Journal of Nepal Geological Society, 1995, Vol. 10, pp. 11-20

Geology of Eastern Karakoram, Ladakh District, India

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ABSTRACT

The eastern Karakoram lies to the north of the Shyok ophiolite melange belt (commonly known as the Shyok Suture). Metamorphic rocks are limited in occurrence and mainly confined to the either side of the batholith. Sedimentation history of the Karakoram Basin or the Karakoram Tethys spans from Carboniferous to post-Cretaceous and was confined to the north of the Karakoram Batholith. To the north and east, this basin was not confined to the Karakoram Range but extends beyond its limits. Lower part of the sedimentary sequence is dominated by argillites, siliciclastics and carbonates of Carboniferous to Permian. Basic to intermediate lava flows, sometimes with large pillows, are commonly associated with these sediments particularly in the eastern part of the area. Upper part of the basin, exposed to the north of Chhungtash and extending beyond the Karakoram Pass, is dominated by the carbonates. The end phase of deposition in the Karakoram Tethys is marked by coarse clastic deposits of molassic nature during the post-Cretaceous period.

The Karakoram Batholith defines the southern limit of the Karakoram in its eastern part. In the north it intrudes the metamorphics and lower part of the Karakoram Tethys. Along the southern margin the granitoids have intruded the Shyok ophiolitic melange and metasediments. Compositionally, the granitoids of the batholith varies from tonalite to granite which become porphyritic to the south. Magmatic activity within the batholith and also in the Karakoram Tethys ended with the intrusion of a variety of dykes within the batholith.

Some of the recent workers working on the Western Karakoram region (from Pakistan side) considered the origin of the Karakoram batholith primarily due to a complex combination of subduction and tectonism. According to them, initially the granitoids were generated by a subdution along the Pamir Suture, subsequently by a subduction along the Shyok Suture and final phase came due to collision. However, present study in the eastern Karakoram points out the emplacement of the batholith along the interface of oceanic and continental margin. The Karakoram batholith is very far from the Pamir Suture. Therefore its origin cannot be related to the subduction along the Pamir Suture. The batholith is very young and has come at the time when Ladakh Batholith was emplaced or at a later date.

INTRODUCTION

The Karakoram Range, lying between the Shyok river in the east and Hunza river in the west, represents a terrain that lies mainly above 4000 m above MSL. This is an extremely cold region, remains mostly snow bound and predominantly unpopulated. Combination of these facts has made this remote region least visited by researchers. As a consequence, the geological information of this area has remained scanty. Since the eighties of the last century efforts have been made by geoscientists to explore this region. Stoliczka (1874) was the earliest worker to briefly describe the geology of this region. This was followed by Auden (1938), Norin (1964) and Desio (1963). The Indus and Shyok suture zones are the main tectonic elements that were active from Cretaceous to Eocene time. The Karakoram Range lying just to the north of these sutures is considered to be the southern margin of the Eurasian plate overriding the northward subducting Indian plate.

Reconnaissance mapping was taken up in the eastern Karakoram by the Geological Survey of India and Wadia Institute of Himalayan Geology in the early eighties. The first detailed geological map was published by Gergan and Pant (1983). The aim of this paper is to provide some more new data on the eastern Karakoram.

GEOLOGICAL SETTING

The area between Siachan Glacier and Shyok Village (Fig. 1) and Shyok Suture Zone to Karakoram Pass was investigated and a geological map is prepared (Fig. 2). Four main litho-tectonic units recognised from south to north are: the Shyok Suture zone (SSZ), Karakoram metamorphics, Karakoram Batholith and Karakoram Tethys.

Shyok Suture Zone (SSZ)

A distinct ophiolite belt is exposed between the Ladakh Batholith and the Karakoram Range. This isolated but very controversial ophiolitic melange belt is intruded by the granitoids of the Ladakh Batholith from the south. To the north, continental crust of the Eurasian plate (also considered as the Karakoram microplate) is thrust over it. The southern margin of the Eurasian plate from the north of Nanga Parbat-Haramosh Massif to the Pangong Tso (eastern Ladakh) represents an Andean-type margin characterized by the emplacement of Karakoram Batholith. This batholith has partially intruded into the rocks of the SSZ.

