CHAPTER V

P E T R O G R A P H Y

In this chapter the author has described in detail the petrographic characters of the various rocks encountered in the study area, and has utilised the data obtained to suitably classify and name the different lithological types.

The classification and nomenclature of the rocks have been based on three important factors

viz. (1) Texture, (2) Textural maturity and (3) Mineral composition. In order to suitably classify and describe the various lithological types, recognised on the basis of his investigations, the author found that somewhat different schemes of classification were suitable for detrital (clastic) and chemical (non-clastic) sediments. For detrital rocks, the system proposed by William, Turner and Gilbert (1954) was found to be the most convenient, while for those of chemical origin, the classification as given by Folk (1965), was found better suited.

In the following pages, the author has described, the rocks of different series in the order of stratigraphical sequence. In each series, firstly the detrital rocks have been considered, and then the chemical. The nomenclature of various rocks, depending on the three factors mentioned above has been given at the end of the description.

ROCKS OF CHARI SERIES:

The rocks belonging to the various members of Chari series have been described as under:

Member A:-

Conglomerate:

1. Colour:	Brick red, yellow.
2. Cohesion:	Moderately hard; compact.
3. Texture:	
Grain size	Pebbles and granules.
Sorting	Poorly sorted.
Roundness	Subrounded.
4. Matrix:	Fine sand, silt and clay.
5. Cement:	Calcareous and ferruginous.
6. Textural Maturity:	Immature.
7. Mineral Composition:	Quartz, felspar (microcline), rock-fragments (pebbles of shale and ferruginous siltstone).
8. Fossils:	Broken shells of gastropods, belemnites, ammonites and other microfossils.
9. Rock Name:	INTRAFORMATIONAL CONGLOMERATE (FOSSILIFEROUS).

Sandstone:

1. Colour:	Purple, brown.
2. Cohesion:	Moderately hard, compact.

3. Texture:

Grain size	Fine to very fine sand (M_z = 2.95 - 3.5 Ø).
Sorting	Moderate to well sorted (σ_I = 0.78 - 0.48 Ø).
Skewness	Fine skewed to near symmetrical (Sk_I = 0.26 - 0.00).
Kurtosis	Very leptokurtic (K'_G = 0.68 - 0.71); Unimodal.
Roundness	Subrounded to rounded (P = 0.39 - 0.53).
Sphericity	Very equant (S = over 0.75).

4. Matrix: Silt and clay (More than 10%).

5. Cement: Calcareous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz, felspar (plagioclase and microcline; both fresh and unaltered; less than 10%). Zircon (very abundant); tourmaline and rutile (very common); biotite (fairly abundant); garnet (rare) and opaques (abundant).

8. Rock Name: CALCAREOUS QUARTZ WACKE.

Shale:

1. Colour: Grey, yellow.

2. Cohesion: Moderately hard, compact.

3. Texture:

Grain size	Clay (M_Z = 8.15 ø).
Sorting	Very poorly sorted (σ_I = 4.90 ø).
Skewness	Fine skewed (Sk_I = 0.23).
Kurtosis	Mesokurtic (K_G' = 0.47).

4. Cement: Calcareous.

5. Mineral Composition: Clay (Illite), gypsum (white and crystalline).

6. Rock Name: CALCAREOUS SHALE.

Member B:-

Grit:

1. Colour: Brown, reddish brown.

2. Cohesion: Very hard, compact.

3. Texture:

Grain size	Mostly coarse to very coarse sand; occasionally medium sand.
Sorting	Moderately sorted.
Roundness	Angular to subangular.
Sphericity	Mostly equant.

4. Matrix: Silt and clay (less than 10%).

5. Cement: Calcareous and ferruginous.

6. Textural Maturity: Mature.

7. Mineral Composition: Quartz (abundant), felspar (microcline, plagioclase; both fresh and unaltered), rock-fragments (quartzite).
Zircon and biotite.

8. Rock Name: CALCAREOUS QUARTZ ARENITE.

Sandstone:

1. Colour: Purple, reddish brown.

2. Cohesion: Moderately hard, compact.

3. Texture:

Grain size	Fine sand (M_z = 2.95 ø).
Sorting	Poorly sorted (σ_I = 1.15 ø).
Skewness	Fine skewed (Sk_I = 0.28).
Kurtosis	Very leptokurtic (K_G^1 = 0.69); Unimodal.
Roundness	Subangular to subrounded (P = 0.15 - 0.4).
Sphericity	Very equant (S = 0ver 0.75).

