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Petrography and Geochemistry of the Siliciclastic Gulcheru Quartzite of Papaghni Group from Cuddapah Supergroup: Implications for Source area Weathering and Tectonic setting.

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Abstract:
Field, petrological and geochemical studies was carried out for basal Gulcheru Quartzite of Papaghni Group from Cuddapah Supergroup relies that the sediments were derived from the moderate to intense weathering condition of source region. The geochemical classification of these sediments
Plotted in the field of arkose to sub arkose, Petrographic studies indicates the high relief weathered granitic source of the sediments. Tectonic setting discrimination diagrams showing from the Active to passive continental margin setting fields.
Keywords :
Cuddapah Basin, Gulcheru Quartzite, Papaghni Group.

1. Introduction

Geochemical studies of siliciclastic sedimentary rocks are primary tools for interpretation of sedimentation, environment of deposition, provenance and tectonic history [1,2]. Geochemical Provenance studies of siliciclastic sediments have clearly reached a significant level of sophistication and a lot of information can be proficient by careful observation petrographical thin sections. As far as sandstones are concerned significant attempt have been made to extract provenance information from compositional and textural features of sandstones [3]. A provenance and depositional environment studies was conducted using geochemical data integrated with petrographical features on the Paleo Proterozoic Gulcheru Quartzite expressing the depositional environment of these sediments are medium to intense weathering conditions. The major rock types are arkose to sub arkosic field.

2. Geology of the study of area

The southern India Proterozoic are recorded as a major sedimentary so called *Purana Basins,* (Holland, 1906) in these the second largest one is Cuddapah Basin is the well studied in all aspects. The crescent shaped intracratonic Cuddapah Basin (Fig. 1) occupies the major Proterozoic record in southern India. Proterozoic sedimentation starts with polymictic Gulcheru conglomerate, shale and quartzite intercalations [4]. Sedimentary cycling of arenaceous and argillaceous are major sequences of the all formations of Cuddapah Basin. Sedimentation in the Cuddapah Basin spatially distributed in four major sub- basins i.e Papaghni, Nallamalai, Srisailam and Kurnool-Palnad [4]. (Fig.1). Papaghni sub-basin consists Papaghni, Chitravati groups. Papaghni Group comprises basal Gulcheru Quartzite and Vempalle Formation. Chitravati Group started sedimentation with Chert pebble Pulivendla conglomerate; Quartzite follows thickest Tadpatri Formation,

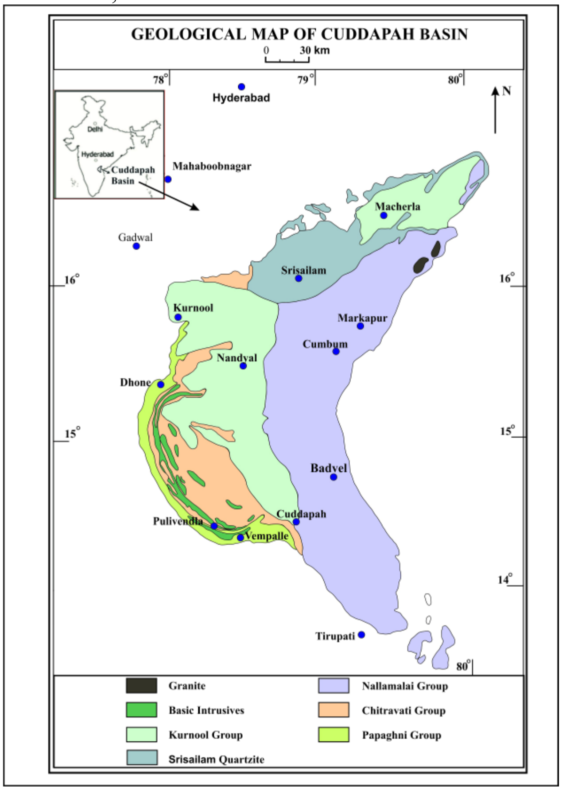

Figure-1. Generalized geological map of Cuddapah Basin showing various groups modified after [4].

