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Reply to the Comment by Côme Lefebvre on the paper: 'Late Cretaceous extension and Palaeogene rotation-related contraction in Central Anatolia recorded in the Ayhan-Büyükkışla basin' by Advokaat et al. 2014

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REPLY

Reply to the Comment by Côme Lefebvre on the paper: 'Late Cretaceous extension and Palaeogene rotation-related contraction in Central Anatolia recorded in the Ayhan-Büyükkışla basin' by Advokaat *et al.* 2014

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We welcome the discussion raised in the Comment by Lefebvre (2015) of our paper on the Ayhan-Büyükkışla basin (Advokaat *et al.* 2014), in particular because this allows us to additionally clarify some aspects of our study and to underline what we consider critical observations. Before doing so, however, we emphasize that the study of deformed sedimentary basins in general hinges on correct interpretations of both their stratigraphy and their structure. In practice, those two aspects may be difficult to separate, and we believe that this to a certain extent may explain the different views emerging in the current discussion. To avoid circular reasoning, it is, therefore, of utmost importance to highlight those data that independently ascertain stratigraphic and/or structural properties of such deformed basins.

The Comment revises in detail a number of localities emphasizing lithological and structural issues. We refrain from a point-by-point discussion of each of the localities discussed and interpret the criticism expressed as being focused on two issues, namely the Killik syncline and the Avuç-Altıpınar thrust.

Killik syncline

In the Comment, the statement is made that

> In fact, the lithologies of the Büyükkışla basin were drastically simplified in Advokaat *et al.* (2014) and only the Mucur and Büyükkışla Fm (B3) remained and were extended through the entire area. This simplification may be the cause of misinterpretation of the 'Killik syncline'. We note that Atabey (1989) recognized the two different clastic formations near *Hacıbektaş-Avuç*. Furthermore, the upper Miocene–Pliocene Yüksekli Fm was not reported by Advokaat *et al.* (2014), although it covers ~50% of the surface geology of the Büyükkışla basin (Supplementary kmz file). Ultimately, this omission led to the error of the authors in *north of Büyükkışla*, where they confused the white-coloured sands and gravels of the Yüksekli Fm with the limestone of the Mucur Fm and wrongly interpreted the unconformity as a thrust.

Irrespective of the implicit suggestion that the present authors are not capable to discriminate between clearly different sedimentary rocks, we emphasize the following quote from our paper notoriously neglected by Lefebvre:

> … the Büyükkışla Formation unconformably overlies metamorphic rocks of the Hırkadağ massif and has a gentle N-dipping stratigraphy (Figure 10a). To the north, this stratigraphy is deformed into the 15 km-wide asymmetric S-vergent 'Killik' syncline (Figure 10b). North of the hinge of the syncline, scattered outcrops in a river valley between Killik and Avuç expose redbeds with gradually steepening S-dipping bedding. Previously, these have been mapped as the Yükseli Formation with volcanic ash deposits with an inferred late Miocene–Pliocene age (Atabey 1989), but the gradual steepening bedding and the similarity with lithologies observed in the northern limb led us to interpret this as the Büyükkışla Formation. Subhorizontal thin volcanic ash deposits such as those mapped by Atabey (1989) are indeed present in the map area and are in place preserved as a thin horizontal veneer unconformably covering tilted Büyükkışla Formation rocks. The northern subvertical to slightly overturned limb (Figure 10c), between Hacibektaş, Avuç, and Belbarak, consists of coarse redbed sandstones, with reworked alveolina fossils, derived from the Mucur Formation. This shows that these rocks are not part of the pre-Lutetian Yeşilöz Formation, as previously mapped (Atabey 1989), but of the post-Lutetian Büyükkışla Formation. (p. 1822–1823)

There is in our view no misinterpretation at stake of the Killik syncline, nor of the associated lithologies, and

