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Petrography of the volcaniclastic of Quartz Feldspar-Porphyry (QFP) from Kadiri Anantapur District, Andhra Pradesh, India

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ABSTRACT

Quartz Feldspar Porphyry (QFP) occurs as volcaniclastics, located from Kadiri towards Hindupur that is due west has reflecting fining upward sequence, i.e., the size of the clast becomes smaller towards the west and finally ends up with the existence of rhyolite that is very occasionally porphyritic. Volcaniclast exhibits the impressions of the depressions caused by the fall of volcanic bombs. Kadiri Greenstone Belt indicates that there are intrusive granitoid. QFP has quartz and feldspars. The quartz appears to have two populations, viz., blue opalescent quartz and white quartz. The size of the blue quartz grades from 1mm to 12mm. Feldspars appears by the slight greenish tinge and also shows twinkling when the sample tilted against the sun. The Quartz feldspar Porphyry of Kadiri shows effect of tectonism and ductile deformation resembling Augen texture. Post-deposition structures are seen as micro faulting, where faulting has affected the individual minerals, and the matrix is seen filling the fracture grains.

Keywords: *QFP, volcaniclastic, K-feldspar, ductile deformation, micro faulting.*

INTRODUCTION

The QFP of the Greenstone belt of Kadiri is located in the topographical map of 57J/4 of Survey of India and is in between 14^0 06' 31" to 14^0 06' 31" North latitudes and between 78^0 07' 24" to 78^0 08' 17" on a scale of 1:50,000. The area is accessible from Pulivendla in the Kadapa district by an all-weather road. It is also accessible from Anantapur by road. The Renigunta-Pakala railway line passes through Kadiri making it easy to access. Further, the road leading to Hindupur from Kadiri passes through the area of study, making it easy to access. The Andhra Pradesh Road Transport Corporation runs a number of buses from many places to Kadiri. Another variety of Quartz Feldspar Porphyry (QFP) Maheswararao (2019) occurs as a dyke body intruding into the granitoid country, located near Namalagudi temple, on the way to Kadiri from Pulivendla.

An early account of the Kadiri Greenstone belt, King (1872) was the pioneer who considered the granitoids of the Kadiri area as a part of the Archaean Crystalline. Later, Foote R.B. (1888) included it under the Archaeans. Sampat Iyengar (1906) identified basic volcanic as amphibolites and the acid volcanic as sheared mylonitic gneiss. Rao (1983) studied the area critically, and he brought out the rock types like metabasalt, meta andesite, quartz-porphyry, quartz-feldspar porphyry, rhyolite, and rhyodacite, etc. Further, he recognized the cataclastic nature of the rocks and also identified a shear conglomerate that was mistaken to be a sedimentary conglomerate.

Kadiri Greenstone Belt is the northern extension of the world-famous Kolar Greenstone belt (known for gold mineralization) of the Karnataka State. This is located in the southeastern part of the Anantapur district and is named after the place called Kadiri. The northern part of this belt is unconformably overlain by the sediments of the Cuddapah basin. This belt is unique in many respects, as indicated below. It has an insignificant percentage of basic volcanic and has extensive acid volcanic and volcaniclastics (quartz-feldspar porphyry) with typical blue quartz (opalescent quartz) reflecting volcanic origin.

The volcaniclastic exhibit primary sedimentary features like cut and fill, as seen in the stream section on the way to Patnam and fining upward sequence in the area to the left of the road as one approaches the Kadiri town.

In the same area, a cone-shaped hole of various dimensions is seen. These holes reflect an acute angle. These are also noticed on the way to Kutagolla. It is opined that these represent the holes created by volcanic bombs falling with a trajectory creating holes with acute angles. Satellite image of the Kadiri belt is given as **Figure.1.** to reflect the regional set up of the belt. This belt represents the top of the Meta-Sedimentary Group of Anhaeusser et al. (1969). Kadiri Greenstone Belt is devoid of gold mineralization. No basal conglomerate is observed at the base of the oldest litho unit of the belt. On the other hand, the Peninsular Gneissic Complex is seen as an intrusive into the belt.

Geological background

The geological map of the Kadiri Greenstone Belt (Figure.1) is given for a better understanding of the general geological set-up of the area. Amongst all the Eastern Greenstone belts Kadiri belt (Figure. 1) has a special status. It is the only belt that shows a very lesser degree of basic volcanic compared to acid volcanics.

