Supplementary information for "Reconstruction of the hydrology of a major storm event from its geomorphic signature: the Ladakh floods, 6 August 2010"

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1. Comparing equations to estimate peak discharges

Many equations exist in the literature to predict channel discharges from measurements of channel geometry, such as cross sectional area, hydraulic radius, bed slope, and grain size. However, none is entirely ideal for the conditions we encounter in this study: steep channels (0.03 < S < 0.25); large grain sizes ($6 < D_{84} < 43$ cm); relatively poor sorting in the channel, including some very large (m-scale) boulders (images of the channel can also be seen in the second section of this document). In the main manuscript, we present discharges calculated from Jarrett's (1987) modification of the Manning discharge equation. However, this additional material presents a summary of the alternatives which could be used with our field data, along with the resulting discharges for the flood event (Table S1). We wish to present

conservative solutions in the main paper, so are primarily interested in the lower bounds on the channel discharges. While the Manning-Jarrett equation is not always the most conservative option, we note that only at two stations out of the 45 measured (i.e., < 4 %) is the lowest calculated discharge below the 95 % confidence interval derived for Manning-Jarrett, based on variability in the collected field data. This justifies our selection of this equation on grounds of conservatism, as well as on grounds of appropriateness of the field conditions.

Our data suggest that regardless of the calculated value, the flood discharges are much greater than the pre-flood bankfull discharges. Unfortunately, none of the existing equations is optimized for floods of such high magnitude (e.g., Wohl, 2000). This may introduce some systematic error into our results. However, inverse correlation between roughness and depth (e.g., Coon, 1994) suggests that our values are probably underestimates, which is encouraging if we wish to interpret our estimated discharges as minima.

We also present the cross-sectional averaged flow velocities, v, derived from these same equations ($v = Q/A_{XS}$), as an additional check on the reasonableness of our calculations of discharge (Table S2). The most conservative solutions indicate typical flow velocities in the lower parts of the catchments of around 4-5 ms⁻¹. These seem not unreasonable values for major floods such steep terrain.

Manning equation, fixed roughness, n = 0.07, n = 0.1

The Manning (or Manning-Strickler) equation describes discharge in a natural channel as

$$Q_M = \frac{R^{0.667} S^{0.5}}{n} A_{XS}$$

(S1)

where *R* is the hydraulic radius, *S* is the channel slope, A_{XS} is the channel cross sectional area, and *n* is a resistance coefficient. Selecting an appropriate value for *n* is the chief difficulty with this equation, since it incorporates not just grain scale roughness on the bed, but also form drag, and also may vary with channel cross section, stage, and density of sediment in the flow. Traditionally, these values have been selected by semi-quantitative comparison of channel characteristics (especially grain size, vegetation, and slope) with known reference cases (e.g., Barnes, 1967). Some authors have advocated calculating *n* as the sum of values representing the isolated effects of factors such as grain size, channel constriction, bank roughness, meandering and vegetation (e.g., Cowan, 1956; Arcement and Schneider, 1989); under these approaches, bed grain size is the largest contributor to *n*. In very coarse bed channels (84th percentile of grain diameter, D_{84} , is boulder fraction), but with relatively low gradients (S < 0.05) the upper bound of *n* is commonly taken as 0.07, discounting form drag (e.g., Benson and Dalrymple, 1967). Similarly, Barnes (1967) reports values of 0.05 < n < 0.075 for boulder bed channels, 0.01 < S < 0.05, though his highest values are associated with grain sizes of around 40 cm. We calculate discharges with a constant value of n = 0.07 as a reference case representing these approaches.

Field observations indicate our flood flows probably have a high sediment concentration. Fortunately, the Manning equation has previously been applied to calculate discharges of debris flows, with results matching discharges well under relatively constant flow rheology (e.g., Pierson, 1986). Our streams may also be reasonable analogues for debris flow conditions since debris flow channels are likely to be steeper and rougher than those to which the Manning equation is usually applied. In the Pierson study, $n \sim 0.1$, and we also present discharge calculations in Table S1 making this assumption. The value of 0.1 can also

be seen as an approximate upper limit for n in this environment under the additive approaches proposed by, e.g., Arcement and Schneider (1989) for fluvial discharge.

