American Geophysical Union, Geophysical Monograph Series "Volcanism and Subduction: The Kamchatka Region". Eds: Eichelberger J., Gordeev E., Kasahara M. et al. 2007. Vol. 172. P. 107-116

Active Faulting in the Kamchatsky Peninsula, Kamchatka-Aleutian Junction

Andrei Kozhurin

Geological Institute of Russian Academy of Sciences, Moscow, Russia

Active faults of the Kamchatsky Peninsula mark where the peninsula block is deforming. The most prominent fault of the peninsula, striking ENE-WSW in its southeast corner, exhibits dominant right-lateral movement at Holocene slip rate of about 4 mm y^{-1}. Shorter faults striking NW-SE to WNW-ESE southeast of it have dominantly normal displacements. Based on these observations, it is concluded that none of active faults of the peninsula can represent an onshore extension of any of large NW-trending underwater faults of the western Aleutians. It is suggested that movement along active faults accommodate a part of the peninsula block clock-wise rotation caused by northwest-directed differential movements of the fault-bounded longitudinal blocks of the westernmost Aleutians.

INTRODUCTION

With the Kronotsky and the Shipunsky peninsulas to the south, the Kamchatsky Peninsula make a common set of promontories along eastern Kamchatka (see Fig. 1 and Fig. 2), but in terms of present geodynamics the latter is distinctive. While the southern two peninsulas are now part of the leading edge of an overriding plate, the Kamchatsky Peninsula lies west of the Komandorsky segment of the Aleutian arc, north of the northern tip of the Kamchatka subduction zone (Fig. 1). The elevated east portion of the Kamchatsky Peninsula elongates SE-NW, that is, obliquely to the main structural trend of the Kamchatka mainland (Fig. 2). Based on this fact and on evident differences between Cretaceous-Paleogene evolution of northern Kamchatka mainland and the Kamchatsky Peninsula, Markov et al. (1969) interpreted the Kamchatsky Peninsula to likely represent an extreme NW element of the Komandorsky segment of the Aleutian island chain.

Either a part of Kamchatka or that of the Aleutians, the Kamchatsky Peninsula centers the area where the two island arcs meet at nearly a right angle. Their interaction is commonly interpreted in terms of active arc-arc collision that has been occurring since the Kamchatsky Peninsula block docked against the Kamchatka ocean margin some time after the mid Cenozoic (Pechersky et al., 1997; Park et al., 2002). Markov et al. (1969) inferred that the Kamchatka mainland and the Kamchatsky Peninsula meet across a regional fault that runs NNE-SSW directly west of the Nerpichie Lake (see Fig. 3), and that the tighter compressed structure of the northern Kumroch Range of central Kamchatka is a manifestation of the Kamchatka-Aleutians interaction. Geist and Scholl (1994) outlined a zone of intensive thrusting in the portion of east central Kamchatka NW of the peninsula and interpreted it as having resulted from the Kamchatka-Aleutian collision. Based on the seismicity pattern, they suggested also that at present the Kamchatka-Aleutian interaction might be occurring somewhere between the Komandorsky chain and the Kamchatsky Peninsula block. Gaedicke et al. (2000) examined possible relationships between Late Quaternary faults of the peninsula and a system of arc-parallel right-lateral underwater faults of the western Aleutians detected from seismic profiling data (Seliverstov, 1983; Baranov et al., 1991; Seliverstov et al, 1995).

Contributing much to understanding the active processes of the Kamchatka-Aleutian interaction, all the

Title
Geophysical Monograph Series

##.####/###GM##

American Geophysical Union, Geophysical Monograph Series “Volcanism and Subduction: The Kamchatka Region”. Eds: Eichelberger J., Gordeev E., Kasahara M. et al. 2007. Vol. 172. P. 107-116

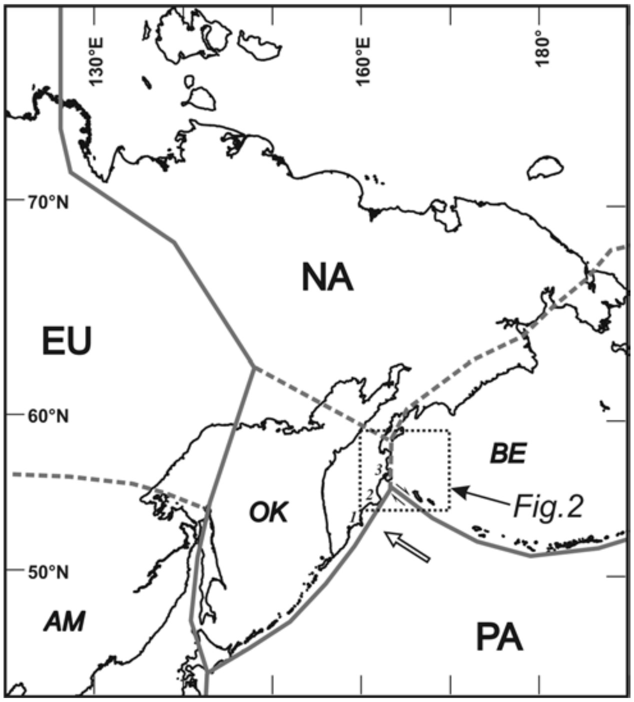

Figure 1. Plate boundaries configuration in NW Pacific. Dashed lines are boundaries of minor plates within major plates. NA = North American Plate, EU = Eurasian Plate, PA = Pacific Plate (DeMets et al., 1990). AM = Amurian Plate, OK = Okhotsk Plate (Zonenshain, Savostin, 1979), BE = Bering Sea Plate (Lander et al., 1994). Open arrow shows direction of NA-PA relative motion. 1 to 3 are for promontories along the Kamchatka east margin: 1 – Shipunsky Peninsula, 2 – Kronotsky Peninsula, 3 – Kamchatsky Peninsula (see also Fig. 2).

works mentioned above incorporated, however, few data on onshore active faulting. The aim of the present paper is to describe geomorphic manifestation of active faulting in the Kamchatsky Peninsula to provide additional insight in the Late Quaternary development of the Kamchatka-Aleutian junction area.

