Ministry of Water & Energy (MoWE)
The Federal Democratic Republic of Ethiopia

THE STUDY ON GROUNDWATER RESOURCES ASSESSMENT IN THE RIFT VALLEY LAKES BASIN IN THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

FINAL REPORT

DATA BOOK

March 2012

Japan International Cooperation Agency (JICA)

Kokusai Kogyo Co., Ltd.

In this report, the project cost is estimated using the November 2011 price and at an exchange rate of 1 US$ = 78.84 Japanese Yen, 1 EUR (Ethiopia Birr)1 = 4.451 Japanese Yen

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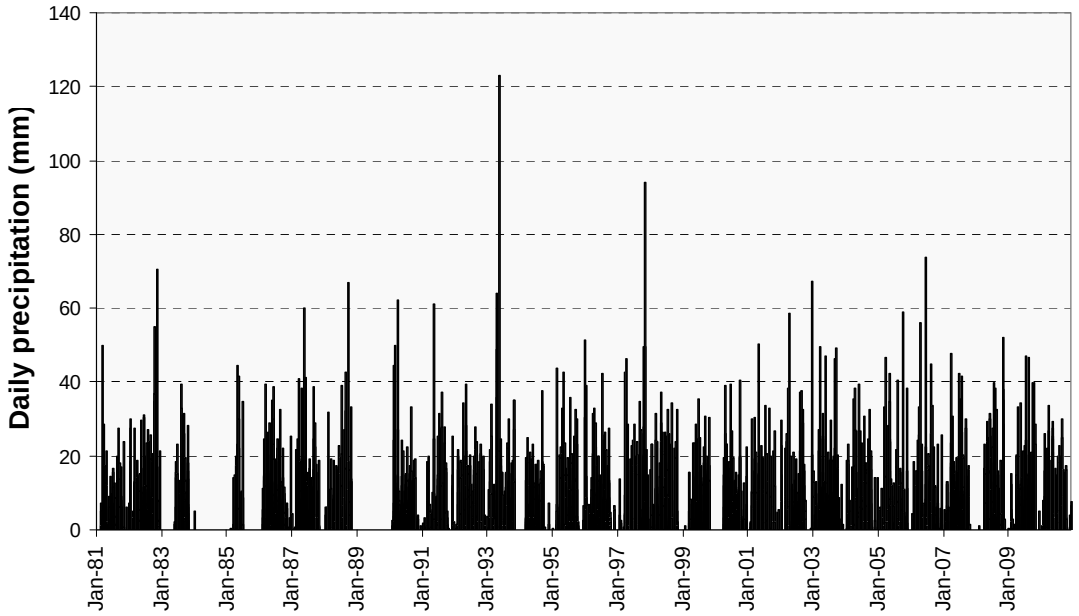

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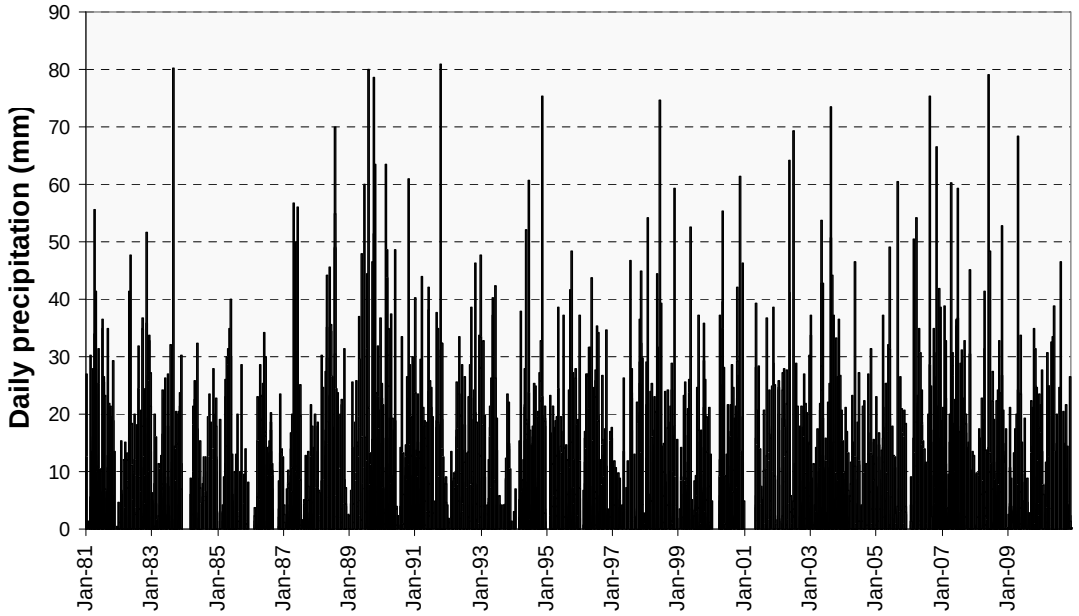

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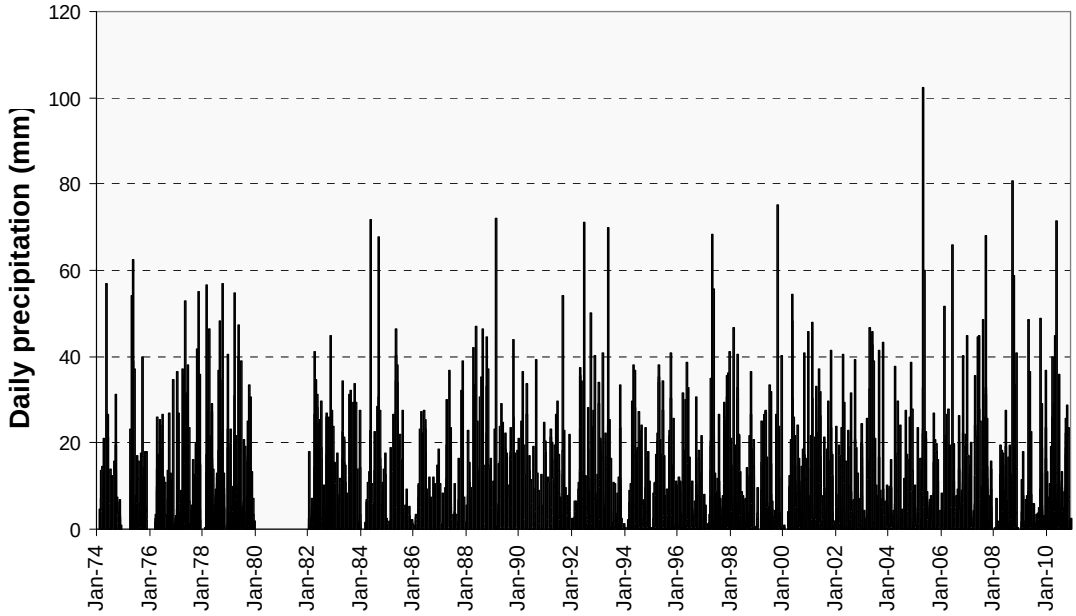

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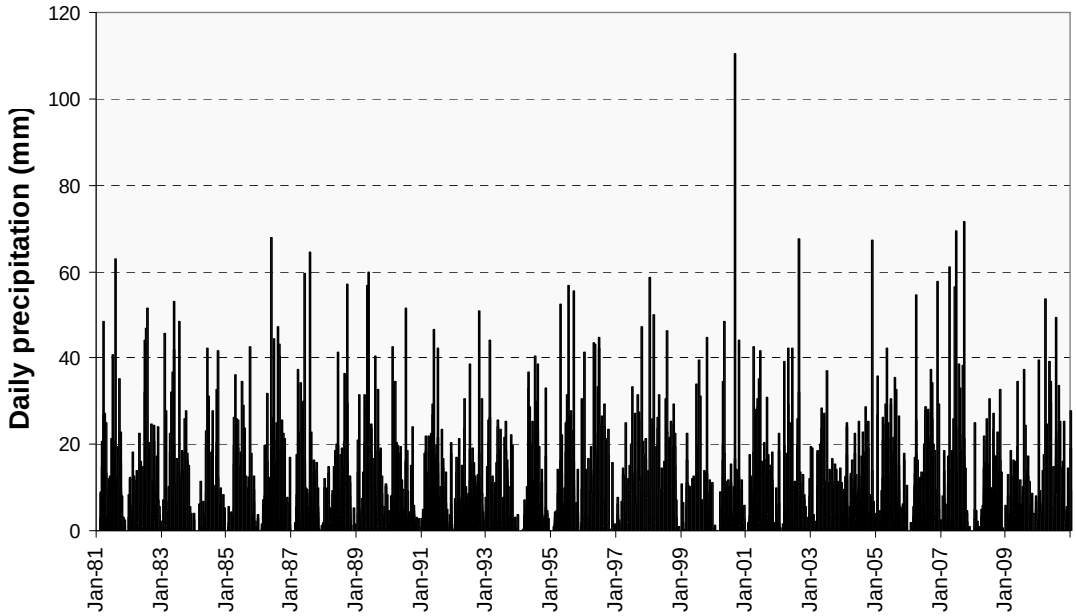

Data 1.1 Daily Rainfall Graph of 18 Major Meteorological Stations (3/9)

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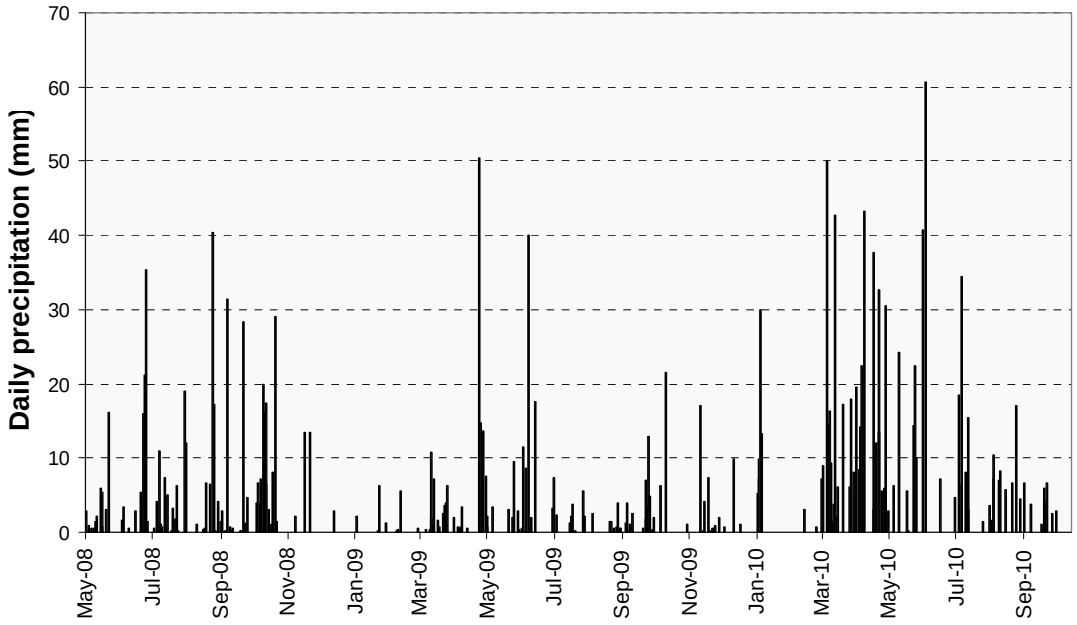

