MECHANICAL AND THERMAL INTERACTION OF ICE AND MAGMA IN SUBGLACIAL ERUPTIONS

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Eruptions under glaciers are common in Iceland and interaction of glaciers and volcanoes occurs in many parts of the world. Observations from subglacial eruptions in Iceland show very high rates of heat transfer between magma and ice, crevassing and subsidence of the ice surface above erupting vents, and drainage of meltwater away from the eruption site towards the edges of ice caps, leading to catastrophic flooding in some cases. Recent basaltic and basaltic icelandite eruptions in Iceland, notably the Gjalp eruption in 1996 and the Grimsvotn eruption in 1998 have provided useful insight into the thermal and mechanical aspects of ice-volcano interaction. Observations have provided numerical values of ice deformation rates that are several orders of magnitude higher than usually observed in glaciers. Thus, ice that would normally be ductile may behave in a brittle fashion leading to crevasses forming that are much deeper than the 20-30 m observed in normal glacier flow. Deformation associated with dyke intrusion to the ice-bedrock interface and possibly into the ice, may cause rupture of the glacier from below up to the surface. For thin temperate glaciers (50-200 m) such rupturing has lead to immediate commencement of subaerial phreatomagmatic eruption through the ice without a noticable preceding subglacial phase. In the case of thick ice (a few hundred metres) known eruptions have had a subglacial phase, influenced by rapid ice-deformation flow towards the vent. In this case the eruption has to melt its way to the surface, a process that may take hours - days - weeks, depending on the vigour of the eruption and thickness of the ice. Some eruptions never reach the subaerial phase. In most cases meltwater seems to drain more or less contiuously away from the vents along a subglacial path. The rate of ice deformation during subsidence of ice cauldrons in eruptions indicates that a considerable part of the load of
the ice overlying the vents is taken up by shear forces in the ice. As a consequence water pressure at subglacial vents is usually less than the load of the overlying ice. This may affect eruption style, favouring explosive activity at several hundred metres depth below the pre-eruption ice surface.