GEOLOGIC AND NEOTECTONIC SETTING

Physiographically, the Kamchatsky Peninsula combines several isolated mountainous massifs surrounding the lowland of the central part of the peninsula with the large lakes Nerpichie and Kultuchnoe (Fig. 3). The massifs are rimmed with successions of marine terraces, development of the oldest of them probably dating back to the beginning of the Middle Quaternary time (Melekestsev, Erlikh, 1974). The massifs are composed of Cretaceous and Paleogene complexes while the lows between them are filled with the Ol’khovskaya suite of late Pliocene to early Quaternary age (Geological, 2002). However, patches of sediments of the Ol’khovskaya suite are present at high altitudes as well in northern and southern regions of the peninsula (Geological, 2002). This presence suggests that modern topography of the peninsula has resulted from mainly Middle and Late Quaternary tectonic vertical movements, slower (~1.6 mm y^{-1}) in the northeast and faster (up to 4.7 mm y^{-1}) in the south (Melekestsev, Erlich, 1974). Judging simply by the massif morphology, block tilting, mostly towards the central part of the peninsula, has been occurring. At the same time, in the southern peninsula, general steepening of marine terraces from younger to older suggests south-directed tilting of the block between the First and Second Pereval’naya rivers (Kozhurin, 1985). Along the southern margin of the peninsula, the inclined form of an unconformity between the Ol’khovskaya suite and underlying rocks (Fig. 2 in Basilyan, Bylinskaya, 1997) may also be evidence of post-Late Pliocene tilting of folding.

Active faults in the region of the Kamchatsky Peninsula, known and inferred from interpretation of aerial images, make up two groups (Fig. 2 and 3). The faults close and parallel to the eastern foothills of the Kumroch Range, west of the Nerpichie Lake, represent the northernmost extension

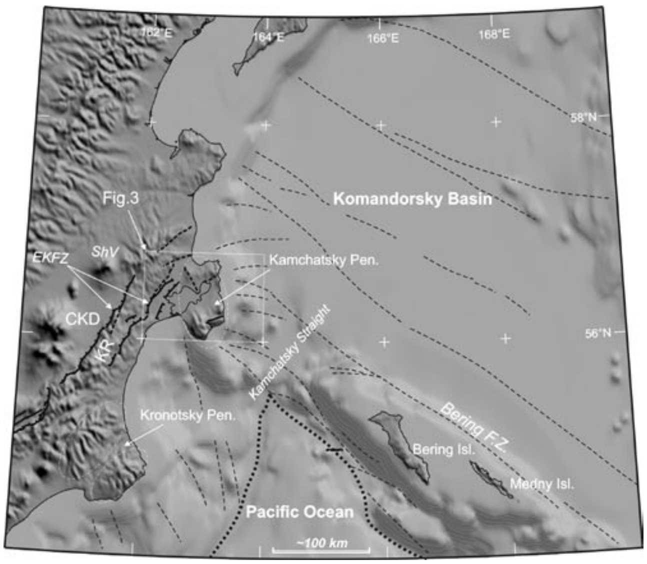

Figure 2. Regional neotectonic setting of the study area. Thick black lines are active faults, dashed where inferred, ticks on downthrown side. Thinner black dashed lines are major underwater faults (Baranov et al., 1991; Seliverstov, 1995, simplified). Dotted black lines are the Kurile-Kamchatka trench and the Aleutian trench. White dashed line ovals are approximate outlines of NW-SE trending elongated uplifted area in the Kamchatsky peninsula and, for comparison, of NNE-SSW-trending (margin-parallel) uplifts in the Kronitsky Peninsula. CKD = Central Kamchatka Depression, KR = Kumroch Range, EKFZ = East Kamchatka fault Zone, ShV = Shiveluch Volcano. See Fig. 1 for location.

American Geophysical Union, Geophysical Monograph Series "Volcanism and Subduction: The Kamchatka Region". Eds: Eichelberger J., Gordeev E., Kasahara M. et al. 2007. Vol. 172. P. 107-116

