"What stuff 'tis made of, whereof it is born, I am to learn."

WILLIAM SHAKESPEARE

PROVENANCE 7

CHAPTER 7
PROVENANCE

GENERAL

"Provenance concerns the location of the source area from which detritus was derived, identification of the rock types exposed in the source area and an interpretation of the climate and relief of the source" (Mc Bride, 1968). Climate during the Lower Gondwana and relief of the source area, inferred from the detrital modes of Lower Gondwana sandstones, have already been discussed in the previous chapter. In this chapter petrographic and mineralogical characters of various Lower Gondwana rock units of the study area have been supplemented with field and palaeogeographic evidences to bring out the location and rock type of the source area.

HEAVY MINERAL ASSEMBLAGES

Representative two to five samples from distinct horizons within different formations were subjected to heavy mineral analysis by following gravity separation method in bromoform as suggested by Carver (1971). Results of the analysis indicate that the quantitative distribution of heavy mineral assemblages in different formations are fairly uniform with very minor variations. The heavy mineral suite is characterised by ubiqutions dominance of garnet which comprises 90 to 95 % of the total population of heavies. Opaques, Tourmaline, Zircon, others (unidentifiable) and monazite make up the result in decreasing order of abundance (Table 7.1).

Table 7.1 : Distribution of Heavy Minerals (Value are in per cent).

Formation	Garnet	Opaques	Tourmaline	Zircon	Monazite	Others
Kamthi	92.2	3.2	2.1	0.6	0.7	0.9
Barren-Measures	93.2	3.7	2.1	0.4	0.2	0.5
Barakar	94.7	4.5	0.2	0.3	0.2	0.2
Talchir	90.2	7.3	0.8	0.8	0.6	0.4
Average	92.57	4.67	1.3	0.52	0.42	0.5

PEBBLE LITHOLOGY AND DETRITAL MINERALOGY

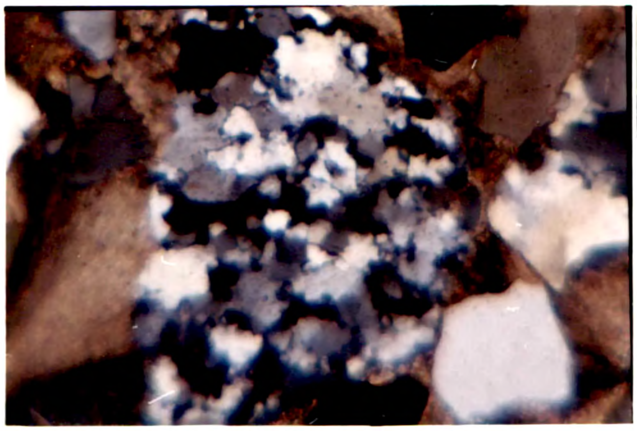
The boulder bed and diamictites of the Talchir Formation consists of pebbles and clasts of granitic and gneissic rocks, pegmatite, ultrabasic rocks, quartzites, limestones, chert, mica-schists and sandstones (Plate 7.1, 7.2, 7.3). Such a varied assemblage of rock fragments are megascopically absent in the succeeding deposit of Barakar, Barren Measures and Kamthi formations. Microscopic examination of the sandstones of these formations, however, indicate abundance of a variety of polycrystalline quartz (e.g. stretched, equant, polygonised, etc.) of which, those having size greater than 1000 M, represent fragments of high grade metamorphic rock (Wilson, 1973). Detrital mineralogy, represented to a large extent by Q : F : R ratio, shows minimum variation among various formations of Lower Gondwana Group.