4. Matrix: Silt and clay (more than 10%).

5. Cement: Calcareous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (abundant), felspar (microcline, orthoclase; less than 10%).
Zircon (very abundant); rutile (fairly abundant); tourmaline, garnet and biotite (common); opaques (heamatite, limonite, abundant), pyrite (rare).

8. Rock Name: CALCAREOUS QUARTZ WACKE.

Shale:

1. Colour: Grey, greenish grey.

2. Cohesion: Moderately hard, laminated.

3. Texture:

Grain size	Very fine silt (M_Z = 7.82 Ø).
Sorting	Very poorly sorted (σ_I = 3.23 Ø).
Skewness	Near symmetrical (Sk_I = 0.23).
Kurtosis	Mesokurtic (K_G = 0.49); Bimodal.

4. Cement: Calcareous.

5. Mineral Composition: Clay (Illite).

6. Rock Name: CALCAREOUS SHALE.

Member C:-

Siltstone:

1. Colour: Brown, yellow, variegated.

2. Cohesion: Moderately hard, compact.

3. Texture:

Grain size	Coarse to medium silt (M_z = 4.58 - 5.58 ø).
Sorting	Poorly to very poorly sorted (σ_I = 1.07 - 2.33 ø).
Skewness	Strongly fine skewed (Sk_I = 0.47 - 0.74).
Kurtosis	Platykurtic to mesokurtic; (K_G = 0.4 - 0.5); Both unimodal and bimodal.
Roundness	Angular to subangular (P = 0.1 - 0.2).
Sphericity	Very equant (S = over 0.75).

4. Matrix: Clay (more than 10%).

5. Cement: Calcareous, occasionally ferruginous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (predominant), felspar (microcline, plagioclase, orthoclase; less than 5 to 10%). Zircon (very abundant); rutile (common), tourmaline (multicoloured and an important constituent); biotite (common); garnet and staurolite (rare); opaques (limonite-quite abundant).

8. Rock Name: FINE GRAINED QUARTZ WACKE.

Shale:

1. Colour:	Dark grey, greenish grey.
2. Cohesion:	Moderately hard, laminated.
3. Texture:	
Grain size	Very fine silt to clay (M_z = 7.3 - 8.0 ø).
Sorting	Poorly sorted (σ_I = 1.75 - 3.2 ø).
Skewness	Near symmetrical (Sk_I = 0.00).
Kurtosis	Mesokurtic (K_G = 0.49 - 0.50); Bimodal.
4. Mineral Composition:	Clay (Illite), gypsum.
5. Rock Name:	GYPSIFEROUS SILTY SHALE.

Limestone:

1. Colour:	Yellow, brown, grey.
2. Cohesion:	Hard, compact.
3. Texture:	
Grain size	Fine calcarenite.
4. Allochemical Constituents:	
Pellets	Ellipsoidal (calcitic; predominant).
Fossils	Broken shells of lamellibranchs, foraminifera and belemnites.

5.	Orthochemical Constituents:	Microcrystalline calcite.
6.	Terrigenous Admixture:	Fine sand.
7.	Mineral Composition:	Quartz, felspar (microcline), opaques.
8.	Rock Name:	SANDY FOSSILIFEROUS PELMICRITE.

Oolitic Limestone (Dhosa Oolite) :

1.	Colour:	Brown, grey, variegated.
2.	Cohesion:	Hard, compact.
3.	Texture:	
	Grain size	Calcilutite.
4.	Allochemical Constituents:	
	Oolites	Ellipsoidal and ovoid (both calcareous and ferruginous).
	Fossils	Shells of lamellibranchs, branchiopods (Rhynconella and Terebratula), ammonites and belemnites.
5.	Orthochemical Constituents:	Microcrystalline calcite.
6.	Terrigenous Admixture:	Coarse silt.
7.	Mineral Composition:	Quartz, felspar (microcline). Zircon, rutite, tourmaline, biotite, garnet.
8.	Rock Name:	SILTY FOSSILIFEROUS OOMICRITE.

ROCKS OF KATROL SERIES:

The rocks belonging to various members of Katrol series are described as under.

Member A:-

Sandstone:

1. Colour: Brown to reddish brown, purple.
2. Cohesion: Moderately hard, compact.
3. Texture:

Grain size	Fine to very fine sand (M_z = 2.85 - 3.88 ø).
Sorting	Moderately well to poorly sorted (σ_I = 0.59 - 1.43 ø).
Skewness	Fine to strongly fine skewed (Sk_I = 0.11 - 0.73); occasionally near symmetrical (0.03).
Kurtosis	Mesokurtic to extremely leptokurtic, (K_G = 0.5 - 0.85); Both unimodal and bimodal.
Roundness	Subangular to rounded (P = 0.16 - 0.6).
Sphericity	Very equant (S = over 0.75).

