新バージョン・キッチン地球科学の役割
Introduction to New Kitchen Earth Science

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After intermission of several years we propose the new version of “Kitchen Earth Science” again. As an introduction to this session we explain the current situation and our new aims toward the session proposal. During the intermission period outreach activities have become active and popular and our previous aim to utilize Kitchen Earth Science matters in such occasions has been more or less accomplished. At the same time new problems have arisen in the university education,particularly around the design of experimental course. As the freshmen education in the universities recent trend is to start professional classes as early as possible at the sacrifice of general arts educations. This trend is coupled with the critical reviews on the conventional classes taught unilaterally in large class rooms. Innovations in the freshman education are an urgent task. Recently the tendency of diminishing numbers of students taking earth science classes in the high schools has been apparent so that the earth science lectures at the freshman education in the universities has become important. If these lectures are eliminated or are not taught carefully the last class of the earth science for the most people should be junior-high school class although social demands for higher comprehensions in the earth science matters are increasing such as the understanding of natural hazards and our future environments. Under consideration of these two aspects we propose experimental courses of earth science at the freshman educations could resolve the problems and improve the quality if we can properly incorporate essence of “Kitchen Earth Science”.As an introduction to this session we show several trails in Tohoku University, Kyoto University and Tokyo University.

キーワード：大学初年度教育、実験科目、最後の地球科学講義
Keywords: freshman education, experimental course, last chance to study earth science

東北大学における文科系・理科系１年生対象の自然科学総合実験について
“Introductory Science Experiments” for first-year students in science and humanity courses at Tohoku University

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Tohoku University provides an opportunity to experience a laboratory work “Introductory Science Experiments” to first-year students in science courses (Medical, Dentistry, Science, Engineering, Pharmacy, Agriculture) since 2004, and also to experience a “Basic Scientific Work” to first-year students in humanities courses (Arts and Letters, Economics, Law, Education) since 2007. Through Introductory Science Experiments, students in science courses learn about scientific logical thinking, basic academic writing skill and willingness to challenge and understand the fundamental concepts of natural phenomena. Students in humanities learn about knowledge of scientific process towards improved scientific literacy by using their own hands in basic laboratory work. More than 19,000 students in scientific courses attended the science laboratory classes during the last twelve years since 2004. About 600 students in humanities courses attended the classes during the last nine years since 2007. We designed five interdisciplinary experiment topics that combined physics, chemistry, biology and earth science for science course students (Earth and Environments, Materials, Energy, Science and Culture, and Life). For humanities students, five topics have been designed (Earth and Environment, Energy, Life, science in our daily life, Science and Culture, and Mathematics as the backbone of natural science). Tohoku University welcomes 2,500 first-year students every year (1,800 students for science courses and 700 for humanity courses). Tohoku University requires all science course (except mathematics and nursing) students to take the laboratory class (compulsory subject), so we open six laboratory classes in a year: three classes in the first and second semesters. Students take time for three hours in pairs to do the laboratory work and then students are required to submit a scientific report based on their own work in a week. About 80 teachers and 180 teaching assistants manage the classes in a year. For humanities students, about 70 students are assigned to the Basic Scientific Work because of its elective subject. Class evaluation by students showed that 62% of the scientific course students found the Introductory Science Experiments were interesting, and 90% of the humanities course students found the Basic Scientific Work were interesting. In the presentation, we introduce an instructional design of the laboratory classes (both science and humanity courses), the detail contents of the classes, their evaluation and future prospect.

水飴を用いたマントルプルームのアナログ実験
Analog experiments on mantle plumes in general education classes

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As mantle convection is related to Earth’s evolution such as plate tectonics and hotspot magmatism, it is essential to visualize and understand the flow pattern in the mantle. However, the visualization of the realistic mantle convection is difficult in a class room because of difference of spatial and time scales. Therefore, we have developed an experimental kit of Kitchen Earth Science (KES) aiming at understanding the mantle plume behavior in general education classes. In order to save the cost for the experimental kit, we performed analog laboratory experiments using sugar syrup and common laboratory tools such as rubber plugs and syringes. In the analog experiments, a cylindrical transparent acrylic tank is filled with the sugar syrup. More buoyant less viscous sugar syrup colored with food dye is injected from a nozzle at the bottom of the tank. The flow behaviors of the upwelling plumes depend on the injection flow rate, the rheological properties and volume fraction of the injected and filled sugar syrup, and boundary condition (wall effect), which give insights into the mantle dynamics. In the presentation we will show some interesting flow behaviors observed in the class room experiment.

キーワード：マントルプルーム、水飴
Keywords: mantle plume, sugar syrup

プヨプヨゲル中のプルーム流れに観るマグマの振る舞い

Magma-like behavior observed in the flow of buoyant plumes in Puyo-puyo gels

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We have conducted laboratory experiments on buoyant plumes in deformable porous media to understand the dynamics of magma transport in a partially molten region. As an analogue material of partially molten media, a mixture of Puyo-Puyo gels (transparent hydrogel beads) and viscous fluids was used. A transparent acrylic tank was filled with the mixture, and a buoyant viscous fluid was injected from a nozzle at a constant volume flux into the mixture. The flow behavior depends on the injection flow rate, the rheological properties of the mixture and the buoyant fluid, the volume fraction of the interstitial fluid, and also the boundary condition of the deformable porous media (wall effect). In this presentation we will show some interesting flow behaviors observed in our experiments: plumes with percolation, spontaneous pulsating flow (wave train), sill and dike structures, and so on. Our homemade experiments will provide inspiration and fruitful information of the dynamics of magma transportation.

