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用Rayleigh面波方位各向异性研究中国大陆岩石圈形变特征

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摘要 中国大陆地质构造历史非常复杂，岩石圈长期积累的形变较大，而利用地震面波传播的各向异性是研究岩石圈形变特征的强有力手段. 本文利用双台窄带通滤波-互相关方法与基于图像分析的相速度频散曲线提取技术，提取Rayleigh面波相速度频散资料，进而反演中国大陆及邻区20～120 s周期Rayleigh面波相速度方位各向异性空间分布图像. 检测板测试结果显示：中国大陆大部分区域的方位各向异性横向分辨率在5°左右. 各向异性研究结果表明：中国大陆地壳上地幔方位各向异性特征存在显著的空间差异，反映出形变特征的空间差异；104°E以东地区地壳上地幔各向异性弱于西部地区，表明其构造变形总体弱于西部地区. 青藏地块及其东缘地区地壳与上地幔顶部变形最为强烈. 但东部的局部地区如华南地块与珠江口地区、鄂尔多斯盆地西南缘以及秦岭-大别造山带，较强的各向异性显示这些区域在不同时期也经历了强变形. 青藏地块内中短周期快波方向自西向东顺时针旋转变化可能指示板块碰撞与挤压过程中软弱物质的流变方向. 青藏地块西部中下地壳和上地幔形变模式相似，可能处于壳幔耦合状态；而中东部及东缘地区地壳上地幔形变模式存在明显差异，壳幔似乎不具备垂直连贯的形变特征. 位于青藏地块北部的塔里木盆地、柴达木盆地以及祁连褶皱带同样经历了强变形. 包括四川盆地在内的上扬子地块快波方向的变化显示中地壳与下地壳上地幔形变模式不同，而形变特征一致的下地壳与上地幔应为强耦合. 大约以103°E为界，龙门山断裂带可分为南西段和北东段，南西段处于低速区，而北东段位于高速区，且方位各向异性强度明显大于南西段；2008年5月12日汶川M_S8.0级地震沿断裂带的单侧破裂模式除与北东段的高应力积累有关外，还可能与北东段地下介质物性存在密切关系，高速坚硬岩体的发育有利于应变能的积累与集中释放.

关键词 Rayleigh面波 相速度 方位各向异性 中国大陆 岩石圈形变

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Lithospheric deformation of continental China from Rayleigh wave azimuthal anisotropy

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Abstract The tectonic history of continental China is complicated and the associated lithospheric deformation is large, while the use of the anisotropic propagation of surface waves is an important way to investigate the history of lithospheric deformation pattern. We measured inter-station Rayleigh-wave phase velocity dispersion from cross-correlation of narrow band-pass filtered surface wave records and an image analysis technique. The dispersion data were then used to invert the distribution of azimuthal anisotropy at periods 20~120 s of continental China and its adjacent regions. Checkerboard tests show that the lateral resolution of phase velocity azimuthal anisotropy is about 5° in most area of continental China. Our results show that the pattern of azimuthal anisotropy in the study area displays clear spatial variations. The tectonic deformation of the crust and upper-mantle east of 104°E is generally weaker than that of the west as inferred from the relative magnitude of azimuthal anisotropy, and strong tectonic deformation had occurred in the crust and upper-mantle beneath Qinghai-Tibet plateau and its eastern margin. In eastern China relatively large amplitude of azimuthal anisotropy is observed in South China block and Pearl River Mouth basin, southwestern margin of Ordos basin and Qinling-Dabie orogenic belt, indicating strong tectonic deformation occurred there in the geological history. Fast propagation direction shows rotational pattern from the west to the east within the Qinghai-Tibet block at short and intermediate periods consistent with the clockwise extrusion (or escaping) of the crustal material in the block after the Eurasian and Indian collision. The deformation pattern in the mid-lower crust of western Qinghai-Tibet block is similar to that of the upper mantle, inferring possible vertically coherent deformation across the Moho

interface. However, the central and eastern Qinghai-Tibet block and its eastern margin show different deformation patterns in the crust and upper mantle, which suggests that there is no apparent vertically coherent deformation between the crust and upper mantle. Strong tectonic deformation had occurred within Tarim and Qaidam basins as well as Qilian fold belt north of Qinghai-Tibet block. The fast propagation direction at the middle crustal depth is clearly different from those both in the lower crust and upper mantle underlying the upper Yangtze block including Sichuan basin. This suggests different tectonic deformation processes between the middle crust and lower crust beneath this block, while the lower crust and upper mantle appears to be coupled as inferred from the similar fast propagation direction at periods above 30 s. The Longmen Shan tectonic zone can be divided into southwestern and northeastern segments at about 103°E. The southwestern segment has relatively lower phase velocity while the northeastern area has higher phase velocity and stronger anisotropy. This suggests that the NE striking unilateral rupture propagation of the Wenchuan M_S8.0 earthquake on May 12 2008, may be related not only to the cumulated high stress of the northeastern section but also to the underlying medium property along the segment with high phase velocity suitable for strain energy accumulation and concentrated release.

Key words Rayleigh waves; Phase velocity; Azimuthal anisotropy; Continental China;Lithospheric deformation

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