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RECONNAISSANCE GEOLOGY OF THE CENTRAL MASTUJ VALLEY

CHITRAL STATE, PAKISTAN

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by

Karl W. Stauffer
U. S. Geological Survey

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ABSTRACT

The Mastuj Valley in Chitral State is a part of the Hindu Kush Range, and is one of the structurally most complicated areas in northern Pakistan. Sedimentary rocks ranging from at least Middle Devonian to Cretaceous, and perhaps Early Tertiary age lie between ridge-forming granodiorite intrusions and are cut by thrust faults. The thrust planes dip 10° to 40° to the northwest. Movement of the upper thrust plates has been toward the southeast relative to the lower blocks.

If this area is structurally typical of the Hindu-Kush and Karakoram Ranges, then these mountains are much more tectonically disturbed than previously recorded, and suggest compression on a scale compatible with the hypothesis that the Himalayan, Karakoram, and Hindu Kush Ranges form part of a continental collision zone.

The thrust faults outline two plates consisting of distinctive sedimentary rocks. The lower thrust plate is about 3,000 feet thick and consists of the isoclinally folded Upper Cretaceous to perhaps lower Tertiary Reshun Formation. It has overridden the Paleozoic metasedimentary rocks of the Chitral Slate unit. This thrust plate is, in turn, overridden by an 8,000-foot thick sequence consisting largely of Devonian to Carboniferous limestones and quartzites.

A key factor in the tectonic processes has been the relatively soft and plastic lithology of the siltstone layers in the Reshun Formation which have acted as lubricants along the principal thrust faults, where they are commonly found today as fault slices and smears.

The stratigraphic sequence in the central Mastuj Valley was tentatively divided into 9 mapped units. The fossiliferous shales and carbonates of the recently defined Shogram Formation and the clastics of the Reshun Formation have been fitted into a sequence of sedimentary rocks that has a total thickness of at least 13,000 feet and ranges in age from Devonian to Neogene.

Minerals of potential economic significance include antimony sulfides which have been mined elsewhere in Chitral, the tungstate, scheelite, which occurs in relatively high concentrations in heavy-mineral fractions of stream sands, and an iron-rich lateritic rock.

INTRODUCTION

Purpose and scope

The objectives of this investigation were to outline the stratigraphy and structure of the central part of the Mastuj Valley, an area within the Hindu Kush Range, and to re-examine the Reshun Formation to certify its age and structural position.

The work was part of a joint project of the U. S. Geological Survey and the Geological Survey of Pakistan sponsored by the Government of Pakistan and the Agency for International Development, U. S. Department of State.

I first visited the central Mastuj Valley for a period of two weeks in October 1962 together with Dr. Curt Teichert, formerly with the U. S. Geological Survey, and K. G. Ahmed, formerly with the Geological Survey of Pakistan. Later a photogeologic map was made from the two photolines flown along the Mastuj River. A planimetric base map was drawn, using as an assumed horizontal plane of reference the Mastuj and Turikho Rivers. In September of 1964 Ahmed and I returned for additional field checking for a period of ten days.

Although the ages of most of the lithological units have been established and the presence of several major thrust faults confirmed, most formational contacts and faults have been examined in relatively few places on the ground and their traces have been extended by the use of aerial photographs. The area actually examined on the ground includes the main valley of the Mastuj River as far as Buni, the Reshun, and Shogram areas, and the subsidiary valleys of the Bindo Gol and Charun Gol. The rest of the map is a photogeological interpretation.

Location and accessibility

The Mastuj Valley, located in the semi-autonomous State of Chitral in northernmost West Pakistan, is one of the principal intermontane valleys of the Hindu Kush Range. The mapped area (fig. 1) lies in the central part of the valley and extends a few miles on either side of the Mastuj River. It falls between latitudes 36° 00' and 36° 20' N., and longitudes 72° 00' and 72° 20' E., and forms a rectangle of about 27 by 8 miles. The Mastuj Valley area, like all major valleys in the Hindu Kush Range, is steepsided and has enormous relief. Within the mapped area, altitudes range from about 6,000 feet near the Mastuj River to well over 15,000 feet 5 miles from the river. Several peaks a few miles beyond the mapped area tower above 20,000 feet, including the beautiful Tirich Mir, whose glistening snow summit reaches 25,230 feet above sea level.

The Mastuj Valley is relatively accessible, considering its remote location. From Peshawar, the principal city of northwestern Pakistan, there is plane service, always contingent on good weather, and a jeep road leads to the town of Chitral, the capital of Chitral State (fig. 1). The road climbs over the 10,230 feet high Lowari Pass, which is usually open from June until the end of October. A very narrow jeep tract follows the Mastuj River from the town of Chitral to beyond the village of Mastuj. The track is built onto the side of the valley, and where it crosses unconsolidated terraces, slides are frequent and a heavy rain commonly closes the track to vehicles. Pack animals and coolies are available locally.

The scarcity of bridges across the Mastuj River necessitate long, roundabout approaches to many areas.

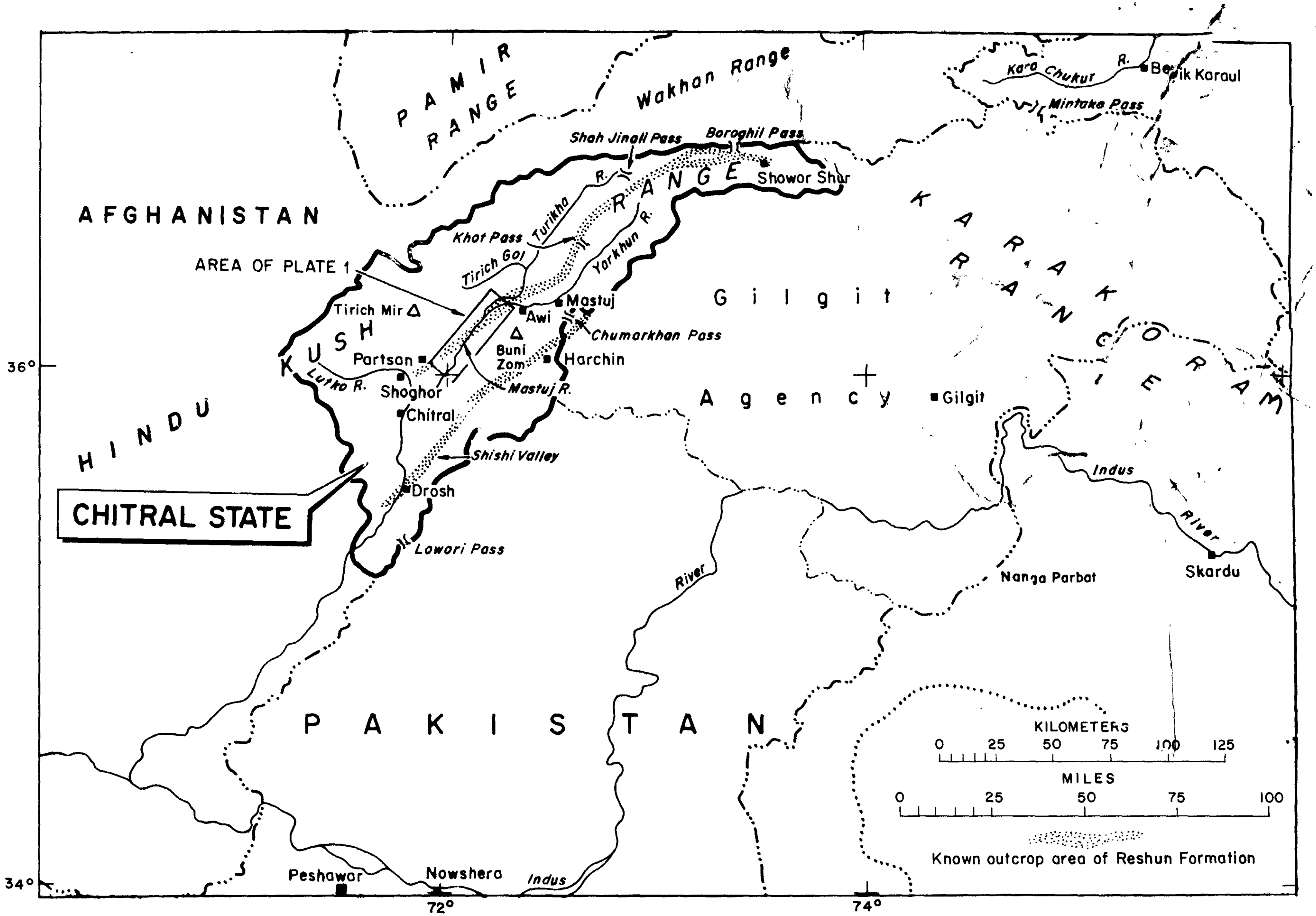

FIGURE 1. Regional map of Chitral and surrounding areas.