contains shale quartzite and basic flows and sills and Gandikota Quartzite gradational contact with Tadpatri Formation [4]. Nallamalai Group contains Bairenkonda (Nagari) Quartzite and Cumbum (Pullampet) Formation. Gulcheru Quartzite considers the conglomerate, Quartzite with shale intercalations. Various depositional environments proposed by different workers follows i.e Pascoe (1973) [5] stated that it characterized an ancient

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shoreline, after the development of various sedimentological and extensive studies on Cuddapah Basin the environmental interpretations are changed based on observed evidences follows tidal environments are expressed by Nagaraja Rao et al., (1987) [4], fluvial and beach environments suggested by Dasgupta et al., 2005 [6] and Reddy et al., 1990 [7] respectively; an alluvial fan–braided stream–fan delta domain, a fan delta depositional realm was suggested by Lakshminarayana et al, (2001) [8] and Chaudhuri et al, (2002) [9] correspondingly. Chakrabarti and Shome (2009) [10] studies at the basal part represented a fan delta complex in a tide and wave dominated beach–shore face environment. The field studies and paleocurrent analysis studies of Goswami et al, 2017 [11] reflecting the shallow marine depositional environment. The review of literature of Gulcheru Quartzite the proper geochemical studies on this Formation not available. The basic importance of this study is fulfilling the geochemical evidences of the depositional environment of Gulcheru Quartzite. The quartzite of Gulcheru horizon generally fine to medium grained and thick bedded, (Fig. 2) flesh coloured purple, grey and white colour but due to weathering some samples show brownish in colour. Some looks like milky ones and the coarse grained types which have a sugary appearance. The quartzite of the Kadiri Ghat section becomes gritty with fragments of vein quartzite, chert and quartzite. Gulcheru Formation is traversed by a number of ENE-WSW to ESE-WNW trending strike faults as well as NE-SW trending diagonal, strike-slip faults and is intruded by E-W to ESE-WNW trending dolerite dykes (Basu et al., 2007) [12]. In the Dhone section the quartzite is light brown or buff coloured, fine to coarse grained and massive with vienlets of quartz traversing along joints. The quartzite near Parnapalli is more arkosic to sub arkosic and coarse grained in nature.

3. Petrography

The texture of this quartzite can readily be identified as matrix supported. Cementation is good and the grains cannot be easily disaggregated. The framework constituents consisting mainly of quartz, feldspar and rock fragments exhibiting floating texture (Fig. 4 a). Quartz is the most abundant mineral varying between 80 to 85%. The grains are anhedral, mostly rounded to sub-rounded few grains are angular to sub-angular (<4%). Quartz is represented by monocrystalline, polycrystalline and secondary quartz varieties (Fig. 4 b). Monocrystalline variety constitute about 80%, polycrystalline variety of quartz is seen as semi composite to composite grains with sutured, planar, concavo-convex contacts (Fig. 4 c).

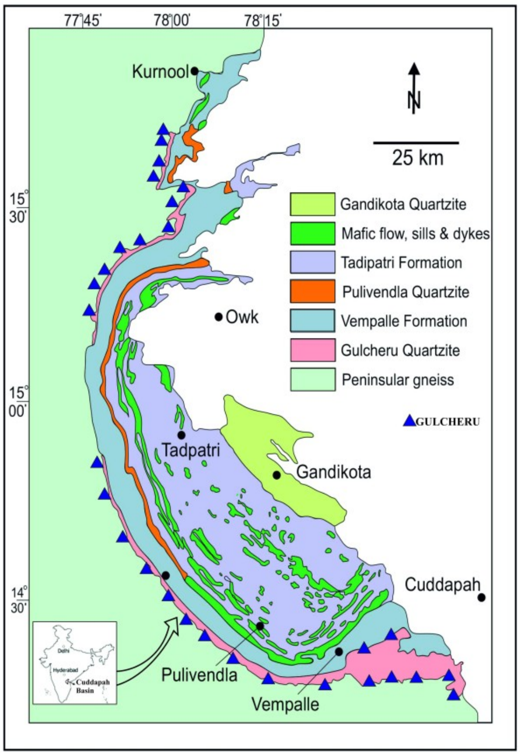

Figure-2 generalized geological map of Papaghni sub- basin showing sample locations modified after Saha et al.,2012.