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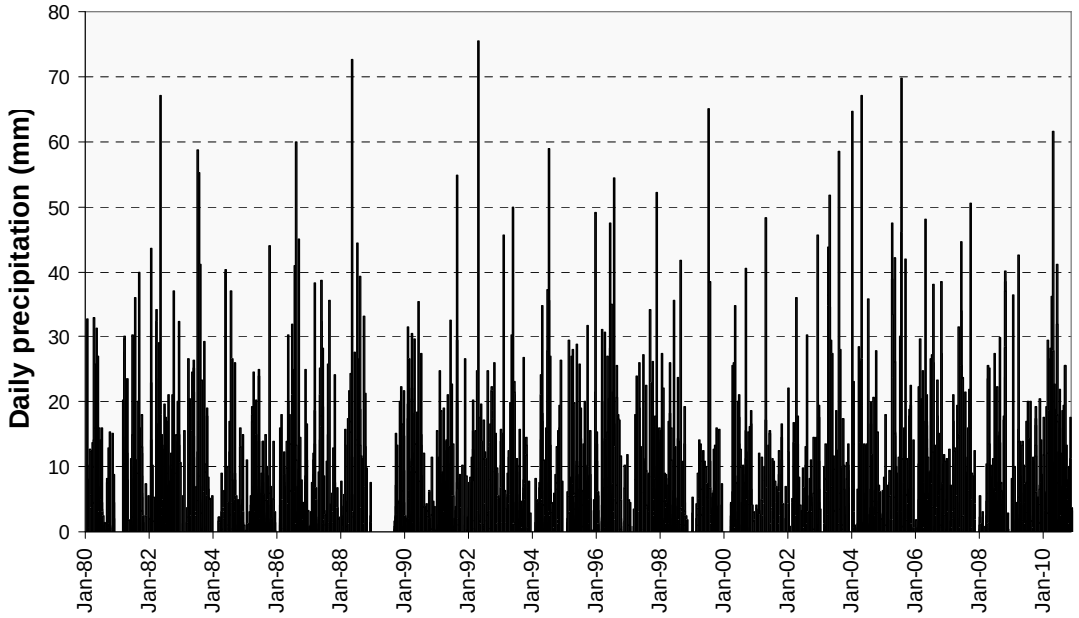

Data 1.1 Daily Rainfall Graph of 18 Major Meteorological Stations (4/9)

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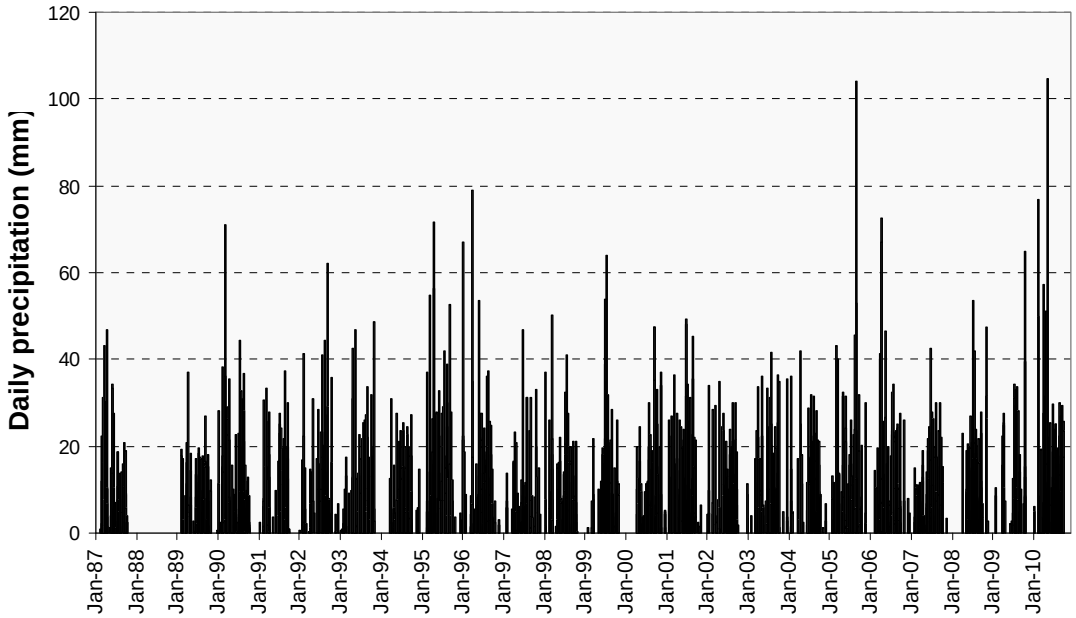

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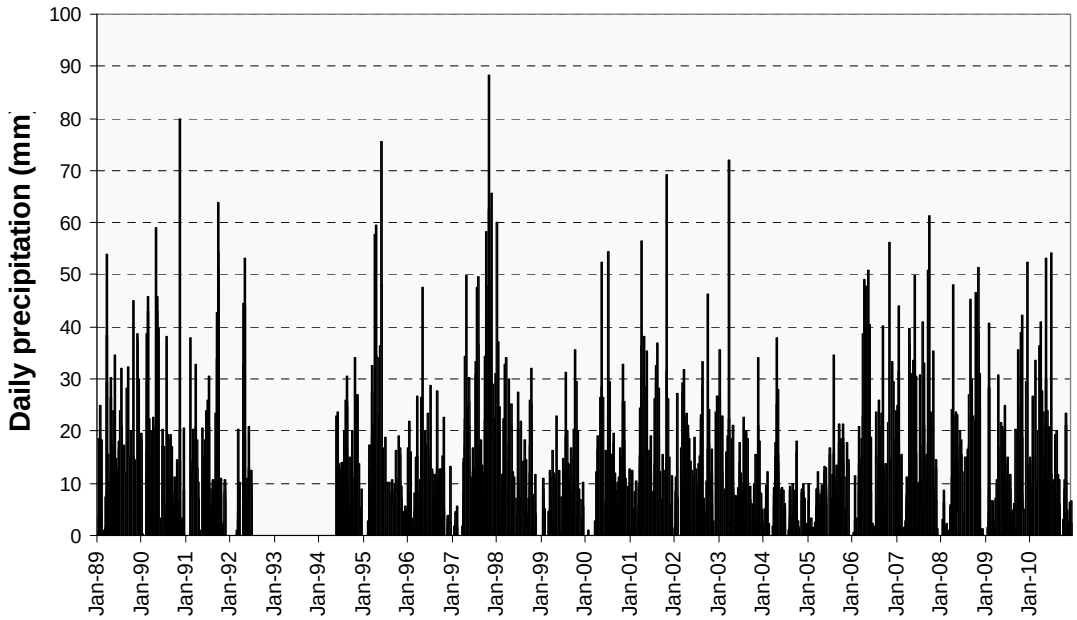

Data 1.1 Daily Rainfall Graph of 18 Major Meteorological Stations (5/9)

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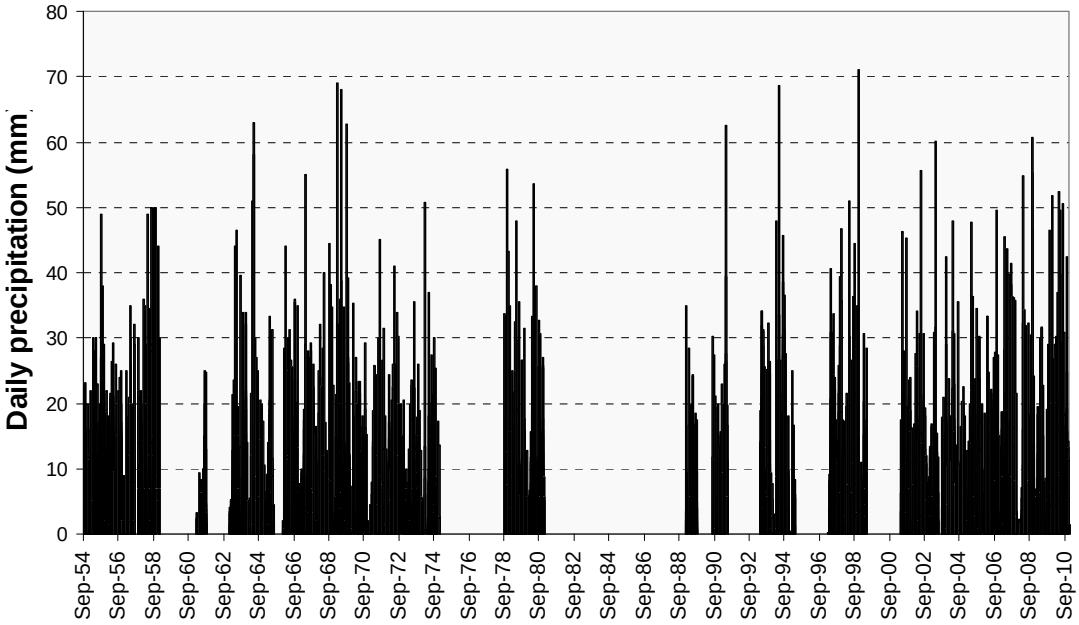

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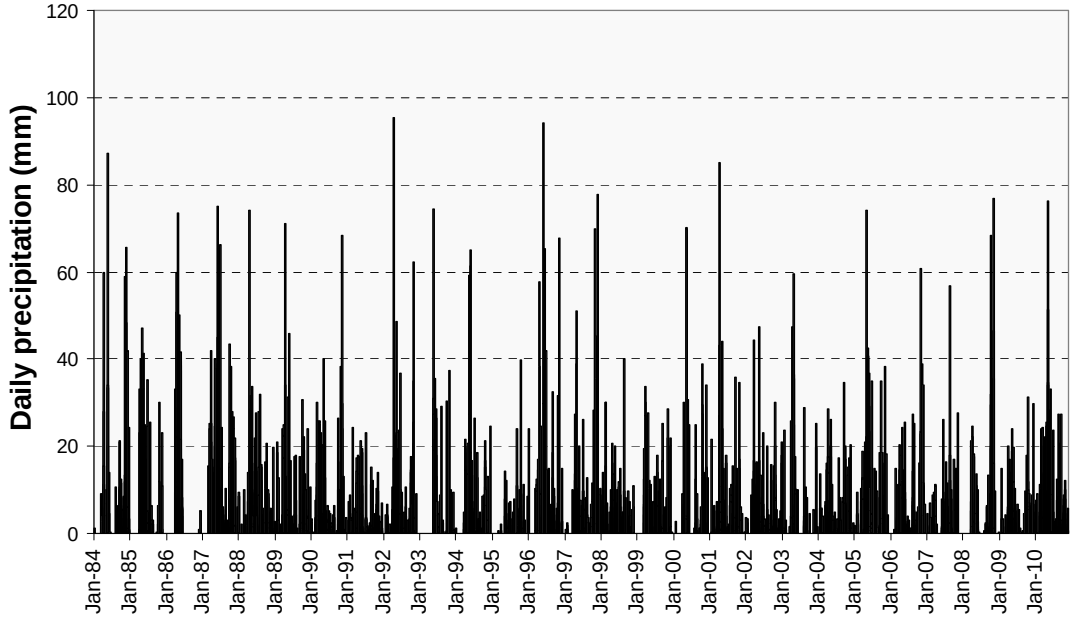

Data 1.1 Daily Rainfall Graph of 18 Major Meteorological Stations (6/9)