Previous work

Chitral was geologically unknown except for its orpiment mines until Major I. H. Grant in 1899 sent to the Geological Survey of India some fossils that were later identified as Early Devonian by Cowper Reed (1911, p. 86-100). The fossils included fragments of trilobites, brachiopods, and some bryozoans embedded in a compact gray limestone (Hayden, 1904, p. 31). These fossils came from near Showar Shur in the Yarkhun Valley about 100 miles northeast of the area of the present report.

In October 1900, Captain B. E. N. Gurdon, then the Assistant Political Agent of Chitral, in the company of Major A. H. McMahon, traversed the Mastuj River valley. Captain Gurdon collected fossils from "..... a bed of limestone exposed in a cliff on the right bank of the Chitral River immediately opposite Reshun" (McMahon and Huddleston, 1902, p. 3). The fossils included corals and brachiopods and were described and figured by Huddleston, who concluded that the brachiopods were definitely Devonian in age, but that the corals were more probably of Silurian age. In the same article, Lt. Gen. McMahon (the Major's father) for the first time described and very roughly located on a sketch map the two most prominent lithological units of the Mastuj area: conglomerate and a gray limestone, called the Reshun Formation, and the Shogram Formation, respectively, in the present paper.

At various times between 1906 and 1914, the Mehtar or ruler of Chitral, employed persons to evaluate the mineral resources of his state. Their reports are mainly lists of real and legendary mineral localities and contain little geological information (Geol. Survey Pakistan, no date).

The first substantial geological work in Chitral was done in 1914 by H. H. Hayden of the Geological Survey of India who walked through Chitral, Gilgit, and the Pamir Range on his way back to England on leave. Considering that he had to cover from 10 to 40 miles each day his geological notes on the trip, published the following year (Hayden, 1915), are remarkable for their wealth of information. In the Mastuj Valley, Hayden was particularly concerned about the age of the Reshun Formation and whether the stratigraphic section along Reshun Gol (gol=stream) was normal or faulted. Hayden's paper includes a map of his route with geological annotations, but no formational contacts are shown.

The fossils collected by Hayden in Chitral were described and figured by Reed in two memoirs, one on the Devonian fossils, (1922) and the other on the Upper Carboniferous fossils (1925). These memoirs are today still the most complete paleontological works on the central Mastuj Valley. The most prolific fossil locality that Hayden found was on a ridge less than one mile south of the village of Kurāgh (lat 36° 13' N.; long 72° 10' E., pl. 1). A photograph in his paper of the western slope of this ridge shows the fossil-bearing horizons.

After Hayden's trip through Chitral in 1914 no geologist visited the Mastuj Valley until 1921, when G. H. Tipper of the Geological Survey of India began a general geological and mineralogical survey of the State of Chitral. During three field seasons, he mapped much of Chitral at a scale of one inch equals four miles, but unfortunately, neither his maps nor his geological reports have been published.* Information about Tipper's work in Chitral is found in the annual General Reports of the Geological Survey of India (Fermor, 1922, p. 55-57; Pascoe, 1923, p. 37-39; Pascoe, 1924, p. 44-48).

The most recent geological work in the Mastuj Valley is that of Ardito Desio and his colleagues of the Italian Expedition of 1955 to the Karakoram and Hindu Kush Ranges. Three paleontological papers describe the fauna. These are the works of Schouppé (1964) on corals, Sartenaer (1964) on the rhynchonellids, and Vandercammenn (1964) on spirifers. Somewhat later, Desio (1966) summarized the data of the Devonian sedimentary rocks in the Mastuj Valley and presented a stratigraphic section of the Devonian sequence of the slope northwest of the village of Shogram (pl. 1).

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* Tipper's maps are in the files of the Geological Survey of Pakistan at Quetta (J. A. Calkins, written commun., 1969).

Acknowledgments

Dr. Curt Teichert, formerly with the U. S. Geological Survey, presently at the University of Kansas, first brought my attention to the stratigraphical problems in the Mastuj Valley, and joined me on my first visit to the area. His help and encouragement, in the field and especially with the earlier litereature is most gratefully acknowledged. K. G. Ahmed, formerly of the Geological Survey of Pakistan, was a cheerful and helpful companion on both trips to the area. A. N. Fatmi of the Geological Survey of Pakistan and E. B. Fritz of the U. S. Geological Survey helped identify the macrofossils and microfossils, respectively. The complete cooperation of the Geological Survey of Pakistan and the use of their facilities is also most gratefully acknowledged. G. E. Tolbert, L. E. Andrews, and J. A. Calkins of the U. S. Geological Survey reviewed the manuscript and offered suggestions that have improved it. Field observations by Calkins (written commun., 1969) have clarified parts of the text and the geological map. All illustrations were drafted by Ramón Gâmez.

GEOLOGICAL SETTING

The Mastuj Valley in Chitral State (fig. 1) is part of the southern flank of the Hindu Kush Range, which together with the Karakoram and Himalayan Ranges forms a series of enormous mountain arcs concave to the south and roughly concentric about the Kashmir-Hazara syntaxis, the sharp, structural bend described by D. N. Wadia (1931, p. 189-220).

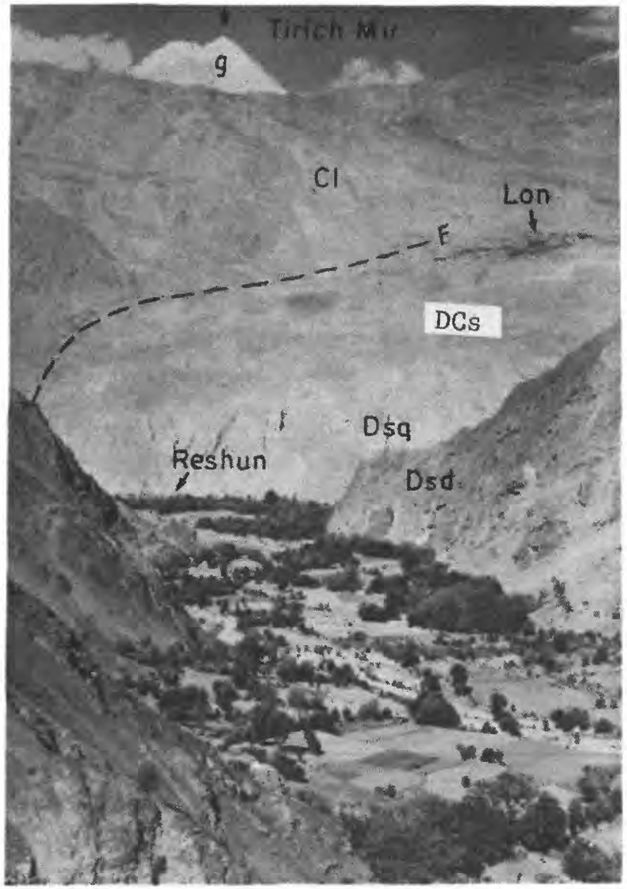

Figure 1. Lower part of Reshun Gol; the summit of Tirich Mir, 25,230 feet high, is in the background.

Figure 2. Reshun Gol, and massive dolomite unit of the Shogram Formation and Mt. Shogram in the middle distance.

PLATE 2. Two views down Reshun Gol toward the northwest. Formational symbols are the same as on geological map (pl. 1). Photo viewpoints are also indicated on the map.

