Volcán de Colima is currently in its most active phase since the last Plinian eruption (1913). Evidence exists that during 1903 – 1913 the activity was similar to current. This combined with its approximate 100 year repose period between large eruptions, highlights the importance of monitoring of the volcano and trying to understand the significance of different signals. Its degassing behaviour is unusual, with very efficient sealing between the Vulcanian explosions, which have been occurring daily since 2003. The upper edifice is complex, with evidence that there are at least 5 dykes or fractures, rather than a central conduit, which have been the source of both effusive and explosive activity.

Recent activity

The current active phase commenced in 1998 and in the last 10 years, Volcán de Colima has had 4 episodes of effusive activity with associated dome growth and lava flows. The effusion rate has varied from a very slow 0.02 m$^3$s$^{-1}$ for the ongoing (Jan. 2009) dome growth which commenced in February 2007, to 6-8 m$^3$s$^{-1}$ a more typical value for an andesitic stratovolcano. Figure 1 shows the dome growing in 2008.

Explosive activity has been continuous since 2003 with 2-25 Vulcanian explosions per day. The magnitude has varied from small low energy ash-less plumes to the large events of 2005, many of which were characterised by collapsing columns, which produced pyroclastic flows that have reached up to 5.4 km from the crater.

Fig. 1 Crater of Volcán de Colima, with actively growing lava dome, 11 December 2008. Photo courtesy of Tapiro.

Monitoring of Volcán de Colima
Fig. 2 Production of SO₂ at Volcán de Colima from May 1998 – Dec. 2006 with continuous and explosive fluxes considered separately. Three effusive episodes can be observed with the total mass of SO₂ produced during each episode.

The current period is critical for the monitoring effort with the importance of detecting any pre-Plinian phase. It is crucial to identify the critical parameters of the monitoring network and to establish the threshold levels which could promote action, like evacuations of close settlements. This requires modelling of conduit/degassing processes. To improve the capability of modelling the complex dynamic system, traditional techniques (seismic, deformation, geochemical) have recently been enhanced with thermal monitoring (infrared camera & radiometers), infrasound, continuous gas monitoring, and Doppler radar.

**Gas measurement & Vulcanian explosions**

SO₂ flux has been measured sporadically since 1998. The correlation spectrometer (COSPEC) was used for both airborne and fixed measurements. In 2007, new scanning devices with miniature UV spectrometers (Flyspec) were introduced which have since been joined by two permanent installations.

Despite the explosive gas release at Volcán de Colima, during the last 10 years gas production is dominated by the effusive episodes. Fig. 2 shows the SO₂ output, obtained by integrating flux measurements. It can be seen that with each subsequent effusive episode the mass of SO₂ released has decreased. Most likely, a volume of magma has remained in a superficial reservoir since emplacement in 1998. Possibly convective overturn continues to supply fresh magma from deeper (Witter et al. 2005). During its ascent and decompression, a gas phase separates and pressurizes the less permeable partly crystallized magma above. This fails explosively, which since 2003, has produced the daily Vulcanian explosions. The rapid degassing of a magma batch increases the rate of crystallization which in turn increases the permeability and forms a new lava cap. The sealing process can be observed by scanning.
though the plume and measuring the SO$_2$ flux. Typically, the flux has fallen to background levels between 1 and 2 hours after the eruption. Fig. 3 shows an example with initially a double peak in flux.

The most recent effusive episode commenced in February 2007 and continues to present (Jan. 2009). Six months prior to the magma’s arrival at the surface precursors were detected in three of the monitored parameters: firstly, a significant peak in boron was detected in the water of three springs located 5-6 km from the crater (fig. 4a). Over the last 10 years, increases in boron and consistently correlated with activity. Secondly, an increase in the number of small magnitude long-period seismic events was registered (fig. 4b). The large number of events associated with large magnitude Vulcanian explosions can be seen in 2005. Thirdly, an increase in temperature was detected at the fumaroles on the N flank (fig. 4c). Since 2005, an infrared camera has been used to remotely record fumarole temperatures (Stevenson & Varley 2008).

Fig. 3 SO$_2$ flux output for Volcán de Colima for an explosion on 6 May 2007

Fig. 4a Concentration of boron in 3 springs located on the S flanks of Volcán de Colima. A peak can be observed prior to the effusive eruption in 2004, then a larger peak 6 months prior to the 2007-9 effusive episode.
Fig. 4b Long-period events per day measured at SOMA short-period seismic station.

Fig. 4c Fumarole temperature measured from Nevado de Colima – note it is uncorrected for transmisivity variations and temperatures are for the whole pixel.

In Fig. 4c it can be noted that the fumarole temperature has decreased steadily since 2006. When the dome was first observed at the surface a significant decrease was observed in fumarole temperatures. This could be explained by a temporary decrease in heat gas emission from certain fumaroles due to changes in the plumbing system.
Conclusions

New monitoring techniques such as fumarole monitoring with an infrared red camera are improving our comprehension of the volcanic system at Volcán de Colima. A model is being developed to explain the changes in magma rheology and rapid sealing of the conduit after Vulcanian explosions. Precursors have been detected prior to magma ascent (Varley & Taran 2003) but further understanding of the degassing processes are necessary, to enable the construction of a probabilistic risk assessment scheme and to be prepared for the next Plinian eruption.

References

