

Ethiopia 2018 Fieldwork – Outcrop details

Frank Zwaan, Nov 2018

Field_stops.pdf provides the general overview of stops from the 2018 Ethiopia field campaign. The list includes various points that have no direct geological importance, these are skipped here. Additional information can be found in the main Data Description file (via Dataset DOI).

Abbreviations:


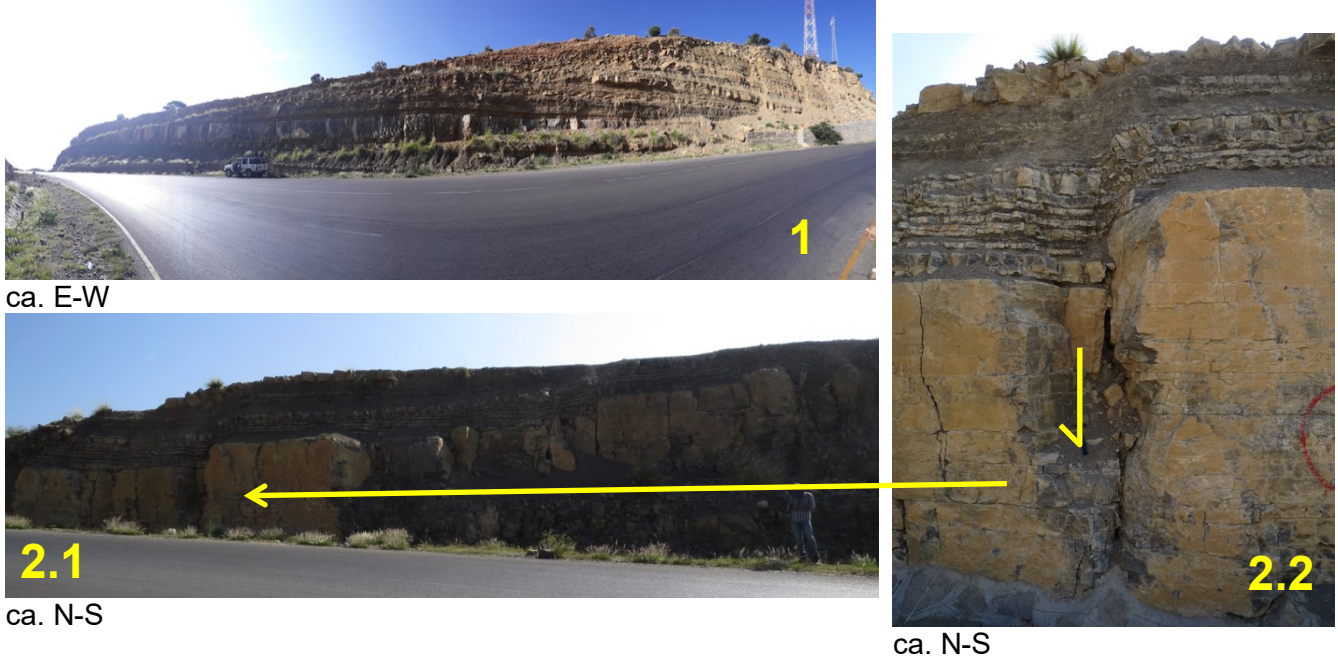
(GPS) (FS: GPS points taken by) Federico Sani, (GPS) GC: (GPS points taken by) Giacomo Corti, MBF: main boundary fault, Paper: [Zwaan et al. \(2019\) Tectonics](#), WGS84: World Geodetic System 1984.

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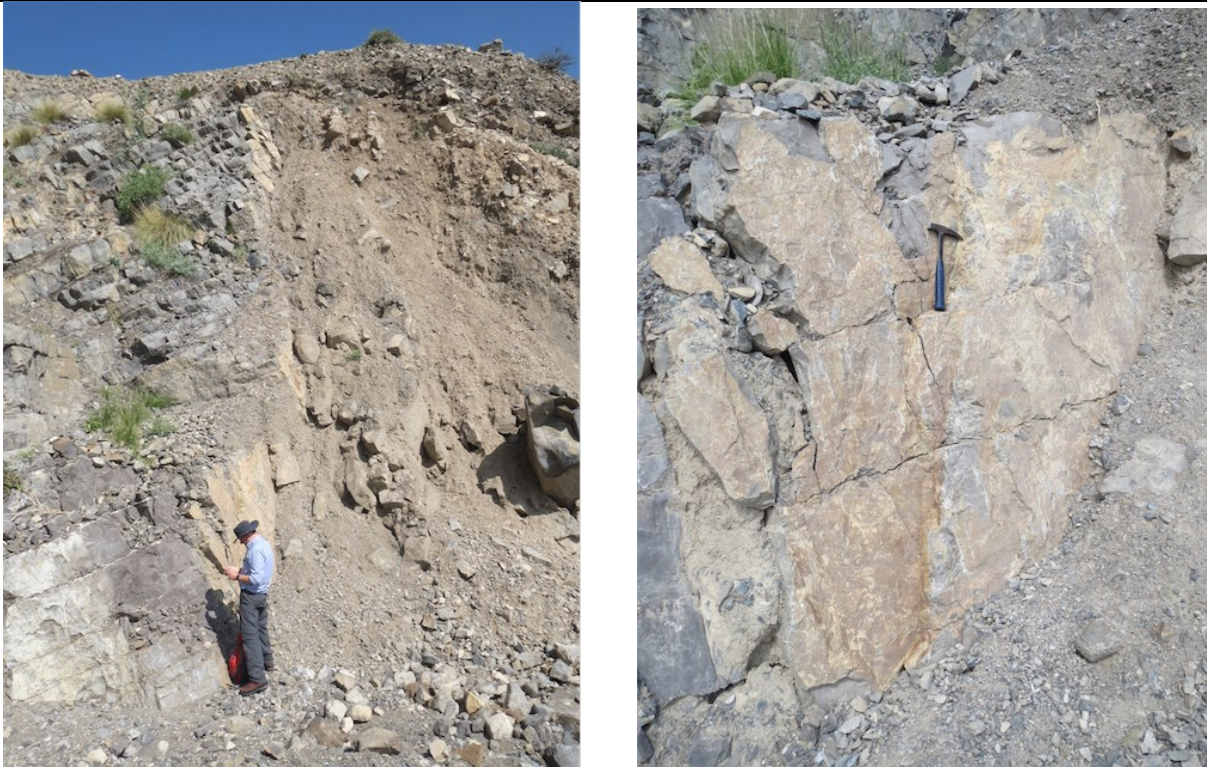
Stop 2 – Point 1.1 - First outcrop: roadcut in Jurassic units

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
1	7 Nov	2(-5)	1.1	245(-248)	13.364244°	39.709006°		First outcrop: roadcut in Jurassic units
Map view (Google Earth)					Picture			
					 <p>ca. E-W</p> <p>2.1</p> <p>ca. N-S</p> <p>2.2</p> <p>ca. N-S</p>			
Description					Fault measurements/observations			
<p>Large roadcut on road to Abala (1)</p> <p>Thickbedded (10-100 cm) Jurassic limestones with fossils (bivalves) and interbedded sequences of marl/mud.</p> <p>layer dip: 084°/04° and 290°/06° (sub-horizontal) at (1)</p> <p>layer dip: 195°/09° at (2)</p>					<p>Bit down the road at (1): a ca. N-S striking normal fault covered by Jurassic undisturbed strata → Jurassic synsedimentary deformation?</p> <p>In the curve (2), a series of three ca. E-W striking normal faults with ca. 50 cm offset in the Jurassic (3). These faults are lower in stratigraphy than the units at (1), thus cutting older strata → also syn-sedimentary? Also, their ca. E-W orientation is perpendicular to the rift trend: 329°/79° (first 2 faults) and ca. 340°/90° (3rd fault plane)</p>			
					<p>Additional fault measurements:</p> <p>327°/75° + 77°</p> <p>338°/85° + 80°</p> <p>270°/87° - 88°</p> <p>347°/85° - 85°</p> <p>185°/65° + 85°</p> <p>185°/60° + 75°</p> <p>329°/79° + 79°</p> <p>329°/79° + 79°</p> <p>340°/90° + 90°</p>			


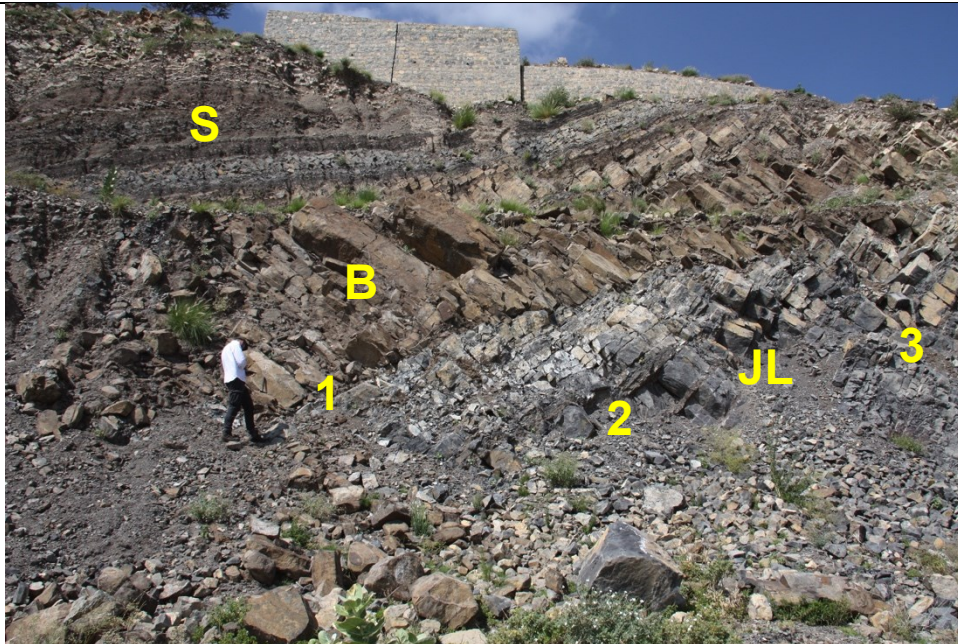
Stop 6 – Panorama point east of Abala

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
1	7 Nov	6	-	249	13.357443°	39.733321°		Panorama point east of Abala
Map view (Google Earth)					Picture			
								
					View to NE-E			
Description					Fault measurements/observations			
View to the N to a river incision exposing massive Jurassic, and to the E, into the Abala Basin					-			



Stop 7 – Point 1.2 - Normal fault near MBF

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
1	7 Nov	7	1.2	250	13.351897°	39.743987°		Normal fault near MBF
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
A ca. N-S striking normal fault (parallel to the nearby Abala Basin main boundary fault), with to the west Jurassic strata and to the east breccia					Fault plane measurements (FZ): <ul style="list-style-type: none"> • 088°/77° + 80° • 080°/76° + 80° • 085°/73° + 84° • 095°/81° (fault plane) and 075°/72° (striae by FZ) (pitch: +86°) 			


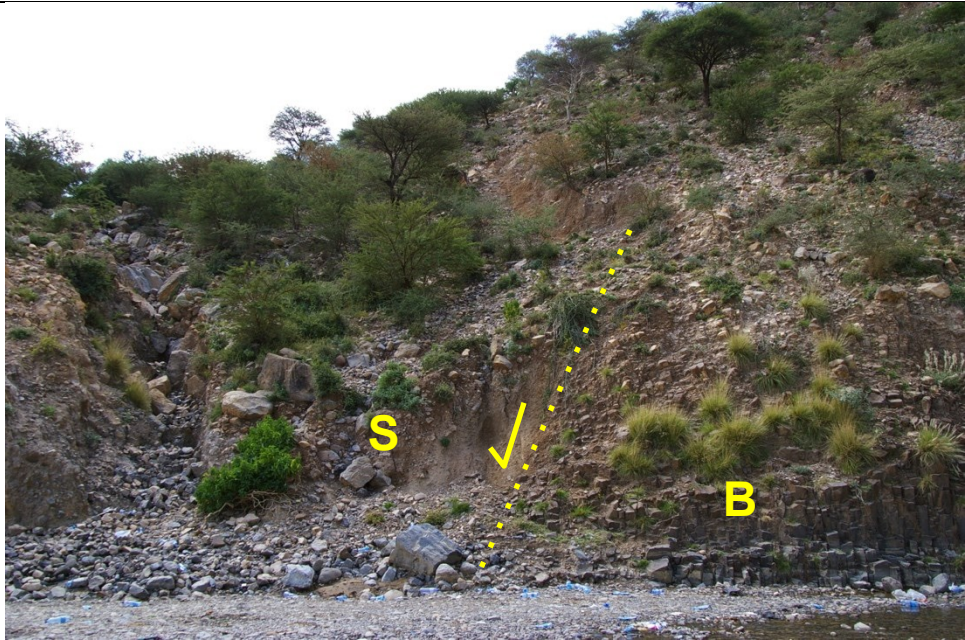
Stop 8 – Point 1.3 - Columnar basalts within Jurassic

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
1	7 Nov	8	1.3	251	13.350103°	39.744677°		Columnar basalts within Jurassic
Map view (Google Earth)					Pictures			
					 <p>photo orientation: ca. SW-NE</p>			
Description					(Fault) measurements/observations			
<p>Tilted columnar basalts (B), discordant on underlying tilted Jurassic limestones (JL) and covered by (concordantly?) overlying Jurassic? sediments (S)</p> <p>Is this a syn-rift intrusion or a Jurassic lava flow?</p> <p>→ it is tilted to the west it seems? (also the columns)</p> <p>What does the tilting indicate? Synrift deformation? or pre-rift Jurassic tectonics?</p>					<ul style="list-style-type: none"> Basalt/underlying strata contact: 176°/34° (1) Tilted Jurassic strata (2): 190°/22° Tilted Jurassic strata (3): 208°/53° and 215°/42° (ca. SW dipping) 			




