

2016-123-SC1:

This is an interesting paper. I am wondering where is the early Permian arc preserved. Is it possible to preserve in the Gympie terrane? You may check the recent paper in tectonics: Li, P., Rosenbaum, G., Yang, J.-H., and Hoy, D., 2015, Australian-derived detrital zircons in the Permian-Triassic Gympie terrane (eastern Australia): evidence for an autochthonous origin: *Tectonics*, v. 34, p. 2015TC003829, doi: 10.1002/2015TC003829.

As discussed in Li et al. (2015), the Highbury Volcanics are basal volcanics in Gympie terrane directly underlying the Alma Formation (lowermost Rammutt Formation) and are separated from them by a dis/un-conformity (Cranfield et al. 1997). This suggests the simple scenario that the Highbury Volcanics are the source of the 302 Ma zircon population in the Alma formation (although they might also be from another unseen source).

If this is the case, then Highbury volcanics may indeed be the new, early Permian volcanic arc, and we can hypothesize (within uncertainty limits of the U-Pb data) the following chronology (given by our Figure 11b-d, corresponding to Li et al. 2015 Figure 7d-e):

- 1) The mafic Bakers Creek Suite plutons track the migration of magmatism, with early fore-arc like magma (chilled margin of Days Creek gabbro) crystallizing at or just before ~305 Ma*
- 2) These transition to back-arc magmas in this area (main Days Creek, Big Bull and Barney House) at 304-305 Ma. The arc magmas themselves may be less likely to be observed as they migrate.*
- 3) Arc magmatism is re-established at ~302 Ma (Highbury Volcanics) albeit so far only indirectly dated by overlying Alma Formation zircons.*

Obviously, a direct U-Pb age for the Highbury Volcanics would provide the best information on its relationship with the Bakers Creek and Hillgrove suites. We have integrated these points into the text at the end of section 7.3 Tectonic Implications.

2016-123-SC2:

1. I am not fully aware of the relationship between the Bakers Creek Suite and Hillgrove Supersuite. They are spatially associated, but was it demonstrated that they are cognate or related petrogenetically? I know that you compared the whole rock geochemistry of Bakers Creek and Hillgrove in NEO 2010 conference proceeding (I may not remember clearly and cannot find that proceeding paper), which you may be able to mention in this paper?

This is a good point that has not been widely discussed in the peer-reviewed literature, despite its fairly obvious importance for these suites. One of the few papers is Jenkins et al. (2002) and they report no samples with SiO₂ in the range 52-61 wt.%, a region in which we have several samples (we refer to them as 'hybrid' compositions; see RC2 below). We have therefore made changes to our major element Figure 4 to show some classic analyses of the Hillgrove and Bundarra suites (Shaw and Flood 1981) to

accompany our single analysis, as well as other changes in line with the comments of reviewer RC2. These show that the Hillgrove Suite exhibits some range in compositions and is more mafic than the nearly homogeneous Bundarra granite.

Despite many identical crystallisation ages (the Bundarra Supersuite at ~292-285 Ma and many larger plutons of the Hillgrove Supersuite at ~293-288 Ma define the main S-type intrusion period; our Figure 10 and section 7.2), the extent to which the Hillgrove and Bakers Creek suites intruded and crystallised contemporaneously was previously not known, because zircon data for the Bakers Creek suite were not yet fully published, and additionally because of a poorly understood U-Pb age range and complexity for certain Hillgrove members (Kent 1994 for Rockvale, and Kemp et al. 2009 versus Cawood et al. 2011 for Tia). We consider addressing this issue to be one of the main objectives for our manuscript. The NEO 2010 conference contribution does indeed summarize the data presented here and it is our intention to present in full the bulk rock elemental geochemistry and zircon U-Th-Pb data available so far.

Additionally, to improve some of the text in the abstract, we have made two small changes: (1) ‘...bodies of the Bakers Creek Suite, which are a heat source for production...’ to ‘...bodies of the Bakers Creek Suite, which sample the heat source for production...’ because although they are related to underplating mafic magmas, such small plutons in the crust are themselves unlikely heat sources for widespread melting and production of the Hillgrove Suite; and (2) ‘...followed by diverse magmatism of mixed compositions...’ to ‘followed by compositionally diverse magmatism’ which makes more sense.

2. Glad to see that you made criteria of Th/U to distinguish zircon ages for the granite crystalline from those of inherited. With no O isotopic data, that is probably the best way to exclude "possible" inherited zircon ages. But as the zircon Th/U ratio of 0.3 is not an absolute reference, it is also very useful to check if individual dating spot is on the clear magmatic rim (Jeon et al. [2012, EPSL] observed that all measured inherited cores and texturally discordant cores have thick overgrowth magmatic rim).