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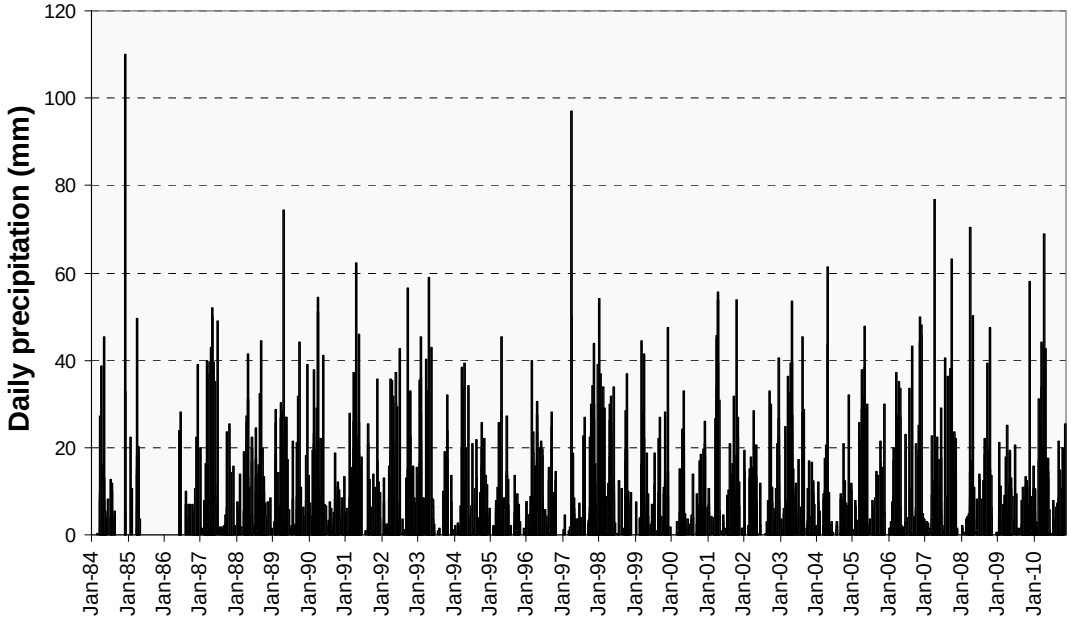

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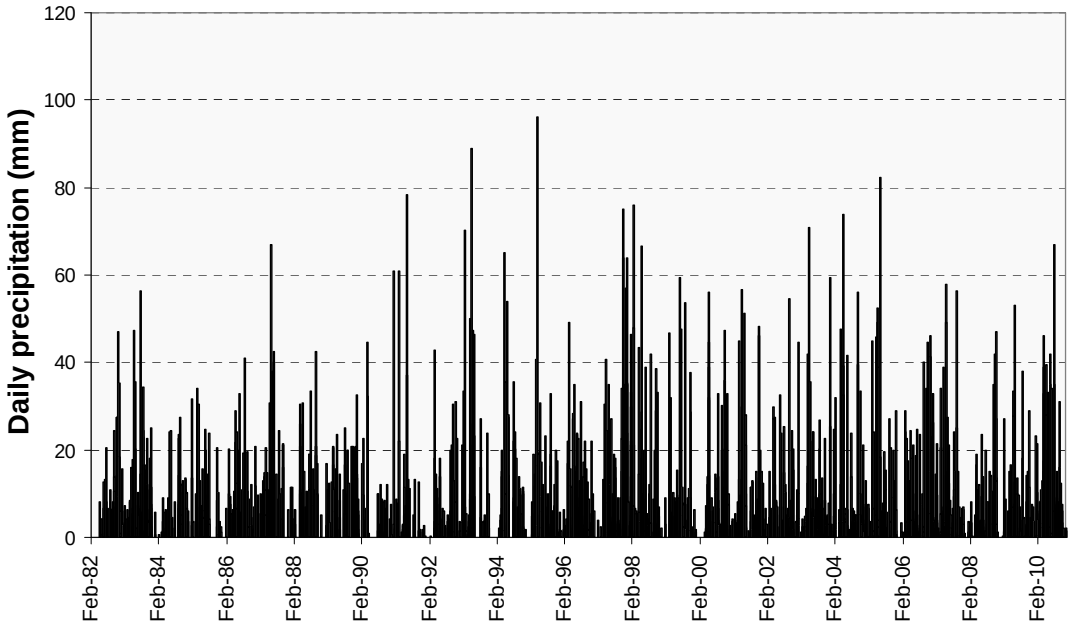

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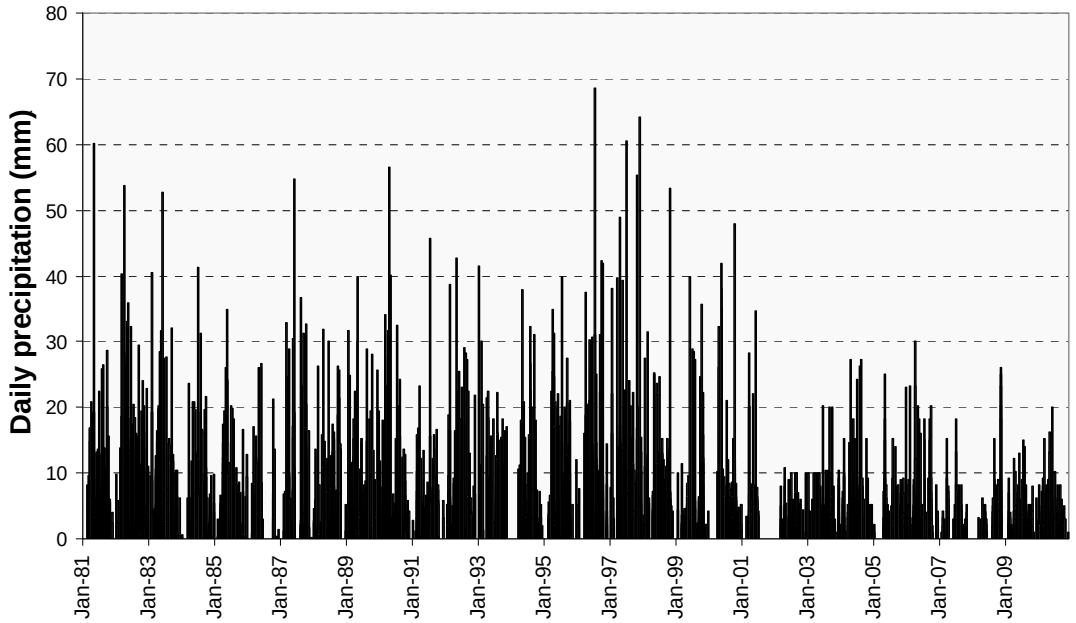

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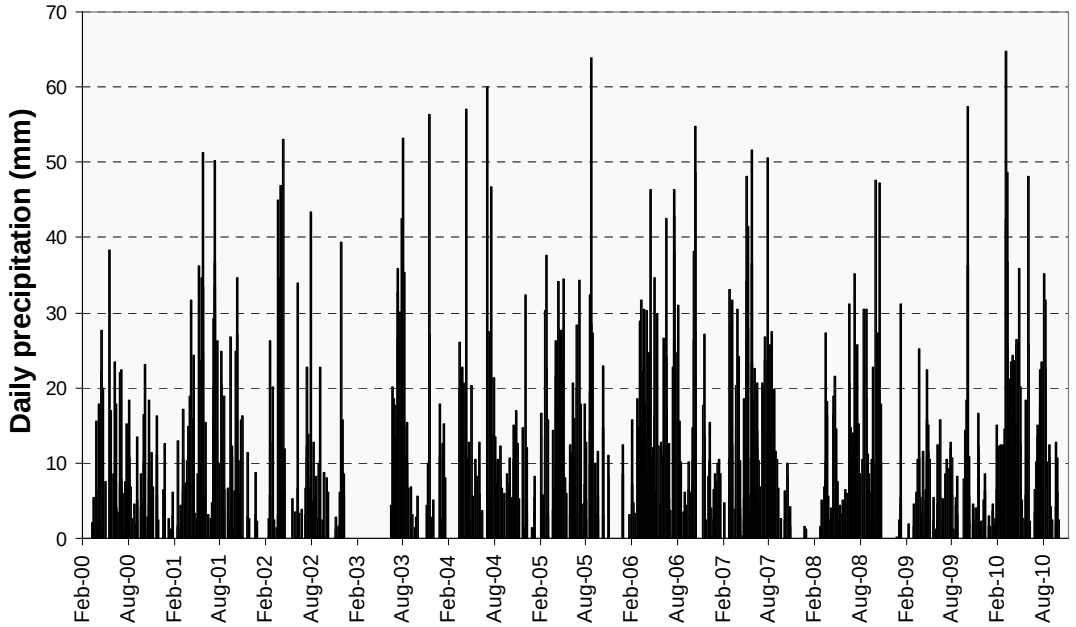

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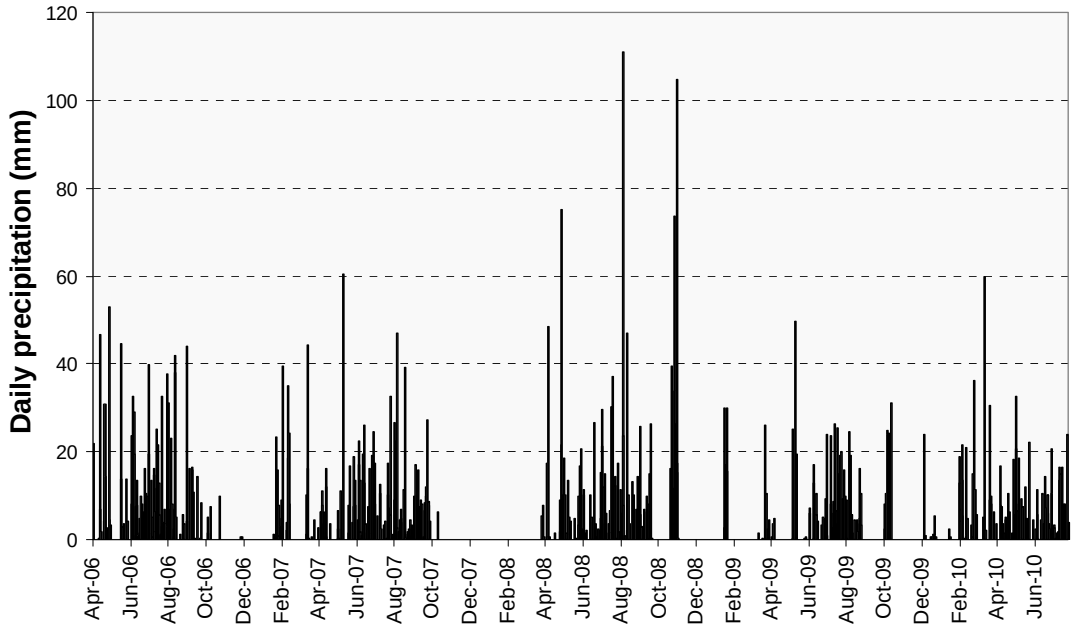

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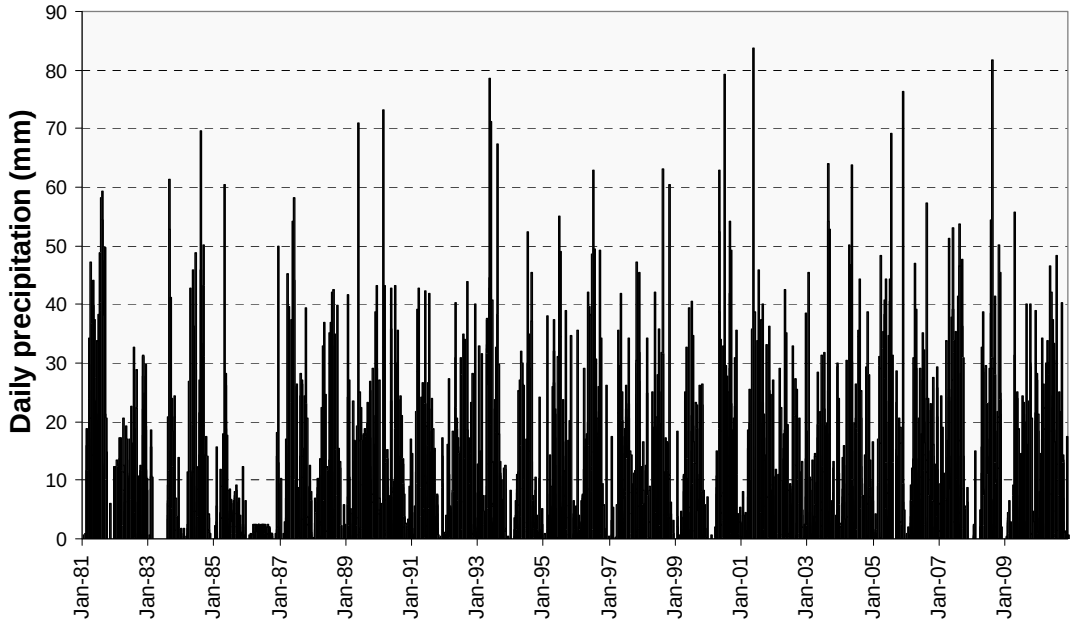

