PETROGRAPHY OF THE BAGHANWALA FORMATION, KHEWRA GORGE, KHEWRA, JEHLUM DISTRICT; PUNJAB: PAKISTAN

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ABSTRACT

This paper presents a petrographic study of the Baghanwala Formation (Late Early Cambrian—Early Middle Cambrian), exposed in the Kkewra Gorge, Salt Range, Pakistan.

The Baghanwala Formation is dominantly composed of shales. Interbeddings of flaggy sandstone occur at several stratigraphic levels. Thin bands of dolomite/limestone are also interlaminated in the lower part. Iron oxide coating of the quartz grains which forms the bulk of the detrital fraction of the interlaminated sandstones is a most conspicuous feature. Carbonates (calcite/dolomite) are the other major minerals which form bulk of the matrix. Other detrital minerals present nre micas (biotite and muscovite), chlorite, plagioclase, microcline, glauconite, and ores. Carbonates, clay, and iron oxide are the cementing materials.

INTRODUCTION

The Baghanwala Formation forms the upper most strata of the Cambrian succession of the Salt Range (Fig. 1). Il is characterized by its light red and variegated shales, and interbedded sandstone strata. The formation conformably overlies the cream coloured Jutana Dolomite. This difference in colour helps to differentiate the Baghanwala Formation from the underlying Jutana Dolomite even from a far distance. When observed from a distance it appears to form steep escarpments and vertical cliffs. However, inside the Khewra Gorge where the section was measured it dips into the ravine and forms a feature resembling rapids with strata dipping up-stream, and only at a few places exposes steep escarpments. The formation is unconformably overlain by a heterogenous glacial boulder bed, the Tobra Formation, and the contact here is very sharp.

Although the formation is mainly composed of shale with interbeddings of flaggy sandstones, thin dolomitic/limestone bands are also interlaminated in the lower part. No regular variation in mineralogical composition is observed from base to the top of the formation. Coating of the clastic grains by iron oxide is common, but abundant in the upper part. It is because of this iron oxide coating that the thin sections, cut from field samples, from the upper part appear brownish-red in colour. Carbonates and clay are the most important cementing materials in the sandstone interbeddings, but In some slides iron oxide is also present as cementing material. Micas are present to the extent of being important detrital (terrigenous) minerals whlle feldspars are rare.

MINERALOGICAL COMPOSITION

The mineralogical composition of sandstones and dolomite bands was determined with the help of thin sections cut from the field samples, while the composition of shales could not be determined because of the fine grained texture and lack of equipment in the laboratory of the Institute. The percentage composition of the various minerals present is evaluated approximately by comparing the visual charts given by Compton (1962), and G V, Chilingar, H. J. Bissell, and R. W. Fairbridge (1967). The detailed mineralogical composition of sample (excluding shales) is given in table No. 1.

The various minerals present can be categorized as following, in order of their abundance:

MAJOR MINERALS

- Quartz
- Carbonate (Calcite/Dolomite)

