THE STUDY OF NATURE AND ORIGIN OF THE TOBRA FORMATION IN THE EASTERN PART OF THE PUNJAB SALT RANGE.

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and
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ABSTRACT

The Tobra Formation of the Early Permian age exposed in the Salt Range, shows different modes of deposition. While the lower part is predominantly of glacial origin, the upper horizon indicates lateral variations from glacio-fluvial to esturine and marine conditions.

In the eastern Salt Range the formation can be divided into six units on the basis of colour, lithology and the particle size. The lower part is a petromict boulder bed but the upper levels are dominantly composed of coarse sandstone and gritstone.

The material constituting the Tobra Formation may have been transported from Rajisthan and further south from Peninsular India or even beyond the present boundaries of the Sub-continent.

The rocks exposed in the Aravalli Outliers are much different from the rock assemblage in the Tobra Formation. The Pre-Cambrian—Cambrian rocks of the Salt Range are also missing. It may be assumed that parts of the area south of the Salt Range might have been covered by thick alluvium during Late Palaeozoic time.

INTRODUCTION

The existance of a glacial boulder bed of Late Palaeozoic times was long known to the geologists of the Sub-continent as Talchir Boulder Bed. The name 'Tobra Formation' was introduced by E.R. Gee (1964) to distinguish it from other deposits of similar nature at different places in the Sub-continent. This name has been approved by the Stratigraphic Committee of Pakistan.

The formation extends east-west in major part of the Punjab Salt Range. In the eastern part it overlies Baghanwala Formation of Late Cambrian age which is dominantly an argillaceous unit with laminated silty strata. After a long period of non-deposition during the entire middle and most of the later part of Palaeozoic Era, the sedimentation ensued in Early Permian when the boulder bed was laid down.

The Tobra Formation is overlain by Saiduwali Formation and Warchha Sandstone which were earlier known as Olive Series and Speckled Sandstone respectively.

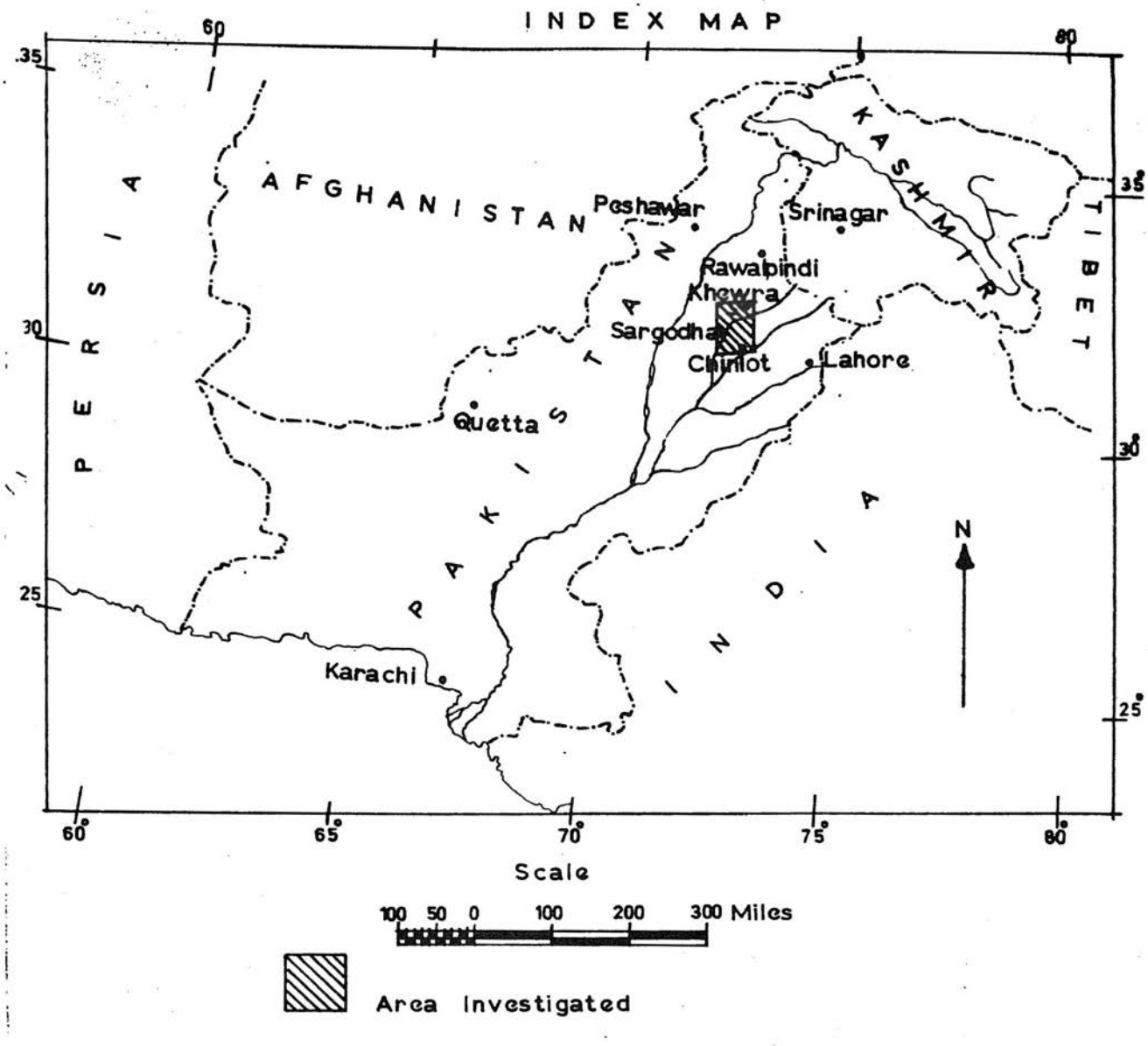
These formations are of Lower Permian age. The Tobra Formation has a normal gradational contact with the overlying formations.