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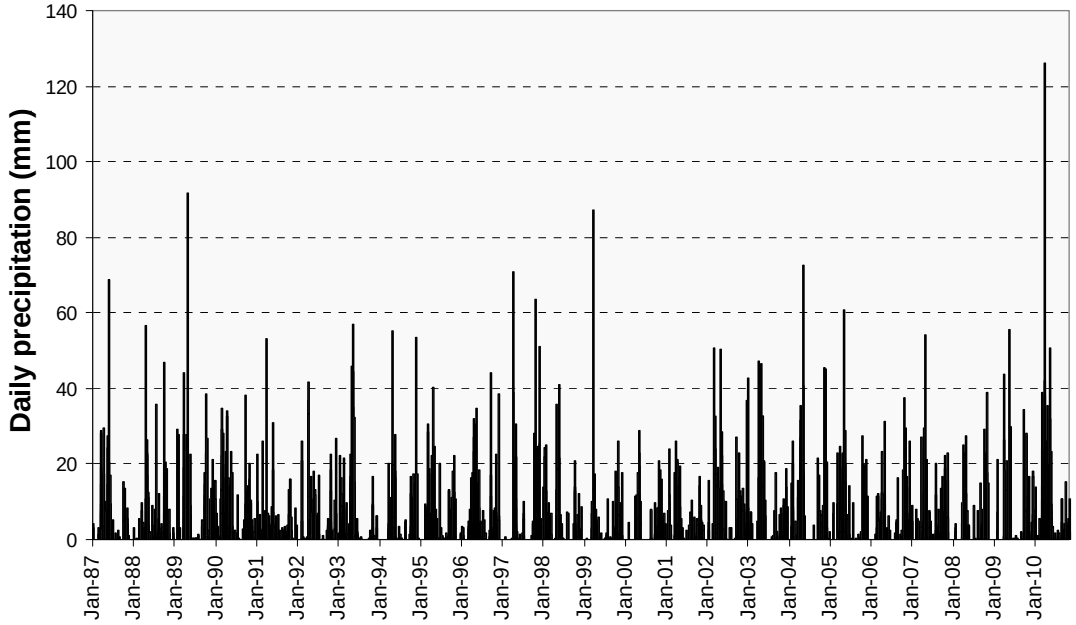

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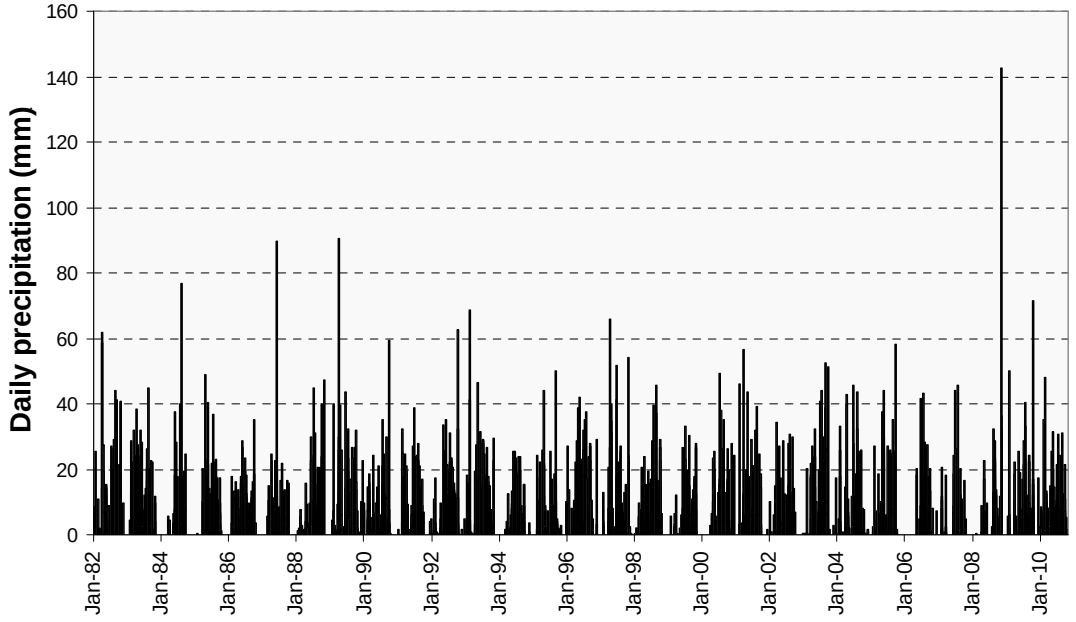

2. *Geology*

TEM
JICA Well

Towns
- Region Capital
- Zone Capital
- Woreda Capital

Roads
- Asphalt
- Gravel
- Major Rivers
- Swamp
- Lake
- Basin Boundary

Geological Structure
- Major fault, downthrown shown
- Major fault
- Normal fault, downthrow shown
- Normal fault
- Inferred fault, downthrown shown
- Inferred fault
- Major fault, downthrown shown, by satellite images
- Major fault, by satellite images
- Normal fault, downthrow shown, by satellite images
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- Inferred fault, by satellite images
- Geology boundary
- Inferred geology boundary
- Caldera edge
- Volcano / Volcanic Cone

Geology

Holocene
- Al — Alluvium; Fine sand - mud
- Q — Unclassified Fluvial Deposits; Sandy gravel-mud
- lac2 — Bulbla Lacstrine Deposits; Lake deposits such as gravel, sand and mud
- Pm — Corbetti Pumice Flow & Fall Deposits; Pumice falls and pumice flow deposits
- Vol — Corbetti Rhyolitic Volcanics; Rhyolite lava flows and Obsidian lava flows
- rb — Butajira Recent Basalt; Basalt lavas and reddish brown basaltic scoria
- lac1 — Meki Lacustrine Deposits; Lake deposits such as poorly-sorted gravel, sand, pumice, tuff, and volcanic sand

Pleistocene
- Y — Langano Poorly Welded Pumiceous Pyroclastics; Yellowish white rhyolitic pumice tuff
- ob — Kulumusa Highly Welded Tuff; Rhyolitic to andestic welded tuff
- W — Ketar River Acidic Volcanic Sedimentary Rocks; Rhyolitic tuffs and pumice tuffs
- G — Gonde Strongly Green Welded Tuff; Rhyolitic to andestic welded tuff
- tb — Adami Tulu Basaltic Pyroclastics; Basaltic tuff breccias and lapilli tuffs
- ba — Ogolche Pleistocene Basalt; Massive basalt lavas
- lake — Lekansho Lacustrine Deposits; Lake deposits such as sand stone and alternate layer

Plio-Pleistocene
- rh — Gademotta Rhyolite; Rhyolite lava flows and rhyolitic tuffs
- N2b — N2b Basalt; Basalt lavas and basaltic pyroclastics
- NQs — NQs Rhyolite; Rhyolitic tuffs

Pliocene
- rht — N1_2n Rhyolitic Volcanics; Plagiocrase rhyolite tuff and rhyolite lava flows containing obsidian
- N1_2n — N1_2n Rhyolitic Tuff; Plagiocrase rhyolitic tuff, pumice tuff and crystal tuff
- N1n — N1n Basalt; Anchar Basalt
- N1ar — N1ar Rhyolite; Rhyolite

Miocene
- Ngs — Sharenga Rhyolite; Rhyolite piles and necks
- Ngu — Upper Basalt; Porous basalt lavas
- Ngb — Beyana Tuff; Lapilli tuff with minor laminated tuff
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Eocene-Oligocene
- Pgs — Shole Welded Tuff; Densely-welded rhyolitic welded tuff
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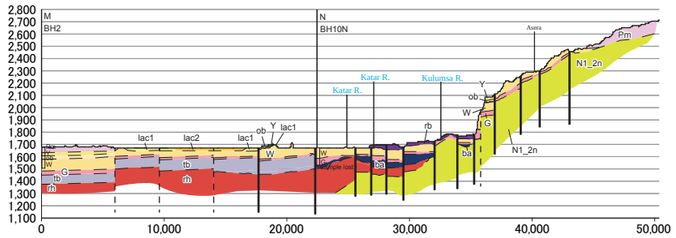
MESOZOIC
- Mes — Adigrat Sandstone, Antaro Limestone; Sandstone, Shale and Limestone

PRECAMBRIAN
- Pre — Biotite Gneiss, Pegmatite; Biotite Gneiss, Granite, Biotite Metagranite

Data 2.1	Geological Map
THE STUDY ON GROUNDWATER RESOURCES ASSESSMENT IN THE RIFT VALLEY LAKES BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)D	

A A’



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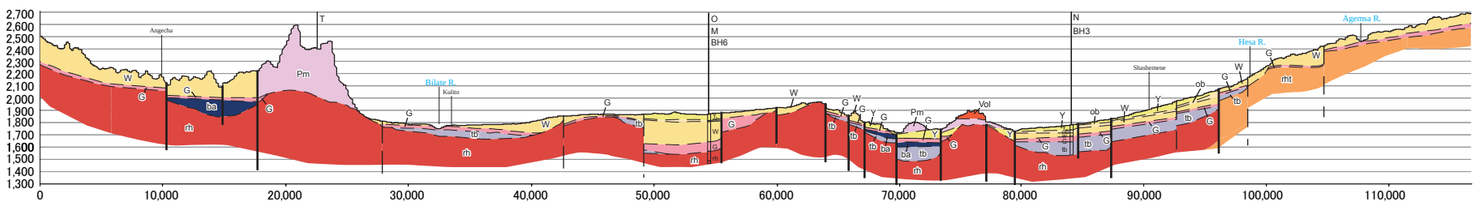

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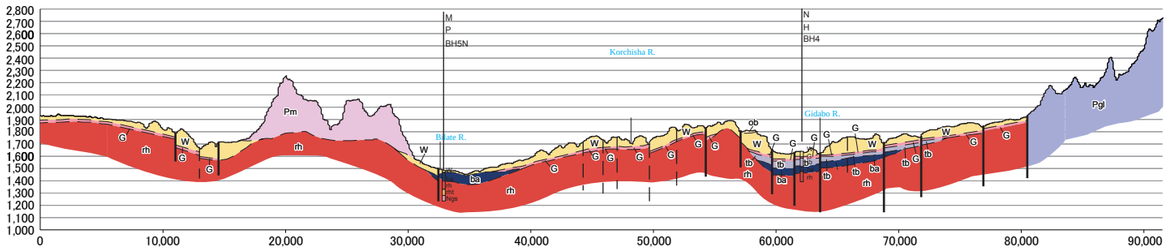

