DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

MEASURED STRATIGRAPHIC SECTIONS OF THE LOWER PERMIAN NILAWAHAN GROUP, SALT RANGE, PUNJAB PROVINCE, PAKISTAN

B.E. Law[1] and T. Hussnain[2]

U.S. Geological Survey Open-File Report 89-464

Report prepared jointly by the Geological Survey of Pakistan and the U.S. Geological Survey under the auspices of the U.S. Agency for International Development.

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

[1]U.S. Geological Survey, Box 25046, Denver Federal Center, Denver, Colorado 80225

[2]Ministry of Petroleum and Natural Resources, Geological Survey of Pakistan, Lahore, Pakistan 54660

1989

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MEASURED STRATIGRAPHIC SECTIONS OF THE LOWER PERMIAN NILAWAHAN GROUP, SALT RANGE, PUNJAB PROVINCE, PAKISTAN

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INTRODUCTION

As part of a cooperative geologic research project between the Geological Survey of Pakistan and the U. S. Geological Survey and funded by the U.S. Agency for International Development, several exposures of the Lower Permian Nilawahan Group in the Salt Range of north-central Pakistan (fig. 1) were measured and described during the months of February and March, 1989. Previous work on Lower Permian rocks has been, for the most part, reconnaissance in nature and only the Lower Permian Tobra Formation of the Nilawahan Group has been studied in any detail. Teichert (1967) has conducted the most significant work on the Tobra and has summarized the work of previous studies. He and workers before him recognized that depositional processes associated with glacial activity have played an important role in the depositional history of the Tobra Formation. The purpose of this report is to provide information regarding descriptions, thicknesses, and preliminary stratigraphic correlations of part of the Nilawahan Group.

STRATIGRAPHY

A generalized geologic column of stratigraphic units in the Salt Range is shown in figure 2. The Lower Permian Nilawahan Group is composed of four formations, which in ascending order are the Tobra Formation, Dandot Formation, Warcha Formation, and Sardhai Formation (Fatmi, 1973). The Nilawahan Group unconformably overlies Cambrian or Eocambrian rocks throughout the Salt Range and is conformably overlain by the Lower and Upper Permian Zaluch Group in the western and central parts of the Salt Range. In the eastern part of the Salt Range, the Nilawahan Group is unconformably overlain by Tertiary rocks, where it is eventually truncated, east of the town of Khewra (Gee, 1980).

Tobra Formation

The Tobra Formation is a very conspicuous dark-colored conglomeratic sandstone that has been studied by several workers, most notably by Teichert (1967). The conglomeratic clasts in the Tobra consist of granite, gneiss, quartzite, conglomerate, and metamorphic boulders and pebbles in a poorly sorted matrix composed of sandstone, siltstone, or silty mudstone. The clasts are as large as 45 cm in greatest dimension, well-rounded to sub-rounded, polished, and occasionally striated. Bedding characteristics vary from obscure to graded. The Tobra is thickest in the western part of the Salt Range where it is 154 m thick at the Zaluch Nala locality (fig. 1). In the central Salt Range it is discontinuous; in some areas it is present only as isolated boulders (fig. 3). In the eastern Salt Range, near Khewra, the Tobra thickens to over 10 m. The tentative stratigraphic correlations of the Tobra Formation are shown in figure 3.

