제 2 차 대형화산 기획과제 단기강좌

일 시: 2011 년 11 월 3 일 (목) 오후 1 시 20 분 – 5 시 30 분

장 소: 서울대학교 지구환경과학부 25-1 동 국제회의실
(참가비 무료)

13:20 – 13:30 등록; 소개 및 인사

13:30 – 14:20 James D. L. White (University of Otago, New Zealand)
“An overview of maar-diatreme volcanism”

14:20 – 15:10 Shane J. Cronin (Massey University, New Zealand)
“Magmatic models and hazard models from monogenetic volcanic fields, insights from Jeju, Korea and Auckland Volcanic Field, New Zealand”

15:10 – 15:30 휴식

15:30 – 16:20 James D. L. White (University of Otago, New Zealand)
“Submarine volcanism: significance, some advances”

16:20 – 17:10 Shane J. Cronin (Massey University, New Zealand)
“Volcanology and volcanic hazards of andesitic stratovolcanoes”

17:10 – 17:30 토의 / 질의응답

서울대학교 25-1 동 국제회의실 약도(G3 gate 로 들어오면, 건물 옆에 주차장 있음)

발표 강좌 요약문

1. An overview of maar-diatreme volcanism (James D. L. White)

Maar-diatreme volcanoes are produced by explosive eruptions that cut deeply into the country rock. A maar is the crater cut into the ground and surrounded by an ejecta ring, while the diatreme structure continues downward and encloses diatreme and root zone deposits. This talk reviews a wide compositional range of maar-diatreme volcanoes, and from historical maar eruptions to deeply eroded or mined diatreme structures. Ejecta rings, while providing invaluable insight into eruption processes and sequence, are incomplete records of diatreme formation because significant parts of an eruption may fail to eject material beyond the crater walls. Deposits within the diatreme structure include, in varying proportions, lower unbedded deposits sometimes typified by subvertical contacts among domains of debris emplaced sequentially, and upper bedded deposits formed by sedimentation on surfaces open to the atmosphere. A basal root zone comprises the transition from coherent magmatic feeder dike to clastic deposits formed by fragmentation of magma and enclosing country rock; root zones are irregular in form, and the clastic deposits are typically intruded by contorted dikes. Irregular root zone-like chaotic breccias cut by contorted dikes are also present within diatreme deposits, where they represent intra-diatreme fragmentation zones and record changes in the location of the explosion locus during eruption. In support of the points addressed, examples are used from historical maar-forming eruptions at Taal Volcano (Philippines) and Rotomahana (New Zealand), and from experimental work. Information is also drawn from the characteristics and origins of ancient deposits from Antarctica, Arizona, and Montana, as well as some diatremes, tuff rings and maars in Korea.

2. Magmatic models and hazard models from monogenetic volcanic fields, insights from Jeju, Korea and Auckland Volcanic Field, New Zealand (Shane J. Cronin)

Understanding the eruption dynamics of monogentic volcanic fields requires a magmatic model that explains the distribution, volume and type of magmas erupted in relation to the tectonic structure. At Jeju Island, initial volcanism was submarine, with dispersed basaltic eruptive centres. These tuff cones were capped by lavas from continuing monogenetic volcanism, and since ~0.5 Ma voluminous lavas, building a composite shield. Pyroclastic products of monogenetic centres are alkali basaltic to trachybasaltic, whereas the more voluminous lava flows and domes of the central island consist of sub-alkali basalt and alkali basalt to trachyte. Early monogenetic centres (pre ~0.7 Ma) are depleted in MgO, Cr and Ni, reflecting olivine fractionation. By contrast, younger monogenetic magmas (<0.2 Ma) reflect fractionation of clinopyroxene and olivine at deeper levels. Isotopic compositions, major and trace element data suggest a common, shallower mantle source (2.5 GPa) for older monogenetic magmas and sub-alkali lavas, in contrast to a deeper source (3-3.5 GPa) for younger monogenetic magmas. As melting deepened, higher volumes of magma were produced from the shallow zone, which may reflect higher rates of convective mantle upwelling. This upwelling may have occurred in lenses, focused along weak, sheared zones created in the mantle during the opening of the Sea of Japan/East Sea at ~15 Ma. These may have been reactivated as rotation of the subduction vector of the Philippine Sea plate occurred ~2 Ma. The implication of this model is that as the depth and extent of melting increased, the proportions of shallow-mantle partial melts rose in the middle and later stages of Jeju's formation, producing a central composite shield and edifice. Mantle upwelling was greater in the core of the system, with lower rates in distal parts of the field. Hence, eruptions in the centre of long-lived monogenetic fields are more likely to produce larger volume, more evolved magma outpourings, compared to those at the outer margins. In the Auckland volcanic field (AVF), some similarities and several differences emerge. The largest outpouring sub-alkali volcanism occurs at the edge of the present known field, although several overlapping medium-volume centres are clustered in its centre. An explanation for this is the relative youth of the AVF (<0.25 Ma). To evaluate the structural controls on this field a new age model for the field was developed by statistically combining direct dating, stratigraphic, geochemical, magnetic and volcanic ashfall information. With this new event-ordering and age model it is seen that both the distribution of vents and the timing of eruptions is in some way structurally related to concurrent plate-boundary processes, even though the subduction occurs >600 km away. The model of magma upwelling along thin lenses of sheared mantle appears also to hold for the AVF, with triggering of eruptive bursts related possibly to changes in the stress field surrounding the subduction system. A pre-adolescent stage of the AVF could also be indicated by an increase in melt volume production from shallow (2.5 GPa) levels of the mantle in the most recent eruption, parallel to the change observed at Jeju.