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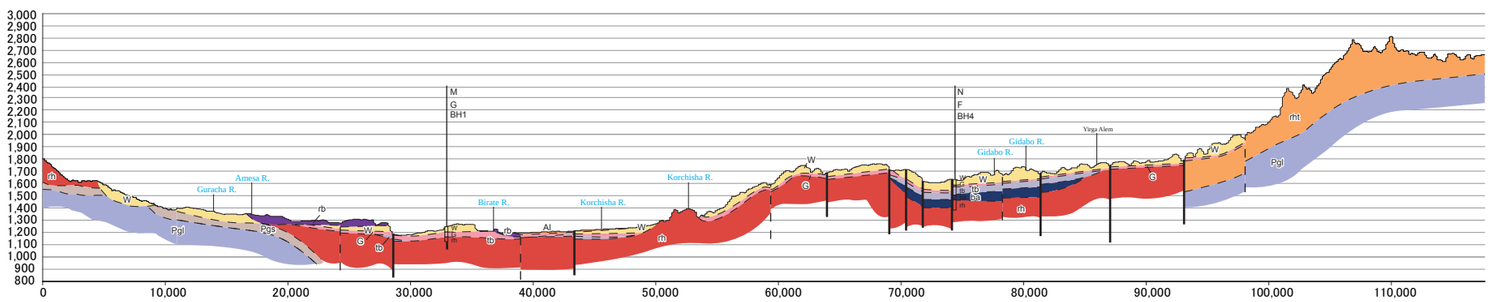

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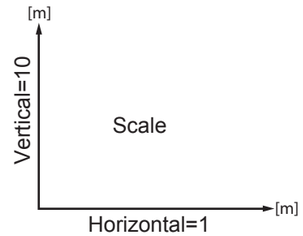

Data 2.2	Geological Cross Section (1/6)
THE STUDY ON GROUNDWATER RESOURCES ASSESSMENT IN THE RIFT VALLEY LAKES BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)	

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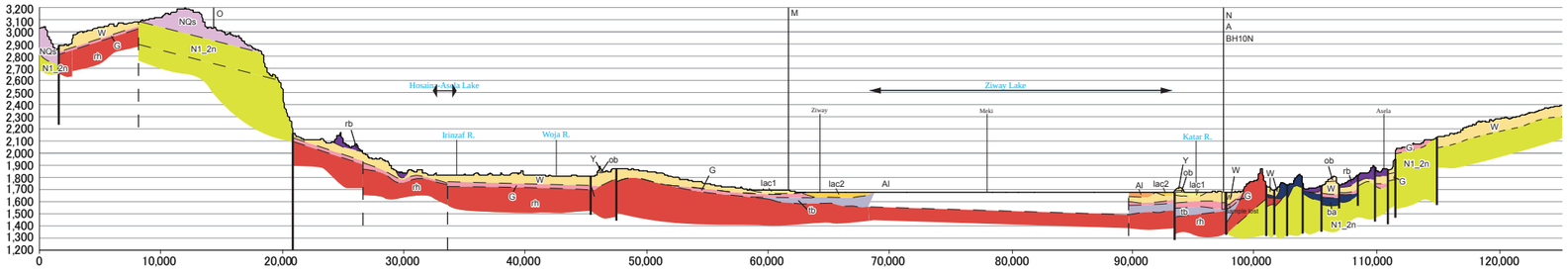

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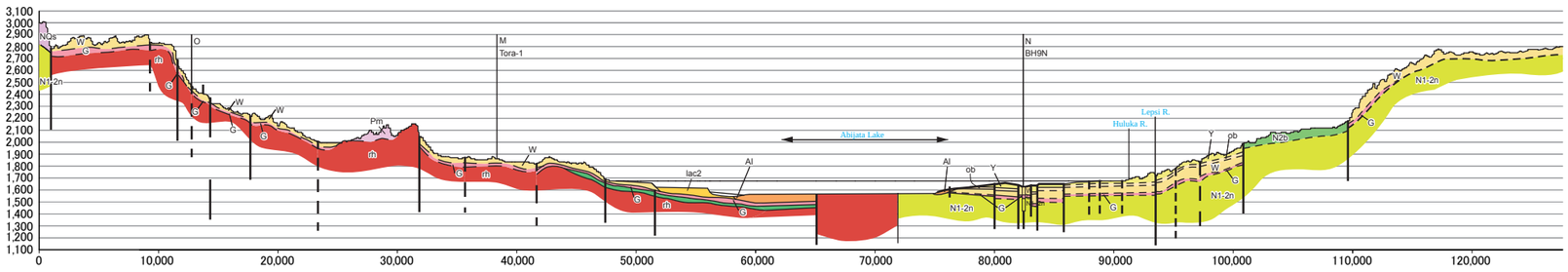

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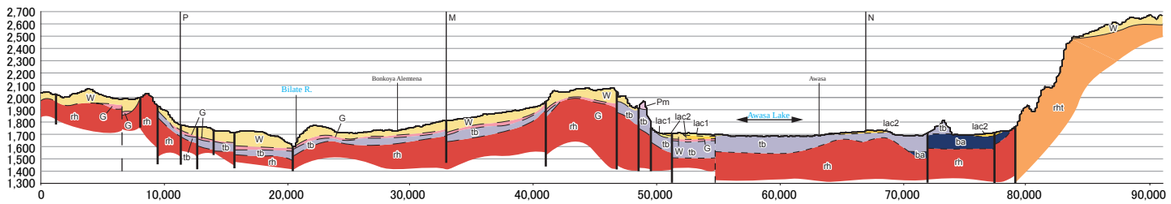

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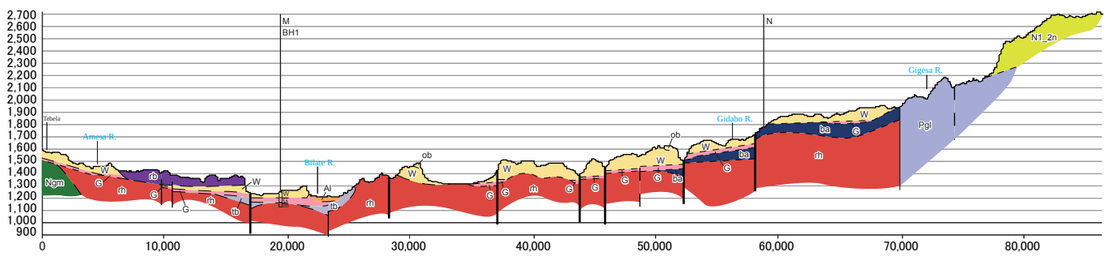

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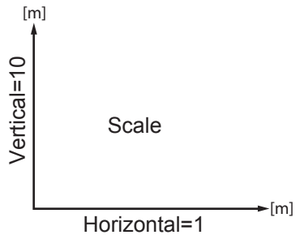

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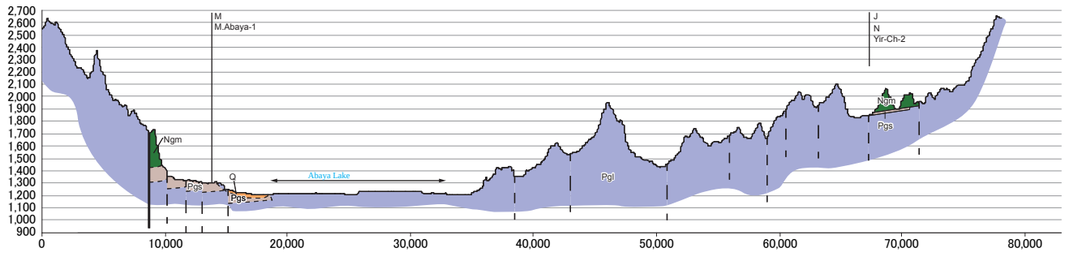

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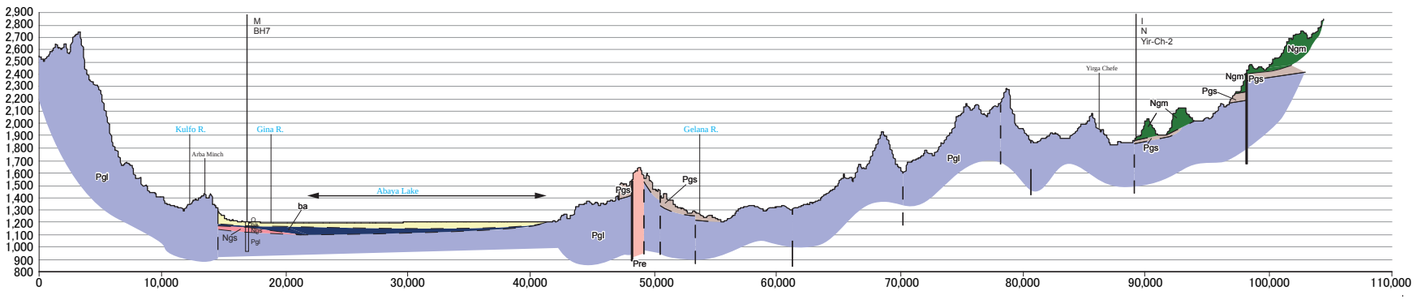

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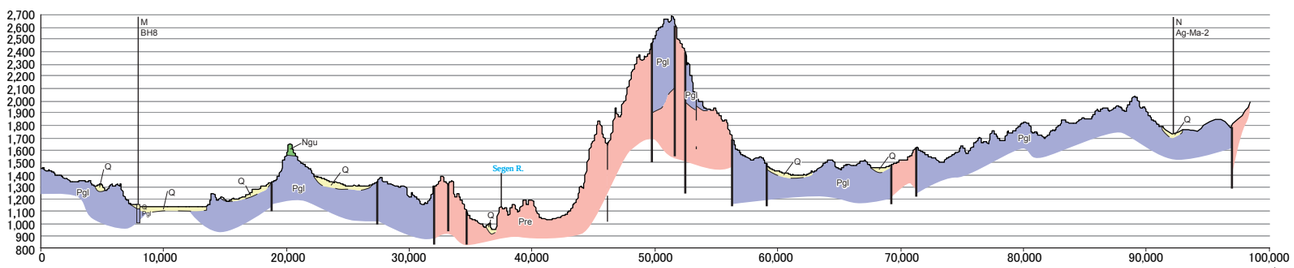

K'

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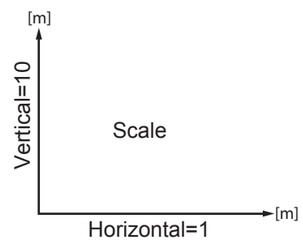
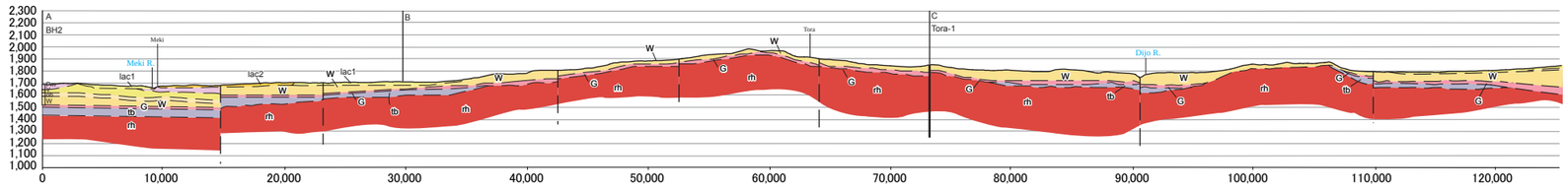
PRECAMBRIAN
- Pre — Biotite Gneiss, Pegmatite; Biotite Gneiss, Granite, Biotite Metagranite



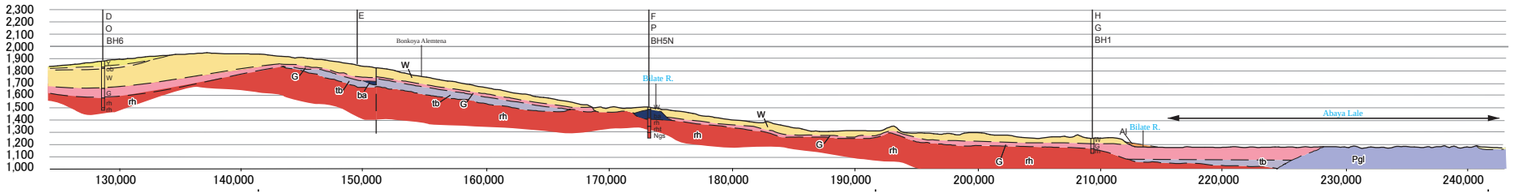
Data 2.2	Geological Cross Section (3/6)
THE STUDY ON GROUNDWATER RESOURCES ASSESSMENT IN THE RIFT VALLEY LAKES BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)	

