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MULTIPLE EPISODES OF CATASTROPHIC FLOODING IN THE PESHAWAR BASIN DURING THE PAST 700,000 YEARS

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ABSTRACT

At least 40 catastrophic floods inundated the Peshawar Basin in prehistoric times. A sequence of graded beds up to 25m thick near Paran record these flood events. These older floods resulted from significantly higher flows than those of the well-documented floods of 1800's. Such floods can be a real threat to the safety of Tarbela Dam and a careful monitoring of the Indus and its major tributaries is required and suggested.

INTRODUCTION

During the mid-1800's, at least four floods coursed down the Indus River and inundated portions of the Peshawar Basin. Historical accounts of these floods (Abbott, 1849; Cunnigham, 1954) describe the disasterous consequences that they brought to in many of the low-lying areas adjacent to the Indus and Kabul Rivers. According to eyewitness accounts (Belcher, 1959), the flood in 1841 caused the Indus to rise about 30 meters in 4 hours at Attock. Flood waters were backed up to Nowshera, where they stood over 1 meter deep. 500 soldiers in Raja Singh's army were overwhelmed by the floodwaters. When the impounded water receded, a blanket of silt was left over the flooded areas (Abbott, 1849).

The historical records of other floods in the 1800's indicate that the flood in 1841, although the largest, was not a fortuitous event. The physiographic characteristics of the Peshawar Basin and the Indus drainage provide a setting conducive to catastrophic flooding. The Peshawar Basin is a broad, low-lying depression which exhibits only minor topographic relief, except along its margins. The Attock-Cherat Range, which defines the southern margin of the Peshawar

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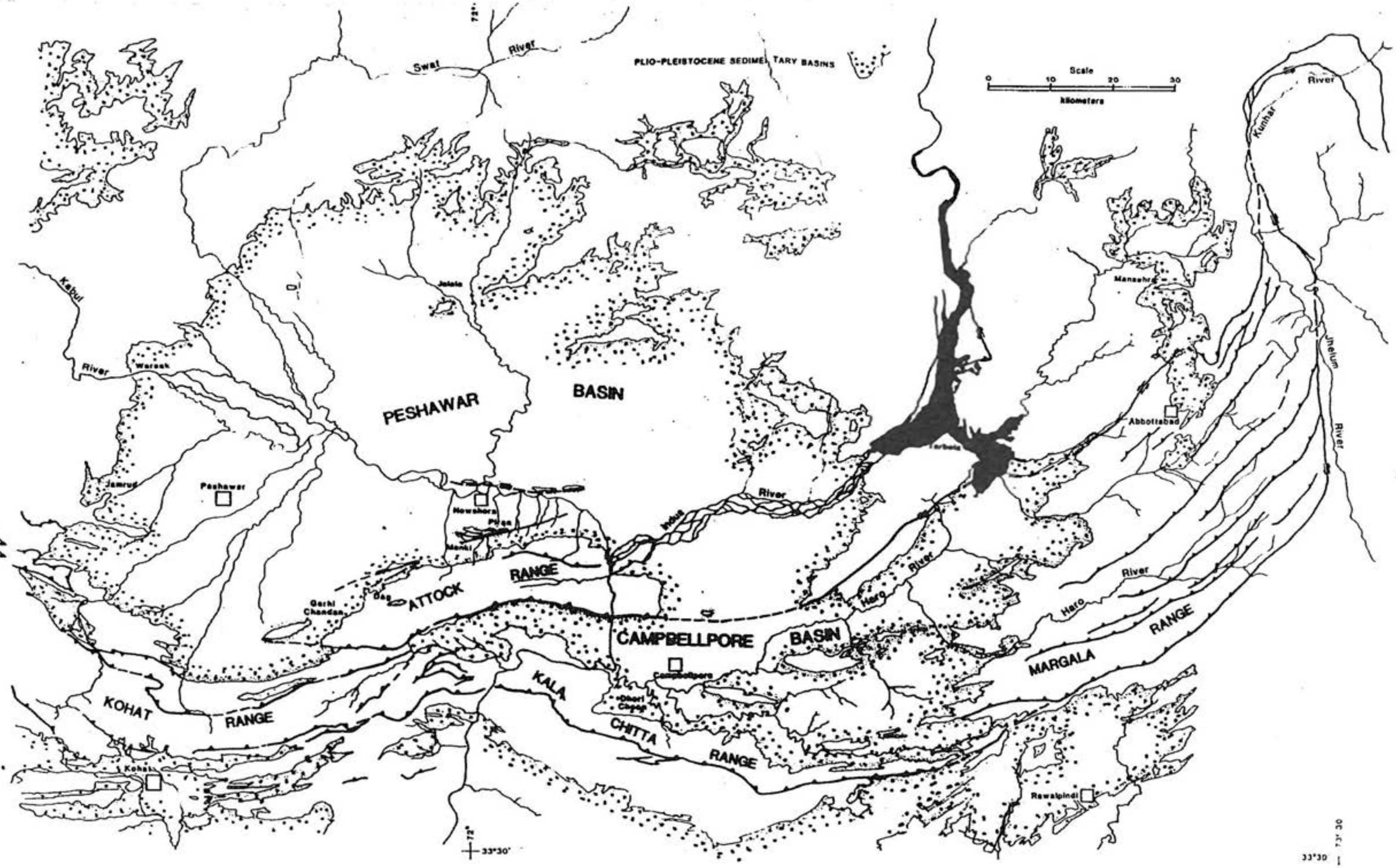