Stop 15 – Point 2.1 - Big river incision in MBF behind Abala

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	15	2.1	258	13.360189°	39.745971°		Big river incision in MBF @ Abala
Map view (Google Earth)					Picture			
					 <p>Left: ca. S-N , right: ca. E-W oriented</p>			
Description					Fault measurements/observations			
<p>Large incision in main boundary fault at Abala.</p> <p>We see a large “bowel” dike structure (as in models by Olivier Galland), that are partially parallel to the stratigraphy and partially break trough the strata (1)</p> <p>Lots of locals washing/taking water → we need a local official</p>					<p>No fault plane visible, probably covered by debris (2). Erosion may also have affected the situation → retreating fault scarp? Potentially less active fault?</p>			



Stop 16 – Point 2.2 - Big river incision in MBF south of Abala

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	16	2.2	259	13.329172°	39.746686°		Big river incision in MBF south of Abala
Map view (Google Earth)					Picture			
								
Description					orientation: ca. E-W			
A contact between sediments (S, basin infill, coarse material, reddish) and altered basalts (B, a bit further upstream the basalts are well preserved).					Fault measurements/observations			
There we also observe how the basalts form intrusions ± parallel to the massive Jurassic strata (which are ca. horizontal)					The fault plane is too altered to discern to detect striae, but we find it where we expect the main boundary fault and it has the same orientation!: 084°/65°			
					Measurement on other side of river (?): 100°/65°			





Stop 18 – Point 2.3 - Ridge between Abala & Teru Basins

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	18	2.3	261	13.297246°	39.823783°		Ridge between Abala & Teru Basins
Map view (Google Earth)					Picture			
					 View to north (Abala Basin): apparent westward dipping Jurassic strata  View to south (Teru Basin): apparent westward dipping Jurassic strata			
Description					Fault measurements/observations			
Panorama point on the ridge between the Abala and Teru Basin. We observe tilted Jurassic strata to the north and south. The inclination seems westward, in agreement with synrift tilting. The tilting is however southward on the ridge itself (thick-layered limestones with shell fossils: 195°/20°)					No fault measurements, but the tilted strata may indicate a) synrift tilting, b) pre-rift tilting or a combination... They do give a strong impression of tilted blocks though → watch out when interpreting! (especially given the previous outcrops with pre-rift deformation evidence: 1.1) The poorly accessible Teru basin features seem quite eroded thus potentially tectonically inactive...			


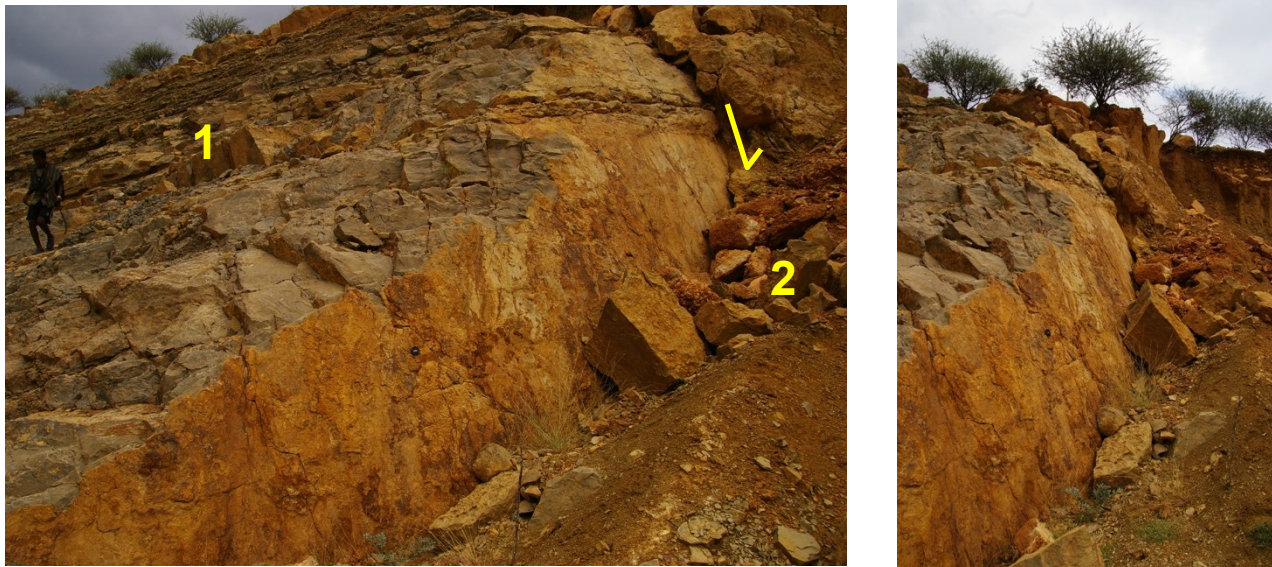
Stop 19 – Point 2.4 - Fault visible in roadcut between Abala and Teru Basins

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	19	2.4	262	13.275122°	39.828552°		Fault visible in roadcut
Map view (Google Earth)					Picture			
					 <p>Measurements: 250°/78° + 78° 235°/70° + 80° 240°/75° - 80° 245°/60° + 65° 250°/77° + 85° 243°/70° + 85° 248°/55° - 85° 253°/70° - 85° 237°/62° - 82°</p> <p>Dextral strike-slip! 235°/58° - 10° 250°/76° - 25°</p> <p>We observe first dextral strike-slip, then normal faulting! (age is unknown, but normal faulting is likely syn-rift. Strike-slip could be pre-rift or early synrift → Chorowicz et al. 1999).</p>			
Description					View: ca. W-E			
Nice fault along the road, cutting the Jurassic. Jurassic strata: 095°/15° (eastward dipping!)					Fault measurements/observations			
					West of the fault: broken Jurassic, east of the fault, intact strata. Poorly developed striae			


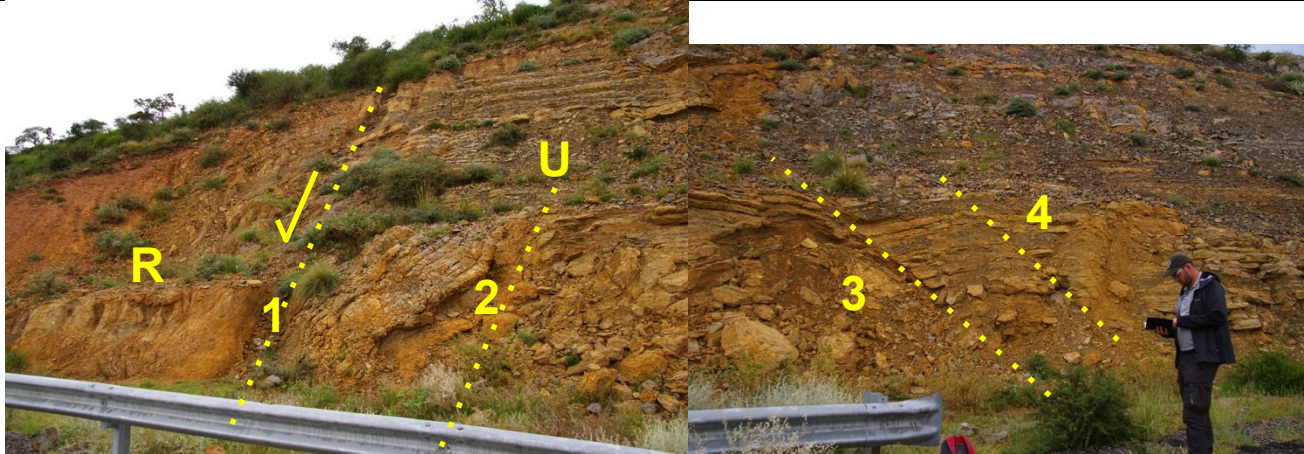
Stop 20 – Point 2.5 - Large fault in Jurassic along road

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	20	2.5	263	13.280766°	39.828414°		Large fault in Jurassic along road
Map view (Google Earth)					Picture			
 <p>Road to NW!</p>					  			
Description					Fault measurements/observations			
Large fault along the road in Jurassic (1) with and NW-SE strike, which also shows rotated blocks it seems, tilted toward the ± S or SE (2). NB: Like in the previous outcrop, we observe a shift from transversal/strike-slip motion to normal faulting					Main fault with well-developed striae: 035°/75° with pitch varying between 0 and +25° 038°/80° - 70° 035°/80° - 25 (dextral) 035°/80° + 85° (nice normal)		Photo striae relationships (3): 045°/65° - 30° (normal) 045°/65° - 55° (normal, sinistral) 045°/65° + 80° (normal)	




Stop 21 – Point 2.6 - E-W normal fault in Jurassic sediments

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	21	2.6	264	13.285701°	39.826859°		E-W normal fault in Jurassic sediments
Map view (Google Earth)					Picture			
					 <p>View ca. N-S</p>			
Description					Fault measurements/observations			
<p>E-W normal fault in Jurassic sediments. North of fault: clean Jurassic strata (1), south: messy rubble (carbonates, 2) Well-defined fault, but orientation is perpendicular to rift trend. We observe striae and fault breccia, age of faulting is not constrained, but probably of pre-rift phase (see orientation of regional E-W faults in Jurassic on geological maps)</p>					<p>190°/65° - 85 192°/75° - 87° 188°/70° - 85° 200°/65° + 90° 205°/70° + 90° 200°/50° - 70°</p>			


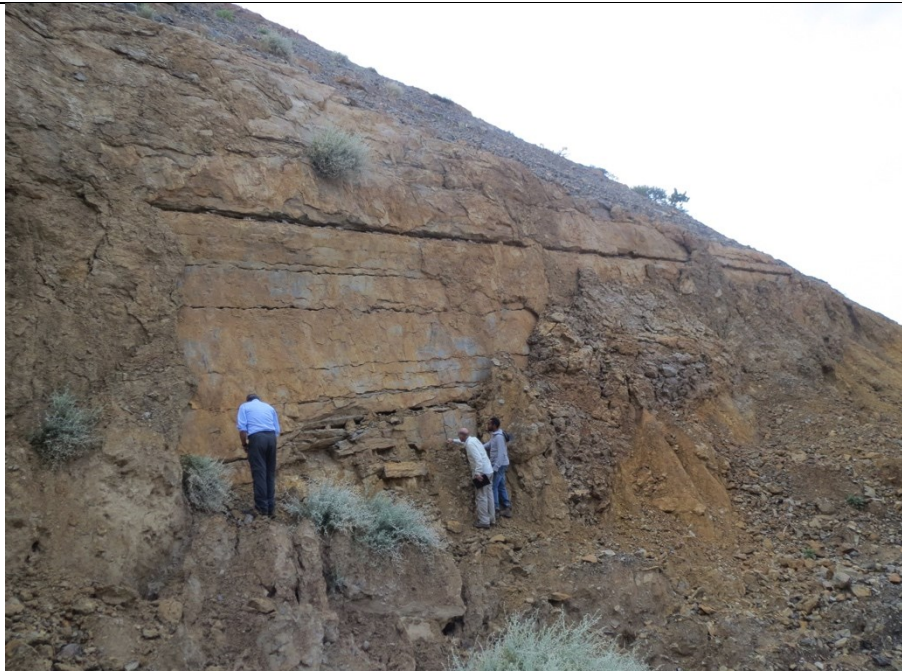
Stop 22 – Point 2.7 - Fault on road to Berhale

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	22	2.7	265	13.423969°	39.863124°	07	Fault on road to Berhale
Map view (Google Earth)					Picture			
					 <p>View: ca. W-E</p>			
Description					Fault measurements/observations			
<p>Relatively intact Jurassic strata (U) on footwall, and carbonate rubble on hanging wall (R). Striae + cataclasts/fault breccia Note the various orientations of the various faults.... Still the main fault aligns well with the regional rift trend (and the faults interpreted from DEM and satellite imagery)</p>					<p>Main fault (1): 289°/55° + 82° 275°/75° + 75° 265°/70° + 70°</p>	<p>Secondary fault (2): 108°/88° - 70° 102°/72° - 70°</p>	<p>Another large normal fault (incl. dragged strata 3): 195°/35° - 88° 198°/30° - 85°</p>	<p>Another minor fault (4): 210°/40° - 75°</p>




Stop 23 – Point 2.8 - Fault on road to Berhale

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	23	2.8	266	13.436628°	39.856025°	08	Fault on road to Berhale
Map view (Google Earth)					Picture			
					 			
					Orientation ca. E-W			
Description					Fault measurements/observations			
Another fault in the Jurassic → eastward dipping! Jur strata to the W, rubble to the E					088°/66° + 80° 095°/46° + 80° 100°/42° + 70° 082°/45° - 86° 085°/40° + 75°	075°/45° + 70° 090°/72° - 77° 102°/50° + 85°		



Stop 24 – Point 2.9 - Fault on road to Berhale

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	24	2.9	267	13.442214°	39.856008°	09	Fault on road to Berhale
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Further north from stop 23 – Point 2.8 in Jurassic Same fault as previous point it seems, small quarry?					075°/78° + 80° (very nice fault with microbreccia, steps, striae) 073°/75° + 80° 075°/75° ± 90° 080°/75° + 78°			75°/80° + 75°




Stop 25 – Point 2.10 - Fault on road to Berhale

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
3	9 Nov	25	2.10	268	13.412517°	39.856988°	10	Fault on road to Berhale
Map view (Google Earth)					Picture			
					 			