In fact, the Th/U ratio of ~0.3 is only the most general guide and is strictly only applicable to Bundarra zircons. That the Th/U ratio of new magmatic zircons is lower than that of inherited zircons is occasionally a useful guiding observation (e.g. NE77/07 for Tia Granodiorite) but a Gaussian distribution may be just as useful, as can be seen for all three zircon ages that we have recalculated according to these criteria (NE75/07 Rockvale, NE77/07 Tia, and NE76/07 Halls Peak; Cawood et al. 2011). Whether any particular analysis belongs to a zircon core or rim is unfortunately not available.

2016-123-SC3:

It is generally accepted that the New England Orogenic phase began with the end of the Kanimblan compression in the Lachlan Orogen and accretion of the Gamilaroi/Calliope island arcs. The Carboniferous arc and associated forearc and accretionary complex are part of the New England Orogen. (e.g. Schiebner 1997 - The Geology of NSW)

We would like to correct the misuse and misclassification of the NEO and have changed the text several places, the most important relating to the Lachlan being:

Section 1 Introduction; we now write: "...the NEO represents outboard migration of magmatic activity into Devonian-Carboniferous forearc basin and accretionary prism sediments on the margins of the Lachlan Orogen (Jenkins et al. 2002)." (page 1 lines 26-27).

Section 2 Regional Geology; we now write: "The Southern NEO is built upon a metasedimentary base comprising the Tablelands Complex (an old accretionary prism) and the Tamworth Belt (a forearc basin) separated by the Peel-Manning Fault System (Leitch 1974; Korsch 1977; Glen and Roberts 2012; Li et al. 2015). Both are related to a poorly exposed Devonian-Late Carboniferous magmatic arc on the margins of the Lachlan Orogen (Leitch 1975)." (page 2 lines 25-28).

Further, because the volcanic/volcaniclastic units related to this arc must naturally be older than the rocks they are intruded by (Hillgrove-Bakers Creek), we qualify the timing and terminology related to our samples. The title has been changed to 'New England Batholith' rather than 'New England Orogen' and we have utilised 'batholith' in a number of places (e.g. Page 2 line 4, 11, 15, and 22, and page 12 line 11).

2016-123-RC1:

This paper presents new petrological, geochemical and geochronological data, which are helpful for understanding the late Paleozoic tectonic evolution along the eastern Australian margin. The data quality is good, and the interpretation is reasonable. Here I provide some suggestion for authors to further improve the manuscript.

(1) A schematic diagram is required to show the major tectonic element of the NEO. This is particularly important for the regional geology section. Otherwise, it is difficult for readers to follow when seeing some terms (the Tamworth Belt, the Tablelands Complex and so on). Authors may be able to refer to Fig 1 in Li et al (2015) or Fig 1 in Glen and Roberts (2012).

The adjoining Tamworth Belt and Tablelands Complex have been well presented in many previous publications and for this reason we did not consider it critical to present this region, especially since the Hillgrove and Bakers Creek suites do not intrude the former. Nevertheless, because of their obvious importance, we now present a regional map of the Southern New England Orogen in the new Figure 1b. As reviewer RC1 suggests we also refer the reader to Glen and Roberts (2012) and Li et al. (2014; 2015) for more regional tectonic discussion.

(2) Section 7.3 for tectonic implication is kind of weak. Actually, there are a large number of structural, metamorphic, sedimentary, magmatic data to support authors' interpretation. The discussion will be significantly strengthened if these data can be incorporated. Authors may also think about discussing a bit how the Permian tectonic

units in New Zealand and New Caledonia, and the Permian Gympie terrane are linked with the tectonic transition mentioned in the manuscript.

As also addressed in short comment SC1, understanding the tectonic setting of the Bakers Creek Suite and the regime controlling the growth of the New England Orogen is an important objective of this paper. We came to our conclusion of a predominantly ‘back-arc’ setting from a more geochemical perspective rather than structural/spatial. The latter has been extensively discussed in relation to orocline development; we have deliberately left the matter open because our focus here is not structural (but we now direct readers to such information in the reference list, e.g. Glen and Roberts 2012; Li et al. 2012; Rosenbaum et al. 2012). However, both approaches seem to lead in the same direction of a back-arc environment. Our contribution here dealing with the U-Pb ages of these rocks and a potential early fore-arc component is especially highlighted in a new subduction zone diagram modelled on Li et al. (2014; 2015) (figure 11).

The possible relationship with the Permian Gympie terrane, as raised in the formal comment SC1, is an important point and we now address this in section 7.3 Tectonic Implications. Regarding New Zealand and New Caledonia, we will attempt to deal with the much larger scale tectonics, the growth of the Australian continent, and mantle input versus crustal recycling, using isotopic data on the Bakers Creek and Hillgrove Suites, in a future publication building upon the study presented here.

(3) Section 7.2 refers to a large number of intrusion names. These names should be somehow demonstrated in a figure. Otherwise, it will be difficult for readers to find out where are these rocks.