Formerly the age of the Tobra Formation was considered to be Late Carboniferous on the basis of spores, leaf impressions and other remains of Lower Gondwana plants in the beds immediately overlying it (Krishnan, 1960). However, recent studies indicate that the age of the Tobra Formation is Early Permian (Teichert, 1967).

The dip of the formation in the eastern Salt Range is gentle, ranging from 20 to 30 degrees and the direction of dip is mostly south-east. The strike changes quite often but the general trend is NE and ENE.

The base of the formation is predominantly composed of boulders, cobbles, and pebbles of granite, quartzite, quartz, rhyolite, jasper, volcanic porphyry, schist, dolomite and some altered rocks. Beds and lenses of finer material of different grades are also present. It may be regarded as tillite facies. In the upper part, the pebbly horizons become less important and the most dominant rock type is sandstone and gritstone of different types. At places cross-bedding is also observed in sandstone.

The maximum thickness in the eastern Salt Range recorded during the course of present work is 53 meters.


INDEX MAP
60
80
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PERSIA
AFGHANISTAN
Peshawar
Srinagar
KASHMIR
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Sargodha
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Quetta
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Karachi
60
65
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Scale
100 50 0 100 200 300 Miles
Area Investigated

PREVIOUS WORK

The stratigraphers of the Sub-continent have been stressing on the need of the detailed investigation of the glacial boulder beds of this region since long (Wadia, 1957; Krishnan, 1960), but very little was known until Teichert (1967) published his work on Tobra Formation. This work provides many interesting details about lithology, age, fossils and the facies change within this formation. His most important contribution is the recognition of three facies belts from east to west i.e. tillitic facies, fresh-water facies and a complex facies of diamictite, sandstone and boulder beds of probably marine or esturine origin.

Teichert and Balme (1967, 1970) have mentioned the presence of some spores, pollens and microplanktons and on this basis, have assigned Early Permian age to the Tobra Formation.

PRESENT WORK

The present work is carried out in the eastern part of the Punjab Salt Range between grids V 128335 Sheet No. 43 H/2 and V 720262 Sheet No. 43 D/10. It includes the study of the rock types comprising the Tobra Formation, their behaviour, textural variations and on their basis the division of the formation into recognizable units. The boulder bed has been investigated more thoroughly and boulder/pebble study has been carried out which includes pebble features, size, shape, lithology and the orientation, in order to determine the nature of the deposition and the source area.

In the course of work it was considered appropriate to examine the rock types exposed in Aravalli Outliers located about 50 miles south of the Salt Range and to establish their relationship if any, with the Tobra Formation. Different sections in Sargodha, Chiniot and Sangla were thus visited and the rock types, their petrography, abundance and attitudes were studied.

FORMATION'S NAME AND TYPE LOCALITY

Tobra village, from where the name of the formation comes, is located at a flat hill top in the eastern part of the Salt Range, grid V 119317 Sheet No. 43 0/14. The dip of the formation and the topographic slopes are gentle. As a result the formation is exposed over a large area. However, the maximum thickness in this area is only 91 meters. Teichert (1967) has observed maximum thickness of the Tobra Formation (121 meters.) towards the western Salt Range, in Zaluch Nala. Besides this, the different

stratigraphic manifestations found in other sections are not present here.

The authors feel that the formation's name has been adopted without enough justification. However, till now, the Tobra Formation is the official name and it is used as such in this paper.