Figure 1. Map of the Peshawar and Campbellpore basins with associated major faults. The Peshawar Basin is delimited on its southern margin by the Attock Range which has been elevated along north-dipping thrust faults. The Indus and Kabul Rivers flow through a watergap near the east end of the range. Several times in the 1980's and on numerous occasions in prehistoric times, catastrophic floods have surged across the site of the modern Tarbella dam.

Basin (Fig. 1) is underlain and transected by active, north-dipping thrust faults (Tahirkheli, 1970, 1980). The stark relief of the Attock Range provides a physical barrier behind which high flows of the Indus River can be impounded.

In addition to predictable annual peaks in runoff due to snow melt, the Indus can generate catastrophic floods due to its physical setting. An antecedent river that is incising into actively growing mountains (Seeber *et al.,* 1981), the Indus River flows through a steep-walled gorge whose sides frequently rise more than 2000m above the river. The precipitous slopes bounding the Indus are susceptible to landslides which can temporarily impound large volumes of water behind a landslide dam. The 1841 flood was caused by a large landslide south of Gilgit. In several places, the terminal of glaciers lie close to or at the level of various tributaries to the Indus. Advances of the glacier snouts across the rivers can also serve to create a temporary reservoir upstream of the glacier. When a landslide or glacier dam fails, floodwaters surge down the Indus gorge and can inundate the Peshawar Basin.

EVIDENCE FOR OLDER FLOODS AND TECTONIC SETTING

Although the major floods since 1800 are well documented, geologic evidence for pre-historic, large-scale flooding in the Peshawar Basin has not been described previously. During a recently completed study of the stratigraphic and tectonic evolution of the Peshawar Basin (Burbank, 1982), deposits up to 25 m thick that are inferred to have resulted from catastrophic flooding were located several kilometers south of Nowshera near the villages of Paran and Tangi.

Figure 2 depicts an inlier of ?Paleozoic slates just north of the villages of Manki and Tangi. Aerial photographic interpretation and ground reconnaissance indicates that this block of bedrock is bounded by recently active faults. The horsetail splay of faults in the western portion of the bedrock inlier suggests a component of sinistral strike-slip motion along the southern marginal fault. Thrusting to the south appears to have elevated the block above the adjacent terrain. This thrusting would be parallel to that along the Attock Thrust which has raised the Attock Range in an analogous fashion. The fault bounding the southern margin of the block at Manki can be traced to the east-northeast past Wali, where Pleistocene alluvial fans (Burbank, 1982) are offset as much as 40 m by differential uplift of the northern block.

The flood deposits reported here lie along the northern flanks of the exposures of Manki slate. Near Paran, exposures are particularly well developed along incised nalas. Depositional contacts with the underlying bedrock are exposed repeatedly along the road to Manki.