M(1)



M(1)'

M(2)



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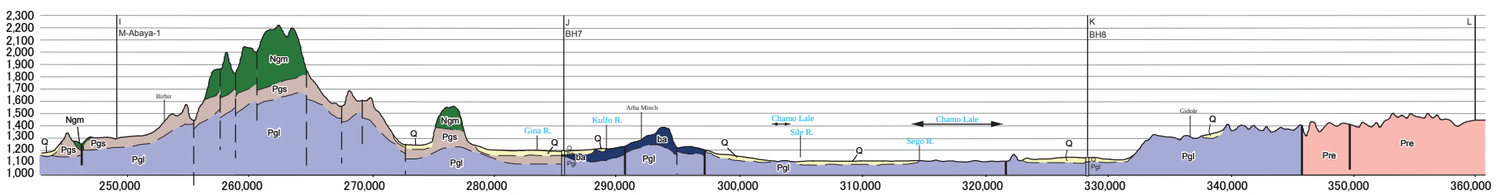

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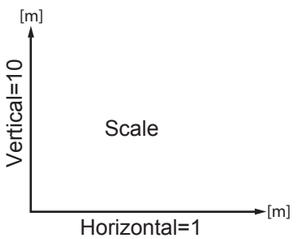


Geology

Holocene
- Al — Alluvium; Fine sand - mud
- Q — Unclassified Fluvial Deposits; Sandy gravel-mud
- lac2 — Bulbla Lacstrine Deposits; Lake deposits such as gravel, sand and mud
- Pm — Corbetti Pumice Flow & Fall Deposits; Pumice falls and pumice flow deposits
- Vol — Corbetti Rhyolitic Volcanics; Rhyolite lava flows and Obsidian lava flows
- rb — Butajira Recent Basalt; Basalt lavas and reddish brown basaltic scoria
- lac1 — Meki Lacustrine Deposits; Lake deposits such as poorly-sorted gravel, sand, pumice, tuff, and volcanic sand

Pleistocene
- Y — Langano Poorly Welded Pumiceous Pyroclastics; Yellowish white rhyolitic pumice tuff
- ob — Kulumusa Highly Welded Tuff; Rhyolitic to andestic welded tuff
- W — Ketar River Acidic Volcanic Sedimentary Rocks; Rhyolitic tuffs and pumice tuffs
- G — Gonde Strongly Green Welded Tuff; Rhyolitic to andestic welded tuff
- tb — Adami Tulu Basaltic Pyroclastics; Basaltic tuff breccias and lapilli tuffs
- ba — Ogolche Pleistocene Basalt; Massive basalt lavas
- lake — Lekansho Lacustrine Deposits; Lake deposits such as sand stone and alternate layer

Plio-Pleistocene
- rh — Gademotta Rhyolite; Rhyolite lava flows and rhyolitic tuffs
- N2b — N2b Basalt; Basalt lavas and basaltic pyroclastics
- NQs — NQs Rhyolite; Rhyolitic tuffs

Pliocene
- rht — N1_2n Rhyolitic Volcanics; Plagiocrase rhyolite tuff and rhyolite lava flows containing obsidian
- N1_2n — N1_2n Rhyolitic Tuff; Plagiocrase rhyolitic tuff, pumice tuff and crystal tuff
- N1n — N1n Basalt; Anchar Basalt
- N1ar — N1ar Rhyolite; Rhyolite

Miocene
- Ngs — Sharenga Rhyolite; Rhyolite piles and necks
- Ngu — Upper Basalt; Porous basalt lavas
- Ngb — Beyana Tuff; Lapilli tuff with minor laminated tuff
- Ngm — Middle Basalt; Porphyritic basalt lavas

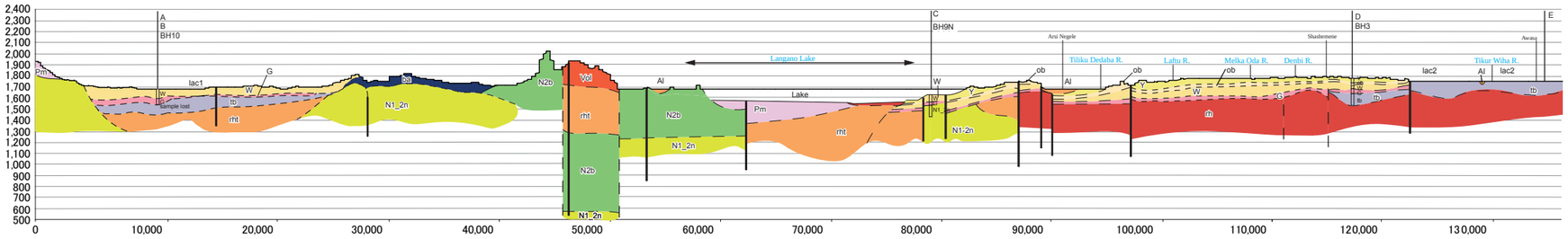
Eocene-Oligocene
- Pgs — Shole Welded Tuff; Densely-welded rhyolitic welded tuff
- Pgl — Lower Basalt; Porphyritic basalt lavas

MESOZOIC
- Mes — Adigrat Sandstone, Antaro Limestone; Sandstone, Shale and Limestone

PRECAMBRIAN
- Pre — Biotite Gneiss, Pegmatite; Biotite Gneiss, Granite, Biotite Metagranite

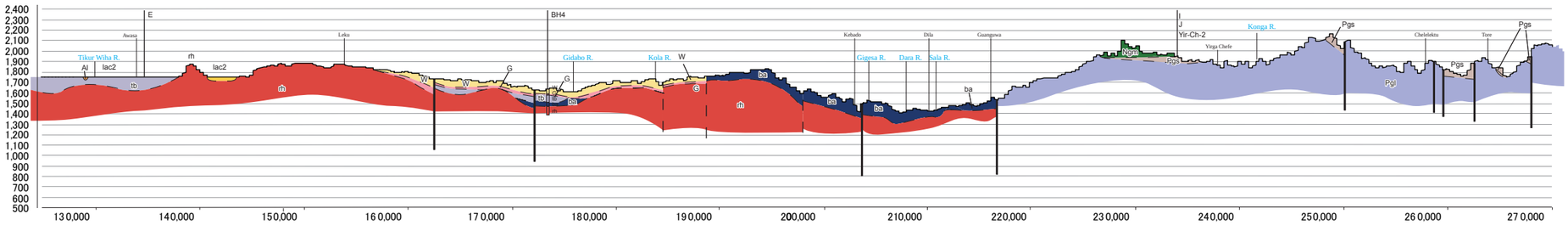
Data 2.2	Geological Cross Section (4/6)
THE STUDY ON GROUNDWATER RESOURCES ASSESSMENT IN THE RIFT VALLEY LAKES BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)	

N(1)



N(1)'

N(2)



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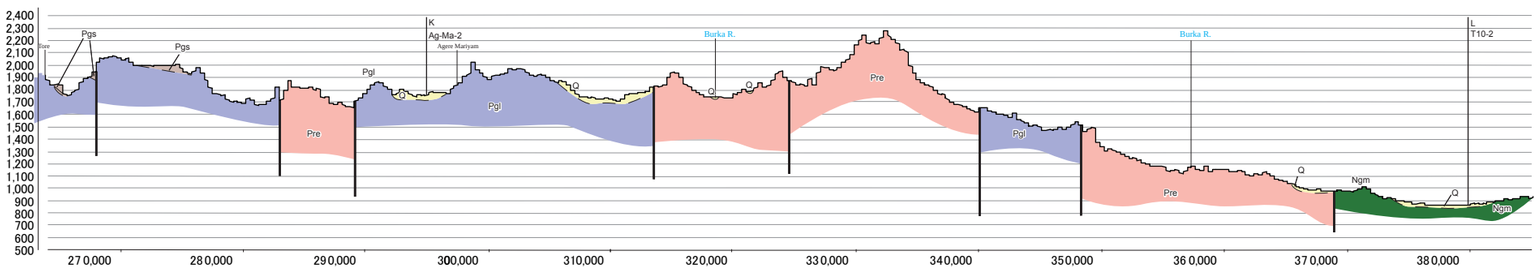

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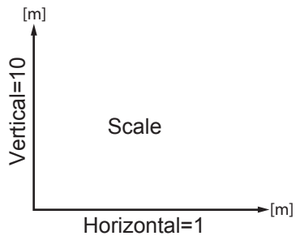

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- Ngb — Beyana Tuff; Lapilli tuff with minor laminated tuff
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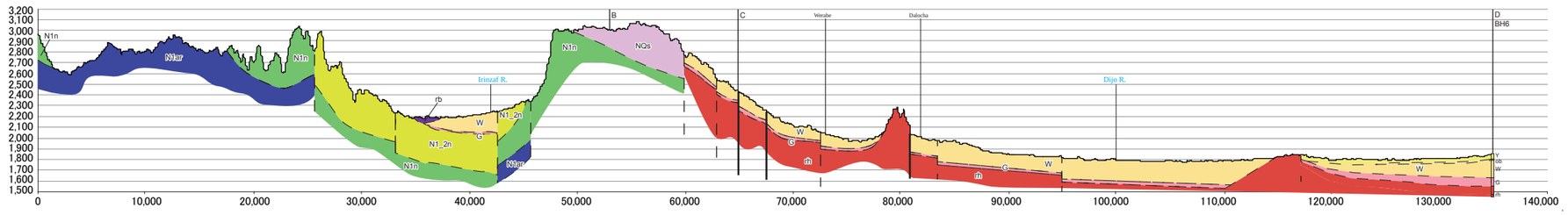
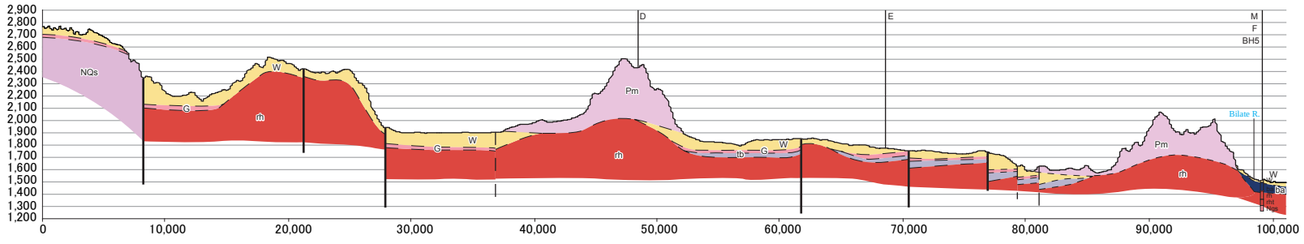
Data 2.2	Geological Cross Section (5/6)
THE STUDY ON GROUNDWATER RESOURCES ASSESSMENT IN THE RIFT VALLEY LAKES BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)	

O



P



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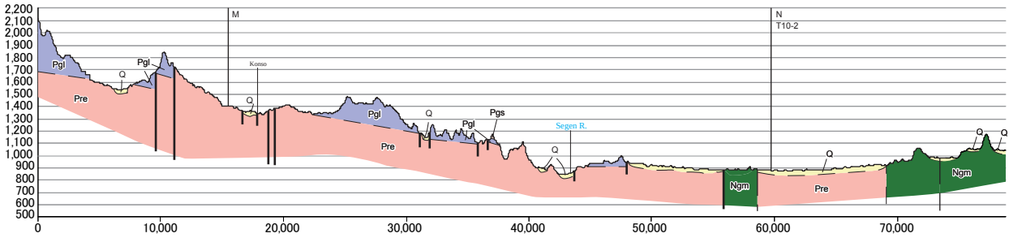