It was indeed difficult to identify the locations of many samples in the list that we have collected, and there are additional problems relating to large multi-generational plutons. While we have done our best to review geochemistry and pluton ages, a dedicated tectonics study consulting the original publications or even contacting the authors is required, rather than trusting our interpretation of locations in the current study. Our Supplement 4 contains all the original references, which we hope are presently sufficient for the reader to follow particular leads and locate sample origins.

Additional minor comments:

Page 2_Line 27: Using “eastward” to replace “outboard”

We have changed the text.

Page 3_line 3: Actually, only that part of the Hillgrove Suite close to the shear/fault zone is foliated. As far as I know, some parts of the Hillgrove Suite are non-foliated.

We have indicated at page 2 line 6 that the Hillgrove Suite is “variably foliated”.

Page 10_Line 18: Li et al. (2014) also dated the basalt of the Alum Mt Volcanics, which yielded an eruption age at around 272 Ma. This age is similar as the SHRIMP zircon age from the felsic part. Such information should be provided.

This was also a good reminder that our assembled chronology is based on U-Pb dates, primarily for zircon (with one EMPA monazite age; Craven et al. 2012) but there are other isotope systems giving a supporting chronology. These are more prone to resetting but are still interesting. We have already directed the reader to some supporting information (Landenberger et al. 1995 Rb-Sr) and have now added Li et al. (2014 Ar-Ar) to section 2 Regional Geology dealing with the importance of regional exhumation, and the end of section 7.2 Chronology of early NEO magmatism, dealing with the closing magmatic events of this period.

Page 10_Line 23: This statement for the Lachlan Orogen is confused. The orogenesis for the New England Orogen had already initiated in the Late Devonian.

This point was also raised in short comment SC3 (above). We have changed the text to read “Magmatism related to a long lived, probably west-dipping subduction zone ceased at ~305 Ma and provided the base of the NEO (Claoué-Long and Korsch 2003; Roberts et al. 2004; 2006; Jeon et al. 2012; Figure 10 and Figure 11a)” at page 11 line 2-3 in section 7.3 Tectonic Implications.

Page 10_Line 34: melting of the Tablelands accretionary complex

We have changed the text.

References: Glen, R.A., Roberts, J., 2012. Formation of oroclines in the New England Orogen, Eastern Australia. J. Virtual Explor. 43, Paper 3.

Li, P., Rosenbaum, G., Vasconcelos, P., 2014. Chronological constraints on the Permian geodynamic evolution of eastern Australia. Tectonophysics 617, 20-30.

Li, P., Rosenbaum, G., Yang, J.-H., Hoy, D., 2015. Australian-derived detrital zircons in the Permian-Triassic Gympie terrane (eastern Australia): evidence for an autochthonous origin. Tectonics 34, 2015TC003829, doi: 10.1002/2015TC003829.

We thank Reviewer RC1 for these reference suggestions and have integrated them into the text, following also short comment SC1 at page 2 lines 26-27 and used the Li et al. (2014; 2015) references to help with construction of our Figure 11 (subduction zone cross section).

2016-123-RC2:

This study presents a new set of geochemical data and U-Pb ages on zircons from the Bakers Creek suite Gabbros. These new data are used to constrain the tectonic settings of the first magmatism of the New England Orogen. As a non-specialist of

geochronology, I have no comments on the zircon chronology work and I leave its evaluation to specialists. I provide here a review on the work related to the geochemistry of major and trace elements.

Major comments:

First, I regret to say that the analytical section suffers from the lack of results on geological reference materials and information on the limits of detection, quantification and LA-ICP-MS settings. Second, I was not convinced by the use of the major and trace element data sets proposed by the authors. Bellow, I report some examples illustrating (1) that the data presentation suffers from the lack of clarity (definition of sample grouping, sample selection, etc.), and (2) that the interpretations are not supported by the use of trace and major elements.

We understand the concerns of Reviewer RC2; at least part of this is due to our deliberate decision not to include many details, which we considered to be routine methods that are well established in the community, described over many papers by Stephen Eggins who is mentioned as contributor to these analyses in the acknowledgements:

- Eggins et al. 1997 *Chemical Geology* 137, 311-326
- Eggins et al. 1998a *Applied Surface Science* 127-129, 278-286
- Eggins et al. 1998b *Earth and Planetary Science Letters* 154, 53-71
- Eggins and Shelly 2002 *Geostandards Newsletter* 26, 269-286
- Eggins 2003 *Geostandards Newsletter* 27, 147-162