4. Matrix: Silt and clay (more than 10%).
5. Cement: Calcareous and ferruginous.
6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (abundant), felspar (microcline, plagioclase; 5 to 10% but occasionally 10 to 20%), muscovite. Zircon (abundant); rutite, garnet, biotite (common to very common); tourmaline (sporadic); epidote, amphiboles, zoisite (all rare).

8. Rock Name: QUARTZ WACKE and FELSPATHIC WACKE.

Siltstone:

1. Colour: Purple, brown, variegated.

2. Cohesion: Moderately hard, compact.

3. Texture:

Grain size	Coarse to medium silt (M_Z = 4.43 - 5.13 Ø).
Sorting	Poorly to very poorly sorted (σ_I = 1.46 - 4.11 Ø).
Skewness	Near symmetrical to strongly fine skewed (Sk_I = 0.01 to 0.395).
Kurtosis	Mesokurtic to leptokurtic (K_G = 0.5 - 0.53); Unimodal.
Roundness	Subangular to subrounded (P = 0.15 - 0.4), occasionally angular (0.13).
Sphericity	Very equant (S = over 0.75).

4. Matrix: Clay (more than 10%).

5. Cement: Calcareous and occasionally ferruginous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz, felspar (microcline and plagioclase; more than 10%). Zircon (very abundant); rutile, tourmaline and garnet (fairly common); staurolite, biotite (common); and opaques (limonite and hematite; abundant).

8. Rock Name: FINE GRAINED FELSPATHIC WACKE.

Shale:

1. Colour: Grey, greenish grey, yellow.

2. Cohesion: Moderately hard.

3. Texture:

Grain size	Fine silt to clay (M_z = 6.0 - 8.5 Ø).
Sorting	Very poorly sorted (σ_I = 2.11 - 0.6 Ø).
Skewness	Fine to strongly fine skewed (Sk_I = 0.105 - 0.55).
Kurtosis	Mesokurtic (K'_G = 0.49 - 0.50); Bimodal.

4. Mineral Composition: Clay (Illite, sometimes Montmorillonite).

5. Rock Name: SILTY SHALE.

Member B:-

Sandstone:

1. Colour:	Purple, brown to reddish brown, variegated.
2. Cohesion:	Hard, compact.
3. Texture:	
Grain size	Fine to very fine sand (M_z = 2.06 - 3.98 Ø), occasionally medium sand (1.79 - 1.90 Ø).
Sorting	Moderately well to poorly sorted (σ_I = 0.65 - 2.00 Ø).
Skewness	Near symmetrical to fine skewed (Sk_I = 0.05 - 0.21), sometimes strongly fine skewed (0.44 - 0.80).
Kurtosis	Platykurtic to mesokurtic (K_G = 0.4 - 0.51), occasionally leptokurtic (0.54 - 0.8); Bimodal, at times unimodal.
Roundness	Subangular to subrounded in coarser fraction (P = 0.15 - 0.40). Subrounded to well rounded in finer fraction (P = 0.3 - 0.62).
Sphericity	Very equant in coarser fraction (S = over 0.75), Elongated to equant in finer fraction (S = 0.6 - 0.75).
4. Matrix:	Silt and clay (more than 10%).
5. Cement:	Calcareous and ferruginous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (predominant), felspar (microcline and plagioclase; 5 to 10%); rock fragments (quartzite).
Zircon (very abundant); rutile, biotite and tourmaline (common to very common); garnet (common); amphiboles, pyroxenes; zoisites (rare); opaques (limonite, hematite; common).

8. Rock Name: QUARTZ WACKE and CALCAREOUS QUARTZ WACKE.

Siltstone:

1. Colour: White, purple, brown.

2. Cohesion: Hard, compact.

3. Texture:

Grain size: Coarse silt (M_z = 4.01 - 4.53 Ø).

Sorting: Poorly to very poorly sorted (σ_I = 1.16 - 2.02 Ø).

Skewness: Strongly fine skewed (Sk_I = 0.40 - 0.68).

Kurtosis: Leptokurtic to very leptokurtic (K_G^1 = 0.54 - 0.78); Unimodal.

Roundness: Subangular to subrounded (P = 0.17 - 0.40).

Sphericity: Elongated to equant (S = 0.6 - 0.75).

