Toyako Volcano Geopark

Japan is a delightful and utterly fascinating country to visit and also has massive geological appeal due to its location on plate boundaries. Some of its active volcanoes, its spectacular geothermal sites and its numerous onsens (the locally popular resorts based around geothermal waters) are well-known on the tourist trail. Perhaps less widely known is the Toyako Volcano Geopark, which offers an unusual and very worthwhile volcano experience in the southern part of Japan's northern island of Hokkaido (Fig. 1).

***Figure 1**. Volcanoes and geothermal sites on Hokkaido.*

Usuzan (or Mount Usu, or just Usu) is an andesitic volcanic cone that tends to have explosive but short-lived eruptions at intervals of about 30 years, with activity either in its summit craters or in one of many parasitic vents around its flanks. In 1663, a huge eruption marked the end of a long period of almost complete inactivity, and since then it has erupted on another eight occasions. Usuzan is distinguished by having viscous magma that has risen to form more than a dozen subsidiary domes spread around its flanks and within the central crater; these include both lava domes that developed with hot rock swelling up in daylight, and also cryptodomes that grew without the main body of the magma breaching the ground surface.

***Figure 3**. Toyako during the late stage of the Konpira eruptions when only steam was emerging from the two vents. The lahar had already occurred, and the displaced bridge deck can be seen (see map Figure 4) (photo: Toyako Museum).*

The Usu volcano stands near the edge of Lake Toya, which lies in a caldera formed at around 110 ka, and has a central island formed by a cluster of later lava domes and cones (Fig. 2). The edifice of Usu dates back no more than about 30 ka, and subsequently it suffered a lateral collapse of its south-western flank around 8000 years ago; this yielded a huge debris flow that extended to and beyond the Pacific coast. The shoreline is currently five kilometres from the volcano's summit, and the intervening lowland has the numerous large and small

***Figure 2**. Caldera of Lake Toya, with its central island of newer domes and cones, and the town of Toyako on the extreme right.*

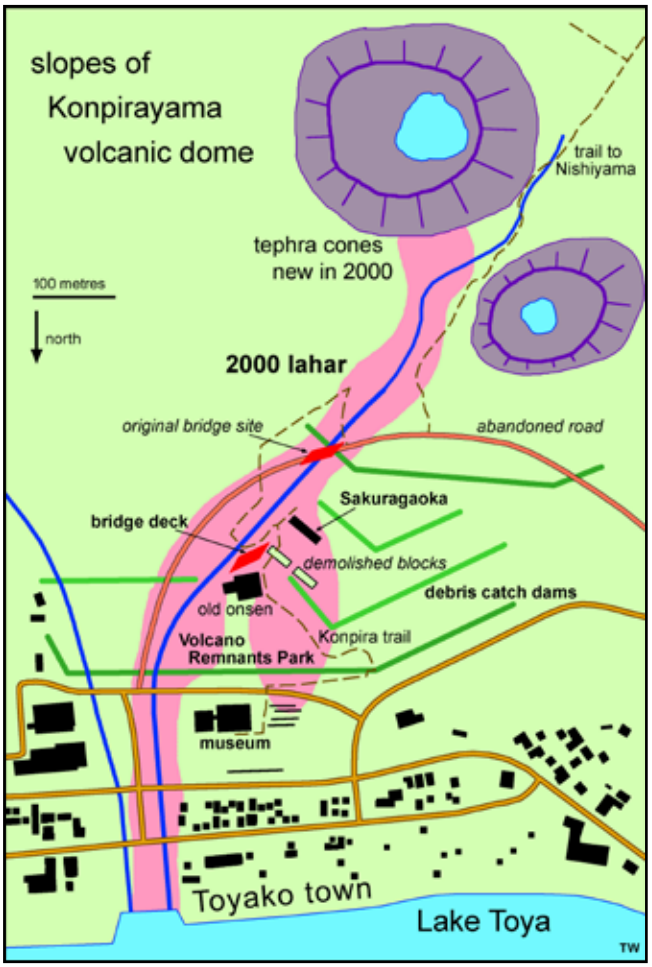

***Figure 4**. A simplified map of the main features related to the lahar damage at Toyako. The two main dams built to catch future lahars are in dark green; those in paler green are to create terraces on the sloping ground. Note that the map has been rotated so that the slope of the ground comes down the page; not all trails are marked.*

hillocks that characterise the terrain of such massive flank collapses. The proximal part of the ancient debris flow is buried by the edifice that has grown during a long series of subsequent eruptions, and the distal part appears only as a dozen tiny islands formed by some of the largest blocks within the debris flow.

