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The thermal expansion model and the Mogi model for volcanic ground deformation

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(1) Basic aspects of the thermal expansion model, which was proposed by the author in this meeting of the last year (Kitsunezaki and Muraoka, 2013), is reorganized in relation to the Mogi model (Mogi,1958). In the Mogi model, the earth's crust is assumed to be a semi-infinite isotropic homogeneous elastic solid with the horizontal free plane (the ground surface). Displacement of the ground surface caused by a spherical pressure source set up in the earth's crust is evaluated. Gravity change associated with the deformation was estimated by Hagiwara(1977). Basically, the inside of the spherical source of this model is void (or material different from the surroundings). As a special case, we assume that the inside is filled with the same material as the surroundings and that temperature in the inside is raised (keeping the outside temperature constant). Thermal expansion of the sphere behaves as a pressure source, and the Mogi model is transformed to the spherical thermal expansion model (ST model). In this case, as the mass of the sphere does not change, the change in gravity on the ground surface is caused by the free-air effect (FE) due to uplift of the ground surface alone.

(2) The above ST model can be extended to the case in which the temperature-rise region (T region) has arbitrary shape. Let the T region be subdivided into a large number of small cubic cells. Every cell effectively behaves as a spherical thermal element. Its outputs (displacement and gravity change on the ground surface) are given by the ST model. The output of the entire T region is given as a sum of the output of each element. Hence in the T region with any shape, the change in gravity is caused by the FE due to the vertical displacement of ground surface alone.*

*[Note] The related description in Kitsunezaki and Muraoka(2013) has been corrected here.

(3) Shallow regions of actual volcanoes may be regarded as porous media. Let's assume that the pores are saturated by water and are in open condition. In the thermal expansion model described in (1) and (2), the earth medium is replaced by such a water-saturated porous medium. In this case, pressure of pore water is kept constant. Hence the solid part (skeleton of the medium) behaves in deformation independently from pore water. Thermal expansion of the solid part causes the displacement of the ground surface and the gravity change due to the FE as described in (2). On the other hand in the T region, the pore water expands freely responding to the temperature-rise (below the boiling point), hence its density decreases. (Thermal expansion coefficient of water is more than ten times larger than that of solid part (rock)).This effect causes negative gravity change, which is added to the FE so as to amplify the total gravity reduction to some degree. This example is numerically demonstrated in gravity variation observed in Akita-Komagatake volcano after the 1970-eruption.

[References]

Hagiwara, Y.(1977): The Mogi model as a possible cause of the crustal uplift in the eastern part of Izu Peninsula and the related
gravity change, Bull. Earthq. Res. Inst., Vol.52, 301-309 (in Japanese).

Kitsunezaki, C., and Muraoka, A. (2013): Gravity variation in Akita-Komagatake volcano and thermal expansion model, Japan Geoscience Union Meeting, SVC52-04 .

Mogi, K.(1958): Relations between the eruptions of various volcanoes and the deformations of the ground surfaces around them, Bull. Earthq. Res. Inst., Vol.36.99-134.

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