Line 76. I suggest adding Morley et al. (2004) JSG. To the references – particulary with reference to lines 77-78 this paper discusses discrete pre-existing fabrics (such as shear zones or fault zones) vs pervasive fabrics, which is what I think you are describing in this passage.

Line 90. I do not understand this passage. Western rift basin? Do you mean western basin in the Turkana area? If so this is wrong, because there are important older rift basins to the west of the rift trend in Northern Lake Turkana (Fig. 1 below). Also the Turkana rift did not propagate northwards from the Kenya Rift. The Turkana area is the site of the oldest rift (Lokichar Basin) in the East African Rift system. The original work on the timing was done in Amoco (myself included), not by Bonini, Ebinger or Vetel and Le Gall.

In Morley et al., 1992 (GSL), 1999 (AAPG studies in Geology 44), Morley (2019, Geosphere), and Morley and Chantraprasert (2022, Ital. J. Geosci., Vol. 141, No. 3 (2022), pp. 295-333,) the models for the evolution of Turkana have changed a bit, but they consistently show the oldest, Paleogene, part of the rift system is in Turkana, possibly down to the Elgayo Escarpment area, and the rift propagated to the south. There is a change from the half graben stage, to the later volcanically dominated graben-in-graben stage (to use an old term), where the boundary fault style is replaced by smaller fault swarms, and the Suguta valley trend and Kino-Sogo Fault belt trend was established. In Turkana this is seen as a shift in fault activity to the east with time.

Line 93. As discussed below it is not cut and dried that the KSFB is part of the Chew Bahr Rift.

Line 98. As discussed below – there are some clear factors we do know are present that make a clear contrast between the Chew Bahr Rift, and the KSFB (timing of activity, influence of basement fabrics vs presence/absence of the Anza Graben and Pliocene volcanics).

Lines 114-115. You might also mention there are some studies where stress deflection has been identified in nature (modern stress from boreholes) deflected around faults (e.g. Tingay et al., 2010, JSG).

Line 498-499 – well visible sounds like a ‘street’ term. This is clearly visible, or well-display, or well-developed

511 the threshold for what? Failure?

Line 554. Isotropic areas, into which the rift segments have yet to propagate.

Line 558 into either

Line 686 approximately (replace somewhat).

I am not convinced Turkana is configured the way you indicate in Figures 1 or 9. Attached is my fault map from 2019, where you can see that northern Lake Turkana is one trend that continues onshore into the Turkana and Kero basins. This is the older trend and there is no evidence for propagation of this trend to the south (as you show in Fig. 9). Offshore the older history of this trend is difficult to discern, because there is a c. 5 Ma volcanic layer that absorbs a lot of seismic energy so imaging below that layer is poor. But onshore the older part is at least Miocene in age. So it would be propagating to the north if anything. Then we jump to the southern part of the Lake, and that is complicated too. This does seem to be a younger trend in general and it trends a bit more NNE-SSW than the northern trend. In the Loriu and also in Mount Porr there are older (Oligocene?, Miocene) rift deposits and faults too. But then this younger rift trend is superimposed on them. There does seem to be a NNE-SSW influence of basement trends to the orientation of the Pliocene rift trend. In the southern Loriu this inheritance is quite clear, because basement outcrops with a thin covering of Miocene and Pliocene lavas. What is important about this outcrop – and what is important for your story, is that here we get a rare view that gives us timing. The Miocene lavas are rotated into normal faults. They are unconformably covered by Pliocene lavas, and some faults offset and tilt those Pliocene lavas (Fig. 3). So on these trends you have to very careful about your models and what relatively simple propagation and linkage history you are trying to describe and the actual history of the area. In that Suguta Valley trend, athough it appears to be young, there are actually 3 phases of rifting revealed in the Loriu area – the one that provided the depocentre for arkosic, basement-derived grits (Oligocene or Early Miocene – probably). The one that tilted the Miocene volcanics, and the one that tilted the Pliocene volcanics. If we go to the Mt Porr area there is even an E-W fault trend in basement, whose timing is uncertain (part of the Anza Rift, or part of the EAR?).

