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GEOPHYSICS

New Findings on the Sources of Strong Earthquakes in Kerch Peninsula Based on Paleoseismological Data

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Abstract—This paper presents the results of the recent paleoseismological studies covering the entire Kerch Peninsula. The Yuzhnoberezhnaya fold-and-thrust belt extending along the southern coast of Crimea in the Black Sea was earlier considered the principal seismogenic structure. Our findings suggest that the seismic hazard on the Kerch Peninsula is largely related to potential strong onshore earthquake sources. The observed discrepancy between instrumental and paleoseismological data suggests that seismic quiescence exists in this region at present.

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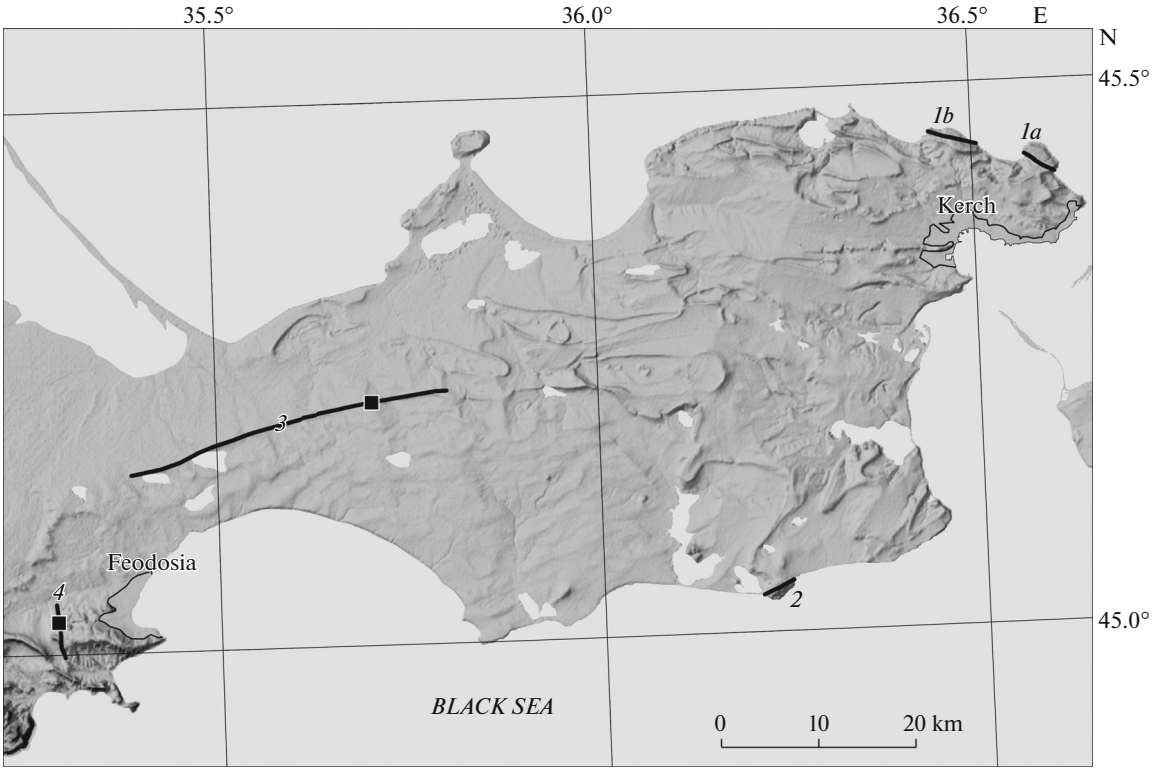

Fig. 1. Kerch Peninsula map of active faults and detailed study areas: *1*, segments of the South Azov fault (*1a*, Yurkinskii fault; *1b*, Tarkhan fault), *2*, Opukskii fault, *3*, Parpachskii fault, *4*, Feodosia fault.

