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Late Proterozoic stratigraphy of the Swabi area, NWFP, N. Pakistan

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ABSTRACT: *A succession of weakly metamorphosed unfossiliferous sedimentary rocks has been described in terms of lithostratigraphy from an area north of Swabi. The succession unconformably underlies the Cambrian Ambar (Dolomite) Formation (=Abbotabad Formation) and represents the supra-crustal sediments of a probable Late Proterozoic age from the Indian-Plate basement. A WNW plunging cylindrical anticline controls the disposition of stratigraphic units. The succession is divisible into two formations; Salkhala and Tanawal. The basal part of the Salkhala Formation, exposed at the west bank of the Tarbela dam, is classified as the Gandaf unit and comprises pelitic and graphitic schists, brown dolomite and white and grey-black marble. The upper part, exposed at the apex of the Kundal anticline, is predominantly argillaceous and contains black mud- and siltstone which grade upward into pebbly green phyllite. The overlying Tanawal Formation is conglomeratic at its base and comprises three units, two of which are quartzitic, while the one, in the middle, is argillaceous. It is suggested that the Tanawal Formation may be a time-equivalent facies change of the Hazara, Manki and Landikotal Slate formations, rather than being younger as suggested in the existing literature. This may explain some of the discrepancies in the existing regional tectonic framework of the Indian plate in northern Pakistan.*

INTRODUCTION

The equivalents of the Lesser Himalayas in northern Pakistan have been tentatively divided into an inner or Abbotabad zone and an outer or Kalachitta zone (Tahirkheli, 1981). The latter comprises unmetamorphosed sedimentary rocks ranging in age from Triassic to Eocene, and includes Kohat, Kalachitta, and Margala hill ranges. The Abbotabad zone comprises unmetamorphosed fossiliferrous rocks of early Palaeozoic age (e.g., Abbotabad Group; Latif, 1970) which overlie a sequence of variably metamorphosed rocks of imprecisely defined Late Proterozoic age [including Salkhala Formation, Tanawal Formation, Hazara, Manki (Attock), Landikotal and Dakhner Slate formations]. The sequence below the Abbotabad Group has been a major geological dilemma. Firstly, it is completely devoid of fossils. Secondly, hitherto not a single section within the limits of northern Pakistan has been described in literature (at least to the author's knowledge) where any of the above named formations has been found intact either internally or in terms of basal or upper stratigraphic contacts. The situation in the hinterlands is even more complicated where not only the existence of an intact lithological column is virtually out of question due to multi-phase deformation (Coward et al., 1988; Treloar et al., 1989), the preponderance of metamorphic imprints has considerably modified the original compositions.

Recent mapping projects in the north-eastern fringes of the Peshawar Plain by the Geological Survey of Pakistan, Oregon State

University and Peshawar University have resulted in a sound stratigraphic reconstruction of a Lower Palaeozoic to Triassic succession (Hussain et al., 1991; S. R. Khan, 1990; Pogue et al., 1991; DiPietro et al., 1993). During the same course of work, the unfossiliferrous strata occurring below the Lower Palaeozoic succession was studied for stratigraphic and structural analyses. In this paper, we present data on a stratigraphic succession from north of Swabi, which we believe comprises equivalents of the Precambrian Tanawal and Salkhala formations. The present work is significant for two reasons. Firstly, it is for the first time that any Precambrian strata in northern Pakistan is defined in terms of its intact stratigraphy from base to the top and secondly, both the formations are subdivided into more than one discrete units. It is expected that a comparison with the Precambrian rocks of the Swabi area may solve several of the stratigraphic and tectonic problems associated with the Precambrian strata in the internal zone of the north-western Himalaya.

