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Chemical Variation in the Talcott Flood Basalt, Connecticut

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Introduction

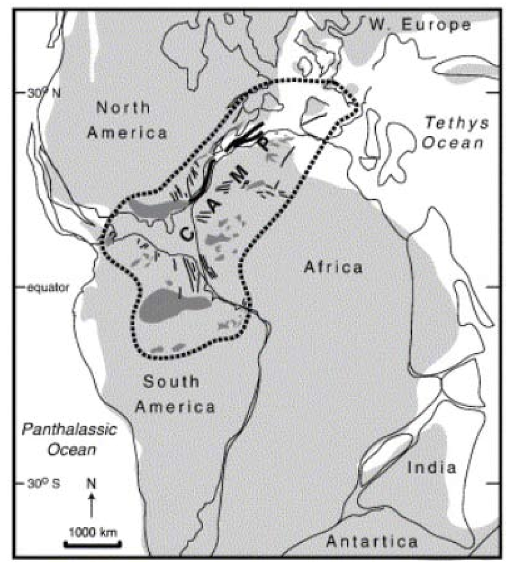
The Talcott flood basalt is the oldest of three Jurassic flood basalts that outcrop in Connecticut. The Talcott is overlain by the Holyoke and Hampden basalts, each separated from the Talcott by Mesozoic sedimentary units. Three basaltic dikes outcrop across the Hartford basin and have been interpreted as feeder dikes for the flows. Multiple intrusive units, the West Rock diabase, East Rock, and Sleeping Giant, have been interpreted as part of the Talcott magmatism.

Previous work has characterized these flows based mostly on major element data. Our purpose is to focus more specifically on the compositional variability within the Talcott flow and its trace elemental compositions as a way to constrain a fractionation/assimilation regime for the origin of the lava and its genetic connections to the later Holyoke flow.

Regional Setting

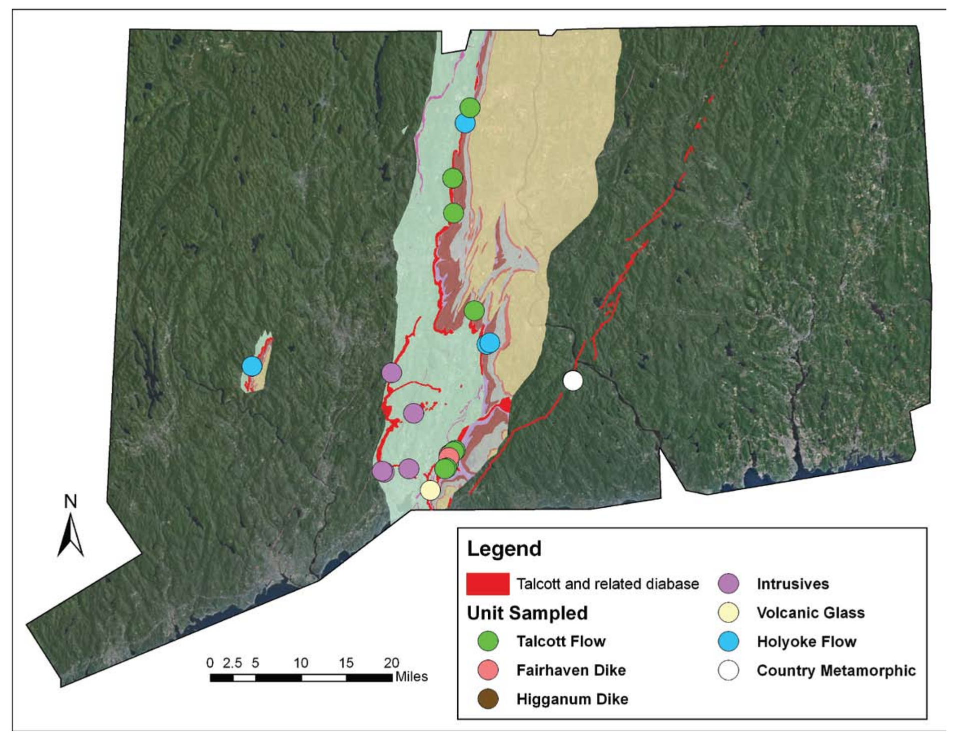
The Jurassic flood basalts in Connecticut are remnants of the Central Atlantic Magmatic Province (CAMP), the largest igneous province on the planet. The CAMP spans over 10^7 km^2 and is associated with the early phase of opening of the Atlantic ~200 Ma. Its traces are found from Africa to Brazil to Europe to Canada across once-contiguous parts of Pangaea.