STRATIGRAPHY

In the eastern Salt Range, the Tobra Formation is divided into six identifiable units which are found in most of the sections.
The basis of the division are:

a) The degree of the coarseness
b) The dominant lithology
c) The striking colour differences

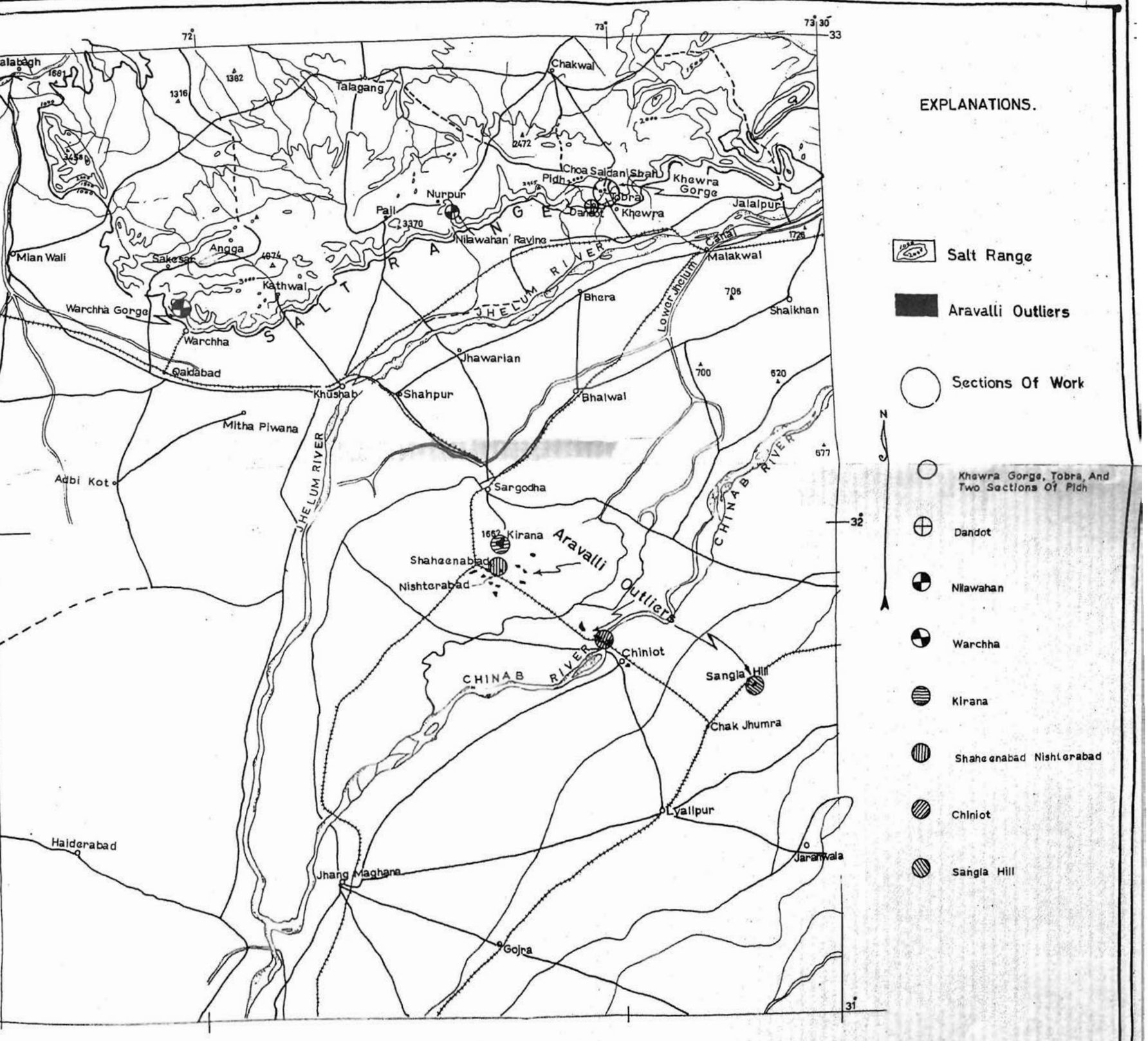
Following is the brief lithological description of the various rock units which compose the Tobra Formation.

1. Boulder Bed: This unit forms the basal part of the Tobra Formation throughout the area under examination. It maintains a uniform thickness and can be regarded as marker horizon. The boulder bed is an unsorted assemblage of pebbles, cobbles and boulders ranging in size from a few mm to 120 cm or more. The pebbles are dominantly composed of different types of granitic rocks, quartzite, rhyolite, quartz, volcanic porphyries and a small percentage of dark coloured rocks embedded in a coarse and petrographically similar matrix. Lenses and discontinuous bands of finer and clayey material are also present. The thickness ranges from 3 to 4.5 meters.

