CHAPTER-III
PETROGRAPHY

3.1 INTRODUCTION

Light microscopy thin section petrography was completed for the cores DNR/58, 60 and 61. It was a first hand observation to study the mineralogical composition, texture and diagenetic inference of the Kaladgi sediments of Mid-Proterozoic age found exposed, as well as in the bore-holes around Deshnur area. The detailed lithological study of these bore-holes reveals the similarity of lithosequence: basement chlorite schist, sedimentary cover of basal arenite, lower conglomerate, quartz arenite, and upper conglomerate. Even the petrography characteristics of these litho-units of the cores, DNR/58, 60 and 61 are very much similar. Hence in this chapter, only petrographic description of the DNR/61 core is presented. The stratigraphic column for DNR/61 core is presented in Chapter-II. For the present work classification of sandstones by Dott (1964) has been followed for describing the petrographic types.

3.2 BASEMENT ROCK

In the study area around Deshnur, basement rock is chlorite schist (Chitradurga Schist), which is encountered in most of the bore-holes. Similarly weathered schist is also found exposed in few nala sections near Deshnur village. Under the microscope the thin section exhibits many linear chlorite grains of pale green to colourless enclosing quartz grains under parallel nicols (Pl.III.1a&b). Chlorite is weekly pleochroic. Occasionally pyrite crystals are dispersed in the schist rock.
3.3 BASAL ARENITE

This petrographic type of this litho-unit varies from subarkose to quartz arenite (Pl.III.1c to Pl.III.1h). In the subarkosic type, feldspar content is considerable and grains are medium size, subangular to subrounded. Minor gradation is found from coarse to fine grained. Larger grains are microcline laths. Most of the feldspars are unaltered. Infiltration of fine grains within coarse grains is noticed. Among quartz grains, many of them are polycrystalline and show unit extinction. The cement is secondary silica.

This petrographic type becomes quartz arenite towards top of the basal arenite (Pl.III.1e & f). In the quartz arenite the grains are medium grained, and subangular. The fabric shows point contact. Rock fragments such as chert and quartzite occur among clasts. Few heavy mineral grains of tourmaline are seen dispersed. Polycrystalline quartz grains are few in number compared to monocrystalline types. Many of the quartz grains show wavy extinction. One or two altered feldspar grains are observed (Pl.III.1g & h). Ferrugenisation is evident in some sections. In these sections, the quartz grains display corroded boundaries. Cement is dominantly secondary silica, followed with ferruginous material. Thin siltstone bands within this unit show argillaceous matrix, with number of opaque minerals.

3.4 LOWER CONGLOMERATE

The boundary between basal arenite and the overlying lower conglomerate is marked with a hybrid petrographic type, showing mixed characteristics of quartz arenite and subarkose (Pl. III.2a & b). The grains are medium in size and show moderate to good sorting. The quartz grains are mostly monocrystalline type and
many of them show unit extinction. The petrographic type is grain rich and feldspars are largely microcline. Packing index of the petrographic type is medium.

In the middle level of this unit, the framework grains of the quartz and feldspars become highly angular (Pl. III.2c & d). Grain flow is observed among linear shape grains. Ferruginous emplacement is noticed in a moderate level. Towards top, the petrographic type is distinctly subarkosic with increasing content of feldspars (Pl. III.2e & f). Feldspars are highly altered, and most of them are microcline. This petrographic type reveals considerable argillaceous matrix along with opaques.