Manning equation, Jarrett modification

One of the major difficulties in applying the Manning equation to mountain rivers is that it has only rarely been calibrated for steep, coarse bedded, rough banked streams. An exception is the Jarrett (1987) modification, which was explicitly tested in steeper (0.002 < S < 0.052), coarse ($0.1 < D_{84} < 0.8$ m) mountain streams. While these slopes are still somewhat lower than many of ours, this equation provides the closest match to our conditions of those we investigated. This approach sets

$$n = 0.32S^{0.38}R^{-0.16}$$

in equation (S1). This method implicitly assumes that the roughness of the bed is dependent in some way upon the power of the flow over it.

Darcy-Weisbach equation, Bathurst modification

The Darcy-Weisbach equation is an equivalent restatement of the Manning equation that describes flow resistance as a dimensionless friction factor, *f*:

$$Q_{DW} = \left(\frac{8gRS}{f}\right)^{0.5} A_{XS}$$

(S3)

(S2)

where g is the acceleration due to gravity. Many authors have provided equations to calculate f, though many of them again are calibrated for low slope, gravel bedded rivers. Bathurst (1985) noticed that many of these forms tended to underestimate changes in flow resistance at higher gradients, and provided the equation

$$f = \frac{8}{5.62 \ln\left(\frac{R}{D_{84}}\right) + 4}$$

(S4)

calibrated in the field for slopes up to 0.04 and grain sizes $0.113 < D_{84} < 0.740$ m, which we adopt here as a form from a field-tested study matching reasonably closely the known channel conditions in Ladakh.

Smart & Jaeggi experimental calibration

Aiming to explicitly address transport rates in steep channels, Smart and Jaeggi (1983) calibrated the empirical relation

$$\left(\frac{8}{f}\right)^{0.5} = 5.75 \left[1 - \exp\left(-0.05 \left(\frac{R}{D_{90}}\right) S^{-0.5}\right)\right]^{0.5} \ln\left(8.2 \frac{R}{D_{90}}\right)$$
(S5)

for flume-scale experimental channels with slopes up to 0.2 and high transport rates. This equation was calibrated only for gravel bed channels.

Ferguson scale-dependent roughness and variable power equations

Ferguson (2007) noted that in steep, natural streams experiencing a range of discharges, existing flow equations did not handle well the transition between shallow flows (where the whole flow is perturbed by the bed roughness) and deep flows (where a logarithmic friction law can apply above the bed). He proposed two potential solutions to this problem. He calibrated his equations using an aggregate data set from the literature, selecting studies looking at gravel to boulder bed streams with slopes 0.0007 to 0.21, though this necessitated substituting *R* for *d*, the flow depth. In our analysis we use *d*, since this information is available. Firstly, he proposed fitting different flow laws to the two regimes, describing the transition in terms of the relative roughness, R/D_{84} . This can be expressed as:

 $R/D_{84} < 4$:

$$\left(\frac{8}{f}\right)^{0.5} = 2.5 \left(\frac{R}{D_{84}}\right)$$

(S6a)

 $R/D_{84} \ge 4$:

$$\left(\frac{8}{f}\right)^{0.5} = 6.5 \left(\frac{R}{D_{84}}\right)^{0.167}$$

(S6b)

Secondly, he proposed that the transition could be modeled by variable power equation, asymptotic to roughness layer formulations at low relative flow depths and to the Manning-Strickler approximation of the logarithmic friction law at high relative flow depths. This gives

$$\left(\frac{8}{f}\right)^{0.5} = 17.7 \left(\frac{R}{D_{84}}\right) \left[56.25 + 5.5696 \left(\frac{R}{D_{84}}\right)^{5/3}\right]^{-0.5}$$
(S7)

Rickenmann & Recking scale-dependent roughness

Rickenmann and Recking (2011) followed Ferguson (2007) and used a similar discrimination between to describe small and large floods. They proposed a tripartite division, using the dimensionless unit discharge,

$$q^* = \frac{Q}{w(gSD_{84}^3)^{0.5}}$$

(S8)

to distinguish the appropriate law, assuming this is known.

