The Link Between Ancient Suture Zones, Strong Earthquakes and Mineral Deposits

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Abstract: Major (*M*>7.0) intraplate strike-slip earthquakes are known to occur in areas not previously identified as prone to high seismic risk. Ancient suture zones represent pathways favorable for the transfer of seismic energy, as well as of heat, magma and ore-forming fluids towards the Earth's surface. The intersections of the suture zones with structures of other trends can develop complex interference patterns, which constitute networks of small-scale faults and fractures. It may become preferential places for the release of seismic energy by earthquakes, or, in connection with lithology and geochemical parameters, become favorable loci for concentration of mineral deposits. A proper identification of lithospheric-scale intersections of long-lived deep fault systems could be the key to understanding problems such as the structural controls of major earthquakes and on the distribution of mineral deposits.

1 INTRODUCTION

The anomalous sequence of M>7.0 strong earthquakes near Gazli gas deposit located within seismically «quiet» region caused the need for the complex study of the earth's crust dynamics in the region and of the peculiarities of residual stress relief in the epicentral zone of these events (Amorese et al., 1995, Plotnikova et al., 1996). The Gazli gas field is located in Western Uzbekistan about 100 km northwest of Bukhara and exploited since 1962. The first significant earthquake occurred on April 8, 1976 at a distance of 20 km from the Gazli gas field boundary. The earthquake magnitude measured 7.1. Just 39 days later, on May 17, 1976, another severe earthquake occurred 27 km to the west of the first one. The magnitude of the second earthquake was 7.3. Eight years later, on March 20, 1984, a third earthquake occurred 15 km to the west of the second earthquake, with a magnitude of 7.2. The hypocentral depths of all three were 25 to 30 km, all within the 32 km thick earth crust in the region. These earthquakes are the strongest of all the known earthquakes in the plain of Central Asia. The kinematics of the 1984 seismic rupture exhibits a pure thrust slip motion of 2.5 m (Amores et al., 1995). Vertical velocities of deformation show uplift of most of the region (Plotnikova et al., 1996). The Gazli earthquakes occurred in an area of hydrocarbon extraction (Amorese et al., 1995, Bossu et al., 1996) suggesting a possible relationship between the two. This sequence proposed triggered by fluid extraction, due to the fact, that the area not previously identified as prone to seismic risk (Simpson and Leith, 1985, Plotnikova et al., 1996). It is important, however, to be critical with some of this data. Because there is historical information about other strong earthquakes along the zone of Aral - Hissar fault in the Turan plate, accompanied by the destruction and casualties in the ancient cities of the region - Bukhara, Samarkand, Urgench, etc (Kondorskaya and Shebalin, 1977).

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2 STRUCTURE OF PALEOZOIC SOUTHERN TIEN SHAN

Two Palaeozoic sutures divide the Western Tien Shan into three tectonic entities: South Tien Shan, Central Tien Shan, and Karakum - Tadjic area. They correspond to two subduction events: the first one resulted from the collision of the oceanic crust of Turkestan ocean with the Kazakh microcontinent and the second one occurred when part of the oceanic crust of Turkestan ocean subducted beneath the northern edge of Karakum- Tadjic microcontinent. Northern from them is presented by Bukantau - Kokshaal belt and to it correspond northern mountains of Kyzyl-Kum's, Nurata mountain, Turkestan - Alay system to the south from the Fergana depression and the Fergana range limiting it from the east. By deep Talas-Fergana fault crossing Tien Shan, active from the end the Paleozoic, there was shear displacement, which amplitude on displacement of various Paleozoic objects is equal to 120-180 kilometers.

Further in the east in the structure of the belt included - Atbashi, Djanier, Borkoldoy and Kokshaal ranges of Kirghiz Tien Shan and then in the Chinese territory ranges Halyktau, Erben and others Muzart - Hongliuhe suture zone. The resultant suture zone between the main two blocks (Kazakh and Turan) has subsequently acted as a major decoupling zone from middle Permian times onward, separating a strongly deformed domain to the SW from a weakly deformed domain to the NE. The large ductile-brittle deformation zones, situated near the tectonic sutures of the northern and southern margins of the South Tian Shan, are the key factors controlling the large-scale mineralization of Tien Shan (Xue et al, 2020).

In the territory of Uzbekistan it partly corresponds to the Nuratau – South Fergana Fault Zone (Nurtaev et al., 2013). This zone is a complex one involving both tectonic, sedimentary, magmatic and metamorphic features. Additionally, it is a zone of significant mineralisation with recorded anomalies of gold, silver and several other elements.