The highest portions or backbones of these arcs are generally formed by elongate igneous intrusions, largely biotite granodiorite of Tertiary age, which crop out in roughly one third of northernmost Pakistan. Between these igneous intrusions are sedimentary and metamorphic rocks into which deep valleys have been carved. The lower slopes of the Mastuj Valley contain no igneous rocks, but the highest nearby peak, Buni Zom 21,494 feet, 10 miles to the southeast is part of an igneous arc, as is Tirich Mir, 25,230 feet, about 15 miles northwest of the Mastuj River (pl. 2, fig. 1). The absence of metamorphic index minerals of higher grade than garnet in heavy-mineral samples from the Mastuj River suggests that metamorphism in this region has been only moderate.

STRATIGRAPHY

The stratigraphic names used in this report have not as yet (1969) been reviewed by the Stratigraphic Committee of Pakistan for formal approval; therefore, some of the names may later be changed in accordance with the decisions of the Committee.

Paleozoic

Greenschist volcanic sequence

The southernmost part of the mapped area is occupied by a copper-bearing greenschist volcanic sequence. On the aerial photographs this unit appears very similar in tone and general morphology to the Chitral Slate, and it was originally included as part of that formation. Recent work by Calkins, however, has shown that it is a separate formation (Calkins, written commun., 1969), but its age and correlations have not been established with certainty.

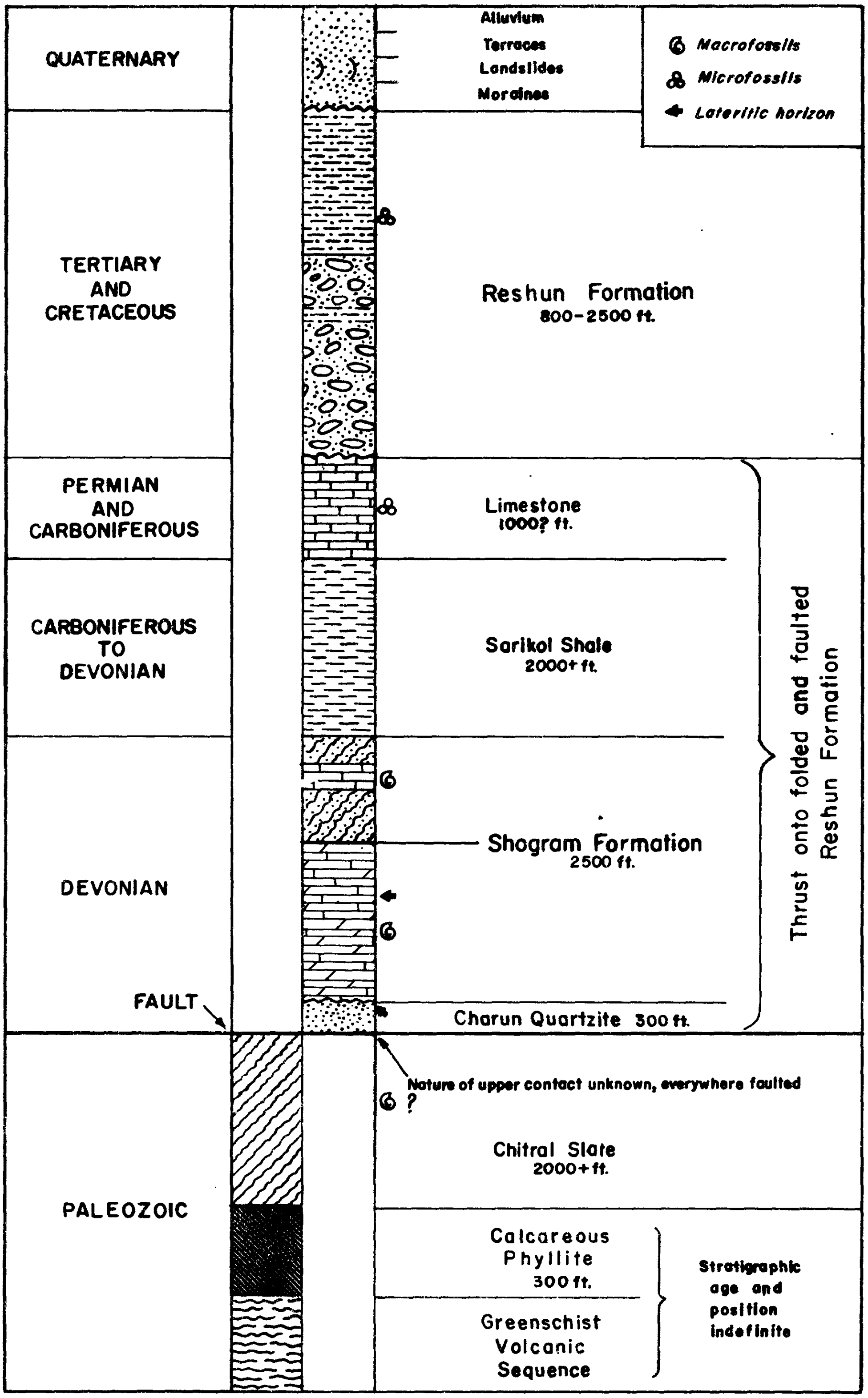

Figure 2.- Schematic stratigraphic column for the Mastuj Valley.

Age: The only fossils so far collected from the Chitral Slate were found by Tipper (Fermor, 1922, p. 56) from a calcareous layer within the slates in the valley of Chitral Gol, the tributary stream which joins the main river at the town of Chitral. The fossils were a *Spirifer*, a small *Dielasma*, and two unidentified corals. If the identification of the *Dielasma* is correct, the age of this part of the formation is late Paleozoic. Attempts to find additional fossils along the Chitral Gol and elsewhere were unsuccessful. The great thickness and extent of the Chitral Slate precludes the assignment of a definite age to this formation on the basis of a single fossil. The best that can be said is that the Chitral Slate is Paleozoic, and probably in part late Paleozoic.

Devonian

Charun Quartzite

Name and type locality: The name Charun Quartzite is proposed here for the quartzite below the Devonian Shogram Formation in the central Mastuj Valley. Exposures along Charun Gol (lat 36° 13' N.; long 72° 12' E., pl. 1), the stream that cuts through the quartzite approximately perpendicular to the strike of the beds, are proposed as the type locality.

Lithology and distribution: The Charun Quartzite at the type locality is a white, medium-grained quartzite in beds ranging from 1 to 6 inches in thickness. The quartzite weathers to a light yellow-brown and its total thickness in Charun Gol is about 250 feet. From a distance, the beds appear to be more distinct and thinner than those of the dolomite above. The Charun Quartzite has been carefully examined in the field only in Charun Gol and farther southwest in Reshun Gol, where it is about 300 feet thick; however, it has been traced on aerial photographs from Parpish to Buni, a distance of about 15 miles, over which its thickness seems to be fairly constant.

The Chitral Slate extends as a continuous outcrop from the border of Afghanistan northeastward almost to the town of Drosh (fig. 1). Here the outcrop is divided into two belts. The formation extends the entire length of Chitral State, generally as two or more belts of outcrops separated by igneous intrusions, volcanic rocks, and folded and faulted sedimentary or metasedimentary rocks. This lithologic unit continues eastward into Gilgit Agency where it is equivalent to all or part of the Darkot Group of Ivanac and others (1956, p. 6-9). In the Mastuj Valley, the Chitral Slate is found on the southeast side of a sequence of complexly faulted Devonian and Cretaceous to Tertiary rocks (pl. 1). The contact between the slates and this band of rocks is a northwest-dipping thrust fault.

The Chitral Slate is well exposed along the jeep track from Barenis to as far as the miniscule village of Nol on the eastern bank of the Mastuj River opposite the village of Parpish (pl. 1). Along this tract, the Chitral Slate consists of fine-grained fissile black slate. The general foliation of the slate strikes from N. 60° E. to N. 80° E., and the dip ranges from almost vertical to about 40° NW. The composition of the slate is quite uniform. Quartzite layers are rare, but limestone layers are seen in some places. The total original thickness of the sedimentary rock which is now the Chitral Slate was undoubtedly less than its present apparent thickness, because of repetition by tight isoclinical folds and probably by faults parallel to the cleavage.