On the opposite (northern) side of Usuzan, between it and Lake Toya, the small resort town of Toyako stands on the lake shore. This has the onsens, with baths and pools of geothermally-warmed water that are almost obligatory at any Japanese resort in a volcanic area. Directly behind the town, Konpirayama (or Kompirayama) is a tree-covered volcanic dome on the north-western slope of Usuzan.

In April of 2000, a cluster of new vents blasted into activity on the lower flank of the Konpira dome (Fig. 3). The eruptions were preceded by hundreds of minor earthquakes, which had prompted complete evacuation of Toyako, with nearly 10,000 people displaced for some weeks. Phreatic eruptions produced columns of stream and ash up to 2000 metres tall, and included a few small pyroclastic surges that did not reach as far as the houses of Toyako. Most of the airfall ash extended to the east, over Usuzan, and Toyako received only a light covering. The eruptions also built new scoria cones (or cinder cones), each to heights around 30 metres, before activity reduced after a few weeks to steady steam emissions.

During the final stage of that brief phase of eruptive activity, the cones of loose scoria and ash were destabilised by heavy rainfalls, and a lahar of mud, water and warm tephra swept down into Toyako (Fig. 4). This overwhelmed its stream channel and spread over land around the Saguragaoka apartment blocks and the adjacent onsen complex. Mud and tephra piled up against the buildings, broke windows and doors, and wholly or partly filled the apartments on their first two floors.

***Figure 5**. The corner of the one remaining block of the Saguragaoka apartments, with the ground-floor flats almost buried and the upstairs balcony that was hit by the bridge carried down by the lahar; the bridge deck can be seen on the right, where it came to rest, on a mound of debris just beyond the footpaths.*

Drama was heighted when the swelling lahar lifted the steel-and-concrete deck of a road-bridge from its abutments and carried it downstream for nearly 160 metres before it came to rest just short of the onsen block. But on its way it had crashed into the corner of the uppermost apartment block. Because the bridge was floating on the dense material of the lahar, it was more than three metres above the original ground level. The ground-floor apartments were already filled with debris, and the bridge hit the balcony of the corner apartment on the first floor, causing significant damage as it passed by (Fig. 5). One can relish the thought of completing the form for an insurance claim.

"Claim: damage to balcony of upstairs apartment."

"Cause: was hit by a passing bridge."

The eruptions of Konpirayama were accompanied by activity around Nishiyama, an adjacent parasitic dome lying about 800 metres away to the southwest. There, another cluster of a dozen new vents burst into action. The main feature of this second site was ground uplift by more than 20 metres; it was a cryptodome in growth mode, during which time only gases and relatively small quantities of tephra emerged above ground. Activity at Nishiyama lasted for nearly four months, before reducing to simple steam emissions.

Since the events of 2000, Usuzan has remained dormant, and the two largest scoria cones on Konpirayama now contain small lakes within their summit craters. However, appropriate precautions have been taken and barriers are now in place designed to catch and retain the debris of any further lahars, thereby preventing damage to the lower town. These barriers were constructed as pairs of sheet-pile walls with the space between filled with locally sourced tephra and then capped with concrete (Fig. 6). These were easier to build than solid concrete structures that would have been difficult to found within the deep cover of weak, ash-rich soils that distinguish the flanks of the volcano. There are two main catch dams across the lower slope of Konpirayama, and also three smaller barriers that will be able to contain terraces on the sloping ground. Two of the apartment blocks have been demolished, along with various other smaller buildings that were damaged or half-buried by the 2000 lahar.

Many of the lahar features have been preserved and made accessible as educational sites within the splendid Toyako Geopark. Created entirely since 2000, this features a new museum and two very good walking trails. The museum (which is the only part with an entry fee, of 600Y, about £4) has excellent displays and exhibits, with labels in both Japanese and English, and tells the story of Usuzan's many eruptions. It is open throughout the year, but the walking trails are only open April to November, as they are normally shrouded in deep snow during the winter.