Rao (1983) carried a detailed investigation on the petrography of the Kadiri belt and identified the units like quartz porphyries, quart-feldspar porphyries. Further, he recognized the autoclastic nature of the Conglomerate near Patnam. Department of Geology of S.V.University, Tirupati, carried out research work on this belt. Padmasree (2001) doubtfully considered the gneissic basement to the belt. Hanumanthu and Padmasree (2003), Hanumanthu et al. (2008) expressed a similar view. Srinivasulu (2010) detailed two suites of TTG, one as a basement to the belt and the other as an intrusive. In the absence of any basement – cover relationship, it is difficult to accept the above-said views. Further, the field evidence in support of the TTG acting as a basement is also not advocated. All the granitoids noticed in and around the belt are intrusives into the Kadiri Greenstone Belt. Quartz veins are also identified, and these are 120m wide and are traceable for a distance of a few kilometers. The prominent trend is NW-SE.

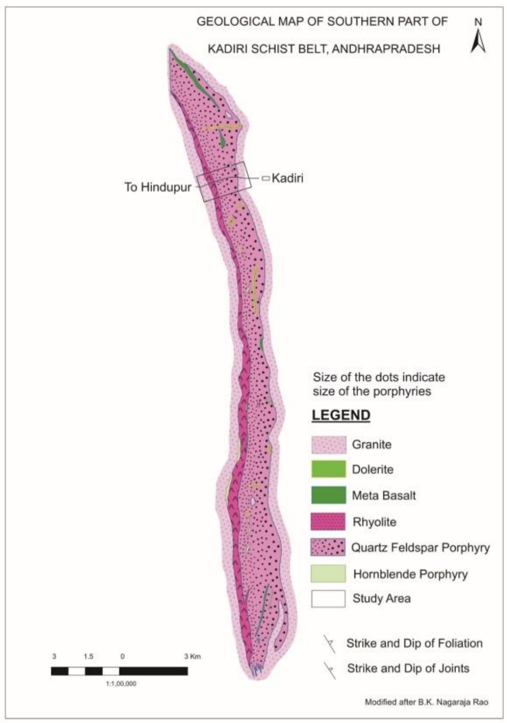

***Figure.1.*Geological map of the southern part of the Kadiri Greenstone belt.**

QUARTZ FELDSPAR PORPHYRY (QFP)

The main sequence of lithological units of the Kadiri Greenstone Belt in the younging direction is – Quartz Feldspar Porphyry indicating the fining upward sequence from east to west and the rhyolites that overlie the QFP.

Quartz Feldspar Porphyry (QFP) is a major lithological unit that covers nearly 65-70% of the total area of the Kadiri Greenstone Belt, as reflected in the geological map. The pyroclastic nature is very clearly reflected by the mineralogy, especially by the presence of opalescent quartz and quartz and feldspar with a sedimentary structure like fining upward sequence, cut, and fill the structure and cross-bedding, etc. This unit has suffered cataclastic deformation. Rhyolite is the topmost unit of the greenstone belt. On the fresh surface, it is honey and dark grey colored, as seen on the road section between Kadiri and Hindupur. Very rarely, the rhyolites exhibit porphyry of opalescent quartz.

The conglomerate noticed at the Nagireddipalle village is not a sedimentary conglomerate. It is mainly an autoclastic conglomerate. The characteristic features of this special type of conglomerate are matrix dominant and at places dominant clastic conglomerate. The matrix is a fine-grained QFP. The clasts are also of QFP. The clasts reflect the imbricate nature of disposition. If the clasts are reconstructed or reset into the original position, it clearly indicates a single lensoid body of QFP (Figure 2.a). This due to shearing (Figure. 2. b) got dismembered, i.e., a sort of brittle deformation and got fragmented. The matrix being very fine-grained got transformed into a plastic material with a certain amount of mobility.

The fragmented clasts were drifted to different positions due to the plasticity of the matrix giving rise to the texture of a conglomerate. Enlarged versions of the conglomerate are given as Figure 3-a & 3-b for better appreciation. As the origin is mainly shearing, it can be called "sheared conglomerate."

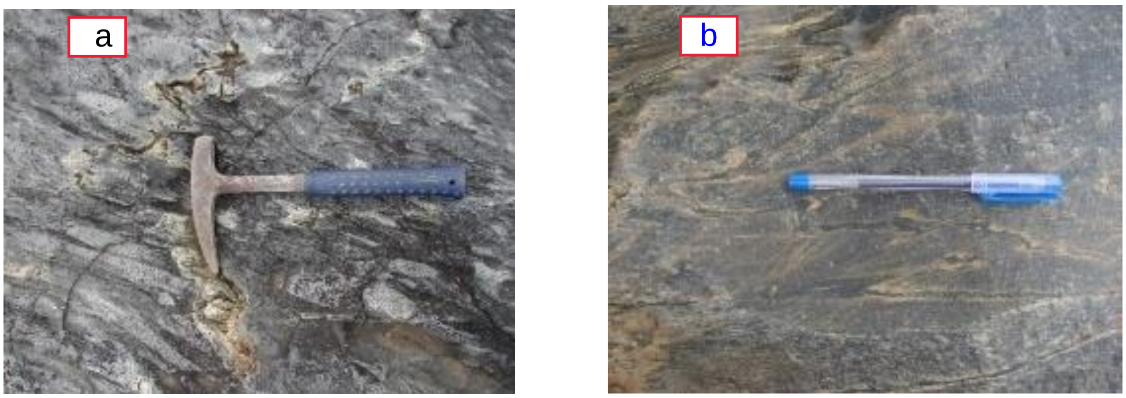

Figure.2. **a. Lensoid bodies of QFP in the sheer conglomerate. b. Shear sensors in the rock**

