窺探大地氣息

陽明山國家公園大屯火山群監測計畫

Probing the Breath of Earth

Monitoring Program of the Datun Volcano Group at Yangmingshan National Park

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火山脈動就像是地球的呼吸，一舉一動都受人矚目 / 營建署國家公園組提供 (2009 年 eye 上國家公園金牌獎，鄭玉員攝)
Volcanic movements are like the breath of Earth, and every move it makes has been watched carefully. /Photo provided by CPAMI.
(Golden Award in "Eyes on National Parks" photography contest in 2009; taken by Yu-yuan Zheng)

火山，究竟是人類的朋友還是敵人？

火山使得人類能享受舒暢養身的溫泉、有源源不絕的地熱能源、能探詢地球地質的秘密……火山脈動就像是地球的呼吸，一舉一動，都緊緊牽繫著住在地表上你我的敏感神經。

火山　令人又愛又畏

自從2012年可能為世界末日的議題，從快被遺忘的印加文明古曆中被挖出，翻拍成好萊塢最夯的電影，這話題看來炒到2012年、世界沒真的走向末日才會停歇。但就像是老天爺也配合電影行銷一般，片中是先從火山產生異狀開始，進而產生連鎖效應導致毀滅，在現實生活中，世界各地有多座火山，竟也真的出現一連串的「躁動」。

2010年3月，冰島沉寂百年的艾雅法拉火山爆發，歐洲空中交通幾乎癱瘓，損失慘重；同年十月印尼梅拉比火山爆發，造成嚴重傷亡；2011年1月26日，位於日本九州南部的新燃岳火山，在沉寂數十年後，從當日到2月3日，已連續9次噴發，而且沒有停歇的跡象，已有專家預測這個活火山噴發活動可能會持續一整年。

或許是處理火山噴發的經驗多了，日本政府這次因應得宜，新燃岳活火山的噴發並無造成如過去紀錄那樣的嚴重傷亡；然而，這次的事件已讓各國對於火山活動研究與監測上的進行，更不容忽視。

Are volcanoes a friend or foe to humans?

Truly, they bring humans relaxing, calming hot springs, inexhaustible geothermal energy, and divulge geological secrets of Earth. But volcanic movements are also like the breath of Earth, and every breath she takes stirs up the nerves of all who dwells on the Earth's surface.

Both Well-liked and Dreaded

Not long ago, the issue of the end of the world is picked again by filmmakers and hyped up into a blockbuster, which is based on the prediction of a 2012 phenomenon in an ancient Mayan calendar. Be it a coincidence or not, just as the film starts with abnormal volcanic activities that ultimately lead to destruction through chain reactions, in reality, there has been a series of volcanic movements occurring around the world.

In March 2010, volcano Eyjafjallajökull in Iceland, dormant for a century, erupted and caused enormous disruption to air travel across Europe. Later in October, the eruption of Mt. Merapi in Indonesia took a death toll of hundreds. This year since January, Mt. Shinmoedake on Japan's southern island of Kyushu has had a succession of nine eruptions, and such activities of this active volcano may continue for one more year, according to experts.

Already a veteran of volcanic crises, the Japanese government is well prepared this time, thus no serious injuries have been reported. Even so, the occurrence of these eruptions has shown the urgency of global volcano research and monitoring.

2010年冰島火山噴發，大量火山灰瀰漫天際，造成重大影響 / 冰島攝影師 Jon Helgasong 提供
In 2010, the volcano eruption in Iceland caused a great impact when large amount of ash was spewed into the air. / Photo by Icelandic photographer Joh Helgasong

大屯火山群是鄰近都會區的火山群 / 齊柏林攝
Datun volcano group is close to metropolitan area. /by Po-lin Chi

大屯山　是睡著還是醒著

世界上火山群的接連爆發，讓人不禁聯想到陽明山國家公園的大屯火山群，它是台灣最鄰近人口密集都會區旁的火山群。一直以來，科學家認為大屯火山群最後一次噴發應在十萬年前，因此被定位為「休火山」。但去年中央研究院地球科學所陳中華研究員提出看法，專家利用火山灰沉積的「層位學」與「碳14」來定年，因為每座火山其火山灰的化學組成與同位素組成都不同，可精確知道沉積的火山灰是來自哪座火山。2006年，研究團隊發現距今1萬8千年前的火山灰；2009年3月，在紗帽山下的乾涸古湖中挖到年代距今約5,500年的火山灰，認為是大屯火山群最近一次噴發紀錄的證據。