The CAMP magmatism is typically tholeiitic and is characterized by large lava flows and tremendous radial dike swarms. Its composition is fairly uniform across its area suggesting rapid widespread melting of its mantle source leading to a very voluminous but fairly short span of eruptions.

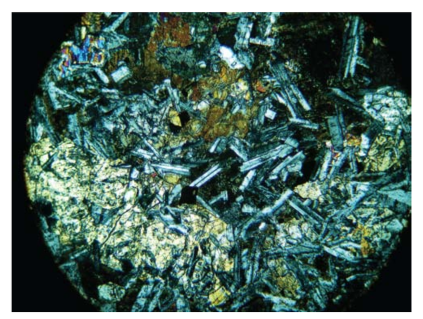


Original extent of CAMP volcanism ~200Ma

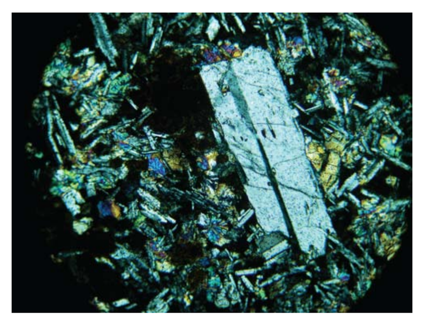
(from Cohen, AS & Coe, AL, 2007. The impact of the Central Atlantic Magmatic Province on climate and on the Sr- and Os-isotope evolution of seawater. *Palaeogeography, Palaeoclimatology, Palaeoecology*: 224, 374-390).



Sample locations. Mesozoic units of the Hartford Basin highlighted.



Typical Talcott textures. Large clinopyroxenes in a finer plagioclase-rich matrix. (10x, crossed polars)

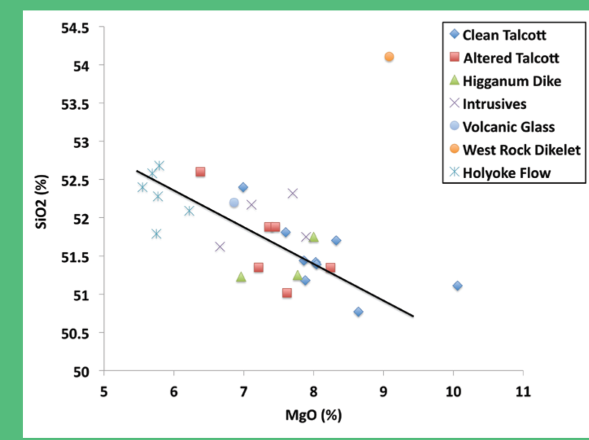


Typical Holyoke textures. Large plagioclase phenocrysts in a finer matrix. (10x, crossed polars)