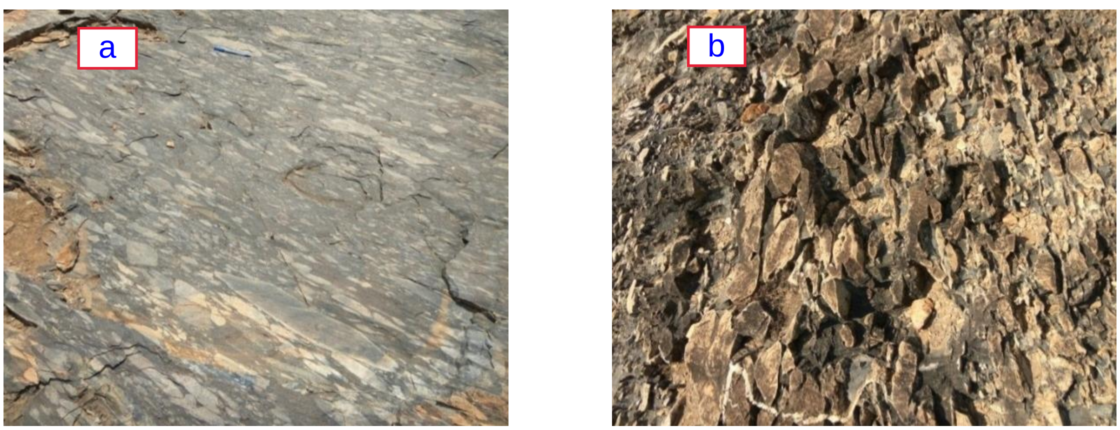

Figure.3. **a. The fragmentation is mainly due to shearing. Note the areas of clast dominant and Matrix dominant. b. The weathered surface of the conglomerate.**

The lowermost unit (Figure. 4) is designated as a unit -A. It has phenocrysts of blue opalescent quartz of the size ranging from < 1 cm to 2.5 cm. The presence of this type of quartz reflects volcanic origin. In addition, subhedral to anhedral clasts of white quartz are also seen. All the clasts show stretching indicating the effect of tectonism.

Further, up in the stratigraphy that is towards the west, the porphyroclasts are reduced in size, and the unit is designated as a unit -B. This unit reflects clear S_0 planes of very fine material alternating with the layers of porphyroclasts (Figure. 3 - 28). Within this unit, there are cycles of fining upward sequences. On the 'A.B.' plane, there are certain conical depressions of different magnitude, all aligned in one direction that is mostly towards the north. These may represent the impressions of volcanic bombs. The conical holes are all inclined at an angle of about 30^0 and taper down the inclination. These may be confused with current crescents, but they are not. This unit is overlain by the unit C- that has very fine-grained quartz and feldspar set in a matrix of the same plus a little of chloritic material. The S_0 planes can be recognized on the weathered surface only. This unit is, in turn, is followed by honey-colored rhyolite. It has occasional porphyries of opalescent quartz.

The stratigraphic sequence within the volcaniclasts is presented as Figure 4.