Ophiolite suture of closed Gissar oceanic basin is the boundary structure of the Southern Tien Shan with Karakum - Tajik unit (Nurtaev et al., 2021Large blocks of granitoids exposed on the surface (Hissar, Karatyube, Zirabulak, etc.) and compose Pre-Mesozoic basement of Bukhara-South-Hissar area (Mubarek, Gazli, Sarycha-Azlatepe, etc.). Deposits of hydrocarbons in Bukhara-South-Western Hissar area are associated with locations of these large intrusions in Paleozoic and Mesozoic rocks

3 RESULTS

We have analyzed and summarized materials of seismic tomography, deep seismic sounding, gravity and magnetic in unified GIS format. By the set of geophysical data, it was tracked system of regional faults, both in open and covered parts of the territory. It is clarified the position of faults of north-north-west (Caledonian) and sublatitudinal (Hercynian) trend. This trend also in agreement with the regional orientation of the maximum horizontal tectonic stress inferred from analysis of local seismicity in Gazli region (Bossu et al., 1996).

According to these data, Aral - Hissar fault, in the zone of influence of which located structure Gazli, is a fragment of an ancient buried suture zone separating the margin of the ancient Karakum - Tajik continent from folded Paleozoic structures of Southern Tien Shan. The location of the fault zone in the southwest part of Central Uzbekistan, together with its trend, and the fact that it extends into the Gissar region, would suggest that it may be related to the short-lived Gissar Basin (which opened to the E to the Kunlun Basin). Width of Aral - Hissar fault reaches 20-30 km, and it is a system of contiguous and variously oriented dislocations of strike-slip type. Dominates the northern dip of the fault at an angle of 70°. According to DSS profiles Farab - Tamdybulak and Romitan – Darbazatau the fault intersects the Earth's crust and Moho surface of 2-4 km, and there is down faulted south wing. There are located huge amplitude gravity step and clear sublatitudinal linear magnetic anomaly (figure 1). Thomas et al. (1999) have suggested that this boundary corresponds to the Turkestan Ocean suture.

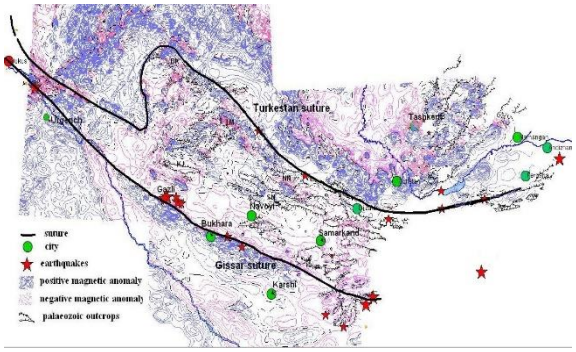

Figure 1: Map of location of suture zones, magnetic fields and strong earthquakes with M>6.5 in Western Central Asia on the base of geophysical data.

3 DISCUSSION

Before occurrence in 1976 and 1984 of Gazli earthquakes on northwest continuation Southern Tien Shan, the site of two Karatag 1907 earthquakes in spurs of Gissar mountains with M=7.4 and 7.3 were considered as the western border between seismic active orogen and practically aseismic Turan plate. Largest earthquakes known in limits of this suture zone which part is Bukhara-Gissar deep fault, has taken place in 1902 in Kashgar, on border of Tadjikistan and China, and has magnitude M=7.8. In the same place in 1955 and 1985 there were earthquakes with M=7.1 and 7.0, accordingly. To large earthquakes belong Khait 1949 (M=7.4), occurred on territory of Tadjikistan, to the east from Karatag earthquakes, and practically same by magnitude (M=7.3) earthquake of 1949 in the west of China, on east termination of considered structure. In 1974 on border of Tadjikistan and China has taken place Markansu earthquake with M=7.3. In the chronicle of the Middle Ages, there is a mention of a powerful earthquake in AD 1208 with magnitude above 6, which occurred on the territory of Khorezm, located in the northern part of Aral - Hissar fault. In the capital (Gurgench), 2,000 people died, in the villages there are even more. Also mentioned powerful earthquakes with magnitude above 6, occurred near the city of Bukhara in 1821-1822 (Kondorskaya and Shebalin, 1977). Major earthquakes along the Aral-Hissar deep fault predominantly indicate thrust faulting and are approximately normal to the traces of the major thrust belts. Ancient buried sutures form zones of weakness in the lithosphere of the inner parts of the continents, and along them often occurs unloading of intraplate stresses. So, it is obvious, that long-lived deep fault systems constitute high-permeability zones and define the location of major clusters of upper- crustal earthquakes, suggesting that these fault systems are still being reactivated under the current stress regime.

4 CONCLUSIONS

During and after the accretions and collisions, numerous intramontane basins formed in a variety of tectonic settings. Thus, the Central Asia region comprises a complex tectonic mosaic of subduction-related complexes, island arcs, ophiolitic assemblages and slivers or terranes of Precambrian crystalline basement. In the structure of fold belts and formed after in their place platforms, or rather their foundations, preserved traces of transform faults that existed in preorogenic phase of their development.

Suture zones are the most important elements of the structure not only of mobile belts, but the entire continent, and from their selection should begin tectonic zoning in the preparation of tectonic maps. A proper identification of lithospheric-scale intersections of long-lived fault systems could be the key to understanding problems such as the structural controls of major earthquakes and on the distribution of mineral deposits.

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