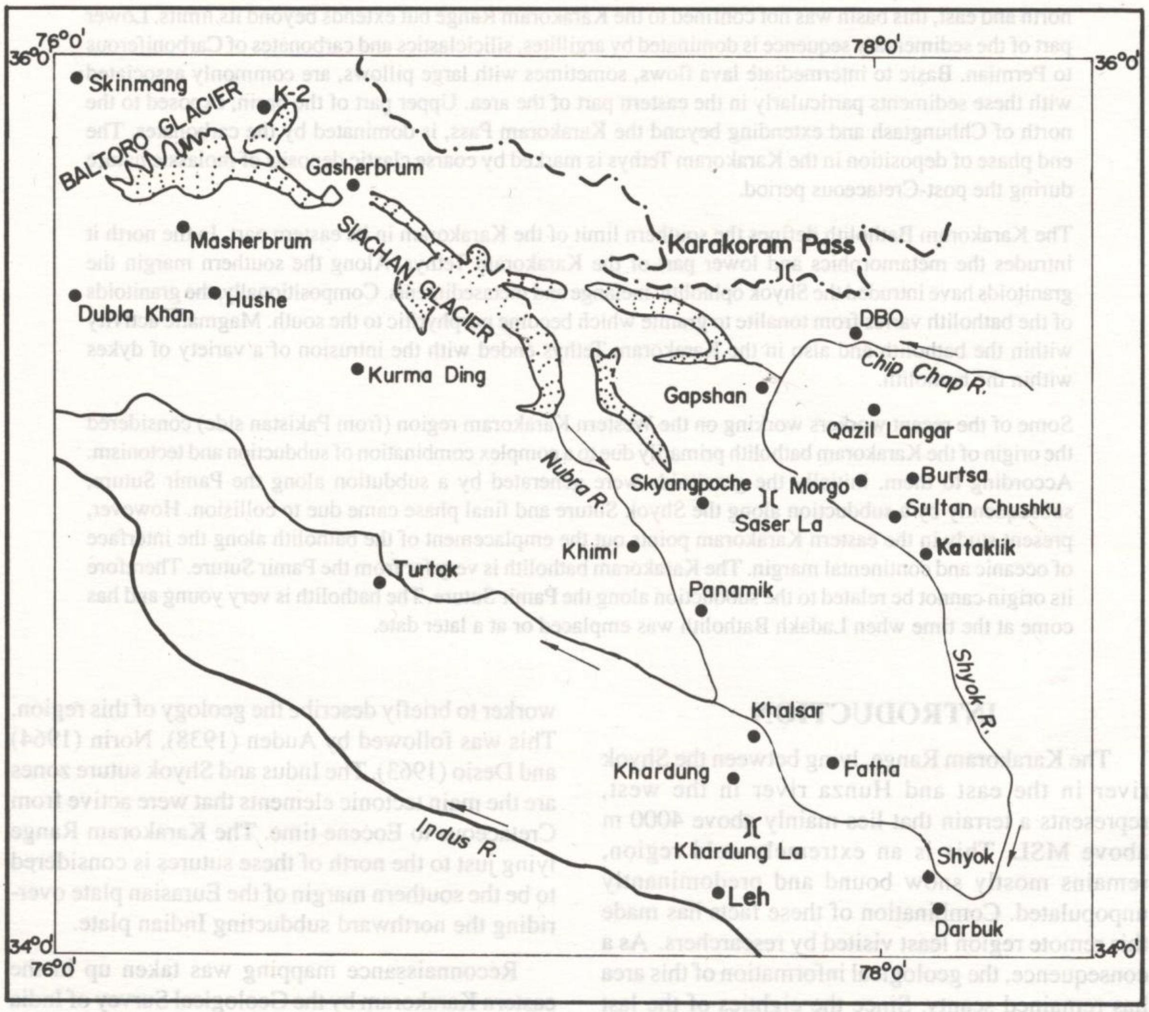

Fig. 1: Location map of the study area

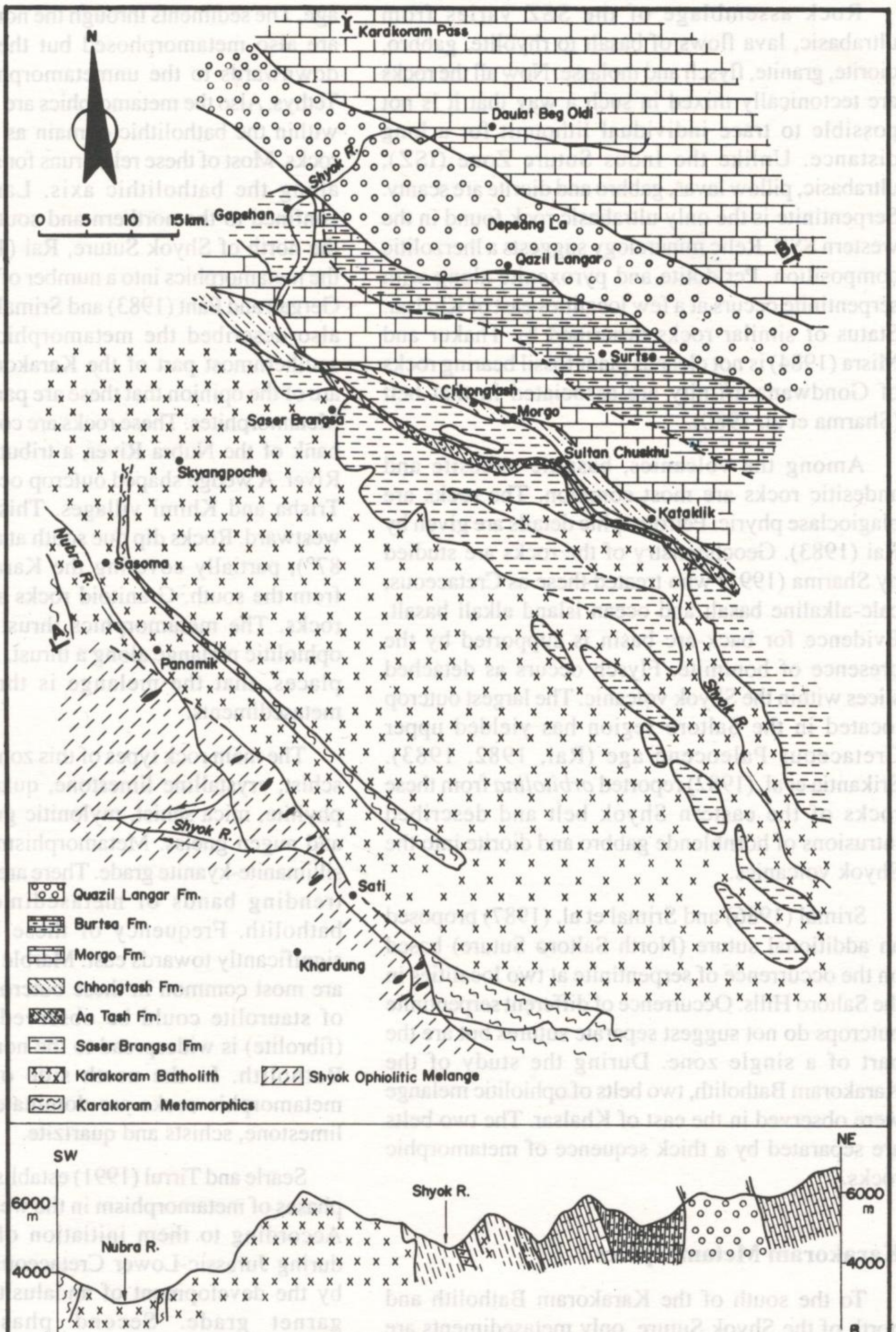

Fig. 2: Geological map of the study area.

Rock assemblage of the SSZ varies from ultrabasic, lava flows of basalt to rhyolite, gabbro, diorite, granite, flysch and molasse. Now all the rocks are tectonically mixed in such a way that it is not possible to trace individual lithounit for a long distance. Unlike the Indus Suture Zone (ISZ), ultrabasic, pillow lavas, gabbro and diorite are scanty. Serpentinite is the only ultrabasic rock found in the western SSZ. Relic mineralogy suggests a lherzolitic composition. Peridotite and pyroxenite along with serpentinite occurs at a few localities east of Khalsar. Status of similar rocks described by Thakur and Misra (1984) is not clear as plant fossil bearing rocks of Gondwana affinity are associated in that belt (Sharma et al. 1980).