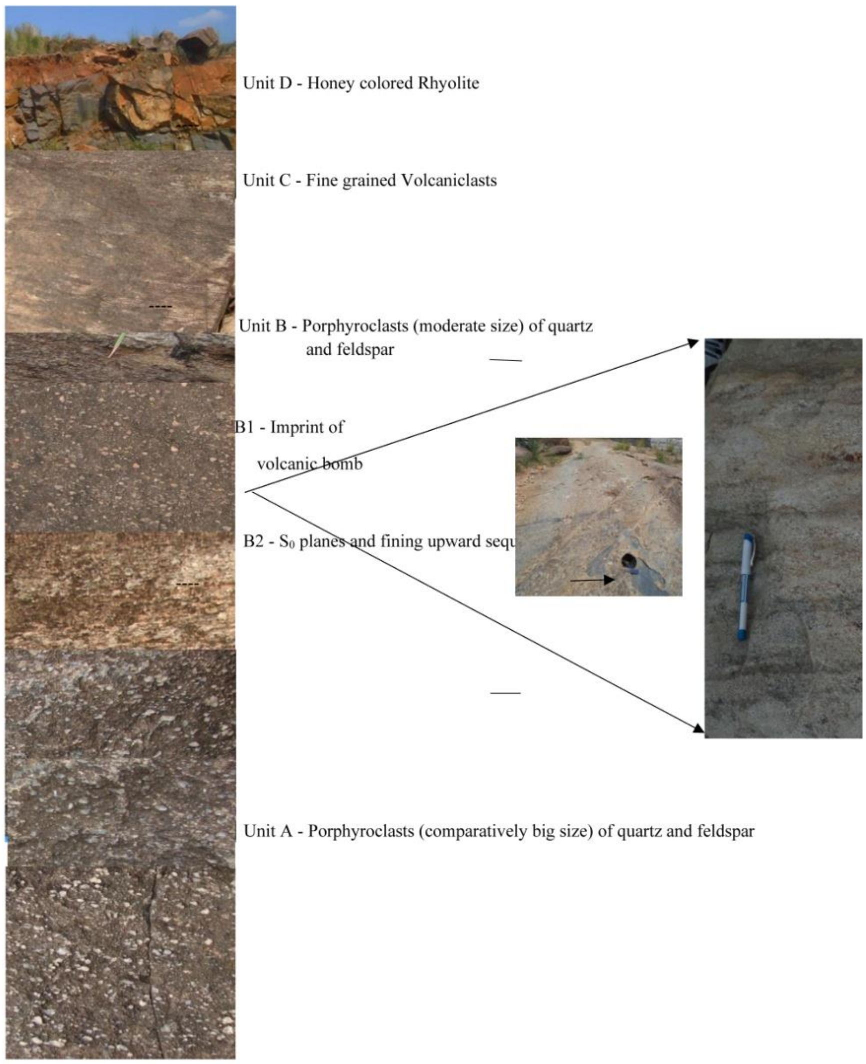

Figure.4. **Bouma log of a volcaniclastic sequence of Kadiri Greenstone Belt along Kadiri – Hindupur transect**

QFP of Kadiri Greenstone Belt

The QFP of the Kadiri Greenstone Belt reflects typical volcaniclastic features. The best transect to study the megascopic features is along the Kadiri-Hindupur road that exposes QFP and rhyolite as the major felsic units of the belt.

MEGASCOPIC CHARACTERS

The entire Kadiri - Hindupur transect covers nearly about 1200 meters exhibiting A-C units (Figure.4) of the QFP and, finally, the youngest unit represented by honey / black colored rhyolites. The porphyries in the QFP are mainly quartz and feldspar (both K- feldspar and plagioclase feldspar). The mineralogy and matrix of the unit are described below.

Quartz: This occurs as two styles of populations, viz., blue opalescent quartz, and white quartz. The percentage ratio between these two is 35**:**65, respectively. The size of the opalescent quartz will range from 1 mm to 12 mm and sometimes even more. The phenocrysts of this can be best seen in the lowermost unit-A (Figure.5-a).

Figure.5. **a) Blue opalescent quartz on the b) Blue opalescent quartz along with the fresh surface of QFP. White quartz on the weathered surface of QFP**

The quartz grains standout conspicuously on the weathered surface. Slight elongation of the grains can also be observed that have developed due to later tectonism. In this, the white quartz is slightly more in percentage than the blue opalescent quartz (Figure. 5- b).

Feldspars: On the fresh surface, the plagioclase can be identified by a slight greenish tinge. K. feldspar can be recognized by slight twinkling when the sample is tilted and exposed to sunlight. The feldspars can also be identified with the help of a pocket lens.

Matrix: Matrix is mainly brown in color, having fine crystals of quartz, feldspar, and dark micaceous minerals (chlorite). Careful observation indicates that the matrix veers around the clasts due to the effect of later tectonism. Towards the top stratigraphic horizon, i.e., towards the rhyolite end, the size of the clasts gets very much reduced, and it consists of very fine material of the above-stated minerals. The identification of individual clasts is difficult (Figure.6).

Figure.6. Very fine-grained Quartz Feldspar Porphyry

Microscopic Characters

Quartz: Quartz occurs in two styles, one is subrounded (Figure.7-a), and the other is elongated and spindle-shaped (Figure7-b) phenocrysts. The sub-rounded ones range from 5mm to 1c m along the longer axis. The elongated and spindle-shaped ones measure up to nearly 2 cm along the longer axis. These phenoclasts constitute about 10% to 50% of the thin sectional area. There are a few inclusions in the phenoclasts. These phenoclasts are characterized by the presence of minute fractures (Figure.7-c) and also exhibit wavy extension, both pointing to the tectonism that the rock has suffered. The effect of tectonism is further noticed by the presence of matrix/groundmass getting along the fracture planes (Figure.7-b). The margins of the phenoclasts are corroded due to the interaction between the matrix and the grain margin (Figure. 7 -d).