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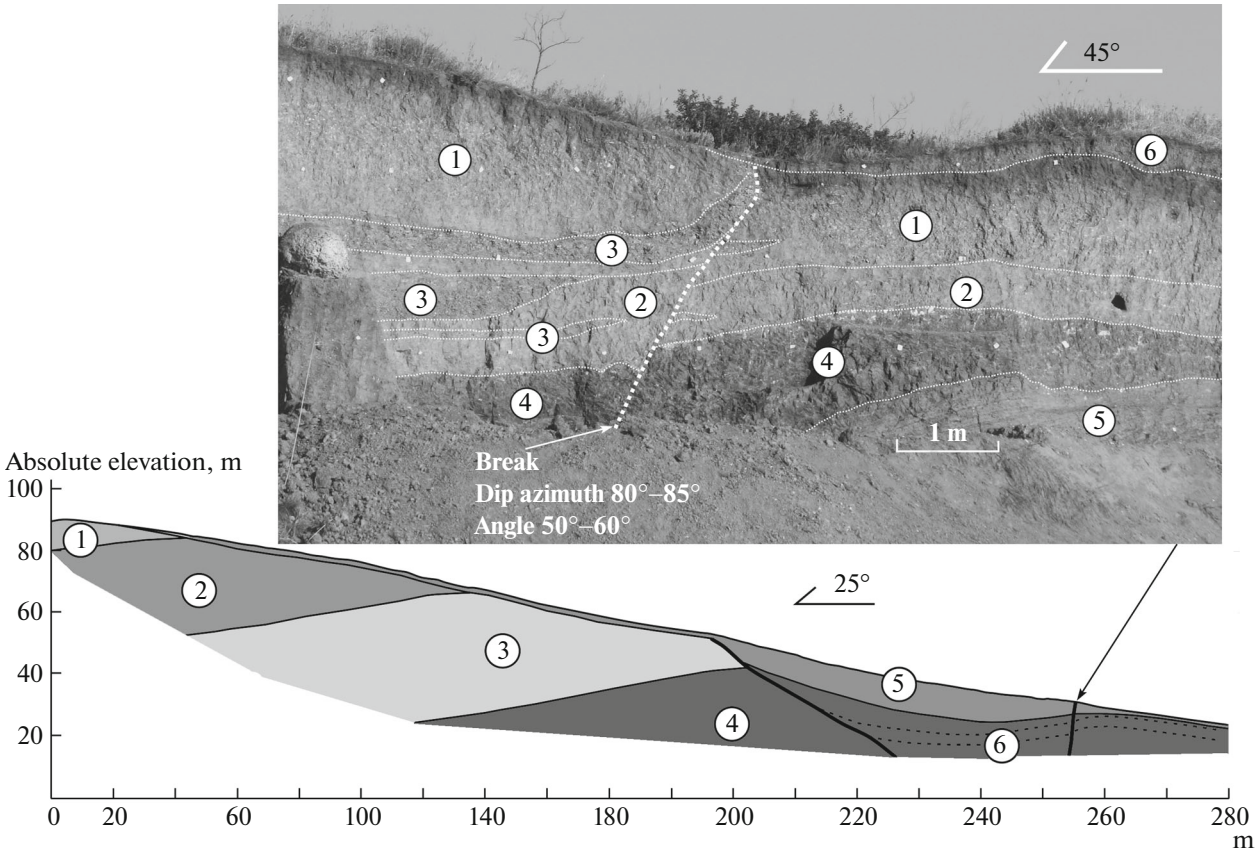

Fig. 2. Sections of Miocene–Quaternary sediments in the zone of the South Azov fault on the northern outskirts of the village of Yurkino. Bottom: general section of a young pull-apart graben. Miocene bedrock: 1, Meotian reef (bryozoan-rich) limestone; 2, Sarmatian greenish-gray clay with thin (up to 0.5 m) interlayers of marl and limestone; 3, alternation of layers of clay marl (4 to 5 m) and limestone (up to 0.5 m) of the Sarmatian stage; 4, black thin layers of siltstone and mudstone with thin interbedded sandstones of the Sarmatian stage; 5, Pleistocene loess. Top (detailed section): 1 and 2, loesses (1, silty loam; 2, silty sandy loam); 3, interlayers and lenses of coarse-grained material; 4, black thin-bedded siltstone and mudstone; 5, alternating thin layers of siltstone, mudstone, and sandstone; 6, breastworks of trench of the Great Patriotic War.

The modern tectonic activity on Kerch Peninsula is manifested in deformations of young geological formations, mud volcanism, and ground motions instrumentally observed. Nevertheless, the level of seismic activity is low there at present, although there is plentiful historical and archaeological evidence of ancient catastrophic earthquakes [1–3]. Therefore, paleoseismological studies are very important for assessment of the seismic hazard of the region.

Our research study covers young tectonic deformations and traces of past strong earthquakes. Particular emphasis is placed on active faults with marks of land movements, which are associated with the outcropping foci of strong earthquakes [5]. Considerable archaeological evidence of seismic damage to ancient monuments of different eras was obtained.

On the basis of our research study, a map of active faults has been produced showing the foci of strong earthquakes (Fig. 1). The results of study of the Opukskii active fault and partly the South Azov active fault were earlier published in [4, 7].