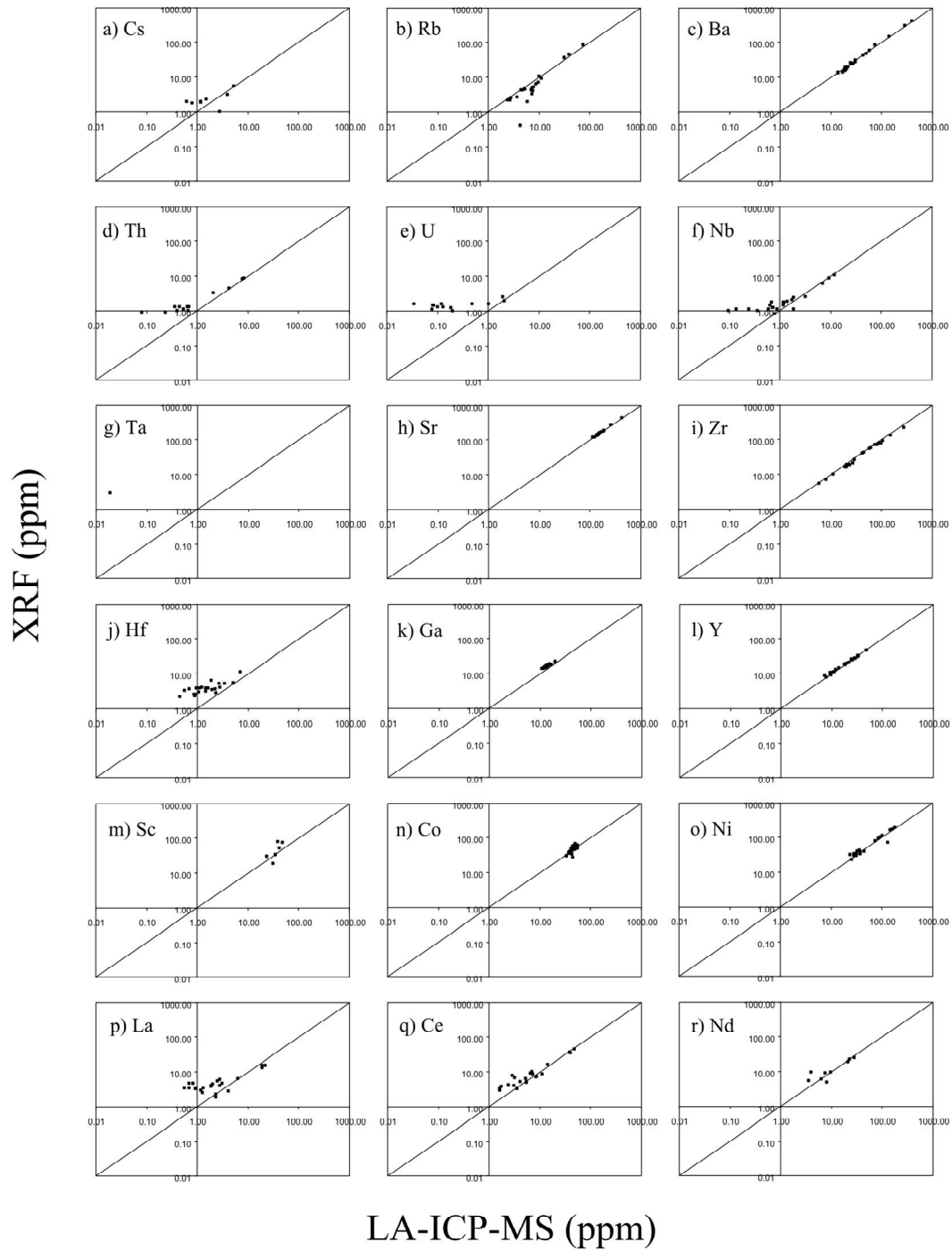
We considered the last of these, dealing with LA-ICP-MS analysis of lithium-borate glasses previously prepared for XRF, to be the most important for our study and therefore cited it in our original submission; we now will attempt to address the above concerns by providing more background to the analyses, and hope that our description of analytical methods, flow of text, and interpretations will no longer be considered insufficient or inconsistent.

1. Analytical session.

Page 3 line 27: “some trace elements”: which ones did you analyzed by XRF and how does these data compared to LA-ICP-MS data? How did the authors measure the L.O.I.?

XRF was used to determine the classical major elements from lithium borate glass discs, which we present as oxides Na₂O, MgO, Al₂O₃, SiO₂, P₂O₅, K₂O, CaO, TiO₂, MnO and FeO. Trace elements were also determined by XRF on pressed powder pellets; we report Pb, P, Ti, V, Mn, Zn, and Cr obtained by this method. Pressed powder pellets were also analysed for S, Cl, Sc, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Zr, Nb, Mo, Ag, Cd, In, Sn, Sb, Te, I, Cs, Ba, La, Ce, Pr, Nd, Hf, Ta, W, Hg, Tl, Pb, Bi, Th, and U. Many of these elements were not usefully detected and most were used only as a check and were superseded by LA-ICP-MS data.