Description					Fault measurements/observations			
Outcrop in Jurassic along interpreted fault					245°/64° + 75° 260°/70° + 80° 225°/70° - 77° (little deflection) 080°/86° + 88°			
Observations of this day: <ul style="list-style-type: none"> Fault breccia is often seen on the hanging wall. There are signs of compression in the Jurassic → post-sedimentary compression? (it seems there is also syn-rift extension) The faults we observe here create topography and were therefore likely recently active (there is a pre-flood basalt peneplain/laterite horizon, indicating that the pre-rift topography was flat) 								



Stop 26 – Point 3.1 - Fault on road to Berhale

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
4	10 Nov	26	3.1	269	13.474332°	39.867624°	11	Fault on road to Berhale
Map view (Google Earth)					Picture			
								
Description					Pictures: ca W-E oriented Fault measurements/observations			
Fault in quartzite layers intercalated with muddy shales → Triassic or basement?					Fault: 070°/85° (no striae) Layers: 343°/08°			





Stop 27 – Point 3.2 - Fault on road to Berhale

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
4	10 Nov	27	3.2	270	13.485969°	39.871661°	12	Fault on road to Berhale
Map view (Google Earth)					Picture			
					 			
Description					Fault measurements/observations			
Bowel-shaped intrusion in quartzite layers Various normal faults a bit higher up the road, offsetting near-vertical dikes No striae Along the road north to Berhale, we observe a lot of dikes in the Jurassic and quartzite layers. The dikes seem to be ca. N-S, parallel to the rift? Question: what is the age of the faults in the quartzite? (if they create topography and are parallel to the rift, they may be syn-rift)					085°/80° 240°/46° 257°/42° 065°/75° 080°/80° 065°/78° 065°/75° 280°/55° 265°/74° - 85° (fault with 2 m offset)			



Stop 28 – Point 3.3 - Fault on road to Berhale

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
4	10 Nov	28	3.3	271	13.648923°	39.868427°	13	Dike intruded in basement
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Large dike (basalt) intruding in basement (schists) Contact with basement: 080°/75° → synrift?					Picture: ± S-N			



Stop 29 – Point 3.4 - Dike at road junction Abala/Berhale/Wikro

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
4	10 Nov	29	3.4	272	13.654454°	39.868905°	14	Dike at road junction Aba/Berhale/Wikro
Map view (Google Earth)					Picture			
					 view ca. E-W			
					 Junction			
					 View ca. W-E			
Description					Fault measurements/observations			
Big dikes running ca. N-S it seems (can be related to point 3.3 and the large N-S features seen on DEM!) Potentially syn-rift structures?					Measured north of junction (1)		Measured south of junction (3)	
					090°/75° 085°/72° 82°/82°	080°/75° 084°/82° 80°/80°	092°/80° 089°/77°	094°/78° 083°/81°




Stop 32 - Berhale area

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
4	10 Nov	32		275	13.925451°	40.035107°		Northernmost point of expedition
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
The area round berhale consistst of basement, mainly shists that are quite weak and eroded. We do not find any useful fault planes in this badland environment. The dominant foliation/schistosity seems however to be dipping to the NE (ca. 45°), which may indicate tilted fault blocks? → caution however, we do not know if the foliation used to be horizontal!								
We do not manage to reach the Jurassic strata in the Garsat Basin to the north.								



Stop 33 – Point 3.5 - Adigrat sst outcrop on road to Wikro

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
4	10 Nov	33	3.5	276	13.650517°	39.846081°	Point, no code	Adigrat sst outcrop on road to Wikro
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Massive red Triassic sandstone, fluvial deposits with prograding structures, deposited on metamorphic basement. Equivalent of Bundsandstein or Verrucano in Europe → postvariscan deposits					Various planes, that may be joints or faults? (no striae!) 060°/50° 090°/80° 100°/65°			



Stop 34 – Point 3.6 - Adigrat sst outcrop on road to Wikro

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
4	10 Nov	34	3.6	277	13.650817°	39.841988°	15	Reverse fault in Adigrat sst
Map view (Google Earth)					Picture			
					  <p>orientation: ca. SW-NE</p>			
Description					Fault measurements/observations			
Reverse (!) fault in Adigrat sst → postdepositional (post-Jurassic?) compression? → pre-rift strata were potentially not horizontal, careful when interpreting! These reverse faults are very steep, potentially inverted normal faults?					127°/50° + 85° (all inverse) 120°/65° + 85° 137°/70° + 75° 135°/80° + 80° 140°/55° + 80° 130°/58° - 85° 300°/75° - 80° (conjugate inverse)			140°/60° + 88° 135°/58° + 86° 317°/82° + 72° (conjugate inverse) 122°/55° - 70° 127°/62° - 86°

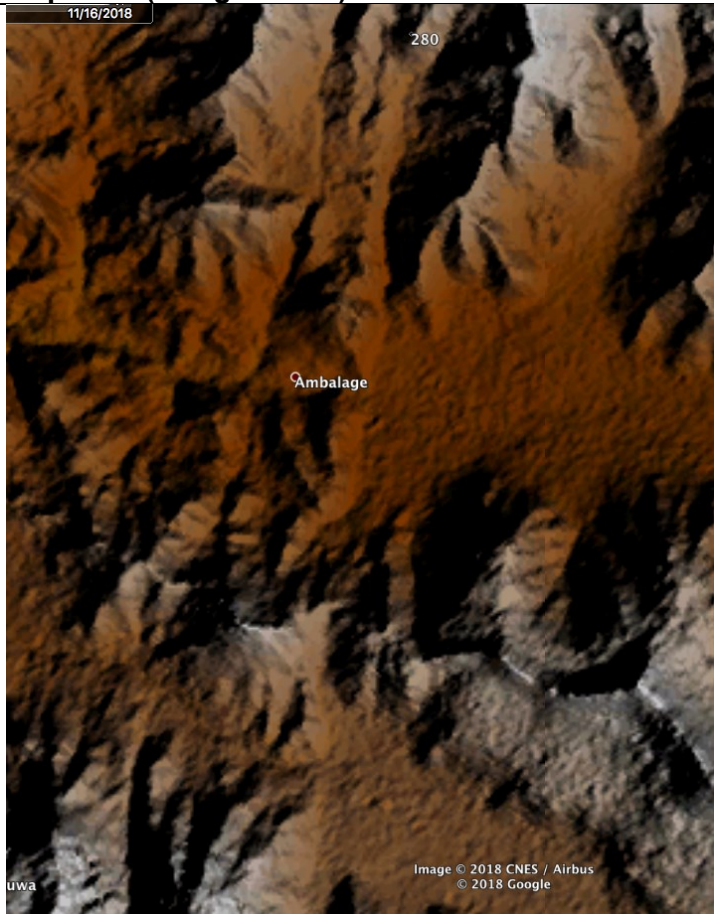
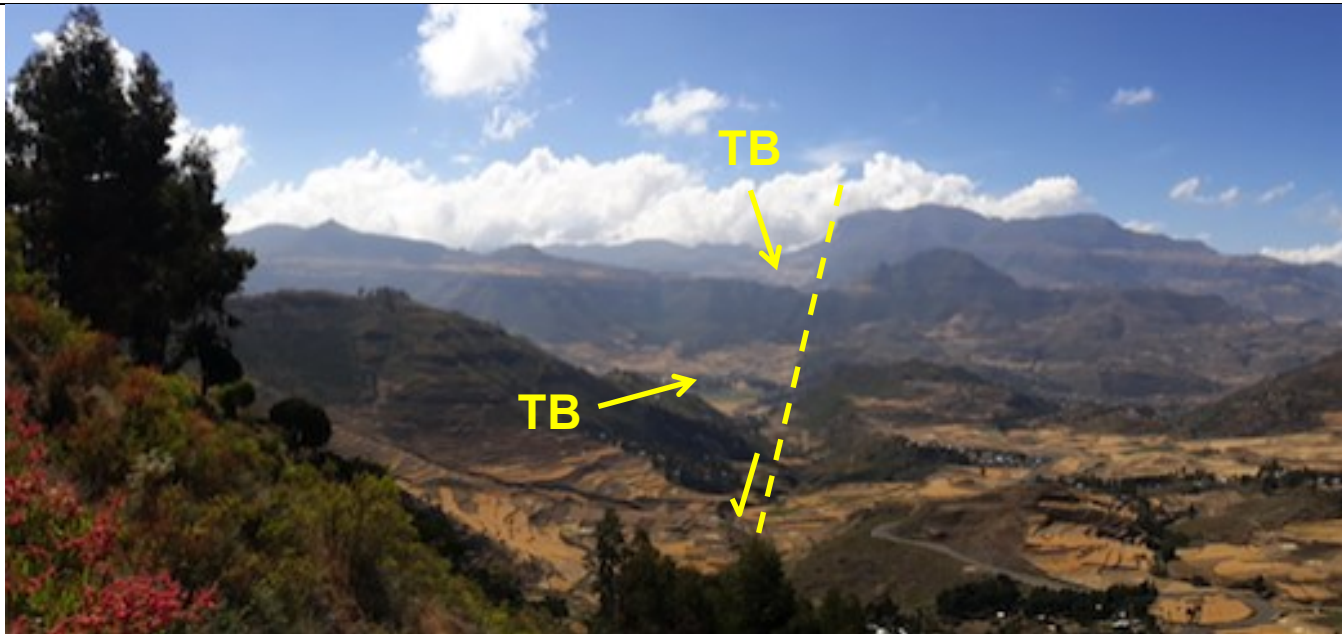
Stop 35 – Point 4.1 – Panorama point near Hiwane

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	35	4.1	278	13.116753°	39.497226°		Panorama point near Hiwane
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
<p>In the mountains to the south, we observe how Traps (T) are overlying and onlapping on more tilted Jurassic/Mesozoic (M) Sediments. It seems there was deformation before peneplanation and subsequent Trap layer formation.</p> <p>The traps here cover quite some Mesozoic → how far did the Mesozoic basin extend? (in the north, it is bounded by a normal fault contact with the basement → Arkins map, but here it is covered by volcanics!)</p>								

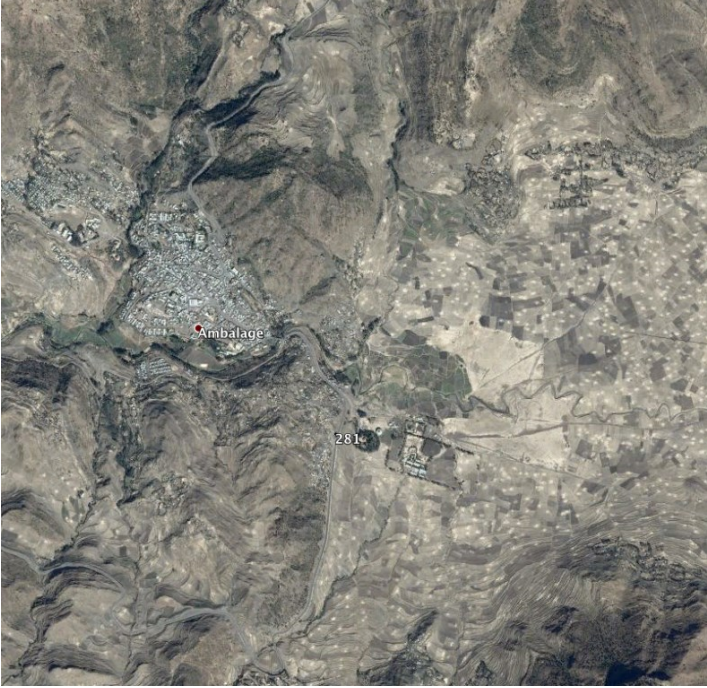

Stop 36 – Point 4.2 – Panorama point on road to Meychew

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	36	4.2	279	13.061729°	39.497762°		Panorama point on road to Maychew
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
View to the west, showing deformed (folded) Mesozoic (M) below Trap cover that form the mountain tops (T). Also here the question: how far did the Jurassic/Mesozioc deposits exist?								


