

Mobility of a Craton: Insights from Chronology and Evolution of Tectonic Movements in the Ordos Basin

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The tectonic movements that a tectonic region underwent are the comprehensive correspondence to the mobility by itself and the tectonic events around it. To establish the chronology, describe the temporal-spatial distribution, explore the signature, and address the mechanism of the tectonic movements is the key issue of continental dynamics. The Ordos Basin is famous for its tectonic stability and is rich in oil and gas, coal, uranium, and salt deposits. It is quite distinct for an absence of sedimentation since the Late Cretaceous and the occurrence of several regional unconformities. It is circled by compressive belts of different periods and grabens since the Eocene, which demonstrates that the basin underwent multi-period tectonic events. To study these tectonic events in the basin is critical to understand its tectonic evolution and its controls on the occurrence of the variety of energy and ore deposits. By use of recent deep boreholes, seismic reflection profiles and geological mapping at the periphery of the basin, we analyzed quantitatively the unconformities, describe the temporal-spatial distribution of the tectonic movements characterized by these unconformities, and discuss the tectonic evolution. The Ordos Basin rests on a crystalline basement which formed during two extensional and compressive cycles in the Paleoproterozoic on the basis of the southern and the northern Archean continental cores. There occur eight regional unconformities such as at Base Changcheng System, Base Jixian System, Base Cambrian, Base Upper Carboniferous, Base Triassic, Base Jurassic, Base Cretaceous, and Base Cenozoic. The hiatus is around tens to hundreds of millions of years. The unconformities document that the basin underwent the Lvliang Movement, the Zha'ertai Movement, the Chengjiang Movement, the Huo-Qiu Movement, the Caledonian Movement, the Hercynian Movement, the Indosinian Movement, the Yanshanian Movement, and the Himalayan Movement, respectively. The unconformities at Base Cambrian, Base Upper Carboniferous, Base Jurassic, and Base Cretaceous are distinct and superimposed unconformities, with the underlying strata of different ages buried by the overlying rocks, which is common in the Yimeng, and Zhen-Jing areas. The superimposed unconformities at Base Jurassic and Base Cretaceous are well developed in the northern part and the western margin of the basin, whereas the unconformity at Base Cenozoic occurs at the southwestern margin of the basin. The Ordos Basin underwent chiefly the following stages: (1) cratonization during then Meso- to Neoproterozoic, including rifting in the Changcheng Period, depression in the Jixian Period as well as uplift in the Qingbaikou to Sinian Period; (2) the cratonic platform and its differentiation processes during the Paleozoic, including the build-up of a marine carbonate platform and the formation of the structural framework of uplifts, intervened with depressions in the platform in the Cambrian to Early Ordovician, the rising and non-deposition in the Middle Ordovician to Early Carboniferous, and the transition from a marine to continental environment in the Late Carboniferous to Permian; (3) the large-scale intra-cratonic depression during the Triassic to Jurassic, strong compression at the periphery in the Early Cretaceous, deep-seated tectonic activity at the end of the Early Cretaceous, and uplift and erosion since the Late Cretaceous; (4) Since 55 Ma, the basin margin extended, subsided, and formed a series of grabens, whereas its interior was uplifted and subjected to erosion, influenced by the rotation and adjustment of the continental block; since 10 Ma, controlled by the uplift of the Qinghai-Tibet Plateau and the northeastward propagation of the structural deformation, transpression along the southwestern margin formed a series of arcuate thrust belts; since 3 Ma, the basin rose as a whole, and peneplanation occurred. The above-mentioned tectonic events were controlled by the activation of the boundary tectonic mobile zones such as the Qinling belt, the Yinshan belt, the Helanshan-Liupanshan belt, and the Lvliangshan belt, or the adjacent much larger-scale plates, such as the Paleo-Asian Ocean, the Pacific Ocean, the Okhotsk Ocean, and the India Ocean. The Ordos Block underwent three extensional to compressional cycles such as the Middle Proterozoic to Devonian, Carboniferous to Triassic, and Jurassic to Quaternary. It experienced tectono-depositional differentiation

during the earlier periods, the depression as a whole during the middle periods, and block uplift during the late periods. The basement configuration, block differentiation, and the correspondence to the peripheral tectonic activities gave rise to the oil and gas distribution framework such as “the gas in the whole basin whereas the oil in the half basin”, and more importantly the tectonic setting for the super-giant or mega-giant oil and gas fields of lower or super-low permeability.