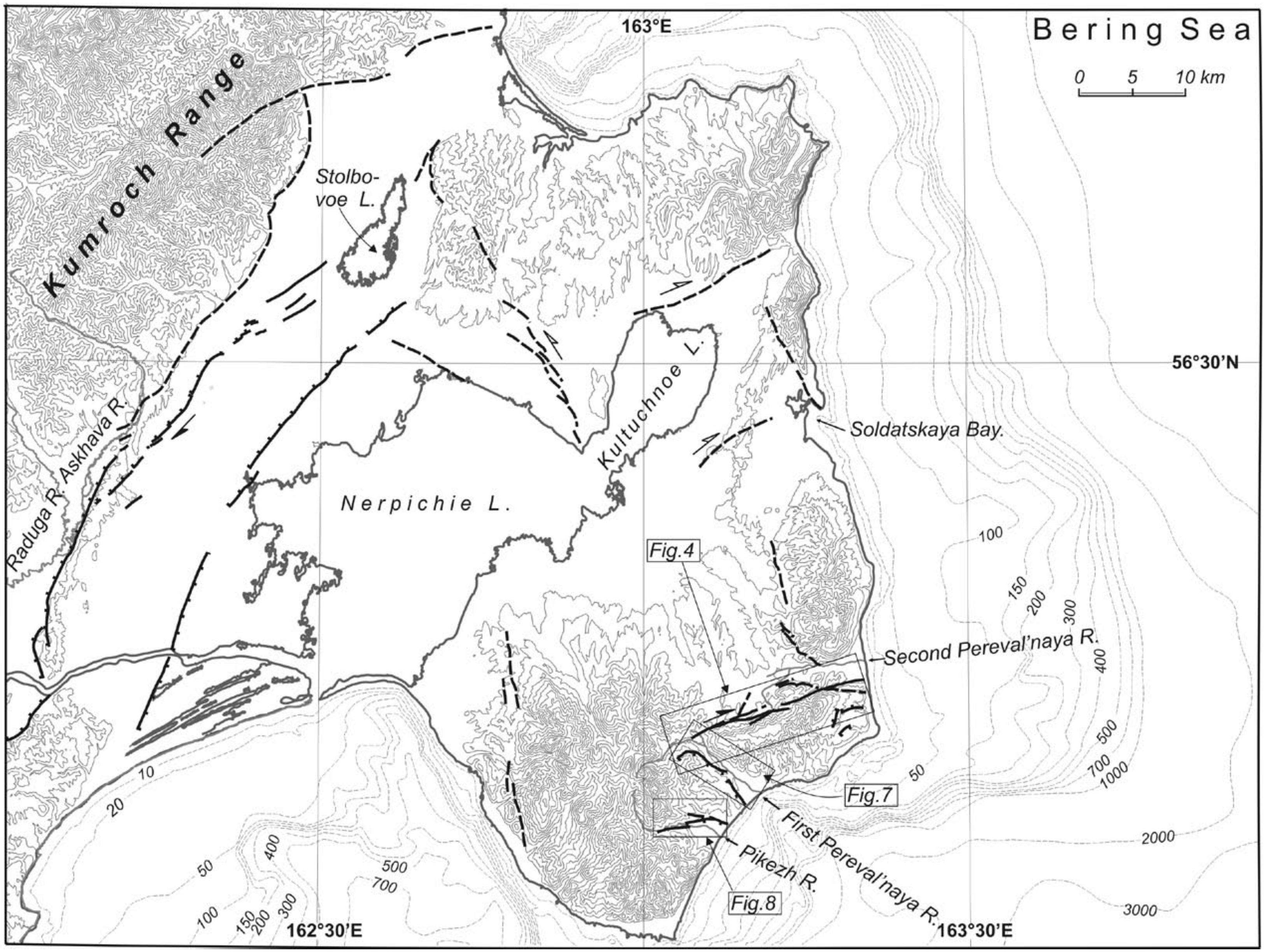

Figure 3. Active faults in the Kamchatsky Peninsula area. Thick black lines are active faults, dashed where inferred, ticks on downthrown side. Arrows mark strike-slip faults, open-headed where lateral movements inferred. Topographic counter interval is 100 m. Bathymetric contours are in meters. See Fig. 2 for location.

American Geophysical Union, Geophysical Monograph Series "Volcanism and Subduction: The Kamchatka Region". Eds: Eichelberger J., Gordeev E., Kasahara M. et al. 2007. Vol. 172. P. 107-116

of the east branch of the East Kamchatka Fault Zone, the major fault system of the Kamchatka mainland. These faults are mostly normal, with the west sides relatively elevated, and some right-lateral component of movements (Kozhurin, 1990, 2004; Kozhurin et al., 2006). East of these faults, there is a separate net of NW-trending and NE- to ENE-trending faults. These faults do not connect to those of the first group and may therefore relate to internal deformation of the Kamchatsky Peninsula.

ACTIVE FAULTING IN THE KAMCHATSKY PENINSULA

Here I describe a group of active faults concentrated in the southeast corner of the peninsula (see Fig. 3). The faults cut Holocene landforms providing good evidences for their kinematics. This group includes a fault that extends ENE from upstream portion of First Pereval'naya River to the mouth of Second Pereval'naya River (Fig. 4 box on Fig. 3). It is likely that this fault continues farther east, beneath the waters of the Kamchatsky Straight, along one of the canyons on the peninsula continental slope. South of this fault, there are two short NW to WNW-striking faults, one in the First Pereval'naya River valley (Fig. 7 box on Fig. 3), and another in the Pikezh River valley (Fig. 8 box on Fig. 3). Both faults also extend up to the shoreline and may continue some distance into the sea.

ENE-WSW-Trending Fault

The fault stretches as a generally continuous, slightly northward-convex line, probably with a short left-hand step near the middle where its downthrown (northern) side becomes mountainous (Fig. 4). The fault is the northern limit of an uplifted block, which bears well-developed marine terraces on its top and gentler southern slope, the oldest of them reported to be Middle Quaternary in age (Melekestsev, Erlich, 1974). From younger to older, the terrace surfaces become notably steeper suggesting southeast-directed tilting of the uplifted block (Kozhurin, 1985).

All along its length, the fault exhibits evidences for right-lateral offset of Holocene landforms - side-crests, gullies and terrace risers, with offset values ranging from about 2 m to 70–75 m (Table 1). Characteristic features are abandoned channels and curved active channels, as well as shutter ridges (Fig. 5). The vertical component of offset is subdued. The average rate of Holocene right-lateral fault movement may be estimated based on offset of two terraces along one of the left tributaries

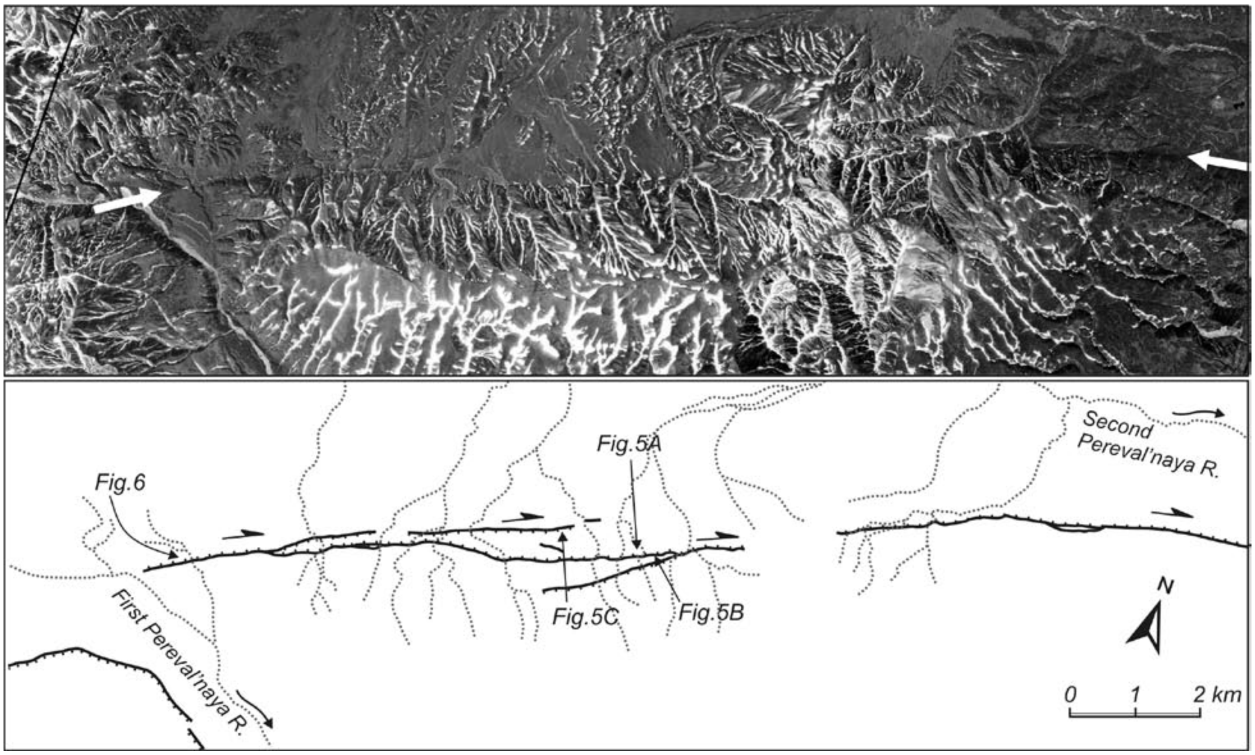

Figure 4. *Top.* Fragment of aerial photograph. White arrows point at the fault line. *Bottom.* Black lines are active faults, ticks on downthrown side. Arrows mark strike-slip faults. Dotted lines are rivers and streams courses. For location see Fig. 3.