INTERPRETATION AND DISCUSSION

From the examination of distribution of various diagnostic minerals and pebble clasts, it becomes apparent that the provenance of Talchir sediments were more varied and areally more extensive than those of the post-Talchir Lower Gondwana (PTLG) deposits. Relative absence of unstable megaclasts of Proterozoic sedimentaries and other rocks in the younger Lower Gondwana formations, which were dominantly deposited in fluvial system, can be attributed to the following reasons:

* The mechanical (transit) stability of labile rock fragments like dolerite, mica-schist, limestone being much less stable than granitic or gneissic fragments, are unlikely to survive in a long fluvial transport.
* The erosive action of a glacier, characterised by rafting and plucking, being more powerful than that of a fluvial current, is likely to derive more assemblages of detritus from the source area.
* Presuming that most of the river courses through uplands, bordering the area of deposition, had already been incised by the glacial trunks, it can be inferred that relatively lesser fresh incisive actions by the fluvial currents were in operation during Barakar, Barren Measures and Kamthi (Lower and Middle) sedimentation.

Plate 7.1-7.4	**Photomicrographs depicting various detrital grains in Lower Gondwana sediments.**
Plate 7.1	Quartzite rock fragments in Barakar Sandstone (75X; Crossed Nicol)
Plate 7.2	Gneissic rock fragments in Barren Measures Sandstone (75X; Crossed Nicol)
Plate 7.3	Garnet in Barren Measures Sandstones (75X; PPL)
Plate 7.4	Tourmaline in Barren Measures Sandstones (75X; PPL)



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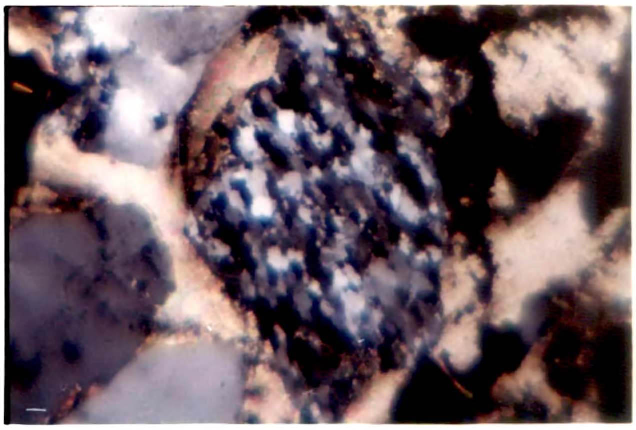

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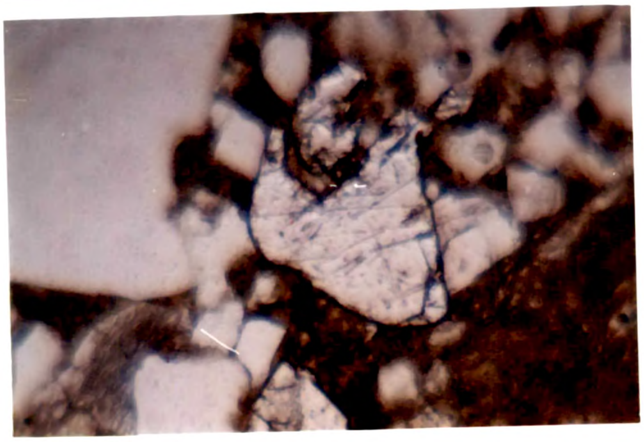

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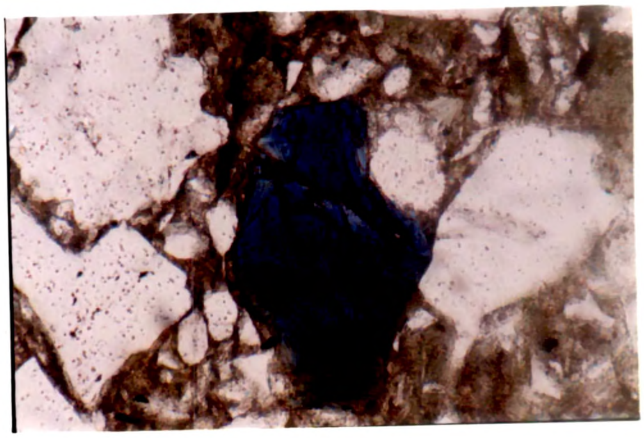


