

Symbol

Rock Mass Classification by The CRIEPI

TL : Talus Deposit (Detrito y coluvio)	Holocene (Holoceno)	Quaternary (Cuaternario)	Geological Boundary (Contacto Geológico)
DF : Debris Flow Deposit (Masamorra) LSD: Land Slide Deposit (Deslizamiento)			
Terrace Deposit (Deposito de Terraza)	Pleistocene		Anticlinal Axis (Eje Anticlinal)
Alternation of Sandstone and Mudstone (Intercaraciones de Arenisca y Limolita)	Miocene (Mioseno)	Tertiary (Terciario)	Sinclinal Axis (Eje Sinclinal)
Mudstone (Limolita)			F-A Fault (Falla)
SS : Sandstone (Arenisca)			F-B Inferred Fault (Falla Inferida)
Conglomerate (Conglomerado)			Dip of bed (Duzamiento de capa)
SS : Sandstone (Arenisca)			Slope failure and Landslide (Derrumbe y Deslizamiento)
SS : Sandstone (Arenisca)	Cretaceous (Cretacico)	Mesozoic (Mesozoico)	Outflow of Groundwater (Efusión de Aguas Subterranas)
Limestone (Caliza)			Debris flow (Masamorra)
Sandstone (Arenisca)	Ordovician (Ordovicico)	Paleozoic (Paleozoico)	P-1 Point of Perforation (Punto de Perforacion)
MS : Mudstone (Limolita)			SCALE (ESCALA) H= 1:100,000 V= 1: 1,000
Shale (Lutita)			
Alternation of Sandstone and Shale (Intercaraciones de Arenisca y Lutita)			
Slate (Pizarra)			

	Description
A	The rock mass is very fresh, and the rock forming minerals and grains undergo neither weathering nor alteration. Joints are extremely tight and their surfaces have no visible sign of weathering. Sound by hammer blow is clear.
B	The rock mass is solid. There is no opening joint and crack (even of 1 mm). But rock forming minerals and grains undergo a little weathering and alteration in partly. Sound by hammer blow is clear.
C _{II}	The rock mass is relatively solid. The rock forming minerals and grains undergo weathering except for quartz. The rock is contaminated by limonite, etc. The cohesion of joints and cracks is slightly decreased and rock blocks are separated by firm hammer blow along joints. Clay materials remain on the separation surface. Sound by hammer blow is a little dim.
C _H	The rock mass is somewhat soft. The rock forming minerals and grains are somewhat softened by weathering, except for quartz. The cohesion of joints and cracks is somewhat decreased and rock blocks are separated by ordinary hammer blow along the joints. Clay materials remain on the separation surface. Sound by hammer blow is somewhat dim.
C _L	The rock mass is soft. The rock forming minerals and grains are softened by weathering. The cohesion of joints and cracks is decreased and rock blocks are separated by soft hammer blow along the joints. Clay material remain on the separation surface. Sound by hammer blow is dim.
D	The rock mass is remarkably soft. The rock forming minerals and grains are softened by weathering. The cohesion of joints and cracks is almost absent. The rock mass collapses by light hammer blow. Clay materials remain on the separation surface. Clay materials remain on the separation surface. Sound by hammer blow is remarkably dim.

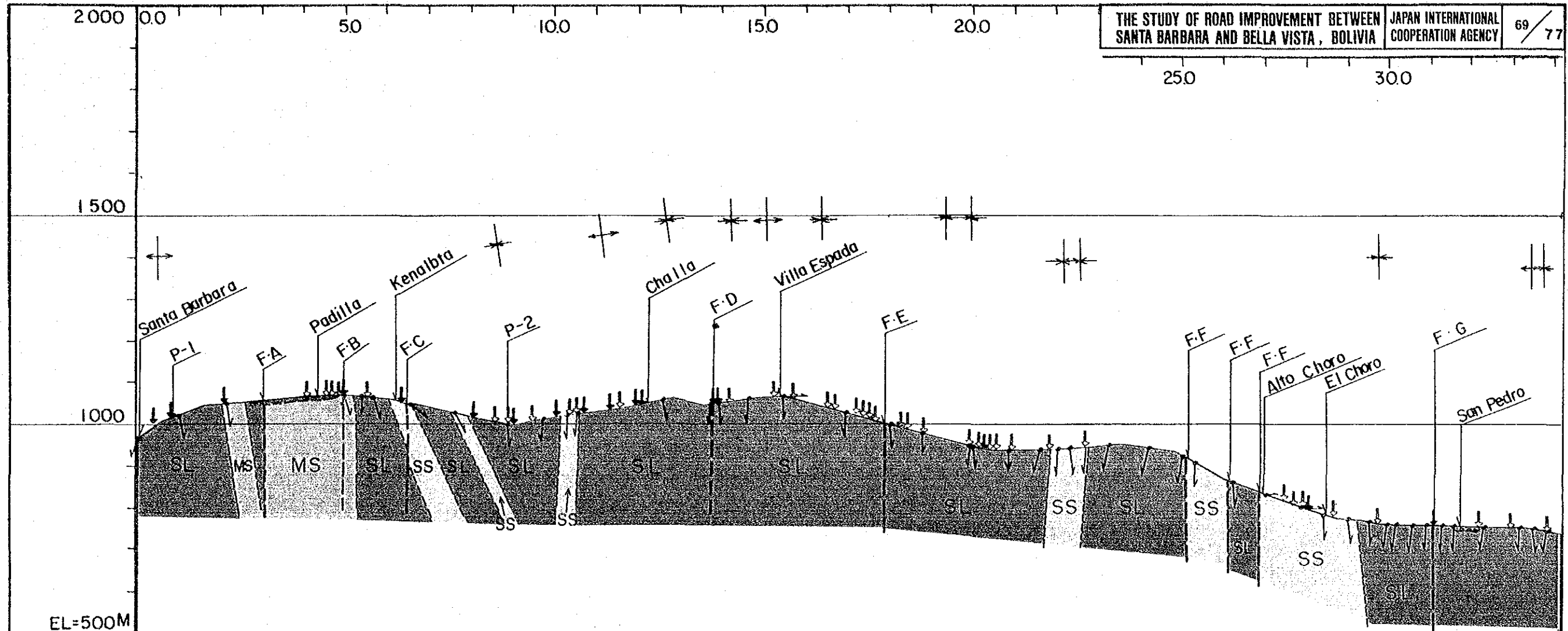
Symbol

Rock Mass Classification by The CRIEPI

	TL : Talus Deposit (Detrito y coluvio) DF : Debris Flow Deposit (Masamorra) LSD: Land Slide Deposit (Deslizamiento)	Holocene (Holoceno)	Quaternary (Cuaternario)		Geological Boundary (Contacto Geológico)
	Terrace Deposit (Deposito de Terraza)	Pleistocene			Anticlinal Axis (Eje Anticlinal)
	Alt : Alternation of Sandstone and Mudstone (Intercaraciones de Arenisca y Limolita)	Miocene (Mioseno)	Tertiary (Terciario)		Sinclinal Axis (Eje Sinclinal)
	MS : Mudstone (Limolita)				F-A Fault (Falla)
	SS : Sandstone (Arenisca)				F-B Inferred Fault (Falla Inferida)
	CNG : Conglomerate (Conglomerado)				Dip of bed (Buzamiento de capa)
	SS : Sandstone (Arenisca)	Cretaceous (Cretacico)	Mesozoic (Mesozoico)		Slope failure and Landslide (Derruabe y Deslizamiento)
	Limestone (Caliza)				Outflow of Groundwater (Efusión de Aguas Subterranas)
	SS : Sandstone (Arenisca)	Ordovician (Ordovico)	Paleozoic (Paleozoico)		Debris flow (Masamorra)
	MS : Mudstone (Limolita)				P-1 Point of Perforation (Punto de Perforacion)
	SH : Shale (Lutita)			SCALE (ESCALA) H= 1:100,000 V= 1: 1,000	
	Alt : Alternation of Sandstone and Shale (Intercaraciones de Arenisca y lutita)				
	SL : Slate (Pizarra)				

	Description
A	The rock mass is very fresh, and the rock forming minerals and grains undergo neither weathering nor alteration. Joints are extremely tight and their surfaces have no visible sign of weathering. Sound by hammer blow is clear.
B	The rock mass is solid. There is no opening joint and crack (even of 1 mm). But rock forming minerals and grains undergo a little weathering and alteration in partly. Sound by hammer blow is clear.
C _H	The rock mass is relatively solid. The rock forming minerals and grains undergo weathering except for quartz. The rock is contaminated by limonite, etc. The cohesion of joints and cracks is slightly decreased and rock blocks are separated by firm hammer blow along joints. Clay materials remain on the separation surface. Sound by hammer blow is a little dim.
C _N	The rock mass is somewhat soft. The rock forming minerals and grains are somewhat softened by weathering, except for quartz. The cohesion of joints and cracks is somewhat decreased and rock blocks are separated by ordinary hammer blow along the joints. Clay materials remain on the separation surface. Sound by hammer blow is somewhat dim.
C _L	The rock mass is soft. The rock forming minerals and grains are softened by weathering. The cohesion of joints and cracks is decreased and rock blocks are separated by soft hammer blow along the joints. Clay material remain on the separation surface. Sound by hammer blow is dim.
D	The rock mass is remarkably soft. The rock forming minerals and grains are softened by weathering. The cohesion of joints and cracks is almost absent. The rock mass collapses by light hammer blow. Clay materials remain on the separation surface. Sound by hammer blow is remarkably dim.

