SUMMARY AND CONCLUSION

The Panjal Traps occupy an important position both in area as well as stratigraphical column of Kashmir. For the most part of their extension they occur in a massive lump shape forming high mountain peaks and steep cliffs. However, on Mount Kayol in Lidderwat area, where these lava rocks exhibit a bedded disposition, thirty-three flows were delineated. The adjacent flows have chilled contacts; no intertrappeans were observed in the area.

Petrographically, except for lower two flows, the whole flow sequence is plagioclase-pyroxene aphyric assemblage with conspicuous sub-ophitic texture. The lower two flows contain large phenocrysts of highly calcic plagioclases (An_{56}- An_{82}) arranged in a star-shaped form. The mineralogical change noted from bottom to top flows follows an iron-enrichment trend in pyroxenes whereas plagioclases show increase in sodic members. Such a change is observed both in micro-phenocrystic mineral phases as well as in groundmass minerals. The proportion of pyroxenes remains subordinate throughout the whole sequence though some increase is noted in pyroxene microphenocrysts in successive upper flows. Olivine is typically absent from the mode of these rocks, nor were observed any ultramafic inclusions or xenocrysts.

Some plagioclase and pyroxene crystals have undergone alteration to epidotes, chlorites, and other secondary minerals.

However, alteration of primary minerals have not affected the original textural relationship of primary minerals. Albite and biotite are also present; they occur along cleavage traces and fractures, and show cross-cut relationship with primary textural features which may suggest their development after the solidification of lava. The origin of both albite and biotite is attributed to the liquids from granitic intrusion of Tertiary age that occur in nearby Gangbal, Kangan area.

The alteration of the Panjal Traps is found to be largely isochemical with the exception of concentration of alkali elements. These rocks are relatively low in MgO content. Chemical characters, such as lower Fe_2O_3/FeO ratio, which indicates low oxygen pressure related to low water content of the magma, suggests that these rocks are of tholeiitic descent. Original lower water content of the magma is also indicated by the absence of primary hydrous minerals. Tholeiitic nature of these rocks is also supported by their trace element composition, such as, high V, Cu, and Ga contents, and high Nb/Y ratio, etc. However, the appearance of olivine and nepheline in the norm of some analyses and the plots of these rocks in high-alumina and alkali-olivine basalt region on alkali-silica variation diagram (see Figure 8) and in calc-alkaline field on MFA diagram (see Figure 9) defy their tholeiitic lineage. This contradictory result is inferred to be due to the enrichment of alkali contents which have caused the build up of olivine and nepheline in the norm and also shift of the points from their actual tholeiite field.

The low MgO content of these rocks may be attributed to the early separation of olivine and a part of pyroxene from the magma during its ascent from deeper source region to crustal reservoir. This is also favoured by the low Ni, Co, and Cr values as all these trace elements are incorporated in the structure of early olivine and pyroxene. In the process of separation of these more mafic minerals, the composition of the magma may have become enriched in Ca and Al relative to Mg and Fe. Also, separation of olivine and pyroxene, both being anhydrous minerals, may have caused an increase in the volatile content in the magma. On reaching low pressure environment, the volatiles along with some lava escaped with violent outburst causing the formation of agglomeratic slate that underlies the Panjal flows. The crystallization of plagioclase prior to pyroxene appears to have taken place due to Ca - Al rich composition of the magma under low water pressure conditions. But this phase of plagioclase crystallization probably did not last for any appreciable time since only little amount of plagioclase as phenocrysts, confined to lower two flows, is present in the whole sequence. The eruption of volatiles and some lava that preceded the main lava eruption may have developed an opening which provided a channel for regular lava outflow with the result magma did not find enough time to reside at shallow reservoirs to fractionate significantly. This is indicated by an overall uniformity of the mineral and chemical composition of these rocks both on local as well as on regional scale and the general absence of the more differentiated members.

The high concentration of Rb and Ba are inferred to be related to alkali metasomatism. Granitic liquids are enriched in Rb and Ba and low in Sr. The invasion of such liquids on the Panjal Traps may have increased Rb and Ba contents leaving Sr unaffected. Low Sr values of these rocks show close similarity with ocean ridge tholeiites and some Sr-depleted continental tholeiites, such as, Tasmanian, Antarctic, Wyoming, and Deccan traps. Shallow wall reaction model suggested for the Sr-depleted character of Tasmanian and Antarctic tholeiites has been found to be inconsistent. Also, extensive plagioclase crystallization suggested for Wyoming diabases does not explain the low Sr content of plagioclase rich lower two flows of the Panjal Traps. Instead, the low Sr content of the Panjal Traps is more reasonably explained by the Sr-depleted mantle source region where the Panjal magma was generated.

The resemblance in low Sr contents of the Panjal Traps with ocean ridge basalts and some continental tholeiites may indicate some genetic relationship. Ridge basalts are accepted to originate along the accreting plate margins. Tasmanian and Antarctic tholeiites, as also, Deccan traps, have been suggested to have originated by the rifting of continental crust. Plots of the Panjal Traps on Ti-Zr-Y, Ti-Zr, and Ti-Zr-Sr diagrams (see Figure 18a, b and c) indicate ocean ridge tectonic set up of their eruption. Similarity of these rocks with the ocean ridge basalts is also indicated on total iron - Fe_2O_3 + FeO/MgO, V — Fe_2O_3+ FeO/MgO, and TiO_2 - Fe_2O_3+ FeO/MgO diagrams (see Figure 12a, b and c). However, the characteristic feature of ocean ridge basalts, the pillow structure, is missing in the Panjal Traps except very limited occurrences reported from two isolated localities. Moreover, their high vesicularity and high CaO contents also indicate continental environment of eruption. This contradiction in geographical and tectonic environment of the Panjal Trap eruption may be resolved by plotting these rocks using TiO_2- K_2O - P_2O_5 diagram which has been proposed for discriminating oceanic and continental environments of basaltic lava eruption. On this diagram the Panjal Traps occupy oceanic region (see Figure 19). The plots of some points in non-oceanic region may be attributed to enriched K_2O contents of those samples. It is inferred that the oceanic affinity of the Panjal Traps on the one hand and continental type of environment of eruption on the other indicates a genetic relationship between the mechanism of lave eruption along ridge basalts and the Panjal Trap activity. On this basis it is suggested that the Panjal lave eruptions represent the early stage of a long extended phase of ridge formation which was later "aborted". Such a suggestion supports the earlier observation of Nakazawa and Kapoor (1973) that the Panjal Traps bear "oceanic affinity", and also, the model suggested by Ahmad (1977) that the Panjal lava eruptions preceded the actual separation of the Siberia from the Gondwanaland and the formation of Tethys ocean by ocean floor spreading along a mid ocean ridge during Triassic period. Later, the formation of the Gakkal ridge in Arctic ocean in Cretaceous period pushed the Siberian-Cathysian block southward. This was homotaxial with the northward oroclinal movement of India about a pivot in Baluchistan. The net result of the movement of the two blocks in their opposite directions was the closure of the Tethys ocean.