3.5 QUARTZ ARENITE

This is one of the well represented and thick litho-units in the bore-hole (DNR/61) which starts at a depth of 188m overlying the Lower Conglomerate and its boundary with overlying Upper Conglomerate is met at a depth of 43m. This unit at the bottom level has subarkosic type (Pl.III.2g & h) with making of larger size quartz and feldspar pebbles of framework clasts. Feldspars are microcline seen with grid-twinning. Many of the clasts are fractured. Trapping of fine clasts within pore spaces of larger clasts is evident. Both monocristalline and polycristalline quartz grains are observed within the framework grains. Polycristalline quartz grains enclose numerous grains inside. Many of the quartz grains are subangular in shape. Cement is secondary silica along with ferruginous material. Subarkose become arkosic towards top with fresh influx of feldspar grains (Pl.III.3a & b). Feldspars are dominantly microcline and most of the larger clasts are found fractured. Polycristalline quartz grains are considerable and many of them show unit extinction. Stylolite structure is evident in this petrographic type, which implies a moderate burial diagenesis. The framework clasts show moderate sorting and are
subangular to subrounded in shape. Cement is secondary silica, along with ferruginous (hematite). Emplacement of chlorite is found in the matrix.

Further towards top, the petrographic type becomes subarkosic (Pl. III.3c; 172.65m). Among quartz grains, few polycrystalline types are seen, and few exhibit wavy extinction. Chert grains are scanty, and sorting of the petrographic type is good. A single grain of ferruginous siltstone is also observed. The grain shape ranges from subangular to subrounded. Largely this petrographic type reveals a tight packing and cement is secondary silica as well as ferruginous. Many clasts show iron coating and quartz are dominantly monocrystalline. Further towards top, this petrographic type persists (Pl. III.3d; 161.60m), but with a recognisable reduction in grain size, and clasts are medium to fine grained. Most of the feldspar laths are cross-hatch twinned microcline. The grains are angular to subangular and tightly packed. Few number of chert grains are noticed. Polycrystalline quartz grains are few in number. However many quartz grains exhibit wavy extinction. Cement is secondary silica.

Subarkose continues to prevail till the sub-depth of 137.10m in DNR/61 (Pl. III.3e; 143.20m) but with slightly increasing content of alkali feldspars, mostly microcline. Feldspars are fresh. Few chert grains are found among clasts. The grain size range from medium to coarse, and reveal a tight packing. Polycrystalline quartz grains are good in number, and most of the quartz grains exhibit unit extinction. Cement is overgrown secondary silica.

Towards the upper horizons in the Quartz Arenite unit, the subarkose become true quartz arenite with drastic reduction of feldspars (Pl. III.3f; 106.40m). Heavy minerals are considerable in number, particularly zircon species. Other heavy minerals identified are rutile and tourmaline. Quartz overgrowth is distinctly seen
around many of the detrital quartz grains. It is quartz enriched and feldspar grains are scarce, and those present are plagioclase type. The petrographic type is medium to fine grained, and shows tight packing. Many quartz grains reveal wavy extinction. This petrographic type extends till 96m towards upper horizons in the core (Pl.III.3g; 96m). It is heavy mineral rich, and authigenic tourmaline, detrital tourmaline, sphene, staurolite, opaques and few zircons are observed. The petrographic type becomes fine grained. Most of the quartz grains are angular, and feldspars are completely eliminated. Undulose extinction is common in quartz grains. Most of the quartz grains are monocrystalline. Authigenic clay matrix is evident. Perhaps some of the detrital feldspars become diagenetically altered to generate authigenic clay matrix. Ferruginous material has emplaced into the pore spaces. Further towards top in the core, quartz grains become texturally immature with assorted size grains (Pl. III.3h; 91.40m), and ferruginous rich. Feldspars are not observed. The only framework grains are quartz and they are subangular to subrounded. Ferruginous filling is enormous.

