Chapter 3. Geological Setting of the Study Area

3.1 Introduction

The study area belongs to the Champaner Group, which forms one of the crucial Pre-Cambrian stratigraphic unit of the SAMB in Gujarat. The study area can be traced with the help of Survey of India (SOI) topographic sheet number 46F/7, 10, 11, 14 and 15, however more than 85% of the area is covered under 46F/10 and 11. The overall geological setting around the Champaner Group reflects the Cretaceous Deccan trap Formation along with few infra-trappean rocks and recent sediments at the west and rest three geographical sides occupies Neo-Proterozoic plutonic intrusive (955 ± 20 Ma. Rb/Sr Method; Gopalan et al., 1979) popularly referred to as “Godhra granites”. The Champaner Group forms an ‘inlier’ surrounded by rocks of younger age and forms roughly a horse shoe shaped outline. This group has been divided into six formations viz., the Lambhia, the Khandia, the Narukot, the Jaban, the Shivrajpur and the Rajgarh Formation on the basis of the lithological homogeneity and occurrence of intra-formational conglomeratic horizon (Gupta et al., 1997). There are two main litho-stratigraphic successions proposed by earlier workers of the Champaner Group, viz, 1. Srikarni and Das, 1996 and 2. Gupta et al., 1997. However, the author is in agreement with the litho-stratigraphic succession proposed by Srikarni and Das, (1996) (Table 3.1). The principal rock-types of this Group encountered are quartzites of manganiferous and non-manganiferous variety, polymict and oligomict meta-conglomerates, carbonaceous phyllites and schists, spotted slates, hornfelses, manganiferous phyllites, biotite schists, dolomitic limestones, calc-silicate rock and meta-greywackes (Fig. 3.1) and are found overlie Paleo-Proterozoic Pre-Champaner Gneissic Complex (PCGC) located at Chhota Udepur region– i.e. “considered basement”, comprising granite-gneisses, quartzites and pelitic gneisses.

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* The part of this chapter is based on our paper published:
(a) Joshi, A U (In-Press) Fold interference patterns in Meso-Proterozoic Champaner Fold Belt (CFB) Gujarat, western India. Journal of Earth System Sciences.
(b) Joshi, A U and Limaye, M A (2018) Rootless calc-silicate folds in granite: An implication towards syn-to-post plutonic emplacement. Journal of Earth System Sciences. 127:67; doi: https://doi.org/10.1007/s12040-018-0968-6.
(c) Joshi, A U and Limaye, M A (2014) Evidences of Syndeformational granitoid emplacement within Champaner group, Gujarat. Journal of M.S.U.S.T, vol.49 No. 1, pp.45-54.

Table 3.1: Litho- stratigraphic succession of the rocks in and around Champaner region (modified after Srikarni and Das, 1996).

Age	Group/Sub-group	Formation	Member	Lithology
Cretaceous to Eocene	Deccan Traps			Basic flows, basic and alkali dykes
Cretaceous	Infratrappean (Bagh Beds)			Sandstones and Limestones
Neo-Proterozoic	Godhra Granite			Post-tectonic and syntectonic granite and granodiorite
Meso-Proterozoic	Champaner Group	Rajgarh	3E	Slates and slaty phyllites with thin calc-silicate bands
			3D	Dolomitic limestone
		Shivrajpur	3C	Manganiferous phyllites and quartzites
			3B	Quartzite and meta-arkose
		Jaban	3A	Polymictic conglomerate with greywacke
		Narukot	2D	Grey phyllite and carbon phyllite
			2C	Meta-arkose and greywacke with intraformational conglomerate
		Khandia	2B	Quartzite and meta-arkose
			2A	Boulder/Cobble conglomerate- clasts mainly of quartzite with minor magnetite, quartzite and phyllite
		Lambia	1D	Phyllite/biotite schist (in the eastern part)
			1C	Dolomitic marble and calc-silicate rock
			1B	Phyllite/biotite schist and spotted slate
			1A	Quartzite and impersistant conglomerate
Palaeo-Proterozoic	Pre-Champaner Gneissic Complex			Granite gneiss, quartzite and pelitic gneiss

Due to the existence of similar rocks across the formations of the Champaner Group and in order to avoid repetition in terms of litho-units, the author has preferred to describe indistinguishable rock-types occurring in each formation collectively.

