Proterozoic felsic volcanics in Alwar Basin of North Delhi Fold Belt, Rajasthan: implication for copper mineralization

Proterozoic Delhi Supergroup consists of a thick pile of meta volcano-sedimentary rocks and is divided into the older arenaceous Alwar Group and the younger argillaceous Ajabgarh Group[1,2]. Felsic volcanic rock-hosted copper mineralization had earlier been reported from the argillaceous Ajabgarh rocks of Delhi Supergroup in the Khetri Copper Belt[3]. However, a recent study at Mundiyawas-Khera area (southwest of Thanagazi) in Alwar Basin reveals a felsic volcanic-hosted thick copper and associated gold mineralization in Thanagazi Formation of Ajabgarh Group within the North Delhi Fold Belt (NDFB)[4] (I. Khan and P. R. Sahoo, unpublished). The felsic volcanics around Mundiyawas-Khera area in the Alwar Basin are represented by felsic tuffs, viz. lithic tuff, lapilli tuff and agglomeratic tuff which are rhyo-dacitic in nature[5]. The felsic volcanic rocks in this area occur as interlayered sequence within the meta-greywacke and fine-grained quartzites, carbon phyllite and dolomitic marble of the Ajabgarh Group (Figure 1). This indicates volcano-sedimentary nature of Thanagazi Formation.

The volcanic rock is grey to black in colour, very hard, compact and glassy in nature with rounded to elliptical vesicles (Figure 2 *a*). The vesicular/pitted appearance of the rock was misinterpreted as due to removal of pyrite from the pyrite-bearing cherty quartzite (S. Mukhopadhyay, unpublished). However, no traces of pyrite were found during the petrographic studies of the rocks. The sizes of the vesicles range from 2 to 15 mm and they are filled with quartz–feldspar-biotite. The felsic rocks have undergone metamorphism with slight grain coarsening. Moreover, the felsic volcanic rocks have suffered hydrothermal alteration imminent in the area with the development of a scapolite-rich zone (Figure 2 *b*). It is also observed that in many samples, the amygdales are scapolitic in composition. The volcanic rocks also exhibit the Delhi deformation with development of foliation plane, and alignment and elongation of the amygdales/scapolite grains.

The fine-grained tuff or lithic tuff is dark grey, compact, cherty in appearance and contains sulphide grains (mostly chalcopyrite, pyrrhotite and arsenopyrite) (Figure 2 *c*). At places, removal of the sulphides (pyrrhotite and arsenopyrite) by oxidation has resulted in elongated voids and sulphur precipitation on the rock surface. Under microscope, the rock