「如大屯火山群證實為一萬年之內曾有噴發紀錄，便可定義為活火山，但國內有其他學者、專家對於這項說法還持保留態度，因此學界目前還是以休眠火山來定義大屯火山群。」陽明山國家公園管理處詹德樞副處長表示。

Datun Volcanoes: Dormant or Active?

One cannot help thinking of the Datun Volcano Group (DVG) in Yangmingshan National Park (YMSNP), a group most adjacent to metropolitan area in Taiwan. For a long time, its last eruption had been dated back to 100,000 years ago, yet a study published last year by Dr. Chang-hwa Chen of Academia Sinica and his team could overthrow the estimation. The research team employed tephrostraitigraphy and Carbon-14 to date the deposit of volcanic ashes, and used chemical and isotopic composition of the ashes to trace their origin. In 2006, they found ashes dated 18,000 years ago, and then in March 2009, ashes from 5,500 years ago were dug out from a dried ancient lake by Shamao Mountain, which was held to be the evidence of DVG's latest eruption.

"If the last dated eruption of DVG is proved to take place within 10,000 years from now, then it should be defined as active. However, since many other domestic scientists express reservations toward this estimation, the academic circle still considers DVG dormant," explained Deputy Director Te-shu Chan of YMSNP Headquarters.

大屯火山群的火山地熱奇景下，是否有蠢蠢欲動的岩漿庫？ / 徐簡麟攝
Is there a magma chamber under the geothermal wonder of Datun volcano group? /by Jian-lin Xu

大油坑底下有岩漿庫 ?!

隨著全球各地火山連環爆造成的疑慮，再加上日前中央研究院地球科學研究所發表一項研究，大油坑附近在2008至2009期間，發生垂直地殼變形，高度約有0.9公分，由於要能使地殼整個抬上來顯示地底下有非常大的力量，因此推論大屯火山群有活動跡象，甚至不排除地底下有「岩漿庫」的存在。

其實，和即將噴發的火山，地殼會明顯抬升來比較，大屯火山群0.9公分的推升可說是極細微的變化。不過，為了掌握更精確的資料，國科會將委託中研院研究團隊與陽明山國家公園管理處合作，設置大屯火山監測所，透過監測所建立地震預報站，推估地底活動、預報火山活動。除嚴密觀測火山活動之外，也可作為研究、教育用平台，並建置全台首座火山爆發預警系統，萬一大屯火山群真有噴發跡象，以目前的火山活動監測技術，約在半年到一年前就能發現；如果火山真的要爆發，也有能力模擬火山灰散布狀況，估算影響區域，至少能做到噴發幾天前、甚至兩個禮拜前就能事先預警。