7.4

During the post-Talchir Lower Gondwana (PTLG) sedimentation, commencement of NNW-SSE syn-sedimentational faulting, mainly along the basin boundaries imparted a linearity to the basin. This factor coupled with the variation in degrees of maturation of various source land topographies led to a more restricted provenance areas for the PTLG sediments. Plot of samples of Barakar, Barren Measures and Kamthi (Lower and Middle) formation in the quartz typology diamond diagram of Basu, et. al., (1975) points to a plutonic provenance for these sediments (Fig. 7.1 a,b,c). This factor in conjunction with the nature of polycrystalline quartz, abundance of k-feldspar fresh and presence of heavy minerals like garnet, tourmaline (Plate 7.4), zircon and monazite suggest a granitic or granitic-gneissic terrain as a possible source area for Barakar, Barren Measures and Kamthi sands of the study area.

Present day morphotectonic map of the P-G basin and surrounding areas (Fig. 7.2) shows that during the Lower Gondwana sedimentation the basin was flanked on the western and eastern sides by Peninsular granite-gneiss of Dharwar Craton and Bastar Craton respectively. Towards the present day south-southweastern side of the basin was bounded by Dharwar meta-sediments and Eastern Ghat complex respectively, the latter being composed of garnetiferrous quartzites, charnockite and khondalite suite of rocks.

From the distribution of above rock types, it can be inferred that the PTLG sediments, showing a distinct granitic-gneissic parentage could have been derived from either the Dharwar Craton or from Bastar Craton or from both. Nature of basement rocks underlying the Proterozoic sedimentaries on the western and eastern flanks of the basin points to the fact that the western margin basement rocks belonging to the Dharwar Craton are k-rich granites while those adjoining the eastern margin and belonging to Bastar Craton are essentially the Na-rich tonalites (T. Srinivasa Rao, 1996). The negligible amount of Na-feldspars in the PTLG sandstones point to the influx of the detrius is more from the western part i.e. Dharwarian craton.

Slow syn-sedimentary NNW-SSE faulting,(which become more pronounced at the end of the Lower Gondwana sedimentation) manifested in the form of present day Albaka scarp along the eastern margin can be regarded as the factor responsible for the absence of systematic distribution of Lower Gondwana sediments, derived from the Bastar craton, in the eastern part of the

