Synopsis Seminar

Seminar Title	: Decoding Dynamics of Magmatic Systems and Interactions with External Stress Perturbations
Speaker	: Sambit Sahoo (Rollno : 519er2004)
Supervisor	: Prof. Bhaskar Kundu
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Abstract

: Volcanoes and hydrothermal systems provide insights into the magmatic system beneath the earth's surface and occasionally cause massive damage through deadly eruptions, seismic activity and ground deformations. Volcanic hazards have increased around the world due to the growing inhabitations for the economic and environmental benefits around the volcanic and hydrothermal systems. Hazard zone risk management needs proper monitoring, public education, and evacuation plans using advanced monitoring systems and a better understanding of the underlying physical mechanisms. Volcanoes and hydrothermal systems have been reported to produce lithospheric deformations which can be further triggered by various external and dynamic phenomena depending upon various physical factors. Further, the triggering potential of these activities and the ability to mitigate and predict the risk is a long-standing question in the Geosciences community due to the complex interplay between the exogenous and endogenous forces.

During inflation, surface displacements, ground tilt, gas emission, and seismicity during volcanic unrest can be analyzed to unravel the magma chamber dynamics. Pre-existing fluctuating meteoric and connate water systems make the inflation process more complex as the systems can attribute an evolved degree of inflation due to the alteration in hydrothermal circulation during the unrest phase. In this phase of elevated deformation and seismic activity, the exogenous process does not affect the general trend of inflation and rate of the uplift but modulates the deformations.

With the increasing rate of inflations, the chamber attains a critical state of stress, increasing the sensitivity to periodic fluctuations of exogenous forces during the pre-eruption stage. Substantially, the micro seismicity associated with the system is exceptionally modulated by tidal loading during the pre-eruption stage compared to the other stages. Further, fault systems of the caldera also play a crucial role in the triggering phenomena where the failure mechanisms possess a complex interplay between the exogenous and endogenous processes and characterize the eruptive histories of the volcanic system. Looking at the eruptive histories and current global climate change scenario, it is observed that volcanic eruptions are primarily episodic. However, the seasonality of the sea level changes, glaciation, and rainfall patterns influence the eruptions in selective volcanic systems and types of eruptions. It is also assumed that specific periodic loading on the caldera walls and fluid pathways, such as tidal loading and seasonal hydrological loading associated with rainfall, can generate stress perturbation large enough to promote eruptions.

Seismicity associated with hydrothermal systems (e.g., submarine volcanoes, mid-oceanic ridges, oceanic transform faults, etc.) share a complex relationship with the tidal loading and induced fluid flow process under different tectonic settings. Tidal loadings modulate the fluid circulation process by squeezing or guiding through expansion and closing of the pre-existing fluid pathways at the brittle-ductile transition zone. Further, tidal modulations are generally observed at the shallow crusts where the tidal loadings generate maximum stress on the fractures or fault zones. However, fluid circulation and brittle crust generate failure at deeper depths in the transition zone, leading to seismicity. In addition to that, at deeper depths, the tidal loading amplitudes are too low to generate a brittle deformation.

In this study, it has been explained that the interaction between exogenous forces (such as tidal and hydrological loading) and endogenous magmatic processes (such as magma chamber depth and inflation rate) plays a crucial role in volcanic and hydrothermal systems, where magma chamber and caldera dynamics vary under different phases of the eruption cycle. Further, during the phases of the evolved degree of inflation, modulation due to long-period and short-period exogenous processes varies accordingly, and the short-period modulations are influential during the critically stressed pre-eruption stage. It is suggested that the presence of shallow or deeper inflated/non-inflated reservoirs in a hydrothermal system shows preferential behavior for the specific compressional/extensional tidal cycles. It has been shown that, at deeper depths, incremental pressure exerted by the tidal loading during higher amplitude variations can modulate the flow of hydrothermal fluid circulation. This explains the complex conditions on a spatial and temporal scale for the exogenous tidal loading and modulations. A deeper understanding of these complex interactions will improve our ability to monitor, predict, and mitigate volcanic and hydrothermal hazards.