American Geophysical Union, Geophysical Monograph Series "Volcanism and Subduction: The Kamchatka Region". Eds: Eichelberger J., Gordeev E., Kasahara M. et al. 2007. Vol. 172. P. 107-116

Table 1. Amplitudes of Right-Lateral Offsets along the ENE-WSW Fault, SE Kamchatsky Peninsula

Fault strike at observation site	Right-lateral displacement, *m*	Vertical separation, *m*	Corresponding figure
70°	5.5	1	
70°	32		Fig. 5B
70°	65–70	~ 5	Fig. 5A
	7		
	30		Fig. 5A
70°	70	~5	
70°	8–10		
	19–20		
	70–75	~5	
70°	72–75	~5	
	37–40		
	35		
	15		
70°	57–58	4–5	
	43–45		
	14–15		
	2		
	20–22		
70°	30—32		
	25		
70°	65	~5	
80°	10–12	0.8–0.9	Fig. 5C
70°	13–14	1.1–1.2	Fig. 6
	23–24	1.2–1.3	Fig. 6

of the First Pereval'naya River, close to the fault's west end (Fig. 6). Both terraces are mantled with soil-pyroclastic deposits with lowermost tephra identified as ash falls from Shiveluch Volcano (Vera Ponomareva, personal communication). The oldest tephra on the lower (younger) terrace (terrace 1 in Fig.6) is SH_{2800} with an age of 2800 ^{14}C yr BP (2900 calibrated years) (Pevzner et al., 1998). On the next higher terrace (terrace 2 in Fig. 6), the oldest tephra is SH_{4800} with and age of 4800 ^{14}C yr BP (5500–5600 calibrated years) (Pevzner et al., 1998). Terrace 2 was traced down to the First Pereval'naya River mouth where ^{14}C dating of its sediments gave an age of 6000 ± 50 ^{14}C yr BP or ~6800 calibrated years BP (Kozhurin, 1990), in reasonable compliance with the tephrochronological dating. Terrace one is displaced right-laterally 13–14 m and Terrace two 23–24 m (Fig. 6). Based on these figures, maximum slip rates can be estimated to be 4.5 to 4.8 mm y^{-1}, for the lower terrace 1, and 4.1 to 4.3 mm y^{-1}, for the higher terrace 2. On each terrace there is about 10–12 cm of loamy soil between the lowermost identified ash and coarser alluvial deposits. Earlier, the rate of accumulation of similar sediments at the base of the west slope of the Kumroch Range was estimated to be 0.1 to 0.4 mm y^{-1} (Kozhurin et al., 2006). This suggests that both terraces can be roughly 500 years older than overlying lowermost tephras, therefore I estimate the terrace ages to be roughly 3.4 ka and 6 ka. Average lateral slip rates based on these observations and reasoning are about 4 mm a^{-1}. Based on this value and the amount of minimal right-lateral offset measured in the fault (2 m, see Table 1), recurrence interval between fault movements can be tentatively estimated as about 0.5 ka.

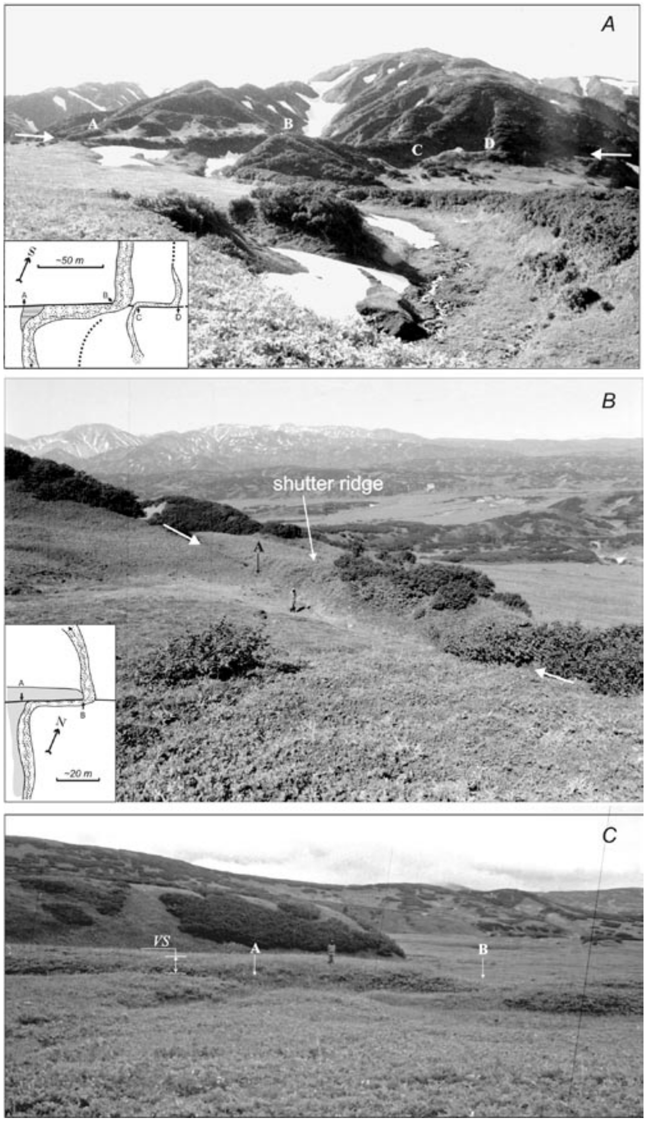

Figure 5. Right-lateral displacements of geomorphic elements along the ENE-WSW fault of the Kamchatsky Peninsula. White arrows point at the fault scarp. For location of photos see Fig. 4. Insets are plan-view sketches of displacements (field drawings). ***A***. AB = 65–70 m, CD = 30 m. View to S. ***B***. AB = 32 m. View towards WNW. ***C***. AB = 10–12 m, VS (vertical separation) = 0.8–0.9 m View to N. (see Table 1).