SEDIMENTARY AND STRATIGRAPHIC CHARACTERISTICS

The flood deposits occur as repititive, graded strata, ranging from several centimeters to nearly a meter thick. At Paran, at least 40 individual cycles are exposed. Usually, each cycle contains three distinct sedimentary units. The sedimentological characteristics of these cyclic strata are similar throughout the expo-

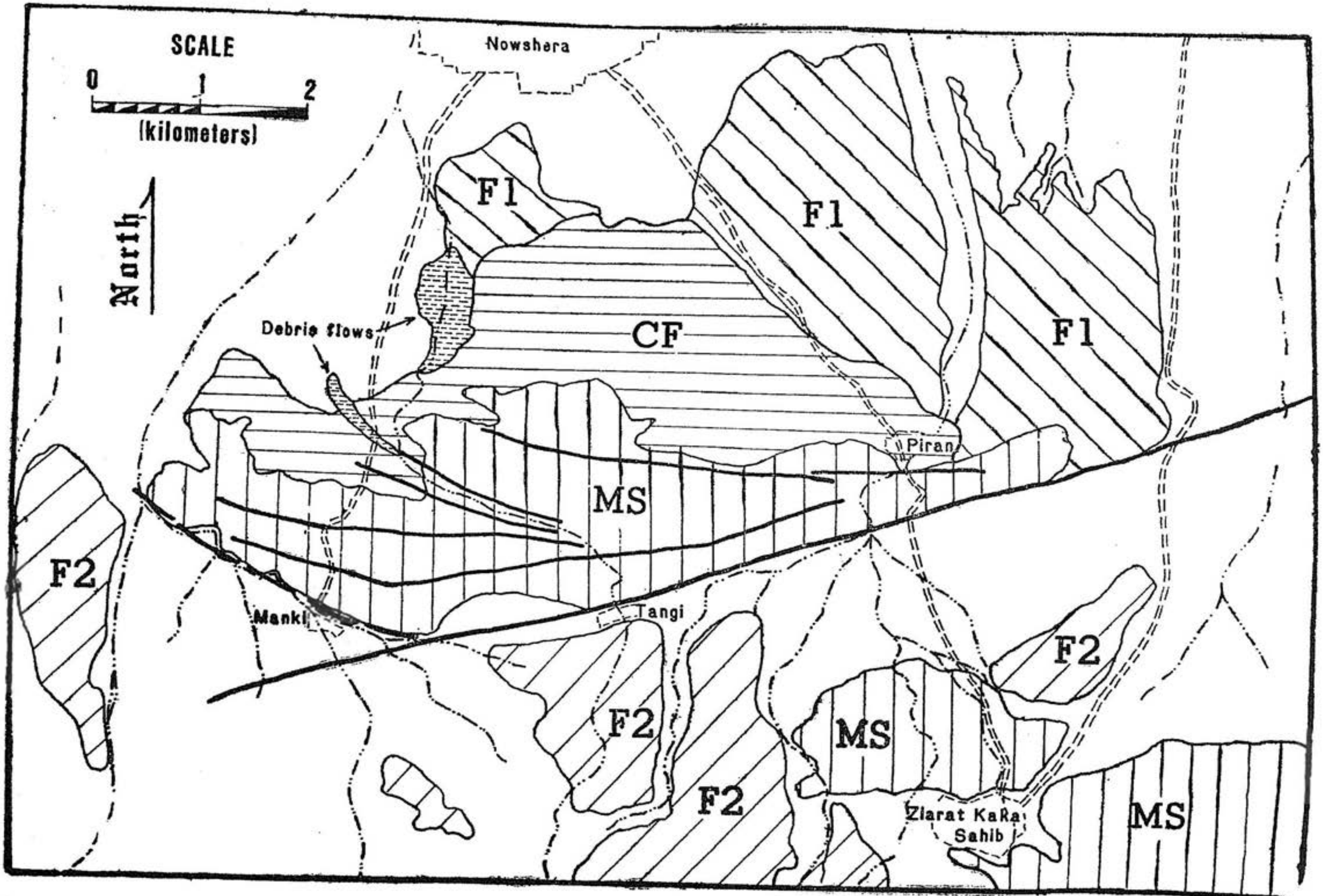

Figure 2. Geological map of the Manki-Paran area. The Manki slates are cut by numerous faults and have been elevated with respect to the land to the south. Outcrops of Pleistocene flood deposits occur along the northern margins of the slate outcrop. Map is based on aerial photographic interpretation and field reconnaissance. (MS=Manki Slates; F1=Younger fan deposits; F2=Older fan deposits; CF=Catastrophic flood deposits).