Among the volcanics, basaltic andesite and andesitic rocks are most common. The rocks are plagioclase phyric. Petrographic details are given by Rai (1983). Geochemistry of the rocks are studied by Sharma (1991) who treated these as Cretaceous, calc-alkaline basalt and ocean island alkali basalt. Evidence for back-arc basin is supported by the presence of bonimite. Flysch occurs as detached slices within the Shyok volcanic. The largest outcrop located in the Saltoro region has yielded upper Cretaceous-Paleocene age (Rai, 1982, 1983). Srikantia et al. (1982) reported *orbitolina* from these rocks of the eastern Shyok belt and described intrusions of hornblende gabbro and diorite into the Shyok volcanics.

Srimal (1986) and Srimal et al. (1987) proposed an additional suture (North Saltoro Suture) based on the occurrence of serpentinite at two localities in the Saltoro Hills. Occurrence of different serpentinite outcrops do not suggest separate sutures but are the part of a single zone. During the study of the Karakoram Batholith, two belts of ophiolitic melange were observed in the east of Khalsar. The two belts are separated by a thick sequence of metamorphic rocks.

Karakoram Metamorphics

To the south of the Karakoram Batholith and north of the Shyok Suture, only metasediments are exposed. These metamorphic rocks have provided an immediate cover for the emplacement of granitoids of the Karakoram Batholith of Tertiary age. The sediments through the north of the batholith are also metamorphosed but they gradually pass downwards to the unmetamorphosed Karakoram Tethys. Also the metamorphics are widely distributed within the batholithic domain as relics of the host rocks. Most of these relics runs for several kilometers along the batholithic axis. Largest bodies are confined to the northern and southern margins. To the north of Shyok Suture, Rai (1983) has divided the metamorphics into a number of lithological units. Gergan and Pant (1983) and Srimal et al. (1987) have also described the metamorphic rocks from the southernmost part of the Karakoram Range. They are of the opinion that these are parts of the Pangong Metamorphites. These rocks are confined to the right bank of the Nubra River, a tributary of the Shyok River. A wedge shaped outcrop occurs between the Trisha and Khimi villages. This outcrop widens westward. Rocks dip due south at a high angle (75°-87°), partially covering the Karakoram batholith from the south. Granitoid rocks also intrude these rocks. The metamorphics thrust over the Shyok ophiolitic melange along a thrust. It also appears, at places, that the melange is thrusting over the metasediments.

The main rock types of this zone include chlorite schist, crystalline limestone, quartzite, calcareous phyllite, mica schist, mylonitic gneiss, migmatites and augen gneiss. Metamorphism have gone upto sillimanite-kyanite grade. There are several east-west trending bands of metasediments within the batholith. Frequency of these bands increases significantly towards east. Marble and biotite schist are most common in these outcrops. Development of staurolite could be observed and sillimanite (fibrolite) is widespread to the north of Karakoram Batholith. In the north side of the batholith, metamorphic rocks are dominated by crystalline limestone, schists and quartzite.

Searle and Tirrul (1991) established three distinct phases of metamorphism in the western Karakoram. According to them initiation of metamorphism during Jurassic-Lower Cretaceous time is marked by the development of andalusite, staurolite and garnet grade. Second phase of regional metamorphism is dated as 37±0.8 Ma. Third and the last phase of metamorphism is related to the thermal rise due to large-scale crustal melting between 25-

21±0.5 Ma. Similar studies are not yet carried out on the metamorphic rocks of the eastern Karakoram. All the metamorphic units are considered to be a part of the Pangong Metamorphites of the NE Ladakh (Bhandari et al., 1979; Gergan and Pant, 1983; Srimal, 1986; Srimal et al. 1987). The age of the metamorphic rocks of the Pangong region are variously interpreted as Archeozoic-Silurian (Lydekker, 1883), Silurian-Devonian (Desio, 1979), Permo-Carboniferous (Srimal et al., 1982), Paleozoic (Srimal, 1986; Srimal et al., 1987), Pre-Cambrian (?) to Middle Paleozoic (Gergan and Pant, 1983) and Carboniferous-Jurassic (Rai, 1983).

Metamorphic history in the western Karakoram is mainly influenced by the idea that there are two suture zones. Subduction and collision along these sutures may be the main causes for this metamorphism. Scenario, however, is quite different in the eastern Karakoram where the Pamir Suture is found very far from the northern margin of this range and it cannot be considered responsible for the metamorphism.