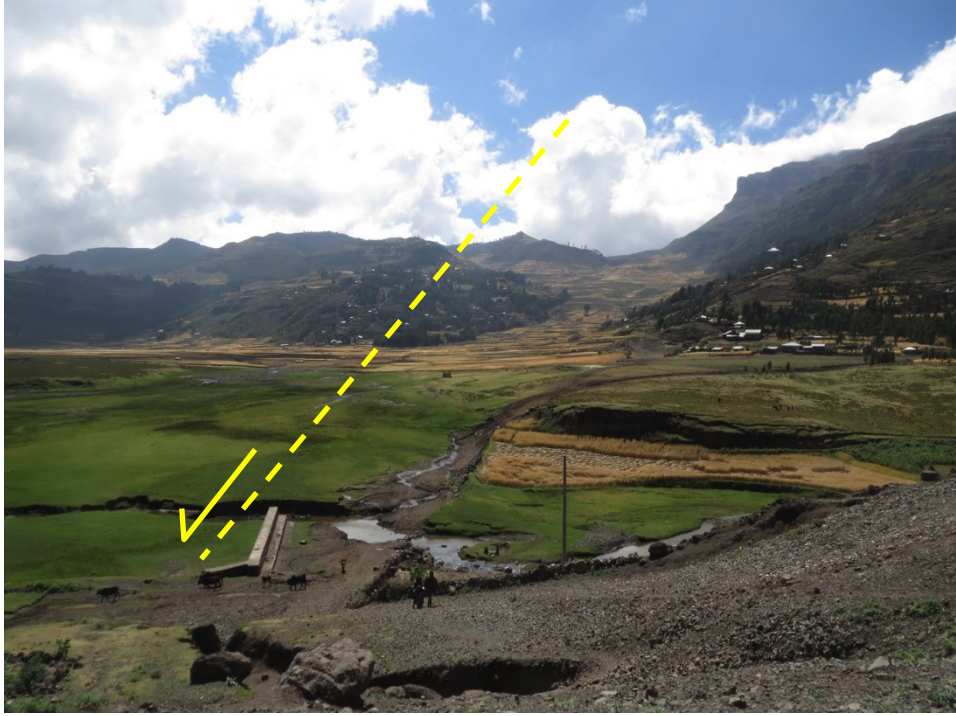
Stop 37 – Point 4.3 + 4.4 – Panorama point of Ambalage fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	37	4.3/4.4	280	12.967431°	39.528491°		Panorama point of Ambalage fault
Map view (Google Earth)					Picture			
					 <p>View: E-W</p>			
Description					Fault measurements/observations			
<p>View to the South, revealing the two triangular basins (TB) of the Ambalage fault</p> <p>It seems like the traps in the background are also affected: tilted blocks due to Ambalage fault activity.</p> <p>Triangular basins are the result of a normal fault cutting a V-shaped valley, thus creating a triangular depocenter where sediments accumulate.</p>								

Stop 38 – Point 4.5 –Ambalage fault



Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	38	4.5	281	12.928489°	39.523116°	16	Ambalage fault
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Outcrop on the Ambalage fault (basalts).					Fault plane with striae 113°/77° + 75° 120°/75° +85° 090°/60° (plane only) 093°/75° + 80° 087°/73° - 65° 092°/72° +82° 095°/55° + 83° 103°/85° - 80° (ugly)		Apparent reverse fault, which may be part of an undulated normal fault surface? 290°/70° + 65° 285°/80° + 85°	Slightly oblique fault in basalts (due to columnar structures in basalt?) 055°/77° - 85° 070°/48° + 78°

Stop 39 – Point 4.6 – Second basin on Ambalage fault



Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	39	4.6	282	12.896378°	39.519347°	17	Second basin on Ambalage fault
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Outcrop on the Ambalage fault (basalts). Second basin, south of Ambalage. The fault itself seems to be situated a bit into the basin, where the same sediments seem to be offset by the fault → could be tested using topography sections, see picture!					<p>Fault footwall: basalts, hangingwall: fault breccia</p> <p>105°/70° - 86° (ugly plane)</p> <p>100°/70° - 85° (ugly plane)</p> <p>090°/67° - 85° (nice plane)</p> <p>195°/65° - 87° (minor antithetic plane)</p> <p>070°/55° + 70° (idem)</p> <p>225°/70° (idem, but no striae)</p>			

View: E-W

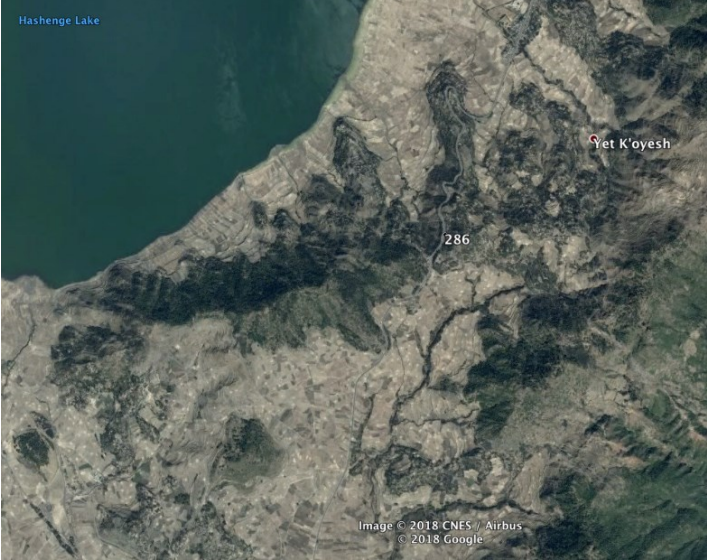

Stop 40 – Point 4.7 – Panorama view into Kobo basin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	40	4.7	283	12.844972°	39.566592°		Panorama view into Kobo basin
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
View to the east into Kobo Basin								



Stop 42 – Point 4.8 – Panorama view into Kobo basin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	42	4.8	285	12.566348°	39.523872°		Panorama view over Lake Hashenge
Map view (Google Earth)					Picture			
					 <p>View: S-N</p>			
Description					Fault measurements/observations			
View to the west over Hashenge basin/lake with large boundary faults in the background								

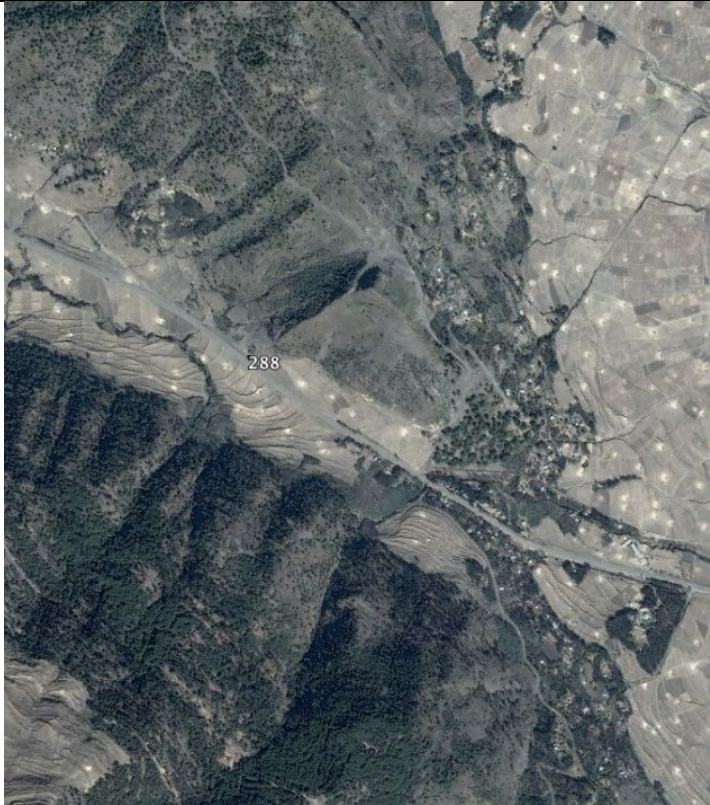

Stop 43 – Point 4.9 – Western BF of Hashenge basin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	43	4.9	286	12.560264°	39.523166°	18	Western BF of Hashenge basin
Map view (Google Earth)					Picture			
								
View: ca. E-W and W-E								
Description					Fault measurements/observations			
Western BF of Hashenge basin in basalt					Normal fault with striae and in some cases steps.			
The Lake lies towards the west and the plain seems to dip towards the west (making the MBF difficult to reach) → indications of fault activity and a dominant BF in the west (quite obvious from the strong topography difference between the plateau and the Hashenge basin)					285°/50 – 85° 285°/60° - 85° 282°/50° - 82° 310°/53° - 70° 300°/55° - 85° 302°/60° - 85°			
					277°/86° + 85° 125°/75° + 70° 282°/50° - 60° 305°/62° - 71° 280°/72° - 82° 290°/65° - 55° 278°/48° - 40°			

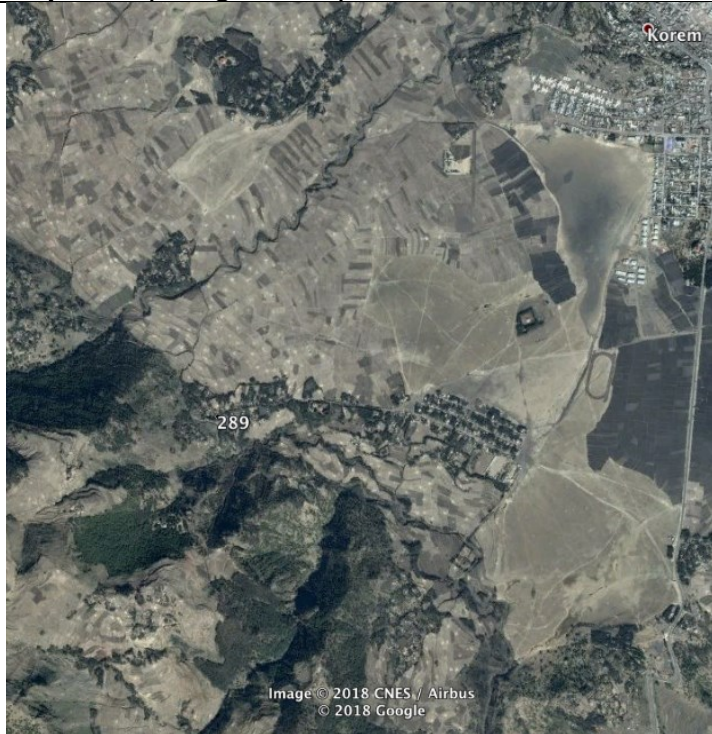

Stop 44 – Point 4.10 – Photo of Western BF of Hashenge basin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	44	4.10	287	12.519559°	39.486632°		Panorama of MBF (Hashenge Basin)
Map view (Google Earth)					Picture			
								
Description					view: W-E			
Fault measurements/observations								



Stop 45 – Point 4.11 – Outcrop near MBF (Hashenge Basin)

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	45	4.11	288	12.523768°	39.479168°	19	Outcrop near MBF (Hashenge Basin)
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			View W-E
Small outcrop in incision perpendicular to main BF, basalts.					Synthetic + antithetic normal faults + striae and incongruent steps (typical for basalts, as in Iceland (FS)), but oblique to BF!?			
					315°/60° + 75°			
					310°/65° + 80°			
					130°/ 68° - 87°			
					290°/85° - 87°			


Stop 46 – Point 4.12 – Outcrop near MBF (Hashenge Basin)

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
5	11 Nov	46	4.12	289	12.491339°	39.501815°	20	Outcrop near MBF (Hashenge Basin)
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
<p>Eroded basalt outcrop near boundary fault → altered volcanics</p> <p>Orientations may be a bit off → columnar basalt influence?</p>					<p>038°/80° - 80° 023°/63° - 73°</p>			<p>Planes with quite nice striae 180°/75° - 84° 215°/65° + 84° (conjugate to MBF?) 195°/80° + 75°</p>

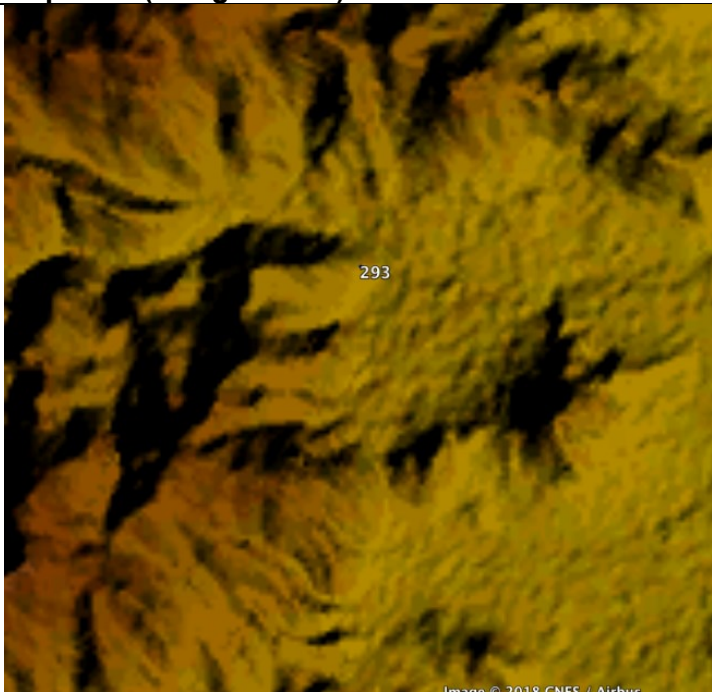

Stop 48 – Point 5.1 – Road to Mahoni

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
6	12 Nov	48	5.1	291	12.775328°	39.558916°	21	Road to Mahoni
Map view (Google Earth)					Picture			
								
Description					orientation? Fault measurements/observations			
Fault plane with very nice striae in volcanics/basalts					160°/70° + 84° 030°/72° + 80° 012°/73° 130°/75° + 77° 270°/80° + 85° 277°/78° + 86°			

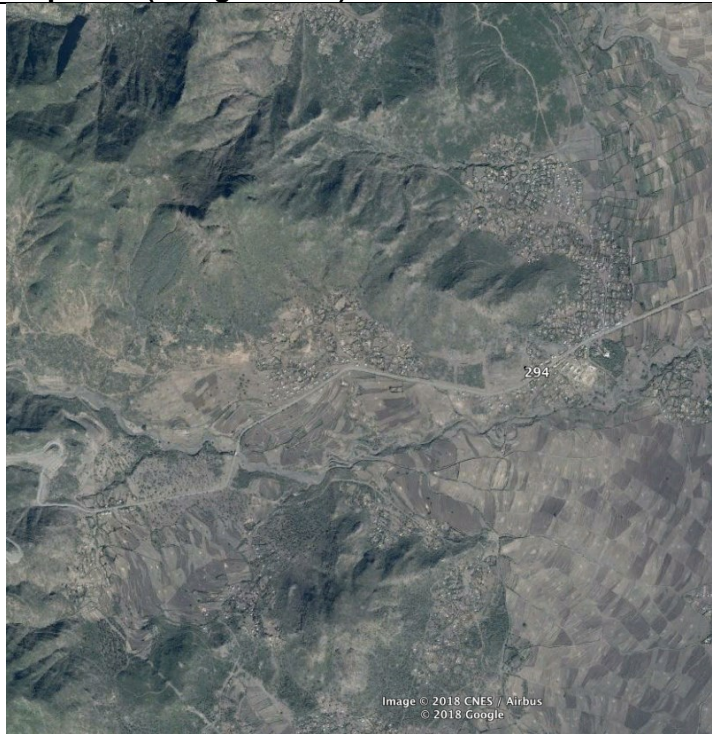

Stop 49 – Point 5.2 – Road to Mahoni

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
6	12 Nov	49	5.2	292	12.769619°	39.591035°	22	Road to Mahoni
Map view (Google Earth)					Picture			
					No photo?			
Description					Fault measurements/observations			
Outcrop in volcanics with potential faults/fractures (oblique to MBF?)					047°/55° 052°/65° + 85° 032°/42° 055°/50° + 82° 010°/60°			