4. Matrix: Clay (more than 10%).

5. Cement: Calcareous and ferruginous.

6. Textural

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (predominant), felspar (microcline, plagioclase; less than 5%).
Zircon (abundant); rutile and tourmaline (very common); garnet and biotite (common); zoisite and amphibole (rare); opaques (limonite; fairly abundant).

8. Rock Name: FINE GRAINED QUARTZ WACKE.

Shale:

1. Colour: Grey, greenish grey, yellow.

2. Cohesion: Moderately hard.

3. Texture:

Grain size: Fine to very fine silt (M_z = 6.4 - 7.75).

Sorting: Very poorly sorted (σ_I = 2.86 - 5.1 ø).

Skewness: Fine to strongly fine skewed (Sk_I = 0.16 - 0.53), occasionally near symmetrical (0.00 - 0.07).

Kurtosis: Meskurtic (K_G = 0.48 - 0.52), sometimes platykurtic (0.46) and leptokurtic (0.53); both bimodal and unimodal.

4. Mineral Composition: Clay (Illite, sometimes, Montmorillonite), at times gypsum.

5. Rock Name: SILTY SHALE.

Member C:-

Sandstone:

1. Colour: Purple, brown.

2. Cohesion: Moderately hard, compact.

3. Texture:

Grain size	Fine to very fine sand (M_z = 2.32 - 3.82 Ø).
Sorting	Moderately to poorly sorted (σ_I = 0.72 - 1.47 Ø), occasionally well sorted (0.34 Ø).
Skewness	Fine to strongly fine skewed (Sk_I = 0.157 - 0.78), sometimes near symetrical (0.03 - 0.06).
Kurtosis	Leptokurtic to extremely leptokurtic (K_G = 0.6 - 0.85), sometimes platykurtic (0.46) and mesokurtic (0.50); Unimodal, occasionally bimodal.
Roundness	Subangular to rounded (P = 0.15 - 0.6).
Sphericity	Elongated to equant (S = 0.6 - 0.75).

4. Matrix: Silt and clay (more than 10%).

5. Cement: Absent (when present - calcareous).

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (predominant), felspar (microcline, plagioclase; mostly less than 10%, but at times between 10 - 20%), rock fragments (quartzite).
Zircon (abundant); rutile and tourmaline (common); biotite (fairly common), staurolite and garnet (sporadic); opaques (limonite and hematite; abundant).

8. Rock Name: QUARTZ WACKE and FELSPATHIC WACKE.

Siltstone:

1. Colour: White, yellow, and variegated.

2. Cohesion: Hard, compact.

3. Texture:

Grain size	Coarse to medium silt (M_z = 4.05 - 5.6 ø).
Sorting	Poorly to very poorly sorted (σ_I = 1.56 - 4.96 ø).
Skewness	Fine to strongly fine skewed (Sk_I = 0.2 - 0.84).
Kurtosis	Leptokurtic to very leptokurtic (K_G' = 0.52 - 0.7), Unimodal.
Roundness	Angular to subangular (P = 0.12 - 0.25).
Sphericity	Very equant (S = over 0.75).

4. Matrix: Clay (more than 10%).

5. Cement: Calcareous and ferruginous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (abundant), felspar (plagioclase and orthoclase; 5 - 10%).
Zircon (very abundant); rutile and tourmaline (common to very common); biotite and staurolite (fairly common); opaques (limonite and hematite; abundant).

8. Rock Name: FINE GRAINED QUARTZ WACKE and CALCAREOUS QUARTZ WACKE.

Shale:

1. Colour: Grey to greenish grey, yellow.

2. Cohesion: Moderately hard.

3. Texture:

Grain size	Fine silt to clay (M_Z = 6.5 - 8.2 Ø).
Sorting	Very poorly sorted (σ_I = 2.13 - 3.9 Ø).
Skewness	Fine to strongly fine skewed (Sk_I = 0.15 - 0.68), sometimes near symmetrical (0.05).
Kurtosis	Mesokurtic to leptokurtic (K_G = 0.47 - 0.52); occasionally platykurtic (0.46); Unimodal, at times bimodal.