The other aspect of the Turkana area that I would like to highlight is the major pre-existing fabric caused by the Cretaceous (reactivated in the Miocene) Anza Graben. It trends WNW-ESE and lies right at the south of the Chew Bahr Rift. I suspect it acted as a barrier to rift propagation. The Chew Bahr Rift shows an unusual rectiliear boundar fault pattern, which is a foliation-fracture pattern in basement.

The Kino-Sogo belt fault pattern is completely different because it is younger than the Chew Bahr Rift, and so instead of the fault pattern being influenced by Precambrian Basement, it is a fault pattern developed on top of both the sediment fill of the Anza Graben, and also Pliocene volcanics that overlie the Anza Graben. So not only is there no basement influence on the fault pattern, there is also the possibility that volcanic processes (dyke intrusion, magma chambers) have influenced the fault pattern. It is not possible for me to categorically say whether the Kino Sogo belt is actually the southwards propagating Chew Bahr rift, or the northwards continuation of the Suguta Valley………….but my prejudice (e.g. Morley et al., 1999) has been that it is part of the Suguta Valley trend (both are of similar age, both involve a volcanic influence. But there is that eastwards step at the north end of south Lake Turkana to explain. Another possibility is that it is it’s own independed system and that it propagated both northwards to the Chew Bahr Rift, and south to the Suguta Valley. That might actually make the most sense – that it nucleated around the volcanic centre over the Anza Graben and propagated N and S from there.

Another tricky aspect of the Turkana area is that on the long-term time scale the rift has not propagated in a N-S direction it has actually migrated (apart from the reactivation of some faults in the Anza Graben) from the west side of the lake to the east-side (Morley et al., 1999, Morley, 2020, Figure 2 below). The oldest part of the rift on a regional scale has actually propagated both to the north and the south from Turkana. The younger part of the rift history that you are focused on in Lake Turkana catches part of the easterly migration – the northern part of the Late being part of the older Miocene trend, with the easterly shift being the Suguta-Kino-Sogo trend. But then as discussed above, even this trend is superimposed on remnants of older rift episodes. In Fig. 4 I made a suggested alternative scenario for Turkana, based on the discussion above.

Morley (2019; Geosphere, v. 16)