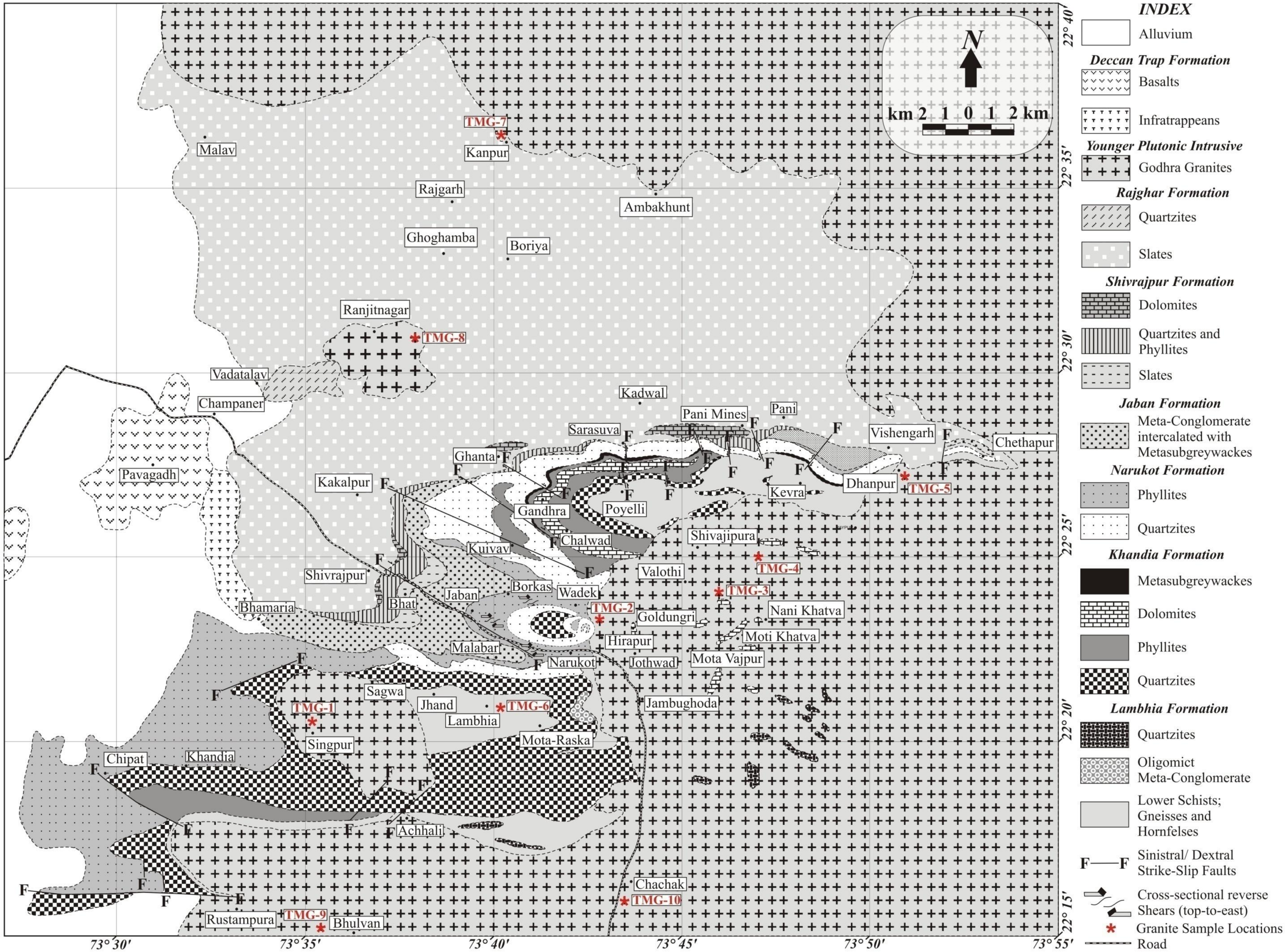

Figure 3.1: Geological Map of the Study area. Modified after, Jambusaria, 1970; Gupta et. al., 1997.

3.2 Field description of rock-types and bearing structures

3.2.1 Quartzites

Quartzites ubiquitous in the Champaner Group, occur as hard, massive, compact at times flaggy and whitish to dark grey and/or black in colour. They are highly jointed with variable grain size from fine to coarse and display varieties of primary sedimentary structures at different locations of the study area. Quartzites occur as high ridges and erratically replicate complex deformation pattern in the form of curvilinear to circular shapes. As the study area represents low grade regional metamorphic terrain, primary sedimentary structures preserved within them are cross-bedding of both planar and tabular nature, graded bedding, symmetrical as well as asymmetrical ripple marks and rain prints. Due to the preservation of these primary structures, bedding plane readings can be recorded at certain places. The quartzites of the study area show mesoscopic structures in the form of (1) tight to open folds with distinct variation in their amplitudes and (2) brittle shear evidences along with the development of breccias and fault gauges. In general these quartzites exhibit E-W to NW-SE strike with variable dip directions.

The quartzites exposed in and around Lambhia are of micaceous nature. The quartzitic rocks show both regional and meso scale folding. The regional scale anticline have E-W trend. Due to increase in the mica (muscovite ± biotite) content they display prominently folds of tight isoclinal variety (Figs. 3.2a; b). There also exists N-S trending open warps over limbs of these earlier folds (Fig. 3.2c). As compared to Lambhia, the quartzites near Narukot are highly massive with eventually less or no mica content. These quartzites also show F_1 and F_2 folds in the form of circular sigma shaped outline. The rocks are dark grey in colour and exhibit parallel to sub-parallel relationship between the bedding and foliation (Fig. 3.2d). The said relationship can be easily appreciated with the help of primary sedimentary structures such as asymmetrical ripple marks and tabular cross-stratification preserved within these quartzites (Figs. 3.2e; f). At places these quartzites also show steep F_3 fold axes plunging due north with an amount of more than 60^{o} (Fig. 3.3a). The quartzites present south of Borkas show evidences of brittle shears. The evidences of mylonitic fabric (‘S and C’) suggest top-to-east sense of brittle shear (Fig. 3.3b).

Quartzites encountered along the road section east of Shivrajpur are mainly intercalated with thin bands of phyllites and show black colour due to the presence of Mn mineralization. The phyllites found along with quartzite tend to be more argillitic in composition and preserve well developed primary laminations. These intercalations demonstrate both F_1 and F_2 folds (Fig. 3.3c). The part exposed along the road section represent northern limb of an anticlinorium. The secondary folds (F_2) developed within the limb of the earlier fold demonstrate variation in terms of its plunge. The Mn content within the quartzites and phyllites is along the core portion of F_1 folds (Fig. 3.3d). The botryoidal form of Mn indicate psilomelane variety. The quartzites exposed at the north-western part of the study area near Vadatalav exhibit first order open type F_2 folds of lesser amplitude versus wavelength ratio (Fig. 3.3e). These folds show prominent cleavage refraction on account of different competency within these quartzites. Noticeable occurrences of asymmetrical ripples along limbs portions suggest folding of primary bedding having ESE-WNW trend with westerly plunging fold axes (Fig. 3.3f).

Apart from mesoscopic fold evidences, the fault gauge on account of normal faulting has been observed (Figs. 3.4a; b). However, these faults are localized and restricted along the specific section. The quartzites also display significant goethite leaching on the upper surface (Fig. 3.4c).

The coarse grained quartzites exposed in and around Rustampura, SW corner of the Champaner region exhibit buff brown colour on weathered surface. Prominent cross-stratification can be observed within these rocks (Fig. 3.4d). The quartzites exposed near Rustampura exhibit intense brecciation, indicating a possibility of shear-zone along WNW-ESE direction (Fig. 3.4e).

The quartzites exposed at the north-eastern extremity near Chethapur exhibit quartz mullions developed due to unidirectional stretching, perpendicular to the stress direction. The plunge of the quartz mullions is 25^o and found to be parallel to the fold axis lineation trending E-W direction (Fig. 3.4f).

Figure 3.2: Field photograph showing: (a; b) Second order F_1 folds of tight isoclinal variety in micaceous quartzites, loc. E of Jhand; (c) N-S trending meso-scale open warps in grey-quartzites, loc. S of Mota-Raska; (d) Parallel relationship between primary bedding and foliation in vertical quarztites, loc. N of Narukot (dome fringe); (e) Asymmetrical ripple marks and (f) Tabular cross-bedding in quartzites, (e) loc. E of Borkas, (f) loc. W of Wadek.

3.2.2 Phyllites/ Slates

Phyllites and slates cover majority of the portions within the study area. Based on the geological map it is evident that majority of the slates in the northern portion represent Rajgarh Formation of the Champaner Group. Approaching towards the central and southern part of the Champaner Group, the slates gradually grades into phyllites. The phyllites and slates are mainly dark grey to metallic grey in colour, very fine to fine grained, massive to fragile and demonstrate well developed phyllitic to slaty cleavages. These rocks more commonly preserved primary bedding in the form of compositional banding, making easy to establish fold events. In vicinity of granties they are hornfelsic and prominently depict maculose structure.