If $q^* < 1$,

$$\left(\frac{8}{f}\right)^{0.5} = 4.42 \left(\frac{d}{D_{84}}\right)^{1.90}$$

(S9a)

If $1 \le q^* < 100$,

$$\left(\frac{8}{f}\right)^{0.5} = 2.82 \left(\frac{d}{D_{84}}\right)^{0.696}$$

(S9b)

If $q^* \ge 100$,

$$\left(\frac{8}{f}\right)^{0.5} = 6.84 \left(\frac{d}{D_{84}}\right)^{0.152}$$
(S9c)

These equations were also calibrated against a large aggregated data set drawn from the literature,

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including overlap with the Ferguson (2007) data set, covering slopes $4 \ge 10^{-5}$ to 0.197 and grain sizes sand to boulder.

Figure DR1 (continued on next page). Discharges calculated by each of the above methods, displayed against upstream drainage area, for axial channels in Basgo (a), Leh (b) and Sobu (c) valleys. Symbology is: red square (with confidence intervals) – Manning-Jarrett; upward triangle – Manning, n=0.1; downward triangle – Bathurst; circle – Manning, n=0.7; diamond – Smart & Jaeggi; left-pointing triangle – Ferguson bimodal roughness; right-pointing triangle – Ferguson variable power; star – Rickenmann & Recking.



Figure DR1 (continued). Symbology is: red square (with confidence intervals) – Manning-Jarrett; upward triangle – Manning, *n*=0.1; downward triangle – Bathurst; circle – Manning, *n*=0.7; diamond – Smart & Jaeggi; left-pointing triangle – Ferguson bimodal roughness; right-pointing triangle – Ferguson variable power; star – Rickenmann & Recking.



Comparing the equations

Table DR1 presents the calculated discharges for our flood data from each of these equations. We also display the data graphically, as Figure DR1. The Jarrett and Manning n = 0.1, and to a lesser extent Bathurst, equations cluster closely, and provide the most conservative estimates of discharge at a given drainage area. The Manning equation with n=0.07 is provides slightly higher discharges, while the Smart and Jaeggi experimental equation provides discharges almost an order of magnitude larger than the most conservative estimates. The Ferguson (2007) approaches and the Rickenmann and Recking (2011) equation provide solutions in between these low and high limits. The error bars shown are 95 % confidence intervals for the Jarrett approach, based on the variability of the field measurements at each station, propagated through that equation.

The clustering of the n = 0.1, Bathurst and Jarrett discharges is extremely encouraging, as these equations were all derived from real field data describing uniformly steep, coarse natural channels, as we see here. The close agreement between them suggests that the values they provide are robust under the flow conditions of the Ladakh floods.

In the main paper we work exclusively with the Jarrett equation. This choice was guided partly by the relative closeness of the Jarrett field conditions to those in Ladakh, and partly by desire to give a conservative estimate of discharge. We note that only in two sites out of 45 is the most conservative calculated discharge lower than the 95 % confidence bound for the Jarrett approach, and even in these cases not by much. This supports our choice of the Jarrett discharges as adequately conservative, when accompanied by the 95 % confidence intervals.

2. Comparison of channel form before and after 2010 floods

The higher and lower reaches of the studied channels responded very differently to the 2010 floods, as detailed in the main text. Here we present photographic documentation of the channels before and after the 2010 floods in Sobu and Basgo valleys.

Higher reaches

In Sobu and Basgo valleys, the higher reaches of each valley show little geomorphic change.

Figure DR2 (next page). A reach of the main channel in Sobu valley, 9.0 km up valley, in **a.** August 2008, **b.** May 2011. Essentially no change has occurred to the banks of the channel, though some cobble caliber sediment has been mobilized (e.g., arrow). There appears to be slightly less sediment in the channel in 2011 than there was in 2008.

Figure DR3 (page after next). A reach of the main channel in Basgo valley, 7.8 km up valley, in **a.** July 2006, **b.** June 2011. Viewpoint differs slightly between images, arrow tags boulder unchanged between images. In this case, some sediment has accumulated in this reach during the flood, though again there is essentially no change in the channel form.





Middle reaches

These reaches are transitional in Sobu and Basgo. They show some change to the form of the channel in the 2010 floods, but not as dramatically as the lower reaches.

Figure DR4 (next page). A reach of the main channel in Sobu valley, 8.4 km up valley, in **a.** August 2008, **b.** May 2011. The bridge has been completely removed by the flood. Although the channel form appears quite similar after the flood, close inspection of the images reveals minor bank erosion and several tens of cm sediment accumulation in the channel (e.g., arrowed boulder). Some large boulders (meter scale) have been mobile.