2. Yellowish Green Sandstone: It is very coarse-grained sandstone, yellowish green to yellowish brown in colour with thick bands of gritty and pebbly material at many levels. Small scale cross-bedding is also observed at two localities. Boulder clay is also present at several levels. Lateral variations in thickness are frequent. In some sections it is not present. Maximum thickness is 21 meters.

3. Carbonaceous Shale and Siltstone: It is greenish grey to black rock with a nodular appearence which may be the result of weathering. This unit exposes its entire thickness in the Khewra Gorge.

Towards the top it becomes more arenaceous and gradually grades into overlying sandstone. Medium to large pebbles and occasionally very big boulders are found in this unit, specially between the middle and upper parts. This unit is found in two sections and the maximum thickness is 6 meters



MAP SHOWING SALT RANGE AND ARAVALLI OUTLIERS WHERE THE WORK WAS CARRIED OUT.

(FAZAL AHMAD)

4. Gritstone: This unit is composed of angular rock fragments with many pebbly bands. The colour is yellow to yellowish green. Inclusions of boulder clay and channel sand are also present. Maximum thickness recorded is 18 meters.

5. *Coarse Sndstone;* This unit is composed of more or less uniform sized sandstone. Occasional coarser material, clay and carbonaceous bands are found. No pebbly horizons are, however, observed. The colour is dominantly cream to light brown. Maximum thickness is 21 meters.

6. Rusty Brown Sandstone: It forms the upper most part of the Tobra Formation and is very persistent. It has a very striking colour and can be easily distinguished. Beds of gritty material and pebbles are frequent. At places it shows platy and flaky structures. Bands of argillaceous material are occasionally present. Thickness ranges from 3 to 12 meters.

PETROGRAPHY

Petrographic studies of the boulders, pebbles and other rocks of the Tobra Foramation reveal that a lot of igneous, metamorphic and sedimentary rock fragments are present in it. Some of the rocks have been altered and are difficult to recognize. The matrix of the boulder bed shows occurrence of mineral and rock fragments like quartz, feldspar, mica, chlorite, iron oxide volcanic glass, carbonates and clayey material. Following is a brief account of the petrographic studies of the rocks identified from the Tobra Formation. The dominant igneous rocks are granites, volcanic porphyries and volcanic breccia.

Granites: They are of many different colours; pink, light pink, dirty white to light grey with variable textures. Most of the granites are fresh except one specimen which exhibits alteration of feldspar to clay minerals.

The dominant minerals in granites are feldspar, quartz, biotite, chlorite, muscovite and ore minerals. Texturally, all the granites are coarse grained hypidiomorphic.

Volcanic Porphyries: They are mostly fresh and show different shades of colours from light grey to brown. Phenocrysts of quartz and feldspar which are white and light pink in colour respectively, can be observed. Greasy appearence on the weathered surface is a prominent feature of these rocks. Spots of pink feldspar are common.

The thin section study reveals the presence of chlorite, biotite, feldspar and quartz which are abundant constituent minerals. Iron oxide and volcanic glass are also found.

Rhyolite: The boulders and pebbles of rhyolite are dark grey in colour and show fine texture.

Phenocrysts of quartz, potash feldspar, and plagioclase are set in a glassy and felsitic ground mass.

Volcanic Breccias: They are mostly brown coloured boulders and are composed of angular rock fragments and some quartz. The fragments are surrounded by volcanic glass and iron oxide.

Quartzites: Among the metamorphic rocks, quartzites are common. They are cream coloured to brown and grey rocks with many textural variations. Quartzites are mostly composed of quartz, iron oxide, biotite, chlorite, muscovite, feldspar and some opaque minerals. The abundance of the constituent minerals, based on the study of five samples is given in table 1.

The common sedimentary rocks in the form of fragments in boulder bed and in different other units are sandstone, siltstones, conglomerates, and carbonates.

Sandstone: The various coloured sandstones, siltstones and associated gritstones are mostly hard, compact and well cemented. Texturally they are coarse to medium grained, moderately sorted with low sphericity and roundness. They are composed of grains and fragments of quartz, feldspar, calcite, iron oxide, biotite, chlorite, muscovite, and clayey material. The iron oxide is most probably epigenetic. Table 2 gives the composition of the different sandstones found in the Tobra Formation.

Carbonates: The limestones are greenish-gray in colour and are badly weathered. They are semi to medium crystalline and show fine texture. These occur as rounded pebbles and boulders. The pebbles of limestone are embedded in argillaceous matrix. The dolomite is quite fresh with a dominant light grey colour and is very finely crystalline.

The rock somples collected from Kirana Hills and their continuation in Aravalli Outliers were found to be mostly altered. However, the following rocks have been identified: (i) Quartzite (ii) Siltstone (iii) Sandstone (iv) Breccia (v) Pebbly carbonaceous-rocks (iv) Volcanic tuffs.