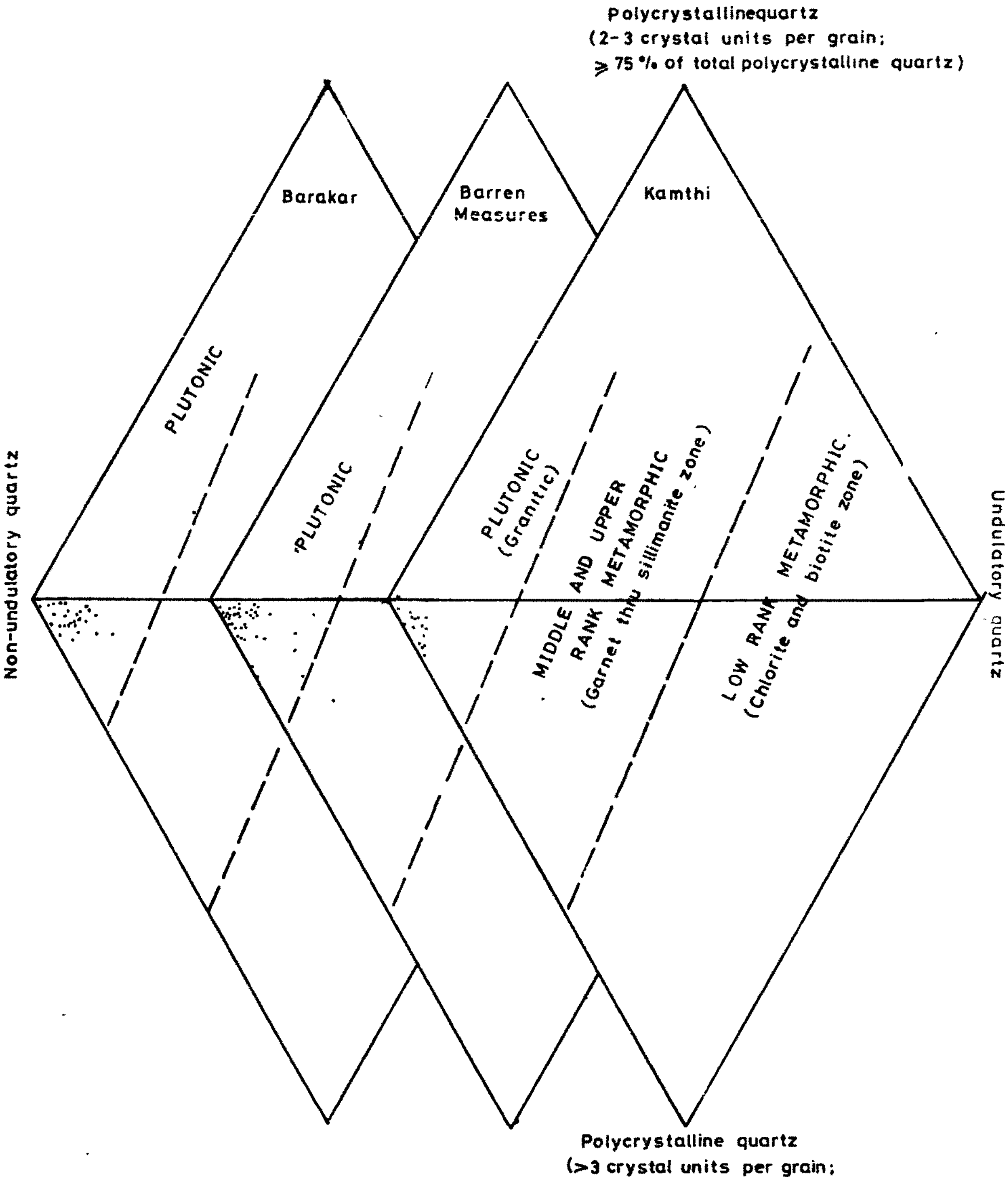
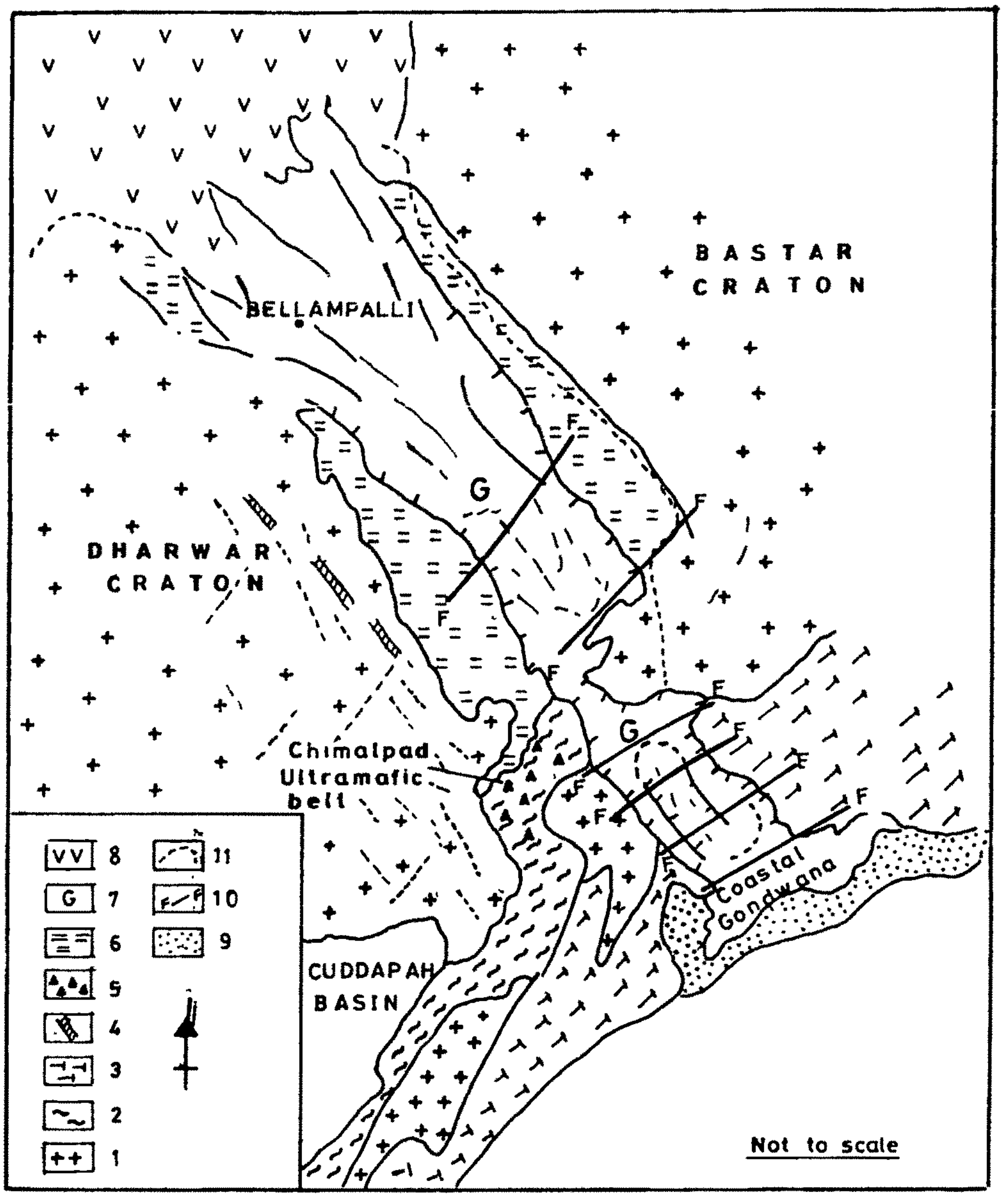