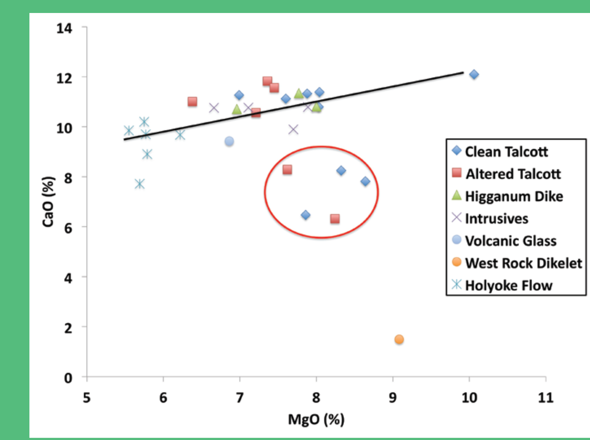
Methods

- The Talcott flow, its associated feeder the Higganum dike, the intrusive units, and the Holyoke basalt were sampled from 32 locations across Connecticut for geochemical analyses
- Loss on ignition determined for every sample to screen for alteration
- All samples analyzed by XRF for major and trace elements at Wesleyan University
- Samples also analyzed for trace elements by ICP-MS at the SGS Lab in Ontario, Canada
- Thin sections were analyzed to help characterize the phenocryst abundances and alteration

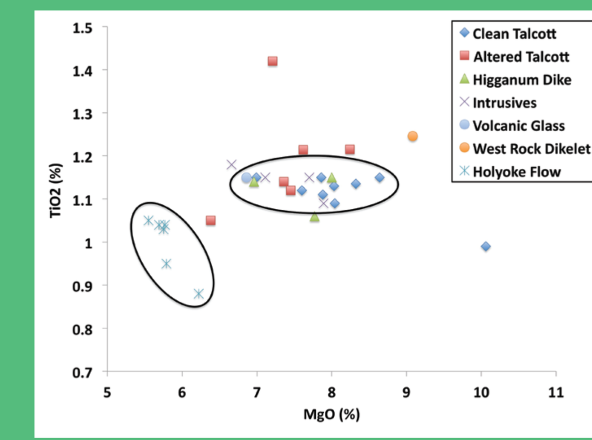
Major Element Plots



Harker diagram showing the negative correlation between silica and magnesium. All Holyoke samples plot beyond the extent of the Talcott samples.

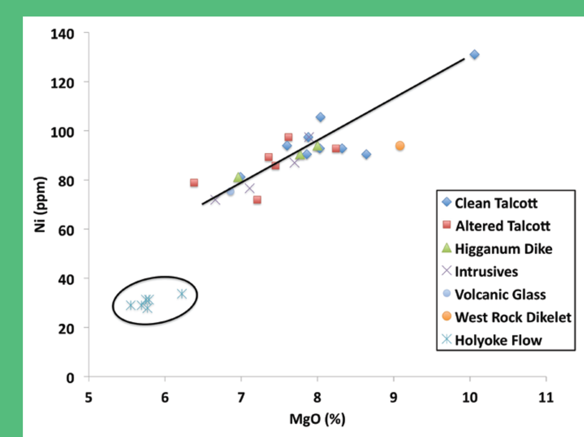


Harker diagram showing the positive trend between calcium and magnesium. The slope is only steep enough to suggest minor plagioclase fractionation but could suggest olivine and clinopyroxene fractionation as well. The one most-magnesian sample was likely affected by olivine accumulation. The five Talcott samples that plot below the rest are a geographic subset, perhaps suggesting the presence of a different alteration regime laterally within the flow.

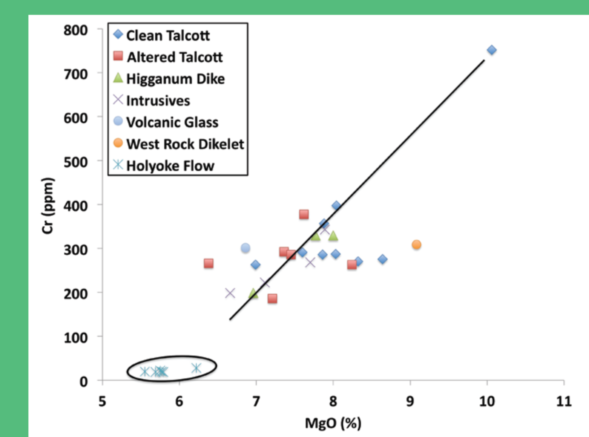


Harker diagram showing the compositional difference between the Talcott and the Holyoke. The range of TiO_2 values within the clean Talcott samples is very small (excluding the one most magnesium-rich sample which may have been affected by olivine accumulation, which might also explain its lower titanium value).

