erroneously called as 'porphyries' by Heim & Gansser (1939). Small puckers and microfolds.in slate related to this folding are quite common and show orientation of fold axes and axial planes identical to the major folds.

(2) Rupturing of the vertical limb of an anticline, giving rise to a high angled thrust (Ramgarh thrust). Along this thrust, due to drag effect, the sheared migmatites, developed monoclinal or open angular folds whose axial planes are seen dipping towards the thrust at low angles. What is most interesting about these drag fold? is that their fold axes are parallel to those of regional flexures and associated minor folds (Fj). This is a clear indication of the fact that the folding and thrusting were genetically related and the thrusting followed the folding, both forming a connected sequence of a single deformational episode. The authors are of the opinion that the Ramgarh thrust is an offshoot of Krol thrust and is perhaps connected with the movement along the Krol thrust.

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GEOLOGY AND MINERALOGY OF THE CHROMITE DEPOSITS OCCURRING NEAR KONDAPALLE, KISTNA DISTRICT, A.P.

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The geological importance of the Kondapalle area is well known due to the economic concentration of chromite within the ultramafic rocks; and the area has been studied by several workers like Srirama Rao (1946, 1947), Krishna Rao (1964), and Leelanandam (1967a, 1967b).

Srirama Rao (1946, 1947) studied the geology and mineralogy of the Bezwada gneiss and the associated rocks, charnockite suite of rocks and the chromites. He considered the chromite as late magmatic and hydrothermal in origin. Brown and Dey (1955) reported that the chromite deposits of Kondapalle are in the form of lenses and pockets in partly serpentinized pyroxenites interbanded with charnockites, and the ore, according to them, pinches out at depth. Ore-microscopic study of these chromites was first undertaken by Krishna Rao (1964) who gave a brief account of the textural features and paragenesis of the Kondapalle chromites. According to him, the chromite is mainly early to late magmatic in origin. Leelanandam (1967a, 1967b) studied some aspects of the ultramafic and basic charnockites as well as of the anorthosites of the area around Kondapalle.

General geology: The stratigraphic sequence of the rock types exposed in the area is as follows:

Pegmatite and quartz vein

f Wide-spread potash metasomatism and "1
\ hydrothermal alteration of the ultramafics f
Ultramafics: Enstatitile, chromitite and dunite.

Granite gneiss (pink)

Charnockite suite of rocks:
Acid charnockite, basic garnetiferous
charnockite and hypersthenite.

Khondalite suite of rocks:
Garnetiferous gneiss, garnetiferous quartzite,
and garnetiferous biotite-schist.

The oldest rock types in the area come under the Khondalite group comprising garnetiferous gneiss, garnetiferous quartzite and garnetiferous biotite-schist. The garnetiferous quartzite and garnetiferous quatzo-felspathic granulites are found inter banded with the gneisses and occur as lenticular patches.

The charnockitic suite of rocks occur in the hill range extending from Kotta Ibrahimpatnam (80^{c}32': 16°35A') in the south to the northern limit of the area. This group is represented by acid and basic varieties of charnockite. The ultramafic type (hypersthene, Mg77) occurs as irregular bands and lenses of small dimensions.

There is an intimate association of the charnockites with the pink granite gneiss. In many places, minor stringers of this granite gneiss are seen to cut across the charnockites. The vertical to subvertical foliation, well developed in the gneiss, trends north-south.

Srirama Rao (1947) too has observed that the granite gneiss has intruded into the charnockites with which the gneiss is closely associated. The granite gneiss is dissimilar to the charnockite in the absence of garnet and hypersthene in it. It appears that the pink granite gneiss may have suffered a less intense metamorphism than the charnockites.

The khondalites and the charnockites show evidences of high grade metamorphism, the mineralogical assemblages suggesting the pyroxene-granulite subfacies within the granulite facies of metamorphism.

Chromite occurrences: The chromite-bearing ultramafic rocks occur as sheet like bodies along the foliation planes of the country rocks. The isolated occurrences are distributed in an area of about 40 square miles in the hills of Kondapalle.