Stop 50 – Point 5.3 – Big fault on road to Mahoni

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
6	12 Nov	50	5.3	293	12.775577°	39.594529°	23	Big fault on road to Mahoni
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Outcrop at slope break → large fault. Whole western Kobo Basin seems strongly eroded (tectonically inactive?) and lacking nice fault outcrops					<div>085°/65°</div> <div>050°/67°</div> <div>055°/72°</div> <div>060°/83°</div> <div>103°/70° + 80°</div> <div>100°/80° - 87° (mineral steps)</div> <div>075°/72°</div> <div>080°/63° + 85°</div>			

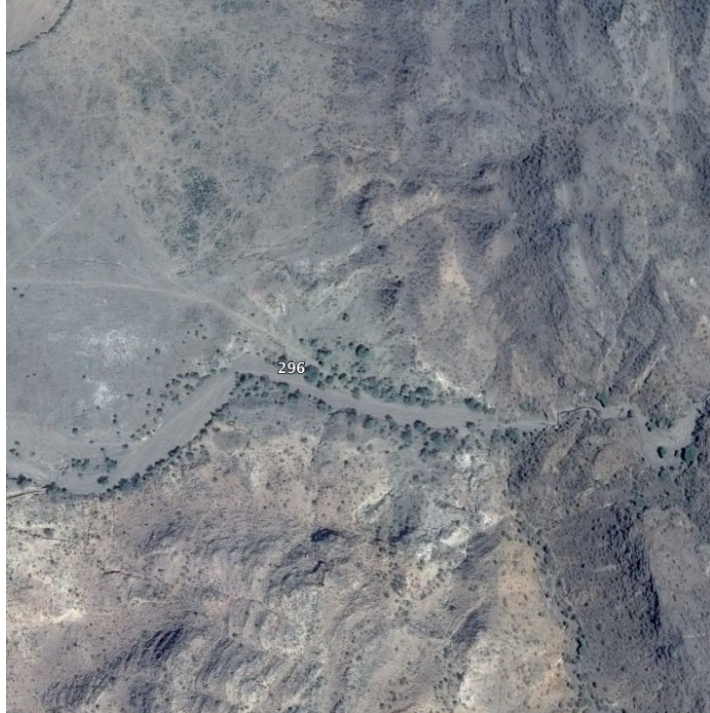

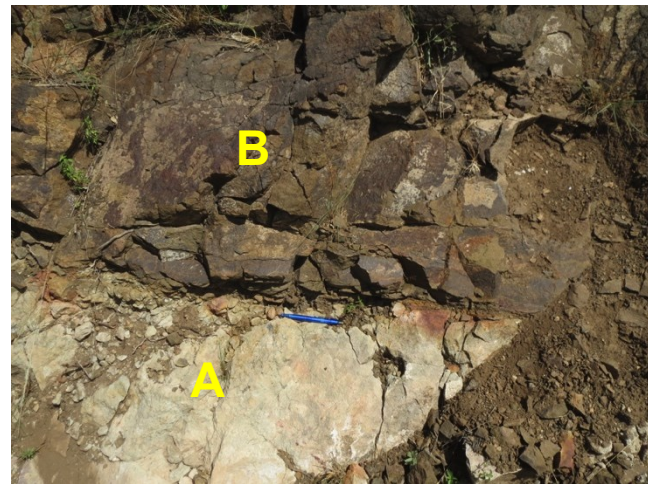
Stop 51 – Point 5.4 – Final edge of Western Kobo margin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
6	12 Nov	51	5.4	294	12.778730°	39.616549°	24	Final edge of Western Kobo margin
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
<p>Final fault interpreted at western margin of Kobo basin</p> <p>We observe that the main active fault west of the Kobo Basin seems to be west of the Hashenge basin. (overstepping the western Kobo Basin margin?)</p>					<p>Fractures (no kinematics) but possible indicators of rift trend?</p> <p>086°/85° 082°/85° 077°/78° 070°/75° 085°/75°</p>			

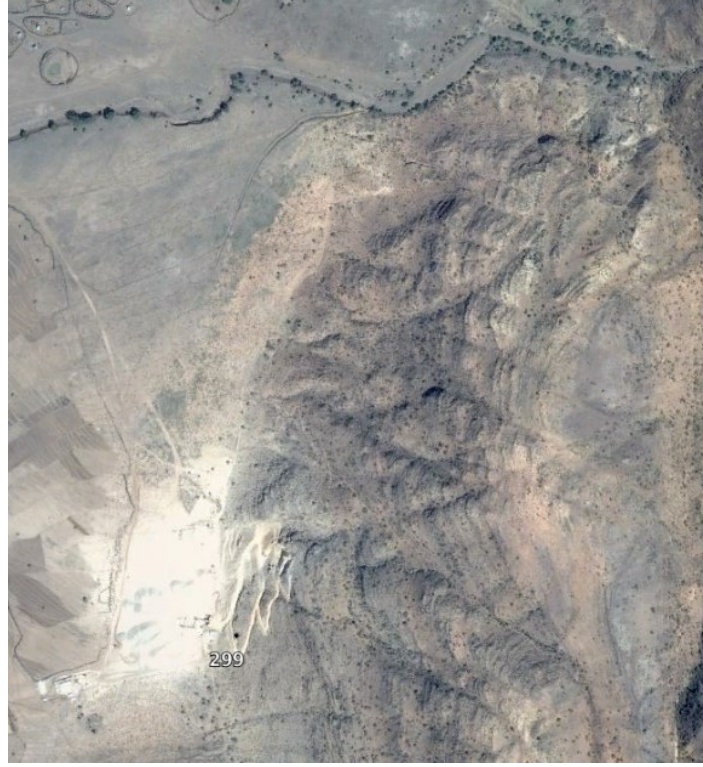

Stop 52 – Point 5.5 – Panorama of Eastern Kobo margin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
6	12 Nov	52	5.5	295	12.781488°	39.771012°		Panorama of Eastern Kobo margin
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Panorama It seems that the Kobo basin is dipping to the east a bit? (towards the fault below the basin found next day, see also satellite image!)								



Stop 53-55 – Point 5.6 – River incision on Kobo MBF

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks																		
6	12 Nov	53-55	5.6	296/97/98	12.741659°	39.816747°	25/26	River incision on Kobo MBF																		
Map view (Google Earth)					Picture																					
					 View to the NW 																					
Description					Fault measurements/observations																					
<p>Outcrop with Adigrat sst (A) underlying Basalts (B)!</p> <p>Adigrat sst dip: 060°/10° and 055°/15° (tilted to NW → tilted fault blocks?) near MBF of Kobo Basin</p> <p>Triassic Adigrat Sst have prograding sets. Coars sst with conglomerates up to ø 2cm, poorly to well-rounded clasts.</p> <p>We get the impression of multiple smaller normal faults/fault blocks, as we see the Traps again to the west, below the Adigrat sst.</p> <p>A bit downstream, we observe Kobo basin sediments onlapping on fractures Adigrat sst. Contact: 290°/50° (potential fault?)</p>					<table><tr><td>253°/65° + 60°</td><td>238°/88° + 82°</td></tr><tr><td>257°/75° + 60°</td><td>240°/65° + 65°</td></tr><tr><td>237°/70° + 60°</td><td>215°/70° - 67°</td></tr><tr><td>235°/68° + 80°</td><td>230°/78° + 70°</td></tr><tr><td>048°/75° - 65°</td><td>273°/55° + 78°</td></tr><tr><td>205°/85° + 80°</td><td>245°/60° + 70°</td></tr><tr><td>240°/67° + 65°</td><td>138°/72° - 82°</td></tr><tr><td>245°/70° + 62°</td><td></td></tr><tr><td>227°/67° + 70°</td><td></td></tr></table>				253°/65° + 60°	238°/88° + 82°	257°/75° + 60°	240°/65° + 65°	237°/70° + 60°	215°/70° - 67°	235°/68° + 80°	230°/78° + 70°	048°/75° - 65°	273°/55° + 78°	205°/85° + 80°	245°/60° + 70°	240°/67° + 65°	138°/72° - 82°	245°/70° + 62°		227°/67° + 70°	
253°/65° + 60°	238°/88° + 82°																									
257°/75° + 60°	240°/65° + 65°																									
237°/70° + 60°	215°/70° - 67°																									
235°/68° + 80°	230°/78° + 70°																									
048°/75° - 65°	273°/55° + 78°																									
205°/85° + 80°	245°/60° + 70°																									
240°/67° + 65°	138°/72° - 82°																									
245°/70° + 62°																										
227°/67° + 70°																										



Stop 57 – Point 5.7 – Panorama of Eastern Kobo margin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
6	12 Nov	56	5.7	299	12.729976°	39.810663°	27	Big quarry on eastern MBF of Kobo Basin
Map view (Google Earth)					Picture			
								
					View: W-E			
Description					Fault measurements/observations			
Big limestone quarry on MBF of Kobo basin. We observe the limestone layers (undeformed: 064°/28°) folded into the fault (photo). The limestones are stratigraphically above the Adigrat sst, but below the basalt Traps. → what is the extent of the Mesozoic? We see fans prograding into the plains → less active faults?					Normal faults with steps and striae + curved kinematic indicators	250°/60° + 70° 260°/65° + 60° 270°/68° + 63° 275°/55° + 60° 263°/47° + 40° 262°/65° + 62° 235°/48° + 85° 255°/75° + 76°	280°/68° + 74° (very nice) 263°/72° + 70° (very nice) 240°/85° + 90° (very nice) 262°/77° + 70° 288°/60° + 55° 252°/88° - 87° 273°/80° + 35° 298°/83° + 35°	293°/74° + 42° 290°/85° + 50°


Stop 58 – Point 6.1 – Quarry exposing basalt just below Kobo plain

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	58	6.1	301	12.652158°	39.757583°	Point, no code	Quarry with basement → fault
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Quarry on topographic step in Kobo basin (see DEM), exposes altered volcanic “basement” below 1-3 m of alluvial sediments (coarse, reddish and angular deposits, partially incising in the volcanic substratum)								
It seems that the MBF to the south continues here below the surface, reducing the activity to the large faults to the east.								
The volcanics are highly altered, potentially due to hydrothermal alteration → magmatic activity? Check the well logs that show high water temperatures								
What is the deep structure of the Kobo Basin? → well data and geophysical surveys! → to check with local geologists!								




Stop 59 – Point 6.2 – Car parking spot/small fault block

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	59	6.2	302	12.591998°	39.794399°	Point, no code	Car parking spot/small fault block
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Small fault. Traps on top of Jurassic limestone (folded into fault) and volcanics again downhill Strata dip: 072°/12° towards fault: 024°/06° No measurement of fault itself (no clear fault plane)								



Stop 60 – Point 6.3 – Trap layer

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	60	6.3	303	12.593078°	39.795950°	Point, no code	Trap layer
Map view (Google Earth)					Picture			
					none			
Description					Fault measurements/observations			
Small tilted block with trap layering tilting: 060°/10°								



Stop 61 – Point 6.4 – Large fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	61	6.4	304	12.594005°	39.797641°	28	Large fault
Map view (Google Earth)					Picture			
					 			
View: ca. W-E								
Description					Fault measurements/observations			
Important contact between volcanics to the west and limestone to the east → big fault					Possible secondary fault in basalts			
Fault plane not very clear, we measure on minor fault planes. The Jurassic limestones are folded towards the fault, which is hidden in a gully (regional limestone dip: 084°/29°)					<div> <div> 190°/68° - 75° 205°/62° - 70° 193°/72° - 82° 245°/55° + 65° 248°/70° + 70° </div> <div> 205°/65° 258°/60° + 85° 250°/77° + 80° 265°/50° + 75° 240°/55° - 87° 240°/57° + 65° 238°/70° - 85° </div> </div>			
Danger from goats causing rocks to fall!					<div> <div> Main fault: 225°/58° + 65° 225°/55° + 65° </div> <div> Larger fault in basalt: 245°/70° - 80° 230°/85° + 87° </div> </div>			
					Antithetic normal fault in gully with very nice strae + steps: 085°/75° - 70° 090°/80° - 70° 080°/50° - 85° 093°/75° - 70°			



Stop 62 – Point 6.5 – Roadcut near school

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	62	6.5	305	12.566182°	39.743481°	29	Roadcut near school
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Nice fault planes with striae in river valley parallel to main fault					292°/60° + 65° 297°/55° + 80° 287°/50° - 75° 295°/55° - 85° 322°/75° - 85° (bit off, not so nice) 280°/50° - 85°		297°/55° + 80° 300°/55° + 80° 305°/60° + 78° 290°/62° + 75° 282°/58° - 70° 285°/68° + 75°	
Lots of school kids!								