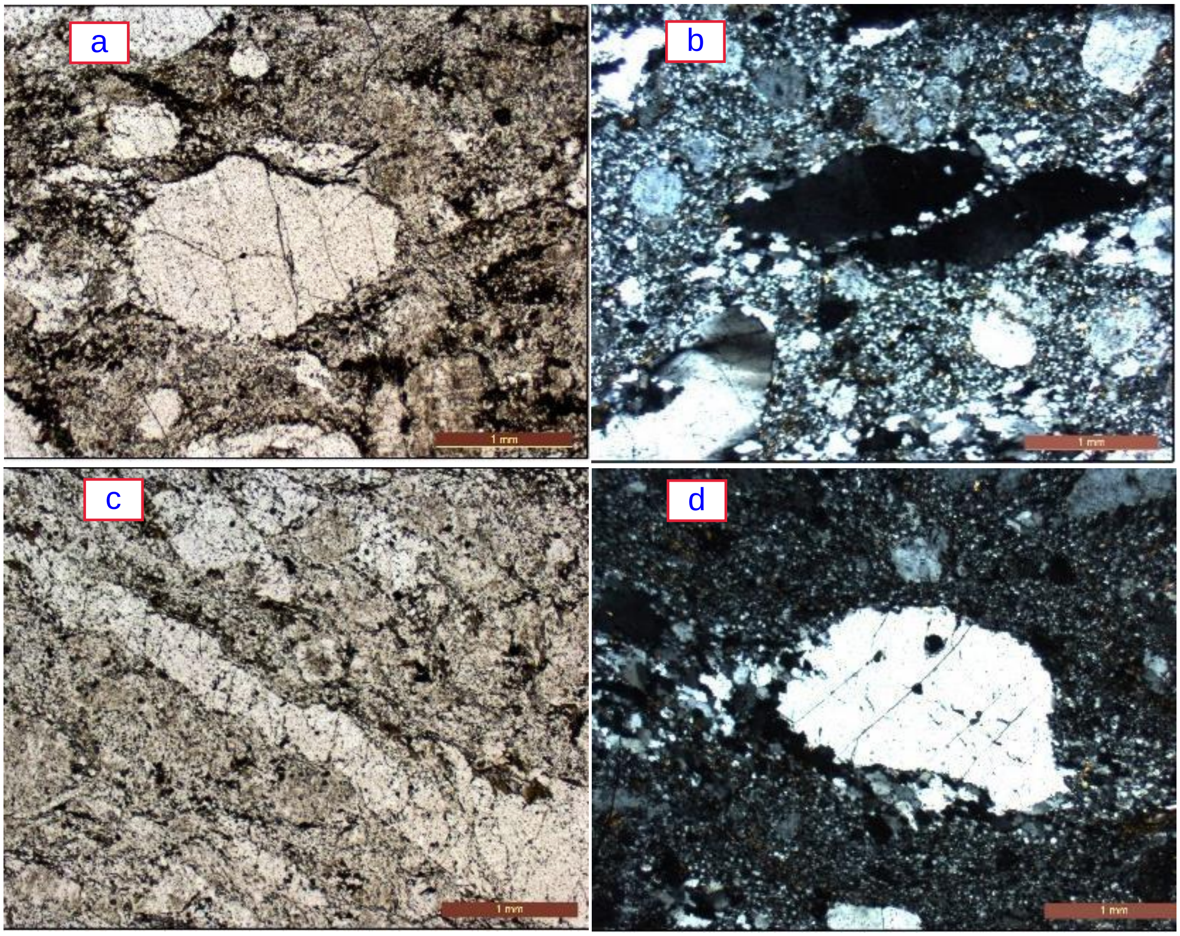

***Figure.7*. Two styles of quartz grains – Subrounded (a) and Spindle-shaped (b). A minor fracture in the quartz grains (c) and corrosive margins of the quartz grain (d). Note that these fractures do not extend into the matrix because of the plastic nature of the matrix. The grains show brittle deformation.**

Feldspars: Feldspars are present in moderate proportions occurring both as subhedral and anhedral grains and have undergone extensive alteration to sericite. The degree of alteration varies from grain to grain, as reflected by the figure number 8. The development of sericite/muscovite is also noticed along the margins (Figure. 8-a) and as inclusions in the grain. K-Feldspar shows Carlsbad twinning (Figure 8-b) with corroded margins with the matrix. In certain cases, partly serialized feldspar (Figure. 8-c) with the inclusion of plagioclase is also seen (Figure. 8-d).

