Classification of arc-trench systems based on the spatial distributions of gravity anomalies and volcanic chains

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The most conspicuous features of arc-trench systems are active seismicity, characteristic topography and gravity anomalies, and volcanism. Therefore, it is natural to classify arc-trench systems based on the distributions of gravity anomalies and volcanoes. Gravity anomalies are generally low in trenches and high in arcs. Volcanoes align along the volcanic front in most arcs. Since both of the high gravity anomalies and volcanic front have a subparellel strike to the trench, based on the spatial relationship between them, we can classify arc-trench systems into two cases: one coincident line or two separate lines of them. When high gravity anomalies and volcanic front are spatially separated two lines, high gravity anomalies always locate in the forearc relative to the volcanic front. Such examples are northeast Japan, southwest Japan, Ryukyu, Kuril, Cascade, Andes, Tonga, and so on. About two thirds of the arc-trench systems in the world are classified into this case. In the other arcs, such as Izu, Mariana, Aleutian, Kermadec, the volcanic front coincides with the zone of high gravity anomalies. All arcs of this type are oceanic. The difference of the two cases is mainly caused by the variation of dip angle of slab. High gravity anomalies are usually situated in the distance of 100 - 200 km from the trench, while the location of the volcanic front is primarily determined by the depth of the slab. Higher dip angle of the slab is likely to result in a coincident line, and the lower dip angle is likely to result in two separate lines.

As for stress state in arcs, there are also two cases: extension and compression. Then, based on the combination of the stress state and the above mentioned coincident or separate lines of high gravity anomalies and volcanic front, we can classify arc-trench systems into 4 (=2$*$2) categories. Here, first of all, we should note that there are no arcs of compression and a coincident line of high gravity anomalies and volcanic chain. Another important feature is that volcanoes locate in topographically low lands in the case of extension and separate lines, while in the other combinations (extension and a coincident line, or compression and separate lines) volcanoes are situated in topographical high. In order to explain these features consistently, first, we have to consider that steeper dip angles of slab always cause an extensional stress field in the arc. Next, plate subduction with lower dip angles of slab should be neutral to the arc stress field. Then, boundary conditions should become more important to the arc stress field. It is natural to consider that strain in the arc tends to concentrate around the volcanic front due to weaker strength there because of higher temperature. When gravity anomalies and volcanic chains are two separated lines, volcanic fronts would be topographically low in a tensile stress field, and high in a compressional stress field. When volcanic front coincides with high gravity anomalies, crustal uplift due to plate subduction, which is the cause of high gravity anomalies, would be dominant to topography. In this case, volcanic chain, high gravity anomalies and topographical high coincide to the same one line.