The thick patch of slates exposed along the northern part of the Champaner Group has light grey colour with a slight greenish shade (Fig. 3.4g). These rocks bear prominent slaty cleavages and are fragile in nature (Fig. 3.4h). Slates can be only distinguished from phyllites of the older formations in terms of their cleavages and frangible nature; otherwise they both possess identical character. These occupy low mounds and most of them are destroyed for agricultural practices. These slates are also characterized by thin bands of calc-silicate rock and quartzite at certain localities (Fig. 3.5a). Two sets of folds have been encountered within Rajgarh slates viz., 1. Broad open folds of larger wavelength with plunge direction towards west on a regional scale and 2. Interlayer tight folds of shorter wavelength with plunge direction towards WNW on mesoscopic scale (Fig. 3.5b). Extension of these slates, west of Shivrajpur near Kakalpur village show isolated occurrences and depict tight folding on meso-scale. The folds observed within slates exhibit evidences of refolding of earlier folds (Figs. 3.5c; d).

The slates present near Bhat are distinctly different than the slates exposed near Rajgarh and Goghamba. They are dark grey in colour, massive and tend towards more phyllitic character. Relict primary lamninations are well preserved within these rocks and show development of incipient S_1 cleavages. Unlike Rajgarh slates, these rocks show neither evidences of interlayer folding nor higher

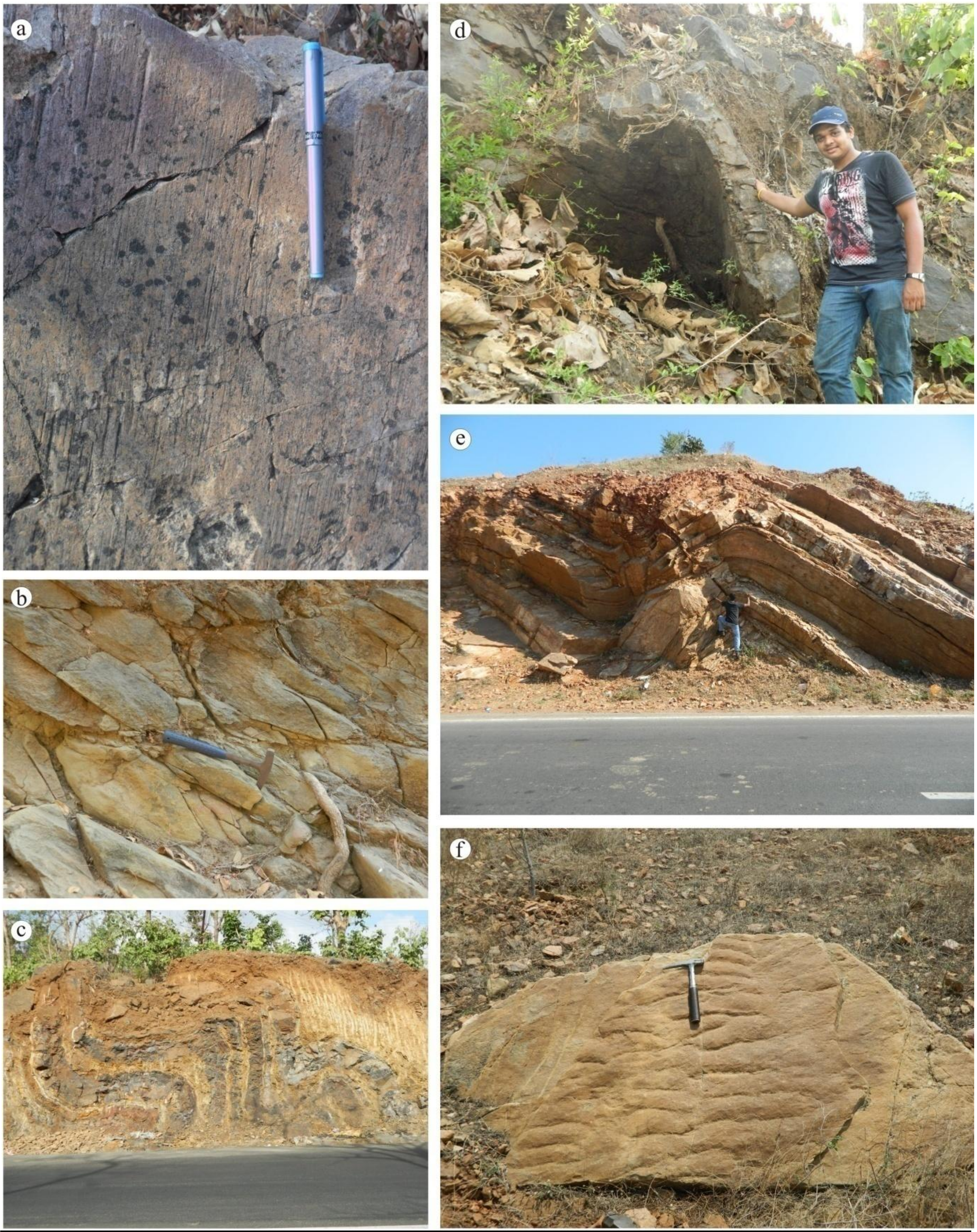

Figure 3.3: Field photograph showing: (a) Steep F_3 fold axes in quartzites, loc. S of Wadek; (b) S-C fabric defining parallelogram sigmoids in quartzites, loc. S of Borkas; (c) Second order tight F_1 folds and first order open F_2 folds in quartzite-phyllite intercalations, loc. E of Shivrajpur; (d) Mined F_2 core for Mn mineralization loc. W of Bhat; (e) First order higher wavelength F_2 open folds in quartzites, loc. Vadatalav (Shivrajpur to Goghamba bypass); (f) Asymmetrical ripples along limbs of F2 folds, loc. Vadatalav (Shivrajpur to Goghamba bypass).

amplitude folds. Nevertheless, secondary cleavage and bedding relationship can be easily established (Fig. 3.5e). Regional scale folding is more prominent with S_2 cleavage converging towards the core.