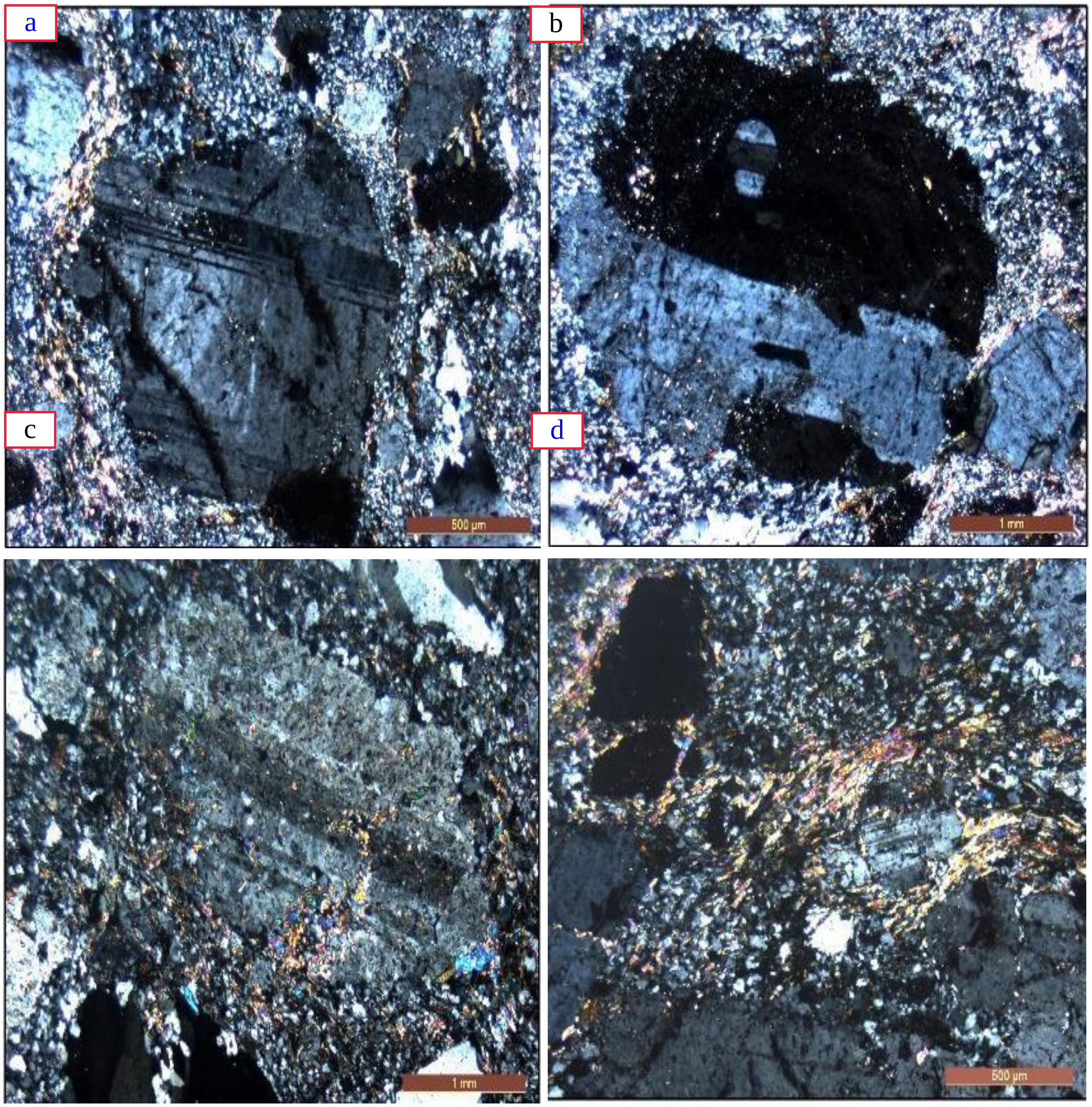

Figure.8.**Development of sericite and corroded margin (a) Carlsbad twinning in feldspar (b) Partly serialized feldspar (c) Sericite with the inclusion of plagioclase (d).**

Ground mass / Texture

The groundmass/matrix of the volcaniclastic of the Kadiri Greenstone Belt has mainly the fine-grained material of quartz and feldspar. In addition, sericite is the common mineral in groundmass. (Figure.9,a-c). Sericite is seen bordering the grains developing in the intergranular space (Figure. 9-d). Very little of chlorite is also observed. Further, groundmass has opaques (Figure. 9 - e) varying to different degrees in different thin sections and very less quantity of biotite and insignificant amount of calcite are also.