Shogram Formation

Name and type locality: The Shogram Formation was defined by Desio (1966, p. 312) as the limestones and quartzitic sandstones of Devonian age exposed on the southeast slope of Mount Shogram (lat 36^{o} 11' N.; long 72^{o} 7' E., pl. 1; pl. 2, fig. 2). Desio stated that this type locality was chosen because the strata are well exposed and appear undisturbed by folds although the top of the section is bounded by a nearly vertical fault. Along Bindo Gol, the stream that flows through the village of Shogram, four additional faults and an isoclinal fold can be seen. However, until the area is mapped in greater detail, no redefinition of the type section can be made.

Lithology and distribution: The Shogram Formation can be divided lithologically into three informal units: a lower massive dolomite; a middle unit of bedded dolomite, fossiliferous limestone and black shale; and an upper quartzite. On the map (pl. 1) the lower two units are combined because of the difficulty of separating them on the aerial photographs.

The lower-most unit consists of a massive, at least 700-foot-thick, light- to dark-gray fossiliferous dolomite in beds 2 inches to 3 feet thick. It is well exposed on the ridge one half mile due east of Reshun (pl. 2, fig. 2) and along the banks of Gabaro Gol.

The middle unit of the formation consists of well bedded dolomite and gray, extremely fossiliferous limestone in beds as much as 6 feet thick, separated by thinner beds of black shales. The upper part of this unit contains fine-grained quartzite beds. These beds gradually increase in thickness from a few inches to more than 20 feet stratigraphically higher in the section.

In Charun Gol, the basal contact of this quartzite is a fault against the Reshun Formation, and the upper contact is with overlying bedded dolomites of the Shogram Formation. In Reshun Gol the upper contact is marked by a yellow ferruginous layer 10 feet thick, which may indicate an unconformity at the top of the Charun Quartzite. The extent and character of the Charun Quartzite outside the central Mastuj Valley are not known.

Age: A number of external brachiopod impressions have been collected from the Charun Quartzite. Impressions found on the right bank of Reshun Gol closely resemble *Rhipidomella*. Other orthoid and also rhynchonellid brachiopod casts were seen in a loose block of quartzite on the first shoulder southeast of Reshun village on the southern bank of Reshun Gol. These probable Paleozoic fossils and the stratigraphic position of the formation unconformably below a Devonian dolomite suggest that the Charun Quartzite is also Devonian or perhaps Silurian in age.

Hayden (1915, p. 288) first suggested that this quartzite might be the equivalent of the Muth quartzite of the Himalayas. Recent stratigraphic studies have shown that there is indeed a white quartzite of Devonian and perhaps partly of Silurian age throughout most of northern Pakistan and Kashmir (Stauffer, 1964).

The upper unit of the Shogram Formation consists of massive, light-gray, hard, fine- to medium-grained quartzite and some dolomite beds, particularly in the basal part. Individual quartzite beds range in thickness from less than 1 inch to more than 6 feet. Worm burrows and crossbedding are fairly common and show that the formation here is not overturned.

The thickness of beds exposed within the Shogram Formation on Mount Shogram, as measured by Desio (1966, p. 296-299), is 2,200 feet (675 meters) but Desio states that the total thickness must be at least 2,600 feet (800 meters).

The Shogram Formation is more resistant to erosion than most other formations in the mapped area and commonly forms ridges (pl. 3, fig. 1). It extends for a distance of at least 35 miles, along the Mastuj Valley from the village of Partsan (lat. 36°3' N.; long. 71°53' E., fig. 1) to the ridge between the Mastuj and Turikho Rivers east of Buni. The same formation may continue northeastward for another 70 miles and may be in part equivalent to the dark-gray or black compact limestone in the Boroghil Pass area (fig. 1) from which Major Grant collected Late Devonian fossils in 1898 (Hayden, 1904, p. 31; Reed 1911, p. 86-100).

The contact of the Shogram Formation with the underlying Charun Quartzite is marked by a yellow ferruginous layer about 10 feet thick which is well exposed on the north bank of Reshun Gol. This layer has the appearance of a weathered (soil) interval, indicating an unconformity. The upper limit of the Shogram Formation wherever examined was in fault contact with the Sarikol Shale.

Figure 1. View due east from ridge near Lon. Sor Zom, 10,980 feet high, is composed of dolomite of the Shogram Formation; ridge in upper right is Reshun Formation.

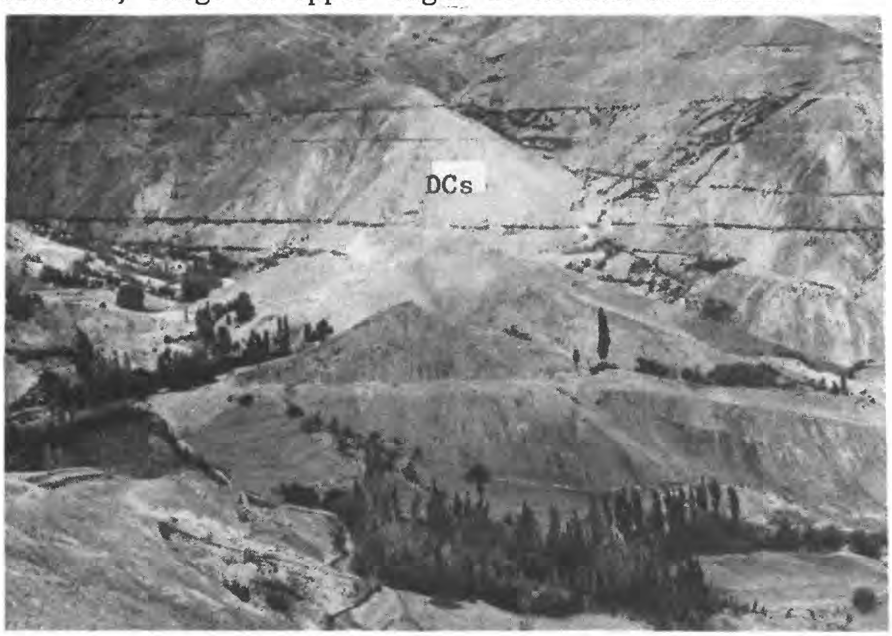

Figure 2. Typical aspect of Sarikol Shale near Lon. Horizontal lines are vegetation growing along irrigation canals.

PLATE 3. Two views from the Lon area. Formational symbols are the same as on geological map, except DCs, which is the Sarikol Shale. Photo viewpoints are also indicated.

Within the formation, a number of faults approximately parallel the bedding, and several cross faults have displaced the formation. The stratigraphic sequence on the southeast bank of the Mastuj River in the central part of the mapped area may include repeated sections. A definite correlation has been established between the fossiliferous limestones near the top of Mount Shogram and those on the ridge just south of the village of Kuragh. Fossil assemblages collected from these two localities are so nearly identical that the beds must be equivalent (Reed, 1922, p. 4; Desio, 1966, p. 301).

Age: The age of the Shogram Formation was determined as Late Devonian (Frasnian) by Reed (1922, p. 130), on the basis of fossil assemblages collected by Hayden from the middle limestone unit on and near the top of Mount Shogram and on the ridge just south of Kuragh (Hayden, 1915, p. 283). Fossil assemblages from these two localities are very similar and consist mainly of colonial and rugose corals and brachiopods, but also include some bryozoans, crinoids, molluscs, trilobites, a gastropod, and a straight cephalopod (Reed, 1922). Late Devonian age has been confirmed by Desio (1966, p. 308), but he believes that Middle Devonian may also be present. Tipper apparently believed that the lower part of the formation was older Devonian, although no evidence was cited for this belief (Pascoe, 1923, p.38). Desio lists two main fossil horizons in the Shogram Formation: a lower limestone containing fragments of brachiopods and large crinoids, and an upper limestone containing abundant brachiopods. On the southwestern end of the ridge between the Mastuj and Turikho Rivers near Roman Dūr (lat 36° 13' N.; long 72° 11' E., pl. 1), a fossil assemblage suggestive of a reef was seen. The assemblage includes stromatoporoids, colonial and rugose corals, and brachiopods, and may be equivalent to the upper brachiopod limestone of Desio; it may be related to the Devonian and Silurian reef belt found near Nowshera in northern Pakistan, about 150 miles due south of the Mastuj Valley (Teichert and Stauffer, 1965; Stauffer, 1968). The coral and stromatoporoid-rich limestone may also be the same horizon that Tipper found in the section west of the village of Owir (lat 36° 9' N.; long 72° 2' E., pl. 1), which he called a "peculiar pseudo-conglomerate coral limestone" (Pascoe, 1924, p. 47). Tipper believed that this horizon was stratigraphically above the Kuragh ridge locality and Late Devonian in age.