The phyllites near Narukot, SE of Bhat form broad 'W' shaped outline on a regional scale and are metallic grey in colour, fine-medium grained and possess occasional occurrences of garnets with ilmenite ores. The generalized strike of the outcrop is E-W with variable dip direction. The outcrops near Malabar west of Narukot show southerly dip with an amount of 25^o, where as the rocks near Borkas show northerly dip with an amount of 27^o. The overall pattern represent plunging fold, the axis of which gently plunges towards WNW with an amount similar to that of adjoining folded quartzitic patch having 20^o. On account of S_0IIS_1 folding there has been developed moderately dipping S_2 cleavages. These cleavages show perpendicular relationship at the hinge and converge towards the core to develop cleavage fanning. The phyllites present NE of Jaban bear evidences of top-to-east ductile shear. The shear senses can be documented with the help of sigmoids developed due to intersection of S-C fabrics (Fig. 3.5f).

The phyllites near Kuivav, west of Gandhra and east of Chalwad represent similar extension exposed near Jaban and Malabar. These phyllites distinctly form inlier near Kuivav along the valley sections engulfed by younger quartzites. These phyllites are light grey in colour with preserved parallel laminations (Fig. 3.6a). The intersection of primary bedding and secondary schistose fabric has given rise to the development of L_1 lineations that matches with the axis of a regional scale fold (i.e. ESE-WNW) (Fig. 3.6b). These phyllites are younger to the quartzites occurring west of Poyelli.

3.2.2.1 Hornfelses

The phyllites in contact with granites along the eastern periphery have been converted to the hornfelses. Spotted slates, andalusite hornfels and cordierite hornfels have been recorded form Wadek and Jharav region. The area near west of Wadek depicts generation of andalusite mineral of chaistolite variety (Fig. 3.6c). The typical cruciform as well as radiating crystals of chaistolite-andalusite have size

Figure 3.4: Field photograph showing: (a) Meso-scale normal fault in quartzites; (b) Fault gauge development in quartzites (feature seen at top left corner of the photograph); (c) Goethite on upper surface of quartzites; (a; b; c) loc. Vadatalav (Shivrajpur to Goghamba bypass); (d) Planar cross-bedding in quartzites, loc. Koba; (e) Fault breccia development along ENE-WSW trending shear zone, loc. Rustampura; (f) Quartz rods preserved in quartzites, loc. Chethapur; (g; h) Massive to Fragile slaty outcrops covered under thick soil and vegetation, loc. S of Rajgarh.

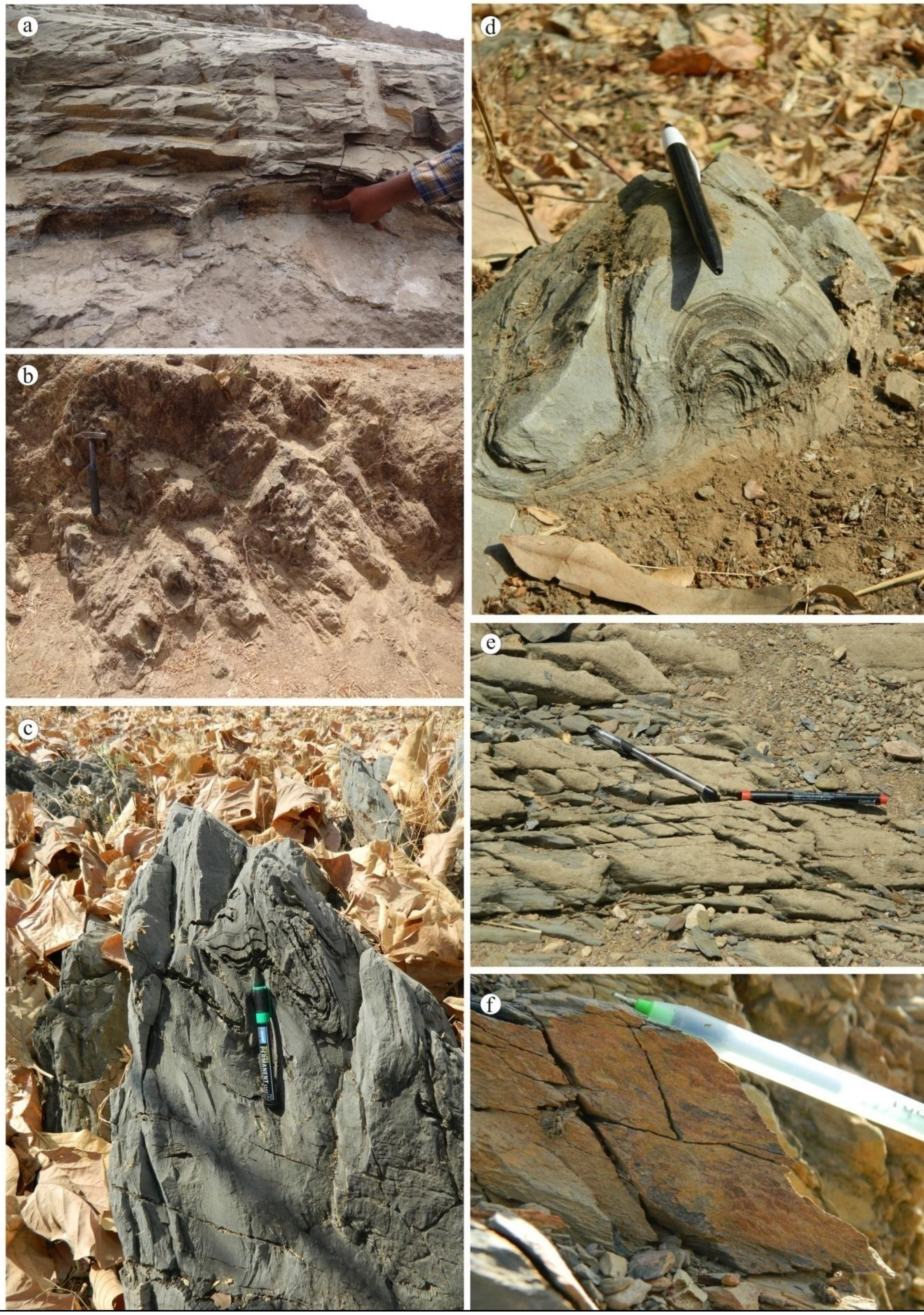

Figure 3.5: Field photograph showing: (a) Thin band of calc-silicate rock within massive phyllites, loc. Quarry section near Boriya; (b) Interlayer tight folds of shorter wavelength within phyllites, loc W of Navagam; (c; d) F2 folds preserved in phyllites, loc. Kakalpur; (e) Oblique relationship between secondary S_2 cleavages and primary bedding S_0IIS_1 loc. Bhat; (f) Sigmoid development in phyllites representing top-to-east sense of ductile shear, loc. E of Jaban.

range of 5-7 cm in length versus 0.5-2 cm in breadth and showoverprinting relationship with the lineation bearing phyllites of Wadek region.

