In his Review of the manuscript by Issler et al., Ketcham questions the costs vs the benefits of analysing compositions for the purpose of extracting thermal history information from apatite fission track data. Ketcham suggests that a major reason that this has been largely neglected to date is the “trouble and expertise” required to acquire compositional data, “since the rewards are unclear, especially since thermal history inversion software will often produce a result without it”.

This suggests that compositional effects are regarded as a secondary issue, and perhaps a luxury that cannot be afforded. Possibly even a waste of time!

We find it frustrating (to say the least) that the importance of allowing for the influence of composition in extracting thermal history solutions from apatite fission track data should still be the subject of debate. We first demonstrated the systematic influence of chlorine content on annealing kinetics in apatite over 35 years ago, in a sample from a present day temperature of 95°C (Figure 1: from Green et al., 1986).

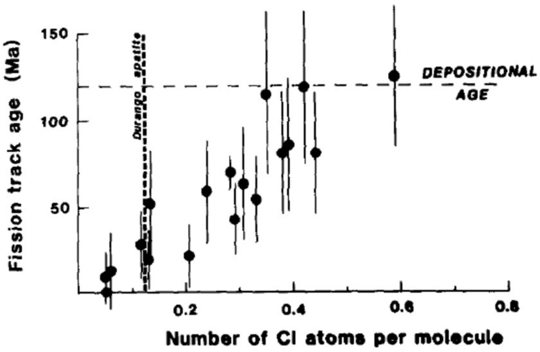


Figure 1:

Since then, a number of laboratory studies have provided further evidence in support of that conclusion. Carlson et. al. (1999) and Barbarand et al. (2003) explicitly downplayed the importance of Cl and highlighted other factors, but as shown by Green and Duddy (2012) and as illustrated here in Figure 2, both datasets clearly display the systematic influence of wt% Cl on annealing sensitivity (below), while other elements showed no systematic effects on annealing.

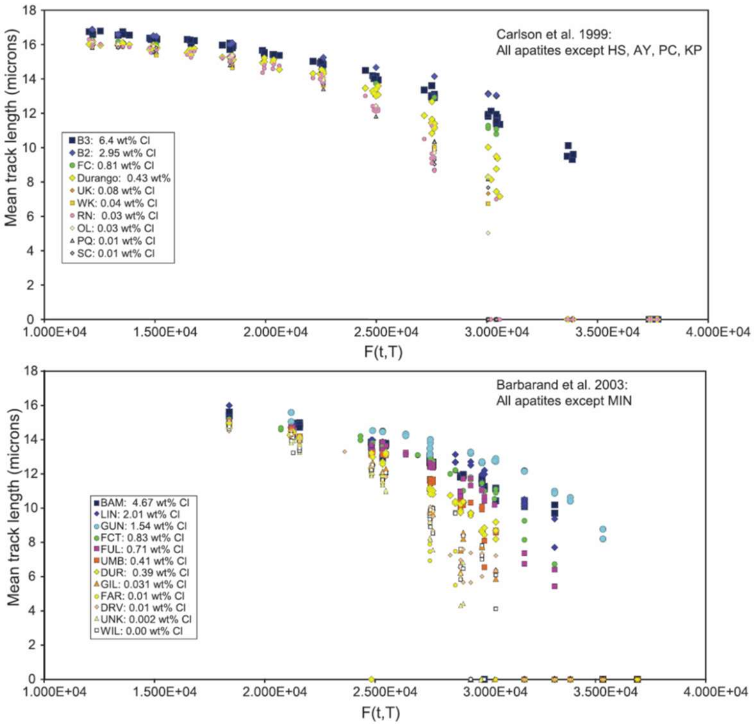


Figure 2:

In these plots, $F(t,T)=[\log t - \log t_0]/[(1/T) - (1/T_0)]$ with $\log t_0 = -10$, and $1/T_0 = 0.001$.

In considering these plots, it is important to realise that detrital apatites from most sandstone samples contain a spread of wt%Cl from 0 to ~0.5 or more. In the appropriate temperature range the variation in annealing sensitivity over this range is pronounced. Accessory apatites in crystalline rocks also often display significant variation in wt% Cl.

