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Uppermost mantle anisotropy beneath the southern Laurentian margin: Evidence from Knippa peridotite zenoliths, Texas

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Measurements of shear-wave splitting (SKS) play a crucial role in imaging the orientation and degree of polarization of mantle fabrics, and constrain models for the formation of these fabrics, including the mantle beneath the south-central North America. In this study, we present petrofabric data for spinel peridotite xenoliths from Knippa, Texas, and use these results illuminate the origin and significance of shear wave splitting beneath the southern Laurentia. Knippa quarry exposes Late Cretaceous basanites with xenoliths of the upper mantle beneath Texas and the transition from Laurentian craton to Gulf of Mexico seafloor. This is the only known mantle peridotite locality in Texas. This transitional lithosphere formed in early Mesozoic time. Mantle xenoliths are hosted by ~86 Ma nephelinites of the Balcones Igneous Province (BIP) in central Texas. BIP volcanoes approximate the boundary between the ~1.1-1.4 Ga southernmost Laurentian (Texas) craton and Jurassic age transitional lithosphere along the GoM margin, Transitional lithosphere also involves the deformed rocks of the Ouachita fold belt. The region that spans the northern GoM margin underwent two complete cycles of continental rifting (540 and 170Ma) and collisional orogeny (ca. 1000 and 350 Ma) along the southern flank of Laurentia. The lithosphere that formed or was reworked during these tectonics events is preserved across a region that extends from the Grenville province of the craton to Jurassic oceanic crust in the GoM. Knippa peridotites are spinel lherzolite and harzburgite (plus minor dunite and clinopyroxene-rich lherzolite) consisting of olivine, orthopyroxene, clinopyroxene and spinel. They are coarse grained and equigranular, with grain boundaries that range from triple junctions to smoothly curving boundaries. Some olivine grains are cut by small serpentine veins. Temperatures determined using the Ca in orthopyroxene thermometer range between 900 and 1000 C, Knippa xenoliths come from the uppermost mantle, from depths of 40-70 km. The dominant slip system in olivine was determined from the orientations of the axes of subgrain rotation and CPO data. Olivine CPO data show strong concentration in [100] and [100]{0kl} patterns in Knippa peridotites. CPO strength is characterized by the dimensionless texture index J. J-index of Knippa peridotites varies from 4.6 to 11.4.
SKS results show that the direction of S1 is parallel to the coast line or Ouachita orogen. The parallelism of olivine [100] axis and S-wave splitting are common in orogenic zone. Besides, the seismic anisotropy resulting from olivine CPO tends to show a maximum seismic velocity parallel to the direction of plastic flow within the upper mantle. Thus, it shows that CPOs might be developed during this orogeny such as Ouachita fold belt. Moreover, the variations of SKS splitting delay time, which change from 0.5 to 1.5 s towards the coast side, might be due to the change of CPO of olivine. That is olivine CPO of continental side peridotites show [010]-fiber patterns like Kilbourne Hole peridotite xenoliths. It induce more weak anisotropy than [100]-fiber patterns in the vertical direction (Z direction). Therefore, we consider it likely that the Knippa peridotite xenoliths are derived from the uppermost mantle lithosphere in the region dominated by compaction due to the collisional orogeny.

Keywords: peridotite xenoliths, seismic anisotropy, Crystallographic preferred orientation, Knippa, USA