Chapter 2
Regional Geology

2.1 Geology of Aravalli Craton

The Aravalli craton occupies the northwestern part of Indian shield which contains a record of varied geological processes and tectonic events since 3500 Ma. The Aravalli craton is bounded by the Himalayas in the north, the Phanerozoic Cambay graben in the south-west, the Proterozoic Vindhyan basin and much younger Deccan Traps in the east, and generally covered by recent alluvium to the west. The rocks of this craton are exposed in the NNE-SSW trending Aravalli mountain range and in the peneplains to the east and west, occupying the state of Rajasthan with sporadic occurrences in the states of Haryana, Delhi in the north and Gujarat, Madhya Pradesh in the south and southwest.

Three major fundamental geological units constitute the Aravalli craton. The oldest and lithologically diverse unit is termed as Banded Gneissic Complex (BGC) which constitutes the Archean nucleus of this craton and includes various types of gneisses, migmatites, high-grade schist and meta basic rocks. Two successive Proterozoic fold belts evolved around the BGC, represented by the Aravalli Supergroup and Delhi Supergroup of rocks (Heron, 1953). During Proterozoic, this craton experienced repeated phases of crustal rifting, development of rift basins, generation of oceanic troughs, deposition of various sedimentary facies in different tectonic settings and emplacement of various kinds of acid and basic igneous rocks. These led to events which were associated with multiple deformation and poly phase metamorphism of the rock sequences. This craton is a classical example of ‘resurgent tectonics’.

The principal fold belts in the Aravalli craton are Paleo- to Meso-Proterozoic Aravalli Fold Belt (AFB) and Meso- to Neo-Proterozoic Delhi Fold Belt (DFB). The basement to these fold belts is the BGC.

2.2 Aravalli Fold Belt

The formation of Aravalli basin was initiated at about 2000 Ma ago. The basin was narrow in the north, and became progressively wider southward. The stratigraphic succession of AFB is given by many workers and summarized in (Sen, 1981, 1983; Roy et al., 1988;
Gupta et al., 1992; Sinha-Roy et al., 1993a and 1993b, Guha and Garkhal, 1993). Most of the workers have proposed two major stratigraphic sequences with in the AFB. A shelf-facies with basic lavas and coarse clastics at the base (Delwara, Debari Group) in the east and a deep-sea turbidite (Jharol group) with ultramafic slivers in west (Mohanty et al., 1993), the latter occurring in a zone approximately marking the contact between the two facies. This zone (Rakhabdav linement) has been considered a suture in the AFB (Sinha-Roy, 1988). The opening phase of the Aravalli basin and the rifting of the BGC craton ceased at about 1700 Ma ago after which a regime of crustal compression was initiated. The most significant results of this compressional tectonics were the development of faults and dislocation zones with in the Aravalli fold belt, especially at the interface between the Aravalli cover sequences and the BGC basement rocks.

2.3 Delhi Fold Belt

The Meso- to Neo-Proterozoic rock sequences in Rajasthan are confined to an important fold belt, the Delhi fold belt, which roughly divides the Aravalli craton into two parts. The eastern part is composed dominantly of basement rocks, Aravalli Supergroup and its equivalent cover sequences, while the western part is essentially a volcanic province (Malani), with Late Proterozoic cover sequences (Marwar) and Mesozoic-Cenozoic sedimentary basins (Fig. 2.1).

Sinha-Roy (1984) proposed a diachronous sedimentation history for Delhi Supergroup and subdivided it into an older northern part (North Delhi Fold Belt -NDFB) in NE Rajasthan, developed in three sub basins in Alwar, Bayana and Khatri areas, and younger southern part (South Delhi Fold Belt-SDFB) along the Aravalli hill range in central Rajasthan. This subdivision is based largely on the Rb-Sr whole-rock isochron data from granites (synkinematically emplaced) that yielded 1.65 – 1.45 Ga and ~ 0.85 Ga ages respectively in NDFB and SDFB (Crawford, 1970; Choudhary et al., 1984). Such a division of DFB has been contested by some other workers (e.g Roy and Kataria, 1999; Roy and Jakhar, 2002) who argue that the total package of rocks constituting the Delhi Supergroup was deposited in different basins having dissimilar evolutionary histories. Evidences of 1.0Ga acidic magmatism in SDFB (Deb, 1999) and the doubts raised on the intrusive nature of the granitoids in NDFB (Gupta and Sharma,1998) have also made these subdivisions
Fig. 2.1: Regional geological map of the Aravalli Delhi Fold Belt showing major lithological units (modified from Roy and Dutt, 1995).
rather untenable. The North Delhi Fold Belt (NDFB) encompasses the Khetri – Alwar – Bayana areas in northern Rajasthan. While the South Delhi Fold Belt (SDFB) runs from northeast of Ajmer through central and south central Rajasthan into Gujarat.

Raialo, Alwar and Ajabgarh Groups (Heron, 1953) of rocks in NE Rajasthan constitute the NDFB. The NDFB records evidence of formation of horst – graben structures within the pre-Delhi basement rocks, the graben having been filled with coarse clastics of the Alwar Group. The pre-Alwar rocks (Raialo Group) are dominated by basic volcanics and carbonates.

The Alwar clastic sedimentation in the NDFB was followed by the transgressive platform sequence of the Ajabgarh Group which contains phosphatic carbonates, pelities and volcano-clastic sediments.

### 2.3.1 South Delhi Fold Belt (SDFB)

The SDFB has developed on an intracratonic rift basin which was floored by an oceanic/transitional crust. The remnants of this crust are preserved as dismembered ophiolitic mélange (Phulad Ophiolite, Gupta et al., 1981) apart from the ductile shear zones (DSZ) related to the ophiolite zone, the SDFB contains an up thrust basement wedge, flanked by two prominent thrust zones. All these tectonic features make the SDFB an imbricate thrust zone which should have deeper crustal significance.