TABLE . 1. Mineralogical composition (%) of some samples of quartzites from the Boulder Bed in the Tobra Formation

No.	Quartz	Iron Oxide	Biotite	Chlorite	Muscovite	Feldspar	Opaque Minerals
3	86	—	10	2	1	—	1
17	63	23	4	3	2	—	5
18	60	25	5	—	—	10	—
27	87	—	4	—	7	—	2
33	67	30	—	—	1	3	—

TABLE - 2. Mineralogical composition of the different sandstones found in the Tobra Formation

No.	Quartz	Feldspar	Botite	Calcite	Iron Oxide	Muscovite	Chlorite	Clay Minerals	Names suggested
Y-b_1	64	8	—	Traces	23	4	—	—	Quartz Iron Oxide Sandstone
C-x_3	55	18	4	Traces	14	3	2	—	Feldspathic Sandstone
R-b_6	48	6	Traces	24	10	6	3	—	Calcareous Sandstone
S-h_2	20	2	—	—	4	Traces	18	55	Argillaceous or Shaley Sandstone

TABLE - 3. Percentage of pebble/boulders of different rock types in the Boulder Bed of the Tobra Formation

	Name of Section	Khewra Gorge		Tobra		Dandot		Tobra Formation (As A Whole)	
	Number of pebbles/ percentage	Total No. of pebbles counted	Percentage	Total No. of pebbles counted	Percentage	Total No. of pebbles counted	Percentage	Total No. of pebbles counted	Percentage
No.	Common rock types								
1.	Quartzite	231	30.4	318	46.0	178	42.4	777	38.3
2.	Granite	238	38.0	166	24.0	126	30.0	640	31.5
3.	Jasper	38	4 5	17	2.5	13	3.1	68	3.3
4.	Rhyolite	16	1.6	14	2.0	3	0.8	33	1.6
5.	Schist	3	0.3	2	0.5	–	0.0	5	0.3
6.	Dolomite	–	0.0	–	0.0	5	1.2	5	0.3
7.	Quartz	80	9.5	84	12.0	21	5.0	194	9.5
8.	Unidentified	145	15.7	89	13.0	74	19.5	308	15.2
	TOTAL	920	100.00	690	100 00	420	100.00	2030	100.00

FREQUENCY DISTRIBUTION OF DIFFERENT ROCK FRAGMENTS IN THE BOULDER BED

The counting of the different rocks present within the boulder bed of the Tobra Formation was carried out at different localities. A total of 920 counts were made. Some rocks were much altered and could not be identified. Table 3 gives the frequency distribution.

GENERAL FEATURES OF PEBBLES AND BOULDERS

Surface features: Features like striations, frost pitting and facetting which are characteristics of glacial moraine were cursorily recorded. Smoothness and polishing is a very common feature in most of the coarser rock fragments, but is not diagnostic of thier entirely glacial origin.

Size: There is a wide range of pebbles and boulders in the Tobra Formation. While the smallest pebbles were less than 0.25 cm, the largest boulder measured 120 cm in length. The average size is between 10 cm to 20 cm. In some localities an overall decrease in size of the boulders is observed from bottom to top. This feature is not persistent and as such no systematic grading within the boulder bed can be established.

Shape: The most dominant shape of the pebbles and boulders is ellipsoidal The larger boulders are more commonly spherical. Smaller boulder, cobbles and pebbles are of many different shapes. Discoidal shaped pebbles are rare.

Sphericity/roundness: The visual estimation of the pebbles and boulders of the Tobra Formation, by studying 635 specimens from different localities, revealed that the rock fragments are rounded to well rounded and the sphericity may be between 0.71 and 0.81.

Pebble orientation: The pebble orientation study based on 206 readings of the long axes of the ellipsoidal and rod-shaped pebbles from 32 localities in four sections, shows random orientation (Fig. 2).

DIAGRAM SHOWING THE DIRECTION OF THE LONG AXES OF PEBBLES/BOULDERS IN TOBRA FORMATION.

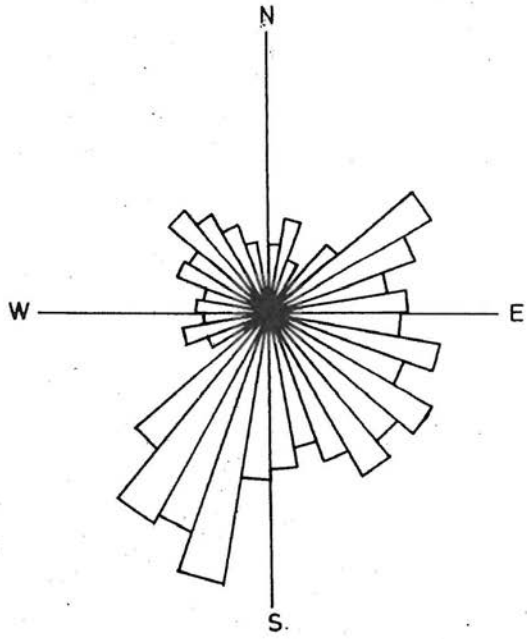


FIG. 2.