On account of adjacent thermal event the mineral show signatures of alkali metasomatism by developing muscovite rim around andalusite on a meso-scale. The process of muscovitization is found to be prominent along the periphery of the granitic intrusion and diminishes away from granite by reduction in size of the chaistolite-andalusite. Adjacent to the andalusite hornfels, the low lying phyllites contain spots of garnet porphyroblasts ranging from 0.2 to 0.5 cm in size. The contact zones near Jharav exhibit globular friable micaceous rock with protruding cordierite over the upper surface. The rock show distinct maculose structure with violet colour cordierite porphyroblasts ranging from 0.4 to 0.6 cm (Fig. 3.6d). The outcrops exhibit steep easterly dipping foliation with N-S strike.

3.2.3 Schists

Limited exposures of schistose rocks are encountered within the study area. One such prominent band can be traced at the north-west of Kevra near Dhanpur east of Poyelli. The older biotite-schists show non-conformable contact with the younger granites. The strike of the outcrop is NE-SW, dipping 30^o due NW. The rocks depict well developed schistose structure with alternate layering of light color quartz and dark colour biotite flakes. The rock exposed adjacent to the granite also possess sheared nature with “phi” shaped porphyroclasts with in the schistosity fabric (Fig. 3.6e). At first instance it can be noticed that the said rock must have derived by the granitisation of the pelitic rock. Few isolated fragments of schists occur as xenolith within the adjacent granite. Another variety of schist of carbonaceous nature has been encountered north of Narukot, inside the dome. The schists prominently display F_1 fold with an axial trace dipping due WNW. F_1 fold has resulted due to folding of S_0 bedding plane by generating S_1 schistosity plane. Moreover, due to the manifestation of later fold events S_0 show sub-parallel relationship with S_1. L_2 lineation can be traced over the outcrop, which plunges 46^o in the direction of N279^o (Fig. 3.6f).

3.2.4 Dolomitic Limestones, Calc-silicate Rock and Skarns

There are two distinct dolomitic limestone horizons present within the study area. First continuous band forms broad anticline and is exposed in an arcuate pattern, starting from NE Poyelli, then swerving SSW through Gandhra, almost upto Chalvad and again turning south east up to Vav. At places the band show occurrences of phosphatic stromatolites. Another band of dolomitic limestone is discontinuous and exposed in patches. This band is younger as compared to the previous one and exposed in isolated lensoidal bodies south of Pani Mines, north of Ghanta and SE of Shivrajpur. Near contact with granite, the dolomitic limestones are converted to calc-silicate rocks and skarns. Few isolated patches depicting such examples are located within the granite country near Jothwad, Nani Khatva and Moti Khatva and along the periphery near Vav.

The dolomitic limestones exposed near Gandhra west of poyelli show pistachio green colour on weathered surface, while the rock appears off white colour on fresh surface with coarse grained crystals. These rocks are devoid of primary laminations and at places exhibit dark grey appearance with occasional presence of sub-spherical stromatolites (Fig. 3.6g). The rock exposed near Vav in vicinity to granite is converted to the calc-silicate rock and show un-oriented needles of tremolite and actinolite (Fig. 3.6h). These needles are 2-7 cm long and 0.5 to 1 cm wide. Isolated occurrences of similar band entrapped within granites are located near Jothwad Moreover; the skarn rock is exposed as an enclave within the surrounding granites (Fig. 3.7a). At few places these rocks preserves folded fragments within the in-situ granites (Fig. 3.7b). The excavated pit located in vicinity of these rocks suggests that there exists granite in the sub-surface (Fig. 3.7c). The meso-scopic tight/ isoclinal folds observed at Jothwad are rootless (Figs. 3.7d-e). Due to combination of various fold events these rocks depicts mushroom shaped outcrop pattern (Fig. 3.7f). Minerals that can be identified within this rock are winchite, piemontite, garnet, epidote and wollastonite (Fig. 3.8a). The wollastonite bearing rocks are restricted to the contact zones between the host and intrusive granite.

The upper discontinuous dolomitic limestone band lies above the manganiferous phyllite and quartzites. Lithologically, these rocks tend towards siliceous nature and dominantly consist of calcite and quartz. Regional scale folding is more common in this rocks having trend of axial trace as ESE-WNW, however mesoscopic folds of tight nature were also observed having similar trend near Sarasuva (Fig. 3.8b). The axial traces of these folds are found to be disrupted to develop axial planar strike slip faults. Similar thin bands can also be traced within the meta-pelite country (west of Shivrajpur) along Dhadhar nala section. These rocks are well bedded, massive, crystalline, dirty white in colour (Fig. 3.8c) and at places preserve penecontemporaneous deformational structures like slumps.

3.2.5 Oligomict/ Polymict meta-conglomerates and metasubgreywackes

Two distinct metaconglomeratic horizons have been encountered within the study area viz. 1. At the base of the Champaner Group located at east of the Lambhia village and 2. Middle horizon located near Jaban. The former is oligomict in nature having impersistent band and found to be associated with quartzites, while the latter is of polymict variety which has its wide spread occurrence and possesses maximum thickness (~ 800mt). The metasubgreywackes is found to be intercalated with the metaconglomerates occurring as a middle horizon near Jaban and also as individual thin bands at the base of the Narukot quartzites.

Figure 3.6: Field photograph showing: (a) Parallel laminations preserved in phyllites, loc.Kuivav; (b) L_1 intersection lineations preserved in phyllites, loc S of Kuivav; (c) Chaistolite- Andalusite mineral development over phyllites, loc. Wadek; (d) Protruding cordierite porphyroblast within hornfels, loc. Zarav; (e) Phi shaped porphyroclasts within sheared schists, loc. E of Dhanpur; (f) L_2 lineations preserved within carbonaceous schists, loc. N of Narukot (within dome); (g) Elephant skin weathering preserved in grey dolomitic limestones, loc. NE of Gandhra; (h) Unoriented actinolite and tremolite needles in calc-silicate rock, loc. Vav.