Geology

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- Ngs — Sharenga Rhyolite; Rhyolite piles and necks
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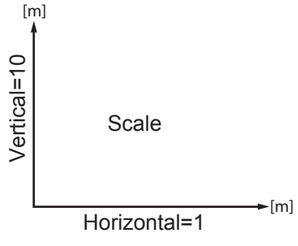


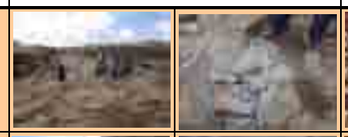
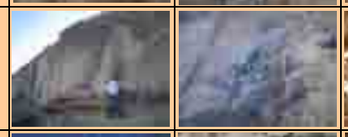
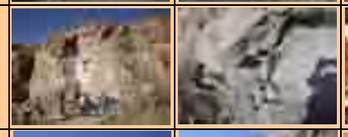
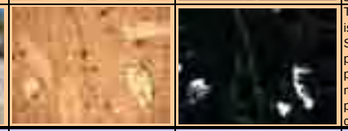
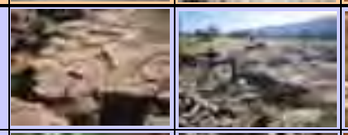
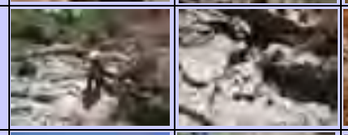
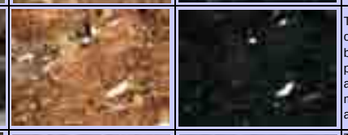
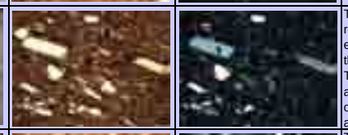
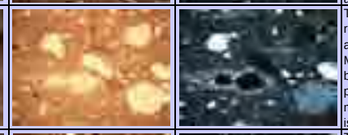
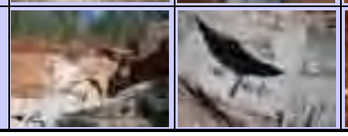
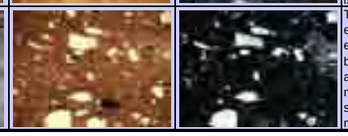
Data 2.2	Geological Cross Section (6/6)
THE STUDY ON GROUNDWATER RESOURCES ASSESSMENT IN THE RIFT VALLEY LAKES BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)	

Data 2.3 Stratigraphy of the Study Area with Measured Absolute Ages

Period/Epoch			Lake Ziway		Lake Langano, Abijata, Shala		Butajira- Hosaina		Lake Awasa		Sodo-Dila-YirgaChafe		Abaya–ArbaMinch		Major Lithology
Cenozoic	Quaternary	Holocene	Alluvium		Alluvium		Alluvium		Alluvium		Alluvium		Alluvium		Fine sand and mud
			Bulbula lacustrine deposits		Bulbula lacustrine deposits				Shalo lacustrine deposits						Lacustrine deposites such as mud, sand, gravel sediments
			Mt. Aluto volcanics	0.04±0.01My(1) 0.08±0.02My(1) 0.27-0.021My(2)	Alge volcanics		Mt. Ambericho volcanics		Corbetti volcanics	0.02±0.01My(1)	Dugna Fango Volcanic				Ryolitic lava, pumice fall, pumice flow deposites, and obsidian
			Deneba Recent Basalt		Awara Recent Basalt		Butajira Recent Basalt		Awasa Recent Basalt		Abaya Recent Basalts				Basaltic lava, reddish brown basaltic scoria
			Meki lacustrine deposits						Wondotika lacustrine deposits						Lacustrine layers of poorly sorted sand and gravel layers. Pumice, tuff, volcanic sand.
		Pleistocene	Asela poorly welded pumiceous pyroclastics		Langano poorly welded pumiceous pyroclastics	0.25±0.03My(2)	Dugda poorly welded pumiceous pyroclastics		Shashemene poorly welded pumiceous pyroclastics					Chamo basaltic cinder cones(Qc)	Yellow to yellowish white rhyolitic pumiceous tuff deposites
			Kulmusa highly Welded-Tuff	0.26±0.04Ma (Uk110129-01SP02,Kulmusa) 1.27±0.04Ma (Uk110122-01SP01,Kibet)	Kuyera highly Welded-Tuff	0.23±0.03My(2) 0.22±0.03My(2) 0.18±0.03My(2) 0.21±0.01Ma (Uk110126-01SP03,L.Shala)	Koshe highly Welded-Tuff		Mt. Kuwe highly Welded-Tuff	1.28±0.03Ma (Uk110128-01SP04,Mt.Kuwe)	Samero highly Welded-Tuff				Rhyolitic to Andesitic welded tuff
			Ketar river acidic volcano-sedimentary rocks		Lake Shala acidic volcano-sedimentary rocks	0.59±0.04My(2)	Kurito acidic volcano-sedimentary rocks		Yiega Alem acidic volcano-sedimentary rocks		Yirga Alem acidic volcano-sedimentary rocks				Rhyolitic pumice tuff and tuff
			Gonde Strongly Green Welded-Tuff	0.21±0.01My(1) 0.22±0.04Ma (Uk110129-02SP06,Deneba)	Bilate river Strongly Green Welded-Tuff	0.21±0.01My(1) 0.28±0.01My(2) 1.35±1.05Ma (Uk110127-01SP07,L.Shala)	Bilate river Strongly Green Welded-Tuff	0.21±0.01My(1)	Hantate Strongly Green Welded-Tuff	0.21±0.01My(1) 0.19±0.02Ma (Uk110125-01SP08,Kulito) 2.33±0.05Ma (Uk110124-03SP09,Hantate)	Hantate Strongly Green Welded-Tuff	0.21±0.01My(3) 0.91±0.03Ma (Uk110124-01SP10,Dila)	Post-rift Volcanics	Degabulae Basalt(Qd)	Rhyolitic to Andesitic welded tuff
			Adami Tulu basaltic pyroclastics		Shala Senbete basaltic pyroclastics				Abaye ridge basaltic pyroclastics	1.27±0.1My(1) 0.96±0.1My(1)	Donga basaltic pyroclastics			Bridge of God Basalt(Qb) 0.68-0.99Ma(2)	Basaltic tuff breccia to Lapili tuff
					Lake Chitu Basalt	0.86±0.15My(2) 1.02±0.03My(2)								Segen Basaltic lava cones(Qs)	Basaltic lave dome
			Ogolche Basalt	1.16-1.97My(1)			Deneba Basalt	1.16-1.97My(1)	Yubo Basalt	1.60±0.1My(1)	Kebado Basalt			Nechsar Basalt:Qn) 1.34Ma(2)	Massive basalt lava
			Lekansho Lake deposits												Lacustrine deposites such as mud, sand and gravel layers
	Neogene	Plio–Pleistocene	Gademotta rhyolite	1.30±0.1My(1) 1.27-1.28My(3)	Aje rhyolite		Gademotta rhyolite	1.30±0.1My(1) 1.27-1.28My(3)	Wendo Genet Rhyolite	1.10-1.85My(1) 2.49±0.1My(1)	Hobicha rhyolite	1.57My(2)	Gecho Rhyolite		Rhyolitic lava and tuff
			Bofa Basalt		Lepis Basalt	2.54±0.1My(1)	N2b (GSE,2003)								Basaltic lava and pyroclastics
		Pliocene					NQs (GSE,2003)								Rhyolitic tuff
			Hangasu Rhyolite		Munesa rhyolite	3.53±0.2My(1) 3.51±0.2My(1)	N1_2n (GSE,2003)	2.59-2.67My(1) 3.6-4.1My(1)	Wijigra Rhyolite	3.69-9.70My(1)					Plasioclase rhyolitic tuff
							N1n Anchar basalts (GSE,2003)	8.3-8.37My(1) 8.5-10.6My(1)							Basaltic lava and pyroclastics
							N1ar (GSE,2003)								Ryolitic tuff
		Miocene											Sharenga Rhyolite		Rhyolitic piles and necks
											Middle Basalt	12.6My(1) 12.9My(1) 11.1My(1)	Middle Basalt	12.6My(1) 12.9My(1) 11.1My(1)	Prous basaltic lava
		Eocene–Oligocene									Shole Welded Tuff	35.5-37.0My(1) 33.9My(1) 29.55±0.65Ma (Uk110124-02SP05,Dila)	Shole Ignimbrite	35.5-37.0My(1) 33.9My(1)	Rhyolitic highly welded tuff
											Lower Basalt	36.7-37.9My(1) 37.6-44.9My(1)	Lower Basalt	36.7-37.9My(1) 37.6-44.9My(1)	Porous basaltic lava
Mesozoic							Adigrat Sandstone Antaro Limestone								sandstone, limestone
Pre–Cambrian							Biotite Gneiss, Granite				Biotite Gneiss		Gneiss, Biotite Metagranite		Biotite gneiss and granite
References			References: (1)WoldeGabriel et. al., 1990 (2)EIGS-GLE, 1985 (3) Laury and Albritton, 1975		References: (1)WoldeGabriel et al, 1990 (2)Mohr et. al. 1980		References: (1)WoldeGabriel et. al., 1990 (2)EIGS-GLE, 1985 (3) Laury and Albritton, 1975		References: (1)WoldeGabriel et. al., 1990		References: (1)GSE, 1994 (2)GSE,2002 (3)WoldeGabriel et. al., 1990		References: (1)GSE, 1994 (2)Ebinger et al.,1991		

Note: The dating data in red are those analuzed in this JICA study and the sample ID in parenthesis is shown below
Note: Numbers in parenthesis indicate the references (see the bottom of each column)

Data 2.4 Petrographycal Description of K-Ar Dated Rock Samples (1/2)