Other localities at which fossils were found include the low dolomite ridges south and east of Reshun, Bindo Gol above Shogram village, and the slopes along Charun Gol. Fossils from these localities are less well preserved, but are similar to those of the Shogram and Kuragh localities; however, they add nothing new to our knowledge of the age of the Shogram Formation.

Devonian to Carboniferous

Sarikol Shale

Name and type locality: The name Sarikol Shale was first applied by Hayden (1915, p. 300) to dark slates found throughout the southwestern corner of China. Hayden specifically described this formation as it appears from near the top of Mintaka Pass (lat 37° 0' N; long 74° 50' E.) along the Kara Chukur River valley and its tributaries and as far east-northeastward as the village of Beyik Karaul (fig. 1), a distance of about 28 miles. That area should thus be considered the type area of the Sarikol Shale. The name is apparently taken from the Sarikol Range, whose crest forms the southernmost part of the boundary between the USSR and China.

Lithology and distribution: In the type area the Sarikol Shale has been described by Hayden as consisting largely of black slates, in places calcareous, but also containing quartzite, volcanic rock, "needle shales," and some beds of limestone. The formation is slaty near granitic intrusions. According to Hayden (1915, p. 300-307), the Sarikol Shale forms the bulk of the Little Pamir mountains in Afghanistan, the Sarikol Range in Turkestan, and a part of the Mustagh Ata Range in China. The formation's metamorphic equivalent, the Wakhan Slate, covers most of the area of the Wakhan Range in Afghanistan (fig. 1).

Hayden believed that the same lithological unit occurs in northernmost Chitral in the area of the Boroghil Pass and farther west (fig. 1). The work of Tipper (Fermor, 1922, p. 56-57) later confirmed the presence of the Sarikol Shale in much of Chitral, including the Mastuj Valley. He traced these rocks from Shah Jinali Pass (lat 36° 47' N.; long 72° 50' E.) in the uppermost Turikho River valley (fig. 1), southwest for more than 50 miles to the ridge above Kosht Gol in the Mastuj Valley (lat 36° 15' N.; long 72° 10' E., pl. 1). Near Shah Jinali Pass, the formation consists of black slate, coarse-grained sandstone, quartzite, epidotized volcanic rocks, and some conglomerate bands of white quartz pebbles in a red clayey matrix. Toward the southwest the rocks gradually change to softer slates and shales.

No reliable measurements of thickness of the Sarikol have been made.

The Sarikol Shale in the Mastuj Valley is found only on the northwest side of the Mastuj River (pl. 1). It forms a continuous outcrop in gray, softly rounded hills from the Owir area northeast to beyond Dastun (pl. 1). Most of the formation consists of gray shale that in places are almost slate. On the ridge north of Kosht Gol, the formation contains beds of quartzite and a few limestone layers. Between the villages of Lon and Barumkagh, the shales have been tectonically so disturbed that they have no coherent form and most hill slopes are merely piles of rubble, (pl. 3, fig. 2). The hummocky topography of some areas suggests that landslides have contributed to the incoherency. Much shale rubble is coated with a thin efflorescence, probably alum, formed by the action of sulfuric acid, derived from pyrite, on the alumina of the shale. West of the village of Shogram the noncoherent Sarikol Shale is slaty and includes much dolomite float, some of which contains crinoid stem fragments. Also prominent in the dolomite debris are white quartz veins.

Age: Hayden (1915, p. 307) found Triassic fossils in the overlying limestone, and concluded that the age of the Sarikol Shale was partly Triassic and partly Paleozoic. Tipper (Pascoe, 1924, p. 47) found several Orthoceras specimens and crinoid stem fragments in this shale, and collected fossils which he considered to be Devonian from a limestone band within the shale. In the Mastuj Valley, the Sarikol Shale is overlain by fossiliferous limestones of Carboniferous to Permian age. For lack of additional fossil evidence, the formation cannot be assigned a definite age, but it must fall within the range from Devonian to Carboniferous.

Carboniferous and Permian

Limestone

The only formation definitely known to be Carboniferous and perhaps Permian in age is the thick, scarp-forming limestone about 2 miles northeast of the village of Parpish (lat 36° 8' N.; long 72° 4' E., pl. 1). Tipper (Pascoe, 1923, p. 38) found fusulinids in this limestone and traced it southwest along the strike for about 7 miles, to the headwaters of Phasti Gol (lat 36° 4'; long 72° 1', pl. 1). No specific identifications are given for the fusulinids. Several fossil horizons were apparently found along a trail between Reri and the headwaters of Phasti Gol, but no details are given by Tipper on their locations or fossil content. Desio (1966, p. 298-302) reports Permian fusulinids (*Pseudofusulina* and *Nankinella*) near Kuragh in a black fossiliferous limestone sample which he suspected came from a fault slice within the Devonian strata.

Similar-appearing limestone ridges are north of Kosht Gol (lat 36° 15' N.; long 72° 4' E.) and near Turigram (lat 36° 20' N.; long 72°15' E.). Although these ridges were not visited, they were seen from a distance in the field and mapped on aerial photographs (pl. 1).

Fusulinid limestone was also reported at two other areas in Chitral by Tipper (Fermor, 1922, p. 56-57). The first is on the northwest side of Tirich Gol (fig. 1) where strongly folded thick limestones containing fusulinids extend northeastward along strike for at least 20 miles. This limestone roughly parallels the fusulinid limestones of the Mastuj Valley and lies about 8 miles northwest of the Mastuj River. Tipper's second fusulinid limestone is probably the northeast continuation of the fusulinid limestone of the Reshun area, and extends from about 9 miles northeast of Buni to Khot Pass (lat 36° 30' N.; long 72° 30' E.), a distance of more than 10 miles (fig. 1).

A fault slice of limestone which may belong to the Carboniferous or Permian system was seen along a ridge about 2 miles east of Jumshili village (lat 36° 6' N.; long 72° 3' E., pl. 1). This massive, badly fractured, light gray, medium- to fine-grained limestone contains nondiagnostic miliolids and what appear to be algae and fragments of bryozoa. Fusulinids have recently been found in a limestone pebble from the Reshun Formation and in float along the headwaters of Reshun Gol. The fusulinid limestones have not been studied in detail and no formal stratigraphic names have been assigned to them.

Cretaceous

Limestone

Cretaceous limestone was first reported in Chitral by Hayden (1915, p. 279) who found an isolated, badly crushed fault slice of Orbitolina-bearing limestone near the town of Drosh (lat 35° 33' N.; long 71° 47' E., fig. 1). A much larger outcrop of Cretaceous limestone is found along the Lutkho River east of Shoghor (lat 36° 1' N.; long 71° 46' E., fig. 1). The limestone is massive, black to gray, partly recrystallized, and contains patches of white calcite that could be fossil remains. Tipper (Pascoe, 1923, p. 38) found Hippurites in this limestone along the Lutkho River but more recent work has failed to confirm this. The limestone strikes about N. 20° E. and dips vertically. Its apparent thickness is about 6,000 feet, but at least two vertical faults were seen which suggest that the section may be repreated. The contact of the limestone with the Chitral Slate is a vertical fault. This thick limestone extends southwest across the Afghanistan border and apparently continues northeast as far as Partsan (fig. 1), where it changes laterally first to red phyllite between Partsan and Pasti and then to conglomerate and red shale between Pasti and Reshun (J. A. Calkins, written commun., 1969).

Cretaceous limestones in the Mastuj Valley were reported by Tipper in the section along Buni Gol. Here, limestone containing many *Hippurites* are associated with the Reshun Formation and faulted against the Chitral Slate. Desio (1966, p. 299) mentions a Cretaceous limestone faulted against other strata and associated with a Tertiary conglomerate near Reshun, but does not elaborate. These limestones could not be distinguished as separate stratigraphic units.