PREVIOUS WORK

The stratigraphy of the Swabi and adjacent areas has been subject of consistent research since early sixties. In a pioneering reconnaissance, Martin et al. (1962) described a group of sedimentary rocks from the area, which they named Swabi-Chamla Group. The group was divided into two subgroups, the lower comprised Chamla formations and the upper Swabi formations. The Swabi subgroup was later found to be fossiliferrous (Davies & Ahmad, 1963), which led to several bio-stratigraphic analyses of the area in the subsequent years (Tiechert & Stauffer, 1965; Stauffer, 1968; Pogue & Hussain, 1986; S. R. Khan, 1990; Hussain et al., 1991; Pogue et al., 1992). As a result the Palaeozoic succession of the Swabi and adjacent region is one of the best described stratigraphic sections in Pakistan.

Unlike the Swabi subgroup, the Chamla subgroup of Martin et al. (1962) drew little attention, probably because of the lack of fossils. The only notable contribution is that of Calkins et al. (1975) who mapped the western bank of the Indus river and divided the area into the Salkhala, Hazara and Tanawal Formations. S. R. Khan et al. (1988) remapped the Tarbela region during a Geological Survey of Pakistan routine mapping programme and extended the domain of the Salkhala and Tanawal formations of Calkins et al. (1975) further to the west in the Swabi area (also see S. R. Khan, 1990; S. R. Khan et al., 1990).

NOMENCLATURE

As mentioned earlier, the succession being described in this paper forms part of the Chamla subgroup of Martin et al. (1962). They divided the subgroup into Chamla phyllitic shales in the lower and Chamla quartzites in the upper part. An alternative nomenclature was adopted by Calkins et al. (1975) while working in the Tarbela area. The extension of the Chamla quartzites of Martin et al. (1962) in the Topi-Tarbela area was referred to as Tanawal Formation, while that of the Chamla shales was included in the Salkhala Formation. In the present study we have adopted the nomenclature used by Calkins et al. (1975), for its regional implications. However, we have subdivided both the Tanawal and Salkhala formations into discrete units (Table 1). In particular, we have extended the domain of the Salkhala Formation from that encompassed by Calkins et al. (1975). As will be described later, the part of the Salkhala Formation exposed near Tarbela represents only the basal part, due to structural control of a major WNW-ESE trending anticline. This part of the formation has been named as the Gandaf Unit during this work. We have mapped and added a unit to the Salkhala Formation from the west-plunging apex of the

EXPLANATION

	Quaternary	Qt	Comprising boulder, pebble, sand, silt and clay.
	Unconformity		
PALEOZOIC — Late Carboniferous	Diabase dykes	Cd	Fine to medium grained dolerite sills/dykes.
	Ambela granite complex	+Ca+	It is leucocratic, porphyritic and foliated at places.
Early Carboniferous	Jafar Kandao Formation	Cj	Consists argillite, sandstone, and conglomerate.
	Unconformity		
Early Devonian	Nowshera Form.	Dn	Contains fossiliferous limestone, marble, dolomite and argillite intercalations.
	Unconformity		
Silurian	Panjpir Form.	Sp	Comprising of argillite with subordinate lenses of fossiliferous limestone and quartzite.
	Unconformity		
Early to Middle Ordovician	Misri Banda Quartzite	Omb	Reddish-brown, well bedded felspathic quartzite.
	Unconformity		
Cambrian	Ambar Form.	Ca	Dolomitic and cherty limestone with subordinate lenses of quartzite and phyllite.
	Chinglai gneiss	Ccg	Leucocratic, biotite-muscovite bearing gneiss.
PROTEROZOIC — Precambrian	Tanawal Form.	PCta	Upper unit consists brownish-grey, quartzite Middle unit contains massive argillite and siltstone. Lower unit comprises coarse grained quartzite which contains lenses of pebbly quartzite, limestone and graphitic schist.
	Unconformity		
	Salkhala Form.	PCs	Upper unit consists quartz-mica schist and argillite. Lower unit comprising of limestone, marble, graphitic schist, siltstone and quartzite.

GEOLOGICAL SYMBOLS

- Strike and dip of inclined bed.
- Strike and dip of overturned bed.
- Strike and dip of inclined foliation.
- Cotact, dashed where approximately located.
- Anticline.
- Syncline.
- Overturned anticline.
- Overturned syncline.

