A B S T R A C T

The thesis embodies the results of investigation carried out by the present worker during the years 1954 to 1958, on the geology of the chromite deposits around Jojohatu ($22^{\circ}31'N$ - $85^{\circ}38'E$) near Chaibasa in Singhbhum district of Bihar State. The area comprises rock units mainly belonging to the Archean System, with basic intrusives, probably, of Cuddapah age and laterite and alluvium of Tertiary and Recent ages respectively. The greater part of the area is covered by the sedimentary and low grade metamorphic rocks of the Iron Ore Series. Large ultrabasic masses have intruded these formations. A small granite body has intruded into the Iron Ore Series and into the ultrabasic rocks. Sills and dykes of dolerite have intruded all the rock types mentioned above.

Based on the structural analyses it has been concluded that the country rocks were affected by two stages of folding. The first stage folds, termed B-folds, trending NE-SW, were caused by vertical stress couple, probably, acting along NW-SE direction due to the Iron Ore Orogeny. This resulted in the formation of asymmetric and overturned folds with axial plane dipping NW. The second stage folds, termed B'-folds, were due to the Singhbhum Orogeny, which produced intense oblique cross folds with E-W axial traces superimposed on the limbs of the earlier B folds. This folding caused the formation of Jojohatu antiform and Roro synform both overturned towards south. The orientation of the B'-folds were controlled and conditioned partly by the preexisting orientation of the compositional layers(S_1) and axial plane cleavages (S_2), and partly by the nature and direction of stress.

The ultrabasic rocks, with which the chromite deposits are associated often show rhythmic banding and are composed of fresh to hydrothermally altered pyroxenites (enstatitite) with subordinate differentiates of altered saxonite, dunite, augite, olivinite and chromitite . The masses exhibit a clear intrusive relation with the rocks of the Iron Ore Series, but they failed to produce any recognizable contact effect on the older rocks. The petrography of the ultrabasic rocks and their metamorphic derivatives have been described. Two main types of serpentine, represented by both antigorite and chrysotile varieties are recognised.

The chemistry of the ultrabasic rocks has shown that, they are poor in alumina, calcium oxide, iron oxide, and comparatively rich in magnesia, but almost devoid of alkalies.

The following succession of hydrothermal metamorphic changes in the ultrabasics, have been proved: (1) serpentinization (2) bastitization (3) steatitization (4) amphibolization (5) dolomitization and (6) chertification.

It is shown that ultrabasic bodies were emplaced as irregular, lenticular and mostly concordant, diapiric plutons along the S-shaped weak zones of the country rocks formed by oblique cross-folding, Tectonic disturbance during and immediately after the emplacement of the ultrabasic, produced complex plunging asymmetric or overturned folds, with divergent axial traces and open flexural folds, accompanied by intense jointing, faulting and development of shear zones within the plutons. The ultrabasic masses were sheared and thrusted at their borders during forceful emplacement modifying the pre-existing S-planes of the country rocks, the intrusion thus produced characters which tectonically resemble salt domes. It is concluded that the intrusion of the ultrabasic took place during or immediately after the thrust movements from the north (Singhbhum Orogeny).

From field and laboratory studies it is concluded that the ultrabasic rocks were derived from a deep seated primary magma, (mainly of pyroxenitic composition) which crystallized and differentiated at depth. Evidences strongly suggest that the bodies intruded as a forceful 'cold intrusion' of the 'alpine type' in more or less solid state.

Chromite has concentrated in almost all the primary ultrabasic rocks to form deposits, more particularly along the ultrabasic boundary. Four main structural types of chromite deposits are identified and described: (1) banded or reef ore (most abundant) (2) schlieren banded ore (3) lenticular ore and (4) disseminated ore.

The petromineralogy and mineragraphy of the different ore types are described. Based on grain size two types of chromite are recognized (1) fine-grained (0.1 - 0.3 mm), euhedral and disseminated chromite in silicate minerals, occurring as streaks and ovoids and (2) coarse-grained (1-2.5 mm), polygonal to anhedral chromite closely packed in banded ores. Their textures are found to be typically magmatic. Ore microscopic studies have shown that apart from the primary chromite, the ore is associated with secondary hydrothermal ore minerals like magnetite, chrome-magnetite, hematite, pyrite, chalcopyrite, galena and covellite.

Ten chromite samples and three high grade ores were chemically analysed and their norm, mineral formula and 'end member composition' were calculated. The components of chromites were plotted on the faces of spinel prism and on graphs, and the interrelationship among the various chromites and in their constituents is discussed. It is found that chromites show, more or less uniform chemical composition; average composition being represented by the formula (Cr_{73} Al_{23} Fe_4''') (Fe''_{49} Mg_{51}). Cr:Fe ratio ranges from 1.89:1 to 2.67:1. Later chromites are slightly richer in iron oxides than earlier ones. Generally the ore is rich in iron oxide. The average grade of the ore has Cr_2O_3 40-45%, FeO(Total iron) 17-20% and SiO_2 5-8%.

After reviewing the earlier views, the genesis of the Jojohatu chromite ores is discussed. The present investigator has concluded that the ore represents the primary differentiate of the ultrabasic magma, and that it crystallized in two generations within the magmatic period, the chromite of the earlier generation is represented by fine-grained chromite while the chromite of later generation is represented by the predominating coarse-grained ore. Banding in the ore is believed to be due to periodic changing of physico-chemical conditions during crystallization , probably, much aided by gravitational settling and by the differing powers of crystal nucleation from supersaturated magma. Minor flowage in the magma resulted in splitting of the main bands and also in the formation of schlieren banded ore. The ovoids of fine-grained chromite in leopard ore, perhaps, separated out as drops at a very early stage and were subsequently followed by the crystallization of coarse-grained chromite during a period when the separation of most of the dry silicate minerals like olivine and enstatite was more or less complete and the magma became less viscous. Later hydrothermal changes brought about the replacement of earlier gangue minerals and gave rise to various types of associational ore. It is concluded that the chromite ore of the Jojohatu area is pre-tectonic and pre-hydrothermal changes.

Regular exploitation of the deposits began in 1913 and almost all the deposits have been mined by open-cast methods upto depths of 20-50 feet down the dip. Underground methods of mining have been recently adopted. A concise account of the individual deposit in different leased areas has been given. It is proved that the area still contains about 281800 tons of medium to high grade chromite ore and nearly 83200 tons of disseminated chromite which can be easily recovered by beneficiation methods. The ores do not satisfy the specifications of metallurgical and high chemical grades, but most of them can be used for refractory and low chemical purposes. It is concluded that with the anticipated increased annual production, the Jojohatu area can supply chromite ore for a period exceeding thirty years.