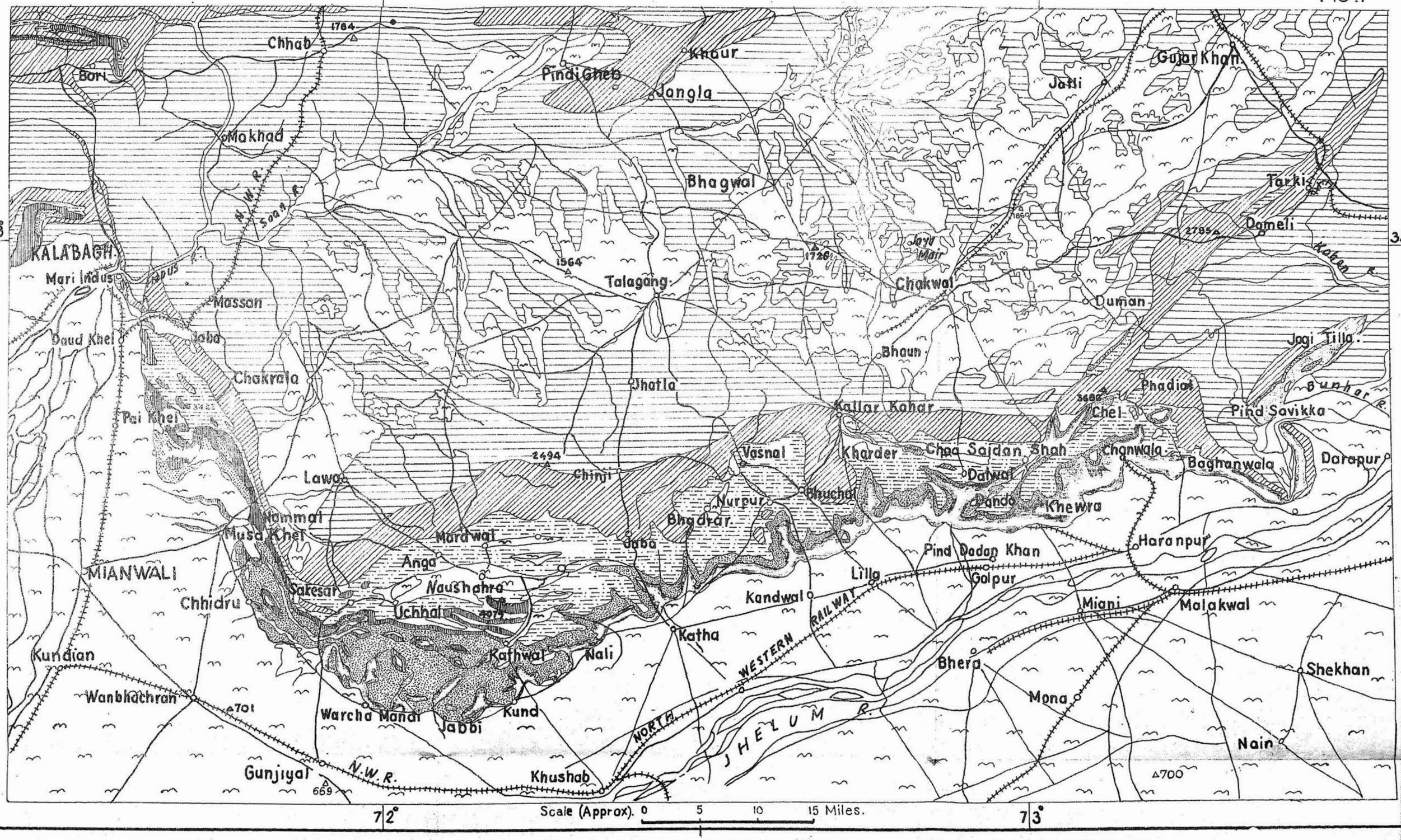
ACCESSORY MINERALS

- Ore minerals
- Mica (Biotite and Muscovite)
- Chlorite
- Plagioclase
- Microcline
- Glauconite

CEMENTING MATERIAL

- Carbonate and Clay
- Iron oxide

FIG. 1



GEOL. MAP OF THE SALT RANGE SHOWING KHEWRA AND BAGHANWALA SECTIONS GEOLOGY BY E.R.Gee.

- Alluvium (Recent & Pleistocene)
- Upper & Middle Siwaliks. (Upper Miocene & Pliocene)
- NIMADRIC FORMATION.
- EOCENE (Kohat Saline series shown
- MESOZOIC.
- UPPER PALAEOZOIC
- CAMBRIAN or PRE-CAMBRIAN.
- CAMBRIAN or PRE-CAMBRIAN

In addition to the petrographic study, the thin sections were also used for the identification and estimation of the cementing material. For this purpose the thin sections were not covered with coverslips and instead dipped in an N/10 HCL solution. This resulted in the removal of carbonates and only clastic quartz grains were left. Presence of clay was also confirmed by this process. In rare cases iron oxide was observed as an important cementing material instead of calcareous cement.