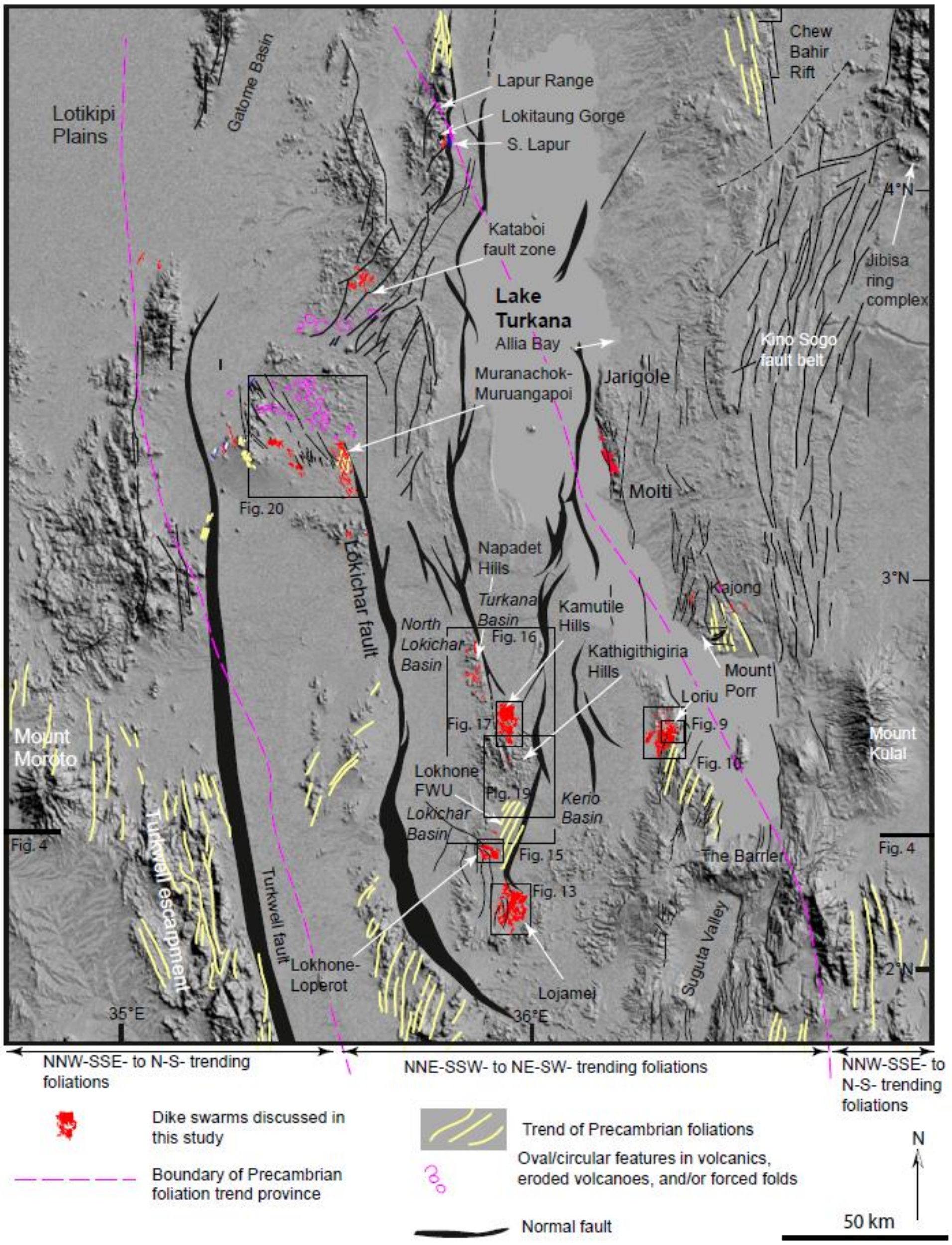

Figure 2. Topographic map (digital elevation model, slope-shader image Aster Global Digital Elevation Map) of the Turkana region, Kenya, showing key rift features and the location of the study area. Rift structure is from Morley et al. (1999a), with some modification from satellite image interpretation (this study) and from Vétel et al. (2005) and Vetel and Le Gall (2006). FWU—footwall uplift.

Fig. 1.