The ultramafic zone is composed of the following rock types:

B. Products of hydrothermal alteration:
Serpentinite and talc schist.

A. Primary differentiates:
Enstatitite, chromitite and dunite.

The ultramafics show marked primary mineral layering, small scale folding and minor faulting. The layering shows cyclic repetition of chromite and silicate and simulate rhythmic banding. These are formed by crystal settling mechanism. Serpentinite bands of variable thickness are found within chromitites. It is very significant that the ultramafic rocks do not show any evidence of chilling at their contacts with the country rocks.

Formerly it was believed by some workers that the chromite in Kondapalle area occurs associated with and is genetically related to the charnockitic rocks; but the present investigations indicate that the chromite-bearing ultramafics have no genetic relation with the charnockites but are later intrusives into them. The evidences are:

1. The chromite is found only with minerals like olivine and enstatite of the ultramafics and not with the charnockites.
2. The orthopyroxene of the ultramafics is enstatite of the composition Mg 94-96 but the orthopyroxene of the charnockitic rocks is a strongly pleochroic hypersthene of the composition Mg 72-77.
   The enstatite of the ultramafics is conspicuously absent in the country rocks and the typical strongly pleochroic hypersthene is not found in the chromite-bearing orthopyroxenite.
3. The charnockites show evidences of high grade metamorphism and the associated hypersthenites do not show any serpentinisation and talcification. On the other hand, the chromite bearing ultramafic rocks have only been hydrothermally altered to serpentine and talc rocks.

Hydrothermal alteration was followed by widespread potash metasomatism of the ultramafic rocks. Perthite and biotite, which are present in profusion even in the chromitites, were formed as a result of this process. According to Srirama Rao (1947), the pink granite gneiss is responsible for the widespread granitisation but; this granite gneiss is earlier than the ultramafics and is closely associated with the charnockites which in turn has no genetic relation with the ultramafites. It has been assumed by the authors that potash-rich solutions from some unknown source (probably a later granite) was responsible for the introduction of K-felspar and biotite within the rocks of this area.

Massive chromite occurs as steeply dipping bodies within the altered to semi-altered dunites and enstatites along the eastern part of the hills of Kondapalle. Another minor occurrence is noted on the eastern flanks of the hills south-west of Gangineni railway station. The host rocks of chromite occur as sill-like bodies within the country rocks.

Banded ores, in which alternate chromite-rich and silicate-rich thin layers or seams impart a conspicuous banded appearance to the rock, are not uncommon in this area.

Chromite also occurs as irregular veins and definite lenticular and pocket like bodies. The chromite lodes have a steep easterly dip of 80° - 85°, the trend being 17° - 197°. The different chromite lodes are cut across by serpentine and magnesite veins of varying thickness.

South-west of Gangineni R. S. (about 9 miles NW of Kondapalle), chromite occurs as highly irregular lenses and pockets within intensely altered dunites and orthopyroxenites. In this area a magnetite-bearing quartzo-felspathic rock is found to occur as a three to four feet wide xenolithic band extending for about 10 ft. within the ultramafites. The peculiar feature of these chromites is that the strongly magnetic variety is located close to the quartzo-feldspathic band, and the magnetic intensity gradually decreases further away from the band and finally the ore becomes non-magnetic.

It is postulated that while the ultramafic rock came in contact with the magnetite-bearing quartzo-felspathic band, some amount of iron from the country rocks migrated towards the ultramafic rocks thereby enriching the adjoining chrome-spinels in iron, and thus making them strongly magnetic in nature. Some amount of free magnetite is also present in chromite along fractures.

Chromites from Kondapalle area sometimes show a reddish brown colour in thin section, whereas those from Gangineni are always completely opaque. The brownish tint in colour in reflected light is more prominent in Gangineni chromites, with which free magnetite grains occur very frequently. Inclusions of needles and plates of rutile in chromite oriented possibly along the octahedral planes of the host are common, more so in the Gangineni ores. It has been assumed that rutile has been formed from Umenite, the latter again being formed by oxidation of the original chromite-ulvospinel solid solution. The iron rich chromites of Gangineni have also been oxidised along grain boundaries and fractures giving rise to a bluish grey feebly anisotropic mineral. Secondary magnetite and martite were formed during serpentinisation when the minute specks of pyrite were also deposited.