In the uppermost level of the Quartz Arenite, the petrographic type is more compact and the quartz arenite shows signs of metamorphism-slight recrystallisation (Pl. III.4a; 54.50m). Perhaps this rock type has undergone deep burial diagenetic changes, and may represent a transitional boundary between sedimentary deep burial diagenesis and low grade metamorphic changes. Quartz grains are angular and poorly sorted. Quartz grains show sutured contacts and evidence of instastratal solutions. Quartz overgrowth is clearly seen around several detrital quartz clasts. Emplacement of iron oxide is considerable within pore spaces in the framework. Perhaps at the boundary between Quartz Arenite and overlying Upper Conglomerate, a thin bed of fine quartz arenite (Pl. III. 4b; 41.10m) with poor sorting is noticed. The framework grains are fine grained and highly angular and assorted. Emplacement of ferruginous material is enormous. The petrographic type
looks like “ferricrete” and around many quartz grains cracks have developed due to overdrying in a semi-arid like environment. Many quartz grains are stretched type and linear in shape (metamorphic source). Few bent mica flakes are also observed. Most of the quartz grains exhibit wavy extinction. Few small feldspar grains (alkali) are found, and are altered.

3.6 UPPER CONGLOMERATE

Upper Conglomerate is comparatively a thin unit, and in the field it is identified as oligomict type. Under the thin section, it is lithic conglomerate (Pl. III.4c & d; 40.20m). The lithic fragments are represented with chert grains, quartzite and a large size reworked sandstone fragment. Framework grains are large size pebbles. Few large size quartz grains show polycrystalline characteristics with straight boundaries among the component grains. Quartzite fragments show interlocking of recrystallised quartz grains. Few mica flakes with slight bending is observed within the framework clasts. This may reveal a moderate burial diagenesis. Ferruginous material and entrapment of fine particles within larger pebbles are other features seen in this petrographic type.

Further towards top, quartz arenite (Pl.III.4e; 39.50m) of fine grained nature is observed. The framework grains consist of dominantly angular fine quartz and few highly altered and decomposed feldspars. However, definite unaltered feldspar grains could not be observed. It shows increasing matrix content, perhaps due to alteration of feldspars in diagenetic environment. It composes many linear stretched quartz grains. Many quartz grains reveal wavy extinction. Considerable iron material has emplaced into the pore spaces. Further at the middle level in the unit, the petrographic type is quartz arenite, and the grain size is coarse subangular to medium subrounded (Pl.III.4f & g). Polycrystalline quartz grains with sutured
boundaries are common, and most quartz grains reveal undulose extinction. Iron oxide coatings around quartz clasts are clearly seen. Cement is dominantly quartz overgrowth.

The topmost part of the unit (Pl.III.4h; 9.5m) is also similar to the previous petrographic type (quartz arenite), but exhibits a bimodal composition: subangular to subrounded large size, as well as fine grains in the framework, mostly quartz grains. Ferruginous coating around the grain periphery is discontinuous, and secondary silica is common cement. Both monocrystalline and polycrystalline quartz grains are found. Large size pebbles are scattered in the petrographic type.

3.7 MODAL ANALYSIS

30 representative sub-samples are selected from DNR-61 core for modal analysis. The modal composition of the petrographic types is shown in Table.3.1. Quartz is dominant, however rock fragments are considerable in lower conglomerate and become more in number at the middle level of the core (130.65) and occur in good number towards top level of the core. Most of the rock fragments are cherts along with quartzites. Next in the order are feldspars, in which microcline dominates over plagioclase and this order is observed in most of the sections studied from conglomerate, ferruginous sandstone, sandstone, basal arenite and siltstone. Prior to plotting, the necessary minerals (quartz, feldspar and rock fragments) were recalculated to 100%, neglecting matrix cement and other detrital minerals. The classification shows the sandstone is mostly quartz arenite and sublithic arenite types (Fig.3.1a-i). Triangular plots of QFR of Dickinson and Suczek (1979), show that they were derived from continental block provenance. In the Qm FRt plots after Dickinson (1985), concentration of samples seemed mainly in the continental block provenance. In the QFR diagram, of Suttner and Dutta
most of the samples fall in the field of humid climate. The petrofacies in Q-F-R ternary diagrams suggest mainly continental provenance of cratonic interior and the quartzose rock types undergone weathering in a humid climate. In the bivariant Log-Log Qp/F+R Vs. Qm+Qp/F+R plot (Fig.3.1j) which is considered more sensitive to climatic control, the samples fall in the fields of semi-arid to humid climate. However most of the samples of Basal Arenite and Lower Conglomerate fall in the zones of semi-arid to semi-humid climate and samples of Quartz Arenite and Upper Conglomerate scatter largely in the zone of humid climate. This trend is correlatable with the petrographic data which suggest occurrence of feldspars in the lower units of Basal Arenite and Lower Conglomerate, which become rare in the upper units of Quartz Arenite and Upper Conglomerate. The source area must be predominantly combined metamorphic schist, and granitic terrain subjected to high intensity chemical weathering under a humid climate.