LA-ICP-MS measurements were made on lithium-borate glasses for Cs, Rb, Ba, Th, U, Nb, Ta, Sr, Zr, Hf, Ga, Y, Sc, Co, Ni, and the REEs La, Ce, Pr, Nd, Sm, Eu, Gd, Dy, Er, and Yb. These are now reported in the text and the more detailed Supplement 5. XRF and LA-ICP-MS data are very well correlated for all elements above ~10 ppm; below this, the detection limit of XRF does not permit good assessment. Supplement 5 Figure 1 and the figure below shows correlations between XRF and LA-ICP-MS data and the deviation for most elements from the 1:1 line below ~10 ppm.



For example, taking some important elements for this study, it can be seen that U and Th (subduction zone sedimentary input), Hf (a high field strength element tracking mantle source) and finally La and Ce (rare earth elements distinguishing arc, back-

arc, and fore-arc) deviate from the 1:1 line because many samples are below XRF detection limits. Importantly, Zr is well determined by both methods and correlated with the Hf data obtained by LA-ICP-MS; these two elements have very similar geochemical behaviour and Zr/Hf is unlikely to deviate at lower concentrations in primitive basaltic compositions. For U, Th, La and Ce (and many other elements), the presence of samples with both high and low concentrations with effectively the same major element composition (e.g. BH2 and DC65) is good evidence for the concentration variations being real, rather than being interferences, standardisation, or other data reduction effects. For Ba, the high concentrations that are well above detection limit give us particularly good confidence in analyses for this element (geological considerations dealt with below). Those samples likely to reflect melt compositions and designated 'anomalous' are so described because they have atypical contents of the above elements.

The BCR2g glass was used to check Ca and V; the former was within 0.6% of the USGS reported value, while V was ~7-10% higher due to possible ArB interference; we illustrate this in Supplement 5 Figure 2 and in the additional figure below (we therefore report V values from XRF rather than LA-ICP-MS in our Supplement 1 Bulk rock geochemistry). This gives further confidence in the quality of our LA-ICP-MS data and justifies interpretation of lower concentrations, down to ~0.1x that of Global MORB levels.

Loss on ignition was determined simply from the change in the weight of each powdered sample after pre-heating to ~1050 °C in air. This powder was then diluted in the lithium-borate flux as described in section 3 Analytical Methods. The above information is also summarised in the new text document, Supplement 5.

Page 3 line 32: please provide the ICP-MS and laser settings (laser energy, laser shots frequency, spot or raster ablation mode, etc.).

Following from Eggins (2003), for the LA-system we used profile (raster) mode across samples using a circular laser ablation spot ~103 μm diameter with pulse frequency of 10 Hz and energy to the sample of ~10 J cm^{-2} . The ICP-MS was tuned to minimise oxide production, monitoring Th and maintaining $\text{ThO}^+/\text{Th}^+ < 0.3\%$ (e.g. Jackson et al. 1992). Counts were collected by single collector peak hopping from one isotope to the next, using pulse counting mode at each peak, with a sweep time for the entire elemental run table of 1.1 s. This resulted in ~50-150 sweeps per lithium borate disc depending on their sectioned thickness.

Which NIST glasses is used for the calibration and what are the reference values used for this NIST? Please provide also the detection limits.

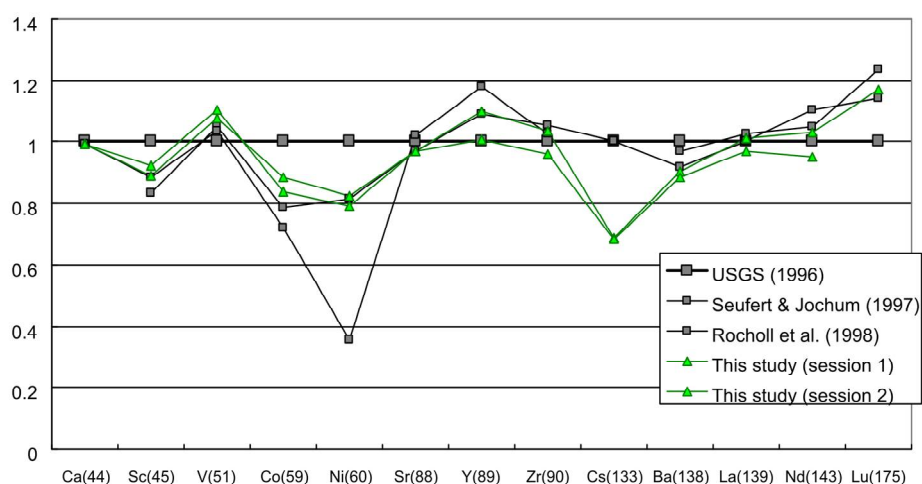
Also following established methodology of Eggins (2003), we used NIST 612 and the concentrations reported by Pearce et al. (1997). Data reduction is conducted according to Longerich et al. (1996). Limits of detection are typically much better than 1 ppm, and generally improve from ~ 10^{-1} to ~ 10^{-3} ppm with increasing element mass over the range from Sc to U (Eggins 2003 Geostandards Newsletter 27, 147-162). All this information has been included in the new document Supplement 5.