Karakoram Batholith

Usually granitoids are associated with the orogens. Commonly these granitoids occur in a linear belts that run parallel to the orographic axis. Granitoids of the Himalaya, Trans-Himalaya and Karakoram regions, the Central Crystallines, Ladakh Batholith and the Karakoram Batholith, run almost parallel to one another and also to the orographic axis of the Himalayan mountain system. Apparently, it appears as if all these granitoid belts suggest their envolvement in a common orogenic pulse that was active during the Tertiary time.

Granitoids of the Karakoram Batholith stretch from Northern Pakistan through north Ladakh to Western Tibet. Exposed between the Nubra-Shyok valley in the south and the Shyok river to the north, in eastern Karakoram, it constitutes the southern most edge of the Karakoram range. It is about 30 km wide and culminates into very high ridge. Recently some workers have attempted to study these granitoid bodies (Bhandari et al., 1979; Gergan and Pant, 1983; Rai, 1983, 1991; Srimal, 1986; Srimal et al., 1987).

The Karakoram batholith consists of a variety of rocks such as tonalite, granodiorite, granite, porphyritic granite, granite gneiss, augen gneiss and mylonites. Beside these igneous rocks, there are enclaves and large septas of the country rocks that run for several kilometers along the length of the batholith. Frequency of distribution of these relics increases eastward. These are mainly composed of marbles and schists. Because of their large size these are considered to be the part of Pangong Metamorphites brought by faults (Srimal, 1986; Srimal et al., 1987). Infact these rocks represent the lower part of the Karakoram Tethys that provided room for the emplacement of batholith and suffered metamorphism upto staurolite grade. There appears no direct link of these rocks with those exposed around Pangong Tso area.

From the field relationship, it is quite evident that the tonalite is the oldest suite and intrudes the base of the Karakoram Tethys. It is equigranular hypidiomorphic rock dominated by plagioclase and quartz with hornblende as main accessory mineral constituent. Plagioclase is mostly oligoclase and andesine (An15-An37) and show twinning, zoning and clouding. K-feldspar is always characterized by cross-hatch twinning. Hornblende forms stout grains showing alteration into biotite and chlorite. It is noteworthy that tonalite remains confined to the northern flank of the batholith. All types of dykes cut across this rock.

Granodiorite and granite are widely distributed throughout the batholith. Both these rocks are intrusive into the tonalite and the Karakoram Tethys. These rocks are also intrusive into the Shyok ophiolitic melange in the Nubra Valley. Though hypidiomorphic grainular texture is characteristic of these rocks, yet the development of porphyritic and mylonitic characters are significant along the southern margin. Cataclastic texture is locally developed. Plagioclase, K-feldspar and quartz are the main mineral constituents. Biotite is the main mafic mineral. Appearance of apatite and zircon is common. Small pink garnets have developed in the southern part around Panamik village.

The magma responsible for the Karakoram Batholith is supposed to be of three generations related to pre-collision, subduction and post-collision stages (Debon et al., 1987; Rex et al., 1988). Age variation is from Upper Cretaceous to late Tertiary (Schneider, 1957; Gansser, 1964; Desio, 1976).

KARAKORAM TETHYS ZONE

Saser Branza Formation

The Karakoram Tethys sequence is exposed to the north of Karakoram Batholith. The lowermost horizon of the Karakoram Tethys in the eastern Karakoram is the Saser Branza Formation. Granitoids of the batholith have intruded into the lower part and metamorphed these rocks. The zone of contact metamorphism varies in width. It is thickest in the east of Saser Branza and thins out westward. Sulphide mineralization is associated with the contact zone. The Saser Branza Formation is dominated by argillites but local dominance of the massive carbonates is also observed. Thinly laminated argillites are interbedded with dark grey and white limestone, calcareous sandstone and siltstone with flysch facies. Detritus in the limestone as well as in siltsone are of quartz, felspar, chert and pyroxene (Gergan and Pant, 1983). Presence of feldspar and pyroxene detritus must be from the basic igneous source.