TEXTURE

Texture of sandstones is expressed by the grain to grain relationship of the framework and the matrix. Framework here is dominantly formed by the monocrystalline and a few polycrystalline quartz grains with some carbonate grains and mica flakes. Matrix is exclusively composed of carbonate minerals calcite/dolomite. Unidentified clay minerals are also present in matrix in most of the slides.

The most important textural feature of sandstone is the size and shape study of the grains present. Size and shape of the grains are of great significance and provide important clues for the interpretation of source rock and transport history of the clastic fractions. It is because of this reason that further work is to be carried out on the size and shape study of clastic fractions of the Baghanwala Formation. This work will be published in near future. Petrographic features are, however, discused as under :

Petrographic studies reveal that the sand grains vary from very fine to coarse grained sand size particles of Wentworth Scale (1914). However, majority of the sandstones are made up of fine sand grains. Fractured quartz grains are common. Due to the abundance of iron oxide, the effect of oxidation can be easily seen in these fractures. These effects are, however, less in the basal part but dominant in the upper part. In some cases the quartz grains are totally coated by iron oxide. Secondary enlargement of quartx grains as a result of authigenesis is also observed. The boundaries of the nucleii are also marked by thin films of iron oxide. In almost all cases quartz grains are embedded in a carbonate matrix and appear as floating in the matrix. In some slides quartz grains are being replaced by the carbonate matrix.

Carbonate minerals constitute the allochemical and orthochemical fractions, and make the matrix for detrital quartz grains. Majority of the carbonate grains are blebshaped, and vary from very fine to medium grained size. In two slides the carbonate minerals are more than 90 percent and are thus pure chemical in orlgin. It is also observed that the carbonate minerals are more prominant in the basal part as compared to the upper part. However, no gradual change is observed.

Recrystallization of the carbonate minerals is also an important textural feature observed in a few slides. The process is, however, limited and appears to have replaced some original pelletoid textural features. Thus only ghost structures are present. The carbonate minerals are coarsely recrystallized in the ghost structures, and merge into the fine grained calcareous matrix. It is possible that these ghost structures have been reworked from the under lying Jutana Dolomite

Mica is a minor detrital, but important, constituent. Biotite, muscovite and chlorite are present, and are prominant in the upper part as compared to the basal part of the formation. Muscovite is fresh because of its chemical resistivity, while biotite is mostly altered to chlorite. Oxidation effects are so pronounced that even biotite contains abundant iron inclusions and in many cases biotite is recognized only because of its flaky nature. In almost all slides mica flakes show a preferred orientation.

Plagioclase, microcline and glauconite are present in very minor amounts in some of the slides. Glauconite is present only in slides Nos. 1 and 2, and appears to be the result of reworking from the underlying Jutana Dolomite.

DESCRIPTION OF MINERALS

Quartz

Quartz is the most important and dominant detrital mineral present in the sandstones and muddy sandstones of the Baghanwala Formation. The grains are embedded in a carbonate matrix, and only in a few cases in an iron oxide matrix. Quartz is present to the maximum extent of, approximately, 74 percent in slide No. 17, and to minimum extent of 2 percent in slide No. 8. Quartz grains show undulatory extinction, which is indicative of their origin from plutonic rocks which were later on subjected to metamorphism. The presence of feldspar in a very minor amount suggests the

derivation of quartz from granite or gneiss or even older sandstone (?). The amount of feldspar deminishes with the increase in the geological age of the formation. Subrounded to rounded nature of (a few coarse) quartz grains is indicative of the fact that they are of multicycle origin. Low percentage of feldspar is also suggestive of the same fact.

Staining of quartz grains by iron oxide is a common feature. However, in many slides the abundance of iron oxide causes evtensive coating around the quartz grains.

Carbonate

The carbonate minerals constitute the matrix and cementing material in all the slides. In many of the slides the carbonate minerals are so much abundant that their separate description is important. The carbonate mincrals, as cementing material, are discussed separately.