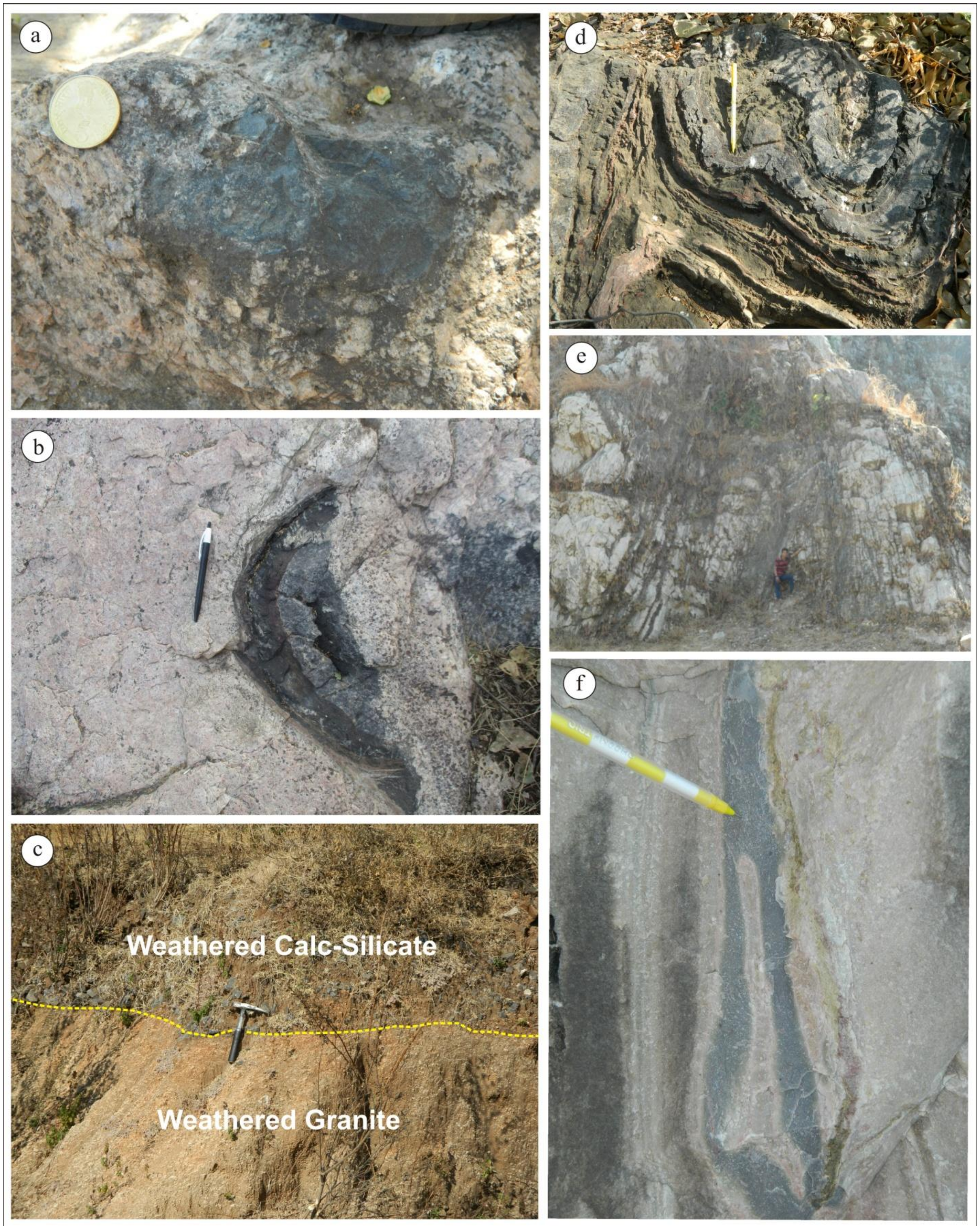

Figure 3.7: Field photograph from Jothwad showing: (a) Enclaves of calc-silicate rock in granite; (b) Caught up folded fragment of calc-silicate rock embedded in granite; (c) Inferred contact between weathered calc-silicate rock and granite at the side face of 5 m deep pit; (e;d) Tight to isoclinal folds in calc-silicate rock; (f) Mushroom-shaped outcrop geometry in calc-silicate rock.

3.2.5.1 Oligomict meta-conglomerates

The oligomict meta-conglomerate horizon has been exposed at the base of the Champaner Group, east of the Lambhia village. The meta-conglomeratic band is discontinuous and found to be associated with quartzites. The rounded to sub-rounded clasts are composed of light to dark grey coloured quartzite, few are of ferruginous quartzite and cherts (Fig. 3.8d). Clasts size ranges from 2-10cm in diameter. The rock contains variable amount of matrix of arenaceous to argillaceous nature.

3.2.5.2 Polymict meta-conglomerates

The thick polymict meta-conglomerate horizon exists from Malabar in the south till Keshavpura in the north in a folded sequence. The said sequence show intercalations with metasubgreywackes and exhibit dark grey colour rock, of massive nature and have rounded to sub-rounded clasts of quartzite, granite and gneiss (Fig. 3.8e). The rock also consists angular to sub-angular clasts of phyllite and calc-silicate rock. The overall size range of the clasts varies between 2cm to 40cm, which adds the prefix to the rock as bounder-cobble conglomerate. The rock show reduction in the matrix content from north to south and has three distinct varieties of matrix such as siliceous, calcareous and micaceous variety. In vicinity to the fault zones (east of Jaban) the rock represents stretching of clasts along with tensional gashes (Fig. 3.8f) where, shear trend can be determined as N120^{o}.

3.2.5.3 Metasubgreywackes

This rock is exposed as an intercalated sequence with meta-conglomerate near Jaban and also occurs as individual thin bands at the base of the Narukot quartzites. The rock is dark grey in colour, massive, matrix dominated and consists angular to sub-rounded clasts of rock fragments (Fig. 3.9a). The occurrence of chlorite indicates recrystallization of matrix. At places the clasts are removed to leave behind the poke marks within the rock on account of weathering.

Figure 3.8: Field photograph showing: (a) Calc-silicate Skarn found in vicinity to granite, loc. Jothwad; (b) ESE-WNW trending meso-scale tight F2 folds within dolomitic limstone, loc E of Sarasuva; (c) Outcrop of massive crystalline limestone (an extension of upper dolomitic limestones, loc. W of Shivrajpur; (d) Oligomict meta-conglomerates having light to dark grey colour quartzitic clasts, loc. E of Lambhia; (e) Polymict meta-conglomertes having rounded to sub-rounded clasts of varied assemblages, loc. Jaban; (f) Tensional gashes within polymict meta-conglomerates, loc. E of Jaban.

3.2.6 Granites

Though granites do not comprise in the age bracket of the Champaner Group its effects are clearly seen on the rocks of the study area. There has been a strong belief of previous workers as well as of the author that the granites have played an important role in defining the structural framework of the Champaner Group. Hence the author finds it rational to give a detailed description of granites present in and around the Champaner Group.