3. Submarine volcanism: significance, some advances (James D. L. White)

Subaqueous eruptions are earth's most abundant, and the proportion of such eruptions that involve explosions, though still poorly constrained, is larger than generally appreciated. Subaqueous eruptions are fundamentally affected by water's ability to vaporize upon contact with magma, its high density (in comparison with air) and the accompanying increase in confining pressure with depth of eruption, its greater viscosity than air, and its high heat capacity and thermal conductivity. The effects are both on source dynamics of the eruptions (exit conditions, fragmentation) and the transport and deposition of eruptive products. Interpretation of ancient subaqueous deposits is important both practically, because they host significant mineral deposits, and more broadly in order to understand how volcanoes work on the ¾ of our planet beneath water. Successful interpretation requires an understanding of the full range of water's effects on eruptions in order to work backwards from deposit characteristics through deposition and transport processes and back into the vents. Investigation of modern seafloor volcanoes demonstrates a range of volcano and eruption styles, and is also providing insight into mineralization sites and processes within still-active magmatic systems.

Development of a better understanding of submarine eruptions must rely largely on interpretation of their deposits, informed by physical models and relevant experimental data. In subaqueous eruptions, arriving lava or a mixture of gas and hot pyroclasts encounters water. For some subaqueous eruptions, the effects of this encounter are fundamental and pervasive through every aspect of eruption behavior. For other eruptions, the effects are significant, but less pervasive, and allow some eruption processes that are fundmentally magmatic to operate much as they would subaerially. Water differs from air in many ways. Consider four that affect the characteristics of subaqueous eruptions. (1) Phase change: water/steam (2) High pressures. (3) High heat capacity and conductivity. (4) Water rheology – dense and viscous.

Under water there is little infrastructure, and virtually no human inhabitants, so explosive subaqueous eruptions pose minimal subaqueous risk. Significant risk attaches to shipping and coastal communities, however, because explosive subaqueous eruptions produce hazards at the surface due to formation of steam and displacement of water. Eruptions under ice and snow are a special case of subaqueous eruptions, because the eruption itself makes the water. By generating water beneath or within ice, which is of lower density than water, catastrophic floods, called jokulhlaups, are generated. In summary, hazards resulting from explosive subaqueous eruptions are many, their causes diverse, and associated risks for coastal communities and surface shipping can be significant. Additional high-resolution swath bathymetry, new sampling programs, and research focused on the processes and products of such eruptions are all needed to census the risks and better understand their origins.

4. Volcanology and volcanic hazards of andesitic stratovolcanoes (Shane J. Cronin)

Stratovolcanoes are large mountain volcanoes (>100 km^3) that are composed of basaltic-andesite through to dacitic lava flows, alternating with pyroclastic deposits. They are the most commonly recognised volcano type along convergent plate boundaries and are also typically the most deadly, primarily because they awaken suddenly and explosively from decades to centuries of repose, catching surrounding communities unaware. Evaluating hazard from these volcanoes takes a multi-faceted approach, with research outlined here including: (1) quantifying volcanic histories, eruption frequencies and forecasting methods; (2) linking geochemistry and magmatic properties to eruption types, magnitudes and frequency, (3) understanding the physics and dynamics of explosive and eruption processes and transitions between these, (4) understanding the dynamics and impacts of mass flows, as well as techniques to model their impacts. Results from these studies show common patterns of behaviour that can be extrapolated between andesitic volcanic systems under similar crustal/heatflow conditions. Long-term volcanic records are essential to take the pulse of individual magmatic systems, but it appears common for regular variations in eruption rate to occur (on periods of 1500 years to up to 5000 years) and be related to long-term magma-feeding system cycles. Magmatic systems typically involve a two or three-stage process, with ponding and modification via fractionation and re-melting processes at the base of the crust (25-35 km depths), rise of new magmas to mid-crustal ponding areas (8-10 km) for further AFM processing and rise to direct eruption, or further shallow-level ponding prior to periodic eruption. Highly complex mixtures of magmas often occur with myriads of small magma batches present, and the history of magmas through the crustal “filter” leads to a large range in magma properties upon reaching the surface, producing extremes of gas-charged magmas and highly explosive pyroclastic eruptions, through to viscous crystal-mushes that ooze slowly out to form domes. Understanding the driving forces of andesitic volcanoes has resulted in new models for the type and nature of hazards occurring on their flanks, with the best conclusions reached by comparing like-volcanoes as analogues. Example volcanoes discussed in this presentation will be Mts. Taranaki, Tongariro and Ruapehu in New Zealand, along with Gunung Merapi and Semeru in Indonesia.