Calcitc appears to be the dominant carbonate mineral, however, some dolomite is also present. In slides No. 4 and 8 the calcite appears to be of orthockemical origin, and samples can be called as pure chemical limestones/ dolomites. In other slides it is of allochemical origin which is inferred by the rounded margins of the grains.

The differentiation of carbonate minerals into matrix and cementing material is an arbitrary one. The writers have, however, considered sparry carbonate minerals as cementing constituents, and rest as the matrix. Excluding the slide No. 4 and 8 the maximum percentage of the carbonate matrix is approximately estimated as 69 in slide No. 1, and minimum amount of carbonate matrix is 5 percent in slide No. 19.

Staining of carbonate matrixs by iron oxide is also observed in my slides and is abundant in the upper part of the formation.

Mica

Mica is present as detrital mineral constituent of the Baghanwala Formation, and is more prominant in the upper part than the basal part. Biotite occurs as small flakea partly altered to chlorite. Pronouneed oxidation has effected the biotite flakes and in some cases only the pseudomorphs of biotite are observed. Muscovite is fresh and occurs as very thin and elongate flakes. However, muscovite also occurs as very thin and small grains in many slides.

Chlorite

Chlorite is observed as an alteration product of biotite. It oecurs as small green pleochroic flakes. Chlorite flakes variously indicate oxidation effects and at places are brownish-red in colour.

Biotite, muscovite, and chlorite are all oriented in the same direction (parallel to bedding), and are inrerlamiuated with quartz grains. These flaky minerals are prtsent in minor amount in slides which contain abundanr matrix.

Plagioclase

Plagioclase is present as a minor constituent and never exceeds more than 1 percent. Its fine subhedral grains are marked by the combined carlsbad—albite twinning. On the basis of extinction angle, approximately determined as 30°, the composition of plagioclase comes to be sodic labradorite. Plagioclase grains like the quartz grains are embedded in carbonate matrix. Kaolinization of feldspar grains has occured which appears as stains and coatings on and around the grains, which indicate that the grains are by no means fresh. The plagioclase grains have been replaced by carbonate matrix in some cases, and in some slides they show alteration to sericite and clay minerals. Secondary enlargement, as a result of authigenesis, is also noticed in many slides. The margins of the nucleii and the overlay are marked by iron oxide in the form of thin film.

Microcline

Microcline is a very rare mineral present in this formation. It never exceeds more than 1 percent, and is absent from majority of the slides studied. Albite-pericline twinning marke identification very easy and sharp.

Glauconite

Glauconite is present as a trace mineral in only two slides (Nos. 1 & 2). The grains are very small and appear to be the alteration product of chlorite. However, this does not seem to be a plausible explanation, because if it is the alteration product of chlorite, it would have been present in almost all the slides which contain abundant chlorite. Over here writers suggest that the

glauconite present in the Baghanwala Formation is neither of primary origin nor an alteration product of chlorite, but has been reincorporated from the underlying Jutana Dolomite. Presence of glauconite in slides which contain chlorite in a very minor amount also substantiates the writers' view. The view is further confirmed by the fact that glauconite is present only in the very basal part of the formation.

Ore minerals

Ore minerals are present in a minor amount in the basal part but dominate the upper part and the shaly intercalations. It is the dominance of these minerals that an overall brownish-red colour is imparted to the formation. Microscopic examination of the various slides shows that these are the oxidized iron minerals, mostly hematite (?). The exact composition of ore minerals could not be determined because of the special and time consuming preparatory techniques and also because of the fact that..."few sedimentary petrologists have had training in ore microscopy" (Blatt, Middleton, Murray, 1973 p, 290). Most of the iron oxide present is finely divided and only a few grains are of larger size. The larger grains appear to have been derived from the igneous or metamorphic source rocks. It may also be possible that remobilization of disseminated iron oxides may have caused its concentration around a nucleus, thus forming larger grains. The finely divided iron oxide appears to have been precipitated and dispersed mechanically in the clay and silt sized grains. Besides magnetite and hematite, limonite and leucoxene may also be present.