3.8 SEM PETROGRAPHY

Representative samples from DNR-58, 60 & 61 have been selected for SEM analysis. The work was undertaken mainly to unravel the diagenetic features of the clastic rocks such as authigenic mineralization, precipitation of cements, replacement features, and matrix distribution. The micro-analysis of the Mid-Proterozoic coarse clastic rocks of Badami Group using a JEOL SEM in general, complements the petrographic and clay mineralogy data. The basement chlorite schist rocks (DNR-58, 60 and 61, Pls. III.5a, III.7c and III.9a) reveal flakes of chlorite mineral grains enclosing the stretched quartz grains. Quartz overgrowths with clear pyramidal faces could be easily discerned in basal arenites of DNR-58 & 60 (Pls III. 5b and III.7d). In DNR-58, highly altered alkali feldspars could be recognised in the basal arenite, as seen in the SEM photograph (Pl. III.5c). In DNR-61 precipitation of globules of authigenic hematite in the pore spaces of basal arenite
can be identified. Perhaps this stage of cementation may be a latter episode than silica cementation.

Significant occurrence of alkali feldspars particularly microcline, and alteration of such feldspars are observed in the SEM photographs of Lower Conglomerate (Pls. III. 5e, 5f, 7e, 9d and 9f). Development of secondary illite and kaolinite clays in pore spaces of Lower Conglomerate has also been clearly brought out through SEM analysis (Pls. III.5d, 6a and 9d).

The occurrence of highly angular quartz grain with sharp edges is also observed in the Lower conglomerate unit (Pls. III. 6b and 9c). A highly uneven overgrowth of quartz has been noticed over the surface of detrital quartz of Lower Conglomerate (Pl. III.9e), and in places where clay flakes sticks over the detrital quartz clast, such growth is prohibited. Similar feature is also observed in the quartz arenite of DNR-61 (Pl. III. 10b).

The SEM photograph of quartz arenite of DNE-58 clearly depicts a multi-layer growth of secondary quartz over a detrital grain (Pls. III. 6e, 7a, 8b and 10a). Significant occurrence of altered feldspars in quartz arenite is clearly visible in SEM photographs and there is a distinct relationship between the altered feldspars, and occurrence of illite and kaolinite clays (Pls. III. 6d, 7b and 8a). It is inferred that during deep burial of these coarse clastics, feldspars have been altered diagenetically in to clays under an enhanced temperature and pressure conditions. Quartz overgrowth and ferruginous cementation are common cementation process in quartz arenite (Pls. III. 7f, 8c, 8d and 8e). Ferrugenisation and hematite cementation is also common in upper conglomerate (DNR-60, Pl. III. 8f). Authigenic feldspar overgrowth as well as growth of secondary feldspars in pore spaces is clearly visible in quartz arenite as well as in upper conglomerate (DNR-61, Pl.III.10c & d).
Plate - III.1 (DNR-61)
Plate- III.2 (DNR-61)
Plate- III.3 (DNR-61)
Plate-III.4 (DNR-61)
Table 3.1 DNR-61 Percentages of Quartz, Feldspar and Rock fragments and modal percentage of Quartz undulose, Quartz nonundulose and polycrystalline Quartz

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Fig. 3.1a Triangular plot of QFR of the DNR-61, (after Pettijohn et al., 1972).