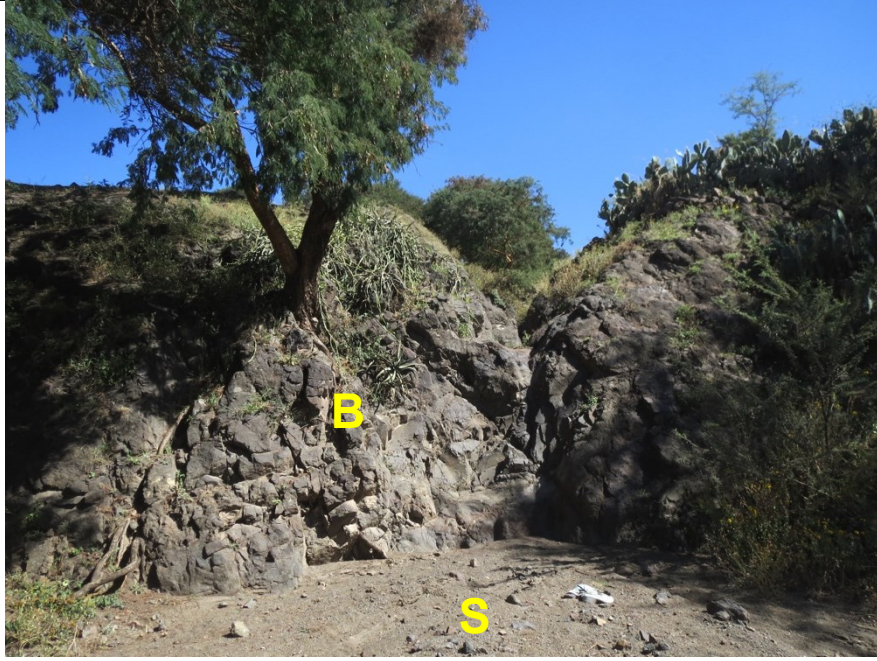
Stop 63 – Point 6.6 – Lava flow/intrusion outcrop

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	63	6.6	306	12.570633°	39.743050°	Point, no code	Lava flow/intrusion outcrop
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
<p>Columnar basalt. Sharp upper contact (060°/50°) → dipping to NW Lava flow or intrusion?</p>								


Stop 64 – Point 6.7 – Outcrop near MBF (lunch spot)

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	64	6.7	307	12.571225°	39.741587°	30	Outcrop near MBF (lunch spot)
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Outcrop near main boundary fault					270°/65° + 90° 268°/60° - 85° 273°/65° + 90° 275°/65° + 90° 285°/64° + 85° 275°/65° + 85°	273°/52° - 88° 265°/40° + 84° 272°/45° + 77° 277°/65° + 85° 260°/60° + 85° 267°/60° + 70°	Antithetic fault 085°/85° - 75°	

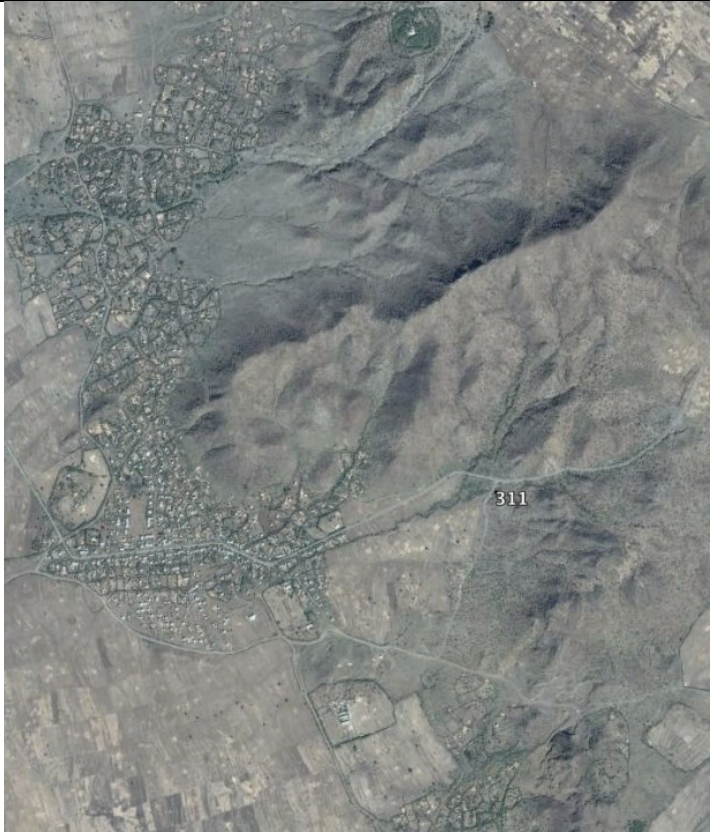
Stop 65 – Point 6.8 – MBF exposed in river bed

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	65	6.8	308	12.571467°	39.740983°	31	MBF exposed in river bed
Map view (Google Earth)					Picture			
								
View ca. N-S								
Description					Fault measurements/observations			
Main boundary fault is exposed in river incision → little knick point of ca. 3 m Very nice “hanging” V-valley → compare with triangular basins @ Ambalage Fault Alluvial sediments (S) (nearly horizontal: 125°/05°) against basalts (B)					283°/50° - 87° 295°/63° - 83° 280°/70° + 84° 280°/67° + 82° 275°/76° + 85° 283°/75° - 80°			

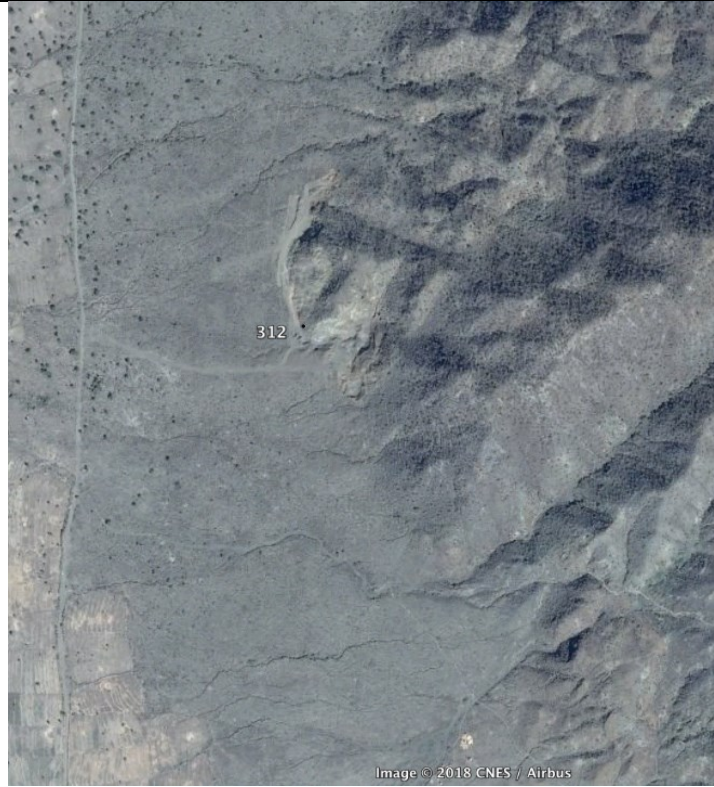

Stop 66 – Point 6.9 – Quarry along road

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	66	6.9	309	12.437413°	39.725822°	32	Quarry along road
Map view (Google Earth)					Picture			
					No picture			
Description					Fault measurements/observations			
<p>Quarry (basalts) @ road near major fault east of the MBF of Kobo Basin.</p> <p>Not so nice planes...</p>					<p>220°/75° - 75° 245°/75° + 80° 155°/55° - 70° 160°/73° - 65° 043°/58° - 80°</p>			



Stop 68 – Point 6.10 – Quarry along road

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	68	6.10	311	12.424435°	39.688453°	33	Small roadcut/quarry on MBF
Map view (Google Earth)					Picture			
					No picture			
Description					Fault measurements/observations			
Small quarry on or near boundary fault in basalts (poor quality)					290°/80° - 80° 305°/55° + 80° 300°/60° - 75° 302°/45° + 75° 305°/55° + 65° 285°/75° - 70°	295°/80° - 74° 280°/88° - 65° 277°/55° + 70° 293°/55° + 60° 273°/53° - 85° 122°/88° + 75°		


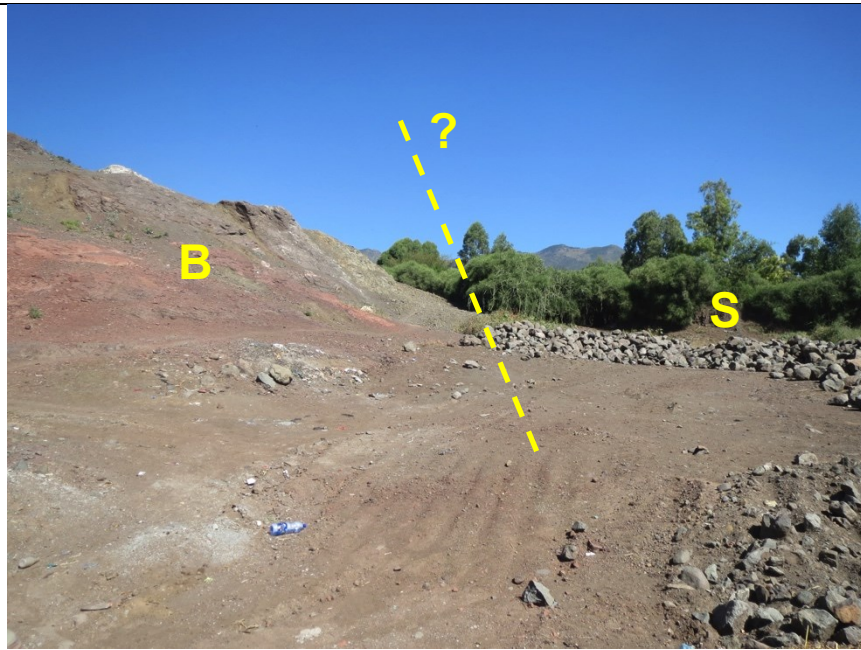
Stop 69 – Point 6.11 – Quarry along road

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	69	6.11	312	12.449573°	39.677745°	34	Quarry on MBF
Map view (Google Earth)					Picture			
								
Description Alluvial sediments (S) against basalts (B) → MBF Not very nice fault planes.					Fault measurements/observations 070°/88° - 85° 253°/55° + 82° 255°/53° + 84° 260°/55° - 67° 235°/55° - 85° 250°/80° - 78°			
					Principal planes, probably better quality than other planes 273°/55° - 85° 270°/47° - 77° 267°/50° - 75°		View ca. W-E	

Stop 70 – Point 6.12 – Quarry along road



Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
7	13 Nov	70	6.12	313	12.477242°	39.683586°	35	Large river incision in MBF
Map view (Google Earth)					Picture			
					 <p>View: W-E and ca. N-S</p>			
Description					Fault measurements/observations			
Alluvial sediments (S) hugging basalts (B) at MBF					260°/58° - 88°	283°/60° + 75°	Oblique fault planes + fault breccia	Other side (north) of river:
Very nice striae and a small dike offset by normal faults.					275°/62° + 70°	274°/55° + 84°		257°/65° + 80°
					273°/55° + 82°	260°/80° + 75°	200°/58° - 75°	Big fault plane with oblique striae
					265°/55° + 83°	287°/58° + 75°	227°/48° - 75°	
					260°/62° + 90°	265°/77° + 70°	230°/50° - 75°	
						280°/55° + 65°	203°/55° - 73°	
						267°/60°	205°/55° - 70°	
					290°/78 - 85°	270°/57° + 80°		275°/80° - 62

Stop 71 – Point 7.1 – Quarry in Alamata, near MBF



Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
8	14 Nov	71	7.1	314	12.416923°	39.552496°	36	Quarry in Alamata, near MBF
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Active quarry in Alamata, near MBF We observe alluvial sediments against basalts (fault itself not visible...) Difficult outcrop, little nice planes, all secondary					127°/40° + 80° 110°/60° - 80° 128°/40° 135°/42° Very nice plane 115°/45° - 58° 113°/40° - 55° Oblique planes 035°/75° + 85° 045°/65° + 80° 042°/68° + 80° 045°/55° + 20° (sinistral?)			