4. Mineral Composition: Clay (Illite, sometimes Montmorillonite), gypsum.

5. Rock Name: SILTY SHALE.

Member D:-

Sandstone:

1. Colour: White, yellow, brown.

2. Cohesion: Soft and friable, hard and compact (ferruginous and calcareous varieties).

3. Texture:

Grain size:	Medium to fine sand (M_Z = 1.28 - 2.9 Ø), occasionally very fine sand (3.16 - 3.9 Ø).
Sorting	Moderately well sorted (σ_I = 0.55 - 0.90 Ø), sometimes well sorted (0.47 Ø) and poorly sorted (1.13 - 2.4 Ø).
Skewness	Near symmetrical to fine skewed (Sk_I = 0.00 - 0.25), sometimes coarse skewed (- 0.17) and strongly fine skewed (0.3 - 0.7).
Kurtosis	Mesokurtic (K_G = 0.48 - 0.52), occasionally leptokurtic to extremely leptokurtic (0.54 - 0.87) and platykurtic (0.43); Bimodal and occasionally unimodal.
Roundness	Subangular to subrounded in coarser fraction (P = 0.15 - 0.40). Subrounded to well rounded in finer fraction (P = 0.26 - 0.7).
Sphericity	Subequal to very equant in coarser fraction (S = 0.69 - 0.75). Elongated to very equant in finer fraction (S = 0.6 - 0.75).

4. Matrix: Silt and clay (less than 10%, occasionally above 10%).

5. Cement: Calcareous and ferruginous.

6. Textural Maturity: Mature, sometimes immature.

7. Mineral Composition: Quartz (predominant), felspar (microcline, plagioclase and orthoclase; less than 10% in the samples from east, more than 10% in the samples from west), rock fragments (quartzite). Zircon (very abundant), rutile and garnet (very common); tourmaline (sporadic to common); staurolite and biotite (fairly common); zoisite, amphibole and pyroxene (rare); Kyanite (sporadic but an important and diagnostic constituent), opaques (limonite and hematite - abundant).

8. Rock Name: QUARTZ ARENITE, FELSPATHIC ARENITE and QUARTZ WACKE.

Siltstone:

1. Colour: White, brown, purple.

2. Cohesion: Moderately hard; compact.

3. Texture:

Grain size: Coarse silt (M_z = 4.08 - 4.42 ϕ).

Sorting: Poorly to very poorly sorted (σ_I = 1.44 - 3.27 ϕ).

	Skewness	Fine to strongly fine skewed (Sk_I = 0.26 - 0.85).
	Kurtosis	Leptokurtic to very leptokurtic (K_G = 0.55 - 0.68); Unimodal and bimodal.
	Roundness	Subangular to subrounded (P = 0.15 - 0.40).
	Sphericity	Elongated to equant (S = 0.6 - 0.75).
4.	Matrix:	Clay (more than 10%).
5.	Cement:	Calcareous and sometimes ferruginous.
6.	Textural Maturity:	Immature.
7.	Mineral Composition:	Quartz (predominant), felspar (microcline and plagioclase; less than 10%). Zircon (very abundant); rutile, tourmaline and biotite (very common); garnet (common); staurolite (rare); opaques (limonite; abundant).
8.	Rock Name:	FINE GRAINED QUARTZ WACKE and CALCAREOUS QUARTZ WACKE.

ROCKS OF UMIA SERIES:

The rocks belonging to Umia series both to the north and south of Katrol fault have been described separately as under:

Umia Series (North of Katrol fault):-

Sandstone:

1. Colour: Purple, brown to reddish brown, yellow.

2. Cohesion: Moderately hard, compact, sometimes friable.

3. Texture:

Grain size	Medium to fine sand (M_Z = 1.43 - 3.85 ø).
Sorting	Moderately to poorly sorted (σ_I = 0.74 - 1.88 ø).
Skewness	Near symmetrical to strongly fine skewed (Sk_I = 0.01 - 0.82).
Kurtosis	Mesokurtic to extremely leptokurtic (K_G = 0.47 - 0.8); Bimodal and unimodal.
Roundness	Subangular to subrounded in coarser fraction (P = 0.2 - 0.4). Subrounded to well rounded in finer fraction (P = 0.33 - 0.66).
Sphericity	Elongated to equant in both fractions (S = 0.6 - 0.75).

4. Matrix: Silt and Clay (More than 10%; in some varieties less than 10%).

5. Cement: Mostly absent; when present it is ferruginous.

6. Textural Maturity: Immature to submature.

7. Mineral Composition: Quartz (predominant), felspar (microcline, plagioclase, less than 10%), rock fragments (quartzite). Zircon (very abundant); rutile, biotite, tourmaline and staurotite (very common), garnet, zoisite, kyanite (rare), opaques (limonite-very abundant).