Figure DR5 (page after next). A reach of the main channel in Basgo valley, 5.6 km up valley, in **a.** July 2006, **b.** June 2011. Tens of cm of bed lowering are apparent, and numerous boulders have moved in fluvial conditions (e.g., arrow).





Lower reaches

The lower reaches in Basgo and Sobu show much geomorphic change, with >1m of sediment deposition and many meters of channel widening, as detailed in the main text.

Figure DR6 (next page). A reach of the main channel in Sobu valley, 4.4 km up valley, in **a.** August 2008, **b.** May 2011. Note (a) looks up the reach, (b) looks down. The changes to the channel are immediately apparent, including sediment accumulation, bank erosion and channel widening. This reach has some elements suggesting mass flow in the main channel at some stage of the flood, such as a boulder levee and mud draping, though we note that a major debris flow enters the channel from the east at this point.

Figure DR7 (page after next). A reach of the main channel in Basgo valley, 2.4 km down valley from the range front, in **a.** July 2006, **b.** June 2011. Note that the channel was at bankfull when photographed in 2006. Again, the channel shows much accumulation of cobbles and boulders, and intense bank erosion, including the removal of very mature trees.





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			SUPF	PLEMENTARY T	ABLE S1. COMPARI	SON OF FLOOD D	ISCHARGES CA	LCULATED BY	DIFFERENT ME	ETHODS			
Distance	Upstream	Channel cross	Channel	Mean channe	I Q _{M0.07} (2 _{M0.1} (Manning's	Q _{DW} (Darcy-	Q _s (Smart &	Q_{F2R}	Q_{FVP}	Q _{RR}	Q _{MJ} (Manning's	95 % confidence
upstream from range front (km)	drainage area, A (km²)	sectional area, A _{vc} (m ²)	hydraulic radius. <i>R</i>	slope, S	(Manning's equ., n=0.07)	equ., <i>n</i> =0.1) (m ³ /s)	Weisbach, Bathurst)	Jaeggi) (m ³ /s)	(Ferguson, 2 regimes)	(Ferguson, variable	(Rickenmann e & Recking)	equ., Jarrett's <i>n</i>) (m³/s)	interval for Q _M (m ³ /s)
(·····)		1 1 CV	(m)		(m ³ /s)		(m ³ /s)		(m³/s)	power) (m ³ /s)	(m ³ /s)		
Basgo Valley, D ₈₄ =	- 0.196 m, D ₉₀ =	0.246 m											
8.633	47.2	7.2	0.73	0.097	25.9	18.2	21.5	80.0	50.8	44.7	52.2	13.1	6.5 - 19.6
8.274	57.6	11.2	0.86	0.097	45.0	31.5	37.6	149.9	102.6	91.6	104.9	23.3	13.2 – 33.4
7.920	58.0	33.0	1.40	0.109	194.7	136.3	163.9	773.9	474.4	464.1	480.3	104.4	71.5 – 137.3
7.426	59.0	17.5	0.98	0.101	78.2	54.7	65.5	273.1	170.5	159.2	174.0	40.7	22.1 – 59.3
6.921	60.0	24.7	1.27	0.072	111.3	77.9	93.7	451.8	241.2	239.0	245.2	68.6	53.0 - 84.3
6.392	75.9	17.1	1.16	0.076	74.2	51.9	62.4	289.0	190.1	177.3	192.9	44.1	36.0 – 52.3
5.916	76.0	39.9	1.39	0.071	189.7	132.8	159.8	794.7	428.2	426.7	434.4	119.4	69.9 – 168.9
5.264	79.0	121.5	2.76	0.079	961.2	672.8	799.9	4663.6	2182.2	2331.4	2190.7	647.8	481.0 – 814.7
4.912	80.0	148.7	3.18	0.077	1280.4	896.2	1060.2	6336.6	2742.1	2995.7	2750.4	890.2	558.6 – 1221.9
4.349	81.3	9.77	2.24	0.033	347.3	243.1	290.7	1702.1	707.3	765.0	714.1	314.5	271.3 – 357.6
3.273	89.4	151.0	2.62	0.065	1050.5	735.4	875.6	5108.9	2267.4	2445.6	2280.6	754.2	739.6 – 768.8
2.099	92.3	274.4	4.11	0.053	2324.8	1627.3	1904.9	11838.6	5072.8	5571.0	5066.7	1938.3	1328.0 – 2548.6