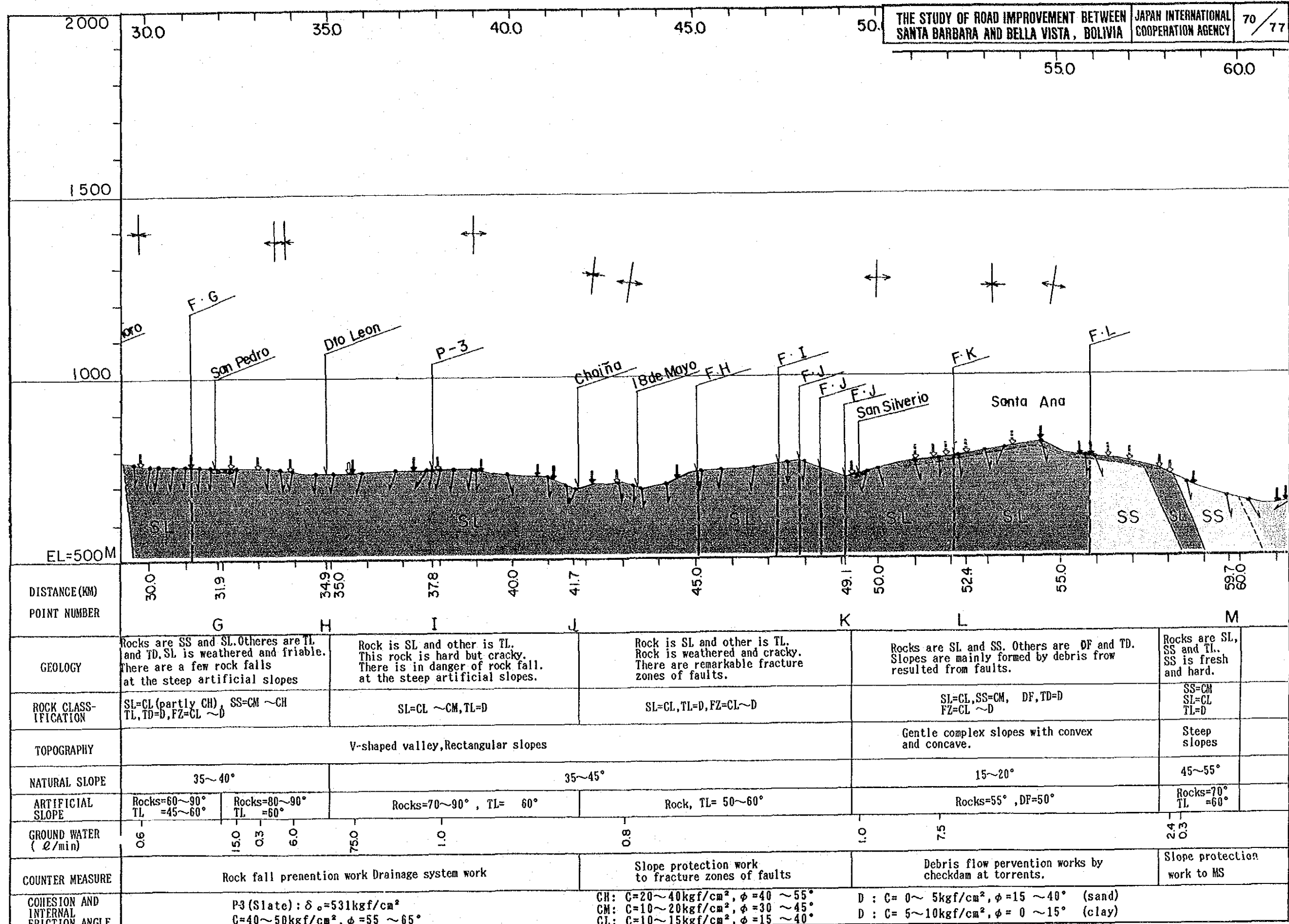
Geological Profile (1)



DISTANCE (KM)	POINT NUMBER	A	B	C	D	E	F	G									
		0.0	2.7	5.0	7.3	10.0	11.6	15.0	15.5	20.0	22.1	25.0	27.0	30.0	31.9		
GEOLOGY		Rocks are SL, MS, SS and TL. They are relatively hard but contain many cracks. There are many slope failures and outflows of ground water.			Rock is SL and other is TL. Rock is hard but cracky. Many rock falls near the fault.		Rock is SL and other is TL. Rock is weathered and friable. There are a few slope failures. and many out flows of ground water.		Rocks are SL, SS, alternation of them and TL. They are good base rocks except fault zone.		Rocks are SS and SL. Others are TL and TD. SL is weathered and friable. There are a few rock falls at the steep artificial slopes.						
ROCK CLASSIFICATION		SL, MS=CL~CM, (partly CH), SS=CM~CH TL=D, FZ=CL~D			SL=CL~CM TL=D, FZ=CL~D		SL=CL (partly CM) TL=D, FZ=CL~D		SL=CL, SS=CM TL=D, FZ=CL~D		SL=CL (partly CH), SS=CM~CH TL, TD=D, FZ=CL~D						
TOPOGRAPHY		Generally gentle and convex slopes, Lack of vegetation.		Generally gentle and convex slopes,		V-shaped valley Rectangular slopes		V-shaped valley, Rectangular slopes Distribution of TL is wide but its thickness is thin.		V-shaped valley, Rectangular slopes							
NATURAL SLOPE		25~40°		30~45°		35~50°		35~45°		35~40°							
ARTIFICIAL SLOPE		Rocks=60° TL=60°	Rocks=60° TL=50°	Rocks=60~80° TL=45~60°		Rock=70~90° TL=60°		Rocks, TL=60°		Rocks=60~90° TL=45~60°		Rocks=80~90° TL=60°					
GROUND WATER (l/min)			1.2 4.95 9.00 9.23 0.5	6.00 3.0 1.50	13.8	1.8	13.8	2.0	0.5 1.2 6.6 1.4 5.4 4.0 2.0	1.70 6.00 1.50 2.00	1.0	0.3	2.0	2.25	9.0	0.6	1.50
COUNTER MEASURE		slope protection work		slope protection work Drainage system works		Rock fall prevention works		Drainage system works		Slope protection work to fracture zone of fault		Rock fall prevention work Drainage system work					
COHESION AND INTERNAL FRICTION ANGLE		P1 (Talus Deposit): C=0~5kgf/cm ² φ=43°		P2 (Slate): δ _u =251kgf/cm ² C=10~20kgf/cm ² , φ=30~45°		CH: C=20~40kgf/cm ² , φ=40~55° CM: C=10~20kgf/cm ² , φ=30~45° CL: C=10~15kgf/cm ² , φ=15~40°		D: C=0~5kgf/cm ² , φ=15~40° (sand) D: C=5~10kgf/cm ² , φ=0~15° (clay)									

Note: δ_u=Unconfined compression(kgf/cm²) C=Cohesion(kgf/cm²) φ=Internal Friction Angle(°)

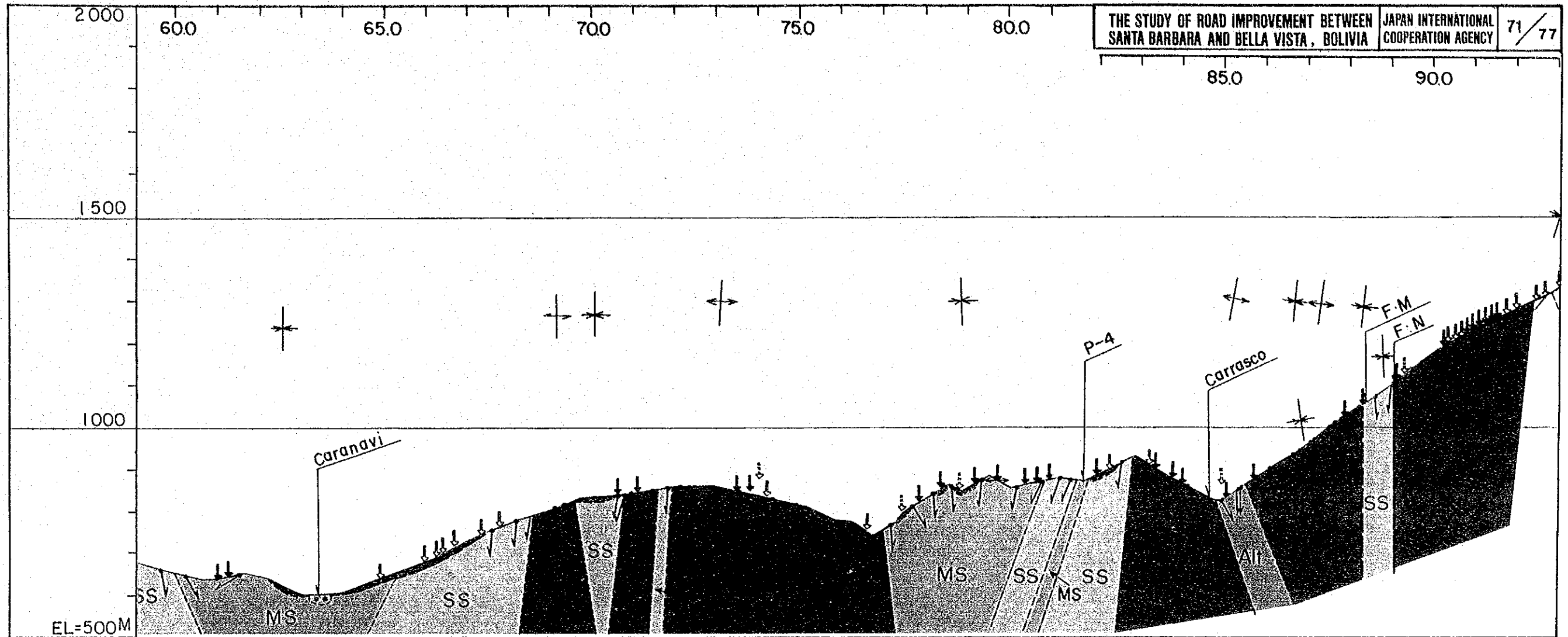
Geological Profile (2)



Note: δ_o = Unconfined compression (kgf/cm²) C = Cohesion (kgf/cm²) ϕ = Internal Friction Angle (°)

Geological Profile (3)

THE STUDY OF ROAD IMPROVEMENT BETWEEN SANTA BARBARA AND BELLA VISTA, BOLIVIA
JAPAN INTERNATIONAL COOPERATION AGENCY 71/77