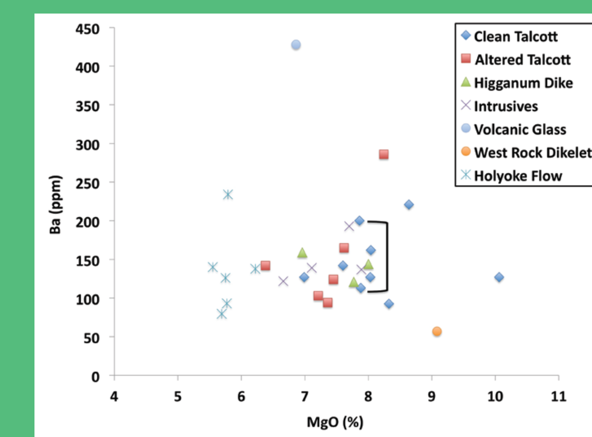
Trace Element Plots



Harker diagram showing the positive correlation between nickel and magnesium suggesting olivine accumulation and clinopyroxene/olivine fractionation. The Holyoke plots separately but along a negative trend.

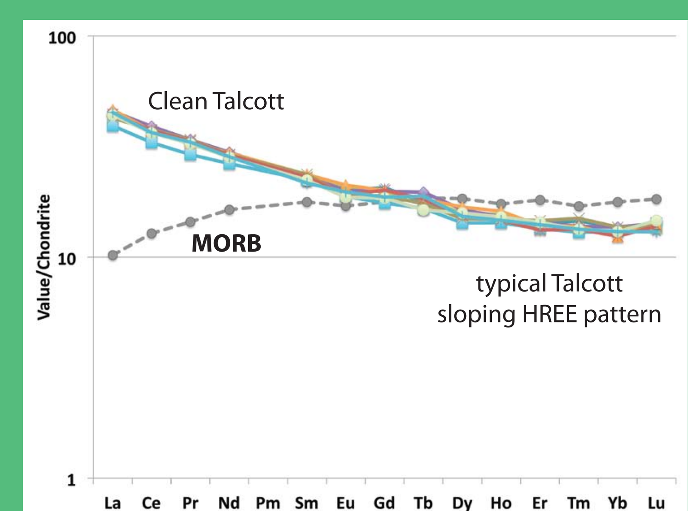


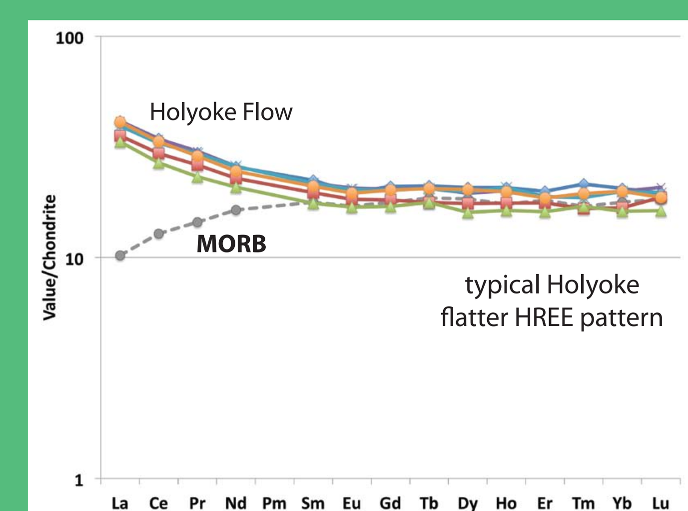
Harker diagram showing the positive correlation between chromium and magnesium, which again suggests olivine and clinopyroxene fractionation within the Talcott as well as between the Talcott and Holyoke compositions.