Fig.7.1: Quartz typology **Diamond** Diagram indicating a plutonic (granitic) provenance for post-Talchir Lower Gondwana sediments.

(After Basu et. al 1974)



1.Peninsular Gneissic Complex 2. Dharwar Schist Belt 3. Eastern Ghat Complex 4.Granulite Belt 5. Ultramafic Intrusives 6. Proterozoic sediments 7. Gondwanas 8.Deccan Volcanics 9. Tertiary Rocks 10. Fault 11. Structural trends.

Fig. 7.2: Morphotectonic framework of Pranhita-Godavari Gondwana Basin and its adjoining areas.

basin axis. However, a narrow strip of Upper Kamthi rocks resembling fanglomerate deposits, is seen abutting against the eastern boundary Pakhal rocks, between Venkatapur and Cherla. From the westward decrease in the incidence of pebbles, Srinivasa Rao, et. al., (1979) suggested an easterly source for these deposits. It is envisaged that similar development of fanglomerate, which resembles piedmont deposits of a fault-bounded basin (Shelly, 1976) must have taken place along the eastern margin of the margin during the Lower Gondwana time, their lack of exposures being attributed to the concealment by Upper Gondwana rocks.

Ternary plots of Quartz, Feldspar and Rock fragments proposed by Dickinson and Suzek (1979) to find out the generic nature of sandstone provenance has been used in the present study. Plot of samples of all formation in the ternary plot (Fig. 7.3 a, b, c) shows that the source materials of the Lower Gondwana sandstones were derived from non-orogenic continental blocks, which in the present case, refers to Dharwar craton. The plot shows that majority of the samples were derived from the exposed shield areas of the craton interior i.e. beyond the areas of basin boundary. Few samples (15% of Barren Measures and 3% of Barakar) falling in the transitional area between the zones representing craton interior and uplifted basement (in the plot) represents sediments derived from the cratonic flank bordering the uplifted western basement margin of the Lower Gondwana basin. Absence of any samples in the 'recycled orogen' zone of the plot highlights the fact that the Eastern Ghat Highlands, which evolved due to the collision and subsequent subduction of the Dharwar-Bastar crotonic pair beneath the Eastern Ghat Mobile Belt during early Proterozoic (Chakrabarti and Chakrabarti, 1996), was not a prominent contributes of the Lower Gondwana sands of the study area. This inference partly agrees with the studies of Rammohan Rao, et. al., (1996), who, based on the absence of sillimanite and low proportion of garnets in the Gondwana sands of Chintalpudi sub-basin, have rather categorically ruled out the possibility of Eastern Ghat Highland serving as a source area for Gondwana sediments in that part of the basin.