American Geophysical Union, Geophysical Monograph Series "Volcanism and Subduction: The Kamchatka Region". Eds: Eichelberger J., Gordeev E., Kasahara M. et al. 2007. Vol. 172. P. 107-116

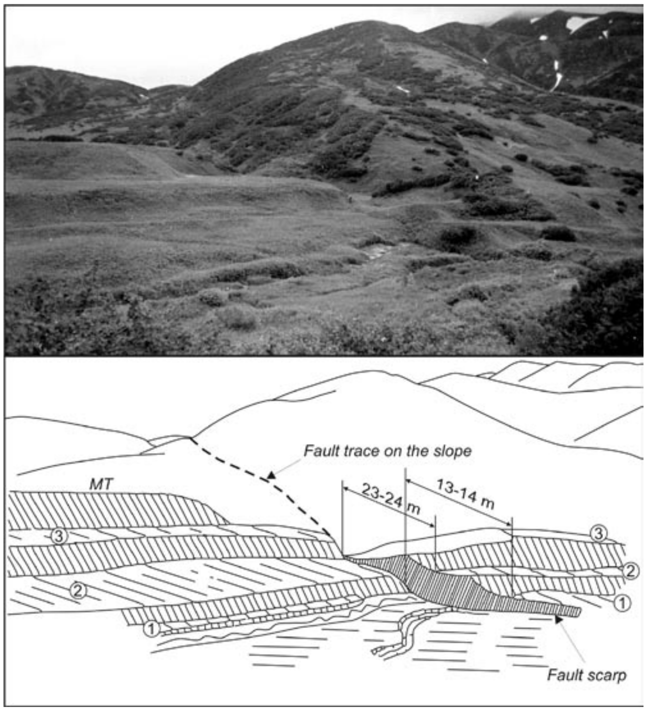

Figure 6. *Top.* Photo of terraces in the First Pereval'naya River valley displaced right-laterally in the west part of the fault. *Bottom*. Interpretation (field drawing). Numbers enumerate terraces (see text). MT = marine terrace. Nearly equal length of arrows indicating offset amounts is due to oblique view distortion. View towards E. For location see Fig. 4.

NW-SE-Trending Faults

Fault in the First Pereval'naya River valley. This fault produces a SW-facing scarp on the west (right-hand) slope of the First Pereval'naya River valley (Fig. 7). In the north, where the valley turns northwest, the fault also turns northwest while keeping its southern side uplifted. This relationship indicates a south to southeast dip of the fault plane and a normal sense of fault movement.

The amplitude of vertical separation of topography varies along the fault, being larger, up to 15–20 m, where the fault strikes E-W (in the north) and decreasing to 5–7 m where the fault strikes NW-SE. At places, right-hand stepping of the fault trace is noticeable. Lateral component of motion is very small and apparently left-lateral. Such motion is obviously missing on the E-W-striking portion of the fault and may be present where the fault strikes NW. So, within a stream valley, NW of the Nepropuskovy Creek (see Fig. 7), the fault displaces by ~1 m vertically and 2 m left-laterally a low water divide between two active, shallow channels. On aerial photographs, the courses of two gullies farther NW seem to bend a little along the fault line, probably reflecting left-lateral displacement of up to 20–25 m. However, it should be emphasized that evidence for lateral movement on the fault is scarce and uncertain, so the fault should be considered mostly normal.

Southeast of the First Pereval'naya R. mouth, there is a well-developed underwater canyon that extends, widening seaward, down to the base of the continental slope (see Fig. 3). Since the location and direction of the First Pereval'naya R. valley were obviously predetermined by the fault movements, the canyon may mark the underwater continuation of the fault.

Fault in the Pikezh River valley. In the area of the lower Pikezh River, several short faults combine in a system that borders a triangular-shaped depression filled with well-developed, low marine terraces (Fig. 8). All the faults produce steep, south-facing scarps and, by appearance, look very similar to the fault in the First Pereval'naya River valley. Total vertical separation of the ground surface across segments amounts to 10–12 m. Typically, fault scarps are accompanied by shallow depressions at their foot (see profile inset, Fig. 8), suggesting normal movement along the faults. As in case with the First Pereval'naya River fault, no reliable evidence for lateral fault movement is apparent.

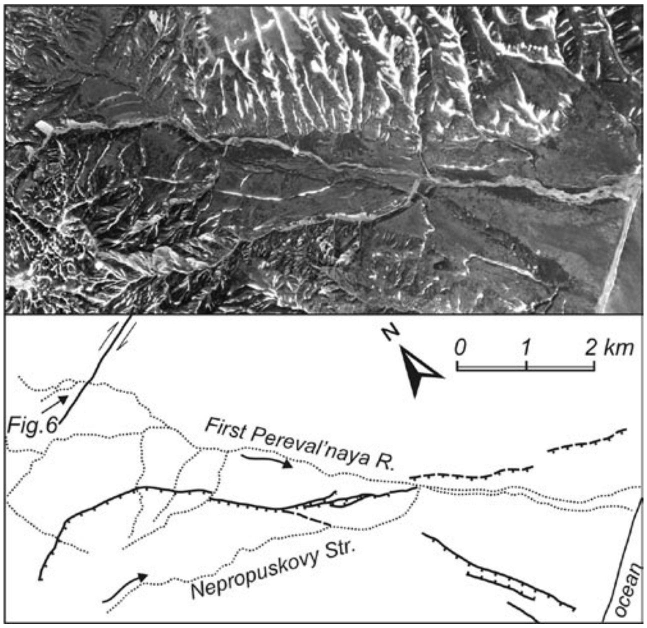

Figure 7. *Top.* Fragment of aerial photograph. *Bottom*. Black lines are active faults, dashed where inferred, ticks on downthrown side. Arrows mark strike-slip faults. Dotted lines are rivers and streams courses. For location see Fig. 3.

American Geophysical Union, Geophysical Monograph Series “Volcanism and Subduction: The Kamchatka Region”. Eds: Eichelberger J., Gordeev E., Kasahara M. et al. 2007. Vol. 172. P. 107-116

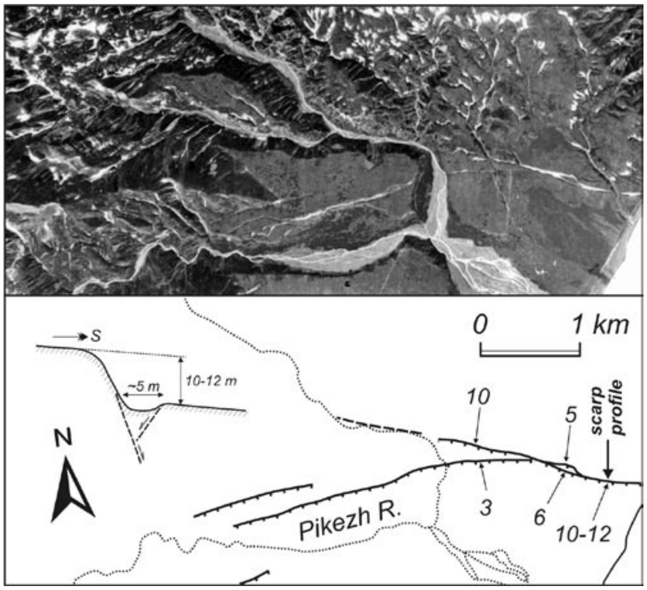

Figure 8. *Top.* Fragment of aerial photograph. *Bottom.* Black lines are active faults, dashed where inferred, ticks on downthrown side. Dotted lines are rivers and streams courses. Numbers are measured vertical separation, meters. On scarp profile, 10–12 m is amount of vertical separation of ground surface, 5 m is the width of fault-related depression, dashed lines mark inferred position of major and antithetic fault planes. For location see Fig. 3.