8. Rock Name: QUARTZ WACKE and QUARTZ ARENITE.

Siltstone:

1. Colour: Purple, white, brown.

2. Cohesion: Moderately hard, compact.

3. Texture:

Grain size	Coarse to medium silt (M_z = 4.22 - 5.38 Ø).
Sorting	Poorly to very poorly sorted (σ_I = 1.55 - 2.47 Ø).
Skewness	Strongly fine skewed (Sk_I = 0.65 - 0.83 Ø).
Kurtosis	Leptokurtic to extremely leptokurtic (K_G = 0.53 - 0.77); Unimodal.
Roundness	Subrounded to rounded (P = 0.25 - 0.6).
Sphericity	Equant (S = 0.72 - 0.75).

4. Matrix: Clay (more than 10%).

5. Cement: Sometimes ferruginous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (predominant), felspar, (microcline and plagioclase - less than 10%), rock fragments (quartzite).
Relatively concentration of 'heavies' is meagre. Zircon, rutile and tourmaline (common), opaques (limonite - hematite; abundant).

8. Rock Name: FINE GRAINED QUARTZ WACKE.

Shale:

1. Colour: Grey to dark grey.

2. Cohesion: Moderately hard.

3. Texture:

Grain size	Fine silt to clay (M_z = 6.2 - 8.0 Ø).
Sorting	Very poorly sorted (σ_I = 3.12 Ø).
Skewness	Fine skewed (Sk_I = 0.131).
Kurtosis	Mesokurtic (K_G = 0.47); Bimodal.

4. Mineral Composition: Clay (Montmorillonite).

5. Rock Name: SILTY SHALE.

Umia Series (South of Katrol fault) :-

Sandstone:

1.	Colour:	White, purple, variegated.
2.	Cohesion:	Moderately hard, compact.
3.	Texture:	
	Grain size	Fine to very fine sand (M_z = 2.26 - 3.85 Ø), sometimes coarse sand (0.78 Ø).
	Sorting	Moderately well to poorly sorted (σ_I = 0.6 - 1.91 Ø).
	Skewness	Near symmetrical to strongly fine skewed (Sk_I = 0.002 - 0.76).
	Kurtosis	Mesokurtic to extremely leptokurtic (K_G = 0.51 - 0.83); Unimodal, occasionally bimodal.
	Roundness	Angular to subangular in coarser fraction (P = 0.1 - 0.25). Subrounded to well rounded in finer fraction (P =0.31 - 0.7).
	Sphericity	Very equant in coarser fraction (S = over 0.75). Elongated to very equant in finer fraction (S = 0.6 - 0.75).
4.	Matrix:	Silt and clay (more than 10% ; in some varieties less than 10%).
5.	Cement:	Sometimes ferruginous.
6.	Textural Maturity:	Immature, sometimes mature.
7.	[illegible]	

7. Mineral Composition: Quartz (abundant), felspar (microcline, plagioclase, orthoclase, between 10 - 20%). Concentration of 'heavies' is meagre. Rélatively zircon and tourmaline (abundant); rutile and biotite (common), garnet, staurolite and augite (rare), opaques (Limonite and hematite - common).

8. Rock Name: FELSPATHIC WACKE and FELSPATHIC ARENITE.

Siltstone:

1. Colour: Yellow, brown, variegated.

2. Cohesion: Moderately hard, compact, sometimes friable.

3. Texture:

Grain size	Coarse to medium silt (M_z = 4.08 - 5.72 ø).
Sorting	Poorly to very poorly sorted (σ_I = 1.32 - 4.28 ø).
Skewness	Fine to strongly fine skewed (Sk_I = 0.21 - 0.85).
Kurtosis	Leptokurtic to extremely leptokurtic (K_G^1 = 0.55 - 0.85); Unimodal.
Roundness	Subrounded to rounded (P = 0.25 - 0.6).
Sphericity	Very equant (S = over 0.75).

4. Matrix: Clay (more than 10%).

5. Cement: None; sometimes ferruginous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (abundant), felspar (Plagioclase and microcline, between 10 - 20%, sometimes less than 10%).
Zircon (very abundant); rutile, tourmaline and biotite (common); staurolite, garnet (sporadic); kyanite (rare); opaques (limonite and hematite - predominant).

8. Rock Name: FINE GRAINED FELSPATHIC WACKE and FINE GRAINED QUARTZ WACKE.

Shale:

1. Colour: Yellow, brown.

2. Cohesion: Moderately hard.

3. Texture:

Grain size	Very fine silt and clay (M_z = 7.35 - 8.00).
Sorting	Very poorly sorted (σ_I = 4.2 ø).
Stewness	Near symmetrical (Sk_I = 0.073).
Kurtosis	Mesokurtic (K_G = 0.5); & Bimodal.

