminated chromite ores concentrated in lateritic soil on the southern of the Mwetaung (23° 22′08″N, 94° 1′ 37″E), (4b) Massive chromite ores above the lateritic soil found at the southern part of Mwetaung.

Due to soil-covered nature of the area, it is difficult to ascertain the continuity of the lenses. Most of the occurrences are composed of massive chromite, although disseminated and nodular types are also present. Massive chromite contains a small amount of weathered serpentine. The chromite ore is also concentrated in the lateritic soil cover. Some ore deposits are mainly of the residual type. South Mwetaung, chromite mineralizations are obviously connected with a layer of harzburgite with abundant smaller dunite lenses. Well-rounded pebbles of massive type chromite up to 4 inches (10 cm) diameter with yellowish to reddish weathered silicates occur along the cart track and on the slope. Small amounts of chromite pebbles occur in slope debris along the footpath.

Types of Chromite Deposits

On the basis of deposit geometry, as well as the petrologic character and tectonic setting of their host rocks, chromite ore bodies occur in two distinct forms: stratiform and podiform (Irvine, 1977). In the study area, podiform chromite only is found.

Podiform Chromite Deposits

Podiform deposits are irregular in shape, but fundamentally lenticular chromite-rich bodies within Alpine peridotite or ophiolite complexes (Thayer, 1964). The morphology of podiform chromite deposits is irregular and lenticular. The podiform chromite ores are texturally diverse. Many podiform bodies are concordant or subconcordant to the foliation in the surrounding peridotites and exhibit fabrics interpreted to be the result of solid-state flow and recrystallization at relatively high temperatures (Fig.5).

Podiform chromite forms by melt-rock reaction as mafic magmas pass through, or are ponded in segments of the upper mantle. Their compositions reflect varying degree of partial melting of the parental peridotites. Economic deposits of chromite, which occur as podiform bodies and tabular masses are formed by partial melting of primitive mantle material (Kearey & Vine, 1996 in Thidar Win, 2014).

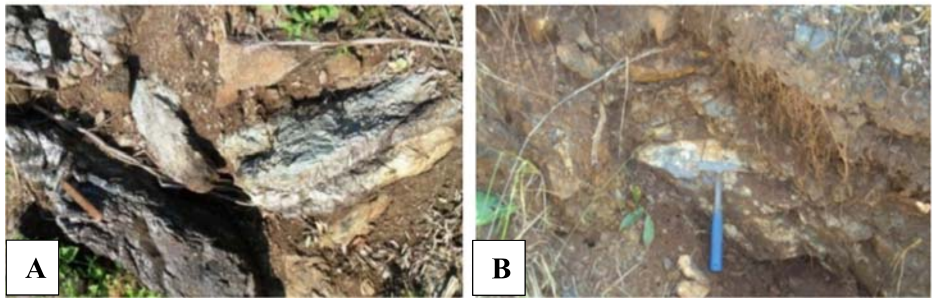

Figure (5a). Podiform chromite forming concordantly with the foliation of the surrounding peridotites (23° 23′03″N, 94° 1′ 52E). Figure (5b) Chromite outcrop in the southern part of Mwetaung (N23°23.03' & E 94°1.528').

Origin of Podiform Chromites

Textural and mineralogical evidences indicate that podiform chromites form by crystallization of mafic magmas in the upper mantle (Lago et al., 1982 in Thidar Win, 2014). The podiform ores have the remarkable nodular texture which is characterized as the primary magmatic feature (Thayer, 1964; Greenbun, 1977). Cumulate textures, cyclical layering, and silicate gangue minerals are all indicative of a magmatic origin and formation in magmatic conduits cutting the mantle peridotites (Lebalance and Ceuleneer, 1992 IN Thidar Win, 2014). Most podiform chromites have dunite envelopes which grade outward into harzburgite or lherzolite. These envelopes are believed to have formed by melt-rock reaction in the same manner as dunites around many dikes in peridotite. In thin section irregular chromite shows intergrowth with olivine (Fig.6). These facts point to the primary magmatic origin of the chromite.