Scale:
1 mm length
represents one pebble

HISTOGRAM SHOWING THE PERCENTAGE OF COMMON ROCK TYPES IN THE BOULDER BED.

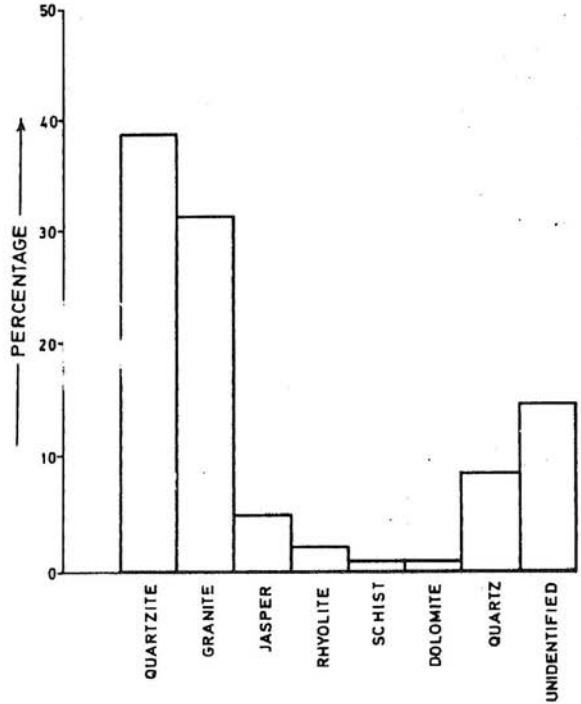


Figure 1

CONCLUSIONS

1. The Tobra Formation can be divided into six recognizable units as follows.

No.	Name of rock unit	Max. thickness (meters)
vi.	Rusty Brown Sandstone.	12
v.	Coarse Sandstone.	21
iv.	Gritstone.	18
iii.	Carbonaceous Shale and Siltstone.	6
ii.	Yellowish Green Sandstone.	21
i.	Boulder Bed.	4.5

The maximum thickness of the Tobra Formation in a single section is 53 meters in the Khewra Gorge.

II. The Boulder Bed is composed of boulders, cobbles and pebbles of granite, quartzite, rhyolite, quartz, porphyries, jasper, dolomite, schist, conglomerate and breccia. The most dominant of these are granites and quartzites which together constitute about 70 percent.

III. The sandstones and other related rocks within the Tobra Formation are of the following types:-

(a) Ferruginous, (b) Calcareous, (c) Argillaceous and (d) Feldspathic.

IV. The presence of fresh feldspar grains in the sandstone is an indication of cold climatic conditions at the time of their deposition.

V. The poor sorting of the material in the Boulder Bed and the random orientation of pebbles and boulders point towards the glacial origin of the lower part of the Tobra Formation. Since the Boulder Bed is traceable in most part of the eastern Salt Range, it may be assumed that the ice sheet in this area was fairly continuous.

VI. The overlying sandstone, siltstone and gritstone beds with inclusions of boulder clay and frequent pebble beds are indicative of stagnant conditions of the ice mass. The presence of cross-bedding in sandstone beds and the absence of pebble beds from coarse sandstone unit is suggestive of shallow marine conditions.

VII. Lateral facies change described by Teichert (1967) in other exposures of the Tobra Formation, was not observed here. In fact lateral varia-

tions in this area are of local nature and might have been the result of relief differences in pre-glacial topography or differential movement in glacial mass.

VIII. The difference in the lithology of the rock exposures of the Aravalli Outliers in Pakistan and those present in the form of boulders and pebbles in the Tobra Formation points toward the insignificance of the former as ranges in the Permian times. The absence of the fragments of the Cambrian rocks immediately underlying the Tobra Formation is also a notable feature. These observations lead to conclude that in the Late Palaeozoic time, the area between Peninsular India and the ocean towards north, might have been a featureless plain with thick alluvial cover.

XI. The variety of granitic rocks, abundance of quartzite, presence of volcanic porphyries, rhyolite, chloritic schist and other rocks in the Boulder Bed of the Tobra Formation lead to believe that glaciers, during the course of their movement, gathered most of their load from southern India.

REFERENCES

BLAME, E. 1970. Palynology of Permian and Triassic Strata in the Salt Range, West Pakistan Stratigraphic Boundary Problem between Permian and Triassic of Pakistan. Special pub. 4, Geology, University Kansas, pp. 305-453.