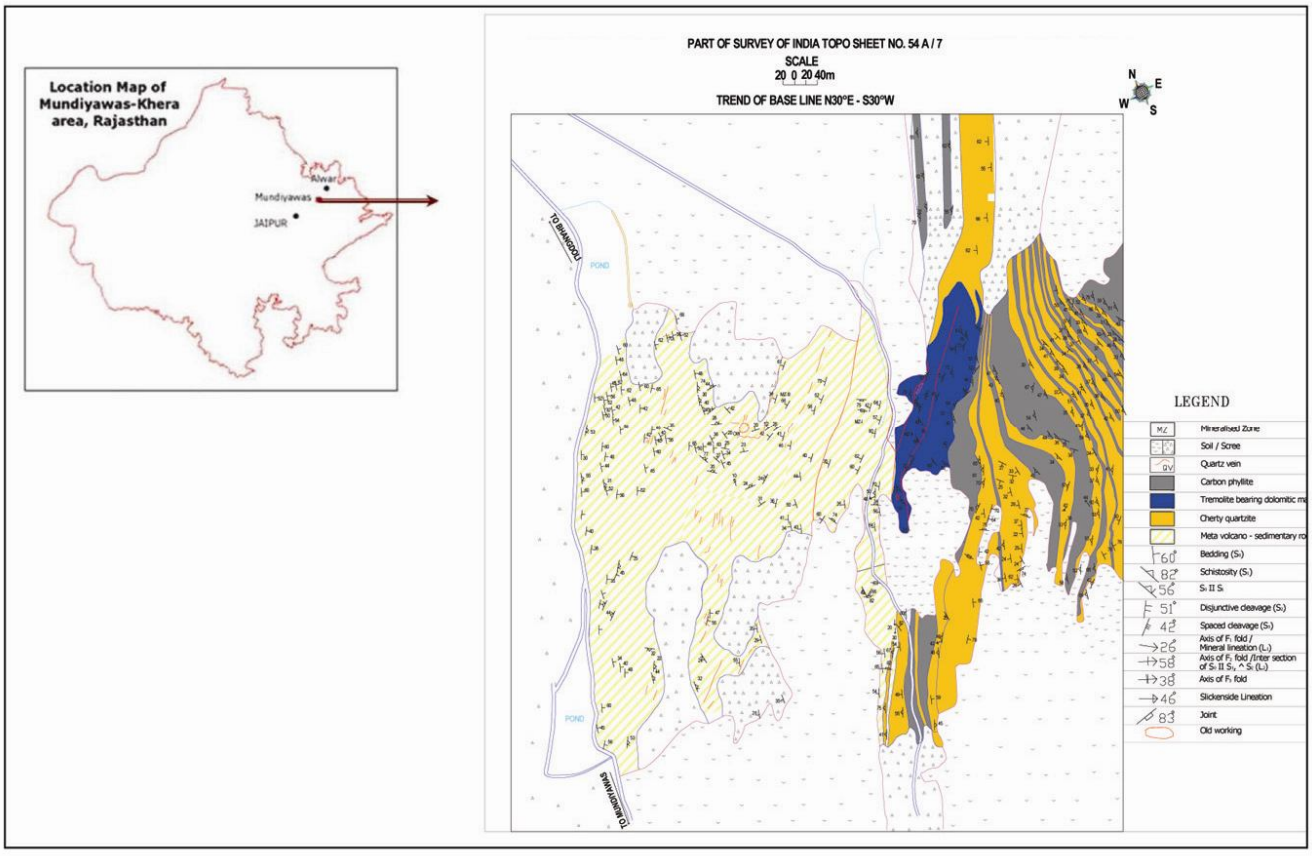

Figure 1. Geological map of Khera Block, Mundiyawas–Khera area, Alwar district, Rajasthan.