Other faults. Other probable active faults on the peninsula, based solely on interpretation of aerial images, include the following (see Fig. 3).

A fault with undoubtedly Late Quaternary movement extends NW by a set of short, NE-facing scarps from the NE corner of Nerpichie Lake (Fig. 3). Markov et al. (1969) inferred left-lateral movement along the fault but reported no supporting data. Based on interpretation of aerial photographs, Late Quaternary activity can be also expected for the NNW-striking fault starting at the northern margin of the Soldatskaya Bay, where marine terraces appear to be vertically displaced. Finally, we suppose that young vertical movement may have been occurring on about N-S faults south of Nerpichie Lake (Fig. 3).

DISCUSSION

The most conspicuous fault of the peninsula is that extending roughly E-W between the First and Second Pereval’naya rivers. Kinematics of the fault is mainly right-lateral. The vertical component of fault movement is much smaller and is likely normal. Based on ^{14}C and tephrochronological age determinations, the Holocene average lateral slip rate is ~4 mm y^{-1}. In the east, the fault reaches the peninsula shoreline and is likely extending underwater along one of the canyons of the peninsula continental slope.

The NW-striking faults in the First Pereval’naya River valley and the Pikezh River valley exhibit mostly normal movement in recent times. Lateral component is negligibly small and left-lateral. This result evidently contradicts the conclusion of Gadeicke et al. (2000) that the fault along the First Pereval’naya River exhibits up to 250 m of cumulative dextral offset imprinted in topography. I maintain, there is no appreciable evidence of right-lateral movement along any of the right-side tributaries, of size and geomorphic position similar to Nepropuskovy Creek. The Nepropuskovy valley has no terraces and in its downstream portion incises the Holocene terrace of the First Pereval’naya River. Thus, attributing 250 m of plan-view bend of the stream to Holocene cumulative displacement yields a six-times faster lateral slip rate (~2.5 cm y^{-1}), than that estimated by tephrochronology and radiocarbon dating for the ENE-WSW-striking right-lateral fault of the peninsula.

Gaedicke et al. (2000) were apparently the first who attempted to connect the large dextral faults of the Komandorsky segment of the Aleutians with active faults on land on the Kamchatsky peninsula. In their model, the onshore ENE-WSW-striking fault is shown as a continuation of one of the NE-SW-striking splays of the Bering fault zone. (Fig. 9). Since the splay strikes obliquely to the main trace of the Bering F.Z., the sense of movement along it must be mainly reverse (as indicated in Fig.3 in Gaedicke et al., 2000). However, field data indicate that the onshore fault moves laterally and that the vertical component constitutes just a very small portion of the overall fault movement. It seems that the only possible model that incorporates the onshore strike-slip fault as a direct extension of the Bering Fault zone could be that of the counter clockwise rotation of a single block of the westernmost segment of the Aleutian island rise and the southwest portion of the Kamchatsky Peninsula. However, the two faults differ too much in their radius of curvature so that the motion on one of them can not be simply accommodated by the motion on the other.

As for the faults in the First Pereval’naya and Pikezh river valleys, their dominantly normal kinematics and lack of any reliable evidence for dextral movement do not allow them to be linked to the dextral Pikezh fault zone (see Fig. 9).

We must conclude therefore that at present any correlation between onshore faults of the Kamchatsky Peninsula and offshore faults of the western Aleutians must remain provisional, if only by reason of differences in resolution of terrestrial and underwater data. Moreover, I suggest there may be another way of examining the problem. I suggest that active faults in the peninsula do not extend beyond the limits of the peninsula block (roughly, landward of the 1000-m bathymetric contour) and reflect therefore just internal deformation of this block. Large right-lateral faults of the Komandorsky

American Geophysical Union, Geophysical Monograph Series "Volcanism and Subduction: The Kamchatka Region". Eds: Eichelberger J., Gordeev E., Kasahara M. et al. 2007. Vol. 172. P. 107-116

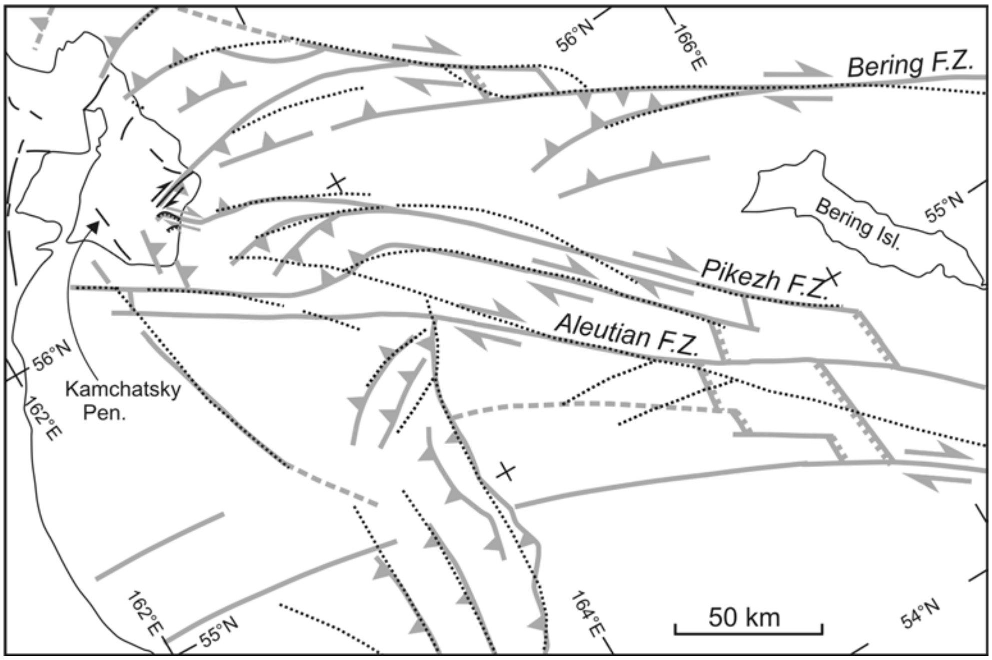

Figure 9. Major fault zones of the westernmost Aleutians. Thick gray lines and kinematic symbols are faults as in Gaedicke et al., 2000. Dotted lines are faults from Seliverstov et al., 1995. Thinner black lines are active faults (this paper). See text for details.

chain, including the Bering F.Z. and the Pikezh F.Z., which accommodate a portion of the transform movement along the Pacific-Aleutian boundary, may be interpreted either to terminate before the eastern limit of the Kamchatsky Peninsula block or to plunge beneath it.