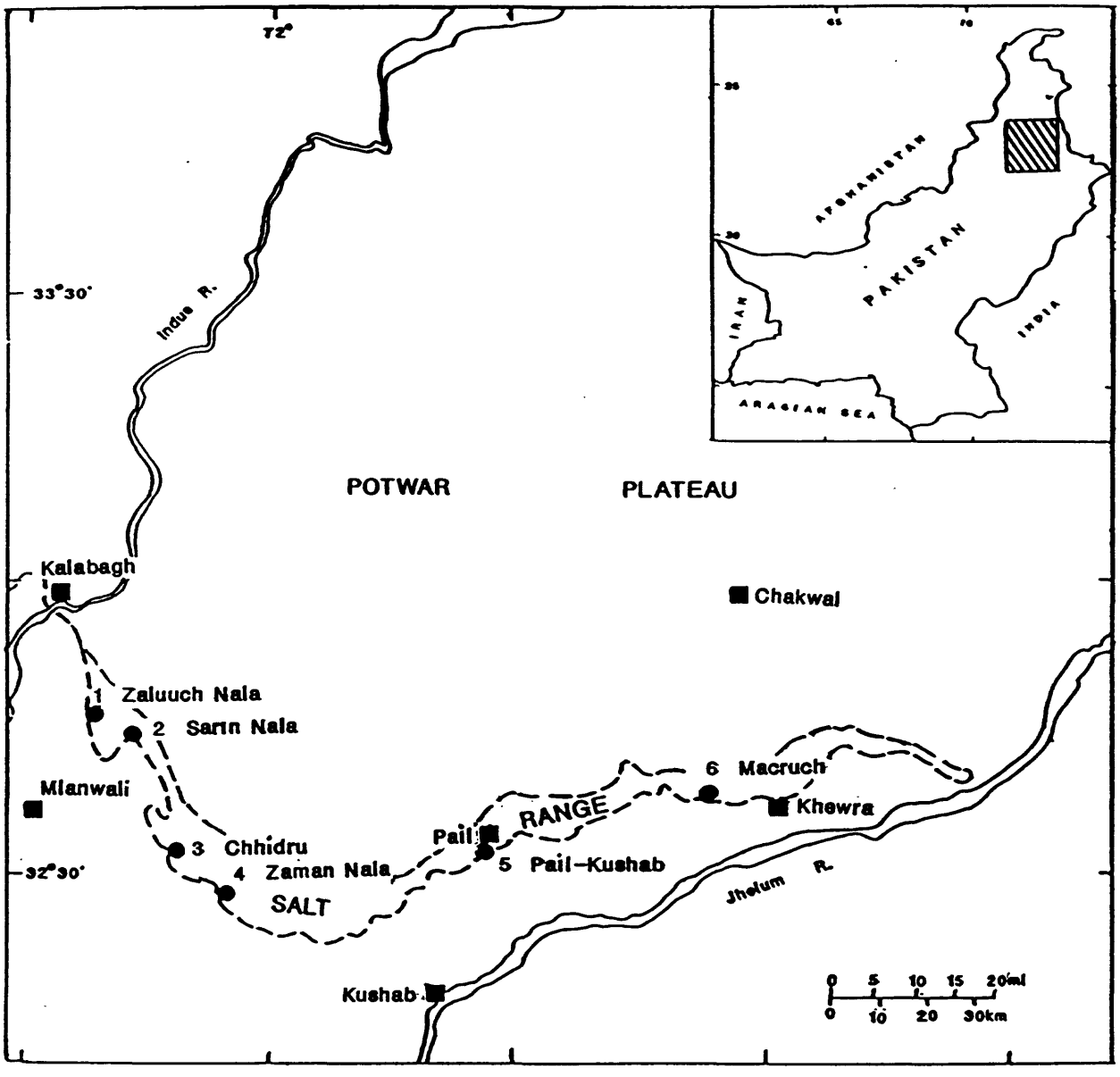

Figure 1.--Map showing location of Salt Range and measured sections discussed in text. Solid circle with adjacent number refers to measured section shown in figure 3.