NON GEOLOGICAL SYMBOLS

- Mettled roads.
- Unmettled roads.
- Intermittent streams.
- A—B, C—D: Lines of section

34° 72° 24'18" 6'19"

72° 45' 34° 20'

NARANJI · Dondai · Chingtai · Bagh · Swawo · Kararal · Dandar · Dahkara · Ganrichatra · Badga · Sandwa · Qadra · Gajal · Kundal · Dewal · Bada · Totalal · Charbagh · Salim Khan Kili · Naugram · Tarako · Shagari · Maneri Bala · Maneri Payan · SWABI · Manal · Gandaf

Furlongs 8 6 4 2 0 1 2 3 Miles

34°6'19" 72° 24'18" Drafted by: Aliya & Nadia

Geology by: Said Rahim Khan 72° 45' 34°6'19"

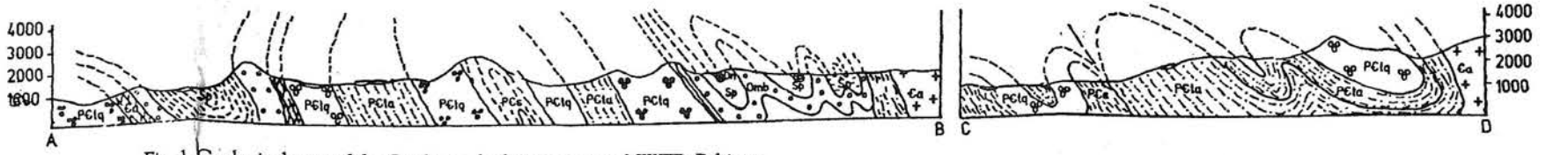

Fig. 1. Geological map of the Swabi and adjoining areas, NWFP, Pakistan.

TABLE 1. THE PREVIOUS AND PROPOSED NOMENCLATURE FOR THE LATE PROTEROZOIC STRATIGRAPHY IN THE SWABI AREA, NWFP

Martin et al. (1962)	Calkins et al. (1975)	This study		
Chamla Quartzites	Tanawal Formation	Tanawal Formation	Upper Quartzite Unit	
			Middle Argillite Unit	
			Lower Quartzite Unit	Upper Green - Phyllite Subunit
Chamla Phyllitic Shales	Salkhala Formation	Salkhala Formation	Kundal Unit	Lower Argillite Subunit
			Gandaf Unit	

above said anticline (equivalent of the Chamla Phyllitic Shales of Martin et al., 1962), which we name the Kundal Unit that is further subdivided into two discrete subunits, (Table 1).

LITHOSTRATIGRAPHIC DESCRIPTION

Salkhala Formation

Field Distribution: Calkins et al. (1975) mapped a complex lithological assemblage comprising phyllites, schists, limestone and quartzite at the right bank of the Indus river near the Tarbela dam, which they referred to as the Salkhala Formation. They showed it to be extending northward along the Indus river in the Amb-Utmanzai area, flanked, on the either side, by the Tanawal Formation. This disposition of the Salkhala Formation was interpreted to be due to its position in the core of a large northward-plunging antiform to which they termed as the Indus re-entrant. The extreme northern tip of this north-verging fold structures has recently been mapped by Williams (1989) confirming that the Salkhala Formation extends up to north of Darband where it plunges northward under the Hazara nappe comprising Tanawal Formation and the Mansehra Granite.

During the course of this work, it has been found that fold structures other than the Indus re-entrant may also contain Salkhala Formation in their cores. The Swabi-Rustam area is folded into a series of WNW-ESE striking cylindrical fold structures, which are at a right angle to the trend of the Indus re-entrant (Fig. 1). One of these fold structures, termed the Kundal anticline in this study, trends WNW-ESE and runs for over 15 kilometres from Tarbela dam in the east up to the village Ghurghushtu in the west. The core is occupied by the Salkhala Formation with the Tanawal and younger formations occurring at the flanks (Fig. 1). Since the anticline is plunging towards WNW, only the upper stratigraphic levels are exposed in its western half, while only the basal half is exposed eastwards near Gandaf at the right bank of the Tarbela dam.