1.608	95.2	186.2	2.93	0.049	1208.8	846.1	1004.0	6023.1	2637.8	2856.0	2648.1	985.4	452.1 – 1518.6
0.446	100.5	265.3	2.34	0.047	1454.3	1018.0	1216.0	7069.0	2967.0	3219.4	2993.2	1160.3	934.7 – 1385.9
-0.800	105.6	110.6	3.02	0.039	653.8	457.7	542.5	3283.7	1426.0	1546.6	1430.9	583.5	427.1 – 740.0
-2.386	113.9	88.3	2.50	0.055	545.2	381.7	455.1	2656.5	1219.3	1299.3	1226.3	415.4	310.2 – 520.5
-3.102	114.5	57.6	1.63	0.041	230.5	161.3	193.9	1060.5	533.5	540.4	539.6	183.6	87.9 – 279.4
<u>Len valley, <i>U</i>84 = 0</u> 20.171	. <u>169 m, <i>U</i>90 = 0.</u> 11.1	<u>216 m</u> 15.9	1.27	0.091	80.0	56.0	67.4	314.5	189.1	183.2	192.0	45.2	14.0 – 76.3
19.877	11.7	62.4	1.56	0.040	241.0	168.7	202.9	1100.4	533.3	543.4	540.3	191.9	120.1 - 263.6
18.362	17.8	82.0	2.76	0.117	792.9	555.0	659.8	3750.6	1935.8	2031.0	1940.1	459.0	339.9 - 578.2
17,888	19.9	97.8	222	0.226	1134.1	9.552	949.5	4755.9	2520.9	2666.3	2540.2	494.9	351.4 - 638.4
17.210	21.6	100.0	2.08	0.152	911.0	637.7	763.8	3931.9	2176.2	2247.6	2191.5	457.0	310.5 - 603.5
16.575	23.6	55.3	2.09	0.129	465.4	325.8	390.2	2048.8	925.2	1001.1	935.5	248.7	131.0 - 366.5
15.952	25.8	52.7	1.78	0.154	433.6	303.5	364.5	1781.4	1201.2	1175.9	1208.5	211.5	159.1 - 263.9
15.374	26.2	6.77	1.69	0.120	549.1	384.3	461.8	2291.3	1179.3	1223.2	1194.1	291.6	261.6 – 321.6
15.125	26.4	144.2	2.83	0.090	1242.8	870.0	1033.5	6005.3	2437.4	2705.2	2454.0	7.797	648.4 – 946.9
14.368	37.5	77.2	2.11	0.096	564.6	395.2	473.2	2565.6	1303.3	1359.5	1313.2	338.0	230.0 – 446.0
13.649	37.9	95.2	2.24	0.089	698.5	488.9	584.6	3238.4	1371.9	1498.0	1386.0	434.5	351.7 – 517.3
13.048	38.2	18.3	1.25	0.077	84.4	59.0	71.0	337.9	205.9	197.5	208.9	50.7	40.8 – 60.5
12.399	38.6	119.8	2.92	0.053	806.8	564.8	670.2	4008.8	1603.4	1776.8	1613.1	637.5	462.2 – 812.9
11.946	40.2	21.9	0.93	0.059	72.4	50.6	9.09	269.8	218.0	185.5	221.0	45.9	35.5 – 56.4
10.995	54.5	30.0	1.59	0.053	134.9	94.4	113.5	604.5	296.2	303.1	300.0	96.9	82.3 – 111.5
Sobu vallev, <i>D₈₄</i> =	0.091 m, <i>D</i> _m = C	1.117 m											
11.658	23.9	3.4	0.50	0.107	10.0	7.0	8.1	24.8	22.4	16.3	20.5	4.6	1.4 - 7.7
10.822	25.3	5.8	0.42	0.115	15.7	11.0	12.5	34.6	64.5	36.8	65.8	6.8	4.4 – 9.2
10.539	33.6	20.9	1.22	0.086	100.6	70.4	84.7	393.5	198.7	200.0	202.5	57.6	22.7 – 92.6
10.182	33.8	22.8	1.37	0.068	105.1	73.5	88.5	440.1	208.0	213.6	211.7	67.0	51.2 – 82.9
9.968	34.0	32.3	1.48	0.090	179.8	125.9	151.4	746.0	487.4	468.2	492.0	104.5	76.7 – 132.3
9.650	34.2	25.8	0.89	0.084	98.7	69.1	82.6	341.2	343.1	277.8	347.0	54.3	33.4 – 75.3
9.441	34.5	21.1	0.95	0.091	87.9	61.5	73.7	308.4	243.8	212.7	247.6	47.4	28.4 – 66.4
9.128	34.7	147.9	2.94	060.0	1308.7	916.1	1086.8	6361.7	3019.1	3224.5	3026.9	845.2	691.2 – 999.2
8.380	41.6	62.6	1.60	0.073	331.3	231.9	278.8	1441.6	1005.1	949.5	1010.7	211.1	163.5 – 258.8
7.892	49.5	79.2	1.86	0.072	460.9	322.6	387.2	2085.6	1376.1	1329.0	1381.1	301.6	232.9 – 370.3
6.663	56.2	155.6	3.42	0.075	1383.8	968.7	1142.8	6907.9	3060.8	3327.6	3064.6	984.5	805.7 - 1163.2
5.902	57.2	134.8	3.01	0.054	933.9	653.8	774.9	4654.0	2313.6	2430.5	2315.0	738.8	598.1 - 879.4
4.685	65.6	262.8	4.84	0.072	2903.6	2032.5	2360.3	14840.5	6461.6	7093.5	6434.9	2208.3	1982.2 – 2434.4

