**西亞高加索地區的剪力波分離與非均向性**

**Shear-Wave Splitting and Anisotropy Observed in the Caucasus Region of West Asia**

童靖惠1、曾泰琳1、林佩瑩2

Jing-Hui Tong1, Tai-Lin Tseng1, Pei-Ying Patty Lin2

1Department of Geosciences, National Taiwan University

2Department of Earth Sciences, National Taiwan Normal University

The Caucasus in west Asia is a natural laboratory to study dynamics of continental collision between the Arabian and Eurasian Plates that initiated ~25 Ma. The new seismic arrays in Armenia and Georgia provide a unique opportunity to constrain seismic anisotropy beneath the region for further exploration on the relationship between lithosphere and asthenosphere associated with the post-collisional volcanisms.

We use the shear-wave splitting (SWS) of SK(K)S phases to estimate the fast-direction and delay time for events recorded during 2010-2020. Moreover, we apply principal components analysis to improve our SWS measurements on accessing linearity of particle motion. Totally, we accomplish 46 stations and 1346 high-quality SWS measurements to map out the lateral variation of azimuthal anisotropy below the study area. The variation along depth, although difficult to constrain, is also investigated with 1-D forward modeling.

Our SWS results show that the fast-direction in Caucasus is oriented primarily at azimuth of NE-SW which is subparallel to the absolute plate motion, similar to previous results in the Anatolia block. However, there is a noticeable decrease in the delay time from 1.06 s in the northwestern Caucasus to nearly 0.70 s in the southeastern Caucasus where Quaternary-Holocene volcanoes are still active in Armenia. We propose that the prevailing NE-SW seismic anisotropy corresponds to long-term & large-scale asthenospheric flow in the Caucasus region; while the reduction in delay time underneath Armenia may be explained by the edge-driven convection (EDC) due to large gradient in lithospheric thickness. It is likely that either a large-scale EDC increases sub-vertical component of mantle flow or a local-scale EDC localizes a thin layer of horizontal deformation near the base of lithosphere. Both scenarios potentially lead to partial melting and thermal erosion.

***Keywords:*** Caucasus, seismic anisotropy, shear-wave splitting, asthenosphere

Reference

Arvin, S., Sobouti, F., Priestley, K., Ghods, A., Motaghi, K., Tilmann, F., & Eken, T. (2021). Seismic anisotropy and mantle deformation in NW Iran inferred from splitting measurements of SK(K)S and direct S phases. *Geophysical Journal International*, *226*(2), 1417–1431. http://doi.org/10.1093/gji/ggab181

Audet, P., & Schaeffer, A. J. (2019). SplitPy: Software for teleseismic shear-wave splitting analysis (v0.1.0). *Zenodo*. http://doi.org/10.5281/zenodo.3564780

Audet, P., Eulenfeld, T. & Mather, B. (2022). paudetseis/Telewavesim: Telewavesim (v0.2.1). *Zenodo*. http://doi.org/10.5281/zenodo.6249382

Audet, P., Thomson, C. J., Bostock, M. G. & Eulenfeld, T. (2019). Telewavesim: Python software for teleseismic body wave modeling. *Journal of Open Source Software, 4*(44), 1818. http://doi.org/10.21105/joss.01818

Bowman, J. R., & Ando, M. (1987). Shear-wave splitting in the upper-mantle wedge above the Tonga subduction zone. *Geophysical Journal International*, *88*(1), 25–41. http://doi.org/10.1111/j.1365-246x.1987.tb01367.x

Fukao, Y. (1984). Evidence from core-reflected shear waves for anisotropy in the Earth's mantle. *Nature*, *309*(5970), 695–698, http://doi.org/10.1038/309695a0

Global Volcanism Program, 2013. Volcanoes of the World, v.4.10.5. Venzke, E(ed.). Smithsonian Institution. Downloaded 09 Sep 2021. http://doi.org/10.5479/si.GVP.VOTW4-2013

Huang, T.-Y., Gung, Y., Kuo, B.-Y., Chiao, L.-Y., & Chen, Y.-N. (2015). Layered deformation in the Taiwan orogen. *Science*, *349*(6249), 720–723. http://doi.org/10.1126/science.aab1879

Kaislaniemi, L., & van Hunen, J. (2014). Dynamics of lithospheric thinning and mantle melting by edge‐driven convection: Application to Moroccan Atlas mountains. *Geochemistry, Geophysics, Geosystems*, *15*(8), 3175–3189. http://doi.org/10.1002/2014gc005414