Magnetite, rutile and pyrite are the opaque minerals associated with chromite in this area. Chromite occurs commonly as coarse to medium grained crystals in a serpentinised groundmass. The larger grains are often fractured whereas the smaller ones are less so. The fractures are filled up by magnetite and/or serpentine. Grain boundaries of chromite are very often corroded which suggests reaction with the surrounding liquid with which chromite grains were in contact. Magnetite formed during serpentinisation of the ultramafic rocks occurs as veins replacing chromite.

Summary and conclusions: Small isolated sill-like dunite-chromitite-enstatitite layered bodies occur along the foliation planes of the charnockitic rocks in the area near Kondapalle. Absence of any chilled margin of the ultramafites indicates that this is a case of pre-emplacement differentiation. Olivine and orthopyroxene have been partly altered to serpentine and talc. The ultramafic rocks contain considerable amount of K-felspar and biotite developed as a result of widespread potash metasomatism.

Magnetite, rutile and pyrite are the common associates of chromite. The evidences at hand indicate that the chromite deposits under consideration are early magmatic in origin and that the layers of chromite were formed by crystal settling during the progress of magmatic differentiation.

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STRUCTURAL STUDY IN THE SORPHATAK AREA, DISTRICT ALMORA U.P. * (A PART OF THE ALMORA NAPPE)

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The area situated between latitude 29°25': 29°30', longitude 79°45': 79°47' forming part of the Almora nappe has been selected for a detailed structural study. The rocks mainly include schists, quartzites, sandy phyllites, gneisses, granites, and granodiorites. The structural elements—planar surfaces (s-planes), lineations (L), faults and folds have been studied. The abrupt culmination of Devidhura granites and their re-exposure at Arukhan a mile NNW of Sorphatak (Fig. 1), different orientations of s-planes in the vicinity, records of slickensides and mineralization, lineation on the bedding planes and minor faults indicate tectonic movement of considerable amplitude. Misra and Sharma (1967) and Sharma (1968) have studied the petrology and structures observed in the rocks of this area.

Structural analysis: The structural data have been collected from the two sectors (Fig. 1). The statistical analysis of the s-planes (S,-lithologic contact or bedding plane, Si-axial plane foliation on S,, S_s-axial plane foliation on S, and S_z, S_4-axial plane foliation on S, and S»); /? axes (/JS_2, £S,,, /?S, - intersections of S,, S?, S, planes and the maxima representing the orientation of mean flexure on the corresponding planes within the domain concerned); and lineations (L, - lineation on bedding planes, L,-slickensides and mineralization, L.,-microcorrugation on S, and S_2 planes, L_4- intersection of S, and Ss, L_5 - intersection of S_s and $S_($, L_6- intersections of *Si* and S,) have been summarised in Tables I and II:

Discussion: On the basis of geometrical analysis of meso and macroscopic structural elements, three generations of folds can be recognized in the Sorphatak area. The majority of #S_2, £S_8, and £S, maxima in sector I plunge 40°/s76°w, 34^o/s40°E, and 45°/N72°E respectively, which represent three generations of folds. Each generation is of cylindrical fold type. However, in this sector the first generation folds show cylindrically curvilinear axes (Fig. 2A). The entire system in this sector being noncylindrical and heterogeneous with respect to /JS_a (Fig. 3E). The angles between the axes are: £S, A j9Ss = 84^0, £S, A £S, = 94°, £S_d A /3$S_{i=}$=50^o (Fig. 3L). The schists and quartzites nearly 1.5 km north of Sorphatak have been profusely permeated by siliceous solutions during folding which resulted in the development of ptygmatic folds, with the mean axial plane dipping 50°/N. At the abrupt end of Devidhura granites in the eastern Sorphatak area (Fig. 1 sector II),

•Part of the problem Nappe System of Kumaon Himalayas.