		SUPPLEI	INEN I ARY I A	BLE 32. LUINIPAR	SUN UF FLUUU V	VALER VELUCITIES	CALCULALED	BY UIFFERENI	INELHUUS			
Distance	Upstream drainage area	Channel cross	Channel	Mean channel	V _{M0.07} (Manning's	V _{M0.1} (Manning's	V _{DW} (Darcy- Maishach	v _s , (Smart & Iaeggi)	V _{E2R} (Farguson 2	V _{EVP} (Eargiison	V _{RR} (Rickenmann	V _M (Manning's
range front (km)	$A (km^2)$	A_{xs} (m ²)	radius, R		(m ³ /s)	(m ³ /s)	Bathurst)	(m ³ /s)	regimes)	variable	& Recking)	(m ³ /s)
Bacao Vallev	-0106 m 0	0 3 16 m	(m)				(m_/s)		(m ⁻ /s)	power) (m ⁻ /s)	(m_/s)	
8.633	47.2	7.2	0.73	0.097	3.6	2.5	3.0	11.1	7.1	6.2	7.3	1.8
8.274	57.6	11.2	0.86	0.097	4.0	2.8	3.4	13.4	9.2	8.2	9.4	2.1
7.920	58.0	33.0	1.40	0.109	5.9	4.1	5.0	23.5	14.4	14.1	14.6	3.2
7.426	59.0	17.5	0.98	0.101	4.5	3.1	3.7	15.6	9.7	9.1	9.9	2.3
6.921	60.0	24.7	1.27	0.072	4.5	3.2	3.8	18.3	9.8	9.7	9.9	2.8
6.392	75.9	17.1	1.16	0.076	4.3	3.0	3.6	16.9	11.1	10.4	11.3	2.6
5.916	76.0	39.9	1.39	0.071	4.8	3.3	4.0	19.9	10.7	10.7	10.9	3.0
5.264	79.0	121.5	2.76	0.079	7.9	5.5	6.6	38.4	18.0	19.2	18.0	5.3
4.912	80.0	148.7	3.18	0.077	8.6	6.0	7.1	42.6	18.4	20.1	18.5	6.0
4.349	81.3	77.9	2.24	0.033	4.5	3.1	3.7	21.8	9.1	9.8	9.2	4.0
3.273	89.4	151.0	2.62	0.065	7.0	4.9	5.8	33.8	15.0	16.2	15.1	5.0
2.099	92.3	274.4	4.11	0.053	8.5	5.9	6.9	43.1	18.5	20.3	18.5	7.1
1.608	95.2	186.2	2.93	0.049	6.5	4.5	5.4	32.3	14.2	15.3	14.2	5.3
0.446	100.5	265.3	2.34	0.047	5.5	3.8	4.6	26.6	11.2	12.1	11.3	4.4
-0.800	105.6	110.6	3.02	0.039	5.9	4.1	4.9	29.7	12.9	14.0	12.9	5.3
-2.386	113.9	88.3	2.50	0.055	6.2	4.3	5.2	30.1	13.8	14.7	13.9	4.7
-3.102	114.5	57.6	1.63	0.041	4.0	2.8	3.4	18.4	9.3	9.4	9.4	3.2
Leh Valley, $D_{84} = 0$	0.169 m, <i>D</i> ₉₀ = 0.1	216 m										
20.171	11.1	15.9	1.27	0.091	5.0	3.5	4.2	19.8	11.9	11.5	12.1	2.8