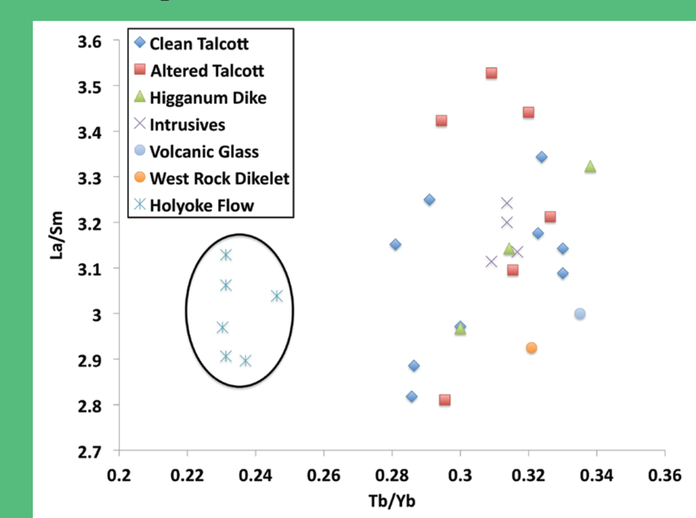
Harker diagram showing the range of LIL enrichment within the Talcott, a difference up to a factor of 2. This same range is seen in the Holyoke samples.