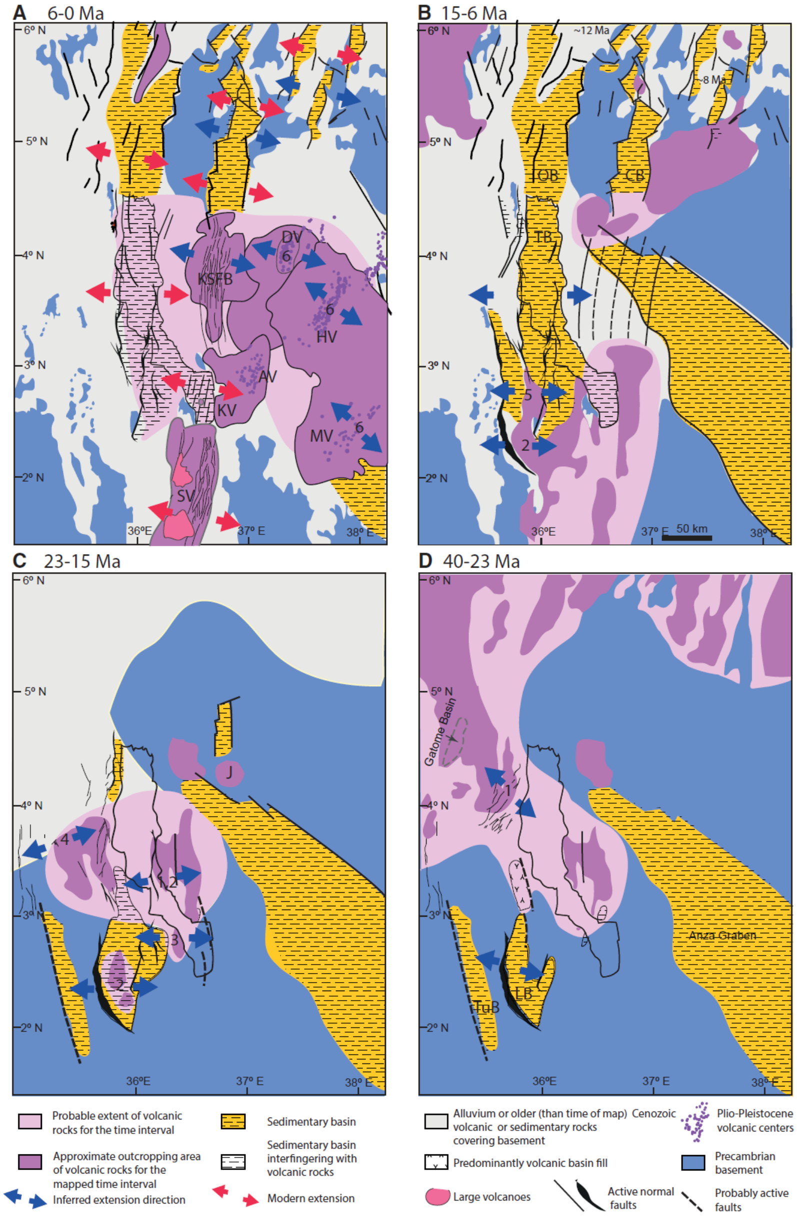

Figure 23. Tectonic development of the Turkana–southern Ethiopian Rift area during the late Eocene–recent. Compiled from information in Morley et al. (1999a), Ebinger et al. (2000), Vetel (2005), Vetel and Le Gall (2006), Balestrieri et al. (2016), Emishaw et al. (2017), McDougall and Brown (2009), Brown and Jicha (2016), and Rooney (2017). The Gatome Basin (panel D) is an older basin of probable Late Cretaceous–Paleogene age that underlies the late Eocene–Oligocene volcanic rocks. CB—Chew Bahir Basin; J—Jibisa; LB—Lokichar Basin; OB—Omo Basin; TB—Turkana Basin; TuB—Turkwell Basin. KSFB—Kino Sogo fault belt; SV—Suguta Valley. Pliocene–Holocene volcanic centers (panel A) mapped from satellite images in this study: AV—Asie volcanic centers; DV—Dukana volcanic centers; HV—Hurri Hills volcanic centers; KV—Kulal volcanic hills; MV—Marsabit volcanic centers. Extension direction estimates: 1—Kataboi fault zone area, activity ca. 28–25 Ma (Ragon et al., 2018). 2—Lojamei area; inferred from dip-slip normal faults to be approximately east-west extension; dike orientations are variable and suggest local perturbation of the stress field by magma chambers ca. 17–15 Ma, and more north-south–oriented dikes and approximately east-west extension direction during the 12–10 Ma period of dike emplacement (panels B and C; see the South Lokichar Basin–Lojamei Area section in text). 3—Loriu area; from dike orientations suggesting east-west extension direction (minimum horizontal stress), with strong local stress field perturbation by magma chambers (panel C; see the Loriu Area section in text). 4—Muranachok- Muruangapoi; from fault and dike trends (panel C; see Muranachok-Muruangapoi Area section in text). 5—Napadet-Kamutile-Kathigithigiria Hills; from north-south dike trends, plus local stress field perturbation by magma chambers (panel B; see Napadet-Kamutile-Kathigithigiria Hills section in text). 6—Minimum horizontal stress direction orthogonal to strong NE-SW to NNE-SSW trend of small volcanic cones and craters (see Discussion section) of AV, DV, HV, and MV for the Pleistocene (panel A; Strecker and Bosworth, 1991). Recent extensional activity (red arrows) as indicated by seismicity and deformed Holocene lake shorelines appears to be focused along the trend of Suguta Valley and Lake Turkana (panel A; Pointing et al., 1985; Melnick et al., 2012). Details of Cenozoic activity within the Anza Graben are not shown, but in general, Paleogene activity (panel D) is more important in the central and southeastern part of the graben, while Neogene activity (panels B and C) was significant in the northwestern part (Morley et al., 1999b). When passively subsiding, it was still an important depression and exerted an influence on drainage; during sea-level highstands, it acted as a marine gulf, apparently enabling an unfortunate whale to be preserved amongst freshwater fossils in the Loperot area of the Lokichar Basin, Turkana (Wichura et al., 2015).