Lithological Subdivision: The Salkhala Formation, in the study area, is divisible into two units (Fig. 2). The basal part of the formation, exposed in the core of the Kundal anticline, is referred to as the Gandaf unit, while the higher stratigraphic levels exposed at the apex of the anticline at Kundal and to the west are included in the Kundal unit.

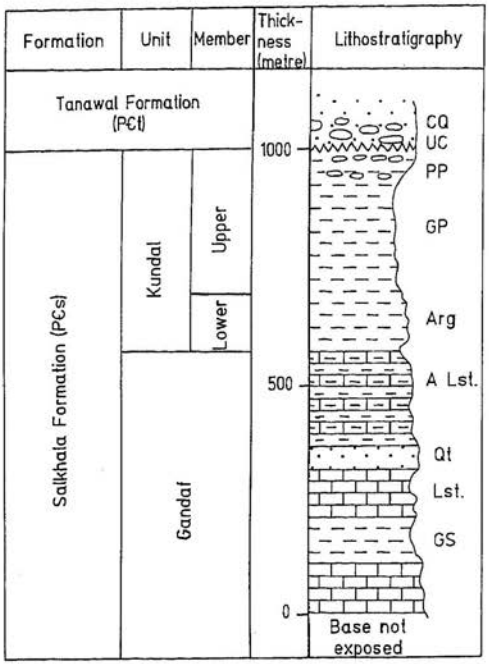

Fig. 2. Generalized lithostratigraphic column of the Salkhala Formation from the Swabi area. UC = Unconformable contact. CQ = Conglomeratic Quartzite, PP = Pebbly Phyllites, GP = Green Phyllites, Arg = Argillites, A Lst = Argillaceous Limestone, Qt = Quartzite, Lst = Limestone, GS = Graphitic Schists.

The Gandaf unit consists of graphitic and pelitic schists, phyllites, calcareous rocks, quartzites and quartz schists. The schists are fine-grained, thinly laminated and have greenish-grey and dark-black colours. The graphitic schist is dark to dark-grey, fine grained and contains disseminated quartz grains and laminae. The pelitic schists are composed mainly of quartz, with 20-40% of chlorite and muscovite. The phyllites, grey to black in colour, are composed of varying amounts of micaceous material and quartz. The calcareous rocks are variable in colour and composition, ranging from brown dolomitic limestone, through greyish-white recrystallised marly limestone to black and greyish white marbles. The marbles are up to 90% carbonates, with minor amounts of tremolite and plagioclase. At places the calcareous rocks of the Gandaf unit contain abundant scapolite, probably as a metasomatic product connected with the intrusion of the gabbroic rocks of "Panjal age" (Jan et al., 1981). The quartzite is flaggy, brownish-grey to light-grey, thin to medium bedded and is highly ferruginous; iron staining along bedding planes and sheared surfaces are commonly observed. Sedimentary structures like ripple marks and cross bedding are frequently found in the quartzitic part of the formation. Hematite mineralisation is found in the lower parts of the formation south of Gandaf. The basal part of the unit is usually associated with pyrite, indicating an aerobic condition during the deposition of this part of the formation. The exposed part of the Gandaf unit may range up to 600 metres in thickness.

The overlying Kundal unit is best exposed in the stream section near the village of Kundal. It is divisible into two subunits. The lower subunit is pelitic in composition with a dull brownish-grey to grey-balck colour on the weathered surface and greenish-grey to olive-grey on the fresh surface. Predominantly, the subunit consists of fine mud, but commonly silt fraction are as abundant as clay, the two alternating on a mm scale yielding spectacular lamination. Graphitic schist is locally present. The thickness of this member is about 100 metres.