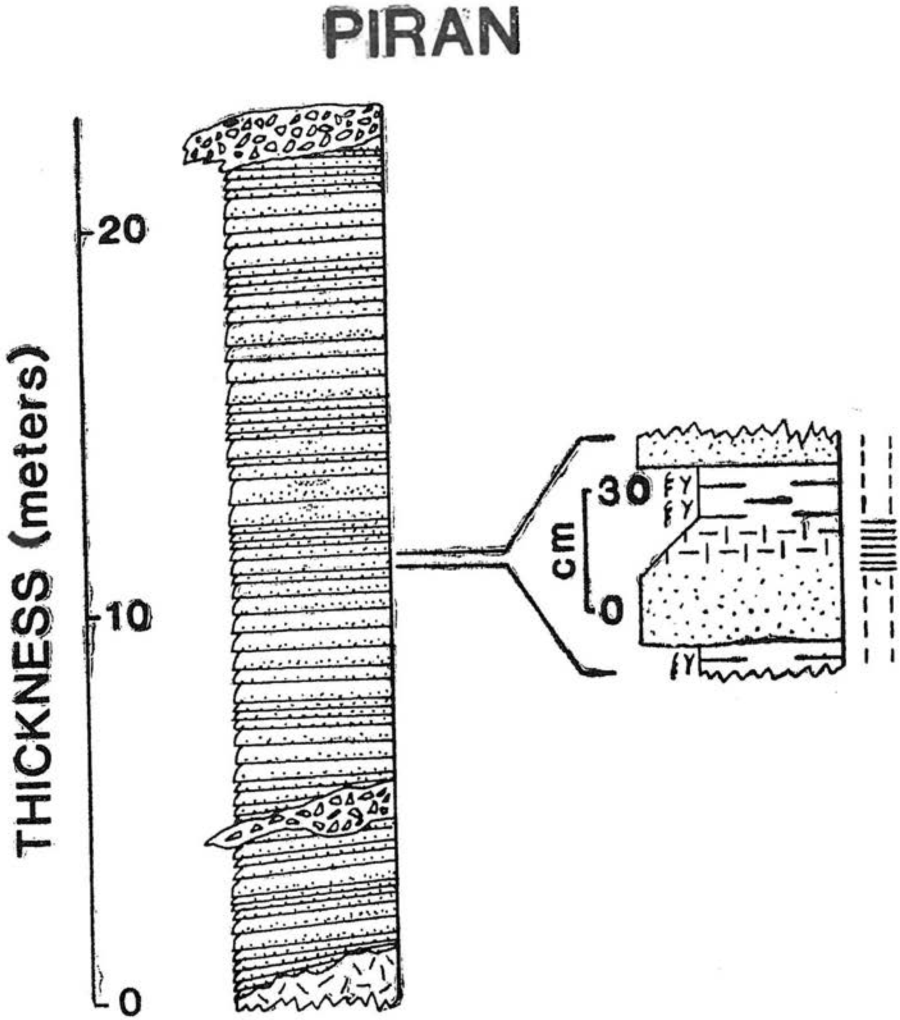

Figure 3. The measured stratigraphic section near Paran comprises a sequence of graded beds. Sedimentological characteristics are very similar from one graded stratum to the next. Note how the sequence is interrupted by a colluvial zone and that the lower sequence of graded beds is more extensively tilted than the upper sequence. The differential tilt of the beds is indicative of syn- and post-depositional tectonic disruption.

sures (Fig. 3). The basal unit typically comprises massive, medium-grained, weakly sorted litharenites. This sandy unit has an abrupt basal contact, occasionally contains mud rip-up clasts, and fines upwards. The middle unit of each cycle consists of well-laminated, gritty silts and very fine sands that display gradational upper and lower contacts. The upper unit comprises muddy silts that are massive and mottled. They contain calcic concretions, as well as occasional burrows.

In the vicinity of the bedrock contacts, the individual cycles thin markedly. They pinch and swell over irregularities in the underlying bedrock. In places, thin colluvial lenses are trapped between the bedrock and the overlying cyclic sediments.