Cementing material

Detrital fragments in the Baghanwala Formation are cemented together by calcareous (calcitic/dolomite) material. The percentage of the carbonate minerals varies greatly and in some slides constitute the major portion of the slides (slide Nos. 1,15 & 18B). The grain size also varies greatly, grained calcite/dolomite have been assigned as cementing material, while the rest as matrix. Besides calcareous material, clay minerals also serve as a loose cementing material. In some cases, however. clay minerals are present to a much greater extent. The presence of calcareous cementing material and clay is also confirmed by the treatment of uncovered slides with N/10 HCI.

Extensive oxidation has resulted in the staining of calcareous material, and in many of the slides from the upper part of the formation it is difficult to

identify calcareous material. In some slides it appeats that iron oxide is serving as a cementing muterial for quartz grains. Calcite/dolomite cementing material occurs as a mosaic of anhedral subsequent crystals. Detailed study of the origin of calcareous cement is beyond the scope of present work. However, briefly, writers suggest that it is the result of saturation of water caused by an increase in the activity of carbonate ions.

Regarding hematite (?) as cementing material "red pigmenting matter in sandstone is present either as a primary pore filling precipitate from solution, as microcrystalline particulate iron oxide deposited with the clastic grains or os iron ions adsorbed on clay mineral surfaces" (Blatt, Middleton, and Murray, 1973, p. 365–366). The ultimate source of iron ions are the igneous and metamorphic roeks. Diagenetic origin of hematite cement is also suggested by some authors (e. g. hematite-cemented quartz sandstones, part of the Hickory Formation of Central Taxas and parts of the Postdam Formation of northern New York). However, the origin of such pigments in immature sandstones can not be discussed with certainity. In the Baghanwala Formation the red pigment may be the combined result of deposition by aging of amorphous iron compounds and diagenesis.

CONCLUSION

The Baghanwala Formation, which forms the upper most unit of the Jehlum Group is dominantly composed of the clastic rocks, which are shales and sandstones.

According to the end member concept, that is carbonate-quartz-and other constituents (micas, chlorite; plagioclase, and ore minerals), majority of the sandy samples collected from the Baghanwala Formation fall within the categories of sandstones, micaceous sandseones, and calearеous sandstones. Only two sample fall into the category of limestone/dolomite. Table 1 and figure 2 show nomenclature and classification of these samples respectively.