Morphologically, the South Azov active fault [2, 3] is confined to the boundary between the Azov region (the most elevated areas of the Kerch and Taman peninsulas) and the shallow basin of the Sea of Azov. Landslides have exposed a young graben in an outcrop on the coastal cliff on the northern outskirts of the village of Yurkino (Fig. 2). There is a strike-slip fault on the southern border of the graben; there is variability in the directions of visible vertical displacements in different horizons of the rock sequence. The facies composition of the uppermost loesses on one side of the fault differs considerably from that on the other side. The opposite sides of the fault plane differ from each other in the initial height, the mode of occurrence of bedrock, and the composition of the covering deposits. Most likely, this is due to the horizontal displacement of one side of the fault with respect to the other by several meters. Modern soil displacements suggest that the latest movements occurred 200 to 300 years ago. Based on these data, we can connect the center of an 18th century strong earthquake, traces

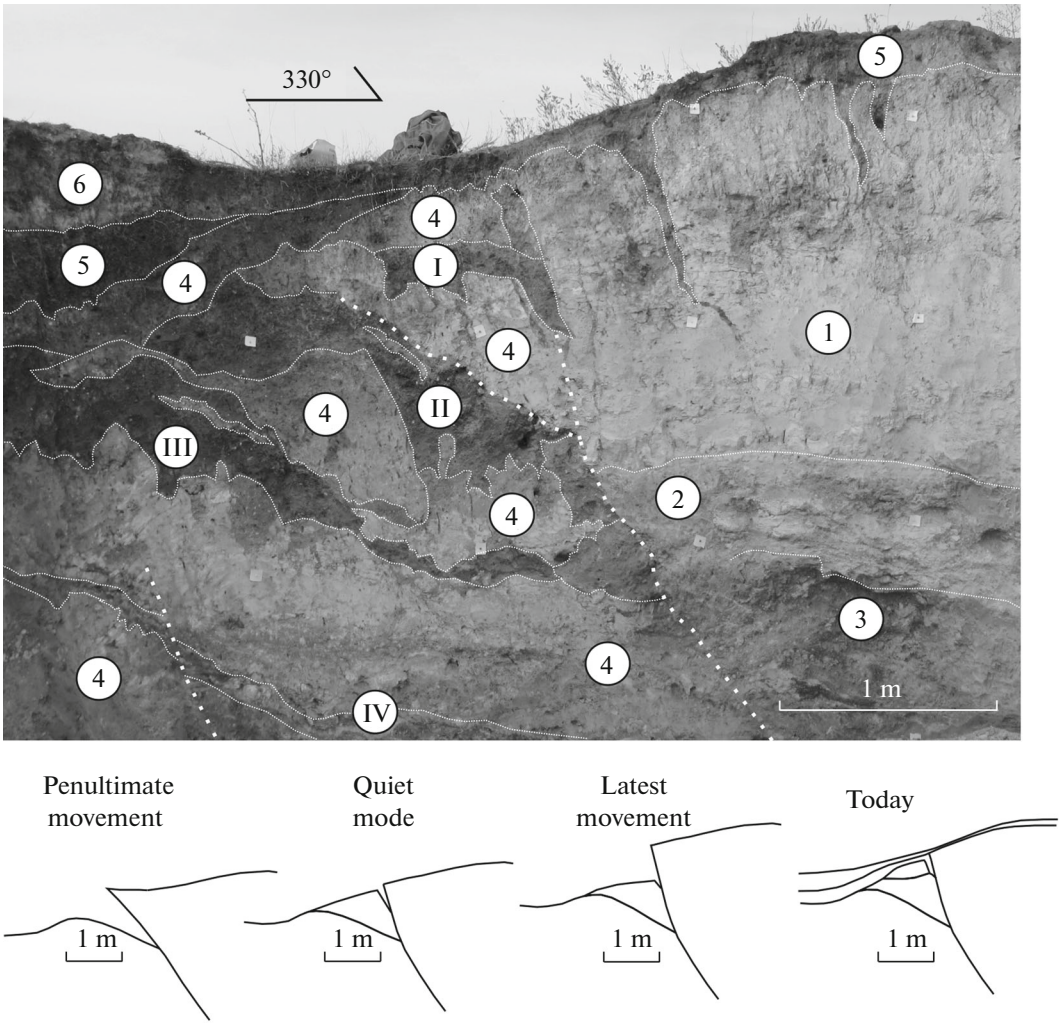

Fig. 3. Section of Miocene–Quaternary sediments in the Parpachskii fault zone (in the vicinity of Lugovoe): The thin lines are the boundaries between layers, and the solid lines are the faults. Bottom: paleoreconstructions of motions. Miocene bedrock of the Sarmatian stage: 1, weathered limestone; 2, greenish gray clays with an interlayer of limestone; 3, greenish gray clay marl; 4, redeposited weathered bedrocks of different ages (sandy loam, gravel, gruss with soil humus); 5, humus horizon of modern soil; 6, dumps of an open pit. Roman numerals are paleosoils of various ages.

of which were revealed from historical and archeoseismological evidence [3], with a certain geological structure.