The upper subunit of the Kundal unit is a green-coloured chlorite-bearing quartz-mica schist. The contact between the predominantly brownish-grey slates of the lower subunit and green phyllites and schists of the upper subunit is gradational over a narrow zone. The basal part comprises alternating horizons of brownish-grey and greenish-grey phyllites, the upper most part of the subunit contains thin horizons of quartzites, interbedded with the phyllites. A characteristic feature of this subunit is the presence of rounded to subrounded pebbles of quartz, quartzites and rare (?)granites, embedded in a green

chlorite-phyllite matrix. The pebbles are commonly a few centimeters in diameters but locally they are as big as 10 cm. There is a gradual but distinct increase in the number of these quartzose pebbles towards the top of this subunit, where up to 70% of some horizons may consist of them. Surprisingly a great majority of these pebbles comprise medium to coarse (up to 4 cm) clear quartz crystals similar to those commonly occurring in the quartz veins but unlike those constituting the quartzites. Some of the quartz pebbles may be originally the quartz veins which attained the present shape following intense shearing and boudinauging. However, involvement of sedimentary depositional processes cannot be ignored completely. This subunit is approximately 300 metres thick, of which the upper pebbly phyllites/schists alone makes more than 100 meters.

Contact Relations: The lower contact of the Salkhala Formation is nowhere exposed in the studied area. The basement gneisses, which are considered to underlie the Salkhala Formation elsewhere like Besham and upper Kaghan, are not exposed in the Swabi or Tarbela area.

The contact between the Gandaf and Kundal units is transitional, while that between the lower and upper members of the Kundal unit is narrow gradational over a narrow zone.

The upper contact of the Salkhala Formation with the Tanawal Formation is transitional (Fig. 2). As mentioned earlier the upper member of the Kundal unit is characterised by a gradual increase in the frequency of pebbly horizons (and also in the number of pebbles) intercalated with green phyllites devoid of pebbles. At the contact the pebbly horizons supported by green phylllite matrix disappear and 10 to 20 cm thick quartzite beds make their appearance intercalated with greenish pelitic beds, indicating a transitional contact. Notably, the basal quartzite beds of the Tanawal Formation are also conglomeratic. The pebbles in the conglomeratic quartzite beds are supported by quartzitic matrix rather than green phyllites as is the case with the upper part of the Kundal Unit of the Salkhala Formation.

Age: No direct evidence either palaeontological, radiometric or even stratigraphic is available for the age of the Salkhala Formation in the study area and its surroundings. In Kashmir, Wadia (1928 & 1931), recognised a sequence in which a thick unit of slates, termed the " Dogra Slates", conformably overlies the Salkhala Formation. Calkins et al. (1975) correlated the Dogra Slates with the Hazara Formation for which there is a radiometric age of 750 Ma. available (Crawford & Davies, 1975). The Hazara Formation, in this study, is considered equivalent, and a facies-change of the Tanawal Formation (see later). On the basis of this indirect correlation a Precambrian (Late Proterozoic) age is assigned to the Salkhala Formation.

Tanawal Formation

Field Distribution: Martin et al. (1962) showed a widespread occurrence of Chamla quartzites in the hill ranges north of Swabi. Later, Calkins et al. (1975) mapped the distribution of the Tanawal Quartzite Formation in Hazra and showed it to be extending into the Peshawar Plain west of the Tarbela dam. During the course of this mapping (Fig. 1), the above-mentioned two occurrences of the quartzite strata have been found physically continuous with each other. More than two-third of the presently studied area is occupied by the Tanawal Formation.

Subdivision and Lithological Description: Several N-S stream sections show excellent exposures of the Tanawal Formation in the hill ranges north of Swabi. The Formation is particularly well exposed in the Kundal valley, and the following description is mainly based on observations in this area.

The Tanawal Formation is divisible into three discrete units, 1) Lower Quartzite Unit, 2) Middle Argillite Unit and 3) Upper Quartzite Unit (Fig. 3).