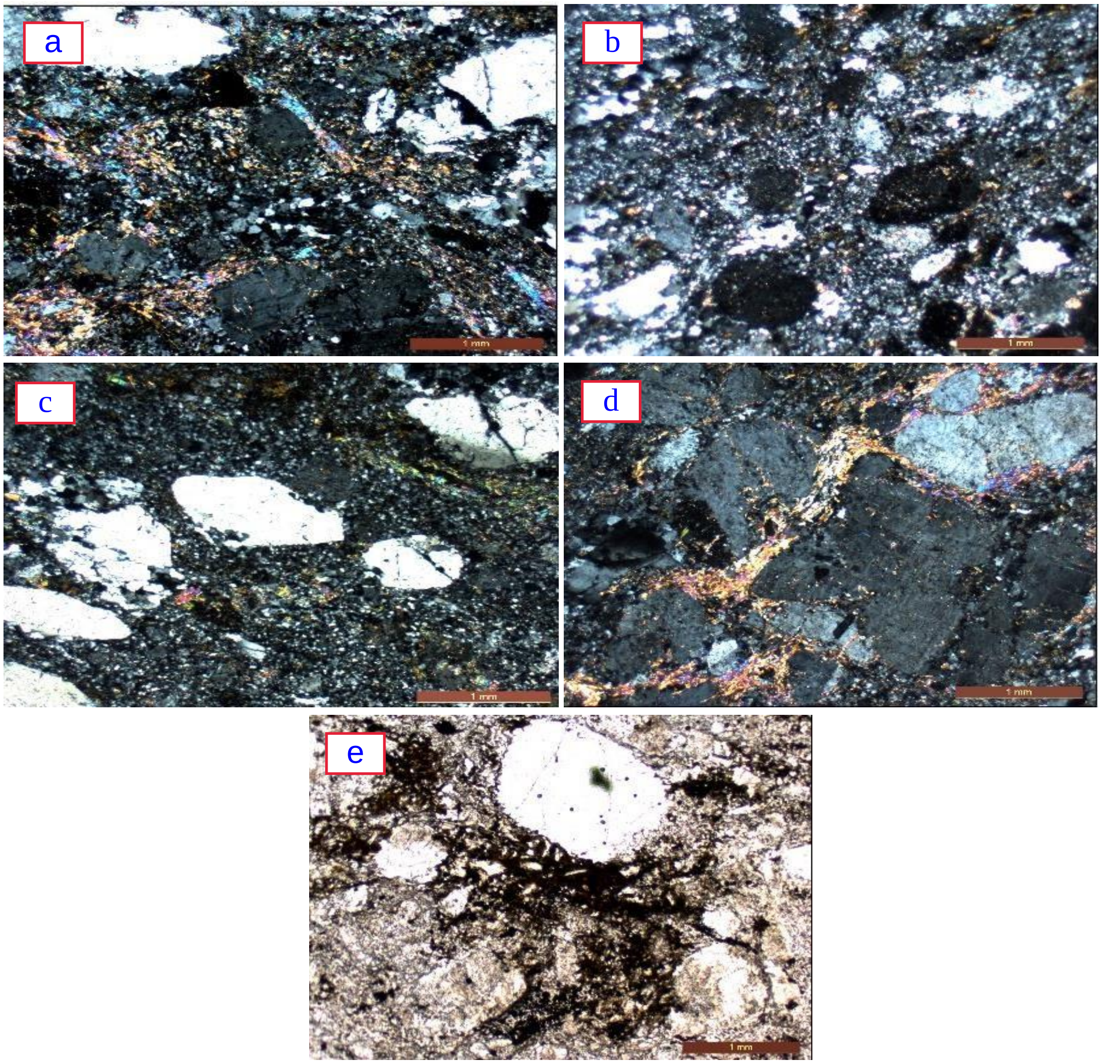

***Figure. 9.* a-c. Sericitised groundmass. Development of sericite in the intergranular space (d). Opaques in the groundmass (e).**

Texture

The study of textures is essential to understand the history of cooling and solidification (Bryon et al. 1995). The QFP of the Kadiri Greenstone Belt clearly reflects the effects of tectonism on it. The porphyroclasts of quartz and feldspar exhibit brittle deformation, whereas the matrix shows ductile deformation (Figure. 10- a & b). The porphyro / phenoclasts being rigid show a well-developed parallel fracture system more in the case of quartz. This is restricted to the clasts alone, and it does not extend into the matrix because of the plastic nature of the latter.