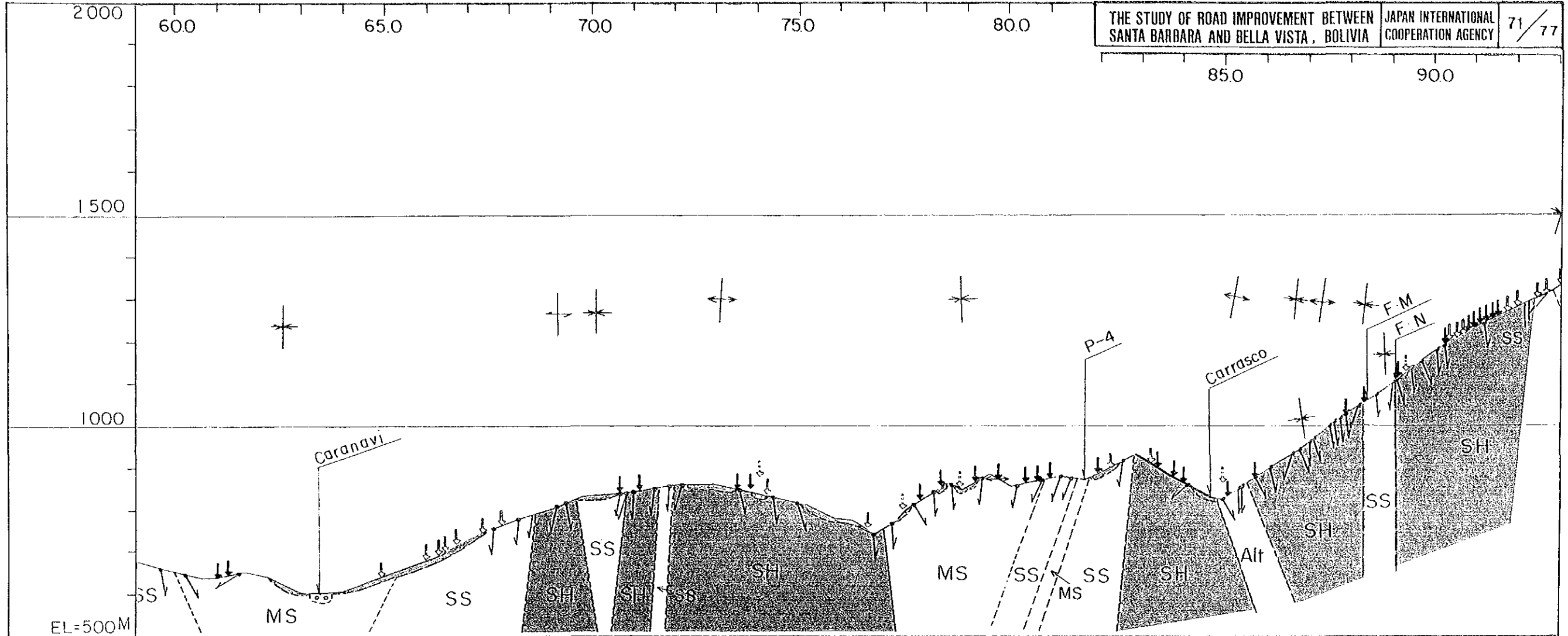


DISTANCE (KM)	59.7	60.0	63.9	65.0	69.2	70.0	75.0	76.8	80.0	80.1	85.0	85.1	87.7	90.0
POINT NUMBER	M		CARA NAVI											
GEOLOGY	Rock is MS and others are TD and TL. MS is very weathered and clayish.		Rocks are SS, MS and SH. Other is TL. MS and SH are friable. Distribution of TL is wide.		Rocks are SH, MS and SS. Others are DF and TL. MS and SH are very weathered and friable. The debris flow are 200 to 300 meter wide.			Rocks are SH, SS and MS. Other is TL. SH and MS are very weathered.		Rocks are SH and alternating bed of SS and SH. Other is DF.		Rocks are SH and SS. Others are TL and DF. There are many slope failures and outflows of ground water.		
ROCK CLASSIFICATION	MS=CL, TL=D		SS=CH ~CM, TL=D MS, CH=CL		SH=CL ~CM, SS=CM~CH DF, TL=D			MS=CL DF, TL=D		SS=CL ~CM, TL=D MS, SH=CL		SS=CM SH=CL DF=D		
TOPOGRAPHY	Gentle colluvial Slopes and terrace surface		Gentle colluvial slopes		Gentle colluvial slopes, Complex slopes with convex and concave.			Complex slopes with convex and concave		Gentle colluvial slopes		Steep colluvial slopes		
NATURAL SLOPE	0~20°		20~35°		25~30°			35~45°		15~35°		30~60°		
ARTIFICIAL SLOPE	Rock, TL=30°		Rocks, TL=60°		Rocks=50° DF, TL=40~45°			Rocks=60~90° TL=60°		Rocks=60°, TL=40°		Rocks, TL=60°		
GROUND WATER (l/min)			1.5 0.2 2.0 3.0 0.2		2.3 0.2			0.2 1.0		0.2 0.2		0.2 0.2		
COUNTER MEASURE	Slope protection work to MS		Drainade system work		Debris flow prevention work to torrents, slope protection work			Slope protection work, Drainade system work.		Slope protection work, Drainade system work.		Slope protection work, Drainage system work, Debris flow prevention work.		
COHESION AND INTERNAL FRICTION ANGLE	CH: C=20~40kgf/cm ² , φ=40~55° CM: C=10~20kgf/cm ² , φ=30~45° CL: C=10~15kgf/cm ² , φ=15~40°		D: C= 0~ 5kgf/cm ² , φ=15~40° (sand) D: C= 5~10kgf/cm ² , φ= 0~15° (clay)					P4 (Mudstone): C=10~20kgf/cm ² φ=20~30°						

Note: δ_u = Unconfined compression (kgf/cm²) C = Cohesion (kgf/cm²) φ = Internal Friction Angle (°)

Geological Profile (3)

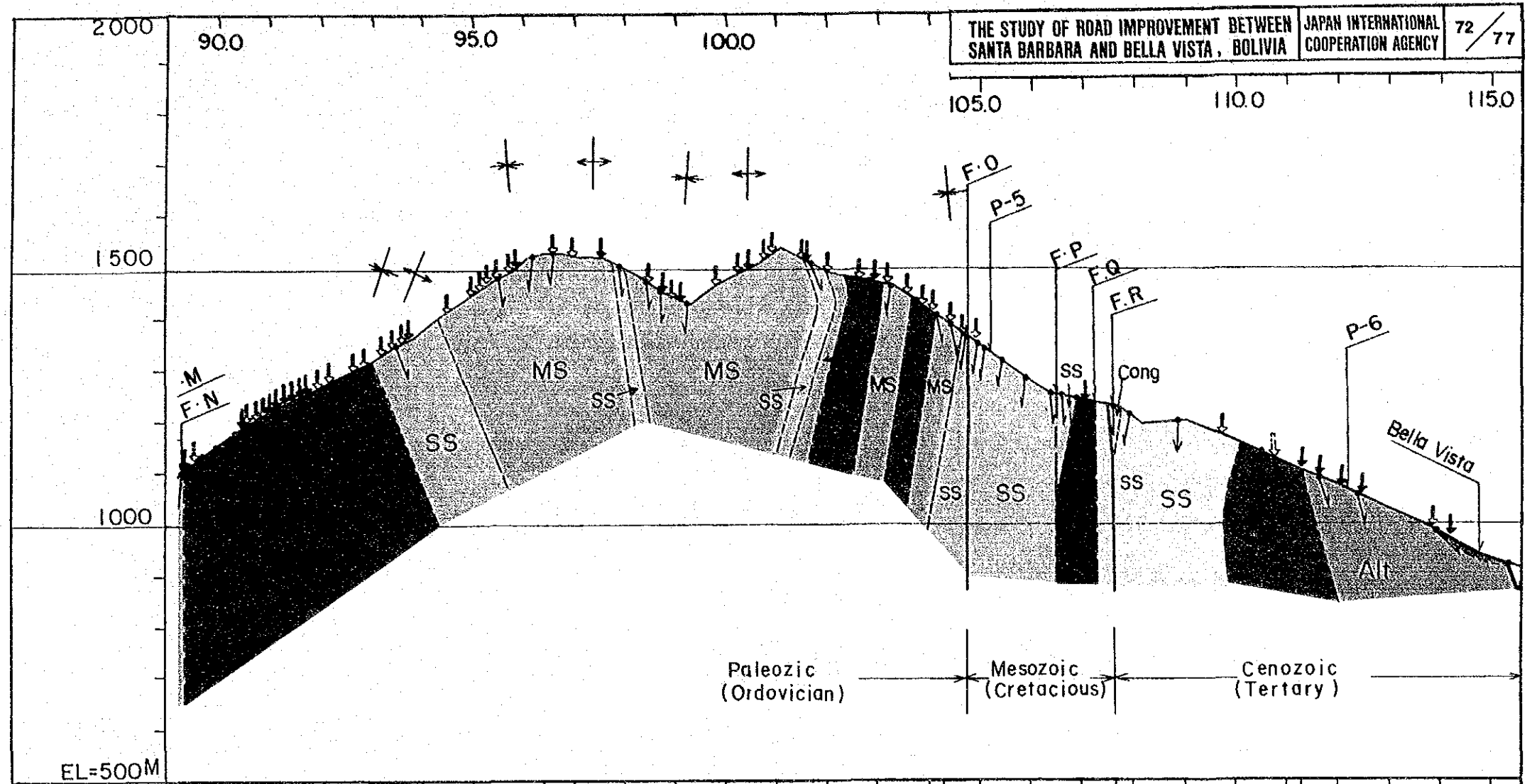
THE STUDY OF ROAD IMPROVEMENT BETWEEN SANTA BARBARA AND BELLA VISTA, BOLIVIA
 JAPAN INTERNATIONAL COOPERATION AGENCY 71/77



DISTANCE (KM)	597	650	692	700	750	768	800	801	850	851	878	900
POINT NUMBER	M	CARA NAVI 639		N		O		P		Q		R
GEOLOGY	Rock is MS and others are TD and TL. MS is very weathered and clayish.	Rocks are SS, MS and SH. Other is TL. MS and SH are friable. Distribution of TL is wide.		Rocks are SH, MS and SS. Others are DF and TL. MS and SH are very weathered and friable. The debris flow are 200 to 300 meter wide.		Rocks are SH, SS and MS. Other is TL. SH and MS are very weathered.		Rocks are SH and alternating bed of SS and SH. Other is DF.		Rocks are SH and SS. Others are TL and DF. There are many slope failures and outflows of ground water.		
ROCK CLASSIFICATION	MS=CL, TL=D	SS=CH ~CM, TL=D MS, CH=CL		SH=CL ~CM, SS=CM~CH DF, TL=D		MS=CL DF, TL=D		SS=CL ~CM, TL=D MS, SH=CL		SS=CM SH=CL DF=D		SS=CM, SH=CL, TL, DF=D, FZ=CL. ~D
TOPOGRAPHY	Gentle colluvial Slopes and terrace surface	Gentle colluvial slopes		Gentle colluvial slopes, Complex slopes with convex and concave.		Complex slopes with convex and concave		Gentle colluvial slopes		Steep colluvial slopes		There are complex slopes with convex and concave. Many small valleys are existent.
NATURAL SLOPE	0~20°	20~35°		25~30°		35~45°		15~35°		30~60°		35~45°
ARTIFICIAL SLOPE	Rock, TL=30°	Rocks, TL=60°		Rocks=50° DF, TL=40~45°		Rocks=60~90° TL=60°		Rocks=60°, TL=40°		Rocks, TL=60°		Rocks, TL=60°
GROUND WATER (l/min)		1.5 0.2 2.4 3.0 0.2		7.3 0.2		0.2 0.2		0.2 0.2		0.2 0.2		0.2 0.2
COUNTER MEASURE	Slope protection work to MS	Drainade system work		Debris flow prevention work to torrents, slope protection work		Slope protection work, Drainade system work.		Slope protection work, Drainade system work.		Slope protection work, Drainage system work, Debris flow prevention work.		
COHESION AND INTERNAL FRICTION ANGLE	CH: C=20~40kgf/cm ² , φ=40~55° CM: C=10~20kgf/cm ² , φ=30~45° CL: C=10~15kgf/cm ² , φ=15~40°			D: C=0~5kgf/cm ² , φ=15~40° (sand) D: C=5~10kgf/cm ² , φ=0~15° (clay)				P4 (Mudstone): C=10~20kgf/cm ² φ=20~30°				