Absence of sillimanite, which is very characteristic and dominant mineral of high grade metamorphic suite of Eastern Ghat rocks, in the heavy mineral assemblages from different parts of the basin (Sinha and Ramanamurthy, 1979; Srinivasa Rao et al, 1979; Rammohan Rao, et. al., 1996; the present study)

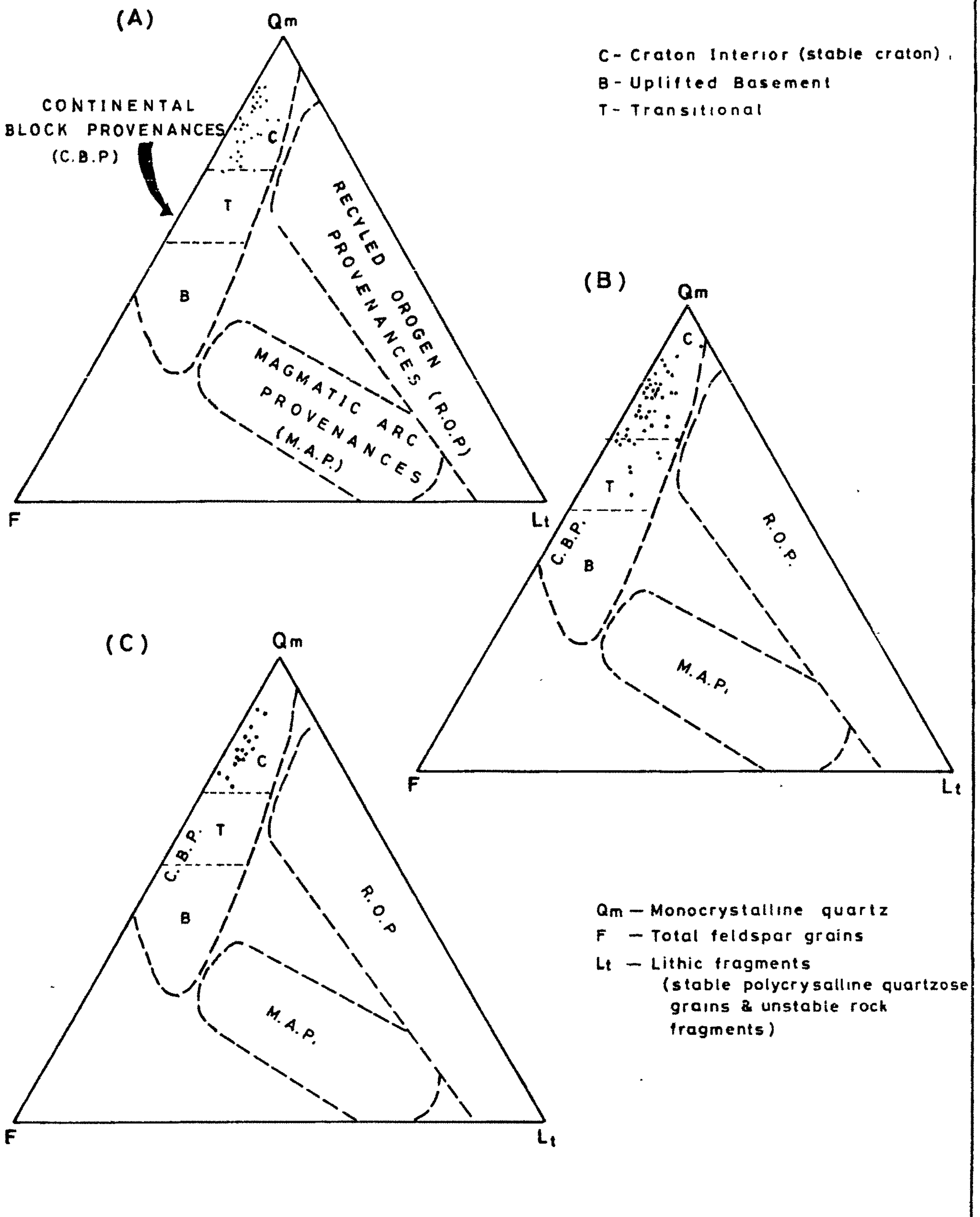


Fig. 7.3: Triangular Q_mFL_t plot showing generic type of Provenance terrane for the sandstone suites of Barakar (A), Barren Measures (B) and Kamthi (C) formations. (After Dickinson and Suzek, 1979)

raise doubts on the Eastern Ghat Highlands serving as one of the source areas for Lower Gondwana sands of the basin. The absence of sillimanite can, however, be attributed to its instability in intrastratal solution (Pettijohn, 1984) that played major role in the diagenesis of the Lower Gondwana sands. Nevertheless, the absence or presence of a particular mineral cannot be taken as a criteria in inferring a provenance. From the study of other mineral association of the Lower Gondwana sands, it can thus be broadly conjectured that the role of Eastern Ghat highlands as a source area for those sediments was not very significant.

Dominance of garnet in the heavy mineral suite of the Lower Gondwana sands of the study area and its low proportion in the area (e.g. Chintalpudi sub-basin) does to the garnet bearing charnockite and khondalite suite of rocks of Eastern Ghat, amply makes it clear that majority of the garnets in the Lower Gondwana sands of the study area were derived from quartz-garnet-feldspar gneiss and granulite belt within the Dharwar Craton close to the basin boundary. These granulite belts also served as a source for monazite and opaque minerals. A significant amount of these opaques might have been derived from the pyroxenite-chromite rich Chimalpad ultrabasic belt in the southeastern part of the basin (Fig. 7.2).

