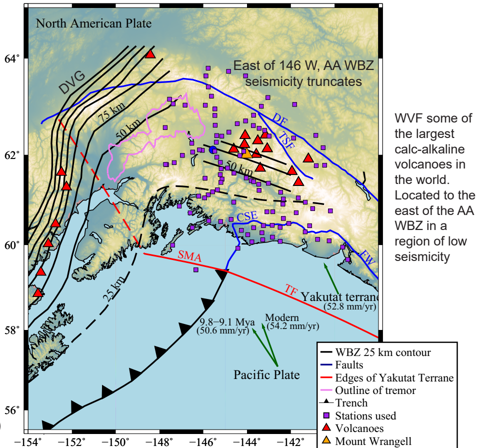
High resolution earthquake location across the Wrangell Volcanic field, Alaska

K.A. Daly(1), G.A. Abers(1), Michael Everett Mann(1), S.Roecker(2), Douglas H Christensen(3)
(1) Cornell University, Ithaca NY; (2) Rensselaer Polytechnic Institute, Troy NY (3) UAlaska Fairbanks

Introduction

Regional questions:
Is there a Wadati-Benioff zone (WBZ) below the Wrangell Volcanic Field (WVF) ? If so, is it continuous or discontinuous with the Alaska-Aleutian (AA) WBZ? [2],[3]

Big question:
Why is the seismicity rate and volcanism so different between WVF and Denali Volcanic Gap (DVG) [1]?



WVF some of the largest calc-alkaline volcanoes in the world. Located to the east of the AA WBZ in a region of low seismicity

Figure 1: Tectonics of this research area. AA WBZ contours are taken from Ratchkovski & Hansen (2002) [6]. The 25 km contour and Wrangell WBZ contours are calculated from our results and other recent studies in this area

Methods

This study used 103 broadband seismometers from the Wrangell Volcanism & Lithospheric Fate (WVLF) array and other stations in Alaska. WVLF is a dense array of 36 broadband IRIS-PASSCAL seismometers active between 2016-2018 distributed around the WVF.

Used the earthquake autodetection code from Comte et al. 2019 [5]. Signals and their onsets are identified automatically using an adaptive-autoregressive algorithm tuned to P and S waves and associated with earthquakes through a process of iterative refinement and nonlinear event location.

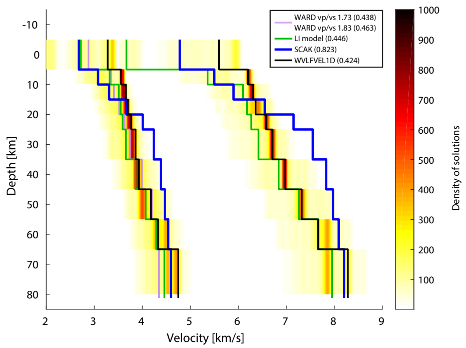


Figure 2: Output models from 2000 VELEST calculations. The green, cyan, blue and black lines are specific input models from the literature. The numbers in brackets are the total RMS values for each model when run through VELEST relocation step.

The 'best earthquakes' have P and S detections greater than 12 and 11 respectively and total location error < 40 km resulting in 408707 P arrivals, 347007 S arrivals for 13234 events.

Hypocenter locations were further improved using double-difference relocation (hypoDD) [7]. All subsequent figures are the hypoDD locations

Inverted for 1D velocity model using VELEST joint hypocenter, 1D velocity and station correction.

Results

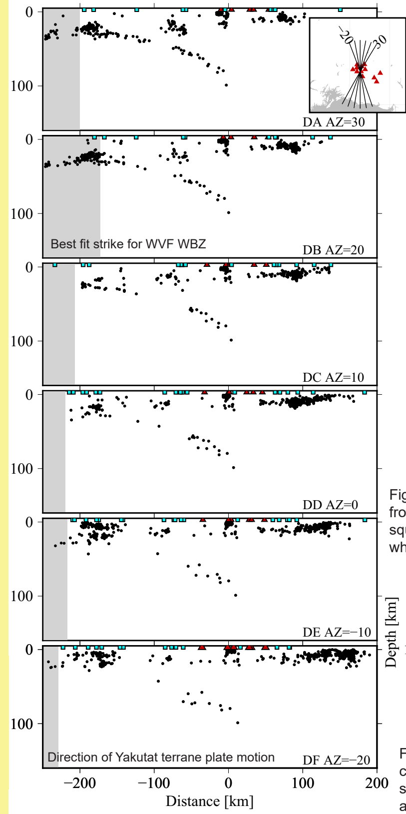


Figure 3: Cross-section at different azimuths for earthquakes within 25 km of the cross-section line centered at 143.7W, 62N. Map inset in DA show the cross-section lines and red triangles for the WVF volcanoes. Cyan squares and red triangles are the projected stations and volcanoes,

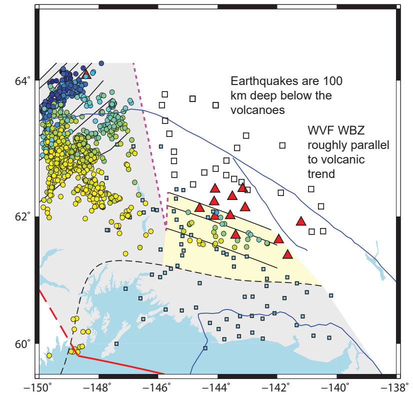


Figure 4: Earthquakes deeper than 50 km. Shaded grey is the Yakutat terrane from previous studies [1] and shaded yellow is the new WVF slab. Blue squares are the stations that see subducting slab in reciever functions and white squares do not. Purple dashed lines outline the edges of the slab tear.