Note: δ_c=Unconfined compression (kgf/cm²) C=Cohesion(kgf/cm²) φ=Internal Friction Angle(°)

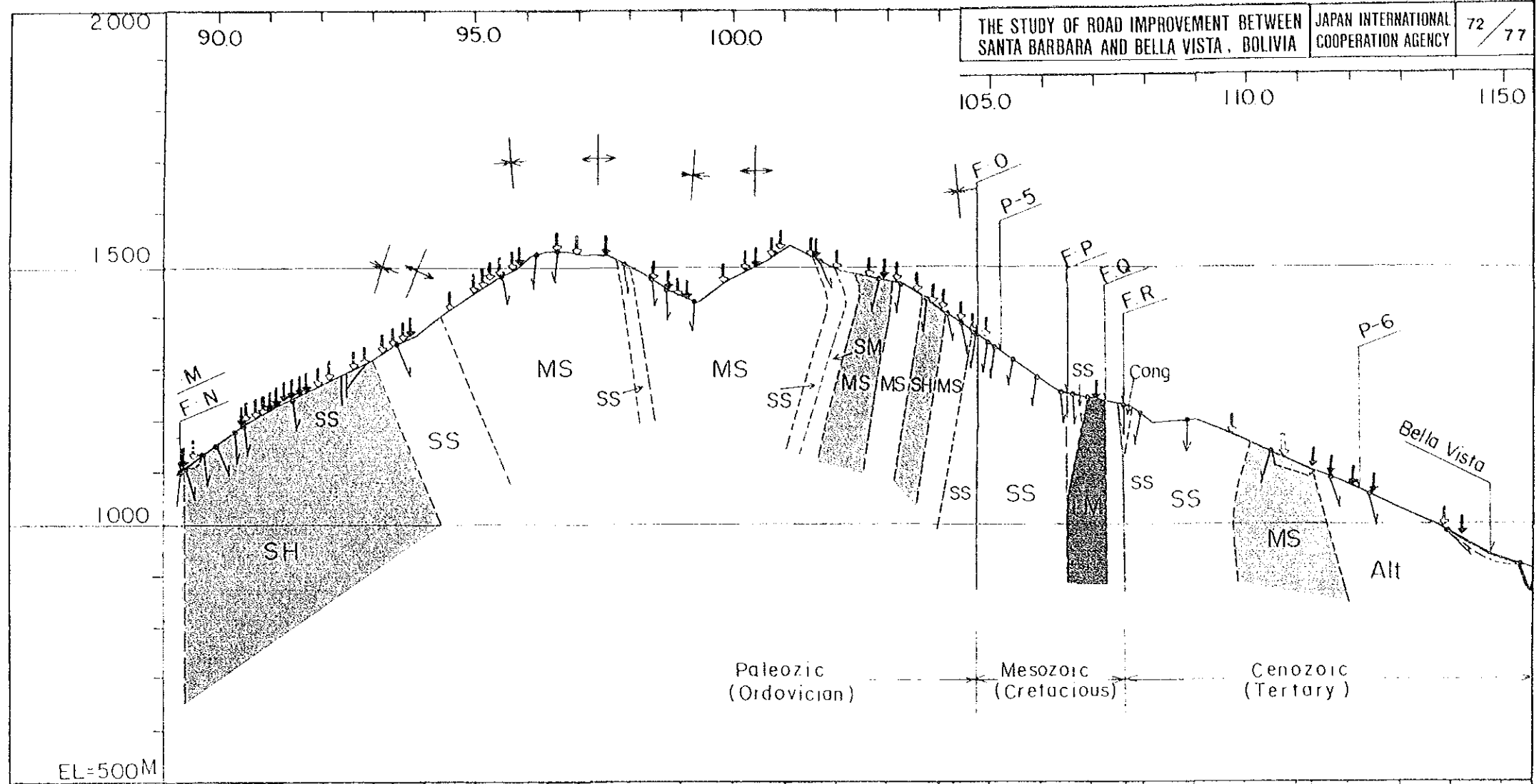
Geological Profile (4)



DISTANCE (KM)	900	934	950	964	1000	1043	1050	1077	1100	1113	1150	1155													
POINT NUMBER		S		T		U		V		W															
GEOLOGY	Rocks are SH and SS. Others are TL and DF. There are many slope failures and outflows of ground water.		Rocks are MS, SH and SS. Other is TL. MS and SH are weathered and friable. There are many surface failures of slopes and outflows of groundwater.				Rocks are SS and LM. Other is TL. Rock mass is good except fault zone.		Rocks are MS, SS, CNG and alternation of them. Others are DF and LSD. MS is very weathered and clayish.																
ROCK CLASSIFICATION	SS=CM, SH=CL, TL, DF=D, FZ=CL ~D		SS=CM, MS, SH=CL, TL=D				SS, LM=CM~CH, TL=D		SS=CM ~CH, MS=CL~D, CNG, DF, LSD=D																
TOPOGRAPHY	There are complex slopes with convex and concave. Many small valleies are existent.						Gentle slopes by landslide, complex slopes with convex and concave.																		
NATURAL SLOPE	35~45°		35~60°				30~50°		10~15°																
ARTIFICIAL SLOPE	Rocks, TL=60°		Rocks 60~90°, TL=60°				Rocks=80°, TL=60°		Rocks=45°, DF, LSD=30~45°																
GROUND WATER (l/min)	227	304	191	10	60	75	20	02	02	02	72	94	06	54	90	30	10	60	10	08	00	00	05	0	75
COUNTER MEASURE	Slope protection work, Drainage system work, Debris flow prevention work.		Slope protection work, Drainade system work.				Slope protection work to Fault.		Landslide prevention work, Debris flow prevntion work																
COHESION AND INTERNAL FRICTION ANGLE	CH: C=20~40kgf/cm ² , φ=40~55° CM: C=10~20kgf/cm ² , φ=30~45° CL: C=10~15kgf/cm ² , φ=15~40°		D: C=0~5kgf/cm ² , φ=15~40°(sand) D: C=5~10kgf/cm ² , φ=0~15°(clay)				P5 (Sandstone): δ _o =637kgf/cm ² C=20~40kgf/cm ² , φ=40~55°		P6 (Weathered Mudstone): C=5.3kgf/cm ² φ=0~15°																