GENERALIZED GEOLOGIC COLUMN

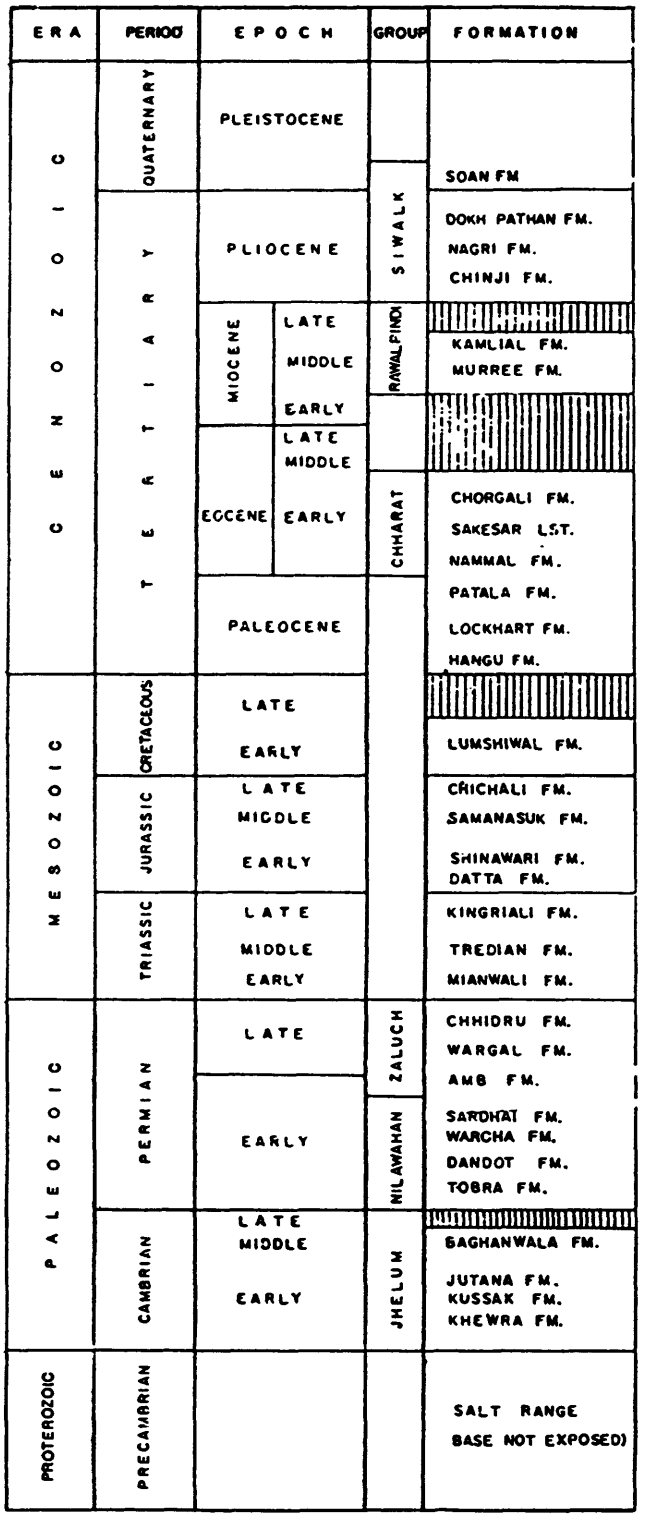

Figure 2.--Generalized stratigraphic column for sedimentary rocks exposed in the Salt Range.