A rich faunal assemblage has been described by Gergan and Pant (1983). Significant fauna are *Spirifer, Costispirifer, Atrypa, Marginifera, Fenestella* and crinoid stem. Trace fossils are widely distributed throughout this formation. On the basis of above fossils, Carboniferous age has been assigned to this formation. This formation is correlated with the Harpatso black slate of western Tibet and Baltoro black slate of NW Baltoro basin. On the basis of age, correlations have been made with Singhie Shales (Desio, 1936), Sarpo Laggo slates (Desio, 1936), Misgar slate (Desio and Martina, 1972), Pasu slates (Schiender, 1957), Khandut slates (Desio et al., 1968), all from the western Karakoram. This formation gradually passes into overlying Permian sequence of Chhongtash Formation.

Chhongtash Formation

Before the deposition of carbonate dominated sequence started, deep marine conditions are suggested by the flysch like Chhongtash Formation. It is overlain by the Triassic limestone of the Morgo Formation. The contact between the two appears gradational. Argillites of Chhongtash just below the limestone becomes calcareous and at places show vertical dip. It is also folded and show micro-faulting. The contact with the underlying Saser Brangza Formation is not sharp, rather the two formations cannot be easily separated in the field. Thickly bedded Saser Brangza Formation changes into thinly bedded Chhongtash Formation, however, the composition and attitude of the beds remain the same. The Chhongtash Formation consists of brownish grey siltstone, sandstone, black shale and limestone. In the uppermost part it has limestone, calcareous sandstone and impure limestone and pillow lavas. Black shales near the pillow lava are nodular having nodules measuring upto 20 cm in diameter. On the basis of faunal assemblge a Permian age has been assigned to this formation (Gergan and Pant, 1983). After the volcanic eruption there was a sudden change in depositional environment. Argillite were succeeded by carbonates.

To the west of Chhongtash, opposite to Ag Tash Glacier, volcanic rocks are in direct contact with the limestone of the Morgo Formation. Contrary to it, lava flows are absent in the south of Morgo. Steep dip and a crushed zone near the contact suggest a tectonic relations between the two. Gergan and Pant (1983) have shown a faulted contact. These characters may also develop due to differential movements during orogeny.

Ag Tash Formation

The Ag Tash Formation is exposed at the base of the Shyok river valley between Kumdan Glacier in the west and Sultan Chushku in the east. It is about 1000-1200 m thick near the crossing of the ropeway over the Shyok river, northeast of the Saser Branza. Thickness increases towards east and attained a maximum thickness of about 1500 m. It is bounded by the Saser Branza Formation from both sides. General dip is upstream (NW), whereas the Saser Branza and overlying sequence of the Karakoram are north or northeast dipping.

Lower part of the formation is dominated by the grey and white massive limestone interbedded with conglomerates and purple shale. In the upper part thick volcanic flows are interbedded with limestone and volcanogenic sediments. The volcanic rocks of the Ag Tash Formation were considered tholeiite and high alumina basalt (Gergan and Pant, 1983). But they are found to range upto rhyolite. From the field studies it is evident that the uppermost part of this Formation is dominated by purple coloured volcanic flows. Gergan and Pant (1983) treated these purple volcanic rocks as a separate unit and put these under their Kumdan Formation. In the absence of radiometric ages and absence of fossils, a comparision is done with the Khardung Acid Volcanics of the Shyok Suture Zone and an Oligocene age has been assigned. Granitoid dykes of the Karakoram Batholith intrude the whole sequence. Also dykes of intermediate composition cut-across this volcano-sedimentary sequence.

Morgo Formation

There is a marked facies change after the deposition of Chhongtash Formation. A sudden change from argillites of the Chhongtash Formation to carbonate dominated lithology of the Morgo Formation must be due to a major change in the environment of deposition. On the basis of Megalodon bearing limestone in the uppermost part of this formation, a Triassic age is assigned (Gergan and Pant, 1983). Corals are limited to the lower part of this formation. Gergan and Pant (1983) described the thickness of this formation as 300 m but in their stratigraphic column it measures around 2000 m. This formation represents a thick carbonate sequence which is definitely more than 1000 m (due to structural complexity exact thickness could not be estimated).

Morgo Formation is characterized by a thick, massive white and grey limestone often with red incrustation. It gradually passes into the overlying Burtsa Formation of Cretaceous age.