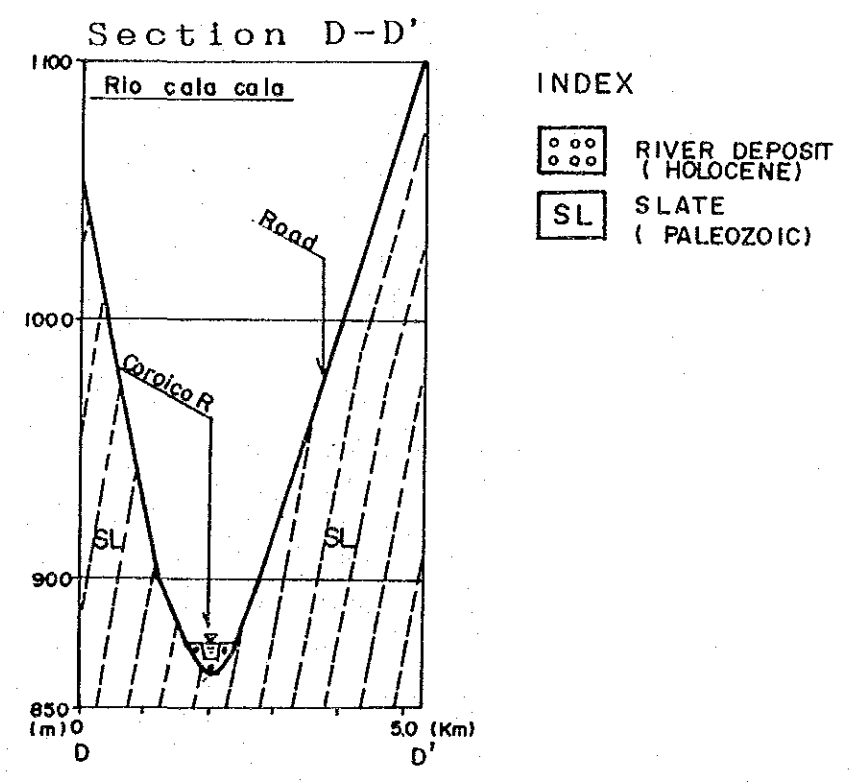
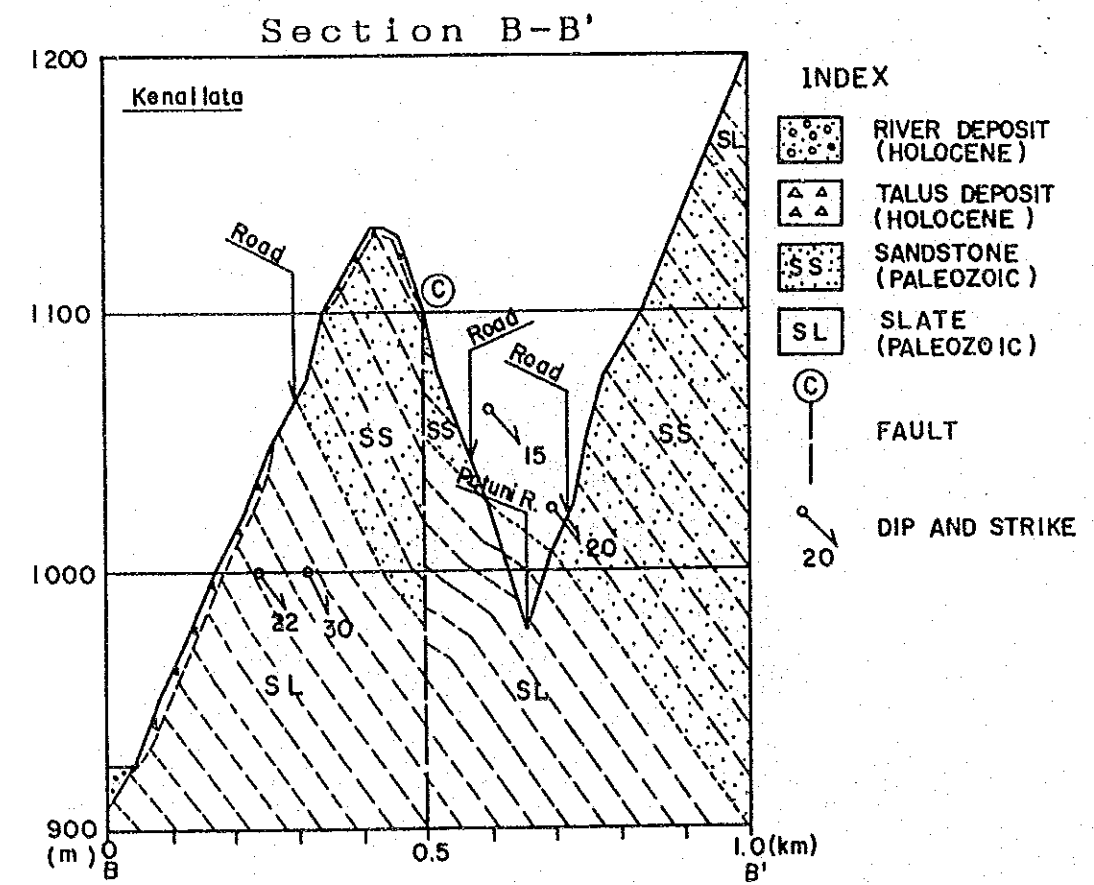
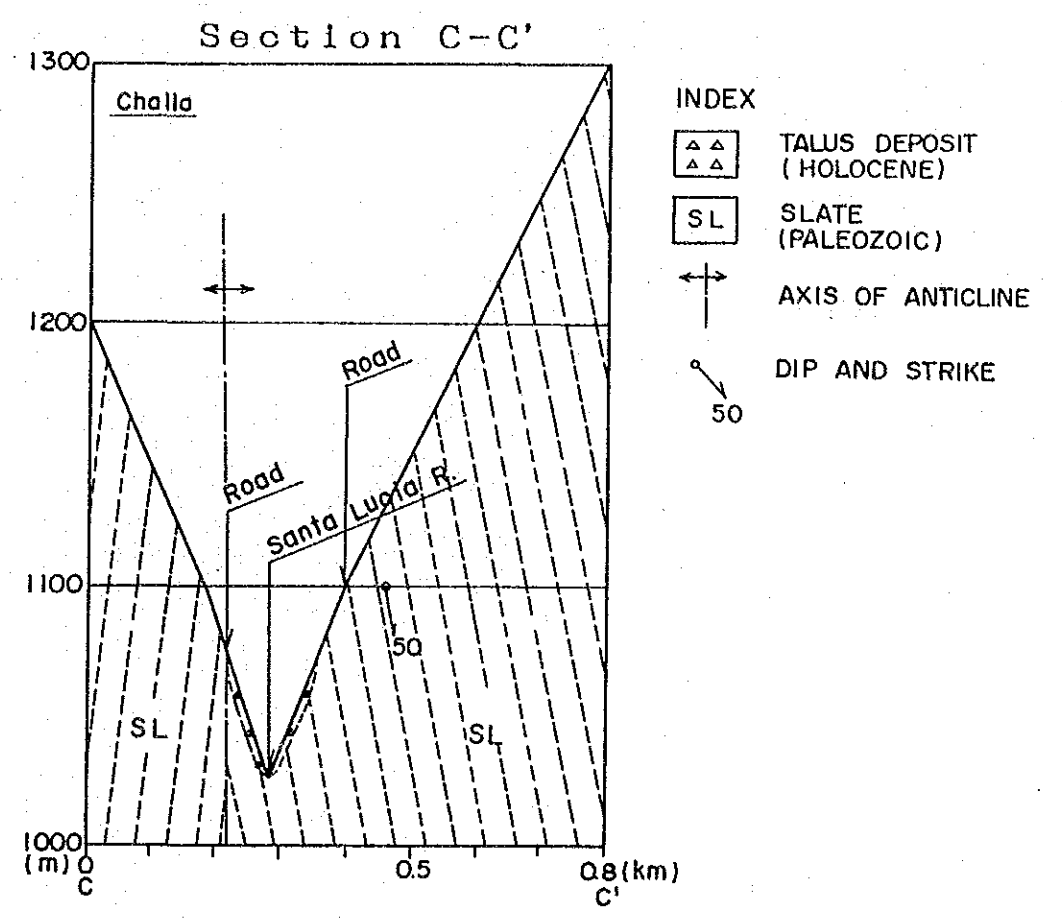
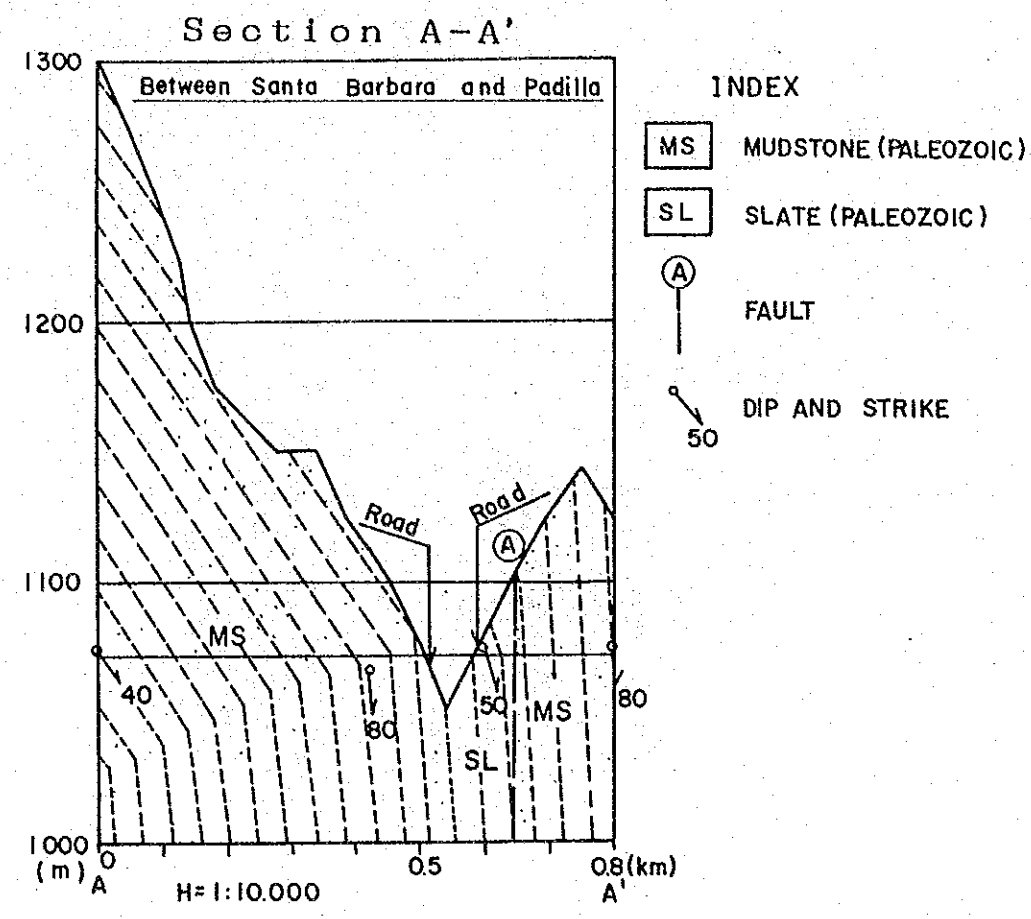
Note: δ_o=Unconfined compression(kgf/cm²) C=Cohesion(kgf/cm²) φ=Internal Friction Angle(°)

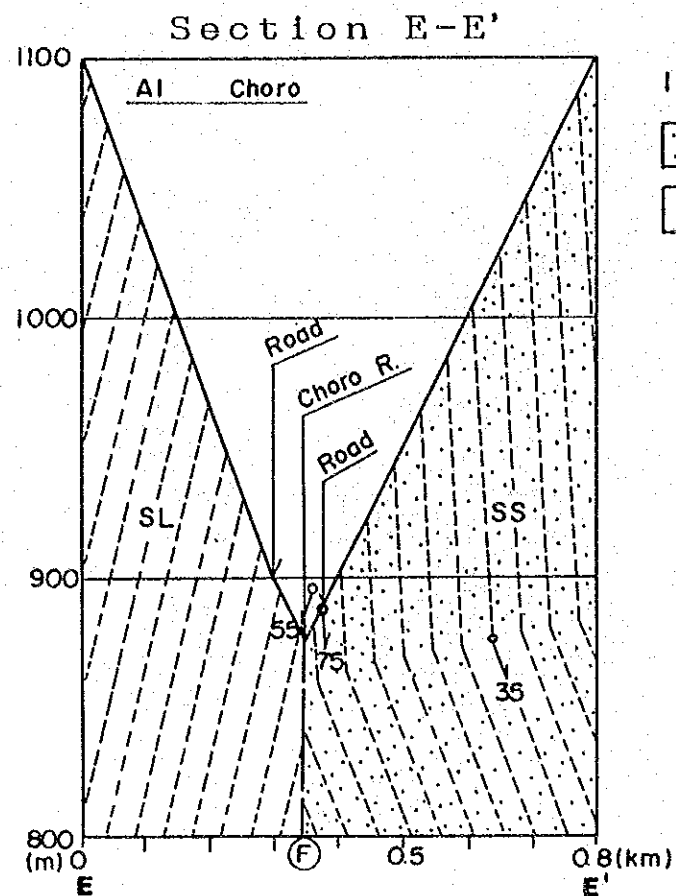
Geological Profile (4)