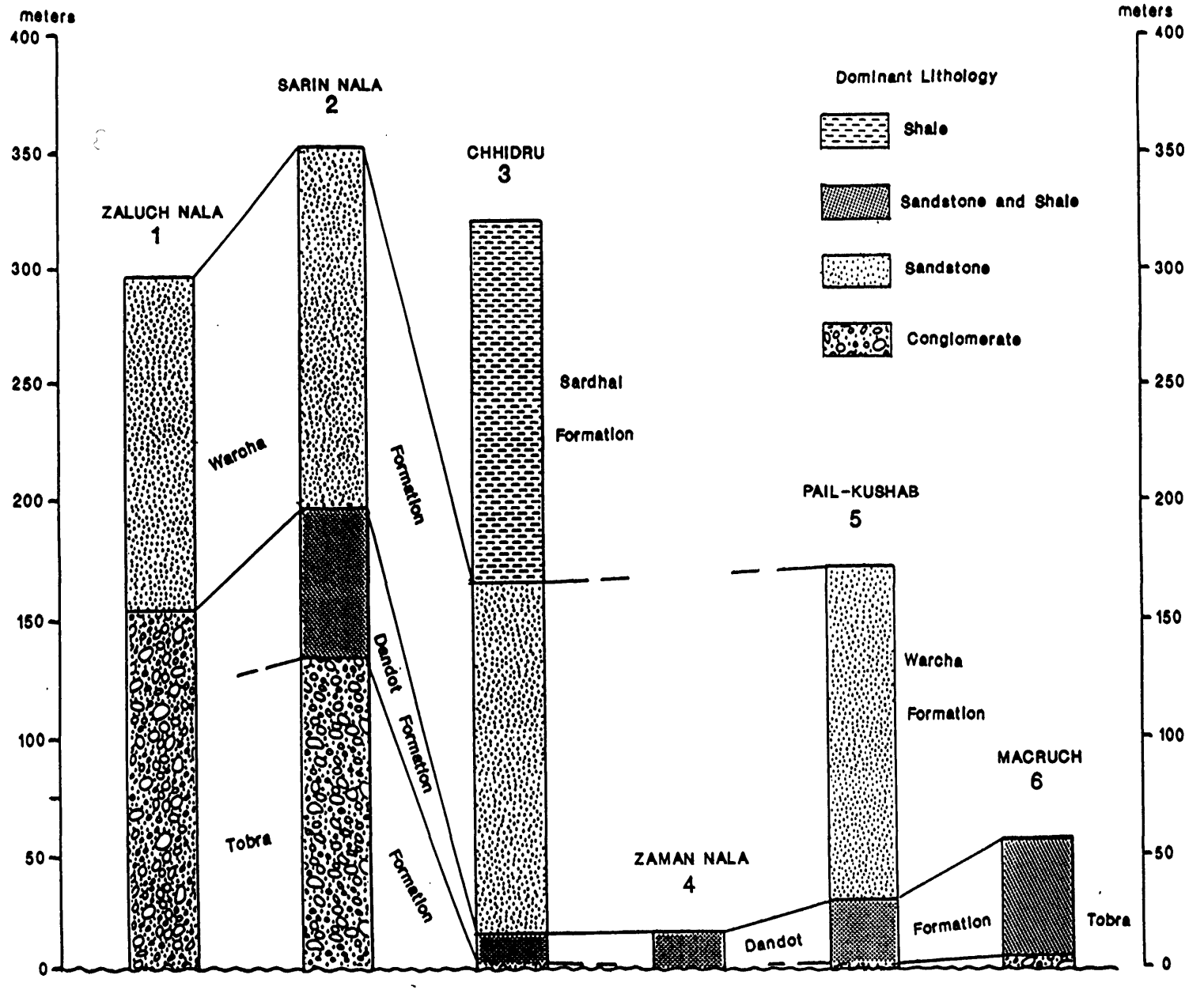

Figure 3.--Preliminary stratigraphic correlations of Lower Permian rocks in the Salt Range. Number at top of each column refers to location of measured section shown in figure 1.

Dandot Formation

The Dandot Formation is not recognized throughout the Salt Range. It is best developed in the central part of the Salt Range, where it is a tan to olive-green sequence of interbedded sandstone, siltstone, and silty mudstone that is commonly burrowed, and the sequence has well developed flaser bedding. In the western part of the Salt Range, it is generally not recognizable, although, at the Sarin Nala locality (section 2, figs. 1 and 2), we measured 70 m of Dandot. The Dandot appears to be conformable with the underlying Tobra Formation but may actually be a facies equivalent to part of the Tobra. At the Sarin Nala locality (figs. 1, 3) and in outcrops near the Macruch locality (section 6, fig. 1), the Dandot contains boulders of granitic composition similar to those contained in the Tobra Formation. The tentative stratigraphic correlations of the Dandot are shown in figure 3.

Warcha Formation

The Warcha Formation is a reddish arkosic sandstone, siltstone, shale, and conglomeratic sequence that ranges in thickness from 140 to 155 m. The Warcha overlies either the Dandot or Tobra Formations. The Warcha generally contains several fining-upward sequences with conglomeratic sandstones at the base and silty shales at the top. The lower parts of the fining-upward sequences are commonly trough cross-stratified, and the finer grained upper parts of the sequences are planar or ripple-laminated with occasional mudcracks. The large thickness variations of the underlying Dandot and Tobra Formations (fig. 3), and the abrupt, well-defined lower contact of the Warcha may indicate the presence of an unconformity. However, additional work is needed to resolve the nature of the contact. The tentative stratigraphic correlations of the Warcha Formation are shown in figure 3.