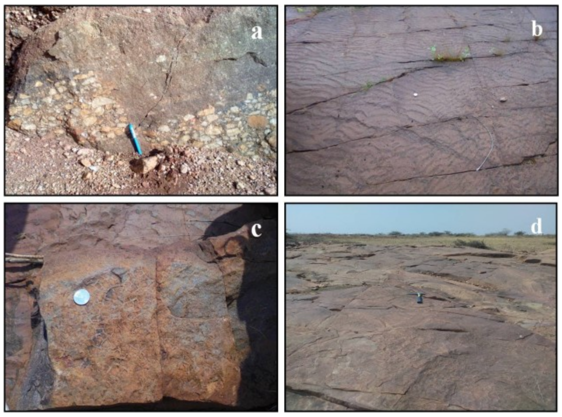

Figure-3 field photographs of Gulcheru Quartzite showing chert pebbles (a), Ripple marks (b), Mud cracks (c) and massive quartzite (d).

The mineral exhibits undulose extinction and some of the grains are fractured. Dusty appearance, secondary overgrowth and corroded grain margins are common (Fig. 4 d). Some of the grains show inclusions of zircon and opaques (Fig. 4 e). Feldspar (3 to 10%) occurs as prismatic and tabular grains

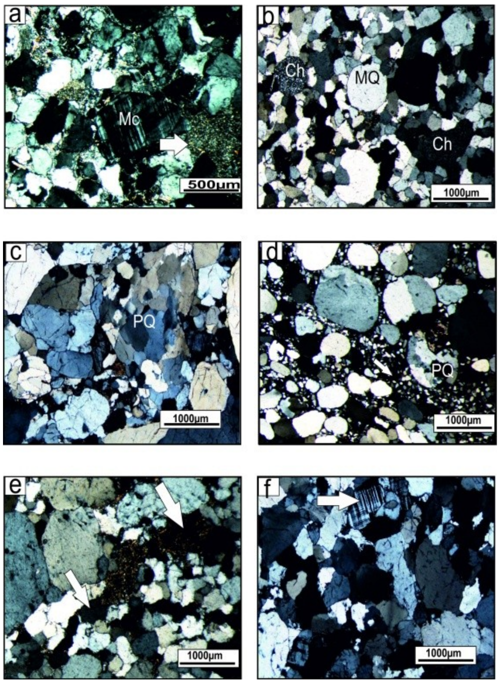

Figure-4. Micro photographs of Gulcheru Quartzite.

(Fig. 4 f). These are represented by potash as well as sodic feldspar and mostly altered. The rock fragments are mainly quartzite. Matrix comprises silica, muscovite, sericite, calcite and chlorite as the framework ingredient. The Gulcheru quartzite is mainly arkose, sub-arkose type.

4. Major Oxides

The geochemical data of the Gulcheru Quartzite presented in Table 1. The quartzites showing enrichments in SiO_2 ranges 75-89 (avg. 85) and depleted in other major oxides. The correlation between SiO_2 with other major oxides showing negative indicates the SiO_2 enrichment and controlling the mineralogy of these sediments. Al_2O_3 ranges 7-13(avg. 8); and it is showing positive correlation with other major oxides except Na_2O (r=-0.09). The positive correlation indicates that the clay minerals are major controlling. Fe_2O_3 (total FeO) ranges 0.01-8 (avg.1.19); MnO ranges are <0.001 in all studied samples; MgO ranges 0.01-2.97 (avg.0.5); CaO ranges 0.04- 0.77 (avg.0.15); Na_2O ranges 0.02-1.24(avg.0.32); K_2O ranges 1.62-8.85 (avg.3.19);TiO_2 ranges 0.0-0.38(avg. 0.09); generally low Ti values indicate that the involve ascendancy of felsic material in the origin and less P_2O_5 ranges 0.0-0.42 (avg.0.05).