View ca. W-E



Stop 73 – Point 7.2 – Panorama of eastern BF

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
8	14 Nov	73	7.2	316	12.218531°	39.671822°		Panorama of eastern BF
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
<p>View over eastern MBF, in the southern Kobo basin at the latitude of Kobo town</p> <p>We see steep alluvial fans, not prograding as before → more active tectonics? May fit with the earthquake distribution from the Hashenga basin area to the eastern?</p> <p>Also, the landscape is wet → depocenter?</p>								



Stop 74 – Point 7.3 – Panorama of eastern BF

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
8	14 Nov	74	7.3	317	12.222479°	39.700841°	Point, no code	Panorama/fault morphology
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Same observations as point 7.2								



Stop 75 – Point 7.4 – Panorama of eastern BF

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
8	14 Nov	75	7.4	318	12.203431°	39.712167°	37	Fault planes near MBF
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Near the MBF, on the zigzag road Main fault not found					Potential fault plane: 305°/75° - 80°			




Stop 76 – Point 7.5 – Panoramio of Kobo Basin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
8	14 Nov	76	7.5	319	12.203273°	39.723484°	38	Panoramo of Kobo Basin
Map view (Google Earth)					Picture			
								
					view to south			
Description					Fault measurements/observations			
We observe a lake close to the MBF → indication of fault activity?					310°/65° + 80° 275°/60° - 85° 307°/55° + 85° 308°/58° + 85° 292°/45° - 80° 305°/60° - 77°		Minor fault surface? 125°/55° + 75° 290°/83° + 85°	
Some potential fault planes in basalts, not very clear → caution								


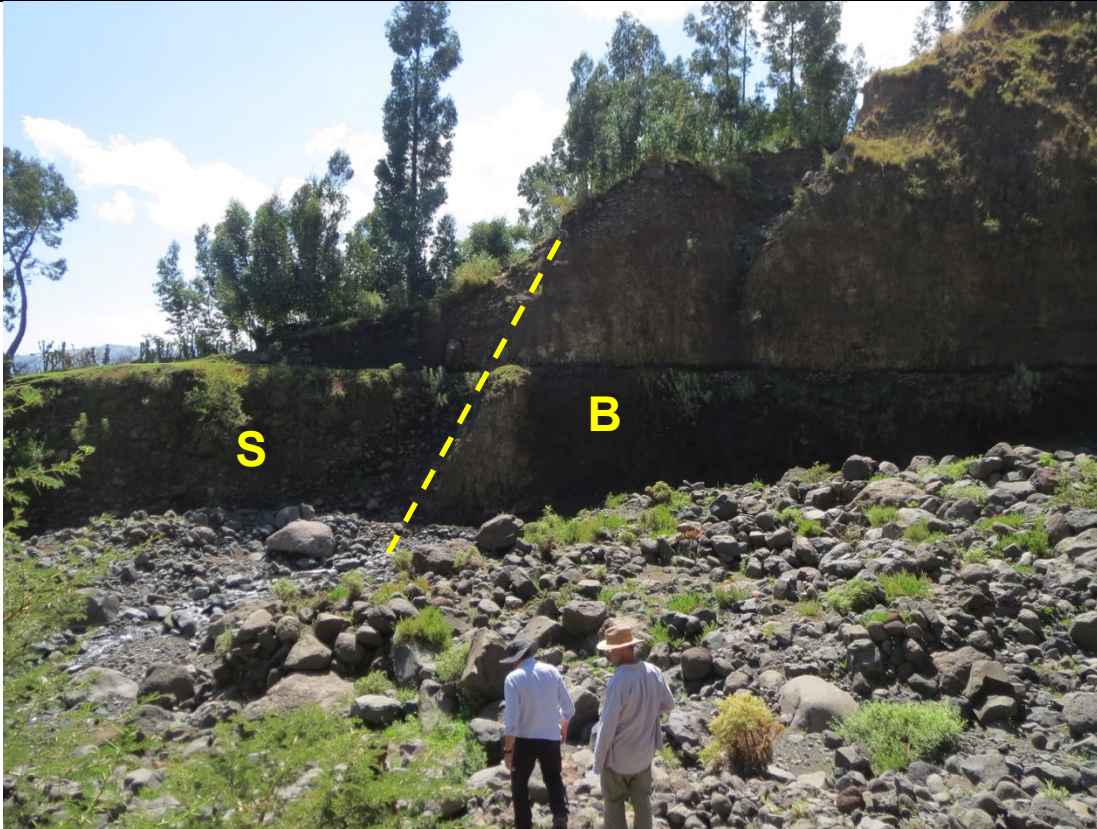
Stop 77 – Point 7.6 – Panoramio of Kobo Basin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
8	14 Nov	77	7.6	320	12.197903°	39.719247°	39	Fault plane on MBF?
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Alluvial sediments (S) on top of <u>granitic</u> material (G). Clear fault plane, but not sure if MBF... (orientation seems off)					300°/52° + 70°	314°/49° + 38°		
					307°/52° + 60°	303°/54° + 40°		
					302°/50° + 60°	307°/55° + 35°		
					297°/62° + 55°			



Stop 78 – Point 8.1 – Measurements on large fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	78	8.1	321	11.883937°	39.523957°	40 + 40bis	Measurements on large fault
Map view (Google Earth)					Picture			
					 <p>View: to the west. Below: ca. NW-SE</p> 			
Description					Fault measurements/observations			
Large fault, bordering a triangular basin Fault plane itself is not clear. A contact plane between massive conglomerates and basalts: 130°/40° River has many terraces → lots of uplift cycles?					Along the road to the north: possible fault plane: 127°/65° + 65° 285°/75° + 63° 115°/80° + 67° 197°/65° - 70° (transversal plane) 155°/55° - 72°			Fault-parallel planes (no striae) Many of these orientations (x5) 135°/85° 142°/80°



Stop 79 – Point 8.2 – MBF outcrop in river incision

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	79	8.2	322	11.909421°	39.435208°	41	MBF outcrop in river incision
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
River incision showing sediments (S) next to basalts (B), exactly where the MBF is expected					Fault plane: 093°/75° No striae, but this must be it			


Stop 82 – Point 8.5 – Panorama view over MBF

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	82	8.5	325	11.943242°	39.429305°		Panorama view over MBF
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Very impressive and steep topography								

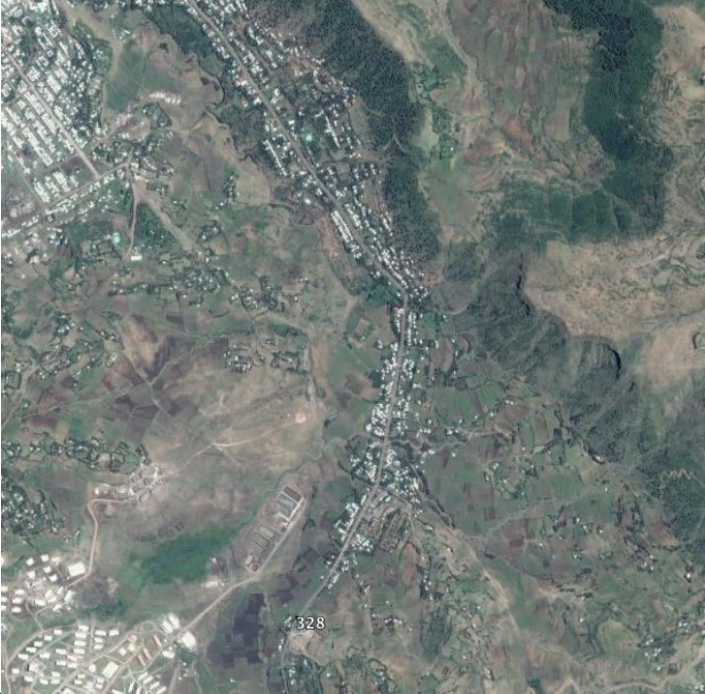

Stop 83 – Point 8.6 – Panorama view over MBF

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	83	8.6	326	11.832700°	39.603950°	42	Outcrop behind Mechare hotel, Woldiya
Map view (Google Earth)					Picture			
								
					orientation: ca. E-W			
Description					Fault measurements/observations			
Basalt outcrop behind Mechare hotel in Woldiya (close to Woldiya fault) with various fault planes					Various minor fault planes with striae		272°/80° - 85°	
					270°/55° + 85°		110°/76° - 84°	
					275°/50° - 85°		358°/86° - 85°	
					265°/67° + 80°		064°/80° + 88°	
					268°/48° + 75°		060°/88° - 83°	
					300°/60° (bit strange plane)		040°/86° + 85° (ugly plane)	

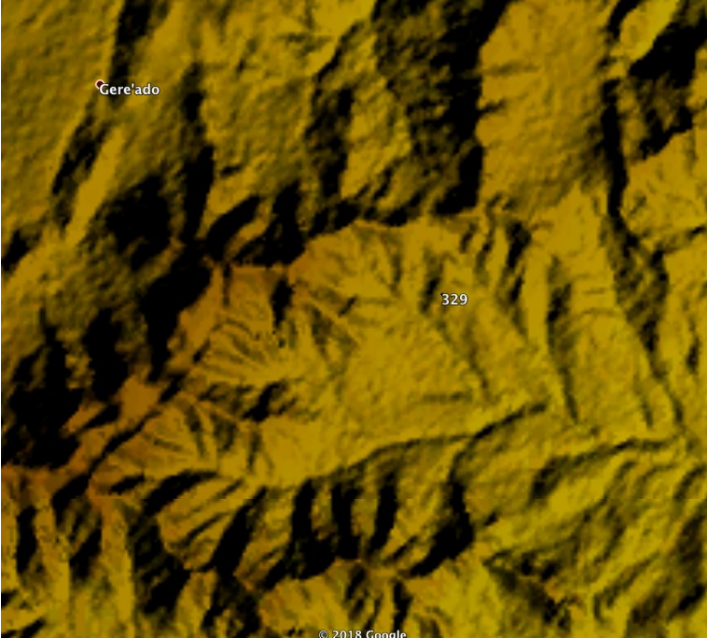
Stop 84 – Point 8.7 – Small outcrop on Woldiya fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	84	8.7	327	11.831049°	39.602688°	43	Small outcrop on Woldiya fault
Map view (Google Earth)					Picture			
					No picture			
Description					Fault measurements/observations			
Small outcrop along the road (basalts). Not very nice outcrop, but the only one along the Woldiya fault. Other outcrops show only reddish alluvial sediments					230°/78° - 80° 227°/88° - 85° 233°/88° - 80° 060°/72° + 82°			

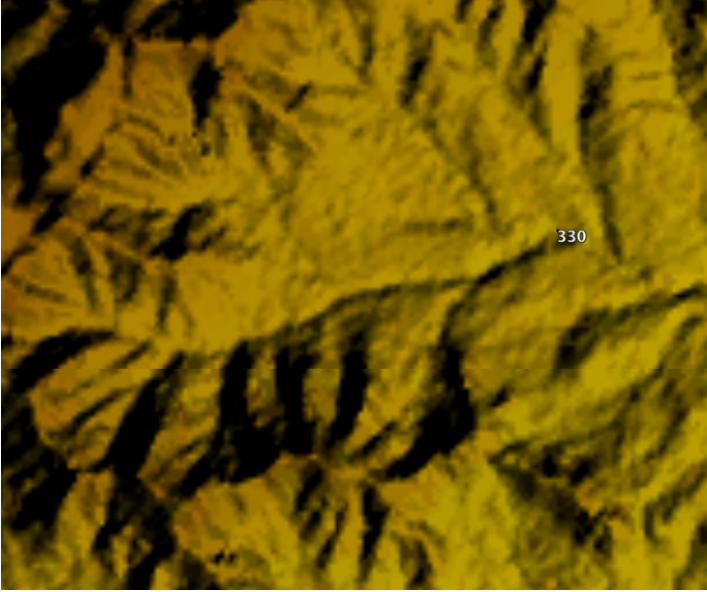
Stop 85 – Point 8.8 – Panorama of Woldiya fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	85	8.8	328	11.805257°	39.608650°		Panorama of Woldiya fault
Map view (Google Earth)					Picture			
					 <p>View to the north</p>			
Description					Fault measurements/observations			
Question: why is there no clear triangular basin at the Weldiya fault? → due to direction of river incision?								

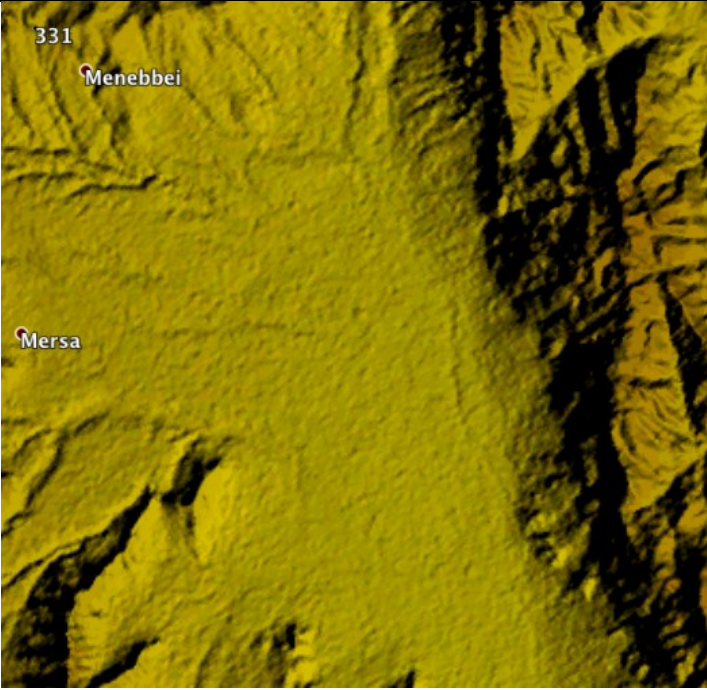

Stop 86 – Point 8.9 – Road view

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	86	8.9	329	11.732612°	39.645624°		Road view (small triangular basin?)
Map view (Google Earth)					Picture			
					No picture			
Description					Fault measurements/observations			
Small triangular basin? → check DEM								

Stop 87 – Point 8.10 – Road view

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	87	8.10	330	11.723819°	39.653266°		Road view (small fault)
Map view (Google Earth)					Picture			
					No picture			
Description					Fault measurements/observations			
Small normal fault (50 cm offset) seen in horizontal strata (alluvial sediments). Orientation: ca. 225°/70° → check regional trends!								