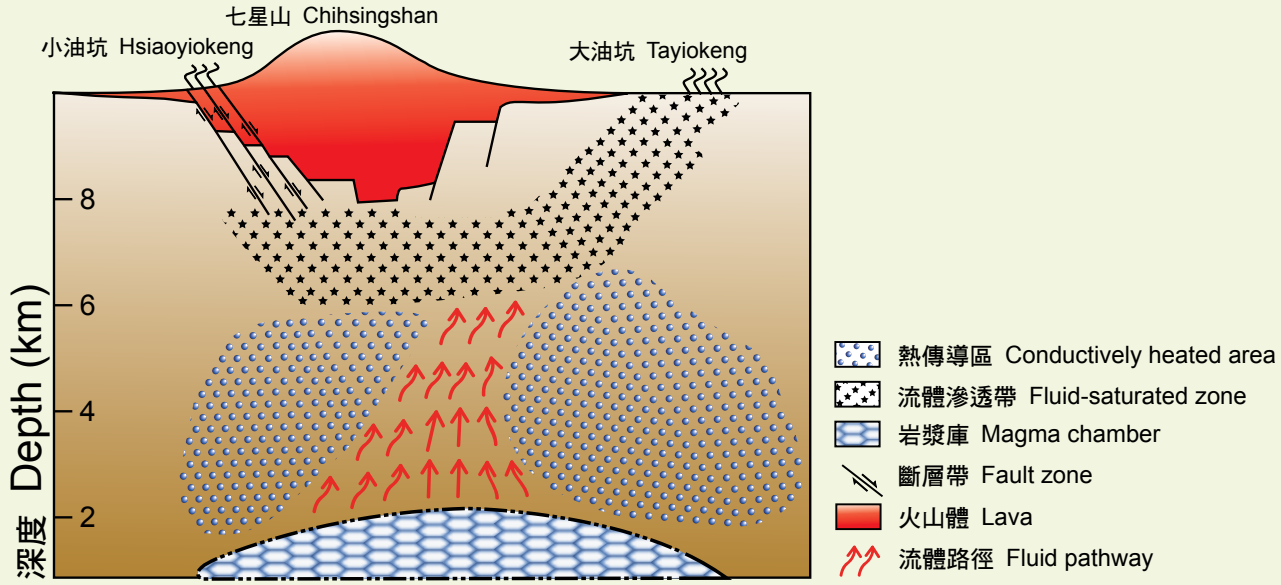
詹副處長特別說明，大屯火山群的監測所是未雨綢繆，藉由觀察地質地形的脈動，讓民眾更了解大屯火山群，大家不用過度擔憂，反倒是應該從增加科普知識的角度，去看待監測所的設立。

A Magma Chamber under Dayoukeng?

Another recent study published also by Academia Sinica may aggravate the worry about the eruption risk of DVG. The research team had recorded a vertical crust deformation of about 9mm in the Dayoukeng area during the period from 2008 to 2009. Since it requires a huge force to lift the Earth's crust, the team suggested DVG's volcanic activities and even the possible existence of a "magma chamber" under the surface.

In fact, compared to an about-to-erupt volcano, the 9mm uplift of DVG can still be regarded as insubstantial. To obtain more data, the National Science Council has planned to work with Academia Sinica and YMSNP Headquarters to set up Datun volcano monitoring station and earthquake forecast station. Such an observatory will not only serve academic and educational purposes, but function as part of an volcanic eruption forecast system: if DVG is truly active, signs of eruption can be detected half to one year ahead of actual eruptions; before a major eruption, the system can also simulate the volcanic ash distribution, estimate risk area and issue an alert as early as two weeks in advance.

Chan continued to clarify that the establishment of the monitoring station is more a preventive act and should not become a reason for worry. Instead, it should be regarded as another source for people to gain scientific knowledge.



藉由研究監測的相關分析資料，為火山活動未雨綢繆 / 陽明山國家公園管理處資料，劉好音繪
The precautions of the eruption of volcanoes are taken based on the related analysis of the data collected from monitoring. /Data provided by YMSNP Headquarters; illustrated by Hao-yin Liu

「大屯火山群不是現在才受到關注，其實從民國八十代年，陽明山國家公園與國科會、中研院等單位就開始進行大屯火山群的監測，對於大屯火山群的狀態很了解，也都在掌握之中。」