Upper Cretaceous to lower Tertiary

Reshun Formation

Name and type locality: The name Reshun first appeared in the geological lieterature in a paper by McMahon and Huddleston (1902, p. 4), where it is referred to as "a bed of conglomerate......below Reshun." The same paper contains a description of the conglomerate taken from field notes of Major McMahon, the author's son, and descriptions of several large hand specimens by General McMahon.

The formation was next mentioned in a paper by Hayden (1915, p. 283-286) in which he called it the Reshun Conglomerate. Hayden did not specifically designate a type area, but he did describe the rocks near the village of Reshun and those in a section along Reshun Gol. The rocks in this section are disturbed tectonically but are well exposed. Inasmuch as this section of rocks has served as the informal type section in the past, it should be given serious consideration to formally designate the section as the type locality for the Reshun Formation.*

Lithology and distribution: The Reshun Formation consists of massive, light-brown, ridge-forming conglomerate and beds of red siltstone. The conglomerate contains pebbles and cobbles of limestone, quartzite, and greenstone in a matrix of medium- to coarse-grained sandstone that contains sandstone layers, 2 to 20 feet thick, and shale. Beds of conglomerate that range from 10 to more than 50 feet in thickness are more resistant to weathering and stand out prominently in contrast to thinner intervening beds of sandstone and shale.

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* As much of the formation, as defined in this report, consists of red siltstone, I have used the name Reshun Formation.

Most of the pebbles are closely packed white or gray limestone and dolomite, some of which contain microfossils, such as Orbitolina, and fragments of macrofossils. In some layers, hard white quartzite pebbles are dominant. Common among the pebbles are greenstones of various types, including epidiorite and metamorphosed andesite and dacite. Rarer pebbles include slate and white quartz. Greenstone pebbles seem to be dominant in the lower part of the conglomerate, and limestone and dolomite pebbles are dominant in the upper part. The pebbles generally range from 1 to 3 inches in diameter but many are as much as 6 inches in diameter. Smaller pebbles are found in thin bands in the sandstone parts of the formation. The pebbles are generally fairly well rounded and well sorted.

The sandstone matrix and the beds of sandstone that separate the conglomerate layers are subgraywackes as defined by Pettijohn (1957, p. 316-321). About half of the grains are subrounded quartz, the remainder, in approximate order of abundance are carbonate, chert, volcanic rock, and feldspar grains. Calcite cement forms a very small percentage of the sandstone volume.

The hematite-red siltstones of the Reshun Formation reach an apparent thickness of about 1,500 feet along Reshun Gol. Within the tectonically disturbed conglomerates of the Reshun Formation are beds of siltstone ranging from 3 to 30 feet in thickness. The siltstones consist largely of quartz silt, partly calcareous, with a matrix of red hematite. Where carbonate dominates, the rocks are a red, silty limestone. In places the rocks are so fine grained that they may be called a red shale, elsewhere they grade into sandstones and conglomerates. If the Reshun Formation in Reshun Gol is not faulted, then the upper part of the unit would appear to consist largely of red siltstone. On the map the dashed line within the Reshun Formation separates the largely conglomeratic part from the largely silty part of the unit as seen on aerial photographs.

Several dark-brown calcareous shale beds containing plant remains are found in the Reshun Formation in a well exposed section along the irrigation channel on the south bank of Reshun Gol. These shale beds are between 5 and 10 feet thick and some contain lenses of shaly limestone.

The Reshun Formation in Chitral State apparently forms two separate outcrop belt (fig. 1). One belt crops out near Drosh and extends northeast along the Shishi Valley (lat 35° 40' N.; long 71° 55' E.), crosses Phargam Gol west of the village of Harchin (lat 36° 7' N.; long 72° 28' E.), continues northeast to the top of Chumarkhan Pass (lat 36° 16' N.; long 72° 39' E.), where it is very thick, and can be seen as a distinct belt continuing onward to the northeast (Pascoe, 1924, p. 45). The continuation of the Reshun Formation in Gilgit Agency has apparently not been mapped separately, but has been included within the Yasin Group (Ivanac and others, 1956, p. 11).

The second outcrop belt parallels the first and has been traced from just northeast of Partsan (lat 36° 2' N.; long 71° 52' E.)(Pascoe, 1923, p. 38) upstream along the right bank of the Mastuj River to Reshun, where it passes under the river and extends along the left bank as far as Buni (fig. 1 and pl. 1). Just beyond Buni, the formation again passes under the river and forms the ridge between the Mastuj and Turikho Rivers and then continues northeast as far as Khot Pass (lat 36° 30' N.; long 71°38' E., fig. 1)(Fermor, 1922, p. 56). Only this second belt of the Reshun Formation passes through the mapped area and has been examined in the field.

The thickness of the Reshun Formation is difficult to estimate. Not only are its upper and lower limits thrust faults, but it has also been folded isoclinally. The minimum unfaulted thickness in the Reshun area is at least 500 feet and may be as much as 2,500 feet. The formation is thinner to the northeast and is only about 50 feet thick at Khot Pass, 25 miles northeast of Buni village (fig. 1).

Age: The position of the Reshun Formation underneath fossiliferous Devonian dolomites and limestones originally led Hayden (1915, p. 284-286) to believe that the formation was also Devonian or pre-Devonian in age. Hayden found limestone pebbles weathered out of the conglomerates with fossils which he then thought to be bryozoans. But he had doubts about the age of the Reshun Formation when he examined it in the field, because he noted that it ".....looked suspiciously young for older Paleozoic rocks." Furthermore, he found volcanic pebbles in conglomerate at Awi 20 miles northeast of Reshun (fig. 1), which suggested to him that the formation could be Mesozoic or Tertiary in age and younger than the Panjal volcanics of Carboniferous to Triassic age. Hayden, not having time for more than a superficial examination of the geology of this area, adopted the simplest solution: that the section in Reshun Gol was normal, which made the Reshun Formation Devonian in age or older. Later, after his return to Calcutta, he examined the supposed bryozoans under a microscope and found that they were really crushed fragments of the Cretaceous Foraminifera Orbitolina. Hayden then realized that the Reshun Formation was probably Cretaceous or Tertiary in age and that there must be major faults in the Reshun Gol section.

Tipper confirmed the Cretaceous or Early Tertiary age of the Reshun Formation and was the first to realize that the formation was bounded by major faults which put it in direct contact on one side against Devonian carbonate rocks, and on the other against the Chitral Slate (Fermor, 1922, p. 56).

Plant fragments were collected from a calcareous shale layer 15 feet thick near the base of a waterfall in Korghulo Gol, a tributary of Reshun Gol about 1½ miles southeast of Reshun village. Curt Teichert, formerly with the U. S. Geological Survey, and R. A. Scott, U. S. Geological Survey, both noted the psilophytic appearance of these plant fragments, which suggested to them that the shale might be Silurian or Devonian in age. This age relationship conflicts with the age as determined from microfossils found in pebbles in the conglomerate. Lack of evidence of faulting along the shale layer prevents solution of the problem of the plant fragments. No spores were found in this shale, apparently because of the effects of metamorphism and oxidation.

Systematic examination of the Reshun Formation found *Orbitolina*-bearing limestone fragments at two locations. One fragment was found in limestone breccia on a hill about 1 mile due south of the village of Reshun. The breccia is composed entirely of crushed fragments of limestone which are traversed by countless calcite veins. The second fragment was found 100 yards south of the waterfall in Korghulo Gol. One of these samples also contained fusulinids. Pebbles of quartzite, dolomite, and greenstone, and sandstone matrix, so characteristic of most of the conglomerates of the Reshun Formation, are conspicuously absent in the *Orbitolina*-bearing breccia.

Orbitolina fragments were identified with a handlens in rounded limestone pebbles in typical conglomerate of the Reshun Formation along the banks of Reshun Gol. However, these pebbles could not be extracted from the well-indurated conglomerate for thin section study.

Evidence bearing upon the age of the Reshun Formation points to a Cretaceous or perhaps Early Tertiary age. To resolve this controversy rounded *Orbitolina*-bearing limestone pebbles should be collected from typical conglomerates of the Reshun Formation and studied in thin section.