What is the purity of the lithium borate flux used for the fusion? Could this be a concern for the sample characterized by very low trace element contents (e.g. Th < 0.05 ppm)?

We indeed do not have any information on the trace element concentration of the lithium-borate flux. This was identified as a potential problem by Eggins (2003) for 'ultra-trace' levels of La (0.07 ppm). However, it should be noted that in this case the low trace element contents we report for some samples would be upper limits, and interpretation of our doleritic samples as melts with fore-arc basalt-like compositions are therefore unchanged (e.g. lowest Th and La contents at ~0.1-0.2 times MORB, or 0.05 and 2.3 ppm respectively). In support, the steady decrease in REE MORB-normalised concentrations from higher to lower mass (in the order Sm, Nd, Pr, Ce) is strong evidence that these deficiencies in the 'anomalous' samples are geological and not due to preparation. Following from this, any influence on higher concentrations in back-arc basalt-type compositions from reagent contaminants is therefore negligible.

Finally, did the authors analyze any of the BIR-1g, BHVO-2g, etc. reference materials to certify their analytical protocol?

We analysed BCR2g in parallel with NIST 612 glass and are able to make a detailed comparison for a selection of elements with the classic study of BCR2g (Rocholl 1998) and works discussed therein. We present below and in new document 'Supplement 5', a figure illustrating USGS (1996)-normalised values for Ca, Sc, V, Co, Ni, Sr, Y, Zr, Cs, Ba, La, Nd, and Lu from the two analytical session of this study and from Seufert and Jochum (1997) and Rocholl (1998).



Most of our reported values are within ~10% of either those given by the USGS (1996) or those of Seufert and Jochum (1997) or Rocholl (1998). In detail, there are wide variations in Ni content reported for BCR2g; our results are in the middle of the range. Cs is another potentially problematic element; it is noted in Rocholl (1998)

that Cs may have been enriched by a factor of 1.4 in BCR2g. We obtained much lower values for Cs but this is entirely consistent with the suggested enrichment not affecting our piece of BCR2g (our values are ~0.96 times the BCR1 value discussed in Rocholl 1998). We therefore consider our Cs results reliable. It should be noted that our data, where seemingly different from USGS values, deviates in the same direction and by nearly the same amount as the other studies (Seufert and Jochum 1997 and Rocholl 1998). The full references:

Rocholl A. (1998) Major and Trace Element Composition and Homogeneity of Microbeam Reference Material: Basalt Glass USGS BCR-2G. Geostandards Newsletter 22, 33-45.

Seufert H.M. and Jochum K.P. (1997) Trace element analysis of geological glasses by laser plasma ionisation mass spectrometry (LIMS): A comparison with other multi-element and microanalytical methods. Fresenius Journal of Analytical Chemistry, 359, 454-457.

USGS (1996) Microbeam Standard Columbia River Basalt (Glass) BCR-2G, United States Geological Survey Special Bulletin (Reference Materials Project). US Geological Survey. Preliminary report, 10pp.

...are now given in Supplement 5.

2. Data presentation

- In figures 4 and 5, the data are sub-divided into basaltic melts (which corresponds in reality to finely and coarse crystalline gabbros), cumulate rocks and hybrid melts. Because the term “Hybrid melts” is not mentioned at all in the discussion or in the data table, the reader has no clues about the nature and origin of this group of sample. To which sample these hybrids melts corresponds to? What does the term “hybrid” stand for?

We have attempted to improve the discussion around our designated ‘hybrid’ compositions and no longer refer to them as melts but simply as hybrid rocks, indicating our interpretation that they are mixtures of mantle and crustal components yielding basaltic-andesite or andesitic compositions (throughout text). Whether they represent melt compositions, and their petrogenesis via mixing between Hillgrove and Bakers Creek suites, is a topic we will address in a future publication dealing with mixing processes, crustal growth and Sr-Nd isotopes of these rocks.

- The authors mentioned also “anomalous samples” in figure 4 and 5. How do they define the anomalous character of these samples? My guess is that these samples correspond to those analyses with extremely low Th contents (i.e. < 0.05 ppm), which could potentially be close or even below the limit of quantification. This observation echoes my comment on the analytical session. These two examples show that it is not very easy (or very time consuming) to understand and follow the links between the figures, the text, and data tables.

We have also tried to improve the discussion around, and make clearer our identification of, 'anomalous' samples. We first identify the three 'anomalous' samples on page 7 line 12 in section 5 Geochemistry and indicate their unusual characteristics. Our definition does indeed relate to the low Th and especially Zr contents of these three samples, and their trace element patterns and petrology (see outstanding flow foliation in quenched margin, sample DC65 in Figure 3a) suggest to us that they are also likely melt compositions. The detection limit issue is of some interest for quantification, but as stated in relation to the other comments by RC2, the much lower Th of some samples acts in the worst case as an upper concentration limit and their 'anomalous' status remains, with tectonic implications for fore-arc like melts remaining.