4. Mineral Composition: Clay (Predominantly Montmorillonite, sometimes Illite).

5. Rock Name: SILTY SHALE.

ROCKS OF BHUJ SERIES:

The rocks belonging to Bhuj Series, both to the north and south of Katrol fault have been described separately as under:

Bhuj Series: (North of Katrol Fault) :

Sandstone:

1.	Colour:	Brown, purple, yellow and variegated.
2.	Cohesion:	Soft and friable, occasionally ferruginous varieties hard and compact.
3.	Texture:	
	Grain size	Medium to very fine sand (M_Z = 1.05 - 3.85 Ø), sometimes very coarse sand (- 0.05 Ø).
	Sorting	Well to very poorly sorted (σ_I = 0.5 - 2.12 Ø).
	Skewness	Near symmetrical to strongly fine skewed (Sk_I = 0.01 - 0.67), occasionally coarse (-ve) skewed (-0.2).
	Kurtosis	Mesokurtic to very leptokurtic (K_G = 0.49 - 0.7), sometimes platykurtic (0.44); Unimodal, at times bimodal.
	Roundness	Subangular to subrounded in coarser fraction (P=0.15 - 0.4). Subrounded to well rounded in finer fraction (P = 0.25 - 0.7).

Sphericity	Very equant in coarser fraction (S = over 0.75). Subelongated in finer fraction (S = 0.63 - 0.66).
4. Matrix:	Silt and Clay (less than 10%, sometimes more than 10%).
5. Cement:	Absent; only sometimes ferruginous.
6. Textural Maturity:	Immature to Mature.
7. Mineral Composition:	Quartz (predominant), felspar (plagioclase, microcline - both fresh and unaltered; less than 5%), rock fragments (quartzite). Zircon (abundant); rutile, tourmaline and biotite (very common); staurolite and kyanite (fairly common; but a diagnostic mineral); opaques (limonite and hematite - fairly abundant).
8. Rock Name:	QUARTZ ARENITE and QUARTZ WACKE.

Siltstone:

1. Colour:	White, yellow, reddish brown and variegated.
2. Cohesion:	Moderately hard, compact.

3. Texture:

Grain size	Coarse to medium silt (M_Z = 4.12 - 5.10 ø).
Sorting	Poorly to very poorly sorted (σ_I = 2.0 - 2.46 ø).
Skewness	Fine to strongly fine skewed (Sk_I = 0.191 - 0.87).
Kurtosis	Mesokurtic to very leptokurtic (K_G = 0.49 - 0.7 ø); Unimodal and sometimes bimodal.
Roundness	Subangular to subrounded (P = 0.17 - 0.4).
Sphericity	Very equant (S = over 0.75).

4. Matrix: Clay (more than 10%).

5. Cement: Absent, only sometimes ferruginous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (predominant), felspar (microcline, plagioclase - less than 10%). Heavies as such are meagre, only occasionally zircon, rutile and tourmaline and opaques (hematite and limonite).

8. Rock Name: FINE GRAINED QUARTZ WACKE.

Shale:

1. Colour: Grey and white.

2. Cohesion: Moderately hard.

3. Texture:

Grain size	Very fine silt to clay (M_Z = 7.46 - 8.0 Ø).
Sorting	Very poorly sorted (σ_I = 3.25 Ø).
Skewness	Fine skewed (Sk_I = 0.191).
Kurtosis	Mesokurtic (K_G = 0.5); Bimodal.

4. Mineral Composition: Clay (Montmorillonite).

5. Rock Name: SILTY SHALE.

Bhuj Series (South of Katrol fault):

Sandstone:

1. Colour: White, yellow, brown, ocherous and variegated.

2. Cohesion: Soft and friable, occasionally hard and compact (ferruginous varieties).

3. Texture:

Grain size	Medium to very fine sand (M_Z = 1.04 - 3.8 Ø), sometimes coarse sand (0.45 - 0.90).
Sorting	Moderately well to poorly sorted (σ_I = 0.6 - 2.0 Ø), sometimes well sorted (0.4 - 0.5).
Skewness	Near symmetrical to fine skewed (Sk_I = 0.03 - 0.29), occasionally coarse (-ve) skewed (-0.11 - 0.12).

Kurtosis	Mesokurtic to leptokurtic (K_G = 0.48 - 0.6); occasionally platykurtic (0.45) and very leptokurtic (0.61 - 0.7); Bimodal and unimodal.
Roundness	Angular to subrounded in coarser fraction (P = 0.15 - 0.40), Subrounded to well rounded in finer fraction (P = 0.25 - 0.7).
Sphericity	Very equant in coarser fraction (S = over 0.75). Elongated to very equant in finer fraction (S = 0.55 - 0.80).