Quaternary

Glacial moraines

Glacial moraines in the Mastuj Valley were observed on aerial photographs in the valleys of Biyo Gol and Lutshalo Gol, both tributaries of Reshun Gol due east of Reshun village (pl. 1). The moraines are rounded, elongate mounds, which have a relatively smooth appearance, along the sides of the valleys. Some parts of the mounds have pitted or hummocky surfaces. The moraines are separated from the bedrock slope of the valley by a long, narrow depression on the uphill side, typical of glacially deposited lateral moraines. The morainal deposits in both valleys extend beyond the limits of the aerial photographs and the limit of the map (pl. 1).

On survey of Pakistan topographic map 42 D/SW, glaciers are shown in both Biyo Gol and Lutshalo Gol valleys about 1¼ miles upstream or south of the limit of aerial photographs (fig. 1).

The morainal deposits lie at an altitude of about 10,000 feet, whereas the lower limit of present glaciers is at an altitude of about 12,000 feet. This represents a vertical change of 2,000 feet and a horizontal retreat of about 2½ miles for the present glacier snouts. Appreciable fluctuations of glacier snouts in the Himalayan, Karakoram, and Hindu Kush Ranges are not unusual and do not necessarily reflect changes in climate. The velocity of glaciers and the relative advance or retreat of their snouts may be due to causes unrelated to climatic changes; such as unusually high or low precipitation in one season; large snow and ice falls that add volume to the glacier; bursting of glacial dams; and the overriding of natural obstacles in the path of the glacier. In general, the Himalayan and Karakoram glaciers have been retreating slowly, although no periodic connection has been observed between glacier variation and possible weather cycles (Mason, 1930, p. 217-221). The retreat of the two small glaciers in the Mastuj Valley of Chitral cannot be considered climatically significant.

Mudflows and landslides

Rock debris which forms numerous talus slopes is common in the steep topography of the Mastuj Valley, but mudflows account for much of the rapid downslope movement of rock and soil and are probably the principal building agents of the cultivated terraces. Mudflows occur just after torrential rains that wash loose small stones, soils, and dust from hillsides into the stream beds. If such debris is carried down toward the mouth of a stream to a narrow gorge, it may accumulate more rapidly than it can be eroded and so form a dam. When the pressure of pent-up water and debris builds up the dam bursts and a mass of mud, rocks, boulders, and water plunges downhill sweeping all in its path. The destruction caused by these mudflows can be enormous and depends largely upon the size and depth of the stream channel through the terrace. If the channel is large enough, the mudflow is confined to it, but if the mudflow overflows the channel at the apex of the terrace fan, it may spread over the whole width of the terrace and destroy everything in its path--crops, livestock, and huts.

The new layer of debris then slowly dries and becomes a part of the terrace. Tipper (Pascoe, 1924, p. 48) was the first to point out the importance of these mudflows in Chitral State both as building agents for the terraces and for their destructive power.

An interesting example of a terrace in the initial stages of formation is the landslide area of Diryānu (pl. 1). Debris in this landslide still has a rough, hummocky surface and the scar on the mountain side, from which most of the material came, can still be seen. Downslope mass movement will continue, and the Mastuj River will be pushed to the far bank. Later, if conditions are suitable, mudflows will build up the terrace and develop the typical concave upper surface.

Another area of prominent mass earth movement can be seen on aerial photographs on the slopes of the north bank of the Mastuj River southwest of the village of Reri (pl. 1). The slope here may have consisted of Reshun Formation thrust-faulted on top of Sarikol Shale. The slope now has an irregular surface characteristic of landslides, and rounded, convex-downslope tongues of noncoherent material below concave-downward slide scars. The darker tone of most tongues suggests that they are largely red siltstone of the Reshun Formation probably mixed with Sarikol Shale and liberally sprinkled with large blocks of dolomite of the Shogram Formation. This landslide area is about 1 mile wide and has spread downslope toward the northeast for a distance of about 3 miles. Many small landslide scars and tongues within the general slide area indicate that the slide was not the result of a single rapid event, but rather of a continuing process lasting many years. Probably downslope movement of the noncoherent mass has been slow, with sudden small or large landslides taking place from time to time, especially after heavy rains or perhaps after earthquake tremors.

Although not mapped specifically as a landslide, the entire area of Sarikol Shale between the villages of Lon and Kosht on the west bank of the Mastuj River shows the effects of downslope mass movements. Much of the topography of this area consists of small, rounded, irregular hills and ridges composed of noncoherent shale debris containing scattered blocks of limestone or dolomite with random orientations. Shale outcrops still in place are rare.

Terraces

Terraces are common in the valleys of all major streams in Chitral State. In the area of plate 1 alone, there are 14 terraces of unsorted alluvial deposits. The terraces have a gently inclined convex surface and are bounded on the upper side by the valley slope and on the lower by a scarp as much as several hundred feet high that descends almost vertically to the river. At the upper end of each terrace, there is invariably the narrow gorge of a tributary stream. The terraces are built by debris brought down by the tributaries in the manner described under mudflows.

Most inhabitants of Chitral live on these terraces which provide virtually the only level area on which some soil can form. Fields are irrigated by means of channels from the streams at the upper ends of the terraces. Debris composing a terrace is derived from a relatively small area and reflects outcrops present in that area. For example, the terrace of Barenis, derived largely from Chitral Slate and granodiorite, is dark with some sandy patches, and the terrace of Reshun, derived in large part from the Reshun Formation, is characterized by boulders and pebbles of conglomerate in a bright red, fine-grained matrix. The soil of terraces built by streams draining siltstones of the Reshun Formation is always bright red.

Alluvium

In the Mastuj Valley, Quaternary alluvium other than that of the alluvial terraces forms talus slopes and river-level sand deposits. Extensive talus deposits are rare because of the steep slopes and the violent erosive action of seasonal rains. Smaller valleys are generally too steep and narrow to permit débris to accumulate, so it is carried downstream during the first severe rainstorm. Talus deposits are almost invariably only a thin veneer on bedrock. River-level sand deposits are found only along major rivers such as the Mastuj, in places where the river has been able to erode a somewhat wider valley, or more commonly, where the debris brought in by tributaries has exceeded the carrying capacity of that part of the main stream. At these places, the river may be diverted to one side of the valley by a terrace. Material that the river erodes from the terrace is distributed along the valley floor forming flat sand banks, as in the Buni area.

Intrusive rocks

Biotite granodiorite

The valley of the Mastuj River lies between two large intrusive granitic masses--the Tirich Mir massif to the northwest and the Buni Zom intrusion to the southeast (fig. 1).

The Tirich Mir massif, which forms the spectacular peak of Tirich Mir, 25,230 feet high, is composed of biotite granite containing phenocrysts of feldspar as much as 4 inches long. Southward from the main massif, the dominant rock becomes an augen gneiss and farther south a fine-grained, foliated gneiss. The age of the Tirich Mir granites and gneisses is very probably post-Permian because the granite contact cuts fusulinid beds and has metamorphosed the Sarikol Shale south of Tirich Mir (Fermor, 1922, p. 57).

The intrusive massif of Buni Zom, 21,494 feet high (fig. 1), is one of several elongate, mountain-forming granitic intrusives in northernmost Pakistan. The Buni Zom intrusion is composed of biotite granodiorite and gneiss and forms the high peaks southeast of the Mastuj Valley. Outcrops of this granodiorite contribute substantially to the debris of some terraces on the southeast side of the Mastuj River. A light-colored intrusion can be seen in the hills above and to the east of the jeep track between Maroi and Barenis. Although the outcrop was not visited, biotite granite boulders in streams draining this area confirmed the presence of this rock, which probably is a part of the Buni Zom intrusion. The Buni Zom granodiorite is intrusive into the Chitral Slate and is therefore post-Chitral Slate in age. On the basis of regional correlations, the Tirich Mir and Buni Zom massifs both are probably Cretaceous or Lower Tertiary (Stauffer, 1964).

STRUCTURE

Regional setting

The Karakoram and Hindu Kush Ranges form a series of mountain arcs about 800 miles long, extending from Afghanistan across northern Pakistan into Kashmir, and roughly concentric about the Hazara-Kashmir syntaxial bend (Wadia, 1931; Geol. Survey Pakistan, 1964). The highest ridges are composed of intrusive Tertiary granodiorites separated by deep valleys carved into sedimentary rocks of Paleozoic to Tertiary age. These sedimentary rocks include a variety of lithologies and many have been altered to low- to medium-grade metamorphic rocks.