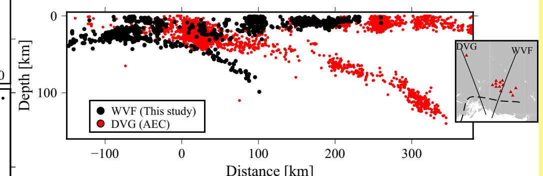


Figure 5: Seismicity beneath the DVG from the AEC catalog (within 25 km of cross section) and hypoDD locations beneath WVF (within 100 km of cross section). Cross section lines are shown in the map inset beneath the DVG at an azimuth of 20W and beneath the WVF at 20E. Both cross sections are centered on the 25 km slab contour.

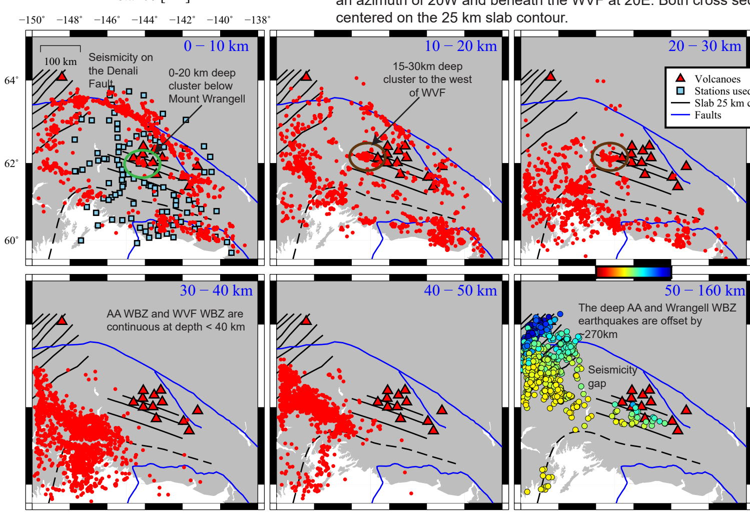
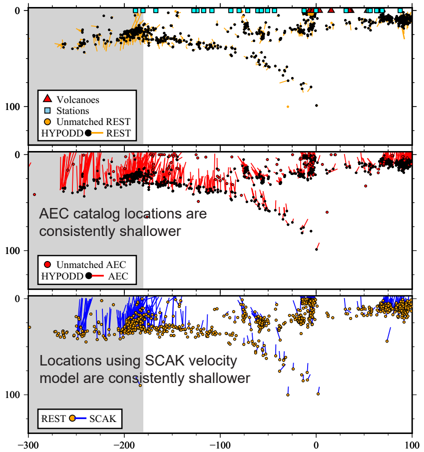


Figure 6: : Maps of 10 km depth slices where the depth range is indicated by the blue values in the upper right of each subfigure. Only the bottom right map has earthquakes colored by depth using the same color scale as figure 4

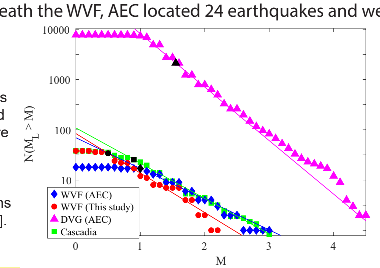
Comparison to AEC catalog

Figure 7: Earthquakes within 100 km of DB cross sections from figure 3. Comparison between HYPODD, REST, AEC and SCAK (velocity model used by AEC catalog)



Deeper than 40 km beneath the WVF, AEC located 24 earthquakes and we located 56.

Figure 8: Gutenberg-Richter plot along WBZ. Colored lines show the maximum likelihood regression. Black symbols are the magnitude of completeness for each corresponding catalog: 1.2, AEC catalog; 1, our detections and 1.4, Cascadia catalog [8].



Conclusion

- We more than doubled the number of >40 km deep earthquake detections around the WVF.
- We observe a WBZ beneath the WVF, dipping at approximately 20 +/- 2N (highly oblique to plate motion).
- WBZ roughly parallels the volcanic trend and reaches 100 km below the Wrangell volcanoes
- The AA and Wrangell WBZ are continuous <40 km depth and extend to the Alaskan coast where known Yakutat terrane is colliding indicating that the same Yakutat terrane is subducting beneath WVF and DVG
- The offset of earthquakes > 40 km deep between the AA and Wrangell WBZ's together with the seismic gap between the two WBZ's leads us to believe the WBZ's are discontinuous and may have a slab tear.
- Different volcanism and seismicity rates between DVG and WVF indicates a thermal difference in the two regions. We hypothesize this is either due to slab tear influence or due to the different orientations of subduction to plate motion

References

[1] Eberhart-Phillips, et al. (2006). JGR, 111, B11303.
[2] Jadamec, M. A., & Billen, M. I. (2010). Nature, 465(7296), 338–341.
[3] Martin-Short, R. et al. (2018), GGG , v. 19, no. 11, p. 4541–4560,
[4] Wech, A. G. (2016) Geology, 44(7), 587–590.
[5] Comte, D. et al. (2019). Earth and Planetary Science Letters, 520, 50–62.
[6] Ratchkovski, N. A., & Hansen, R. A. (2002). Bulletin of the Seismological Society of America (Vol. 92, Issue 3).
[7] Waldhauser, F., & Ellsworth, W. L. (2000). Bulletin of the Seismological Society of America, 90(6), 1353–1368.
[8] McCrory, et al. (2012). JGR: Solid Earth, 117(9), 1–24.