An important consequence of the uniform kinematics of the NW-SE faults of the Komandorsky islands is the decrease in rate of dextral movement from one fault to another with distance from the Aleutian-Pacific interface. This, in turn, implies a gradual northward decrease in the rate of convergence between the Kamchatsky Peninsula block and the longitudinal, fault-bounded blocks of the Komandorsky Island chain. The expected result of this specific multi-block interaction may be some clockwise rotation of the Kamchatsky Peninsula block, some part of this rotation being accommodated by movements along the peninsula faults (Fig. 10).

Supporting evidence for this model include the following:

1) NW-directed movement of longitudinal, fault-bounded slivers of the Komandorsky segment comply with slip vectors and orientation of compression axes obtained from focal plane solutions of strong earthquakes immediately east of the Kamchatsky Peninsula (Cormier, 1975; Zobin et al., 1988) (Fig. 11).
2) Along-arc translation and clock-wise rotation of blocks may be occurring in the central Aleutian Island arc (Geist

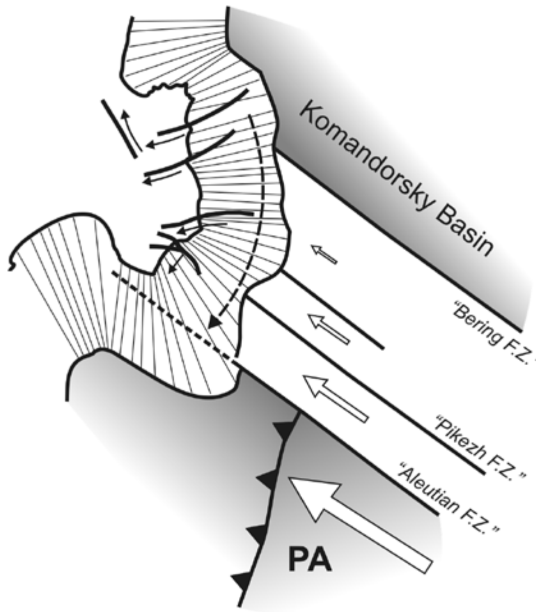

Figure 10. Idealized representation of the Kamchatsky Peninsula – Aleutians interaction. Thick black lines are active faults both known and potential (see Fig. 3) with their inferred underwater extensions. Hatched area is underwater slope of the Kamchatsky Peninsula block. Open arrows indicate direction of movements relative to Kamchatka, longer arrows for faster movements. PA is the Pacific Plate.

American Geophysical Union, Geophysical Monograph Series "Volcanism and Subduction: The Kamchatka Region". Eds: Eichelberger J., Gordeev E., Kasahara M. et al. 2007. Vol. 172. P. 107-116

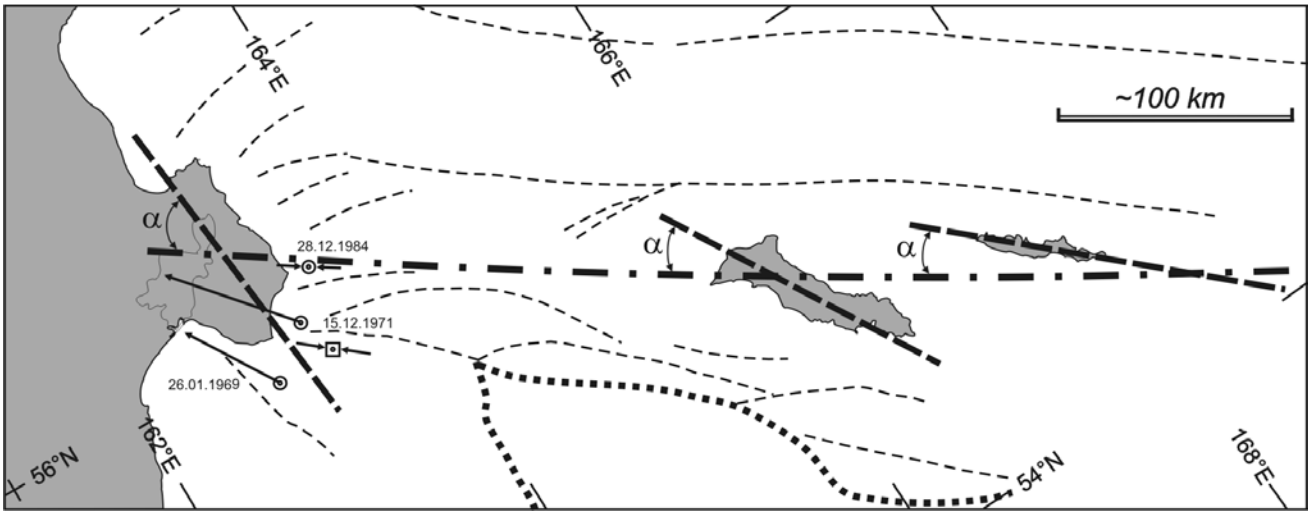

Figure 11. En echelon arrangements of the Komandorsky islands and the Kamchatsky Peninsula. Dashed-dotted line marks the axis of the single elevation of the Kamchatsky Peninsula + Komandorsky Islands, thick dashed lines are axes of the individual islands and the peninsula. Single arrows starting from circles are azimuths of earthquake slip vectors (Cormier, 1975), two opposite arrows show horizontal projection of P-axis (Zobin et al., 1988), quadrangle is location of the 15.12.1971 earthquake as in Zobin et al. (1988). For other symbols see Fig. 9. Note that the obliquity angle α is regularly increasing northwestward.

et al., 1988), probably in association with arc-parallel extension (Lallemant and Oldow, 2000).

3) Similar to the Komandorsky islands (Bering and Medny islands), the elongated Kamchatsky Peninsula block is oriented oblique to the trend of the west Aleutians but at larger angle (see Fig. 11). It may be speculated that the extra obliquity accumulated due to rotation of the peninsula block caused in turn by differential NW-directed movement of the Komandorsky segment.

It follows from above, that the Kamchatka-Aleutian interaction may be occurring somewhere between the Komandorsky chain and the Kamchatsky Peninsula block as suggested by Geist and Scholl (1994) based on seismicity pattern, rather than directly within the peninsula, as later suggested by Gaedicke et al. (2000).