At least three north-dipping thrust faults have been recorded in the Karakoram Range (Gansser, 1964) in addition to those thrust faults that outline the syntaxial bend farther south. None of these faults have been traced directly from the Karakoram Range westward into the Hindu Kush Range, but the prominent northwest-dipping thrust faults in the Mastuj Valley suggest that the structure of the two ranges is similar, and that they probably belong to the same structural system.

The Mastuj Valley of Chitral is one of the major valleys of the Hindu Kush Range located between two igneous arcs. This valley, carved by the Mastuj River in sedimentary and metamorphic rocks, is bounded on both sides by peaks and ridges of granitic rocks rising well above 20,000 feet.

Faults

Structurally the Mastuj Valley consists of a band of folded Upper Cretaceous to Lower Tertiary sediments, faulted between Devonian rocks on the northwest and the Paleozoic Chitral Slate on the southeast. Two major northwest-dipping thrust faults mark the upper and lower limits of the Cretaceous to Tertiary rocks.

Evidence for the presence of these thrust faults includes the superposition of the fossiliferous, Devonian Shogram Formation on top of the fossiliferous, Cretaceous, or Tertiary Reshun Formation; brecciation along the contacts; slickenslides along some faces of contact; sheared pebbles of various lithologies in conglomerates along the lower limit of the Reshun Formation; and irregular slices of red siltstone along both contacts. All of these features can be observed where the thrust faults cross the narrow valley of Reshun Gol. Fault slices of red siltstone are prominent along much of the extent of the faults in Reshun Gol and on the western bank of the Mastuj River across from Jumshili.

Additional thrust and a few reverse faults of apparently small displacement are found within the band of Cretaceous to Tertiary rocks. These faults cannot be followed over long distances, and deformation and brecciation along their traces are generally minor. All of these minor faults dip toward the northwest.

Only minor thrust faults were seen outside the band of Cretaceous to Tertiary rocks, but reverse faults are common, especially in the Shogram Formation. The boundary between these dolomites and quartzites and the Sarikol Shale appears to be a steep reverse fault. The strike of this reverse fault is northeastward, as are the strikes of almost all faults of this area.

One other set of faults has been mapped by using aerial photographs. This set consists of four faults, all essentially vertical and striking slightly west of north. Three faults are between Parpish and Reshun and the fourth is just downstream from Kuragh (pl. 1). These faults cut the southwest-northeast reverse faults and two of them pass apparently undisturbed across thrust faults into the Cretaceous to Tertiary band of rocks, suggesting that they are the youngest faults in the area.

The sequence of faulting in the Reshun area was probably (1) thrust faulting with minor reverse faults, (2) reverse faulting in the dolomites and quartzites, and (3) finally, the nearly vertical north-northwest striking faults.

Folds

All the folds examined in the Reshun area conform to the regional structure--fold axes strike southwest. The most spectacular are isoclinal folds involving the Reshun Conglomerate. These can be seen best high above the western bank of Reshun Gol and on the western bank of the Mastuj River opposite Jumshili village. Most of the folds are isoclinal and overturned toward the southeast, and in places they contain arcuate slices of sheared siltstone. Tight folding of the Reshun Formation has involved considerable slippage along the shale beds within the conglomerates of the formation and the adjacent siltstone beds, which accounts in part for the finely crushed appearance of these strata. Because the folds are structurally compatable with the thrust faults, they were probably formed simultaneously.

The Chitral Slate is a structurally homogenous formation. Foliation of the slate everywhere strikes southwest and the general dip ranges from nearly vertical to about 40° NW. Minor fold axes follow the regional strike and plunge to the northeast.

Structures in the Sarikol Shale are largely obscured by the slumped, noncoherent shale debris. The few field measurements of minor fold axes and mineral lineations coincide with the regional strike and plunge 10° - 15° SW. Most of the shale has been so disturbed, first tectonically, and later by landslides, that it is now a noncoherent mass of debris. Generally, the limestone beds in the formation are the only horizons that can be used for reliable structural measurements.

In the Buni area, two prominent, gently dipping synclines, one in the Sarikol Shale and the other in the Shogram Formation follow the trend of the regional structure. The relation between these gentle synclines and the sharp isoclinal folds and thrusts elsewhere in the Mastuj Valley is not clear.

ECONOMIC GEOLOGY

No economic mineral deposits have been found in the Mastuj Valley of Chitral, although minerals of some interest are present in small quantities. The following discussion is limited to the mapped area. Mineral localities elsewhere in Chitral have been mentioned by various workers including Crookshank (1949, 1951), S. I. Ali (1951, 1953a, 1953b), S. T. Ali (1949, 1962), Kidwai and Iman (1958), Nath (1943), Rahman (1949), and Sondhi (1942).

Antimony

No antimony minerals were seen in place in the Mastuj Valley, but pieces of antimony sulfides were brought in by local villagers who reported that they had been collected from somewhere above (to the NW) the village of Lon. This is not unlikely as antimony minerals have long been known to exist in Chitral and periodically have been mined in the area 3 miles southwest of Partsan (fig. 1). There the Chitral Slate contains antimony sulfides in quartz veins. These have been mined in a southwest trending area about 2 miles long (Heron, 1950, p. 4-5). Additional antimony mineralization has been reported from the Mastuj Valley at various distances northeast of Partsan. The antimony sulfides near Lon could well be another similar deposit approximately along the regional strike.

Iron and aluminum

A potential source of iron and aluminum was found at two beds. The thinner of the two beds at the top of the Charun Quartzite; the other is within the Shogram Formation. These beds, both of Devonian age, are believed to have been formed by subaireal weathering and may be in part lateritic. Only three other Paleozoic laterites have apparently been reported (Font-Altaba and Closas, 1960), therefore the two found in the mapped area are of special interest. The thicker layer is fully described elsewhere (Stauffer, unpub. data). Recent field work by J. A. Calkins (written commun., 1969) indicates that although parts of these layers represent zones of weathering, other parts are bedded and thus do not fit the definition of a laterite.

The thinner layer at the top of the Charun Quartzite is exposed on the ridge southwest of Reshun Gol. Here it consists of a soft ocherous yellow rock about 10 feet thick, in irregular contact with the quartzite below; pisolitic structures are distributed throughout. It is a soft layer badly weathered and could not be followed for more than about 100 feet.

The more extensive layer, ranging from 5 to 20 feet in thickness and bright red in color, was found within the Shogram Formation. It is exposed on both sides of the valley of Damun Gol, about one mile due east of the village of Reshun. This layer has irregular contact surfaces with the dolomites and consists of hematite-red material with darker red or black, structureless nodules from 1 to 5 millimeters in diameter. Nodules in all stages of development, from vague concentric rings in the groundmass to fully defined dark, rounded masses, can be seen in thin section. The original apparently porous texture has now been firmly cemented by secondary calcite. It is reasonably certain that this layer in part is a laterite and represents a temporary emergence of the area, which was followed by submergence and further carbonate deposition.

Chemical and X-ray analysis have shown that this layer contains 35 percent Al_2O_3, 16 percent Fe_2O_3, 10 percent FeO, and 22 percent SiO_2. The high silica content and remote location of these rocks probably precludes commercial exploitation.

Tungsten

Heavy-mineral suites of sand taken from near the mouth of Reshun Gol and from the Mastuj River just upstream from Reshun Gol do not show unusual concentrations of heavy minerals except scheelite. Heavy-mineral studies in other areas of northern Pakistan have shown that in areas containing granitic or gneissose rocks, stream sands contain an average of one or two scheelite grains per gram of heavy minerals, (Stauffer, unpub. data). The Reshun Gol and Mastuj River samples contained 4.4 and 7.6 grains of scheelite per gram of heavy minerals, respectively, two to three times the "normal" amount of scheelite that could be expected anywhere in northern Pakistan. It probably is derived from granitic and geissose rocks of the area. This scheelite quantity is not considered economically significant except as an indicator that may lead to more important deposits.

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