Sardhai Formation

The Lower Permian Sardhai Formation is a light- to medium-gray silty shale, siltstone, shale, and sandstone unit that commonly forms poorly exposed slopes. The one section of the Sardhai Formation that we measured at the Chhidru locality (section 3, figs. 1, 3) is 166 m thick. The base of the Sardhai is lithologically gradational with the underlying Warcha Formation and grades upward into the overlying Lower Permian Amb Formation of the Zaluch Group.

MEASURED SECTIONS

The location of Lower Permian outcrops visited during the course of field investigations are shown on figure 1, and the tentative stratigraphic correlations are shown on figure 3. Although several outcrops were visited, only four sections were measured and described in detail. Sections were measured with a tape and Brunton compass. At locations where the rocks are steeply dipping, those portions of the sections measured with a Brunton compass were corrected graphically.

Zaluch Nala

Measured by Ben E. Law and Tamanna Hussnain, February, 1989. Section begins about 350 m from entrance to Zaluch Nala near top of Eocambrian Salt Range Formation (32° 46′ 59" N. lat, 710° 38′ 25" E. long, section no. 1 on figure 1) and continues east and north for about 800 m.

	Thickess (meters)
Warcha Formation:	
Conglomeratic sandstone, sandstone, siltstone, and silty shale, white to light-gray, reddish-white. Sandstone is very fine- to coarse-grained, non-calcareous. Granules and pebbles composed of angular to sub-angular feldspar, quartz, and lesser amounts of mafic rocks and minerals. Unit consists of several fining-upward sequences as thick as 30 m, with coarse-grained conglomeratic sandstones at the base grading up to very fine grained sandstone and silty shale. Conglomeratic sandstones and sandstones are commonly trough cross-stratified and silty shales are ripple laminated. Tops of fining-upward sequences are erosional and abruptly overlain by conglomeratic sandstones of the next fining-upward sequence.	
Total Warcha Formation----------	142.0
Tobra Formation:	
Conglomeratic sandstone, gray, lavender, black, very poorly sorted; conglomeratic clasts are composed of granite, quartzite, and dark-colored metamorphic rocks that range in size from 1 to 25 cm and are well-rounded to sub-angular; a few of the clasts are striated. The clasts are suspended in a matrix composed of sandstone, siltstone, and mudstone. There is no apparent fabric or orientation of the clasts----------	101.0
Conglomeratic sandstone, brown to tan, non-calcareous. Sandstone contains abundant grains of red-colored feldspars, poorly sorted, very fine to coarse grained, angular to rounded. Conglomeratic clasts are composed of granite, quartzite, and metamorphic rocks. Graded bedding occurs in sandstone lenses containing small pebbles and granules--	11.2
Conglomeratic sandstone, gray, lavender, black, very poorly sorted. Conglomeratic clasts are composed of granite, quartzite, and dark-colored metamorphic rocks that range in size from 1 to 25 cm and are well-rounded to subangular. The clasts are suspended in a matrix composed of sandstone, siltstone, and mudstone. There is no apparent fabric or preferred orientation of the clasts. Base not exposed-----	42.2
Total Tobra Formation----------	154.4

Sarin Nala

Measured by B. E. Law and T. Hussnain, March, 1989. Section begins about 900 m from entrance to Sarin Nala, at base of Eocambrian Salt Range Formation (32° 44′ 51" N. lat, 71° 43′ 04" E. long, section no. 2, fig. 1) and continues north about 150 m.