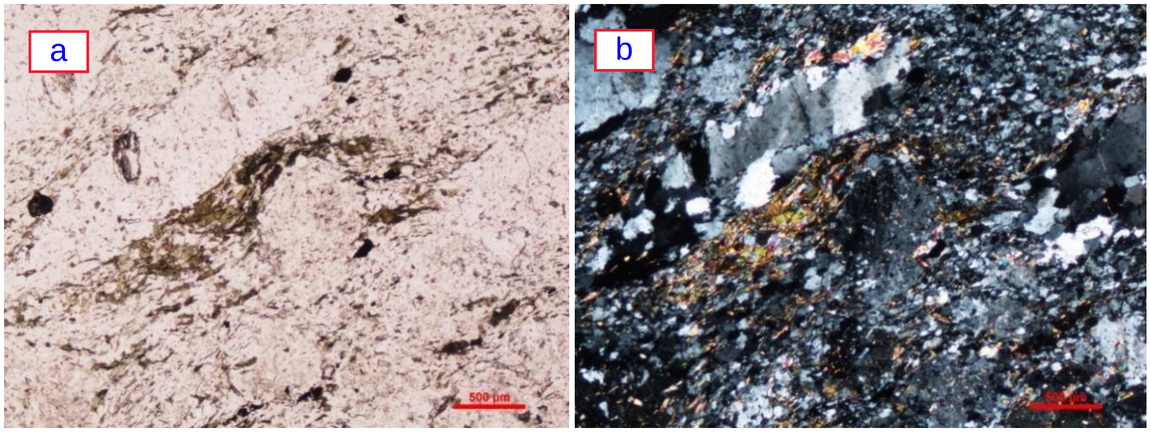

Figure. 10. a & b. **Fluidization of the matrix and the tectonic imprint that is seen and the development of mica between the quartz and feldspar porphyries under plane-polarized light (a) and the same under crossed Nicols (b)**

One of the quartz porphyry in the photograph (Figure. 11 - a & b) is highly crushed, reflecting the cataclastic nature. Under ordinary light fracturing within this is not seen clearly (Figure. 11- a), but under crossed Nicols due to cataclastic nature, this can be recognized easily (Figure. 11 - b). As in the other cases, the matrix between the porphyries are highly crushed and exhibit fluidity and the good development of mica in the rock.

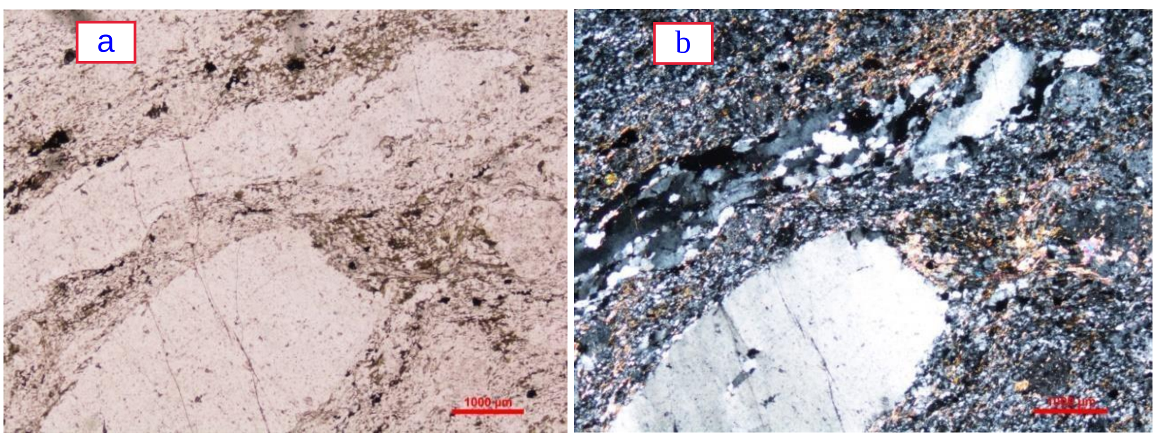

Figure. **11.a & b. Stretching of the porphyries and fluidization of the matrix with the crushing effect are conspicuously seen. (a) is under plane-polarized light and (b) is the same under Crossed Nicols.**

CONCLUSIONS

The study of the QFP has led to the following conclusions. It is a unique rock in the local geological set-up. In respect of the Kadiri Greenstone Belt, no basement could be observed. In other words, no basement-cover relationship could be recognized. Hence, the granitoids that occur around the greenstone belt is considered to be intrusive into the belt. Amongst the Eastern Greenstone Belts, Kadiri has a special status. It is the only belt that shows a higher degree of acid and Calc-alkaline components.

The QFP that occurs in the form of volcaniclastics covers the maximum area. The study of the transect from Kadiri towards Hindupur that is due west has reflected fining upward sequence, i.e., the size of the clasts becomes smaller towards the west and finally ends up with the existence of rhyolite that is very occasionally porphyritic. The volcaniclastic exhibit primary sedimentary structure like cross-bedding, cut and fill the structure and fining upward sequence, etc., pointing to its aquatic origin also, in addition to the volcanic source. The volcaniclastic are characterized by the presence of blue opalescent quartz that reflects the volcanic origin of the unit.

Texturally, the QFP of Kadiri shows the effects of tectonism and ductile deformation resembling the Augen texture. The cataclastic effect in the form of crushing of quartz grains is clearly observed.

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