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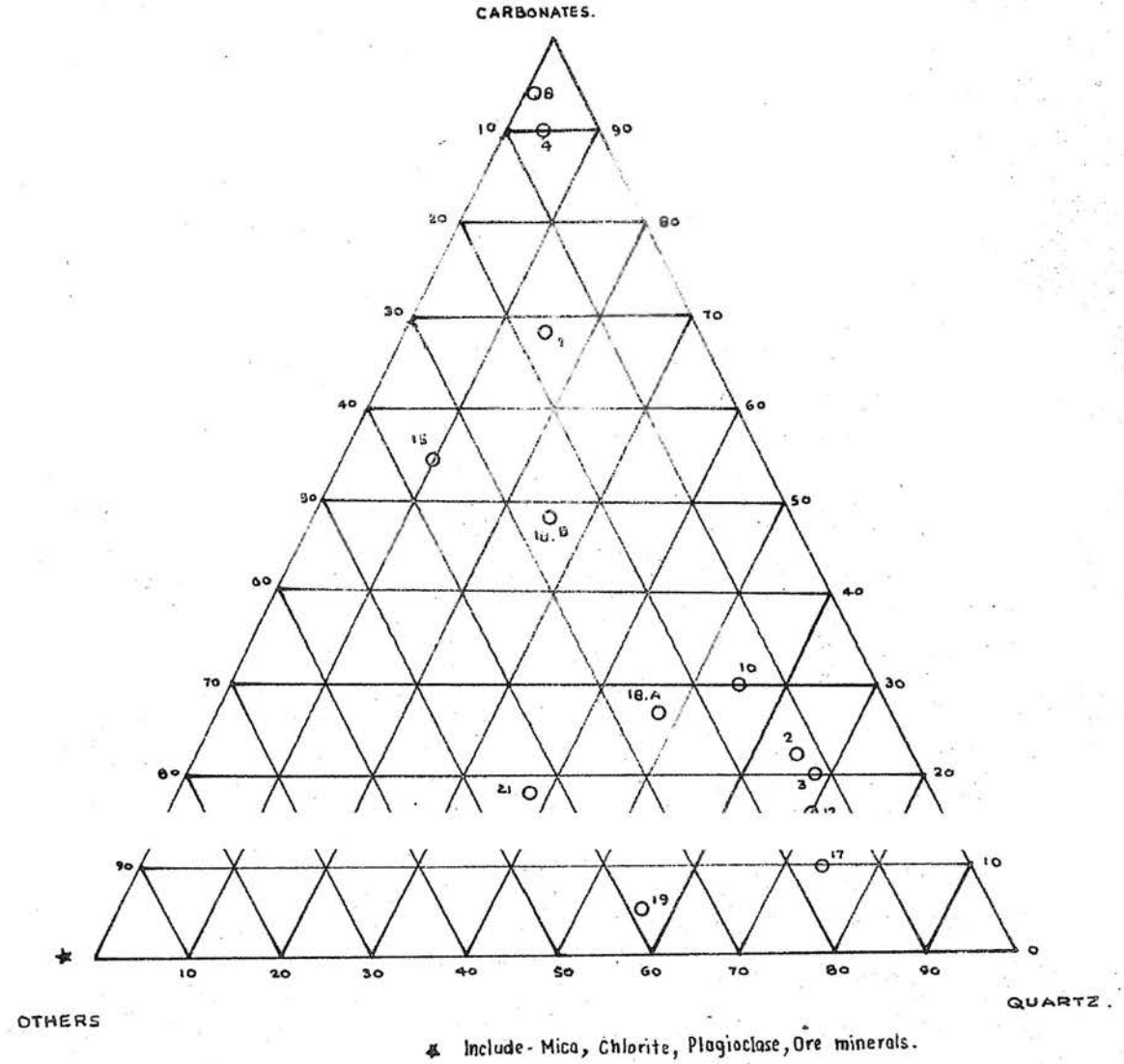
MINERALOGICAL COMPOSITION (%) OF THE BAGHANWALA KHEWRA GORGE SALT RANGE.

ide No.	Quartz.	Carbonate.	Biotite.	Muscovite.	Chalorite.	Glauconite.	Plagoclase.	Microcline.	Clay.	Ore Minerals.	N o m e n c l a t u r e.
1.	15	68	7	5	1	TRACE.	1	1	1	1	Micaceous Sandstone.
2.	66	22	2	1	–	TRACE.	1	1	3	4	Sandstone.
3.	68	20	2	2	TRACE.	–	1	–	3	4	Sandstone.
4.	4	90.0	2	1	–	–	1	–	1	1	Limestone. / Dolomite.
8.	2	94	2	1	–	–	–	–	–	1	Limestone. / Dolomite.
10	55	30	2	1	TRACE	–	1	1	5	5	Sandstone.
12	70	16	1	1	– –	–	–	–	5	4	Sandstone.
15	20	54	2	4	3	–	–	–	5	2	Calcareous Sandstone.
16.	40	15	2	1	–	–	–	–	7	35	Sandstone.
17.	74	10	5	3	2		TRACE	–	4	2	Sandstone.
18. A	47	27	15	8	–	–	TRACE	–	–	3	Micaceous Sandstone.
18. B.	25	48	10	6	–	–	–	–	3	8	Micaceous Sandstone.
19.	56	5	1	1	–	–	1	1	15	20	Sandstone.
21	39	16	4	2	1		1	TRACE.	8	27	Sandstone.



The Composition of some Samples from the Baghanwala Formation, Khewra Gorge Salt Range

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