Green and Duddy (2012), following up one results shown in Figure 1, demonstrated the systematic influence of wt% Cl on annealing sensitivity in geological conditions, in a detailed study of data in core samples from present-day temperatures between 95 and 124°C in the Flaxmans-1 well in the Otway Basin (Figure 3):

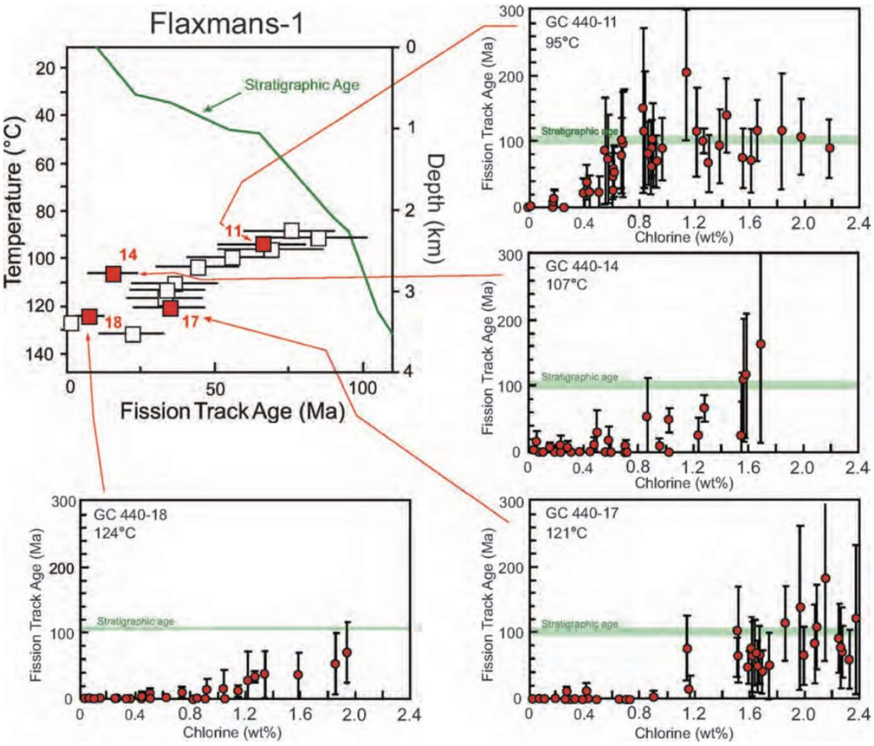
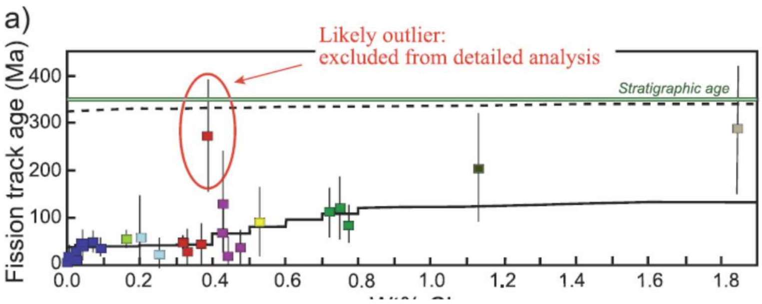


Figure 3:

In both the Carlson et al. (1999) and Barbarand et al. (2003) studies a small number of apatites analysed showed results that differ from the systematic trends dominated by wt% Cl (Fig. 2), suggesting that additional influences may exist. In recent years, the effects of multiple elements on annealing have been incorporated into kinetic descriptions via the r_{mr0} term (Ketcham et al.1999, 2007), as adopted by Issler et al. in the paper under review However, the relationship between r_{mr0} and various elements is not well defined, leading Carlson et al. (1999) to urge caution in its application (caption to their Figure 5).

We have published a number of natural datasets in which fission track age varies systematically with wt% Cl in samples which have been heated to the appropriate temperature where differential annealing kinetics in apatites with different chlorine contents are sufficient produce a range of responses (varying degrees of age reduction). These studies also highlight a number of outliers which may correspond to more unusual compositions similar to those highlighted by Carlson et al. (1999) and Barbarand et al. (2003). Experience has shown that such anomalous data are rare, and can readily be identified as outliers in trends of age or length vs wt% Cl and eliminated prior to interpretation (Figure 4, from Green and Duddy, 2012). In the vast majority of cases, variable levels of annealing in apatites from a single sample can be described solely by variation in wt% Cl.

Figure 4



These examples illustrate that failure to incorporate compositional influences on annealing kinetics in extracting thermal history must lead to inaccurate and misleading results. To question the costs vs benefits of doing so is to accept a result that may not even represent a rough approximation to the true history, instead of performing the analysis in the most technically appropriate fashion.

In this respect, we find it amusing to contrast the negative attitude to compositional analysis evident in Ketcham's review with the willingness of many thermochronology labs to invest in expensive new machines to measure uranium for fission track studies by laser ablation, and to measure U-Th/He ages, when these methods are far from proven and have been shown to provide misleading results in many cases.

Issler et al. in the paper under review are to be commended for emphasising the importance of variation in annealing systematics between apatite grains within a single rock sample. We do not find their approach convincing, based as it is on investigation of ages and lengths vs r_{mr0} rather than wt% Cl. But that is another issue which we are not concerned with here. We simply ask why investigation of compositional effects in apatite fission track data, for which overwhelming evidence exists, is apparently considered an unnecessary luxury, especially when so much money has been devoted to investment in other aspects of thermochronology which are far from proven.

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8th October 2021