The Lower Quartzite Unit comprises predominantly of quartzite (about 90% by volume), while the rest is made up of intercalated argillites.

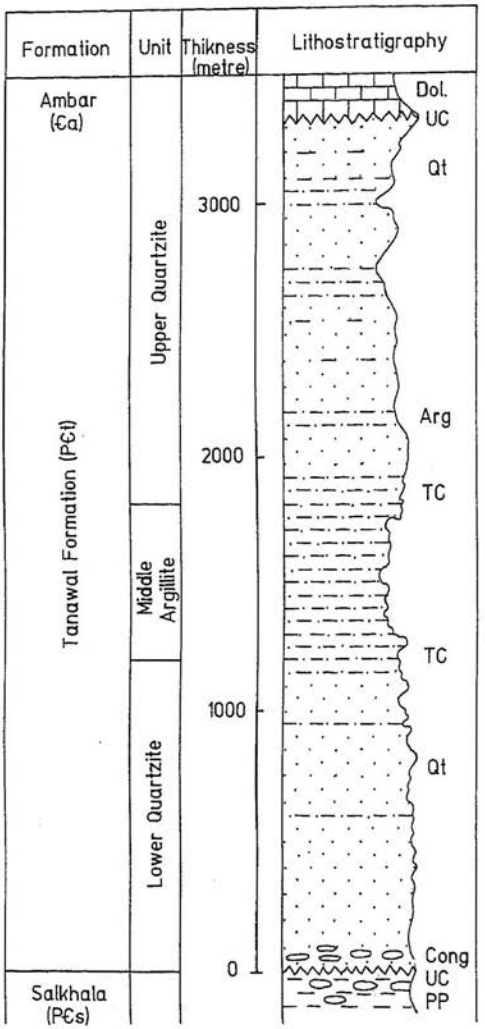

Fig. 3 Generalized lithostratigraphic column of the Tanawal Formation from the Swabi area. UC = Unconformable contact, TC = Transitional contact, Dol = Dolomite, Qt = Quartzite, Arg = Argillite, Cong = Conglomerate, PP = Pebbly Phyllites.

The quartzite is brownish-grey to light-grey and white, medium to thick bedded, hard and compact. Sedimentary structures like cross and graded bedding are well developed. Iron staining along the bedding planes, joints and fractured planes is common. Dark-grey, thick bedded to massive, unfossiliferrous and recrystalised limestone is found in the form of lenses. The limestone also contains intercalations of graphitic schist. The thickness of this unit is about 1200 metres. From base to top, the unit shows the following variations:

i) The quartzites in the basal part of the unit are generally very coarse grained. They are commonly microconglomeratic and rarely conglomeratic. Subrounded pebbles of quartzose to quartzite composition are supported by a quartzite matrix. Intercalations of a greyish/greenish black argillite are fairly common in this part.

ii) The middle part of the unit is predominantly quartzitic, however, thin argillite intercalations (few cm to < 0.5 meter) are almost always there. Commonly the argillaceous beds define the top of graded quartzite bed(s) which are up to 5 meters thick. The graded beds are cyclically repeated comprising coarse-grained or often microconglomeratic quartzite at the base, fine-grained laminated quartzite in the middle and argillites at the top. Sedimentary structures like cross-bedding and scour channels are common and reflect deposition from channelized flows, probably associated with fluvial or tidal flat environments.

iii) The uppermost about 20 meters of the unit comprise distinctly fine-grained pinkish white quartzites. These quartzites are thinly bedded and internally laminated, defined by alternating silt- and clay-sized fractions. Cross bedding is abundantly common and so are the scour channels.

The latter comprise coarser quartzites in the basal parts, which grade into clay-sized fractions in their upper parts.

The Lower Quartzite Unit of the Tanawal Formation has a transitional contact with the overlying Argillite Unit marked by the intercalations of up to 10 cm thick quartzite beds with argillite beds of more or less similar thickness. This transition persists over a thickness of about 10 meters when argillites become the principal and only lithology in the Middle Unit of the Tanawal Formation.