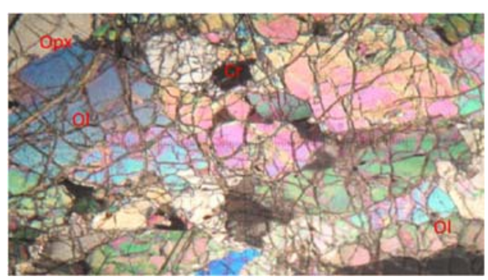

Figure (6). Photomicrograph showing intergrowth with olivine (Ol), orthopyroxene (Opx) and chromite(Cr) in dunite (Under X.N, 40x).

Continuous melt-rock interaction would result in the precipitation of chromite alone to form massive ores. The magmas and host rocks reached equilibrium to form disseminated ores. Nodular ores probably form by a combination of chromite precipitation and convective overturn of the magma pocket. Podiform chromite ore bodies are found in ophiolite complexes i.e. mafic to ultramafic rocks derived from the upper part of the earth's mantle. The chromite deposits of Mwetaung are primary magmatic segregations. The chromite floats occur as segregated boulders and pebbles in small area and also as lenticular blocky bodies in the weathered serpentinized peridotites. The lenticular masses are considered to be formed by the segregation in the primary mafic rocks. The disseminated chromite in the serpentinized dunite and peridotite crystallized at the same time as the primary olivine and pyroxene. Late magmatic crystallization is indicated by the formation of irregular, elongated grains of chromite among olivine and pyroxene.

Tectonic Setting of Podiform chromites

Chromite occurs at Mwetaung as small pockets, lenses and pods and it is similar to those of Alpine type in their mode of occurrence, physical and chemical characters (Fig.7a). They are associated with the ultramafic units of the ophiolite suite. The abundance of volatile-and alkali-rich mineral and fluid inclusions in chromite grain of the Mwetaung indicates relatively high water contents in the parential magmas which, in turn, suggest formation in a supra-subduction zone environment. It is suggested that podiform chromites of the study area formed primarily in supra-subduction zone sections and that their chemical compositions can be correlated with formation in different tectonic settings (Fig.7b). Ophiolites formed in such environments would be characterized by depleted mantle peridotites produced by high degrees of partial melting.

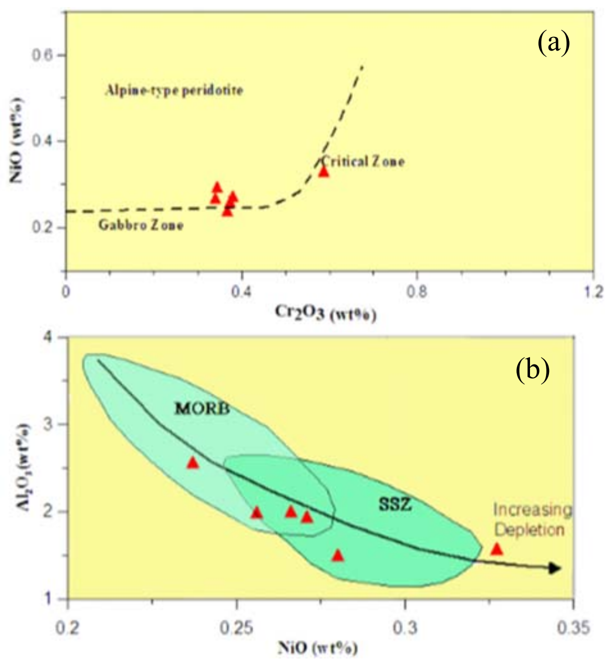

Figure (7). (a) NiO/ Cr2O3 discrimination diagram (After Irvine and Findley, 1972), (b) whole rocks Al2O3-NiO plot for peridotite from Mwetaung Area (After Pearce et al., 1984).

Discussion

Mwetaung area is located along the eastern edge of the Northern Chin Hills that form part of the Indoburman Ranges (Western Ranges). Of all the ophiolite bodies in Kalemyo area, Mwetaung is the best-known for its significant nickel (garnierite)- podiform chromite occurrences. Nickel occurs as garnierite in the weathering zone of the peridotite/dunite and is contained in the lateritic soil of the summit area. Garnierite is always found highly weathered and disseminated residual patches. Chromite mostly occurs as pockets, pods, lenses and stringers in dunite lenses in harzburgite bodies and also as residual pebbles in clusters on weathered ultramafic rocks. The plots of NiO-Cr2O3 and whole rock Al2O3-NiO reveal that most of the serpentinized ultramafic rocks in the study area fall in the Alpine type peridotites and Supra-Subduction Zone (SSZ) ophiolites.

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