

Maksimov A.P. Physicochemical mechanism of the deep degassing of aqueous magmas.

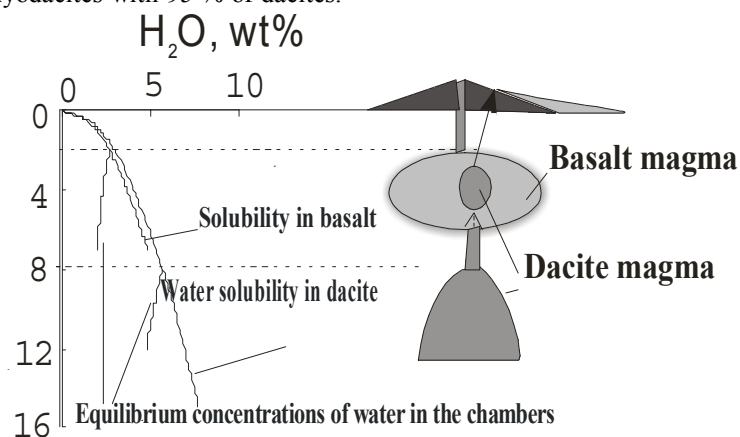
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Evidence for the high volatile contents in andesite and even more acidic magmas is their explosive character of eruption. The effusive acidic magmas containing aqueous minerals are of special interest. The Quizapu cone on the slope of the S'erro-Assul' volcano (Chili) is such an example.

The cone formation is associated with huge eruptions described in [1]. The first eruption was in 1846-47. Except for the very short beginning stage this eruption was mostly effusive. The volcano was resting for several decades. The eruptive activity of various intensity took place from 1907 till 1932. In 1932 the explosive eruption of the 9.5 km³ pumice took place. The first in historical time fumarole and the weak explosive activity lasting for several years began in two weeks 7 km to the north of Quizapu.

The 5 and 4 km³ of the hornblende dacite magma (re-calculated to the solid rock) was erupted during the Quizapu eruptions in 1846 and 1932, respectively. The lavas from 1846 were the first in the S'erro-Assul' volcano to contain hornblende (Hb). Both dacite eruptions give the narrow 67-68 % interval of SiO₂. A specific feature of the 1932 eruption is extremely wide range of its product composition: from basalts to rhyodacites with 95 % of dacites.



Complex structure of the S'erro-Assul' – Quizapu feeding zone is supported by polymodal composition of the eruptive rocks. The chamber depth where the Hb-dacites formed is more than 5 km. The upper chamber is at the depth of first kilometers where amphibole is unstable at any temperatures and water concentrations. According to the thermodynamic equilibrium law the water concentration should decrease with depth in the vertically elongated chamber and its solubility should be substantially lower than that followed from the solubility curve. This is illustrated by the diagram of equilibrium distribution of water with depth (fig.) calculated from the K. Burnham solubility model considering the H₂O fugacity coefficient. The water concentration decreases with depth and the difference between the water solubility and the water equilibrium concentration increases. Thus, magma in the chamber

The magmas are almost identical by mineralogy, chemistry, geochemistry and isotopes. Their temperature regime is also the same. Definitely, both magmas were erupted from the same chamber. At the same time the first eruption was effusive, and the second was explosive, plinian.

According to experimental data Hb is not stable in acidic water saturated melt at pressures lower than 1000-1250 bar. The water solubility at these pressures and the phenocryst crystallization temperatures of the Quizapu dacites (840-870°C) is about 4-5 wt%. During the ascent to the surface the magma unavoidably degases and Hb breaks down. Since the opacite rims around Hb in the 1846 lavas are not observed the duration of the ascent and degassing was probably no more than several days [2]. The water content in dacites is only 0.1-0.3 wt%. Therefore, no less than 500 mln tons of water (0.5 km³ of liquid water) was separated from the magma. Neither fumarole activity nor hot sources were noticed in this region before the explosive activity in 1907. Thus, the effusive character of the first eruption supposes pre-eruptive degassing of the magma. In contrast, the dacite magma from 1932 underwent intensive surface degassing, which was reflected on plinian eruption. In both cases the initial water content in the melts was high enough for catastrophically explosive eruption, but in the first case the volatile loss took place in absolutely different way - in the depth.

Model of deep degassing. According to our opinion "Quizapu mystery" can be explained by existing magmatic chambers on various depths, the dacite chamber being the deeper one, whereas the basic chamber being closer to the surface (fig.).

excluding its roof, where crystallization occurs, is undersaturated in volatiles.

Inflow of the actively degassing dacitic magma to the lower levels of the upper chamber unavoidably is accompanied by water dissolution in the basic magma. Probably this process involves only a part of the chamber that the dacite magma passed through. Thus, the upper chamber will be such a "trap" of volatiles. About 3-4 times more volume of the basalt magma is required to dissolve all the water contained in 5 km³ dacite magma in the 2-6 km deep chamber. The basic and the acid magmas cannot be efficiently mixed due to the big difference in their viscosities, and the acidic magma of lower density shall emerge through the basalt one. At the depths of the upper chamber this process is avalanche-like due to the sharp increase of the volatile volume. The magma mostly emerged through the liquid basalt magma but not along the narrow channel,

which caused its fast approach to the surface and perfect Hb preservation.

After the eruption the amount of water dissolved in melt significantly exceeded its equilibrium content. This excess water was a potential spring of the moderate explosive activity observed in 1907-1931 and also after April 1932. The water drop could happen only by diffusion. Due to its low rate the explosive process was not instant but was extended in time. Time for significant excess water drop by diffusion was probably not enough. In 1932 the basalt chamber could accumulate the volatiles exsolved from the dacite magma in sufficient extent, and the last eruption was plinian.

Conclusions. The observed facts of the Quizapu volcanic activity can be figured out as a logic scheme considering occurrence of the two magma chambers, the acidic magma being deeper than the basic one. The vertical distribution of volatiles causes the magma chamber to be the trap of volatiles exsolved from the inflowing deep magma. Such a model of deep degassing allows explanation for effusive eruptions of the initially water rich acidic magmas.

References:

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