During Triassic time huge thickness of limestone was deposited throughout the Tethys Himalaya (e.g. Kashmir, Zanskar, Spiti etc.). Almost similar conditions were prevailing in the Karakoram region. Carbonates of the Himalayan Tethys are associated with volcanic activity which is altogether absent in the Karakoram Tethys. The volcanic activity in the Himalayan Tethys is related to the rifting, particularly in the Kashmir and Zanskar regions. An extension regime during Permian-Triassic period is suspected in the western Karakoram but no such possibility is indicated for the eastern Karakoram. It may raise the question whether the Karakoram was more stable than Himalaya throughout the geological past. It is difficult to answer this question at this stage.

Burtsa Formation

The last phase of marine environment, within the Karakoram Tethys, is represented by a Jurassic-Cretaceous carbonate dominated sequence. This is conformably resting over the Morgo Formation and is named Burtsa Formation by Gergan and Pant (1983) after the place Burtsa on the main route to Karakoram Pass, where it is well developed. Rock types are thinly bedded limestone, black and purple shale, pinkish white massive limestone, gypsum beds, carbonaceous shale and laterite. This formation is folded into a large synclinorium. In the lower part, it conformably overlies the *Megalodone* limestone of the Morgo Formation. Gergan and Pant (1983) have described rich Ostracod and Foraminifera assemblage of Lower Lias and Upper Mastrichtian. They compared the ostracods of this formation with those of the West Germany and Alps, whereas the foraminifera show affinity with south India, North America and Europe.

Presence of gypsum and laterite bearing horizons alongwith deep water fauna suggest a periodic fluctuation in the environment of deposition, from deep marine to fresh water. The Jurassic and Cretaceous rocks are well developed throughout the Karakoram Tethys, from western Karakoram to westernmost Tibet. Upper Cretaceous beds were described from the area between Pulo and Daulta Begulde (to the north of Chip Chap River) and also from the snout of the North Rimo glacier (Dainelli, 1993-94). Similar rocks occur in the core portion of the syncline in Aghil Range (Desio, 1979), top of Falchan Kangri (Desio and Zanettin, 1970), Serviia Limestone and Khalkhal Sandstone (Desio, 1963; Desio and Zanettin, 1970), Baltoro Kangri and Mt.Shanoz in Hunza Valley (Schneider, 1957; Desio and Martina, 1972).

Qazil Langar Formation

After the deposition of Burtsa Formation in a deep water conditions, there was a sudden break in deposition due to marine regression and initiation of the orogeny. The region was uplifted and subjected to erosion and deposition in tectonic depressions.

The Qazil Langar Formation was deposited in one of such basins. A rapid deposition of coarse clastics took place in this basin. Stoliczka (1874) was the first to report these continental synorogenic deposit. Recently these were reinvestigated by Gergan and Pant (1983). Lithology is dominated by conglomerates. Top part is composed of conglomerates having clasts as big as 4 x.5 m. Size and dominance of conglomerates show a marked decrease downward. Near the bottom of the sequence, calcareous shale, sandstone, calcareous sandstone and thinly bedded limestone are common. Clasts are of white, brown and grey limestone, shale and conglomerates. The limestone clasts are fossiliferous and oolite bearing. Main contribution is from the Burtsa and Murgo Formation of Cretaceous and Triassic ages respectively. It attains a maximum thickness of about 800 m.

The Qazil Langar Formation is considered to be homotaxial with the Urdok Conglomerate of the western Karakoram. The later forms the lowermost part of the Ghil Formation in the Shaksgam Valley. On the bases of fauna recovered from the clasts, an Early to Late Triassic age has been assigned (Stoliczka, 1874; Desio, 1979). Still younger age (Cretaceous) has been assigned by Gergan and Pant (1983) and Gergan and Pant (1983). Gergan and Pant (1983) have described Lower Jurassic to Upper Cretaceous faunal assemblage from the Bustra Formation. Occurrence of clasts of Burtsa Formation within the Qazil Langar Formation suggests a Tertiary age for these molassic deposits of Qazil.

DISCUSSION

Because of meagre geological information, the stratigraphy of the Karakoram is poorly established with a number of uncertainities. The region constitutes a northern part of the Alpine-Himalayan orogenic belt. The Himalayan Tethys lies to the north of the Central Crystallines, similarly the Karakoram Tethys is also bounded by the granitoids of the Karakoram Batholith, in the south. Probably, the Central Crystallines provided the base (floor) for the deposition of Tethys sequence, whereas the granitoids of the Karakoram Batholith intrude the Karakoram Tethys. To the north, limit of the Himalayan Tethys is marked by the presence of a mega-lineament; the Indus-Tsangpo Suture. The South Pamir Suture defines the northern limit of the Karakoram Tethys in the northwestern part, but this suture does not exist in the north of Karakoram Tethys in eastern Karakoram.