The K_2O/Na_2O values of the samples show wide variation 2.77–88.0 with very high average value 45.34 compared to the PAAS 3.08. Enrichment of SiO_2 compared to Al_2O_3 and TiO_2. The low SiO_2/Al_2O_3 ranges 5.49- 11.32 (avg. 9.81) and the high Al_2O_3/TiO_2 values 25.39-796 (avg. 300.92) ratios, respectively. K_2O/Al_2O_3 values ranges from 0.20-0.64 (avg.0.34) indicates more K-Feldspar in studied samples than plagioclase. Major oxide geochemical classification diagram of Pettijohn, 1987 (14) (Fig. 5) the studied sediments plotted in the field of arkose to sub-arkose.

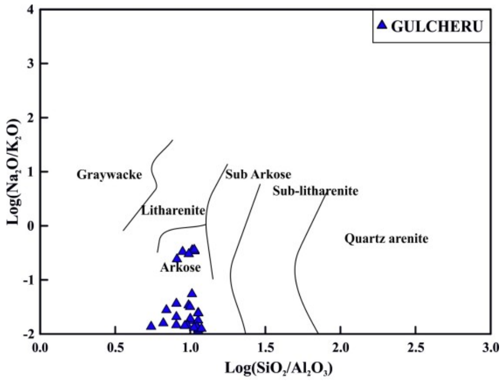

Figure-5. Geochemical classification of Gulcheru Quartzite after [3]

5. Discussion

5.1. Paleoweathering

The Chemical Index of Alteration (CIA) [13] of the samples range between 66 and 86 (Avg.73). The CIA values indicate derivation of the sediments from a moderately to intense chemically weathered terrane. The well-rounded quartz and feldspar grains observed in majority of Quartzite samples of the Gulcheru Formation point out that the extra-basinal component of these sediments was a texturally mature arkose to sub-arkose. Folk (1980) suggests that the latter indicates tectonic quiescence, dry climate, and beach or shallow marine environments.

A-CN-K plot (Fig. 6) along CIA values of Gulcheru Quartzite indicates that the sediments of studied area were moderate to intense weathering and plotted in the field of A-K line near A-apex near illite region and the source region was suffered from moderate to intense weathering conditions.

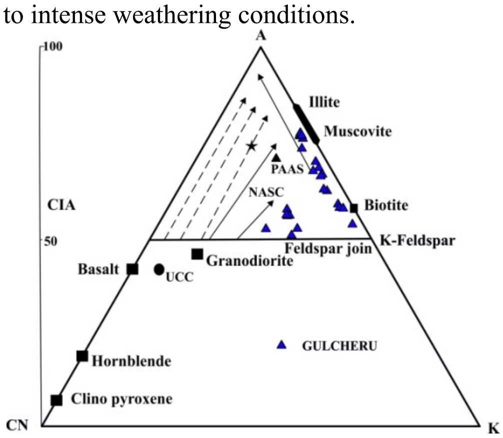

Figure- 6. A–CN–K Ternary diagram of molecular proportions of Al_2O_3 -(CaO+Na_2O)- K_2O for the Gulcheru Quartzite after [13]

The Index of Compositional Variability:

ICV may be applied to sediments as a measure of compositional maturity. It is formulated as given bellow.

[$ICV=(Fe_2O_3+K_2O+Na_2O+CaO+MgO+MnO+TiO_2)/Al_2O_3$]