	Thickness (meters)
Warcha Formation: (Top not exposed; faulted)	
Sandy, silty shale, red to lavender; irregular wavy bedding; weathers to form slopes	57.6
Sandstone, pale red, medium-to coarse-grained; arkosic with angular feldspar grains; fines upward; trough cross-stratified	9.2
Silty shale, red to lavender, irregular wavy bedding; poorly exposed	12.8
Sandstone, red, fine-to coarse-grained; arkosic with angular feldspar grains, trough cross-stratified	14.4
Silty shale and siltstone, red to lavender, irregular wavy bedding; contains a few thin sandstone beds	19.0
Sandstone, red, medium-to coarse-grained with a few granule size grains; arkosic with angular feldspar grains; fines upward; trough cross-stratified	41.6
Total Warcha Formation	154.6
Dandot Formation:	
Conglomeratic sandstone, tan to light gray, fine- to medium-grained; few thin (<1.0 cm) discontinuous, carbonaceous shale lenses. Coal is locally mined from this interval	8.2
Sandstone, tan to light-gray, fine- to medium-grained; bedding indistinct	4.6
Conglomeratic sandstone and siltstone, gray; no apparent bedding; matrix-supported clasts	9.4
Conglomerate, tan; fines upward; forms resistant ledge; erosional base	8.0
Sandstone with few lenses of pebble conglomerate, tan to light-brown; fines upward; erosional base	6.3
Conglomeratic sandstone, tan; bedding indistinct. Boulders well-rounded and as much as 35 cm in longest dimension. Unit fines upward; forms resistant ledge	17.0
Shale, lavender to light-green, splintery; top of unit is erosional; weathers to slope	8.8
Sandstone and silty shale, dark-brown to lavender; indistinct bedding	7.95
Total Dandot Formation	70.25
Tobra Formation:	
Conglomeratic sandstone, lavender to dark-brown; sandstone fine- to coarse-grained, poorly sorted, angular grains; clasts composed of granite, gneiss, conglomerate, and mafic rocks that are well-rounded and 12 much as 45 cm in longest dimension	9.6

	Thickness (meters)
Tobra Formation:	
Sandstone, tan to light-brown; plant fragments; contains a few thin conglomeratic lenses	6.4
Conglomeratic sandstone, lavender to dark-brown; sandstone is fine- to coarse-grained, poorly sorted; bedding indistinct; granitic clasts; forms resistant ledge	35.2
Conglomeratic sandstone, tan to medium-gray; base of unit is erosional. Unit contains three fining-upward sequences	9.6
Conglomeratic sandstone, lavender to dark-brown; sandstones are fine- to coarse-grained, poorly sorted with angular grains; bedding indistinct; clasts are matrix supported	51.2
Conglomeratic sandstone, tan; grades up to siltstone; planar cross-stratified and ripple-laminated at top. Transport direction N 40° E	0.46
Conglomeratic sandstone and siltstone, lavender to dark-brown; sandstone fine- to coarse-grained, poor sorting; angular grains; bedding indistinct. Clasts composed of granite, gneiss, conglomerate, and mafic rocks; clasts are rounded to sub-rounded and as much as 45 cm in longest dimension. Base not exposed	22.2
Total Tobra Formation	134.66

Chhidru

Measured by B. E. Law and T. Hussnain, February, 1989. Section begins at top of Cambrian rocks, about 350 m from entrance to unnamed canyon approximately 1.7 kilometers east of Chhidru village (32° 32′ 41" N. lat, 71° 47′ 48" E. long, section no. - on figure 3) and continues northeast about 600 m to base of Permian Amb Formation.

	Thickness (meters)
Sardhai Formation:	
Silty shale, gray; grades up to interbedded, very fine-grained sandstone and carbonaceous shale; ripple laminated	22.4
Carbonaceous shale, brown to dark-gray, thinly laminated; contains jarosite	1.0
Silty shale, mottled, gray, green, lavender, calcareous. Contains irregularly-shaped calcareous nodules; forms slope	111.8
Sandstone, tan to brown, fine- to coarse-grained; iron concretions; trough cross-stratified	3.0
Silty shale, gray; bedding indistinct	17.6
Total Sardhai Formation	155.8