Kennet, B. L. (1991). IASPEI 1991 seismological tables. *Terra Nova*, *3*(2), 122–122. http://doi.org/10.1111/j.1365-3121.1991.tb00863.x

Legendre, C. P., Tseng, T.-L., Chen, Y.-N., Huang, T.-Y., Gung, Y.-C., Karakhanyan, A., & Huang, B.-S. (2017). Complex deformation in the Caucasus region revealed by ambient noise seismic tomography. *Tectonophysics*, *712-713*, 208–220. http://doi.org/10.1016/j.tecto.2017.05.024

Lemnifi, A. A., Elshaafi, A., Karaoğlu, Ö., Salah, M. K., Aouad, N., Reed, C. A., & Yu, Y. (2017). Complex seismic anisotropy and mantle dynamics beneath Turkey. *Journal of Geodynamics*, *112*, 31–45. http://doi.org/10.1016/j.jog.2017.10.004

Lin, C.-M., Tseng, T. L., Meliksetian, K., Karakhanyan, A., Huang, B. S., Babayan, H., et al. (2020). Locally thin crust and high crustal ratio beneath the Armenian volcanic highland of the Lesser Caucasus: A case for recent delamination. *Journal of Geophysical Research: Solid Earth*, *125*(9). http://doi.org/10.1029/2019jb019151

Lin, Y.-C., Chung, S.-L., Bingöl, A. F., Yang, L., Okrostsvaridze, A., Pang, K.-N., et al. (2020). Diachronous initiation of post-collisional magmatism in the Arabia-Eurasia collision zone. *Lithos*, *356-357*, 105394. http://doi.org/10.1016/j.lithos.2020.105394

Raeesi, M., Zarifi, Z., Nilfouroushan, F., Boroujeni, S. A., & Tiampo, K. (2017).  Quantitative Analysis of Seismicity in Iran. *Pure and Applied Geophysics,* *174*(3),793–833. http://doi.org/10.1007/s00024-016-1435-4

Reilinger, R., McClusky, S., Vernant, P., Lawrence, S., Ergintav, S., Cakmak, R., et al. (2006). GPS constraints on continental deformation in the Africa-Arabia-Aurasia continental collision zone and implications for the dynamics of plate interactions. *Journal of Geophysical Research: Solid Earth*, *111*(B5). http://doi.org/10.1029/2005jb004051

Sandvol, E., Turkelli, N., Zor, E., Gök, R., Bekler, T., Gurbuz, C., et al. (2003). Shear wave splitting in a young continent-continent collision: An example from eastern Turkey. *Geophysical Research Letters*, *30*(24). http://doi.org/10.1029/2003gl017390

Scholz, J.-R., Barruol, G., Fontaine, F. R., Sigloch, K., Crawford, W. C., & Deen, M. (2016). Orienting Ocean-Bottom Seismometers from P-wave and Rayleigh wave polarizations. *Geophysical Journal International*, *208*(3), 1277–1289. http://doi.org/10.1093/gji/ggw426

Şengör, A. M., Özeren, S., Genç, T., & Zor, E. (2003). East Anatolian high plateau as a mantle-supported, north-south shortened domal structure. *Geophysical Research Letters*, *30*(24). http://doi.org/10.1029/2003gl017858

Silver, P. G., & Chan, W. W. (1991). Shear wave splitting and subcontinental mantle deformation. *Journal of Geophysical Research*, *96*(B10), 16429. http://doi.org/10.1029/91jb00899

Priestley, K., & McKenzie, D. (2013). The relationship between shear wave velocity, temperature, attenuation and viscosity in the shallow part of the mantle. *Earth and Planetary Science Letters*, *381*, 78–91. http://doi.org/10.1016/j.epsl.2013.08.022

Wessel, P., Luis, J. F., Uieda, L., Scharroo, R., Wobbe, F., Smith, W. H., & Tian, D. (2019). The generic mapping tools version 6. *Geochemistry, Geophysics, Geosystems*, *20*(11), 5556–5564. http://doi.org/10.1029/2019gc008515

Wüstefeld, A., & Bokelmann, G. (2007). Null detection in shear-wave splitting measurements. *Bulletin of the Seismological Society of America*, *97*(4), 1204–1211. http://doi.org/10.1785/0120060190