ICV measures the abundances of alumina relative to the other major cations in sediments. Silica is excluded to remove problems of quartz dilution. The higher values of ICV indicates the presence of higher amount of clay minerals, higher proportion of Al_2O_3 Compositionally immature sediments that contain a higher proportion of non clay silicate minerals, or that are rich in clay minerals such as montimorillionite and sericite will have high values of this index. The ICV index for Gulcheru Quartzite ranging from 0.24 to 1.59 (avg.=0.59). The lower values of ICV (<1) indicate that they are compositionally mature sediments, poor in non clay silicates or dominated by minerals such as those of the clay family that have low values and possibly derived from a tectonically quiescent or cratonic environments [14] and sediment recycling is active, produced by intense chemical weathering of first cycle material [15]. The K_2O/Al_2O_3 ratio may suggest how much alkali feldspar vs. plagioclase and clay minerals were present in the original rocks (Cox et al., 1995). The K_2O/Al_2O_3 ratio decreases from alkali feldspar (≈0.4-1), illite (≈0.3) to other clay minerals (≈0) (Cox et al., 1995). Sediments with K_2O/Al_2O_3 ratio greater than 0.5 suggest a significant quantity of alkali feldspar relative to other minerals in the original source, while sediments with ratio less than 0.4 suggest minimal alkali feldspar in the source [16].

All the Gulcheru Quartzite samples have K_2O/Al_2O_3 ratio around 0.2 (< 0.4), thus indicating minimal alkali feldspar in the source rock of these sediments and in turn presence of plagioclase oriented rocks.

5.2. Tectonic setting

Discrimination function diagram (Fig. 7) of Bhatia, 1983[2] using major oxides the studied sediments plotted in the field of active to passive continental margin setting fields. Bivariate plot of TiO_2 vs. (Fe_2O_3+MgO) (Fig. 8) for tectonic discrimination (after Bhatia, 1983) the studied sediments plotted in the field of active to passive margin setting fields.

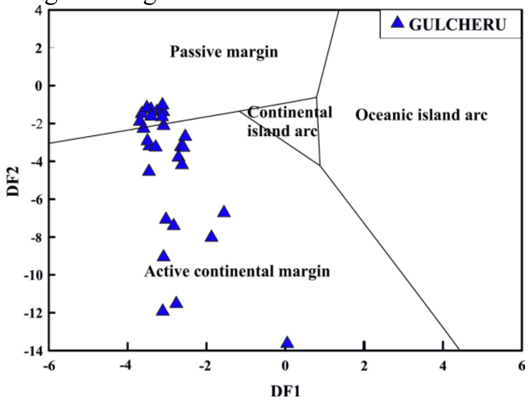

Figure-7. Tectonic discrimination function diagram for Gulcheru Quartzite after [2]

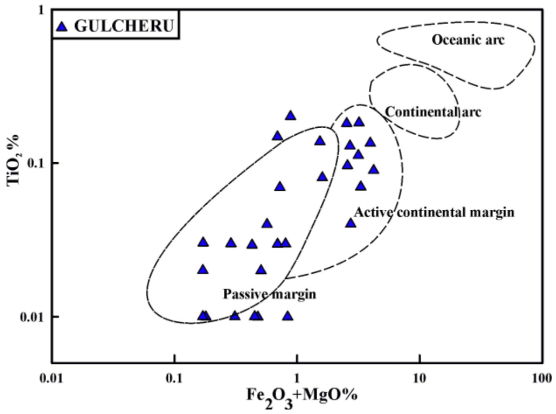

Figure-8. Major oxide Tectonic discrimination function diagram for Gulcheru Quartzite after [2]

Table-1 major oxide data of Gulcheru Quartzite.

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LOI	CIA	ICV
CQ2-15	76.71	8.64	8.48	0.01	0.77	1.07	3.23	0.19	0.42	0.49	63.00	1.59
CQ3-15	85.31	8.00	0.41	0.02	0.07	1.11	3.16	0.03	0.02	1.87	64.82	0.60
CQ15-15	87.00	8.44	0.01	0.01	0.04	1.11	3.12	0.00	0.03	0.24	66.38	0.51
CQ17-15	79.82	9.80	2.37	0.65	0.33	1.13	4.69	0.27	0.17	0.77	61.45	0.96
CQ19-15	86.72	8.13	0.28	0.01	0.05	1.11	3.26	0.03	0.02	0.40	64.81	0.58
CQ20-15	86.38	8.13	0.67	0.02	0.06	1.14	3.16	0.03	0.03	0.39	65.11	0.62
CQ21-15	82.41	8.44	2.84	0.07	0.25	1.24	4.13	0.13	0.13	0.36	60.03	1.03
IA13-73	77.24	9.57	6.28	0.95	0.22	0.06	4.06	0.38	0.10	1.14	68.78	1.25
CQ1-16	87.02	8.57	0.31	0.50	0.11	0.05	2.84	0.03	0.01	0.57	74.08	0.45
CQ2-16	87.00	8.70	0.09	0.42	0.11	0.06	3.13	0.02	0.01	0.47	72.51	0.44
CQ3-16	79.27	11.43	1.77	0.97	0.13	0.16	5.79	0.04	0.02	0.43	65.27	0.78