2- data interpretation

Because of the lack of clarity (linearity) in the data presentation, I was not really able to evaluate properly the geochemical interpretation of major and trace elements data. Nonetheless, I address below a few major comments for the authors.

- The authors use the geochemistry of Large Ion Lithophile Elements (LILE) to demonstrate the arc-sub-arc settings of Baker Creek suite gabbros (page 9 line 4-9 and figures 5a and 9a). Given the age of these samples (~ 300 Ma), the authors should first demonstrate that the LILE abundances of these samples have not been modified by alteration.

Although we use some LILE data, much of our interpretation of subduction zone related basaltic melts comes from the observation of Nb and Ta, deficits. The use of Th/Yb seems justified to us on the basis of the extremely fresh and flow-like petrology of the chilled margin of Days Creek (see Figure 3a for sample DC65), which is one of our freshest and most convincingly basaltic melt-like samples. Its geochemistry identifies it as an 'anomalous' composition from which we infer a fore-arc component to the Bakers Creek suite.

For the rest of our LILE data, the good reproducibility of these compositions (especially Th; Figure 5a) across three plutons (Bakers Creek, Days Creek, and Big Bull gabbros) leads us to conclude that the LILE data are reliable indicators of magmatic compositions rather than alteration (or are in fact direct determinations of magmatic melt compositions).

- As far as I understand, the Th/Yb ratio is the only non-LILE trace element ratio that suggests a sub-arc setting for Bakers Creek gabbros. This result should also be confirmed by the use of other trace element ratios such as Nb/La, Nb/Ta and Th/La. Note that I do not see any evidence for a sub-arc setting from the trace element ratios involving Ti, Zr, Y and V.

As well as the Th/Yb ratio, in figure 8a we present Nb/Yb which strongly indicates a subduction zone related setting for the majority of our compositions that we identify to be likely melt compositions. Specifically, a sub-arc setting (i.e. island arc- or early arc-tholeiite) is not preferred to a back-arc or fore-arc setting (i.e. adjacent to the arc itself), where tholeiitic basalt generation is common. Because of the large number

of correlations in the data, we present only the minimum number of ratios, selecting those that are informative as well as already established in the literature. The Ti-V and Zr-Y plots (figure 7) are well established (e.g. Arculus et al. 2015 Nature Geoscience), and the purpose of this is to show that some characteristics of fore-arc basalts are present in our dataset (but the variety of 'fore-arc' basalts also indicates that not all characteristics are present in all occurrences). Rather than a generally subduction zone or specific arc-related setting, the data in the Ti-V and Zr-Y plots is consistent with BAB-type magmatism, with Zr-depletion in some samples (designated 'anomalous' and given in purple) being an extreme FAB-type characteristic. We here refine the existing interpretations of the Bakers Creek Suite with the suggestion of evolution through fore-arc to back-arc settings; the location of the arc itself is relevant to formal comment SC1 and we have addressed that point above and in the text at section 7.3 Tectonic Implications.

- The MORB reference should not be restricted to one point. Please report the MORB field instead of a single point. Baker Creek gabbros might certainly overlap with MORB data in figures 7.

We now present, as well as the Global MORB of Arevalo and McDonough (2010), the data associated therewith, and additional data from Jenner and O'Neill (2012) and PetDB data surveyed by Class and Lehnert (2012), totalling 3835 analyses, in figures 4, 7, and 8. This indicates the similarity between our inferred melt compositions to those of MORB basalts in terms of major element contents, but some important differences in trace elements that indicate back-arc and rare fore-arc like characteristics.

- The sub-arc setting is discussed only on the basis of 10 analyses of Bakers Creek gabbros. Five of these analyses display an "anomalous signature" or correspond to coarsely crystalline gabbros that may not be representative of melt compositions. How representative are the geochemical results of Bakers Creek gabbros in this context? What is the story of the "Hybrid melts" and "cumulate" rocks? Is it compatible with the one from Bakers Creek gabbros?

The compositions we designate 'anomalous' are a new and interesting addition to the known compositional diversity of Bakers Creek Suite. They are indeed not representative of these gabbros, but we think that their incorporation into some kind of tectonic or magmatic model is important; in this case we conclude that a fore-arc or related setting is the best explanation. The gabbroic samples in question were identified from trace element patterns as distinct from most other gabbros, and so geochemically similar to the fine grained gabbros that we concluded that they represent in-situ crystallisation. This is of course likely to be a rare occurrence, and we identify only two of samples, so their petrogenesis is indeed non-representative. However, their similarity to the doleritic or fine grained gabbro compositions lends support to the representativeness of those compositions and their likelihood to represent melt compositions.

The other cumulate gabbro samples, and higher-silica hybrid rocks (note that we no longer refer to them as melts) represent an added complexity; these rocks probably

have a petrogenesis involving crystal accumulation, filter pressing to remove interstitial melt, or interactions with evolved crustal rocks. We hope to address their petrogenesis in a future publication.