BLANFORD, T. 1886. Notes on Smoothed and Striated Boulders from a Pre-Tertiary Deposit in the Punjab Salt Range. Geol. Mag. Vol. 3, 574, pp. 494-95.

FATMI, A.N. 1972. (EDITOR) Lithostratigraphic Units of Kohat-Potwar Region, G.S.P. Information Release No. 46 pp. 18-20.

FOX, C.S. 1928. A Contribution to the Geology of the Punjab Salt Range, Indian Geol. Surv. Rec. Vol, 61 pt . 2, pp. 147-179.

KRISHNAN, M.S. 1960. Geology of India and Burma, Higgnbothams (Private) Ltd. Madras-2.

OLDHAM, R.D. 1887. Note on the Faceted Pebbles from the Olive Group of the Salt Range, Punjab, India. Geol. Mag. Vol. 4, pp. 32-35.

PASCOE, E.R 1964. A Manual of the Geology of India and Burma (3rd Ed) Vol. 1, 483 p. Vol.2, 1338 p. Govt : Ind. Press, Calcutta.

TEICHERT, C. 1967. Nature of Glacial Permian Record, Salt Range, Khisor Range etc. Pakistan, Neues : Jahrb. Geol paleo., Abst., Vol. 120,

WADIA, D.N. 1961. Geology of India, 3rd Ed, Macmillan and co. Ltd : N.Y.,

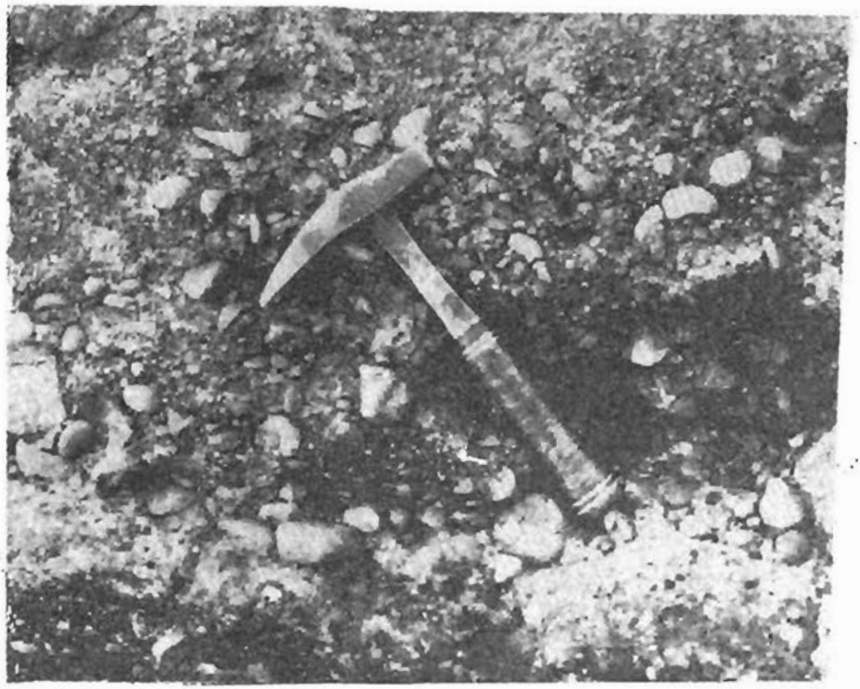


Plate 1. Boulder Bed in Nilawahan Ravine, The size of the boulders is compartively smaller.

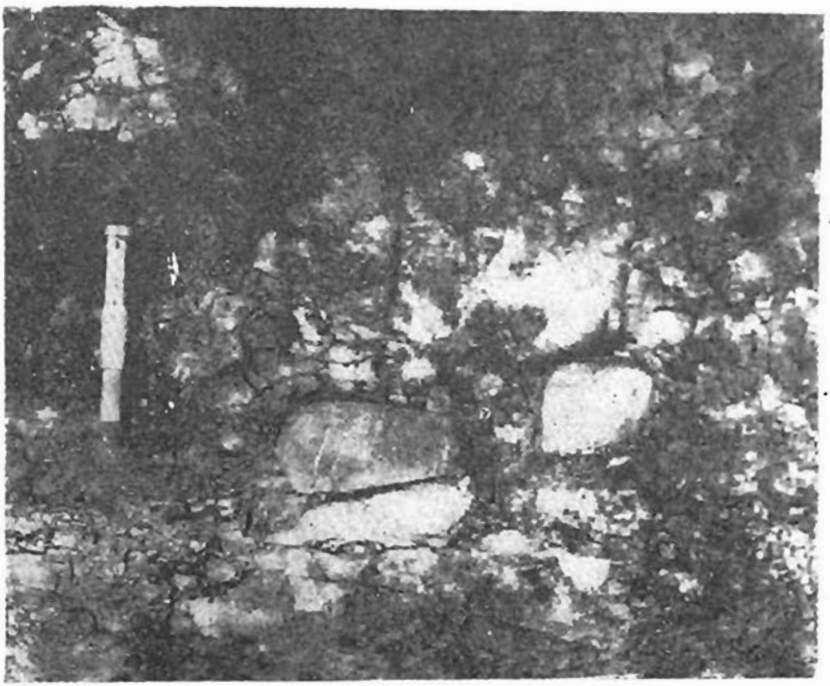


Plate 2. A closer look of the carbonaceous shale/siltstone. Note the big boulders sticking out in finer material.