Evidence for syn- and post-depositional tectonic activity is recorded within the cyclic sediments at Paran. About 10 cycles are preserved in a position directly overlying the bedrock. These beds tilt at about 10° towards the basin centre. Their upper boundary has been irregularly eroded and is overlain by a line of angular colluvium (Fig. 3). This layer is succeeded by thirty or more cycles that dip towards the basin centre at about 2°. The entire sequence is capped by a younger zone of colluvium that is interbedded with lenses of loess.

INTERPRETATION

Each of the graded beds is interpreted as a deposit resulting from a single catastrophic flood. The persistent fining-upwards trends within each stratum suggest that the intensity and turbulence of each flood waned systematically to produce a graded bed. The mottled and bioturbated tops of each cycle indicate that a period of subaerial exposure probably intervened between separate flood events. The tendency of individual beds to pinch over bedrock protuberances, as well as the graded nature of each stratum, resembles characteristics displayed by turbidity-current deposits. However, the mean thickness of each cycle at Paran (40 cm) exceeds the thickness of the average abyssal turbidite and suggests a very proximal setting for these flood deposits. Well-documented catastrophic flood deposits that can serve as analogues for these in the Peshawar Basin are located in south-central Washington State, U.S.A. Over forty catastrophic floods are recorded by the cyclic sediments of the Touchet beds (Waitt, 1980). During the late Pleistocene, huge volumes of water (up to 2000km^3) drained abruptly from a large, ice-dammed lake and coursed across central Washington. These floods carved canyons over 300 m deep and 4 km wide through the Columbia Plateau basalts. However, in the distal portions of the basin hydraulically ponded floodwaters deposited extensive graded beds averaging about 30 cm in thickness and grading upwards from coarse sand to silt.

The laminated silts in the upper portions of the Touchet cycles strongly resemble those at Paran, as do the frequently massive basal sands. The low variability in sedimentology and structures between individual strata both at Paran and in the Touchet beds, in conjunction with the graded nature of the deposits and their broad lateral extent, suggest that both sets of deposits resulted from a similar cause: catastrophic floods.

The age of the flood deposits at Paran can only be loosely constrained. The major portion of sediment aggradation within the Peshawar Basin began about 3 m.y. ago and continued until about 600,000 yr ago (Burbank, 1982). Although limited lacustrine strata are present near Dag (Fig. 1) within the young portions of these basin-filling sediments, no strata resembling the catastrophic-flood deposits at Paran were located within these sequences. The accelerated uplift that appears to have terminated widespread sedimentation within the Peshawar Basin around 600,000 yr ago may have created the conditions necessary for catastrophic flooding: a basin bounded by a continuous topographic barrier with all drainages constrained to flow through a narrow watergap. The sediments at Paran are normally magnetized. This suggests that they belong to the Brunhes chron and are less than 700,000 yr old.

The angular unconformity within the Paran sequence indicates continuing tectonic activity during the Brunhes. After the initial set of flood deposits were laid down above the bedrock, unlift caused basinward tilting, erosion of the graded beds, and progradation of a coarse, colluvial layer across the truncated surface. A long, uninterrupted series of floods followed and apparently was terminated by a second episode of uplfit, tilting, and colluvial accumulation. The fac that the tilted deposits at Paran lie 100 m above the rivel level at Nowshera suggests that both incision of the modern drainages and differential uplift of the faulted basin margins have occurred after deposition of the graded beds.

SUMMARY AND CONCLUSIONS

At least forty catastrophic floods inundated the Peshawar Basin in prehistoric times. A sequence of graded beds up to 25m thick near Paran records these flood events. Although similar to the well-documented floods in the 1800's within the Peshawar Basin, these floods probably resulted from significantly higher flows, as evidenced by the greater thickness of individual flood deposits (up to 1m). These flood deposits are likely to be less than 600,000 yr old. Unconformities within and above them record Pleistocene tectonic activity resulting from continued southward overthrusting.

This newly described record of older floods, in addition to the well-established floods in the 1800's, have important cultural implications for the Peshawar Basin. The reoccurrence of floods of this magnitude would be very likely to cause the Tarbella dam to fail. Such a failure would intensify the damage caused to the inhabitants of the Peshawar Basin and their property. I suggest that the Indus River and its tributaries be carefully monitored in order to provide adequate forewarning of impending outburst floods.

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