REE Spider Diagrams

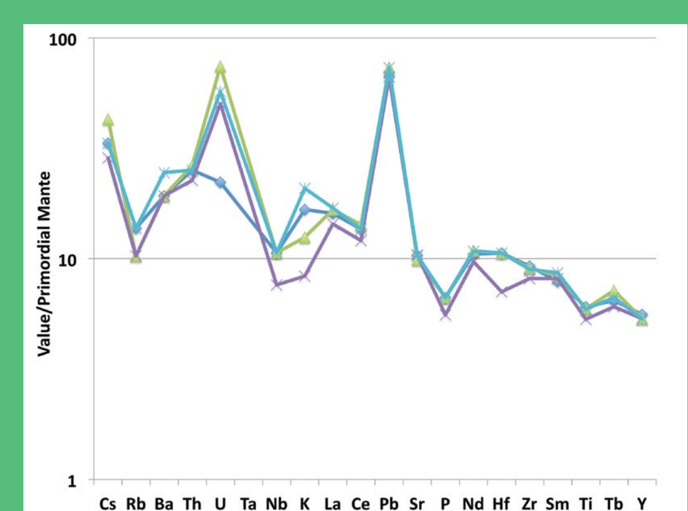




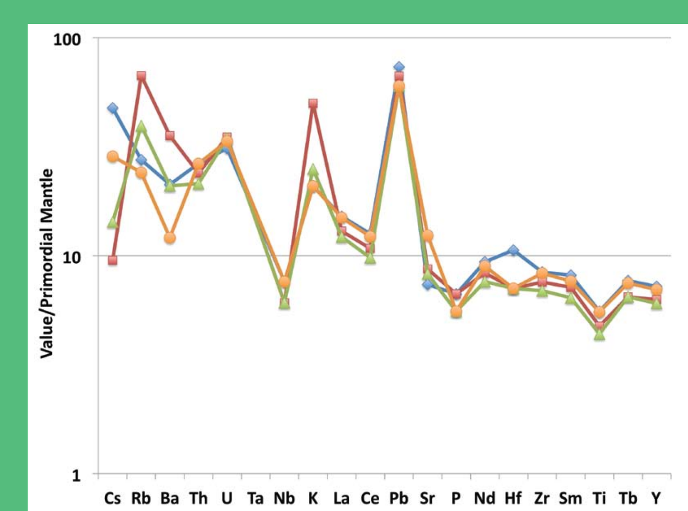
Slope LREE vs. HREE



Incompatible Spider Diagrams

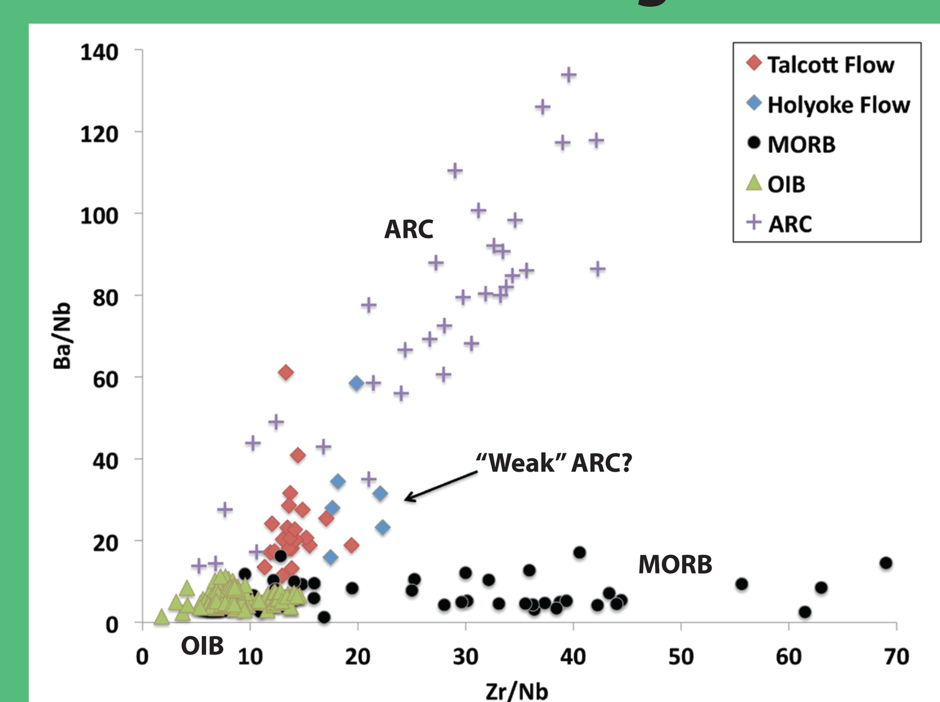


representative Talcott trace element signature



representative Holyoke trace element signature

Potential ARC signature



Fractionation Modeling

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The Parent magma(P) is   TAL-21 HIG RS

 Coef    %Solid    Min/Magma
 0.171    49.3     PL new RS
 0.142    40.9     CPX new RS
 0.034     9.8     OL new RS
 0.653             TAL-8 HOL RS Daughter(D)

           SiO2  TiO2 Al2O3   FeO   MnO   MgO   CaO  Na2O   K2O  P2O5   NiO Cr2O3
Daughter  53.22  1.07 14.04 12.44  0.22  5.64 10.00  2.63  0.61  0.14  0.00  0.00
Parent   TAL-21 HIG RS
Obs       52.18  1.08 14.55  9.63  0.17  7.91 11.55  2.35  0.46  0.12  0.00  0.00
Calc      52.48  0.73 14.72  9.72  0.15  7.91 11.55  2.16  0.40  0.09  0.00  0.05
Diff*Wt    0.12  0.35  0.08  0.09  0.03  0.00  0.01  0.19  0.06  0.03  0.00  0.05
Sum of squares of residuals= 0.196