Geology of the eastern Karakoram starts with the deposition of Carboniferous sequence, base of which is still unknown. This argillite dominated sequence was deposited in a marine euxinic condition (Gergan and Pant, 1983). There is a gradual change from the lower thickly bedded Carboniferous argillites (Saser Branza Formation) into thinly bedded Permian argillites in the upper part (Chhongtash Formation). There hardly appears any break in sedimentation. Top part of this sequence has witnessed basic volcanic activity. Occurrence of pillow basalt allowed to speculate the existence of an extension regime during the late Permain time - an event comparable with that of the Himalayan Tethys. Just after the eruption of pillow lava the region was subjected to a drastic change in the depositional environment. A platform type, thick carbonate sequence was deposited over the argillites during Triassic period (Gergan and Pant, 1983). Causes for this change is still unknown. The uppermost part has yielded large *Megalodon,* and this part in particular, is comparable with that of the Himalayan Tethys of Spiti (Kioto Limestone) and have wide distribution throughout the Karakoram and western Tibet (extension of the same basin). Above the *Megalodon* bearing beds, deepening of the basin is suggested by the thinly bedded limestone of the Burtsa Formation. Though this formation initially was deposited under deep water conditions, occurrence of gypsum, coal and laterite in the later phase are of nonmarine nature. It appears that there was frequent changes from marine to lacustrine conditions during the deposition of Burtsa Formation. This may suggest the initiation of orogenic impulses in the Karakoram. The Burtsa Formation was folded and faulted during post-Cretaceous period. This deformation created an intramontane basin in which the molassic deposits of the Qazil Langar were deposited. In general, marine condition prevailed in the Karakoram till late-Cretaceous. The granitoids of the Karakoram Batholith intruded the lower part of Karakoram Tethys sequence. To the south this batholith has intruded the metamorphics and the Shyok ophiolitic melange. The melange contains Paleo-Eocene fossiliferous sediments, so the intrusions are post-Eocene. Emplacement of the Karakoram Batholith was along the boundary between Shyok ophiloitic melange and the Eurasian continental margin.

The metamorphic rocks are confined to either side of the Karakoram Batholith. The metamorphics of the Saser Branza Formation exposed to the north, represent the lower part of the Carboniferous. The metamorphism is only due to the batholithic emplacement. Problem is complex with those metasediments which are exposed south of the batholith and also occur within the batholithic domain along the southern margin. Lydekker (1883) considered these as Archeozoic and Silurian, Srimal et al (1982) put these as a part of Permo-Carboniferous Pangong Group and Rai (1983) vaguely described these rocks as Carboniferous to Jurassic.

Gergan and Pant (1983) while mapping the area between Nubra Valley and Karakoram Pass, traced several mapable units of metasediments particularly along the southern slope of the batholith. On the one hand, they put these as the lowermost part of the Karakoram Tethys, and on the other hand, grouped them in the Pangong Tso group. Precambrian (?) to Middle Paleozoic age has been assigned.

According to Zanchi (1993) the sediments of the Karakoram Tethys reflect a very complex and polyphase structural history in western Karakoram. He recorded several phases of folding, thrusting and late-stage extensive wrench tectonics. The low grade metamorphism in the Cretaceous sediments represents the oldest tectonic event. This metamorphic event has been related to the collision of the Kohistan island arc with the Karakoram micro-plate during late Early Cretaceous (Searle et al., 1991; Gaetani et al., 1983, Zanchi, 1993). Time of this collision is doubtful as Cretaceous-Eocene marine fauna has been described from the eastern part of the Shyok Suture (Rai, 1982). Therefore, both the Shyok and the Indus suture may have closed in late Eocene or post-Eocene time. This is the time when Himalayan orogeny started. Orogeny in the Karakoram started in the post-Cretaceous period (after the deposition of Burtsa Formation) and appears contemporaneous with the Himalayan orogeny.

ACKNOWLEDGEMENTS

The author is grateful to the Director, Wadia Institute of Himalayan Geology, Dehra Dun for providing facilities.

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