CONCLUSIONS

1. Active faults in the Kamchatsky Peninsula form a specific group independent of active faults in the rest of Kamchatka. The main fault of the peninsula is the about E-W-striking fault moving right-laterally at the rate of ~ 4 mm y^{-1}. Shorter NW-SW faults breaking its southern side are mostly normal.
2. By strike and sense of movement, the faults of the peninsula can not represent direct extensions of the large underwater longitudinal faults of the Komandorsky segment of the Aleutian Islands rise or subordinate elements of their system, and reflect therefore internal deformation of the peninsula block.
3. The probable mechanism of active faulting in the area may be active rotation of the peninsula block caused by lateral pressure applied by the fault-bounded longitudinal blocks of the westernmost Aleutians moving at different rates to the northwest.

Acknowledgements. I am grateful to Jody Bourgeois and Alan Terril for their help in improving the English of the manuscript. I also wish to thank Jody Bourgeois and two anonymous reviewers for many helpful comments.

REFERENCES

Avé Lallemant, H. G., Oldow, J. S., Active displacement partitioning and arc-parallel extension of the Aleutian volcanic arc based on Global Positioning System geodesy and kinematic analysis, *Geology,* 28 (8), 739–742, 2000.

Baranov, B. I., Seliverstov, N. I., Murav'ev, A. V., Muzurov, E. L., The Komandorsky Basin as a product of spreading behind a transform plate boundary, *Tectonophysics,* 199, 237–260, 1991.

Basilyan, A. E., Bylinskaya, M. E., The shelf of the Kamchatsky Peninsula, eastern Kamchatka, in the Late Pliocene and Early Quaternary (Ol'khovaya time), *Stratigraphy. Geological correlation,* 5(3), 83–91, 1997.

Cormier, V. F., Tectonics near the junction of the Aleutian and Kuril-Kamchatka arcs and a mechanism for middle Tertiary magmatism in the Kamchatka basin, *Geol. Soc. Amer. Bull.,* 86, 443–453, 1975.

DeMets, C. R., Gordon, R. G., Argus, D. F., Stein, S., Current plate motions, *Geophys. J. Inter.*, 101, 425–478, 1990.

Gaedicke, C., Baranov, B., Seliverstov, N., Alexeiev, D., Tsukanov, N. and Freitag, R., Structure of an active arc-continent collision area: the Aleutian – Kamchatka junction, *Tectonophysics*, 325, 63–85, 2000.

Geist, E. L., Scholl, D. W., Large-scale deformation related to the collision of the Aleutian Arc with Kamchatka, *Tectonics,* 13(3), 538–560, 1994.

Geist, Eric L., Childs, Jonathan R., Scholl, David W., The origin of summit basins of the Aleutian Ridge: implications for block rotation of an arc summit, *Tectonics,* 7(2), 327–341, 1988.

Geological Map of Russian Federation. Scale 1:200000. East Kamchatka Series, Ust’-Kamchatsk, Sheets O-58-XXVI, XXXI, XXXII, MNR RF, 2002.

Kozhurin, A. I., Quaternary tectonics of the Kumroch Range and Kamchatsky Mys Peninsula, *Geotectonics,* 2, 76–87, 1985 (in Russian).

Kozhurin, A. I., Recent strike-slip faults in the Kumroch Range and Kamchatsky Peninsula area, Eastern Kamchatka, *Tikhookeanskaya geologiya*, 6: 45–55, 1990 (in Russian).

Kozhurin, A. I., Active faulting at the Eurasian, North American and Pacific plates junction, *Tectonophysics*, 380, 273–285, 2004.

Kozhurin, A. I., Acocella, V., Kyle, P. R., Lagmay, F. M., Melekestsev, I. V., Ponomareva, V., Rust, D., Tibaldi, A., Tunesi, A., Corazzato, C., Rovida, A., Sakharov, A., Tengonciang, A., and Uy, H., Trenching active faults in Kamchatka, Russia: paleoseismological and tectonic implications, *Tectonophysics*, 417, 285–304, 2006.

Lander, A. V., Bukchin, B. G., Droznin, D. V., Kiryushin, A. V., The tectonic environment and source parameters of the Khailino, Koryakiya earthquake of March 8, 1991: Does a Beringia plate exist? *Computational Seismology and Geodynamics (English edition of the Geodinamika i prognoz zemletriaseniy. Vychislitel’naya seismologiya)*, 3, 80–96, 1994.

Markov, M. S., Seliverstov, V. A., Khotin, M. Yu., Dolmatov, B. K., On the conjugation of structures of the Eastern Kamchatka and Aleutian island arc, *Geotectonics,* 5, 52–61, 1969 (in Russian).

Melekestsev, I.V ., Erlikh, E. N. Denudational-tectonic mountainous uplifts, *in History of relief development in Siberia and Far East. Kamchatka, the Kuril and Komandor Islands*, edited by I.V. Luchitsky, pp. 100–141, Nauka, Moscow, 1974 (in Russian).

Park, J., Levin, V., Lees, J., Peyton, V., Gordeev, E., Ozerov, A. A., Dangling Slab, Amplified Arc Volcanism, Mantle Flow and Seismic Anisotropy in the Kamchatka Plate Corner, *in Plate Boundary Zones. Geodynamics Series.30*, edited by S. Stein and J.T. Freymueller, pp. 295–324, 2002

Pechersky, D. M., Levashova, N. M., Shapiro, M. N., Bazhenov, M. L.,Sharonova, Z. V., Palaemagnetism of Palaeogene volcanic series of the Kamchatsky Mys Peninsula, East Kamchatka: the motion of an active island arc, *Tectonophysics,* 273, 219–237, 1997.

Pevzner, M. M., Ponomareva, V.V., Melekestsev, I.V., Chernyi Yar—reference section of the Holocene ash markers at the northeastern coast of Kamchatka, *Volcanol Seismol.*, 19/4, 389–406, 1998.

Seliverstov, N. I., The structure of Kuril-Kamchatka and Aleutian Islands according to single-channel seismic data, *Volcanol. Seismol.*, 2, 53–67, 1983 (in Russian).

Seliverstov, N. I., Sugrobov, V. M., Yanovsky, F. A., On geology and evolution of the Komandorky Basin, *Volcanol. Seismol.*, 1, 38–53, 1995 (in Russian).

Zobin, V. M., Fedotov, S. A., Gordeev, E. I., Guseva, E. M., Mityakin, V.P., Large earthquakes in Kamchatka and Commander Islands in 1962–1986, *Volcanol. Seismol.*, 1, 3–23, 1988 (in Russian).

Zonenshain, L. P., Savostin, L. A., Introduction to geodynamics, Nedra, Moscow, 311 pp., 1979 (in Russian)