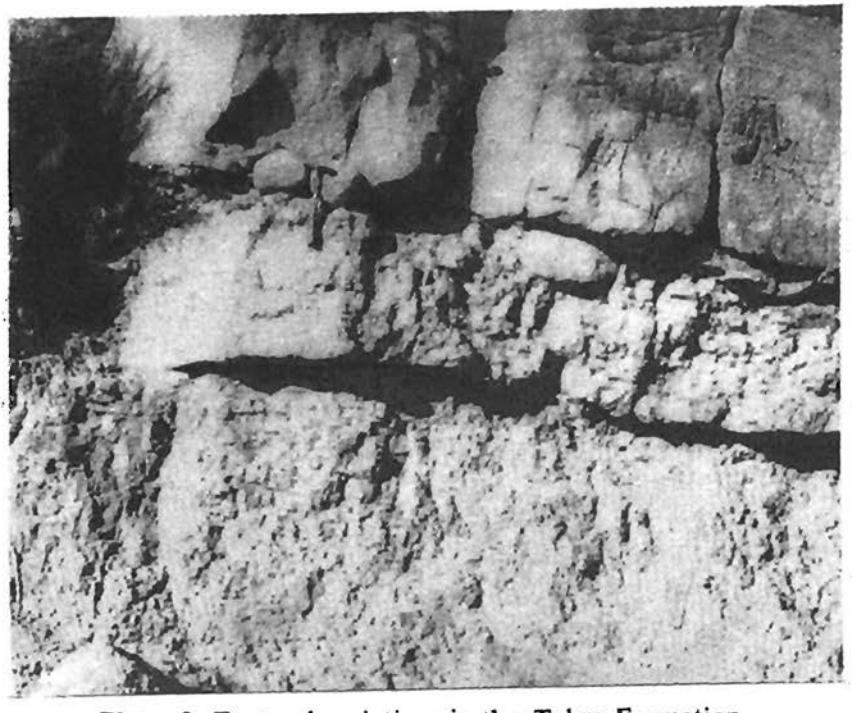


Plate 3. Textural variations in the Tobra Formation (South East of Tobra Village).

Plate 4. Cross - bedding in the upper part of coarse sandstone. (Dandot Section)

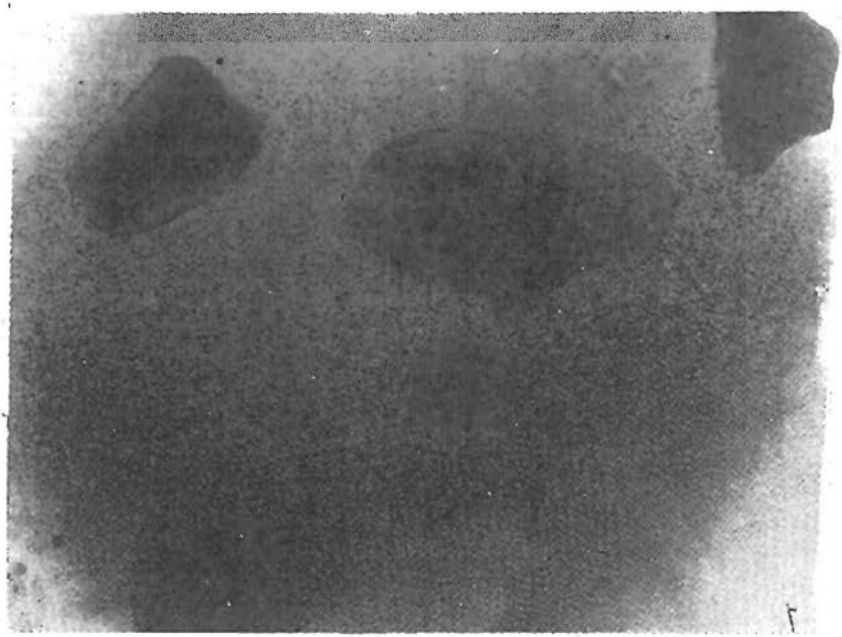


Plate 5. Micrograph (× 55) showing two grains of hornblende. Grains have rounded to subrounded edges and stuby shaye.