Fig. 2.

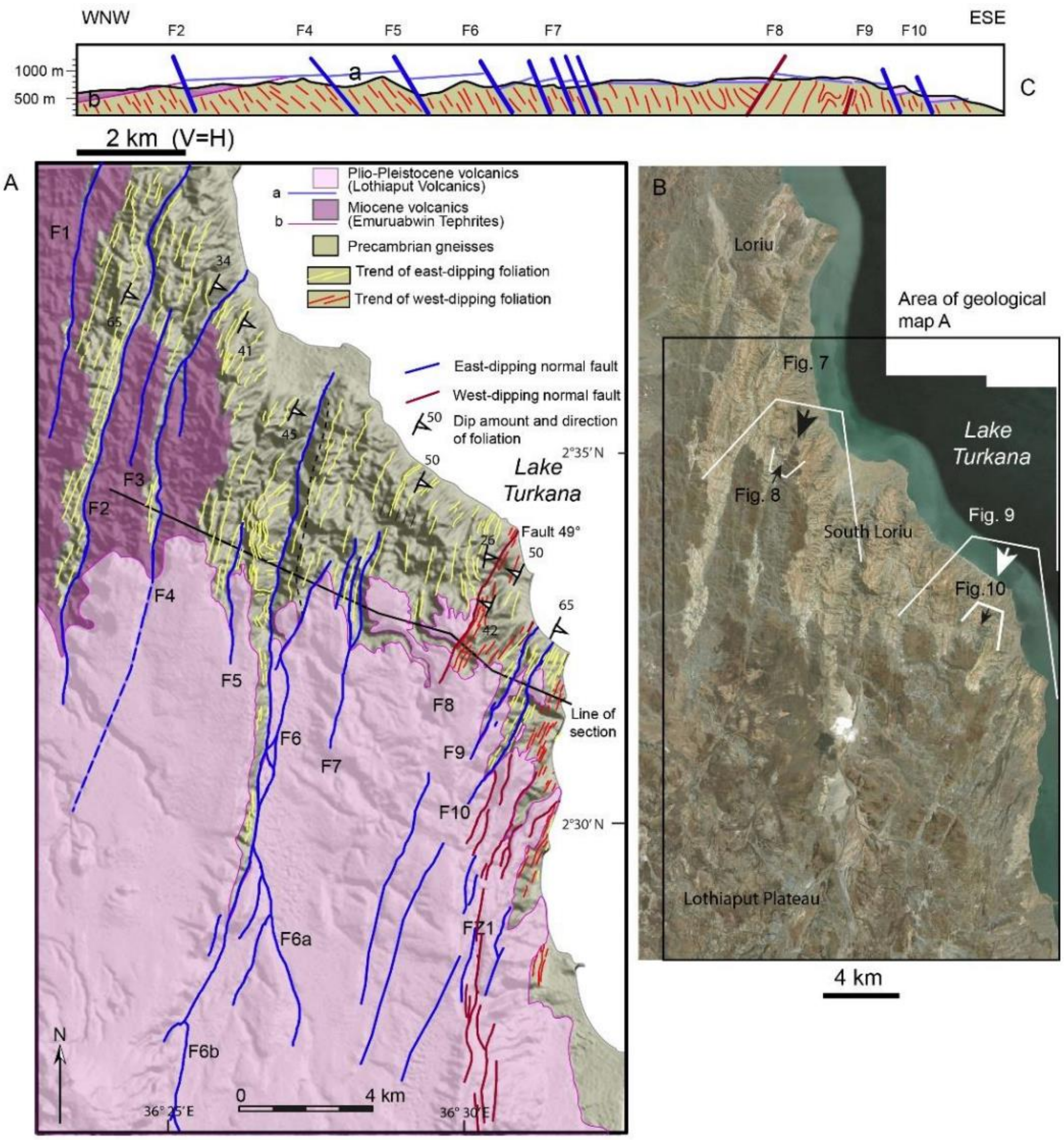

Fig. 3. South Loriu area. An unpublished figure of mine from a paper on basement inheritance that got rejected Showing the two phases of fault activity, with greater rotation of the Miocene volcanics than the

Plio-Pleistocene ones.