The Argillite Unit of the Tanawal Formation consists of argillites with only a minor component of quartzites. The basal two third of the unit comprises predominately of dull greyish black massive shale, with local horizons of laminated argillites defined by mm scale alternating silt and clay. White-coloured fine sand and silt form up to 10 m thick horizons at least three times in the lower two-third part of the unit. The greyish-black argillites transitionally pass upward into greenish argillites which make rest of the unit. Again both silt and clay-sized fractions are present, often forming alternating lamination. Locally the green argillites are sheared forming green phyllites which look similar to the upper member of the Kundal unit in the Salkhala Formation. This Middle Argillite Unit of the Tanawal Formation is approximately 500 metres in thickness.

The contact between the middle and upper units of the Tanawal Formation is transitional. The contact zone between the two units is less than 5 meters thick. The green argillites of the middle unit give way to beds of quartzite alternating with blackish grey argillites, which become progressively subordinate upward in the stratigraphic column. However, irrespective of the predominance and greater thickness of the quartzite beds, the intercalated argillites, like in the case of the Lower Quartzite Unit, are persistently present. In parts of the unit where quartzite is volumetrically predominant, the argillites occur as laterally discontinuous lensoid layers. The quartzite of the Upper Unit is brownish-grey, coarse grained, thick-bedded, hard, compact and forms high ridges. Sedimentary structures like lamination, graded and cross bedding are common. Barite and magnetite mineralisation is restricted to this unit mostly along the shear zones and faults. A characteristic feature of this quartzite is the abundance of ferrugeneous material often present in the form of globular structures of few mm in diameter (i.e., speckled structures). These structures may be used to distinguish the quartzites of the Upper Unit from the those of the Basal Unit which are lacking in them. The thickness of the Upper Unit is about 1500 m.

Contact Relations: The Tanawal Formation is unconformably overlain by the Ambar Formation of Cambrian age which occurs at the base of the Palaeozoic succession of the Peshawar Plain (see Hussain et al., 1991; Pogue et al., 1992). The unconformity between the two formations is indicated by a 18-21 metres thick conglomerate bed, consisting of pebbles and cobbles of quartzite embedded in a groundmass of quartzite and phyllite. The lower contact with the Salkhala Formation, as discussed above, is transitional.

Age: The Tanawal Formation is devoid of fossils and thus lacks any direct evidence of age. Its extension in the Hazara area, east and northeast of the presently studied area, is extensively intruded by a granite of batholithic dimension, which has been radiometerically dated to be 516 Ma (LeFort et al., 1980). This implies a Cambrian or older age for the Tanawal Formation. Stratigraphically, the Tanawal Formation in the Hazara area is overlain by the Abbotabad Formation. The Hazira member of this formation has yielded an Early Cambrian fauna (Fuchs & Mostler, 1972; Rushton, 1973; Talent & Mawson,

1979) which implies a Late Proterozoic age for the Tanawal Formation.

REGIONAL CORRELATION

The equivalence of the quartzites of the studied area with those of the Tanawal Formation of the Hazara area was first recognised by Martin et al. (1962). Additionally they rightly correlated the Swabi Quartzites (the Misri Banda Quartzite of Hussain et al., 1991and Pogue et al., 1992) with those forming part of the Cambrian Abbotabad Formation rather than equating them with those of Chamla or Tanawal, which are older. The two-fold division of the quartzites in the Swabi area, as outlined by Martin et al. (1962) and now confirmed by the recent detailed stratigraphic analyses of Pogue and Hussain (1986), Hussain et al. (1991) and Pogue et al. (1992), is fully supported by the present work. However, we feel that this distinction and division was not followed by Calkins et al. (1975) and other workers in the Tarbela area resulting in an unnecessarily complex scenario in terms of regional tectonics (see later).