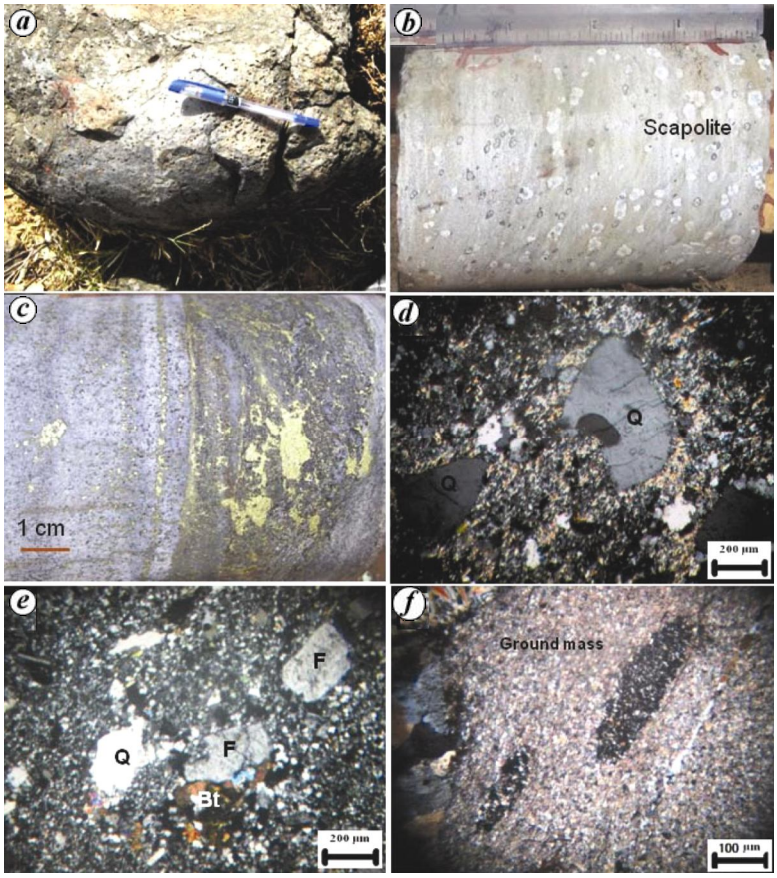

Figure 2. Field photograph showing (***a***) vesicles within the felsic volcanic (felsic tuff); (***b***) scapolite grains from the alteration zone; (***c***) disseminations, stringers and foliation parallel chalcopyrite and minor pyrrhotite within the felsic meta-volcanic; (***d***) embayed quartz grains within the sericitized groundmass; (***e***) embayed quartz and feldspar grains within the groundmass consisting of fine glassy material and biotite segregates; (***f***) ellipsoidal armed lapillies within the felsic volcanics.

is mainly composed of anhedral quartz with corrugated grain boundary set in a fine-grained groundmass of quartz, sericite and biotite grains. In the lithic tuff, quartz, feldspar and biotite occur as porphyroblasts set in the grey glassy groundmass of palagonite (?) which gives porphyritic appearance to the rock (Figure 2 *d* and *e*). Unlike the typical felsic volcanic, this felsic volcanic unit contains comparably more biotite which occurs either as clusters or occupying the peripheral zone around quartz and feldspar grains (Figure 2 *e*). Both quartz and feldspar grains show embayed texture which is indicative of the volcanic origin (Figure 2 *d* and *e*). Feldspar is either sericitized or in relict form and often exhibits sieve texture. The lapilli tuff is composed of more or less equi-dimensional ellipsoidal armed lapilli, compositionally same as to the groundmass (Figure 2 *f*).

The chemical analyses of 12 samples of felsic volcanic rock (lithic tuffs and lapili tuffs) show 61–75% SiO_2, 9.28–22.76% Al_2O_3, 1.13–4.49% Fe_2O_3, 0.34–6.04% Na_2O, 0.18–6.47% K_2O, 0.01–0.51% TiO_2 and 0.01–0.26% P_2O_5. Total alkali versus silica (TAS) plot of some representative samples falls within the dacite and rhyolite field[5]. Hence, the felsic volcanic (tuff) is rhyo-dacitic in composition. This is supported by the low concentration of P_2O_5 (< 0.26%).

Subsurface drilling operation in the area has proved more than 100 m thick sulphide mineralization associated with the meta volcano-sedimentary sequence (I. Khan and P. R. Sahoo, unpublished). The sulphide mineralization comprising chalcopyrite, arsenopyrite and pyrrhotite occurs in the form of disseminations, veins, stringers and foliation parallel layers irrespective of the litho-units (Figure 2 *c*). In the felsic volcanics, the sulphides occur in dissemination form and at places within the biotite segregate which either occurs as rhombic or rectangular and often in stretched shape. This suggests syngenetic-type copper mineralization within the felsic volcanic. Hence, the felsic volcanic is one of the important factors in bringing out the mineralization, which later got concentrated along the foliation plane developed during deformation. Besides these, vein and fracture-filled sulphide mineralization and foliation parallel rich sulphides imply a massive hydrothermal activity in the area which is well established by the presence of quartz-carbonate veins within the felsic litho-unit as well as within the dolomitic marble. Tremolite grains are developed within the dolomitic marble at the contact zone of the felsic volcanic and the quartz veins. Occurrences of carbon phyllite layers and carbonate veins within the litho-sequence favoured the precipitation of sulphides due to reducing nature. The widespread distribution and association of sulphide minerals (dominated by chalcopyrite, pyrrhotite and arsenopyrite) within the meta-greywacke, quartzite, felsic volcanics and their altered varieties in different modes suggest a volcanic origin for copper mineralization. Hence, this can be utilized as an exploration guide in the adjoining areas.

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