

# Linear surface ruptures detected by SAR -- *the Kumamoto earthquake, the Northern Osaka earthquake and the Hokkaido Eastern Iburi earthquake*

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## 1. Introduction

The radar interferogram of ALOS-2 for the 2016 Kumamoto earthquake (M7.3) generally shows elastic deformation caused by the main earthquakes but many other linear discontinuities showing displacement are also found (Fujiwara et al., 2016).

We also found similar linear surface ruptures of the Northern Osaka earthquake on June 18, 2018 (M6.1) and the 2018 Hokkaido Eastern Iburi earthquake (M6.7).

In this presentation, we will show the characteristics of these linear surface ruptures.

## 2. General characteristics of the linear surface ruptures

The linear surface ruptures are those that Sangawa *et al.* (1985) presented about active faults in the southern part of Suruga Bay West Coast, and did not cause a large earthquake independently and the faults moved as a result of other large earthquakes.

The followings are the common features of the linear surface ruptures:

- (1) The standard length of them is several kilometers, with linear or gentle curvilinear shape. The displacement is on the order of a few centimeters to several tens of centimeters.
- (2) They are far from the seismogenic fault, and it is unlikely that they are the main seismic fault itself or the branch faults.
- (3) There is no evidence that they generated large earthquake ground motions at the time of the main earthquake.
- (4) They were likely moved passively, and it is considered to be the resultant faults, not the cause of the main big earthquake.
- (5) Since there is a correlation between the topography and the displacement, some of them are recognized as "active faults" from their topographical features. Therefore, there is a possibility that similar fault movements have been accumulating from the past.
- (6) The direction of strike and the displacement pattern of them are consistent with the surrounding stress field.

## 3. Characteristics for each earthquake

### 3-1) 2016 Kumamoto Earthquake

- (1) About 230 linear surface ruptures have been confirmed.

- (2) The form of displacement accounts for most of the normal fault.
- (3) The interval, depth and displacement of them are almost constant and uniform for each area, and they form several groups of the linear surface faults.
- (4) There are fault groups of similar shape from Beppu Bay to Unzen in the central part of Kyushu, Japan. This implies a possibility that there is a common form of them in central Kyushu.
- (5)  $\Delta$ CFF based on the fault model of the Futagawa fault zone and the Hinagu fault zone for the Kumamoto earthquake can not explain the cause of the displacement of them.

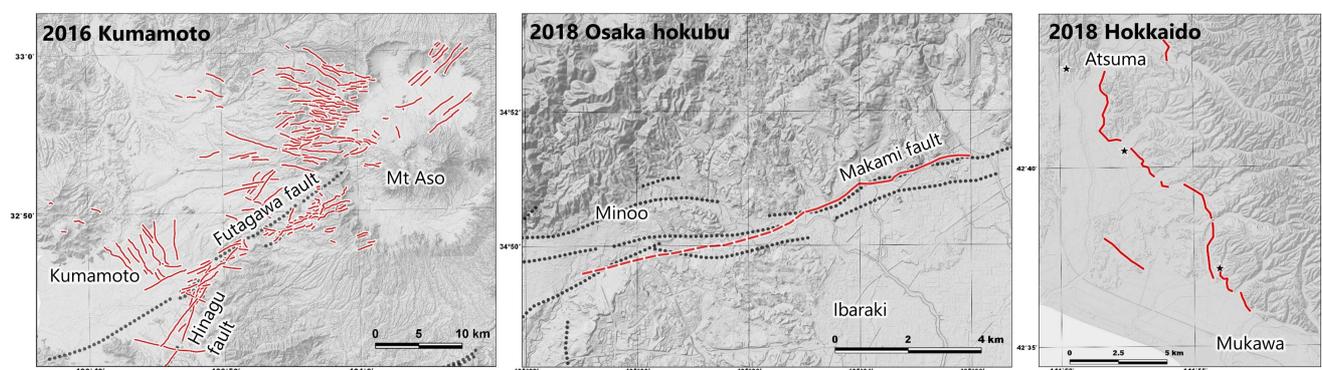
### 3-2) Northern Osaka earthquake on June 18, 2018

- (1) The linear surface rupture was recognized at a place coincident with one of the faults of the Arima–Takatsuki fault zone (Makami fault). Makami fault has been confirmed that it moved at the time of the 1596 Keicho–Fushimi earthquake (M 7.5).
- (2) Although the right–lateral fault component is dominant, the rupture does not reach the surface of the ground, but the displacement of the deviation component spreads by a width of about several hundred meters.
- (3) On the linear surface rupture, vertical displacement of the south side down is found.
- (4) According to the long-term observation before the earthquake, a wide belt around the linear surface rupture has continuously sunk.
- (5) The general crustal deformation due to the main shock is small, and it is about several cm at the maximum.

### 3-3) 2018 Hokkaido Eastern Iburi earthquake

- (1) The displacement shows east–west shortening, and there are almost no vertical components. Then, they can be described as reverse fault motion with very low dip angle.
- (2) The trace on the ground surface is not a straight line but a somewhat complicated curve that follows the terrain.
- (3) The traces of them have not been recognized as active faults.
- (4) In the seismic exploration (Yokokura et al., 2014), deviations in the basement are recognized just under them and they may be a hidden fault.

Keywords: Kumamoto earthquake, Northern Osaka earthquake, Hokkaido Eastern Iburi earthquake, Crustal deformation, Active fault, ALOS-2



**Figure** Comparison of linear surface ruptures for three earthquakes.

The red lines demote linear surface ruptures. The black dotted lines demote known active faults by HERP.

The stars denote estimated fault positions by seismic reflection survey (Yokokura et al., 2014)