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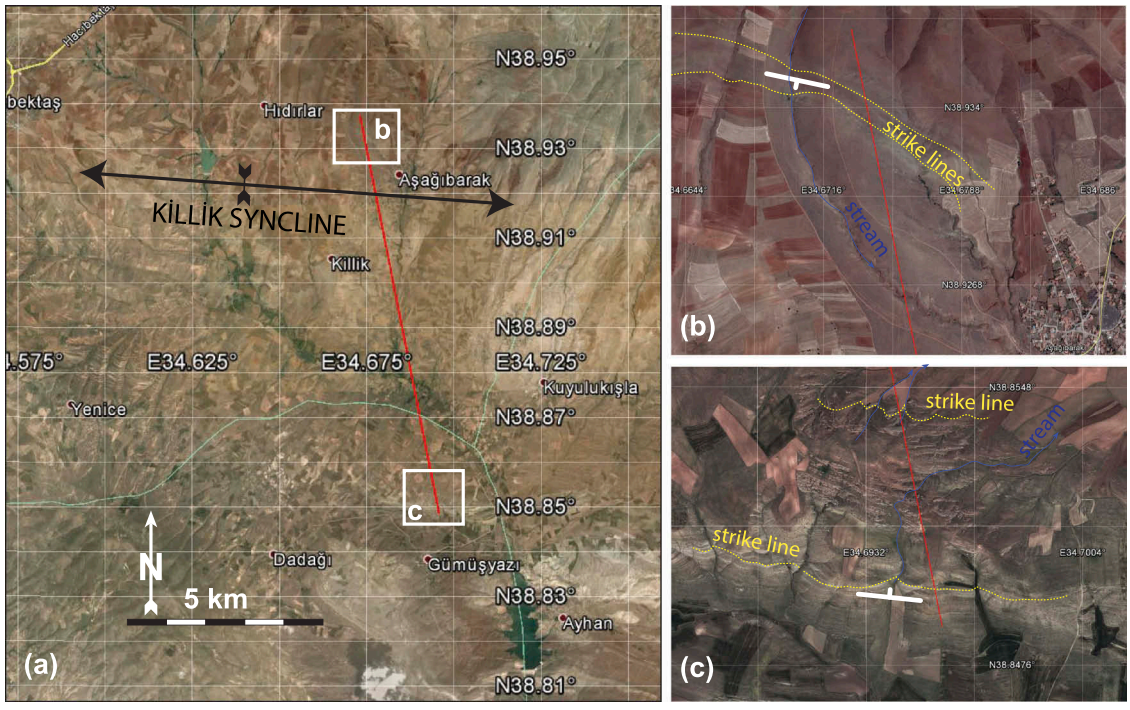

Figure 1. DigitalGlobe WorldView-2 images (provided by Google Earth) of the region around Killik showing the N- and S-dipping limbs of the Killik syncline. (a) Overview of the region. Detail showing part of the (b) northern limb and (c) southern limb.

we emphasize that this structure is real as documented and photographed in Figure 10 of Advokaat *et al.* (2014), whilst currently available high-resolution satellite imagery clearly shows the structure at a larger scale, as shown here in Figure 1. We cannot conclude any differently than that the several kilometre thick Büyükkışla Formation is folded into a major syncline.

Avuç-Altıpınar thrust

We now turn to the statement by Lefebvre that the Avuç-Altıpınar thrust and additional thrusts at the northern margin of the Büyükkışla Basin, as documented in Advokaat *et al.* (2014), do not exist. It is argued that the thrusts mapped in Advokaat *et al.* (2014) are instead unconformities, with Eocene limestones overlying 'pre-Lutetian' conglomerates. Three different critical observations preclude such an interpretation, two of which are purely stratigraphic (1, 2) and one structural (3) as follows.

(1) First, the inferred 'pre-Lutetian' conglomerates of Lefebvre contain pebbles of Lutetian limestones of the Mucur formation, as documented by Advokaat *et al.* (2014). They are, therefore, not pre-Lutetian but post-Lutetian instead. We emphasize in this context that the sheer nature of the sediments, deposited in alluvial fan and braided river systems, may well lead to variable detrital contents, and that it is *the presence in places, not the absence of such detritus* which is diagnostic. The contact, interpreted by Lefebvre as an unconformity, thus juxtaposes older (Lutetian) on top of younger (post-Lutetian) rocks.

(2) Secondly, in the klippe of Hacıbektaş, and in the thrust sheet of Gözsu Tepe, the Eocene sediments of the Mucur formation are in unconformable contact with metamorphic basement of the Kırşehir block, as shown in Advokaat *et al.* (2014). All these rocks clearly overlie the conglomerates of the Büyükkışla formation. As the hanging wall is in part made up of metamorphic basement, the underlying contact cannot be anything else than a thrust because previously metamorphosed (hence older) rocks overlie non-metamorphic (younger) ones.

(3) Thirdly, south of Avuç, a small quarry exposes the base of the Lutetian limestones, separated by a 20 m non-exposed interval from vertically bedded Büyükkışla formation conglomerates. This base is intensely brecciated and faulted, perfectly in line with a brittle thrust contact between the strata above and below.

Taken together, we consider these observations critical to decide that the main contact discussed by Lefebvre

is not an unconformity but indeed a thrust. We therefore reject the interpretation of Lefebvre that the Ayhan and Büyükkışla basins are fully unconformable and consequently reject his explicit conclusion that we have presented a misleading view of the geology of the Büyükkışla basin. We recall our introductory remarks on the analysis of deformed sedimentary basins emphasizing that *accurate* identification of stratigraphic and structural features indeed allows a critical evaluation of the deformed basin geometry, and conclude that the geological interpretation of the Ayhan-Büyükkışla basin presented in Advokaat *et al.* (2014) is scientifically sound, hence justified and viable.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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