CQ4-16	86.43	8.88	0.15	0.54	0.11	0.11	3.19	0.15	0.01	0.43	72.24	0.48
CQ5-16	85.41	8.57	1.03	0.50	0.18	0.09	2.78	0.14	0.04	1.26	73.75	0.55
CQ6-16	82.08	10.16	0.93	0.67	0.16	0.11	5.34	0.08	0.05	0.41	64.42	0.72
CQ7-16	80.83	10.00	1.23	2.97	0.19	0.15	4.10	0.09	0.06	0.38	69.26	0.87
CQ9-16	77.53	11.73	1.27	2.04	0.14	0.10	6.33	0.07	0.03	0.76	64.12	0.85
CQ10-16	75.48	13.75	0.45	0.43	0.18	0.12	8.85	0.20	0.07	0.46	60.04	0.74
CQ12-16	85.84	8.37	1.37	1.48	0.11	0.11	2.01	0.23	0.02	0.46	78.96	0.63
CQ13-16	88.79	7.88	0.33	0.40	0.10	0.02	1.74	0.07	0.02	0.65	80.89	0.34
CQ14-16	89.70	7.96	0.11	0.06	0.09	0.03	1.69	0.03	0.00	0.33	81.46	0.25
CQ15-16	89.90	7.94	0.12	0.06	0.09	0.02	1.62	0.01	0.01	0.23	82.13	0.24
CQ16-16	89.75	7.96	0.25	0.06	0.09	0.02	1.62	0.01	0.00	0.25	82.13	0.26
CQ17-16	89.51	7.93	0.40	0.08	0.09	0.04	1.63	0.01	0.01	0.30	81.81	0.28
CQ18-16	89.39	7.90	0.48	0.09	0.10	0.04	1.64	0.04	0.01	0.31	81.57	0.30
CQ19-16	89.60	7.93	0.40	0.05	0.09	0.02	1.64	0.01	0.00	0.25	81.90	0.28
CQ24-16	89.86	7.94	0.02	0.15	0.09	0.02	1.63	0.01	0.01	0.27	82.01	0.24
CQ25-16	84.04	9.14	1.94	0.87	0.12	0.04	2.80	0.16	0.02	0.87	75.53	0.65
CQ26-16	89.84	7.94	0.02	0.15	0.09	0.02	1.62	0.02	0.01	0.30	82.09	0.24
CQ31-16	89.11	7.89	0.64	0.20	0.09	0.02	1.68	0.01	0.01	0.36	81.55	0.33

6. Conclusions

Primary sedimentary structures on Gulcheru Quartzite like ripple marks, mud-cracks, cross bedding indicating that the sedimentary environment of Gulcheru Quartzite was shallow marine environment. Petrographic studies of Gulcheru Quartzite well rounded, moderate to well-sorted quartz grains, suggests the source region was rapid uplifted granitic composition. Major oxide sandstone classification diagram of Gulcheru Quartzite plotted in the field of arkose to sub- arkose. Tectonic discrimination diagrams using major oxides suggesting that the Gulcheru Quartzite shows in the fields of Active to passive continental margin setting fields, indicating at the time of sedimentation tectonically controlled with multiple cycles of basement uplift and erosion during the basin opening stage, initially active rifting and gradually converting to passive margin settings. A-CN-K diagram reflecting that the Gulcheru Quartzite suffering moderate to intense weathering conditions.

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