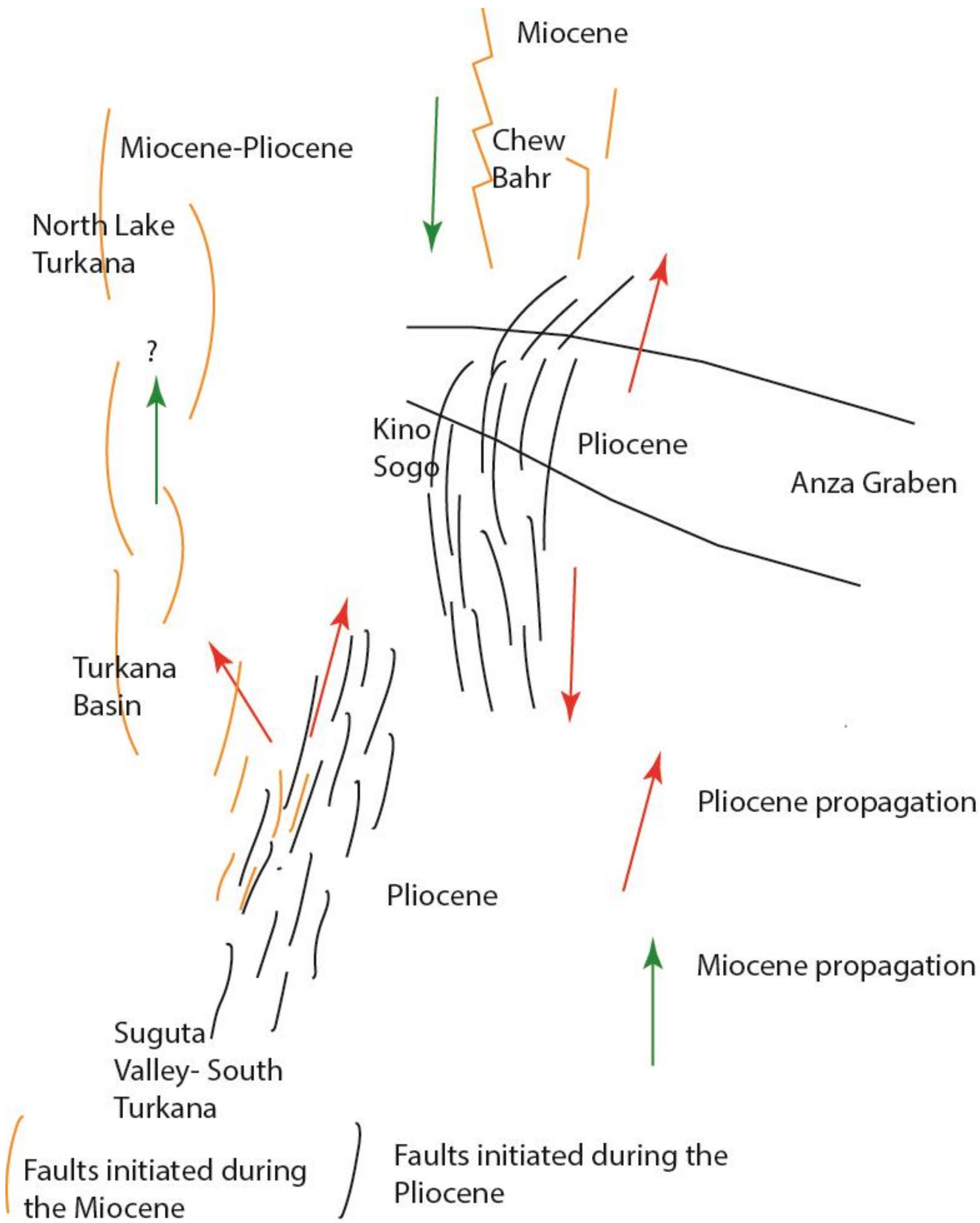

Fig. 4. A sketch showing what I think are the key components to the fault pattern