Fig. 3.1b Triangular plot of QFR of the DNR-61, (after Folk, 1980).

Fig. 3.1c Triangular plot of QFR of the DNR-61, (after James et al., 1986)
Fig. 3.1d Triangular plot of QFR of the DNR-61, (after Dickinson et al., 1983).

Fig. 3.1e Triangular plot of QmFRt of the DNR-61 (after Dickinson et al., 1983).

Fig. 3.1f Triangular plot of QFR and Provenance field boundaries DNR-61, (after Dickinson and Suczek, 1979).
Fig. 3.1g Triangular plot of $Q_n$Fr$_1$ of the DNR-61 (after Dickinson 1985).

Fig. 3.1h Triangular plot of $Q_s$Fr$_1$ of the DNR-61, (after Dickinson, 1985).

Fig. 3.1i Triangular plot of QFr of the DNR-61 (after Dickinson 1985).
Fig. 3.1j Bivariate Log-Log plot of the ratio of polycrystalline quartz to feldspar+rock fragments against the ratio of total quartz to feldspar+rock fragments for interpretation of palaeoclimate from the DNR-61 samples, (after Surtttner and Dutta, 1986).
Plate III.5 (DNR-58)
Plate III.6 (DNR-58)
Quartz Arenite 35m (DNR-58)  
Chlorite Schist 280.80m (DNR-60)  
Lower Conglomerate 222.50m (DNR-60)  
Quartz Arenite 180m (DNR-60)  
Basal Arenite 232.60m (DNR-60)  
Plate III.7 (DNR-58 & 60)
Quartz Arenite 180m
Quartz Arenite 157.70m
Quartz Arenite 109.35m
Quartz Arenite 83.50m
Quartz Arenite 34.20m
Upper Conglomerate 16.50m
Plate III.9 (DNR-61)
Plate III.10 (DNR-61)
Plate III.1a  **Chlorite Schist:** Weekly pleochroic chlorite mineral grains enclose quartz grains (Parallel Nicols, 40X)

Plate III.1b  **Chlorite Schist:** (Crossed Nicols, 40X)

Plate III.1c  **Quartz Arenite:** Quartz grains of assorted size with corroded grain surface due to ferruginisation (Parallel Nicols, 40X)

Plate III.1d  **Quartz Arenite:** Photograph shows both polycrystalline and monocrystalline quartz grains of assorted size (Crossed Nicols, 40X)

Plate III.1e  **Quartz Arenite:** A tightly packed coarse frame work with ferruginous filling at top left corner (Parallel Nicols, 40X)

Plate III.1f  Same under crossed nicols shows many polycrystalline quartz grains and wavy extinction.

Plate III.1g  **Subarkosic Arenite:** A coarser framework of quartz and microcline feldspar, but with entrapment of fine particles (Parallel Nicols, 40X).

Plate III.1h  Same under crossed nicols showing grid-twinned microcline feldspar and polycrystalline quartz grains.
Plate III.2a **Subarkosic Arenite:** A grain rich framework showing subrounded to sub-angular quartz and feldspar grains; most of the feldspars are fresh, and sorting is moderate to good (Parallel Nicols, 40X)

Plate III.2b Same under crossed nicols exhibiting grid-twinmed microcline feldspar and monocrystalline quartz grains.

Plate III.2c **Arkosic arenite:** A feldspar rich framework showing poor sorting and “grain flow” along with ferruginous cement (Parallel Nicols, 40X)

Plate III.2d Same petrographic type under crossed nicols revealing medium to fine grained angular quartz and feldspar grains; most of the quartz are monocrystalline.

Plate III.2e **Arkosic Arenite:** Photomicrograph under crossed nicols shows poor sorting along with a grid-twinmed large size microcline (40X)

Plate III.2f Same petrographic type under crossed nicols showing polycrystalline quartz grains, and highly altered feldspars with slightly increasing matrix content.