The possibility of an Antarctic source area for the Lower Gondwana sediments as proposed by Elliot (1973) and Veevers, et. al., (1996) needs to be examined here. Analysis of palaeogeography of Indian peninsula clearly demonstrates that the Pre-Cambrian terrain of the Eastern Ghat were uplifted during the early Proterozoic and was acting as a stable unsurmountable barrier between the Godavari valley and adjacent Antarctic land mass during the Lower Gondwana sedimentation. The idea of a common drainage between Antarctica and Godavari basin is this incompatible with the geomorphic setting of the eastern margin of the Indian land mass during the Permian and the Amery basin of East Antarctica, where the oldest Gondwana Formation belongs to the Upper Permian, also goes against the concept (Elliot 1973) that the Permian sediments of Peninsular India and East Antarctica were deposited in a formerly more extensive master basin.

Examination of current structures at selective preserved outcrops of the study area reveals a north-northwesterly (mean vector azimuth 335°)

palaeocurrent direction during the Lower Gondwana time. Palaeocurrent studies of earlier workers (Sengupta, 1970; Srinivasa Rao, et. al., 1979; Ramanamurthy, 1985) in other parts of Godavari basin suggest a NW to NNW palaeocurrent direction which occasionly swings to north. Casshyap (1979) envisaged a regional north to northwesterly palaeoslope during Gondwana sedimentation upto Middle Triassic period. These findings along with the inferences drawn in the previous paragraphs of this chapter imply that the Dharwar Craton lying to the south and southwest of the present day basin constituted the chief provenance for the Post-Talchir Lower Gondwana sediments of the Godavari sub-basin within which the study area lies. During the Talchir sedimentation the source area was more expansive and possibly included the Bastar also, as evidenced by strip of Talchir rocks along the eastern basin boundary near Manuguru. It is envisaged that the source of the main channel of the fluvial system that was prevailing during major part of Lower Gondwana sedimentation lay in the southwestern part of the present day basin (somewhere beyond Kothagudem. Tributaries arising from different parts of Dharwar Craton were responsible for shedding to the basin enormous volume of sediments of granitic and gneissic parentage that characterise almost 2500 meter thick Lower Gondwana fluvial deposits.