No	Sample No	Points	Strata Name/Lithology	K-Ar Resuls	Photo in the field	Photo under microscope		Description	Texture	Phenocryst					
						Opennicol	Crossnicol			Sanidine	Anorthoclase	Amphibole	Biotite	Clino pyroxene	Fe-Ti minerals
1	Uk110122-01SP01	South Butajira: Kibet	Highly Welded-Tuff（Ob-Wt)/ Felsic Welded Tuff	1.27Ma±0.04Ma				The sample is least welded among the 10 samples. The texture of the essential pumice fragments can clearly recognized. The welded glass is brown and the essential pumice fragments show pale brown color. The phenocsysts (and the crystals of this size) are sanidein, amphibole, biotite,	Eutaxic	Most of them are euhedral or fragmented. Few have melted outlines. Max diameter 2 mm.		Euhedral to subhedral are dominant. Max diameter 0.4mm.	Many are in euhedral forms. Max diameter 0.6mm.	Euhedral to subhedral forms. Many are subhedral. Forms cluster phenocrysts with Fe-Ti minerals. Max diameter 0.4mm.	Granular forms. Max diameter 0.6mm.
2	Uk110129-01SP02	West Asela: Kulumsa	Highly Welded-Tuff（Ob-Wt)/ Felsic Welded Tuff	0.26Ma±0.04Ma				The glass is brown and the welded glass lenses became pearlite. The phenocrysts include sanidine, amphibole, Fe-Ti minerals, and opaque minerals. The sample is rick in rock fragments.	Eutaxic	Euhedral or fragmented shape. Max diameter 1.8mm.		Euhedral to subhedral. Many are subhedral. Max diameter 0.5mm.			Granular forms. Max diameter 0.6mm.
3	Uk110126-01SP03	Kuyera Quarry	Highly Welded-Tuff（Ob-Wt)/ Felsic Welded Tuff	0.21Ma±0.01Ma				The glass is brown. Some welded glass lenses originated from the essential pumice fragments are observed. Spherulites appear in these lenses. The phonocrystes are sanidine, amphybole, clino-pyroxine, Fe-Ti minerals, and opaque minerals. Especially rich in sanidine and amphibole phenocrysts.	Eutaxic	Many show corroded outline but still euhedral shpes. Max diameter 2.4mm.		Many have euhedral forms. Max diameter 0.6mm.		Subhedral or fragmented forms. Max diameter 0.4mm. Fragmented ones may not be essential crystals.	Granular forms. Max diameter 0.5mm.
4	Uk110128-01SP04	South Awasa Mt.Kuwe	Highly Welded-Tuff（Ob-Wt)/ Glassy Welded Tuff	1.28Ma±0.03Ma				The sample is highly welded. The welded lenses are elongated and show micro-banded texture. The glass is pale brown and are pearlite overall. The phenocrysts are sanidine, anorthoclase, amphybole, clino-pyroxine, Fe-Ti minerals, and opaque minerals. The sample is also rich in rock fragments	Eutaxic and pearlite	Many show corroded, or corroded euhedral or fragmented forms. Max diameter 2.4mm.	Fragmented form. Max diameter 1.2mm.	Euhedral to subhedral. Max diameter 1.5mm.		Fragmented forms. Max diameter 0.4mm.	Granular forms. Max diameter 0.6mm.
5	Uk110124-02SP05	West Dila: Walem hill	Highly Welded-Tuff（Ob-Wt)/ Glassy Welded Tuff	22.55Ma±0.65Ma				The sample is highly welded. The glass is pale brown and are pearlite. Spherulites appear in the glass. The phonocrysts are sanidine, pseudomorphs of mafic minerals, Fe-Ti minerals, and opaque minerals. The pseudomorp are concidered those of clino-pyroxine from their shapes. The	Eutaxic and pearlite	Corroded euhedral forms or fragmented forms. Many are corroded. Max diameter 1.8mm				Euhedral to subhedral and some are pseudomorphs. Max diameter 0.8mm.	Granular forms. Max 0.3mm.
6	Uk110129-02SP06	West Asela: Deneba	Strongly Green Welded-Tuff/ Felsic Welded Tuff	0.22Ma±0.04Ma				The glass is brown and recrystalized. Micro crystals of biotite and spherulites appear in the glass. The phenocrysts are sanidine, amphybole, clino-pyroxine, biotite, Fe-Ti minerals and opaque minerals.	Eutaxic	Euhedral or fragmented forms. Max diameter 1.6mm.		Euhedral to subhedral. Many are subhedral in form. Max diameter 0.4mm.	Euhedral forms. Max diameter 0.3mm.	Euhedral in forms. All are in pseudomorph. Max diameter 1.2mm	Granular forms. Max 0.4mm.
7	Uk110127-01SP07	Lake Shala East wall	Strongly Green Welded-Tuff/ Felsic Welded Tuff	1.35Ma±0.05Ma				The glass is brown and recrystalized overall. Small crystals of amphybole can be seen in welded lenses. The phenocrysts are sanidine, anorthoclase, amphybole, clino-pyroxine, Fe-Ti minerals and opaque minerals. The amout of anorthoclase is very small.	Eutaxic	Euhedral or fragmetned forms. Max. diameter 1.5mm.	Fragmented form. Possibly originate from non-essential rock fragments. Max diameter 0.4mm.	Euhedral to subhedral. Many are in euhedral forms. Max 0.8mm.		Subhedral to fragmented forms. Some forms cluster phenocrysts with Fe-Ti minerals. Fragmented ones may have come from non-essential	Granular forms. Max diameter 0.6mm.
8	Uk110125-01SP08	Kulito: along Riv.Bilate	Strongly Green Welded-Tuff/ Felsic Welded Tuff	0.19Ma±0.02Ma				The glass is brown and partially recrystalized. Welded lenses of essential fragments can be seen and they contain spherulite micro-crystals. The phonocrysts are sanidine, amphybile, biotite, Fe-Ti crystals, and opaque minerals. The sample is rich in amphybole and poor in rock fragments.	Eutaxic	Corroded euhedral form or fragmented form. Few show corroded forms. Max diameter 2.0mm.		Many are in euhedral forms. Max diameter 0.6mm.	Euhedral forms. Max. 0.3mm.		Granular forms. Max 0.4mm.
9	Uk110124-03SP09	West Hantate: Balto Quarry	Strongly Green Welded-Tuff/ Biotite Rhyolitic Welded Tuff	2.33Ma±0.05Ma				The glass is pale brown and recrystalized overall. Spherulite crystals appear in the essential glass lenses. Micro-crystals of amphybole can only been seen in the glass. The phenocrysts are sanidine, biotete, Fe-Ti minerals, opaque minerals. The sample is rich in sanidine and biotite crystals	Eutaxic	Corroded euhedral or fragmented forms. Some show remarkable corroded from. Max diameter 2.2 mm.			Euhedral forms. Max. 0.4mm.		Granular forms. Max 0.3mm.
10	Uk110124-01SP10	West Dila: Walem Quarry	Strongly Green Welded-Tuff/ Felsic Welded Tuff	0.91Ma±0.03Ma				The sample is highly welded and the essential welded lenses are remarkably elongated. The glass is fresh and pale brown. The phenocsysts are sanidine, amphybole, clino-pyroxine, Fe-Ti minerals and opaque minerals. The sample is rich in sanidine cystals and mafic phenocrysts mostly remain as	Eutaxic	Many are euhedral forms or fragmetned forms. Max diameter 2.2mm.		Many are in euhedral forms. Some are pseudomorphs. Max diameter 0.8mm		Euhedral to subhedral. Many form clustered phenocrysts with Fe-Ti minerals. Max diameter 0.8mm.	Granular forms. Max diameter 0.6mm.

No 1 - No.2 : Kulmusa Highly Welded Tuff
No 6 - No 10: Gonde Strongly Green Welded Tuff

Data 2.4 Petrographycal Description of K-Ar Dated Rock Samples (2/2)

No	Sample No	Points	Strata Name/Lithology	K-Ar Resuls	Groundmass (Essential lense)	Rock fragment	Description of feldsper（Sanidine）						Description of anorthoclase					
							Alteration	Zoning	Reaction fring	Inclusion	twin crystal	Angle of axis（2V)	Alteration	Zoning	eaction fring	Inclusion	twin crystal	Angle of axis（2V)
1	Uk110122-01SP01	South Butajira: Kibet	Highly Welded-Tuff（Ob-Wt)/ Felsic Welded Tuff	1.27Ma±0.04Ma	Brown glass with sanidine, amphibole, Fe-Ti mineral. Slightly altered. Supherulite crystals appear in the glass.	Volcanic rocks, tuff. Some volcanic rock fragments include sanidine, ampibole, clino-pyroxene	Fresh	None	None	Glass clino pyroxene	Carlsbqd type simple twin	Less than 40° (measured 15° - 40°)						
2	Uk110129-01SP02	West Asela: Kulumsa	Highly Welded-Tuff（Ob-Wt)/ Felsic Welded Tuff	0.26Ma±0.04Ma	Brown glass with sanidine, amphible, Fe-Ti minerals. The glass is slightly altered.	Volcanic rocks, altered volcanic rocks and tuff are dominant. Some volcanic rocks contain clino-pyroxene as phenocryst.	Fresh	None	None	Glass, Fe-Ti minerals	Carlsbad type simple twin	Less than 40° (measured 15° - 40°)						
3	Uk110126-01SP03	Kuyera Quarry	Highly Welded-Tuff（Ob-Wt)/ Felsic Welded Tuff	0.21Ma±0.01Ma	Brown glass with sanidine, amphibole, clino pyroxine, Fe-Ti minerals. Slightly altered. Spherulite crystals appear in the welded glass.	Volcanic rocks, altered volcanic rocks are domenant. Some volcanic rocks contain many clino-pyroxene phenocrysts.	Many are fresh and some are altered.	None	None	Glass, Amphibole, clino pyroxene, Fe-Ti minerals	Carlsbad type simple twin	Less than 40° (measured 0 - 40°)						
4	Uk110128-01SP04	South Awasa Mt.Kuwe	Highly Welded-Tuff（Ob-Wt)/ Glassy Welded Tuff	1.28Ma±0.03Ma	Page brown glass and became pearlite overall. Includes sanidine. Amphibole, Fe-Ti minerals.	Altered volcanic rocks, tuff, and volcanic rocks with anorthoclase phenocrysts.	Slightly altered overall	None	None	Glass, amphibole, Fe-Ti minerals,	Carlsbad type simple twin	Less than 40° (measured 15° - 40°)	Partly altered	None	None	None	Small cluster phenocrysts	Around 40° (measured 40° - 45°)
5	Uk110124-02SP05	West Dila: Walem hill	Highly Welded-Tuff（Ob-Wt)/ Glassy Welded Tuff	22.55Ma±0.65Ma	Pale brown glass with sanidine, clino-pyroxene, Fe-Ti minerals.	Valcanic rocks, pumice. Both contain sanidine crystals.	Slightly altred overall	None	Observed in large clino-pyroxene phenocrists	Glass, pyroxene, Fe-Ti minerals	Calsbad type simple twin	Some are over 40° (measured 40° - 60°)						
6	Uk110129-02SP06	West Asela: Deneba	Strongly Green Welded-Tuff/ Felsic Welded Tuff	0.22Ma±0.04Ma	Brown glass with sanidine, ampibole, biotite, Fe-Ti minerals. The glass is moderately recrystalized overall.	Volcanic rocks, tuff, altered volcanic rocks.	Slightly altered	None	None	Glass, Fe-Ti minerals	Carlsbad type simple twin	Less than 40° (measured 0° - 40°)						
7	Uk110127-01SP07	Lake Shala East wall	Strongly Green Welded-Tuff/ Felsic Welded Tuff	1.35Ma±0.05Ma	Brown glass with sanidine, ampibole, Fe-Ti minerals.	Vlocanic rocks, tuff. Some volcanic rocks are altered and some contain clino-pyroxene phenocrysts. Anorthoclase phenocrysts in tuff fragments.	Fresh	None	None	Glass, Fe-Ti minerals	Carlsbad type simple twin	Less than 40° (measured 15° - 40°)	Fresh	None	None	None	clustered twin	Around 40° (measured 40° - 45°)
8	Uk110125-01SP08	Kulito: along Riv.Bilate	Strongly Green Welded-Tuff/ Felsic Welded Tuff	0.19Ma±0.02Ma	Brown glass and slightly altered.	Volcanic rocks, tuff. Many are altered. Contain relatively mafic volcanic rocks and many clino-pyroxene crystals.	Slightly altered	None	None	Glass, amphibole, biotite, Fe-Ti minerals	Carlsbad type simple twin	Less than 40° (measured 15° - 30°)						
9	Uk110124-03SP09	West Hantate: Balto Quarry	Strongly Green Welded-Tuff/ Biotite Rhyolitic Welded Tuff	2.33Ma±0.05Ma	Brown glass with sanidine, biotite, amphibole, Fe-Ti minerals. The glass is recrystalized overall.	Volcanic rocks. Many are altreed	Fresh	None	None	Glass, biotite	Carlsbad type simple twin	Some are over 40° (measured 40° - 60°)						
10	Uk110124-01SP10	West Dila: Walem Quarry	Strongly Green Welded-Tuff/ Felsic Welded Tuff	0.91Ma±0.03Ma	Brown glass with sanidine, biotite, ampibole and Fe-Ti minerals.	Volcanic rocks. Contains sanidine as phenocrysts	Fresh	None	None	Glass, biotite	Carlsbad type simple twin	Less than 40° (measured 30° - 40°)						

No 1 - No.2 : Kulmusa Highly Welded Tuff
No 6 - No 10: Gonde Strongly Green Welded Tuff