The granites in and around the Champaner Group are exposed in the form of monadnocks, hills, bosses, knobs and tors (Fig. 3.9b). The pronounced surface exposure of main granitic pluton has engulfed the study area from northern, eastern and southern sides. The granites are fine to coarse grained, leucocratic (light grey to pink coloured) and often show the porphyritic nature where large feldspar (mostly potash feldspar) phenocrysts are set in a mosaic of quartz, biotite and accessory minerals. The following two variants of granites have been identified (a) Fine grained grey granite and (b) Coarse grained pink granite of porphyritic and non-porphyritic variety.

3.2.6.1 Fine grained grey granite

The fine grained grey granite dominantly exposed as bosses and hills in the north-eastern and northern parts of study area near Shivjipura, Dhanpur and Kanpur. The prominent hills in study area namely Makhaniya Dungar (at North-eastern margin of study area) and Dev Dungar (at northern margin of study area) are composed of this variety. The granites are leucocratic, equigranular and massive in nature (Fig. 3.9c). The average crystal size is $<$ 5 mm, where dominant minerals such as feldspars, quartz and mica represent uniform crystal size distribution. These granites show poor evidences of deformation. However, the granite at Dev Dungar located at the northern margin of study area represents N-S oriented phenocrysts of feldspar. Xenoliths of meta-sedimentary rocks in almost all the observed locations, show orientation and are indicative of deformation within granites. Southeast of Valothi, the contact between fine grained grey granite and coarse grained pink granite is observed which suggests the intrusive relationship of the latter variety (Fig. 3.9d). The contact between granite and meta-sedimentary rocks is observed east of Dhanpur which exhibit the evidence of intrusive nature of granite with respect to surrounding meta-sedimentary rocks (Fig. 3.9e).

3.2.6.2 Coarse grained pink granite of porphyritic and non-porphyritic variety

The coarse grained pink granites dominantly occur in the eastern and southern parts of the study area. In the south near Chhuchhapura, Bhulvan and Chachak, whereas in the east the areas near Valothi and Mota Vajpur represents coarse grained varieties of pink granites. Moreover, the scattered outcrops are also present around central portions of the study area near Sagwa and Singpur.

The distinct porphyritic variety is observed near Singpur, Sagwa, southwest of Chachak, Valothi and Mota Vajpur localities in the field. The porphyritic nature of granite is specifically noticed in the coarse grained granites, show phenocrysts of K-feldspar or plagioclase are developed in the groundmass of quartz, biotite and accessory minerals (Fig. 3.9f). The average size of phenocrysts is ranging from 1cm to 6cm; at places the phenocrysts larger than 6cm are also observed. The pink colour of the coarse grained granite is attributed to the dominance of K-feldspar as phenocrysts and in the groundmass. Along with porphyritic granites near Valothi some local feldspar segregation is also observed which suggest the accumulation of feldspathic melt during crystallisation (Fig. 3.10a).

The coarse grained non-porphyritic variety of granites occur near Chuchapura and Bhulvan marks the southern boundary of study area. The size of crystals composed within the granite is almost uniform which gives rise to the equigranular non-porphyritic granites (Fig. 3.10b).

3.2.6.3 Xenoliths and signatures of deformation within Granites of the study Area

The granites of study area remarkably show presence of xenoliths. On the basis of field studies, these xenoliths can be classified into two types, 1) Metamorphic xenoliths and 2) Granitic xenoliths.

The fine grained granites of Valothi, Makhaniya dungar and Dev dungar noticeably contain metamorphic xenoliths. The metamorphic xenoliths mainly include the schists, phyllites and the calc-silicate rocks. The xenolith of schists has been observed from Makhaniya hill and typically show schistose structure, while the xenoliths of phyllite from Ranjitnagar exhibit primary bandings, suggestive of meta-sedimentary origin (Figs. 3.10c; d). The calc-silicate rock xenoliths are observed at the localitions SE of Valothi and near Zab village (Fig. 3.10e).

The second variety of xenolith is of granites. They are fine grained, grey coloured and protruding from within the host (coarse grained granite) (Fig. 3.10f). Occurrence of granitic xenoliths suggest possibility of two pulses of granitic emplacement. The fine grained granites originated from the older pulse and the coarse grained granite is the product of later emplacement.

The granites of study area exhibit signatures of deformation. The granites in contact with the Champaner meta-sediments exhibit foliated nature. The macroscopic observations suggest orientation of phenocrysts and xenoliths within the granites. The coarse grained granites ofSingpur and Lambhia preserve orientation of feldspar grains as also fine grained granites of Kanpur represent stretched mineral segregations having ESE-WNW trend (Figs. 3.10g; h).