Plate III.2g **Subarkosic Arenite:** Photomicrograph pointing out coarser framework of quartz and feldspars along with entrapment of fine particles (Parallel Nicols, 40X)

Plate III.2h Same petrographic type under crossed nicols showing a larger size quartzite rock fragment.
Plate III.3a  **Arkosic Arenite:** Petrographic type showing tight packing of grains along with stylolite structure with angular framework grains (Parallel Nicols, 40X)

Plate III.3b  Same petrographic type under crossed nicols exhibiting a quartzite fragment along with a highly fractured quartz grain; chlorite is seen in the pores.

Plate III.3c  **Subarkosic Arenite:** Petrographic type under crossed nicols shows a tight framework of both monocrystalline and polycrystalline quartz along with a ferrugenised siltstone fragment.

Plate III.3d  **Subarkosic Arenite:** Photomicrograph exhibiting a tightly packed angular framework of monocrystalline quartz and microcline feldspar grains (Crossed Nicols, 40X)

Plate III.3e  **Subarkosic Arenite:** Photomicrograph under crossed nicols showing a tight framework of large size feldspar grain (alkali), and dominantly monocrystalline quartz grains.

Plate III.3f  **Quartz Arenite:** A fine grained tightly packed petrographic type showing even size quartz grains along with number of ultrastable heavy minerals (mostly zircon) (Crossed Nicols, 40X)

Plate III.3g  **Quartz Arenite:** A much fine grained petrographic type showing tight packing of angular quartz grains along with several heavy mineral species (authigenic and detrital tourmaline, sphene, and opaques) (Crossed Nicols, 40X)

Plate III.3h  **Quartz Arenite:** A loosely packed petrographic type with large emplacement of ferruginous material in pore spaces (Parallel Nicols, 40X)
Plate III.4a  **Quartz Arenite:** Petrographic type showing sign of low grade metamorphism with recrystallised quartz grains along with a quartzite fragment (Crossed Nicols, 40X)

Plate III.4b Poorly sorted arenite showing angular framework of quartz grains with one or two mica flakes; many linear quartz grains derived from metamorphic source (Crossed Nicols, 40X)

Plate III.4c  **Lithic Conglomerate:** Photomicrograph showing a larger framework of quartz, and quartzite grains with fine particles trapped; ferruginous cement emplaced in pore spaces (Parallel Nicols, 40X)

Plate III.4d Same petrographic type shows a slightly bent mica along with monocrystalline quartz grains (Crossed Nicols, 40X)

Plate III.4e  **Quartz Arenite:** A much fine arenite showing grains of monocrystalline quartz along with several heavy minerals (Crossed Nicols, 40X)

Plate III.4f  **Quartz Arenite:** Photomicrograph showing a tight framework of angular assorted quartz grains with stylolite feature (Parallel Nicols, 40X)

Plate III.4g Same photographic type under crossed nicols showing several polycrystalline quartz grains, and wavy extinction.

Plate III.4h  **Quartz Arenite:** A quartz rich framework showing bimodal texture (coarse and fine) (Crossed Nicols, 40X)
Plate III.5a  **Basement chlorite schist:** (DNR-58) SEM Photo shows chlorite flakes enclose quartz grains.

Plate III.5b  SEM photo shows authigenic bi-pyramidal quartz grown in pore spaces (DNR-58) of basal arenite.