	Thickness (meters)
Warcha Formation:	
Conglomeratic sandstone, sandstone, siltstone, and silty shale, red to lavender; sandstones are arkosic with abundant angular feldspar grains; bedding is horizontal parallel laminated, trough cross-stratified, and ripple laminated. Occasional mudcracks at top of silty shales	114.8
Sandstone, reddish-white, fine- to coarse-grained, arkosic; with angular feldspar grains, poor sorting. Granule to pebble-size clasts composed of silty shale, siltstone, and limestone. Unit fines upward	6.0
Silty shale, mottled, lavender to gray; bedding indistinct; forms slope	3.1
Sandstone, interbedded with thin silty shale, reddish-white, weathers red; fine- to coarse-grained, arkosic, slightly calcareous; bedding is horizontal parallel laminated and cross-stratified	25.6
Total Warcha Formation	149.5
Dandot Formation:	
Silty shale, olive-green, thin-bedded; forms slope	6.4
Sandstone, tan to olive green, fine- to medium- grained, ripple laminated with interbedded, thin, irregularly bedded silty shale and mudstone; burrowed	3.2
Sandstone and shale, tan to olive-green; flaser bedding; resistant ledge	0.63
Sandstone, tan; very fine- to fine-grained, friable; horizontal and ripple laminated; trough cross-stratified; forms resistant ledge	3.2
Sandstone, siltstone, carbonaceous shale, tan, geenish-gray; sandstone very fine-grained; fair sorting; flaser structure and ripple laminated; forms slope	1.75
Sandstone, greenish-tan; very fine- to fine-grained; bedding indistinct, ripple laminated at top; resistant ledge	1.25
Sandstone, siltstone, and coaly mudstone, tan to greenish-gray; sandstone is very fine grained, thin-bedded, and irregular, ripple laminated, burrowed; forms slope	0.7
Total Dandot Formation	17.13
Tobra Formation:	
Represented by the occurrence of an occasional granitic boulder; otherwise, not present. Angular discordance between Permian rocks and underlying Cambrian rocks	0.2
Total Tobra Formation	0.2

Pail-Kushab

Measured by B. E. Law and T. Hussnain, March, 1989. Section located on west side of Pail to Kushab road. Section begins at top of Cambrian Kussak Formation, about 3.5 kilometers north of the foot of the Salt Range (32° 33′ 28" N. lat, 72° 27′ 14" E. long, section no. 5, figure 1) and continues north for about 325 meters.

	Thickness (meters)
Warcha Formation:	
Alternating sequence of arkosic, poorly sorted sandstones and shaly siltstones, pink to light-red; weathers red to lavender; sandstones fine- to coarse-grained with lenses of conglomeratic sandstone; clasts are pebble size and are angular to sub-angular; trough cross-stratified; calcareous nodules occur in upper 35 m	140.6
Total Warcha Formation	140.6
Dandot Formation:	
Sandy siltstone, olive-green; thinly laminated; micaceous	1.6
Silty sandstone, tan to light-gray, thin-bedded, platy, ripple laminated, burrowed. Upper 1.0 m resistant sandstone; ripple laminated	4.8
Sandy siltstone and shale, olive-green, micaceous; poorly exposed	3.2
Sandstone, olive-green to tan, very fine- to fine-grained, micaceous, burrowed; ripple and parallel laminated	1.42
Shaly siltstone and sandstone, tan, thin-bedded, platy; ripple-laminated; burrowed	0.9
Silty sandstone, olive green to medium-gray, burrowed; flaser bedding; grades up to siltstone, ripple-laminated	10.54
Sandstone, olive-green to tan, very fine- to fine-grained; non-calcareous; horizontal parallel laminated and ripple laminated	1.47
Sandstone and silty shale, tan to brown, burrowed; flaser bedding	1.9
Sandstone, tan to brown; very fine- to medium-grained; some small (<.2 cm) pebbles; minor amount of burrowing; wood fragments; horizontal and trough cross-stratified; coarsens upward; transport direction, N 3° E	3.8
Silty sandy mudstone, greenish-tan, highly burrowed, ripple laminated; flaser bedding; mottled appearance; ripple crests trend S 62° W	2.2
Total Dandot Formation	31.83
Tobra Formation:	
Conglomerate; pebbles and small boulders; granitic clasts. Base is erosional; striations on top of Cambrian rocks trending in N 55° W direction	0.07
Total Tobra Formation	0.07

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