19.877	11.7	62.4	1.56	0.040	3.9	2.7	3.3	17.6	8.5	8.7	8.7	3.1
18.362	17.8	82.0	2.76	0.117	9.7	6.8	8.0	45.7	23.6	24.8	23.7	5.6
17.888	19.9	97.8	2.22	0.226	11.6	8.1	9.7	48.6	25.8	27.3	26.0	5.1
17.210	21.6	100.0	2.08	0.152	9.1	6.4	7.6	39.3	21.8	22.5	21.9	4.6
16.575	23.6	55.3	2.09	0.129	8.4	5.9	7.1	37.0	16.7	18.1	16.9	4.5
15.952	25.8	52.7	1.78	0.154	8.2	5.8	6.9	33.8	22.8	22.3	22.9	4.0
15.374	26.2	77.9	1.69	0.120	7.0	4.9	5.9	29.4	15.1	15.7	15.3	3.7
15.125	26.4	144.2	2.83	060.0	8.6	6.0	7.2	41.6	16.9	18.8	17.0	5.5
14.368	37.5	77.2	2.11	0.096	7.3	5.1	6.1	33.2	16.9	17.6	17.0	4.4
13.649	37.9	95.2	2.24	0.089	7.3	5.1	6.1	34.0	14.4	15.7	14.6	4.6
13.048	38.2	18.3	1.25	0.077	4.6	3.2	3.9	18.5	11.3	10.8	11.4	2.8
12.399	38.6	119.8	2.92	0.053	6.7	4.7	5.6	33.5	13.4	14.8	13.5	5.3
11.946	40.2	21.9	0.93	0.059	3.3	2.3	2.8	12.3	10.0	8.5	10.1	2.1
10.995	54.5	30.0	1.59	0.053	4.5	3.1	 8.	20.2	9.6	10.1	10.0	3.2
Sobu valley, <i>D</i> ₈₄ =	: 0.091 m, <i>D</i> ₉₀ = C	0.117 m										
11.658	23.9	3.4	0.50	0.107	2.9	2.1	2.4	7.3	6.6	4.8	6.0	1.4
10.822	25.3	5.8	0.42	0.115	2.7	1.9	2.2	6.0	11.1	6.3	11.3	1.2
10.539	33.6	20.9	1.22	0.086	4.8	3.4	4.1	18.8	9.5	9.6	9.7	2.8
10.182	33.8	22.8	1.37	0.068	4.6	3.2	3.9	19.3	9.1	9.4	9.3	2.9
9.968	34.0	32.3	1.48	060.0	5.6	3.9	4.7	23.1	15.1	14.5	15.2	3.2
9.650	34.2	25.8	0.89	0.084	3.8	2.7	3.2	13.2	13.3	10.8	13.4	2.1
9.441	34.5	21.1	0.95	0.091	4.2	2.9	3.5	14.6	11.6	10.1	11.7	2.2
9.128	34.7	147.9	2.94	060.0	8.8	6.2	7.3	43.0	20.4	21.8	20.5	5.7
8.380	41.6	62.6	1.60	0.073	5.3	3.7	4.5	23.0	16.1	15.2	16.1	3.4
7.892	49.5	79.2	1.86	0.072	5.8	4.1	4.9	26.3	17.4	16.8	17.4	3.8
6.663 E 003	56.2	155.6	3.42	0.075	8.9 0 7	6.2	7.3	44.4	19.7	21.4	19.7	6.3 E E
202.C 7.685	7.7C	134.0 262.8	3.U1 4.84	4c0.0 770.0	0.4 11.0	4.V 7 7	۰. م	с.42 Г.А.Г	1/.2 246	18.U	77.1 24.5	0.0 4 8