- The role of crustal contamination is also not discussed in this paper. Is it possible for example that the high Th/Yb ratios measured in Baker creek sample (Fig 8a) could result from crustal assimilation?

This is in fact the reason for interpretation (by us and others previously) of a subduction-zone related setting, which given the relatively low trace element concentrations of the basaltic end member is most consistent with a back-arc setting rather than, for example, and island arc tholeiite. Assimilation of and mixing with crustal materials resulted in the 'hybrid' component between the basaltic end member and the Hillgrove component (given by our Eastlake Monzogranite analysis and previous literature data). We are indeed interested in further investigation of this process and will address the in-situ evolution of the Bakers Creek magmas and their interactions with crustal components in a future publication dealing with Sr-Nd isotopes, building upon this contribution, which is the first detailed report of the petrogenesis and age of the Bakers Creek Suite since Jenkins et al. (2002).

Minor comments

Page 6 line 8: the figure shows only FeO vs. MgO.

We have expanded figure 4 to show also CaO and Al₂O₃ versus MgO. The large number of correlations in the data yields some redundancy (e.g. TiO₂ and P₂O₅ are similar to the FeO plot).

Page 6 line 9: replot the MORB and BABB fields in Fig 4.b.

In figure 4, we now show a large MORB dataset drawing on three studies (Arevalo and McDonough 2010; Jenner and O'Neill 2012; Class and Lehnert 2012 PetDB compilation) indicating the similarity of the Bakers Creek Suite to MORB in terms of major element contents. This is the normal case for BAB-type basalts; they are only subtly distinguished from MORB and best identified from trace elements (hence figure 5, e.g. Nb deficit).

Page 6 line 24: It is not possible to see clearly these samples in Fig. 5. There are 5 different symbols and 3 different colors.

The coloured fields in this figure have been used to reduce the amount of data to a manageable level, a common convention in normalised multi-element plots. The individually plotted samples in this figure are a subset of the 37 that we think are particularly important because we interpret them to reflect melt compositions (plus a single granitic sample that is sufficiently different from the higher silica 'hybrids' to warrant its own point). That we plot many of the basaltic points in green is to

illustrate their similarity – there is in fact no need to individually identify most of the green samples because they differ significantly only in terms of Cr and Ni (easily modified by slightly different degrees of olivine removal). The purple symbols, representing ‘anomalous’ samples (e.g. with lower Th, U, and Zr, or higher Ba) are worth considering separately and this is why we selected this colour.

Page 7 line 1: replace “peaks” by “anomalies”

We have changed the text.

Page 8 line 10: “Magmatic differentiation occurred before or during emplacement of magmas at depth in the mantle wedge” Why would differentiation occur within the mantle wedge?

Differentiation of magmas during ascent is a common phenomenon, and as well as obvious potential for modification of basaltic melts in the crust, it can occur in the mantle as well. The range of magma compositions present in the finely crystalline gabbros and quenched margins, which we consider to in fact represent melt compositions, indicates that some differentiation has occurred before rapid crystallisation or quenching in the upper crust. Considering the very high Mg# of these melts, this may in fact have occurred in the mantle wedge, with magmas equilibrating with peridotite at slightly different temperatures and pressures during ascent and immediately before extraction. To remove ambiguity we have shortened the text to read “...magmatic differentiation seems to have occurred before or during emplacement of magmas during ascent through the mantle wedge and overlying crust. Some differentiation also seems to have occurred in situ,...” in the first paragraph of section 7.1 Tectonic Setting.

Page 8 line 15: I found the uses of the term “melt” abusive for the chemical composition of plutonic rocks. I think that this statement needs to be discussed and argued in the text.

We have expanded our reasoning behind interpretation of some compositions as predominantly melt compositions, especially using finely crystalline gabbros and quenched margins, at page 7 lines 4-7 and page 8 line 22-26. Their identification as melt compositions is supported by micro-gabbroic, doleritic, and chilled margin (even flow foliated) textures, major element compositions similar to MORB, and trace element concentrations similar for most to Global-MORB but with diagnostic anomalies (e.g. Nb) that give further insight into possible BAB and FAB settings.

Page 9 line 18: please specify the nature of the components.

We now state specifically here “The trace element geochemistry of Bakers Creek Suite samples, and of fore-arc basalts in general, therefore indicates separation of some components, especially Ti and Zr (Figure 7) in addition to those attributed to sedimentary or slab-fluid components (Th/Yb and Ba/La; Figure 8) that are

ordinarily associated, or correlated, in subduction zone associations.” (Page 9 lines 30-32) We hope that this reinforces our interpretation of the preceding paragraph.

Data table: The data table could benefit from the addition of petrography information (grain size, cumulate, chilled margin, etc.).

We have added an extra column with a brief description of each sample to Supplement 1.