THE INVESTIGATION OF FUMAROLIC GASES AS A CONTRIBUTION TO DETECT INSTABILITIES INSIDE VOLCANIC SYSTEMS

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The forecast of eruptions can be considered as the most important task of the study of volcanoes but, in spite of heavy damages derived during the last decades to human lives and properties, this problem does not seem to have produced a sufficient attention from the scientific community.

According to the scanty information arising from the historical record, the most catastrophic volcanic events are related to explosive activities at apparently dormant volcanoes (e.g. Vesuvius AD 79 and 1631, Krakatau 1883, La Pelée 1902, Lamington 1951, Mount St. Helens 1980, Nevado del Ruiz 1985, Pinatubo 1991) so that any attempt at understanding an increase of eruptive probability appears to deserve special efforts in investigating quiescent systems.

Natural phenomena are supposed to evolve at a gradual rate, and some kind of prercursor can be expected to precede also apparently abrupt natural events.

Volcanoes must be regarded as the surficial part of deeper fluctuating systems, which occasionally give rise to eruptive phenomena. Because of their nature, gaseous species are readily sensitive to any physicochemical change at depth, and volcanic systems which behave in closed manner with respect to magma ascent are normally not closed with respect to gases.

In extensional areas, fluid magmas generating basaltic volcanism do not allow the storage of significant concentrations of gaseous species, which are gradually released during the ascent of magmas towards the earth's surface; seismic activities and ground deformations are mainly recorded as short-term forerunners of effusive events.

In compressional areas, a large fraction of volatiles can persist even at shallow depth in viscous magmas feeding andesitic or more acidic volcanism, so that important degassing is also expected to occur before any eruptive episode.

Uprising hot magmatic fluids can interact with groundwater, producing vaporization and a pressure build-up. This interaction can represent an important factor in triggering eruptive activities, whose characters strongly depend on the mass balance between the energy output from magma bodies and the water availability.

Sufficient vapour pressures to initiate explosive eruptions are expected when both components are operating, while effusive phenomena are observed for exceeding heatflows, and substantially hydrothermal activities result from predominating water recharges.

Quenching of ascending high-temperature gases is expected as the results of their interaction with shallow aquifers.

High pressures inside volcanic systems can be associated to higher extents of quenching, that is to greater discrepancies between equilibrium and observed temperatures.

Chemical disequilibrium appears as a necessary condition, even if not sufficient, for the occurrence of eruptive activity, and resumed activities of quiescent volcanoes are expected to follow conditions of chemical disequilibrium.

Several equilibrium reactions among chemical components of the fluid phases emitted from volcanoes have been considered to derive theoretical equilibrium temperatures, and any of them can normally provide a sufficient idea about the cooling occurred during the ascent of a gaseous flow from the magmatic environment to the surface. The comparison among the results from different reactions, however, allows to obtain further information about the physicochemical conditions which characterized the uprising fluids.

Minor values of variation coefficients among "apparent equilibrium temperatures" obtained through the different reactions correspond to gradual changes, while any perturbation affecting the same reactions at different extents produces substantially increasing values of variation coefficients. Accordingly, relatively higher values of variation coefficients appear to be related to greater extents of disequilibrium and, consequently, of changes in progress in the systems considered. Since resumed activities at quiescent volcanoes are expected to start with some kind of change in the feeding system, any perturbation seems to deserve further attention.

In order to verify to which extent this "working hypothesis" can be applied to procedures of volcano surveillance, the data available for a certain number of volcanoes from different tectonic environments, with or without recent eruptive activities, have been considered.

REFERENCES

Blong R.J. (1984) Volcanic hazards, Academic Press, Sydney, 424 pp.

Bullard F.M. (1978) I vulcani della Terra, Newton Compton, Roma, 636 pp.

Giggenbach W.F., Martini M., Corazza E. (1986) The effects of hydrothermal processes on the chemistry of some recent volcanic gas discharges.
Per. Mineral., 55, 15-28

Martini M. (1996) Chemical characters of the gaseous phase in different stages of volcanism: precursors and volcanic activity. In Scarpa/Tilling (eds.) Monitoring and mitigation of volcano hazard, Springer, Berlin, 199-219