       D     Obs(P)   Calc(P)   Diff    TAL-8 HOL RS(D)  F=0.653
RB   0.04    14.7     11.1      3.54     16.7
SR   0.92   170.5    144.0     26.5     148.9
BA   0.09   123.2     96.4     26.8     142.2
ZR   0.11    86.8     61.3     25.5      89.6
NI   8.16    92.1    620.5    528.42     29.5
CR  15.62   335.7  10138.0   9802.36     20.1
 V   0.46   274.0    287.3     13.36    361.2
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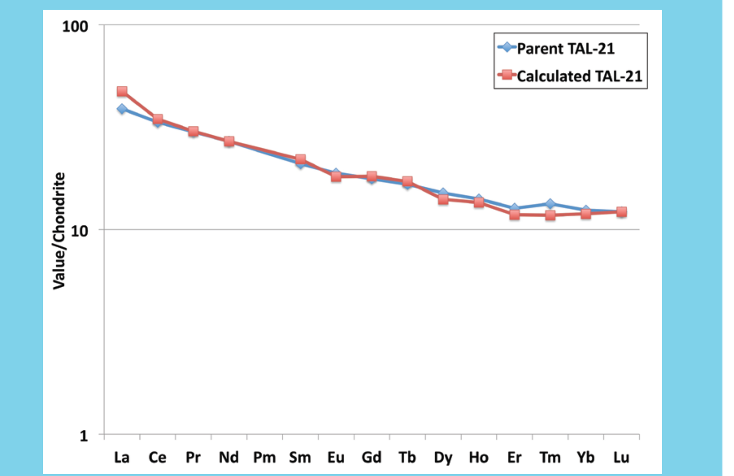
Our best fractionation residual between Talcott and Holyoke samples. Major elements provide a good fit but compatible elements are overcalculated beyond levels of analytical uncertainty.

(after Philpotts AR & Reichenbach, I, 1985. Differentiation of Mesozoic basalts of the Hartford Basin, Connecticut. *Geological Society of America Bulletin*, vol. 96, pp. 1131-1139)



Excellent agreement between observed and calculated REE patterns of one Talcott sample vs. the calculated composition from a fractionation model from another Talcott sample. This involved fractionation of 3% plagioclase, 1% clinopyroxene, and 2% orthopyroxene yielding a residual of 0.084 and good agreement between major and trace elements.

Discussion

The major element data highlights the compositional differences between the Talcott and the Holyoke. The Talcott is richer in magnesium, titanium, and calcium, and poorer in silica. It also suggests some minor plagioclase fractionation in the petrogenesis of the Talcott.

The trace element data suggests that olivine accumulation and clinopyroxene/olivine fractionation occurred during the evolution of the Talcott magma. This data also shows the range in trace elemental compositions within the flow which suggest that crustal assimilation may have played a part in the evolution of the Talcott magma.

The incompatible spider diagrams show typical ARC signatures e.g., the negative Nb anomaly and LIL and LREE enrichment which we are interpretting as a "weak-ARC" signature.

Our fractionation modeling has been testing the proposal by Philpotts and others that the Holyoke magma is a daughter of the Talcott magma through fractionation of plagioclase, olivine, and clinopyroxene; their calculations require the addition of orthopyroxene from an unidentified source. IgPet modeling of our samples yields a plausible genesis of Holyoke magma as a daughter of the Talcott intrusives and feeder dike (with some distinct trace element problems), but not of the composition of the flow itself. We speculate that magma as found in the dikes and the intrusives remained at the base of the crust and fractionated to later produce the Holyoke magma. The exposures of the dike presumably represent the last batches of Talcott magma prior to cessation of that volcanic phase.

Conclusions

- The Talcott basalt shows signs of olivine accumulation and clinopyroxene/olivine fractionation as well as potential minor plagioclase fractionation.
- The Holyoke can be linked by fractional crystallization to the Talcott magma, but only from a restricted set of compositions (the last magma emplaced).
- Talcott and Holyoke magmas show clear but weak ARC signatures.

Future work will continue modelling the relations between the Talcott and Holyoke, and estimating the composition(s) of the source mantle.

Acknowledgements

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