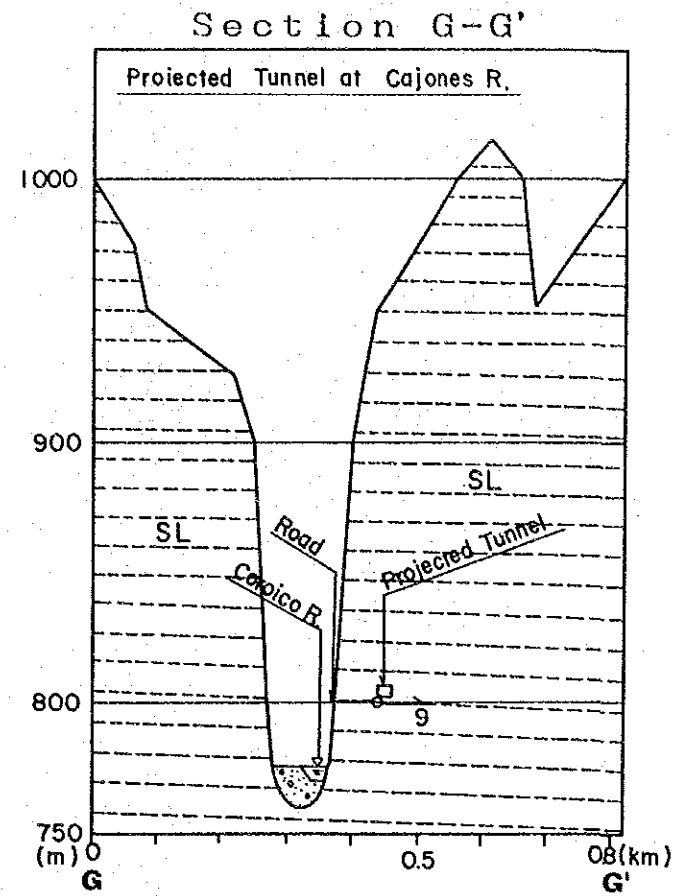
DISTANCE (KM)	900	934	950	964	1000	1043	1050	1077	1100	1115	1150	1155
POINT NUMBER		S		T		U		V		W		
GEOLOGY	Rocks are SH and SS. Others are TL and DF. There are many slope failures and outflows of ground water.		Rocks are MS, SH and SS. Other is TL. MS and SH are weathered and friable. There are many surface failures of slopes and outflows of groundwater.				Rocks are SS and LM. Other is TL. Rock mass is good except fault zone.		Rocks are MS, SS, CONG and alternation of them. Others are DF and LSD. MS is very weathered and clayish.			
ROCK CLASSIFICATION	SS=CM, SH=CL, TL, DF=D, FZ=CL ~D		SS=CM, MS, SH=CL, TL=D				SS, LM=CM~CH, TL=D		SS=CM ~CH, MS=CL ~D, CONG, DF, LSD=D			
TOPOGRAPHY	There are complex slopes with convex and concave. Many small valleys are existent.											
NATURAL SLOPE	35~45°		35~60°				30~50°		10~15°			
ARTIFICIAL SLOPE	Rocks, H=60°		Rocks 60~90°, TL=60°				Rocks=80°, TL=60°		Rocks=45°, DF, LSD=30~45°			
GROUND WATER (C/min)	2.2~2.4 0.0~0.0		0.5~0.7 0.2~0.2				0.2~0.4 0.0~0.0		0.6~0.7 0.0~0.0			
COUNTER MEASURE	Slope protection work, Drainage system work, Debris flow prevention work.		Slope protection work, Drainage system work.				Slope protection work to fault.		Landslide prevention work, Debris flow prevention work			
COHESION AND INTERNAL FRICTION ANGLE	CH: C=20~40kgf/cm ² , φ=40~55° CM: C=10~20kgf/cm ² , φ=30~45° CL: C=10~15kgf/cm ² , φ=15~40°		D: C=0~5kgf/cm ² , φ=15~40°(sand) D: C=5~10kgf/cm ² , φ=0~15°(clay)				P5 (Sandstone): δ _c =637kgf/cm ² C=20~40kgf/cm ² , φ=40~55°		P6 (Weathered Mudstone): C=5.3kgf/cm ² φ=0~15°			

Note: δ_c=Unconfined compression(kgf/cm²) C=Cohesion(kgf/cm²) φ=Internal Friction Angle(°)

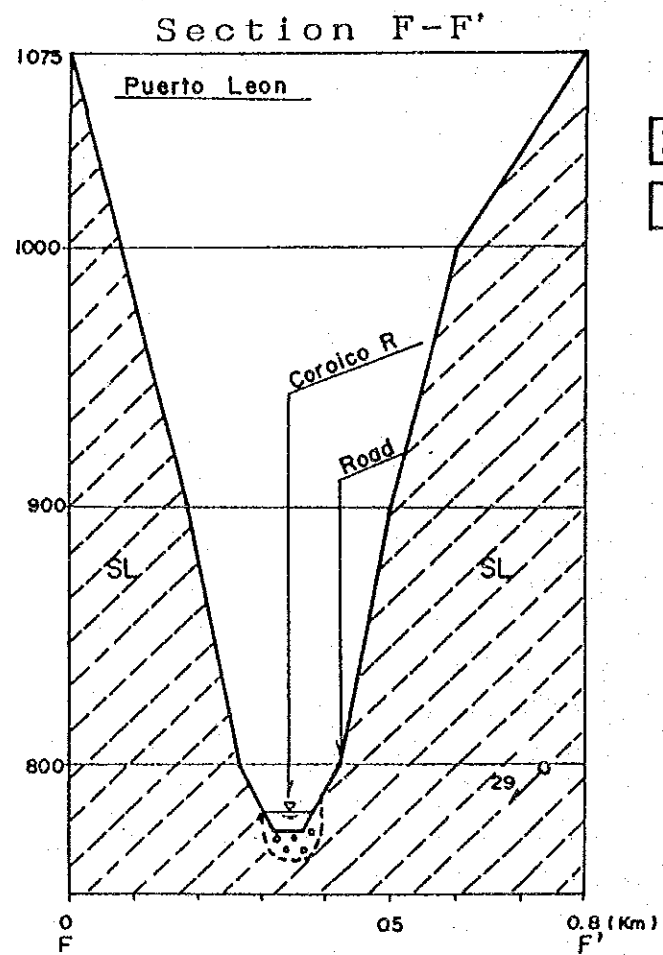




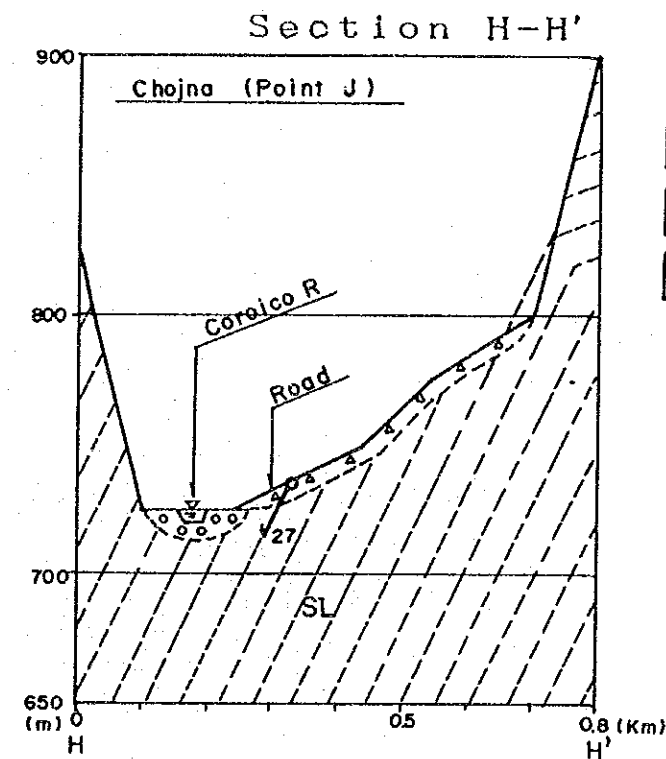
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 - (F) FAULT
 - 75 DIP AND STRIKE