The Parpachskii fault extends along the Parpachskii ridge in the central part of Kerch Peninsula. Structurally, the Parpachskii ridge is a crestlike anticlinal fold with a steep southern limb and a gently dipping northern limb. A series of young faults with different displacement kinematics are observed in Late Miocene sediments along this ridge for 33 km. The main fault plane, viz. a steep (70°–80°) reverse fault dipping north, has been studied in an open pit near the village of Lugovoe (Fig. 3). Its downthrown block exhibits several paleosoil horizons covered by weathering products of the bedrock. The buried paleosoils indicate that a few seismic motions occurred in the Late Holocene due to the outcropping of the foci of strong earthquakes. As a result of the event marked by paleosoil III (see Fig. 3), bedrock was thrusted over the paleosoil containing antique ceramics; i.e., the last three movements occurred in the past 2000 to 2500 years.

The Feodosia fault crosses the preorogenic fold-and-thrust structures of the Crimean Mountains in the meridional direction on the east flank plunging underneath Cenozoic sediments of Kerch Peninsula. A series of submeridional strike-slip faults was first identified there by M.V. Muratov in 1937. Expressive young displacements of right-lateral strike-slip kinematics have been identified in the fault zone (Fig. 4). The young fault is no less than 5.5 km long. Traces of three Holocene land movements were observed in the vicinity of the village of Nasypnoe; these events resulted in instantaneous rejuvenations of the com-

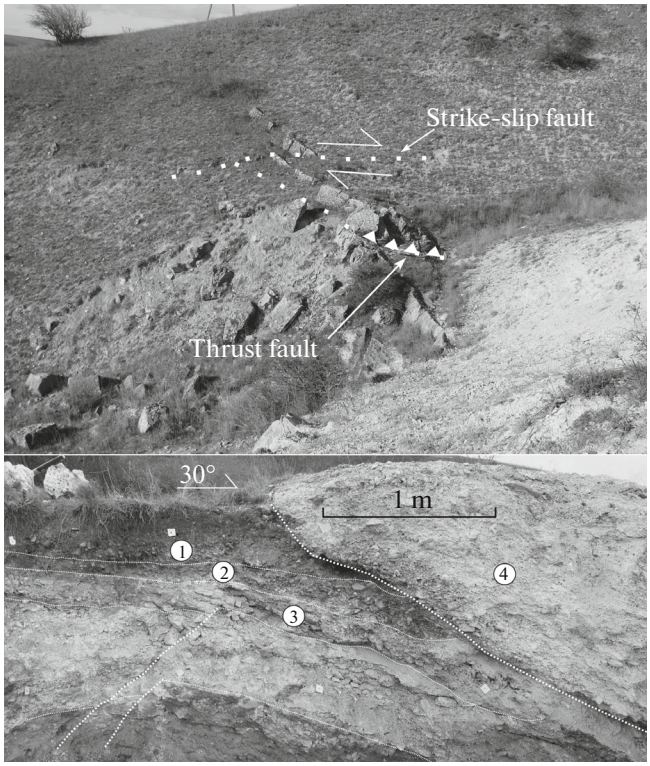

Fig. 4. Young seismotectonic deformations in the Feodosia fault zone (between the villages of Yuzhnoe and Nasypnoe). Top: thrust fault and strike-slip fault expressed in young displacements of a strong limestone layer embedded in Cretaceous deposits (in the vicinity of Yuzhnoe). Bottom: cross section of a compressive strike-slip fault in the zone of the Feodosia fault (in the vicinity of Nasypnoe); the thin lines are the boundaries between layers in the footwall block of the fault; the solid lines are strike-slip faults; 1, 2, and 3, coarse layers with buried paleosoils marking the last three land movements; 4, Pliocene conglomerates.

pression zone bounded by the thrust fault. Along this fault, Pliocene bedrock conglomerates were repeatedly thrusted over paleosoils, which mark deformed fragments of the ancient ground surface.

The main result of our study is identification of the sources of strong earthquakes on Kerch Peninsula. The Yuzhnoberezhnaya fold-and-thrust belt extending along the southern coast of Crimea in the Black Sea was earlier considered as the principal seismogenic structure. However, there is no unequivocal archaeoseismological evidence that many historical earthquakes were quakes centered offshore. It has been found that there are great discrepancies between the instrumental and paleoseismological data concerning the level of seismic hazard on Kerch Peninsula. It can be assumed that the region is in the stage of seismic quiescence at present.

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