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3D and 2D inversion of magnetotelluric data from the continental collision zone in the Pamirs and Tien Shan, Central Asia

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Many geodynamic processes governing intra-continental collisional orogeny are largely unexplained and controversial. A key question is the state and dynamic behaviour of the lithosphere at middle and lower crustal levels while continental collision progresses. The Pamir – Tien Shan region in Central Asia may be the best location on Earth to study such lithospheric deformation processes in situ. The mountain ranges and high plateaus formed at the tip of the north-western Indian promontory through the Cenozoic experienced rates of shortening similar to the adjacent Himalaya-Tibet system. Today, the Pamir – Tien Shan orogenic belt hosts some of the deepest active intra-continental subduction zones on Earth and absorbs the highest strain rate over the shortest distance that is manifested in the India–Asia collision zone. The multi-disciplinary Tien Shan – Pamir Geodynamic Program (TIPAGE) was designed to address some of the geodynamic key questions in this region. A magnetotelluric (MT) survey was carried out in concert with other geophysical and geological observations in Kyrgyzstan and Tajikistan, predominantly along a 350 km long and 50 km wide corridor from southern Tajikistan to Osh in Kyrgyzstan across the Pamir Plateau and southern Tien Shan mountain ranges. In total we recorded MT data at 178 stations, 26 of them combine long-period and broad band recordings. We present and compare 2D and 3D MT inversion results. Strike analysis of the data revealed an overall mean geo-electric strike direction consistent with the predominant tectonic trends. 2D inversion yields a reasonable data fit, with exception of some sites which exhibit phases above 90 degrees. 3D inversion was carried out with the ModEM package. We inverted for all four impedance tensor components and the vertical magnetic transfer functions. Topography was also included. The 3D models are generally in agreement with the 2D results but achieve a better data fit, particularly phases which could not be fitted with 2D inversion. The MT inversions reveal an upper crust of the Pamirs, which is generally resistive, with embedded conductive parts correlating to suture zones. Several distinct zones of high conductivity appear beneath the southern Pamirs and the central/northern Pamir at mid crustal levels, possibly reaching mantle depths. We interpret the southern mid-crust conductor as hot and partially molten, viscous felsic material. To the north, the conductor is bound by a resistive block which correlates with the miocene gneiss of the Muskol dome. The second conductive zone north of the Muskol dome could originate from brittle and fractured crust. Faults and old deformation zones can form pathways for aqueous fluids in the crust. When highly mineralized fluids penetrate fractured brittle areas, the entire region can become conductive. Further north, the seismically active Main Pamir Thrust which separates the Pamir from the Tien Shan corresponds to a sharp, south-dipping conductivity contrast between resistive upper crust in the Pamirs and conductive crust beneath the Alai valley.