A succession of siliceous schists, locally containing calc-silicate marbles, termed Manglaur Formation, has been recognised as the country rock of the Swat gneisses in the Swat area. Together with the latter, they are unconformably overlain by the Palaeozoic Alpuri Group (Kazmi et al., 1984; Lawrence et al., 1989; DiPietro et al., 1993). Close resemblance in lithology and stratigraphic position below the Palaeozoic succession has led the above mentioned workers to suggest a correlation with the Tanawal Formation. In the Kaghan area several successions of quartzites are exposed but their correlation with the Tanawal Formation is highly uncertain (Ghazanfar et al., 1992).

The Gandaf Unit of this study was referred to as the Salkhala Formation by Calkins et al. (1975). The recognition of a second unit termed Kundal Unit in this study is based on its physical continuation with the underlying Gandaf Unit (Fig. 1). The correlation of the Salkhala Formation exposed in the Tarbela (Calkins et al., 1975) and Swabi area (S. R. Khan, 1990 and this study) with that exposed in Kaghan (Calkins et al., 1975; Ghazanfar et al., 1992; Greco & Spencer, 1993) and Kashmir (Wadia, 1931; Calkins et al., 1975; Greco, 1991) appears logical on the basis of close resemblance in the component lithologies.

Whereas, individually the Tanawal and underlying Salkhala formations have their respective correlatives in rest of northern Pakistan, regional correlation becomes problematic when they are considered together in the context of a coherent stratigraphic succession. This is for the reason that nowhere else in northern Pakistan, the Salkhala Formation is directly overlain by the Tanawal Formation or its equivalents. For instance, at its type locality (Neelam valley, Kashmir; Wadia, 1931) the Salkhala Formation is overlain by the Dogra slates, which are equated with the Hazara Slates and their equivalents in Ghanghar, Attock, Cherat and Khyber. The Tanawal Formation, all over northern Pakistan, is considered at a stratigraphic position directly above the "Slates" (Marks & Ali, 1961; Ali, 1961)

This may be applicable to the Hazara region (Calkins et al., 1975), but is clearly not the case west of the Indus river in Gandaf-Swabi area. The discrepancy is particularly obvious in the Tarbela area. The Tanawal Formation, east of the Indus river overlies the Hazara Formation, but west of the river, rests directly atop the Salkhala Formation with an altogether absence of the Hazara Formation (see maps by Calkins et al., 1975). Probably this was the reason which led Calkins et al. (1975) and Williams (1989) to mark a tectonic contact between the Salkhala and Tanawal formations.

The present study has demonstrated that the Tanawal Formation is not exclusively

quartzitic but a major unit in the middle part of the formation is argillaceous. In essence, the "slate" formations of northern Pakistan (including Dogra, Hazara, Manki and Landikotal) are an admixture of agillites and sandstones/quartzites. We find no reason for assigning a stratigraphic position and age to the Tanawal Formation different from the Hazara Formation and equivalents (see Chaudhry & Ghazanfar, 1991-1992, for similar views)). We speculate that these two formations are mutually continuous with each other and any difference in quartzite (sandstone) vs. argillite (slate) proportions is due to facies changes rather than age or different stratigraphic position.

CONCLUSIONS

The stratigraphy of the area north of Swabi and west of the Tarbela dam has been revised through this study.

1. The Chamla phyllitic shale of Martin et al. (1962) has been renamed as Kundal Unit, which is found to be physically continuous with the Salkhala Formation mapped by Calkins et al. (1975) at the western bank of the Tarbela dam. The latter has been assigned a new name i.e., Gandaf Unit, which together with the overlying Kundal Unit constitute the Salkhala Formation of the present study.
2. The Chamla Quartzite of Martin et al. (1962) is assigned the status of a formation and is divided into three units. Whereas the upper and lower units are mainly quartzites with ubiquitous presence of argillite intercalations, the middle unit is massive to laminated argillite with minor quartzite intercalations.
3. It is tentatively suggested that the Tanawal Formation may be a stratigrafic equivalent of the Hazara, Manki and Landikotal formations, rather than being younger as suggested by the earlier workers.

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