The western boundary of the SDFB is defined by a dislocation zone, the Phulad Dislocation Zone (PDZ), against the basement rocks, while the eastern boundary is a prominent thrust zone Kaliguman Dislocation Zone (KDZ) which separates the Delhi rocks from the Sandmata-Mangalwar complex rocks of BGC in the north and the Aravalli sequence in the south (Sinha-Roy, 1984).

The NE-SW trending Delhi Supergroup of rocks in SDFB are bounded by pre-Delhi gneisses and schists on either side. A structural inlier of pre-Delhi gneiss (Beawar gneiss) having identical trend and truncated at southern end bisects the Delhi Supergroup into two separate sub-basins: the western Barotiya-Sendra basins and the eastern Rajgarh-Bhim basins (Gupta et al., 1995). Accordingly, the Delhi Supergroup of rocks in SDFB are divided into Barotiya, Sendra, Rajgarh and Bhim Groups, on the basis of mutual stratigraphic and structural interrelations and on their relations with the basement rocks (Gupta et al., 1995).
The eastern sub basin contains pelitic and psammitic rocks of the Rajgarh group signifying a continental slope facies and a platformal pelite-carbonate sequence of the Bhim Group. The western sub basin contains basic and felsic volcanics with shallow-water clastics forming the Barotiya and the Sendra Groups. The contacts between the different sequences are defined by prominent DSZ and thrusts. From tectonic development and presence of prominent DSZs and basement slivers, the SDFB appears to represent a mélange zone.

2.3.2 Barotiya Group

The western basin fill have been divided into two litho tectonic assemblages, namely, the Barotiya Group on the west and the Sendra Group on the east. The Barotiya Group is dismembered into three tectonic units. The western tectonic unit comprises Barr mica schist and conglomerate, impure marble, sub-arkose and metavolcanics with associated intertrappeans of meta-pelite and calc-schist. The middle unit comprised the Nanana marble with metavolcanics. The eastern unit comprises meta-volcanics, sub-arkose and impure-marble.

2.3.3 Deformational history of Barotiya Group

Four phases of folding are identified on mesoscopic scale within the Barotiya Group (Gupta et al., 1995). The earliest structure is represented by rootless, highly flattened isoclinal folds (F₁) having inclined upright to near reclined geometry. The second phase of folding has generated tight to isoclinal folds (F₂). These reclined folds are usually flattened with subrounded hinge. The third phase of folding resulted in open to tight often isoclinal folds (F₃) associated with longitudinal shears occurring in conjugate sets. The fourth phase of folding has produced cross warps and folds (F₄) with highly variable axial plunge.

The deformational characteristic of other groups, Sendra and Rajgarh Group shows four phases as explained above whereas Bhim Group is affected by three phases of deformation.

2.3.4 Acid magmatism in South Delhi Fold Belt

The closing of Delhi orogenic cycle has been followed by the two major fold episodes, F₂ and F₃ respectively trending NNE-SSW and WNW-ESE and widespread acid magmatism in SDFB and to the west yielding among other intrusives, the most prominent bodies of Erinpura granite and Malani igneous suite. Granitic activity between 900 and 700
Ma is widespread in SDFB as shown by nearly concordant ages of Erinpura type granite along the Aravalli mountain range and to the west of it. Choudhary et al., (1984) suggested a common magmatic evolution of granite occurring in the main SDFB axial zone south of Ajmer and in the Trans-Aravalli belt to the west. Roy (1988) considered the granitic activity in the southern part of Aravalli hill range to be a part of anorogenic magmatism, post-dating the Delhi orogeny.

2.3.5 Tungsten Mineralisation in South Delhi Fold Belt

Some of granites emplaced along the western margin of SDFB in central and southern parts of Rajasthan are associated with tungsten Mineralisation, including three well known tungsten deposits in Degana, Balda and Sewariya-Govindgarh areas.

In Degana, a Li-F-rich granite emplaced in the form of small stocks (less than 1 km wide) within mica schist is associated with wolframite Mineralisation in the form of greisen-bordered quartz lodes, network of thin greisen veinlets and breccia fill in granite and phyllite (Pandian and Varma, 2001). Presence of zinnwaldite and topaz in granites, aplites, greisen and ore-bearing veins (except breccia fill which contains muscovite) is a characteristic feature of this deposit (Fig.2.2).

In Balda, a biotite-bearing tourmaline leucogranite emplaced within folded mica schist (few km long and less than 1 km wide) is associated with wolframite Mineralisation in quartz veins occurring along shear zones in granite-mica schist intrusive contact (Chattopadhyay et al., 1982, Singh and Singh, 1997). Presence of tourmaline (schorl-type), muscovite and fluorite in granite, ore-bearing veins and altered wall-rocks is a characteristic feature of this deposit (Fig.2.3).

In Sewariya- Govindgarh areas (the present study area), a dyke swarm (few cm to few m thick and few 10s of m long) of biotite-free tourmaline leucogranite emplaced within Barotiya rocks and a older biotite granite (known as Sewariya granite, which is equivalent to Erinpura granite) along the western margin of SDFB, is associated with wolframite-bearing quartz veins. Presence of tourmaline with colour zoning (dominantly schorl-type), muscovite and fluorite in granite, ore-bearing veins and altered wall-rocks is a characteristic feature of this deposit.
Fig. 2.3: Geological map of tungsten prospects in Sirohi area (after GSI, 1982).