Plate III.5c  SEM photograph of a highly altered feldspar grain in diagenetic environment (DNR-58, Basal Arenite)

Plate III.5d  SEM photo shows illite flakes within pore spaces (diagenetic origin) (DNR-58, Lower conglomerate)

Plate III.5e  SEM photograph showing altered feldspar and diagenetic illite clay (DNR-58, Lower conglomerate)

Plate III.5f  SEM photo of a large microcline feldspar lath (DNR-58, Lower conglomerate)
Plate III.6a  SEM photograph showing books of kaolinite clay (DNR-58, Lower conglomerate)

Plate III.6b  An angular quartz grain of Lower Conglomerate showing conchoidal fractures and sharp edges (DNR-58)

Plate III.6c  A microcline feldspar showing caverns along twin lamellae and alteration due to attack of diagenetic fluids (DNR-58, Lower Conglomerate)

Plate III.6d  Generation of authigenic clay (illite) in the pore spaces (DNR-58, Quartz Arenite)

Plate III.6e  A multi-layer growth of secondary quartz over the detrital grain (DNR-58, Quartz Arenite)

Plate III.6f  Precipitation of hematite in the pore spaces of Quartz Arenite (DNR-58)
Plate III.7a  Growth of authigenic quartz in pore spaces of Quartz Arenite showing pyramidal faces (DNR-58)

Plate III.7b  Generation diagenetic kaolinite clay books due to alteration of alkali feldspars in Quartz Arenite (DNR-58)

Plate III.7c  Stacks of chlorite grains, and linear quartz grains at the bottom as seen in basement chlorite schist (DNR-60)

Plate III.7d  A tightly packed Basal Arenite showing a linear hair-line gap between overlays of quartz overgrowths over two adjacent detrital quartz grains (DNR-60)

Plate III.7e  A twinned feldspar grain showing sticky clay flakes at places (DNR-60, Lower conglomerate)

Plate III.7f  Precipitation of hematite cement in the pore spaces of Quartz Arenite (DNR-60)
Plate III.8a  Stacking of clay flakes (illite) in the pore spaces of Quartz Arenite (DNR-60)

Plate III.8b  An array of authigenic quartz grains along a linear pore space in the Quartz Arenite (DNR-60)

Plate III.8c  A tightly packed Quartz Arenite showing uneven growth of secondary quartz over detrital grains alongwith ferruginous cement (DNR-60)

Plate III.8d  Quartz Arenite showing authigenic quartz crystal faces surrounded by ferruginous cement (hematite) (DNR-60)

Plate III.8e  Arrays of authigenic quartz growth in pore spaces of Quartz Arenite with particles of clay (DNR-60)

Plate III.8f  Large size linear detrital particles cemented with ferruginous clay (Upper Conglomerate, DNR-60)
Plate III.9a  Linear stretched quartz grains and chlorite flakes in chlorite schist (DNR-61)

Plate III.9b  Precipitation of globules of hematite cement in the pore spaces of Basal Arenite (DNR-61)

Plate III.9c  A large size detrital quartz grain showing conchoidal fractures and sharp edges surrounded with ferruginous clay (Lower Conglomerate, DNR-61)

Plate III.9d  SEM photo exhibits diagenetic alteration of a feldspar grain and development of authigenic illite clay (Lower Conglomerate, DNR-61)

Plate III.9e  SEM photo showing uneven growth of secondary overgrown quartz over a large size detrital quartz grain; perhaps deposition of sticky clay over the parts of larger detrital quartz grain prohibits growth of secondary quartz (DNR-61, Lower Conglomerate)

Plate III.9f  A tightly packed framework of quartz and feldspar grains; feldspars are under diagenetic alteration due diagenetic fluid movement, and the detrital quartz exhibits secondary overgrowth (Lower Conglomerate, DNR-61)
Plate III.10a A multi-layer growth of quartz over the detrital quartz  (Quartz Arenite, DNR-61)

Plate III.10b SEM photo showing secondary quartz overlay with sticky clay particles (Quartz Arenite, DNR-61)

Plate III.10c SEM photo shows a highly degraded feldspar grain (detrital) as well as secondary feldspar overgrowth (alkali) (Quartz Arenite, DNR-61)

Plate III.10d SEM photograph showing the growth of authigenic feldspar in the pore spaces of Upper Conglomerate; also seen in the photograph is authigenic clay (DNR-61)