善用科學　為大屯山體檢

陽明山國家公園自成立以來，就持續進行火山活動的相關監測與研究；但嚴格來說，火山觀測從日治時期就開始進行，光復後調查研究更為深入。

只不過隨著時代更迭，監測的方法與技術更上一層，尤其大屯火山群鄰近人口密度稠密的都會區，陽明山國家公園與專家對大屯火山群的「體檢」從沒輕忽。

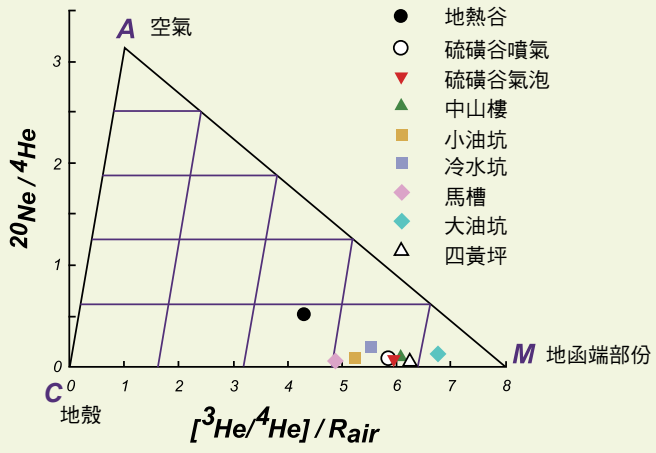
"It is not true that DVG had not received any attention until recently. YMSNP, NSC and Academia Sinica have all started monitoring on DVG since the 1990s, and have a rather clear picture of its conditions."

Scientific Checkups for Datun Mountain

YMSNP has conducted continuous volcano monitoring and research since its establishment. But in fact, related volcano watch was initiated during the Japanese rule, and further surveys and studies were carried on after the retrocession of Taiwan.

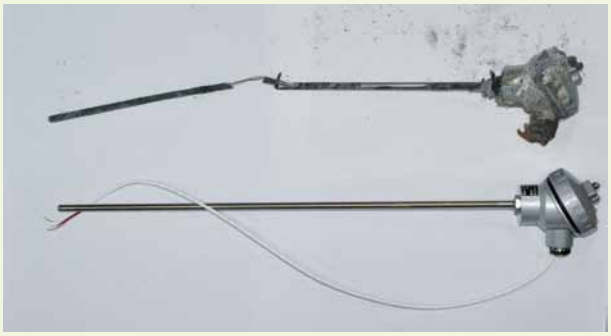
As the monitoring measures and technology keep scaling new heights with time, the "checkups" for DVG are getting more careful and detailed, given DVG's proximity to urban areas.

陽明山國家公園管理處持續進行火山監控，圖為噴氣孔溫度監測系統示意圖。藍色實心圓為溫度感應器，紅色為防腐蝕性電纜線，電纜線長度約為 150 公尺，為傳輸溫度訊號用，綠色方塊為溫度記錄器和溫度展示螢幕（位於遊客中心內）/ 江協堂博士提供
YMSNP Headquarters has been conducting the volcano-monitoring program. The picture shows the diagram of fumarole temperature monitoring system: the blue zone represents temperature sensors; the red line represents the anti-corroding cable, which is 150m in length, and is used to transmit the signals of temperature; the green zone represents temperature recording machine and temperature display screen (within visitor center). /Photo provided by Dr. Hsieh-tang Chiang



大屯火山地區氣體樣品之 He-Ne 三端元成份投影圖。除了地熱谷外，大屯火山群之氣體成份皆有大於60% 之地函源氣體成份。(楊燦堯等，2003)
This picture shows the projection of He-Ne 3 end-members, which comprise the gas sample of Datun volcano area. BesidesThermal Valley, mantle source gases dominate the composition of the gases of Datun volcano group (> 60%). (Tsan-yao Yang, et al., 2003)

將溫度感應器埋入火山地表，以記錄溫度變化 / 江協堂博士提供
In order to record the changes of temperature, the temperature sensors are buried beneath the surface of volcanoes. /Photo provided by Dr. Hsieh-tang Chiang



火山的熱與氣體易造成溫度感應器的腐蝕。圖為腐蝕的不鏽鋼管 / 江協堂博士提供
The temperature sensors are corroded easily by the heat and gases of volcanoes. The picture shows the corroded stainless steel pipes. / Photo provided by Dr. Hsieh-tang Chiang

詹副處長用淺顯易懂的方式，說明了陽明山國家公園長期進行的火山監測原理。「首先是觀察地球化學方面，針對火山噴氣尤其是氦同位素 (^3He ／ ^4He) 的比值，因為氦氣在大氣中幾乎不存在，但卻是岩漿的重要氣體，因此可藉利用精密的氦同位素質譜儀分析技術來進行觀察。根據泛太平洋環火山帶其他火山活動地區的研究，火山爆發前氦同位素的比值會明顯變化，此時即需配合其他監測工作進行仔細觀察，如果像目前維持在背景值，就無需過度擔心，因此長期收集氦同位素比值可了解火山是否正在活動。」