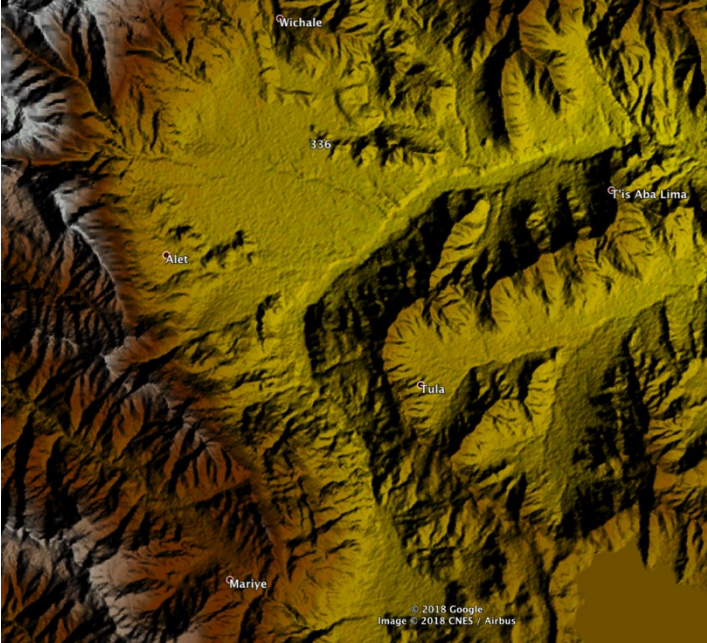

Stop 88 – Point 8.11 – Panorama of Mersa fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	88	8.11	331	11.705315°	39.660148°		Panorama of Mersa fault
Map view (Google Earth)					Picture			
					 <p>view: ca. N-S</p>			
Description					Fault measurements/observations			
View on Mersa fault to SE Well-pronounced structure								



Stop 89-92 – Road comments

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	89-92	8.12-15	332-335	11.700688°	39.652704°		Panorama of Wichale triangular basin
Map view (Google Earth)					Picture			
<p>(334) layered basalt along the road seems to be dipping east → tilted blocks due to antithetic faulting?</p> <p>(335) Wichale basin: MBF has large (sedimentary?) cones along the escarpment!</p>								
Description					Fault measurements/observations			



Stop 93 – Point 8.16 – Panorama of Mersa fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
9	15 Nov	93	8.16	336	11.479490°	39.621084°		Panorama of Wichale triangular basin
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
View of impressive fault scarp. Note the collapsed mountainside (CM) to the southern edge of the Wichale basin								



Stop 95 – Point 9.1 – Small waterfall on minor fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
10	16 Nov	95	9.1	338	10.961942°	39.776965°	44	Small waterfall on minor fault
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Small waterfall/knick point of ca. 6 m of Basalt in contact with alluvial sediments in a river incision that seems to follow the fault The orientation of the fault is oblique to the main Borkenna basin BF (Kombolcha fault)					325°/75° - 85° 320°/80° - 85° 325°/80° - 85° 327°/62° - 85° 352°/82° + 60 352°/82° + 70°	Bit uphill from waterfall: big outcrop on hillside 330°/86° + 70° 313°/88° + 85° 320°/68° - 85° 305°/75° + 85°	Dike: 025°/85° (± perpendicular to main fault?)	



Stop 96 – Point 9.2 – Panorama on large waterfall on MBF

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
10	16 Nov	96	9.2	339	10.898029°	39.802374°		Panorama on large waterfall on MBF
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
The waterfall marks the MFB								



Stop 97 – Point 9.3 – Large waterfall on MBF

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
10	16 Nov	97	9.3	340	10.893177°	39.813008°	45	Large waterfall on MBF
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Massive waterfall on MBF (contact between basalts with large phenocrists and reddish alluvial sediments downstream) Main fault plane not so clear, but minor fault planes all follow the MBF orientation					268°/55° + 70° 255°/65° + 70° 258°/63° + 75° 245°/70° + 74°		248°/55° 250°/55° + 77° 250°/57° + 75° 293°/53° + 90°	


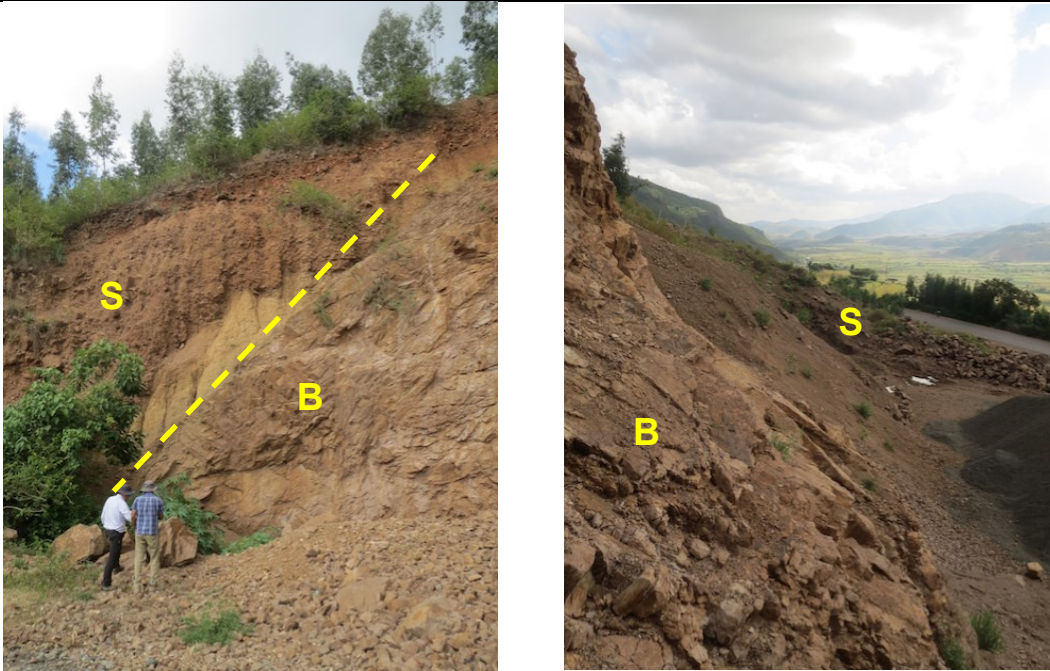
Stop 99 – Point 9.5 – Quarry on MBF, north of Karakore

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
10	16 Nov	99	9.5	342	10.635762°	39.923149°	46	Quarry on MBF, north of Karakore
Map view (Google Earth)					Picture			
								
View to the north. Pond on other side of road (to the west)								
Description					Fault measurements/observations			
Old quarry on the MBF. Many planes in basalts. Pond on other side of the road → thermal spring!					240°/70° + 78°	225°/75° + 75°	250°/65° - 85°	
					225°/85° + 85°	100°/85° + 85°	270°/80° + 85°	
					055°/85° - 80°	265°/88° - 85°	257°/70° + 80°	
Also, note that the river south of the quarry leaves the basin instead of entering → Borkenna basin is not an isolated basin.					043°/58° - 75°	330°/75° + 75°		
					045°/72° - 70°	257°/88° - 87°		
					248°/68° + 80°	225°/85° - 85°		
					235°/85° + 77°	257°/70° + 80°		
Hills within the basin seem to generally consist of basalts → local uplift, leftover after erosion, volcanoes (e.g. Afar). This explanation doesn't work for the northern basins with Jurassic/basement...					037°/86° + 87°	263°/65° - 80°		



Stop 101 – Point 9.6 – Panorama into Robi Basin

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
10	16 Nov	101	9.6	344	10.419437°	39.934619°		Panorama into Robi Basin
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Point along the road in Karakore								


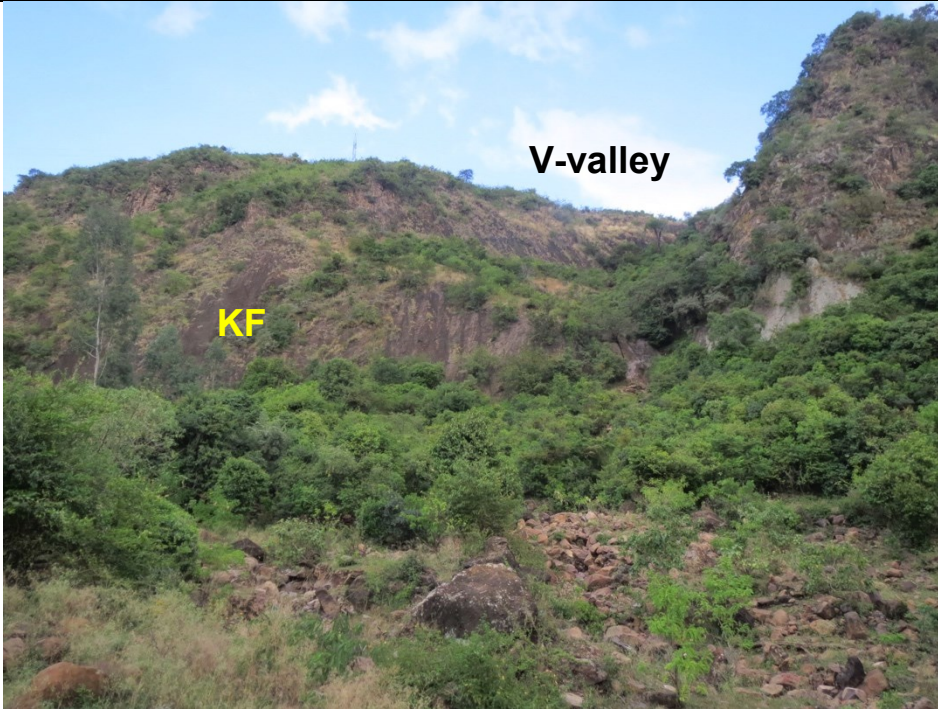
Stop 102 – Point 9.7 – Quarry on MBF, just south of Karakore

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
10	16 Nov	102	9.7	345	10.415248°	39.936547°	47	Quarry on MBF, just south of Karakore
Map view (Google Earth)					Picture			
								
View W-E and E-W								
Description					Fault measurements/observations			
Sediments/rubble/breccia (S) on contact with Basalt (B) → Karakore fault					Main fault:			
+ panorama picture					<div> <div>282°/60° + 85°</div> <div>285°/65° - 82°</div> <div>286°/70° - 78°</div> </div> <div> <div>287°/72° - 80°</div> <div>285°/40° + 80°</div> <div>285°/65° + 78°</div> </div> <div> <div>Lateral plane:</div> <div>205°/75° - 75°</div> </div>			


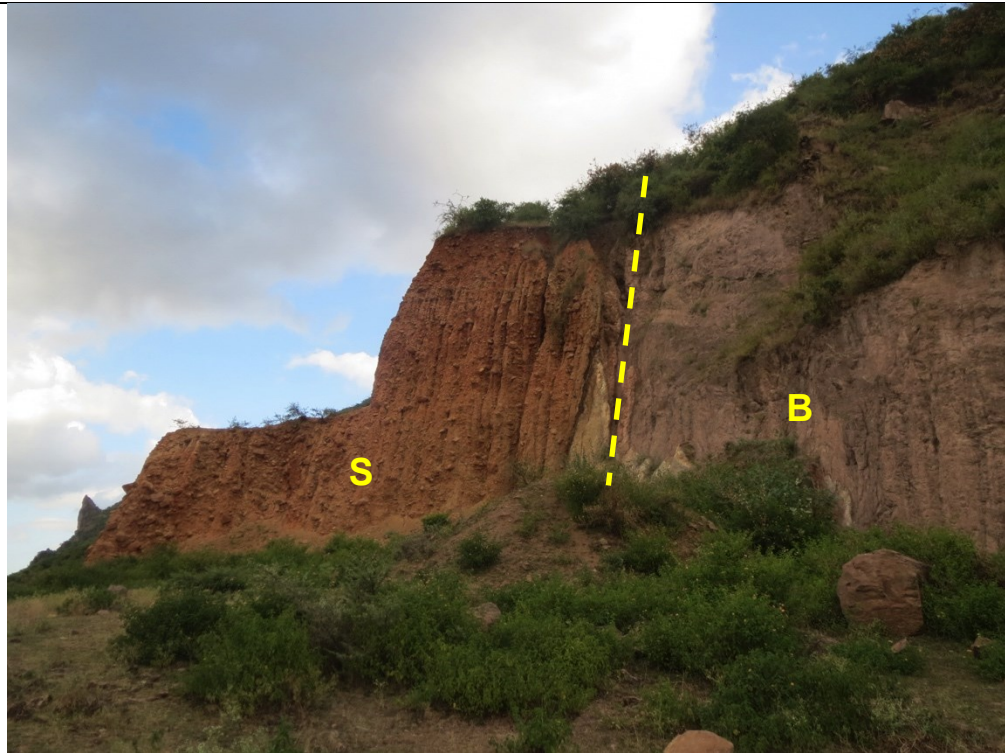
Stop 103 – Point 9.8 – Panorama view

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
10	16 Nov	103	9.8	346	10.407358°	39.933736°		Panorama view
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
View of the Karakore fault (KF) to the south								

Stop 104 – Point 9.9 – View of Karakore fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
10	16 Nov	104	9.9	347	10.401052°	39.937889°	Point, no code	View of Karakore fault
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Karakore fault (KF) visible, but not reachable. Hanging V-valley indicates ongoing uplift, faster than erosion!								

Stop 105 – Point 9.10 – View of Karakore fault

Day	Date	Stop	Point (Paper)	Point GPS (FS)	WGS84 Latitude (GPS FS)	WGS84 Longitude (GPS FS)	Point Tablet (GC) ET-2018-...	Remarks
10	16 Nov	105	9.10	348	10.365494°	39.934283°	48	Final quarry with Karakore fault
Map view (Google Earth)					Picture			
								
Description					Fault measurements/observations			
Famous quarry along Karakore fault with hanging wall sediments hugging footwall basalts. Clear striae at the base of the fault, potentially exposed by the 1961 Karakore quakes! (Fubelli & Dramis 2011 field guide) Fault has a 1-1.5 m width/fracture zone					275°/65° + 85°	285°/85° - 72°		
					292°/86° - 75°	288°/88° - 82°		
					305°/80° - 77°	282°/86° - 70°		
					288°/76° - 79°	110°/82° + 78°		
					300°/75° - 78°	300°/75° - 75°		