The adjacent Volcano Remnants Park has easy footpaths around the key sites of the 2000 eruption and also passes by the lahar barriers that were built later; the car park is on top of the main catch dam. One of the Saguragaoka apartment blocks remains in place, and has the bridge-damaged balcony right beside the path. The building can also be entered as it is regarded as

***Figure 6**. One of the lahar catch dams built after the 2000 event.*

***Figure 7**. Rooms choked with lahar debris inside the Saguragaoka block that has been preserved.*

having educational value in showing how homes can be filled with lahar debris that then consolidates into very resistant material (Fig. 7). Nearby, the offending bridge deck remains where it was finally dumped by the waning lahar. Balcony and bridge combine to make an impressive site.

A longer trail continues up the hill to the two new Konpira craters, and onwards to link to the Nishiyama Craters Trail, which is also accessible from a road-head further west. This trail follows a section of old road broken by a succession of fault scarps that developed during growth of the cryptodome in 2000 (Fig. 8). It also loops round a dozen or so small craters and cinder cones that still emanate steam, but no longer eject solid material (Fig. 9), besides passing some buildings that were deformed on a spectacular scale by the cryptodome's ground movements.

***Figure 8**. An old road broken by a series of fault scarps that developed during growth of the Nishiyama cryptodome.*

***Figure 9**. One of the new craters on Nishiyama, beside a school that was wrecked by ground movements during growth of the cryptodome.*

Besides the attractions of the Toyako Geopark, Usuzan has more to offer. A cable car reaches up its eastern flank to a viewpoint on the rim of the summit crater. This is a complex feature nearly 2000 metres across, with its own perimeter trail.

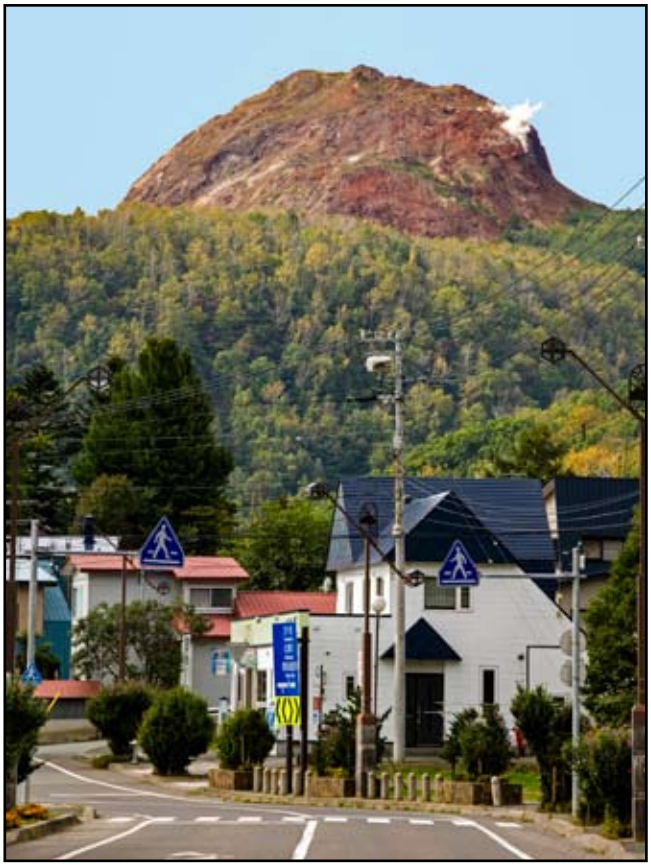

***Figure 10**. The youthful lava dome of Showashinzan, with steam rising from a minor vent, as seen from near the post office in Sobetsu.*

The Usu cable car also provides excellent views of the adjacent Showashinzan (meaning Showa new mountain). This is the volcano famously documented by Masao Mimatsu, the postmaster in the nearby village of Sobetsu. Through 1944 and 1945 he documented the growth of its lava dome with repeated profiles drawn on paper stuck to his window. A cryptodome grew by nearly 200 metres, with the ground rising by two metres on some days. Then the magma broke the surface and a lava dome rose to a final height of 290 metres above the original ground level. Mimatsu's study was a classic, and the bare rock of the new lava dome still looms over his village (Fig. 10). It complements the Toyako Geopark to make Usuzan a worthwhile destination for anyone with an interest in geology.

Tony Waltham

tony@geophotos.co.uk