4. Matrix: Silt and clay (less than 10%, only sometimes more than 10%).

5. Cement: Occasionally ferruginous.

6. Textural Maturity: Submature to mature, some varieties immature.

7. Mineral Composition: Quartz (predominant), felspar (microcline, plagioclase - less than 10%, only sometimes 10 - 20%); rock fragments (quartzite); Zircon (very abundant); rutile, tourmaline and biotite (very common); staurolite and garnet (fairly common); zoisite, amphiboles (rare); kyanite (rare but an important and diagnostic constituent); opaques (limonite, hematite - abundant).

8. Rock Name: QUARTZ ARENITE, QUARTZ WACKE and FELSPATHIC ARENITE.

Siltstone:

1. Colour: White, grey, purple.

2. Cohesion: Moderately hard, compact.

3. Texture:

Grain size	Coarse to medium silt (M_Z = 4.66 - 5.98 ø).
Sorting	Very poorly sorted (σ_I = 2.49 - 3.16 ø).
Skewness	Fine to strongly fine skewed (Sk_I = 0.165 - 0.69).
Kurtosis	Mesokurtic to leptokurtic (K_G^1 = 0.5 - 0.68); Unimodal.
Roundness	Angular to subangular (P = 0.1 - 0.20).
Sphericity	Very equant (S = over 0.75).

4. Matrix: Clay (more than 10%).

5. Cement: Mostly absent.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (predominant), felspar (microcline, plagioclase; less than 10%).
Zircon (very abundant); rutile, tourmaline and biotite (very common); staurolite, garnet (fairly common); kyanite (rare); opaque (limonite - abundant).

8. Rock Name: FINE GRAINED QUARTZ WACKE.

Shale:

1. Colour: White, grey.

2. Cohesion: Moderately hard, compact.

3. Texture:

Grain size	Fine silt to clay (M_z = 5.23 - 8.05 Ø).
Sorting	Very poorly sorted (σ_I = 2.49 - 5.10 Ø).
Skewness	Near symmetrical to strongly fine skewed (Sk_I = 0.06 - 0.43).
Kurtosis	Mesokurtic to leptokurtic (K_G = 0.48 - 0.58); Bimodal and unimodal.

4. Mineral Composition: Clay (Montmorillonite).

5. Rock Name: SILTY SHALE.

SUPRA - TRAPPEANS:

The rocks of Supra-Trappeans are described as under.

Sandstone:

1. Colour: Green, brown.

2. Cohesion: Moderately hard, compact, occasionally friable.

3. Texture:

Grain size	Medium sand (M_z = 1.84 Ø).
Sorting	Poorly sorted (σ_I = 1.68 Ø).

Skewness	Strongly fine skewed (Sk_I = 0.3).
Kurtosis	Platykurtic (K_G^1 = 0.46); Bimodal.
Roundness	Subangular to subrounded in coarser fraction (P = 0.16 - 0.30). Rounded to well rounded in finer fraction (P = 0.47 - 0.7).
Sphericity	Subequant to very equant in both fractions (S = 0.69 - 0.9).

4. Matrix: Silt and Clay (more than 10%).

5. Cement: Calcareous and ferruginous.

6. Textural Maturity: Immature.

7. Mineral Composition: Quartz (predominant), felspar (less than 5%). Zircon (abundant); rutile and biotite (very common); garnet (fairly abundant); tourmaline and staurolite (sporadic); opaques (abundant).

8. Rock Name: QUARTZ WACKE.

SUBRECENT OOLITIC LIMESTONES:

The rocks of Sub-Recent age are described as under.

Limestone:

1. Colour: Dirty white to brownish white.

2. Cohesion: Moderately hard, compact, occasionally friable.

3. Texture:

Grain size: Calcilutite, occasionally fine calcarenite.

4. Allochemical Constituents:

Oolite: Round and ovoid, mostly unbroken and intact.

Fossil: Well preserved and intact; shells of foraminifers (Miliolides).

5. Orthochemical Constituents: Microcrystalline calcite.

6. Terrigenous Admixture: Fine sand, pebbles of rock-fragments (Sandstones, basalt).

7. Mineral Composition: Quartz, felspar (microcline), hornblende, zircon and apatite.

8. Rock Name: SANDY FOSSILIFEROUS OOMICRITE.