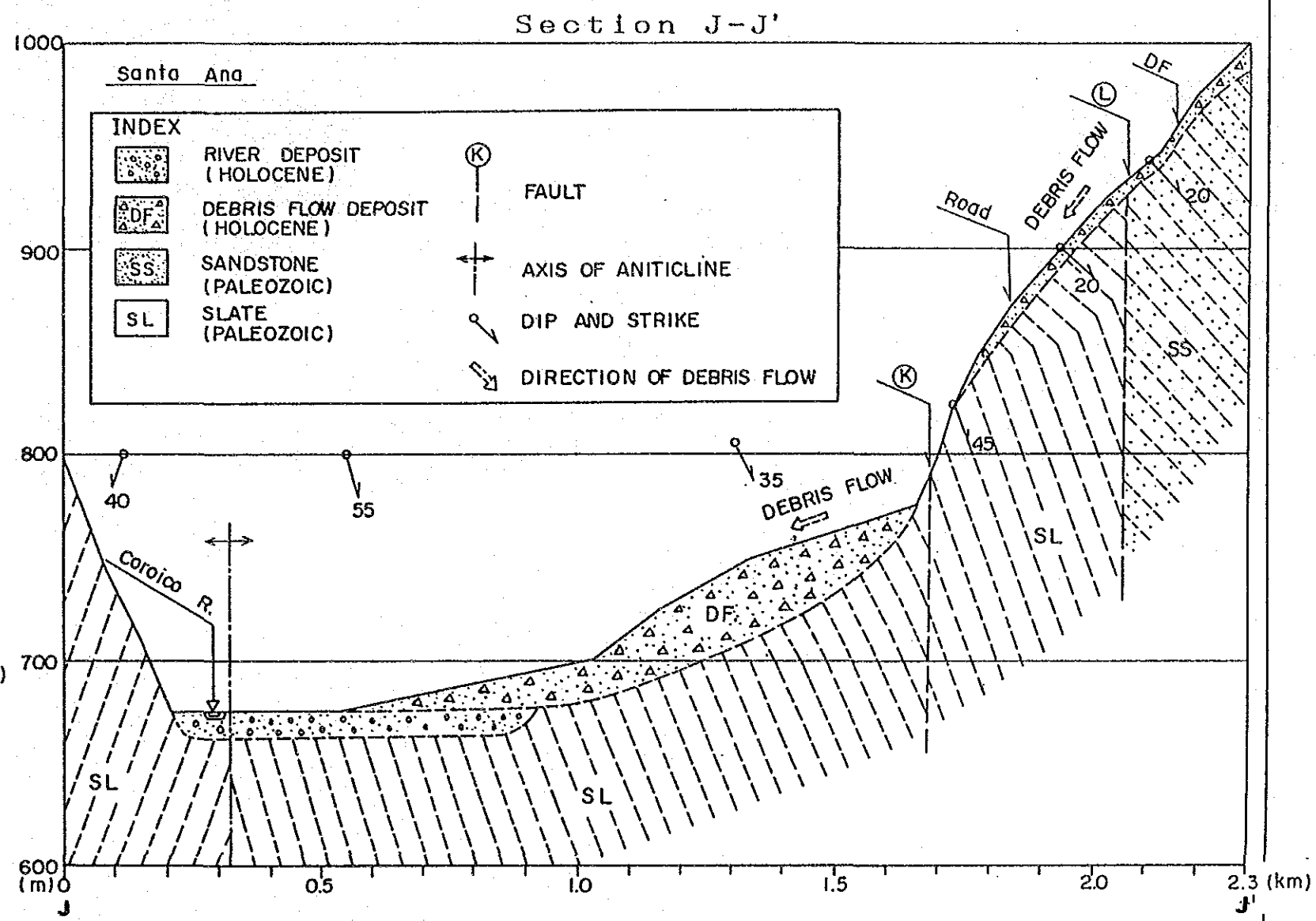
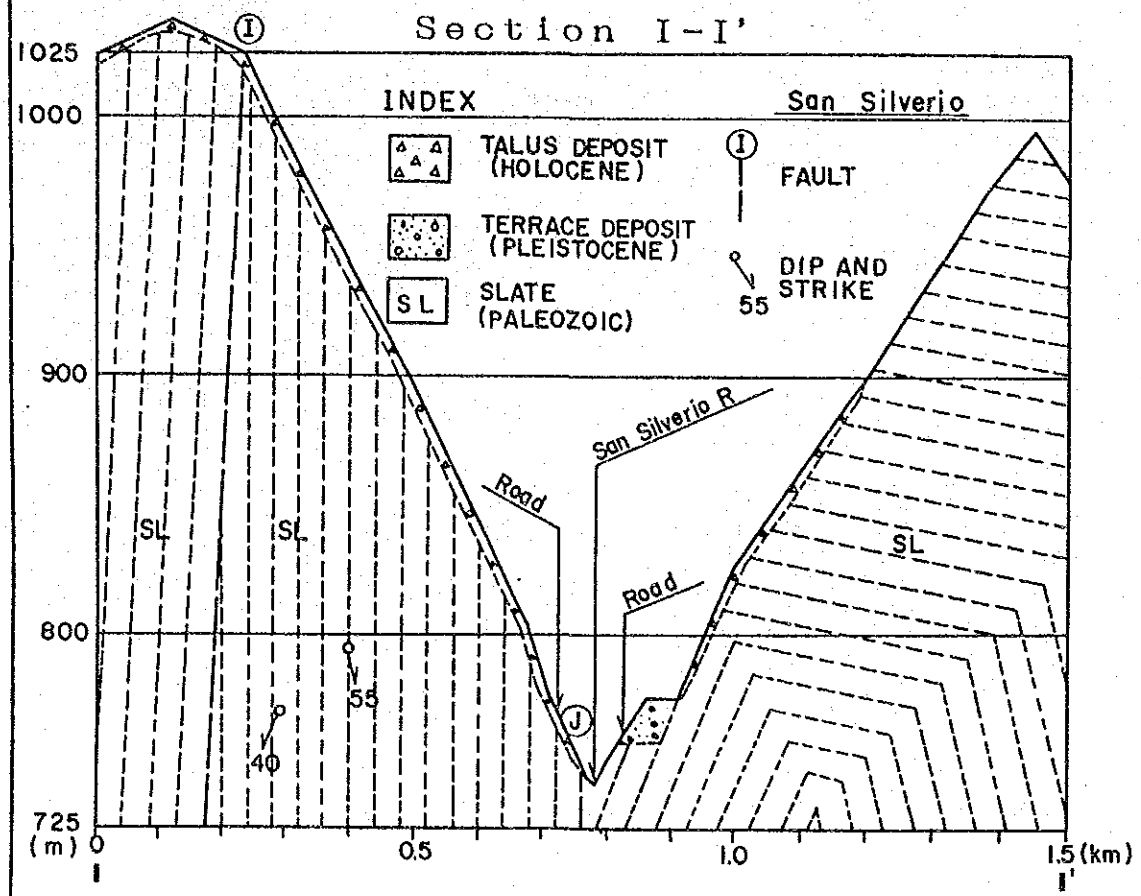
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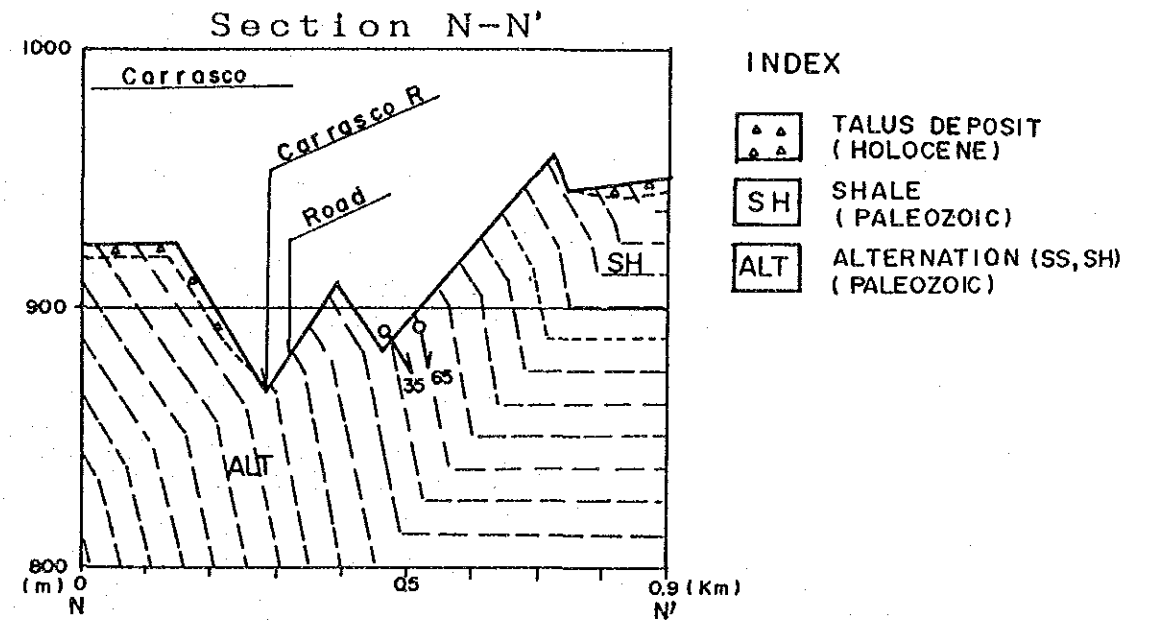
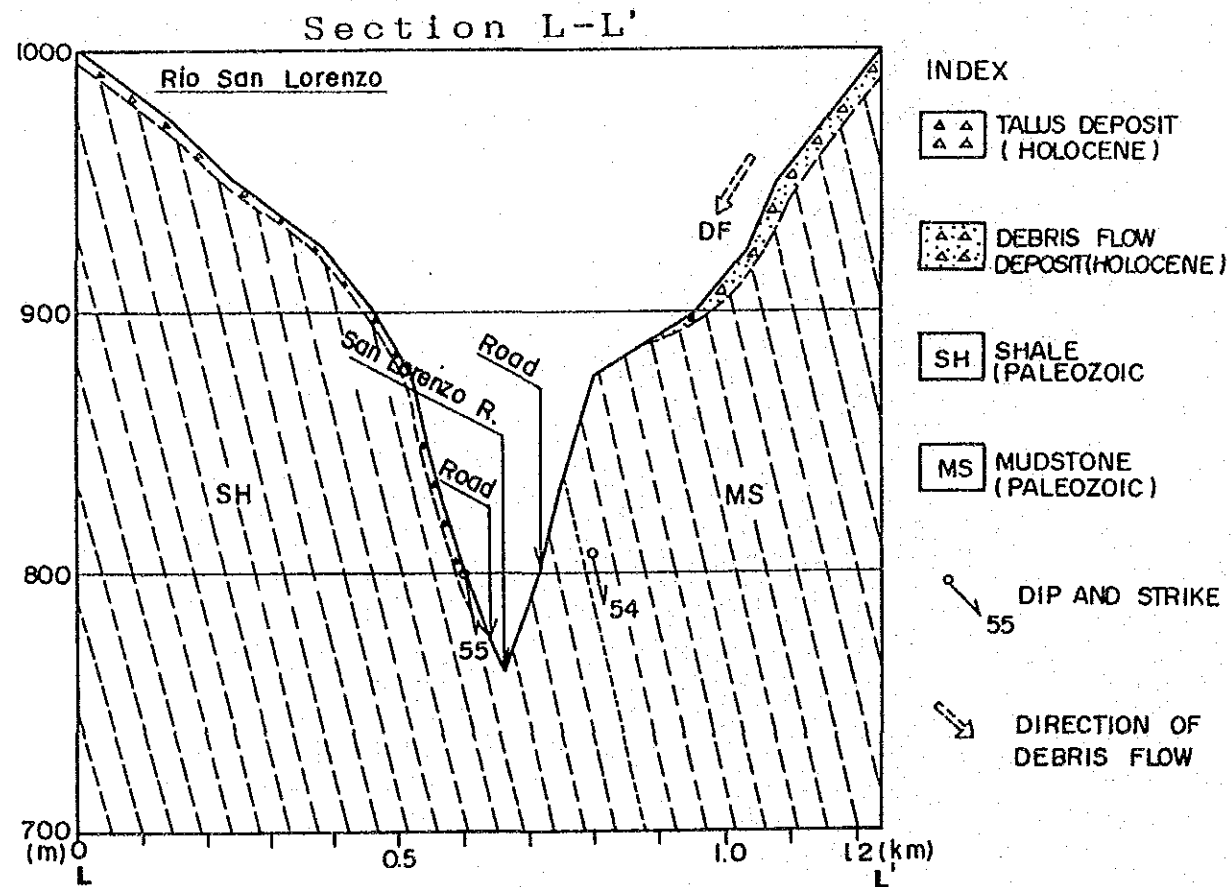
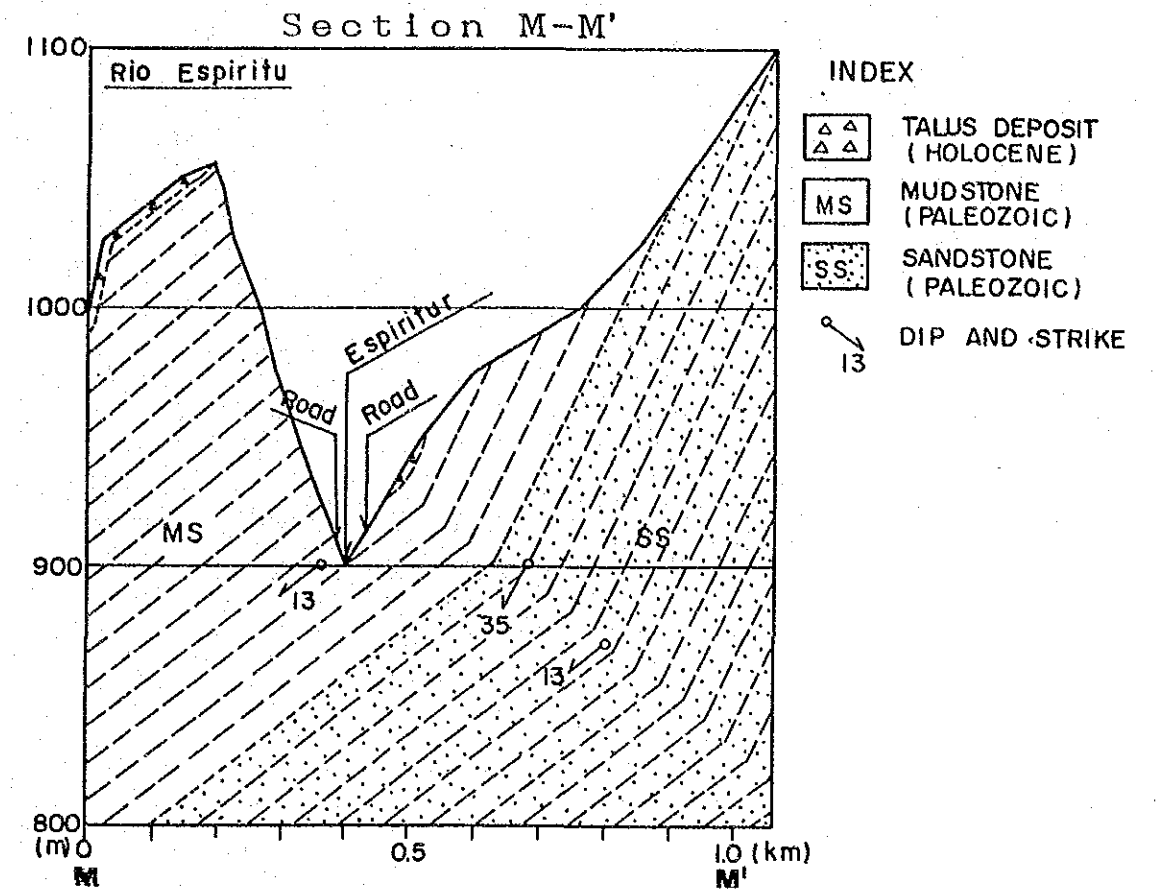
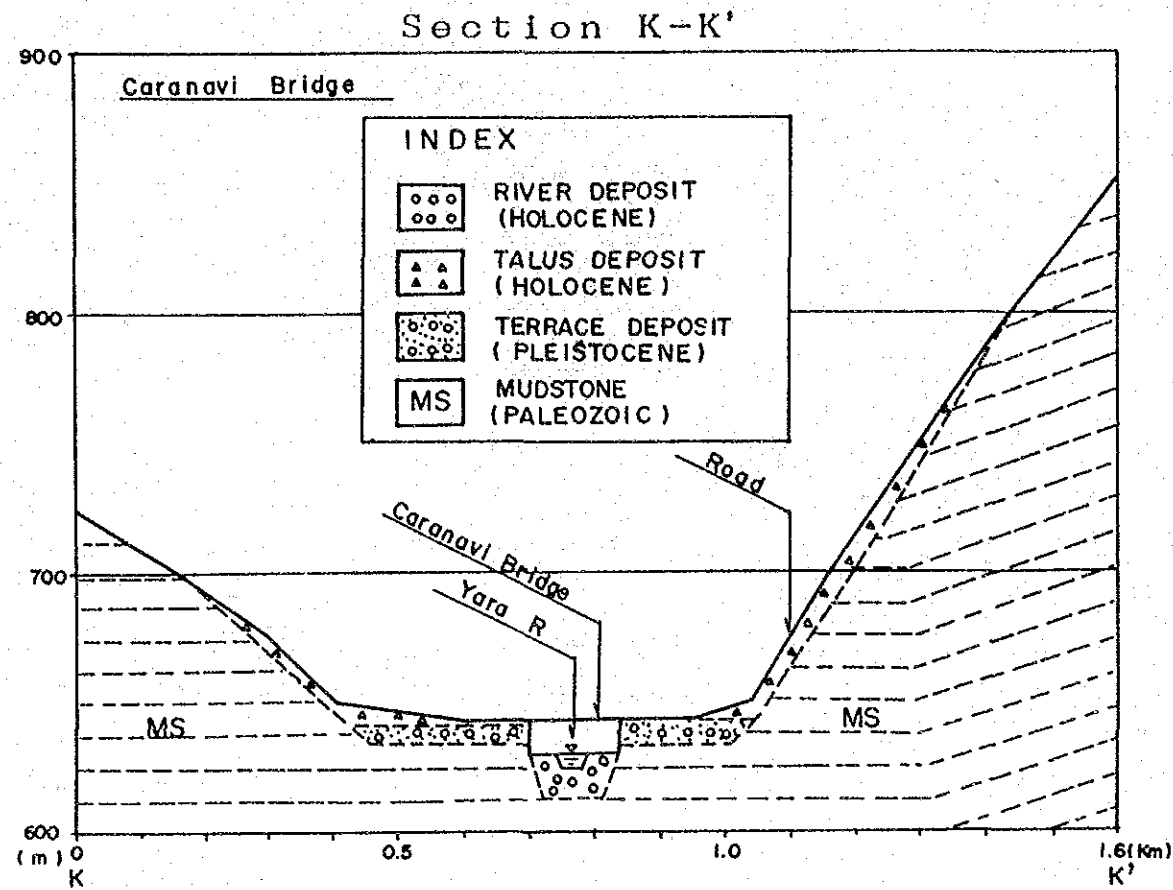