再來是地球物理的監測。陽管處長期設置很多微震站，記錄人體在無法感知但儀器可以監測到的地震波。專家彙整了地球化學及物理兩項資料，才推論出陽明山國家公園靠近大油坑地表下，可能有岩漿庫的存在。「這只是趨勢，不是結論，火山觀測並非一朝一夕的工作，要長期進行的資料收集才能驗證。」

此外還利用大地電磁法。「利用電磁波來觀察土壤的導電度，如果土壤是堅硬的固體，當然電阻大；倘若是流體，像是岩漿，則電阻小。」以往國家公園所做的監測都是離地表下30公里以內的深度，「結果，我們在6公里處發現到一個疑似正在冷卻的岩漿庫。」

In a simple way Chan explained the major measures employed by YMSNP in volcano monitoring. “First we collect geochemical data, especially the ratio of $^3He/^4He$ in volcanic exhalation. Because helium barely exists in the atmosphere yet is a significant gas in magma, accurate analyses of the result presented by mass spectrometer of $^3He/^4He$ serve as important means. The isotope ratio of helium would change drastically before volcanic eruptions; once such changes are observed, more advanced monitoring measures will immediately be adopted for further conclusions. If the ratio stays within the background value, as is the current case, there’s no need to panic.”

Then the geophysical monitoring. YMSNP has long set many microseismic stations to record earthquake waves detectable only to monitoring instruments. It is after synthesizing the geochemical and geophysical data did scientists infer the probable existence of a magma chamber under the Dayoukeng area. “But this is more an inclination than conclusion. It cannot be verified within a short time or without a collection of long-term data.”

Besides, magnetotellurics is employed to measure the level of conductivity of soil by electromagnetic waves. “If the soil is hard solid, the electric resistance (R) would be great; if the soil turns liquid, then R would be small.” The monitoring conducted by national parks has been within the depth of 30km, “but we found a suspected case of magma chamber at 6km underground.”

大屯山的火山景觀，吸引國內外遊客駐足欣賞／賴宛靖攝
Volcanic scenery of Datun Mountain attracts tourists home and abroad to stop by and appreciate the beauty of it. /by Wan-ching Lai

但詹副處長也說，監測還持續進行，現在論定大屯火山群底下是否有岩漿庫，都言之過早，「假如說真有岩漿庫的存在，也可能是離地表4、50公里深，不可能是淺層，這都要長期監測下去才會有比較明確的答案。其他像是地殼變形、地溫監測等研究，也都在持續進行。」

民眾對火山活動不夠了解、加上近期全球火山活動頻繁，擔心大屯火山群爆發是理解的。詹副處長特別強調，科學是講求證據的，不能任由謠言像火山灰一樣到處飄散。對於大屯火山群的任何一絲氣息，都在專家學者的掌握之中。地處台北都會區旁的大屯火山群，依然還是你我的好鄰居，大家不妨放下心中的疑慮，到陽明山國家公園賞花踏青、泡泡湯、看看雲霧，感受一下大自然奇妙的脈動吧。

However, it is still premature to make any conclusion regarding the existence of the magma chamber. “Even if it exists, it is more likely to be 40 or 50km deep. A more definite answer cannot be given without continuous monitoring. Other surveys like topographic transformation and geothermal evaluation are also persistently under way.”

People’s worry about the risk of DVG’s eruption is expected, given their lack of understanding about volcanoes and recent eruption incidents all over the world. But Chan emphasized that science is based on facts; any unproved conclusions should be stopped wisely as rumors. He assured again that every movement of DVG is closely monitored by scientists. Before further signs are detected, YMSNP is still a wonderful choice for hiking, hot spring soaking, and bloom watching. So, put down your worry and go up to feel the amazing pulse of nature.

簡介 *Profile*

詹德樞
Te-shu Chan

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Chan received his master degree from the Department of Forestry of National Taiwan University, and he specializes in forestry technology, forest ecology, Nature conservation and environmental education. Chan is currently Deputy Director of Yangmingshan National Park Headquarters, and he was once the Chief of Conservation Section and the Secretary of Yangmingshan National Park Headquarters.