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Volcano monitoring using self-potential technique

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The self-potential (SP) distributions have similar features on a number of volcanoes: SP first decreases several hundred millivolts as one climbs the slopes of the volcano, then rapidly recovers to the level measured on the flank of volcano as the summit crater is approached. Consequently, the entire SP profile along a survey line starting from the foot, passing near the summit and reaching the foot on the opposite side often has the shape of the letter "W".

In most cases, the streaming potential associated with thermally driven upflow was believed to be the primary cause of the positive anomalies observed around volcanic craters or vents associated with fumarole activity. However, numerical simulations of electrokinetic potentials recently carried out by Ishido [2004] show that this mechanism is secondary especially for volcanoes having thick unsaturated zone. Instead, in a new quantitative model proposed by Ishido, the primary cause of the "W"-shaped SP distribution is a combination of the electrokinetic drag current associated with the downward liquid flow in the unsaturated and underlying saturated layers and the presence of a shallow conductor near the volcano summit. If the shallow conductor contacts a deep conductive layer, this conductive structure provides a current path between the low-potential shallow and high-potential deep regions, resulting in increase in SP around the summit. Assuming a plausible value of zeta potential and liquid-saturation dependency of drag current, the terrain-related SP on the peripheral area is calculated as about -1 mV/m, which is typical of the magnitudes observed at a number of volcanoes. The calculated "W"-shaped profile is stable even with periodic groundwater recharge, which is also consistent with field observations. However, the calculated high SP amplitude around the summit is sensitive to the conductivity structure, which is thought to change over time due to volcanic activities such as magma ascent, development of hydrothermal convection etc. SP changes over period of days to years around the summit would be an interesting target of volcano monitoring.