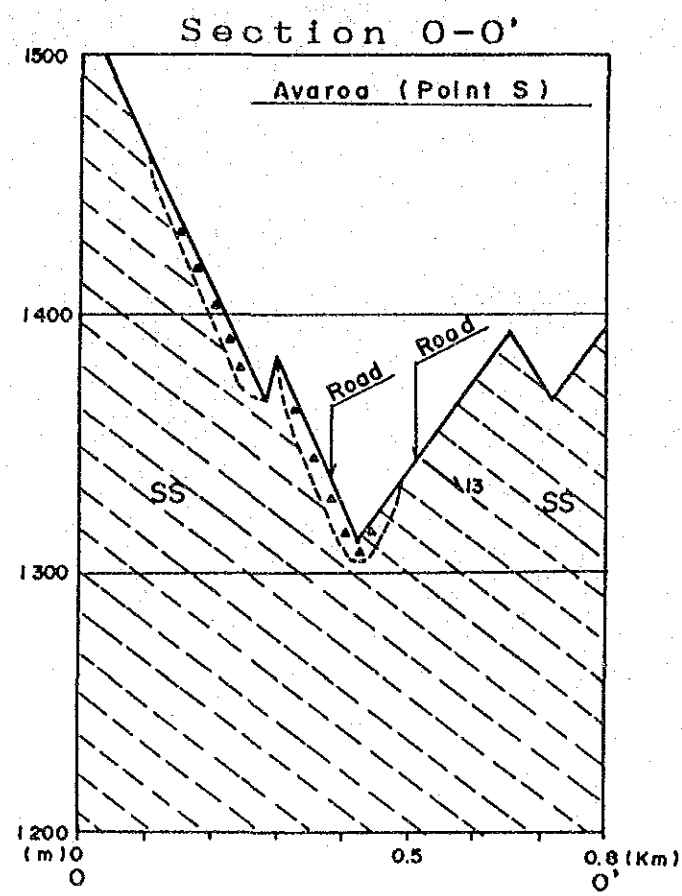
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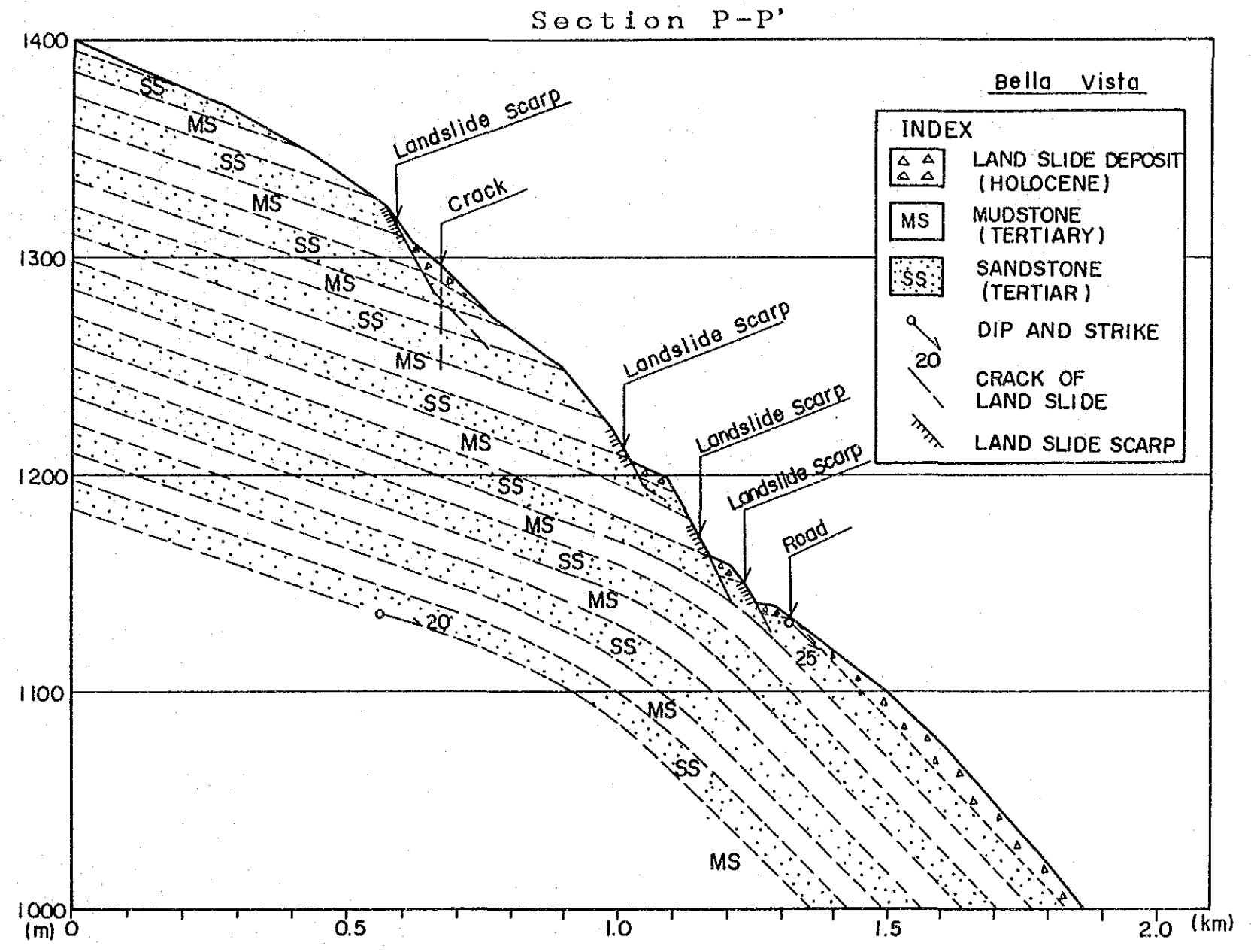






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