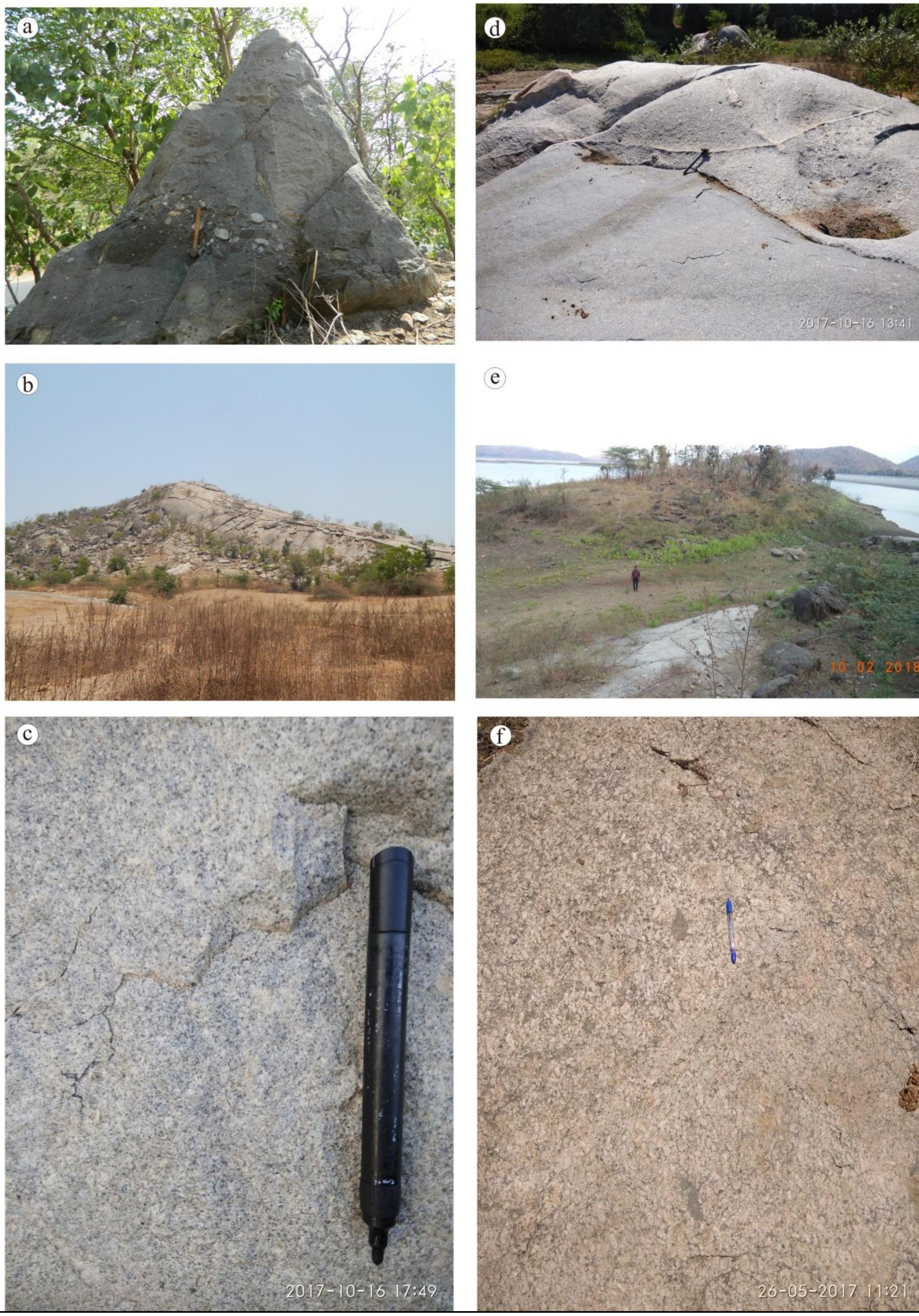

Figure 3.9: Field photograph showing: (a) Intercalations of meta-subgreywackes and meta-conglomerates, loc. W of Jaban; (b) Panoramic view of granite country, loc N of Dhanpur; (c) Leucocratic equigranular fine grained grey granite, loc. Ranjitnagar; (d) Contact between coarse grained pink granite and fine grained grey granite, loc. SE of Valothi; (e) Intrusive contact between the Champaner meta-sediments and granite, loc. E of Dhanpur; (f) Porphyritic variety of pink granite having oriented feldspar phenocrysts, loc. Singpur.

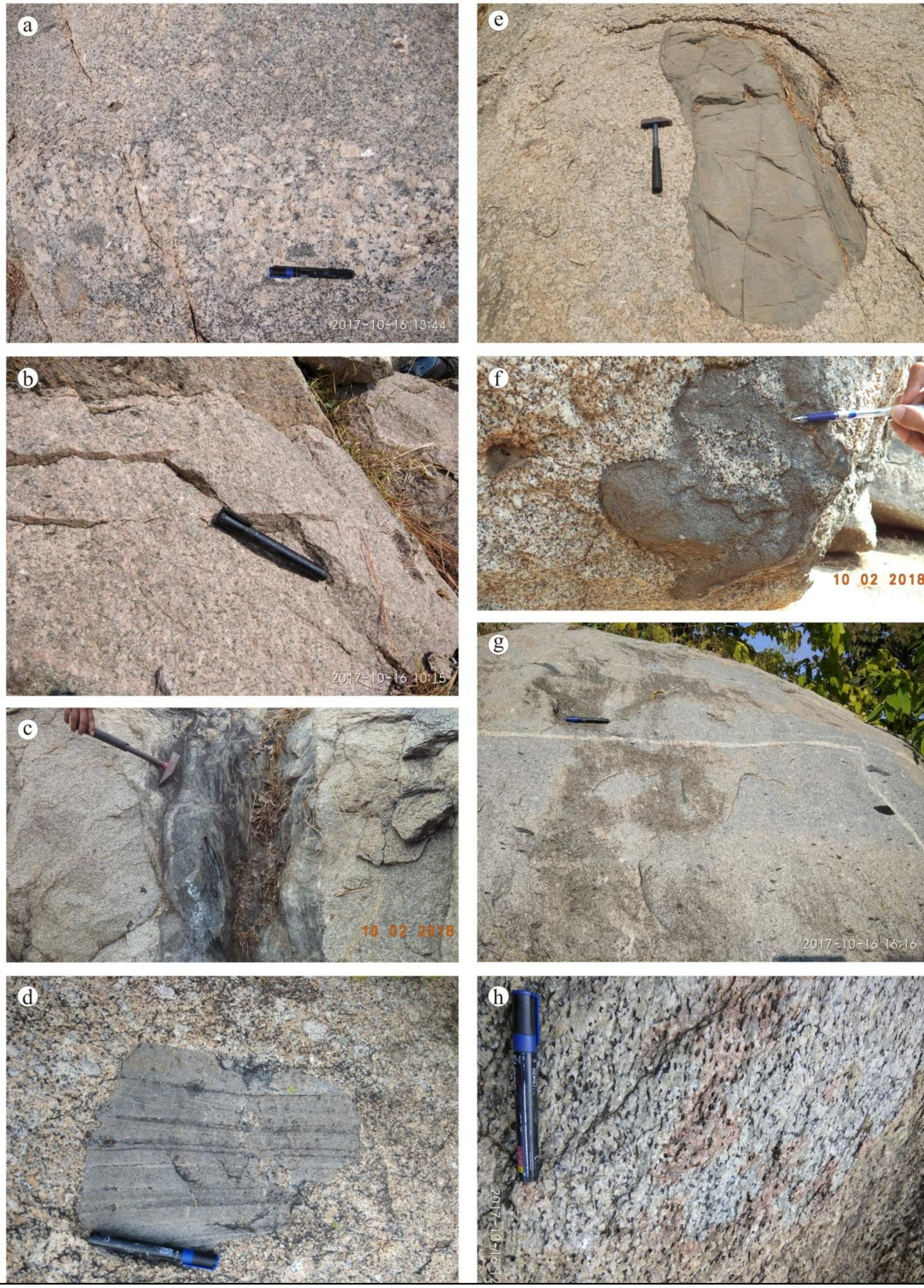

Figure 3.10: Field photograph showing: (a) Feldspar segregation observed in the coarse grained pink granite, loc. Valothi; (b) Equigranular non-porphyritic pink granite, loc. S of Kevra; Xenoliths of (c) Schists; (d) Phyllites; (e) Calc-silicate rock; (f) Fine grained grey granite within granites of the study area, loc. (c) E of Dhanpur; (d) Ranjitnagar; (e) Zab; (f) Ranjitnagar; (g) Oriented mineral segregations within granites, loc. Kanpur; (h) Orientation of minerals within foliated granites, loc. E of Lambhia.

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