キーワード：マグマ、プルーム、実験
Keywords: Magma, Plume, Experiment

べっこう飴クラック
Bekko-ame cracking

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Fracturing is essentially a transient phenomenon and also characterized by more or less probabilistic nature. In demonstrations of fracturing phenomena in class rooms and public outreach activities these are difficult constraints and simple and easy-to-use materials are still necessary. This could be a good challenge in “Kitchen Earth Science”. In this presentation we show an example of Bekko-ame thermal cracking as a class-room subject in understanding the nature of fracturing phenomena. This subject has been used in the university lectures for high school/junior high school students over 5 years. The essential advantages of this material is,1) easy to prepare as a kitchen matter, 2) timing of fracturing is predictable, which can be used in a lecture without a fear of failure, 3) total time scale is up to 10 min., which can be easily implemented in the lecture, and 4) easy observability of the phenomenon by using daily-life instruments.Staffs to prepare and necessary equipments:sugar syrup, vinegar, a cooling pan, a thick-walled container such as Sukiyaki nabe, a thin-walled container,the container size should be around 10-15 cm in diameter. IH heater as a heating device, ice, optional equipments:IR thermometer, sound recorder, digital camera or smart phoneExperimental procedure:1) heating sugar syrup to boiling by IH heater to reduce the water content. A tea-spoon vinegar is added at highest temperature. The amount of syrup is prepared so as to be the final thickness of Bekko-ame in the container of about several mm(2- 6 mm). 2) cool down slowly to about 60C. Make sure to confirm the surface completely solidified. Tapping the surface to check elastic sounds.3) put the container in a cooling pan of ice-water.4) watch carefully by eyes and ears. Just concentration under silence.A sudden cooling induces thermal crackings efficiently. The crack morphology is interestingly dependent on type of the container. In the case of thick-walled container shell-like small circular cracks are formed. The average size depends on the thickness of Bekko-ame. Progressive development of circular cracks is observed with light sounds. In the case of thin-walled container, on the other hand linear vertical large cracks are formed with fairly big fracture sounds. The occurrence is controlled by the thickenss, a longer time delay is necessary for a thicker sample.In both cases origin of stress to induce cracking is a subject to consider. The concept of thermal cracking and stress heterogeneity should be consider to modify the crack morphology. In the thick-walled system space-filling process can be explained in relation to site selection rule of the “next” cracking. The sequential photographs by a digital camera/smart phone can help to grasp the development. In the thin-walled system if crack sounds can be recorded by a sound recorder/smart phone wave form give further interesting information such as an interaction to seismology. Comparing a large event and a small event in the amplitude,duration time and even the spectrum could be further interesting. In the presentation we explain the formation process of cracking based on the variation of temperature fields.We recommend this Bekko-ame cracking as a simple experimental subject not only for outreach demonstrations but also the materials in the introductory experimental class at university because there are plenty of rooms of extensions if students get interested.

キーワード：破壊現象、地震発生、モデル実験

Keywords: fracturing phenomena, earthquake generation, demonstration experiment

火山観測機器開発を通じた分野融合教育
Interdisipilinary Education by Development of Instruments for Active Volcano

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【大学院教育】東北大学では大学院教育として「グローバル安全学トップリーダー育成プログラム」を実施している。養成したい人材像は、人文学の素養と明確なビジョンをもち、学術に立脚した確かな知識をもとに自ら考え実行できる能力を有すると共に、我国や世界が直面する、巨大地震や津波などの自然災害あるいは気候変動、エネルギー問題などの多様なリスクの発生メカニズムの理解により、防災・減災などのための工学的・社会科学的システム設計ができる人材、である。
【プログラム】「安全安心を知る」、「安全安心を創る」、「安全安心に生きる」という３つの視点からの「実践的防災学」と「総合科学」にもとづく大学院教育カリキュラムを整備している。単一ディシプリンではなく、実践的防災学講義シリーズを中心としたマルチディシプリナリ講義、プロジェクトベースドラーニング型Convergence Lab.研修による自立的チームワーク学習やグローバルコミュニケーションスキル研修・自主企画研修、その他、国際的通用力を育成する海外研修・国際インターンシップ、企業との共同研究を基盤とするスーパーインターンシップなどである。
【自主企画研修】プロジェクトベースドラーニング型の研修で、マルチディシプリナリからインターディシプリナリへの発展・展開をねらう。複数分野の学生による、自主的な企画・運営を行う。本発表では、火山活動時の観測機器の開発を手がけた、「長期運用可能な無人火山観測装置の開発と噴煙観測システムの提案」をとりあげる。
【長期運用可能な無人火山観測装置の開発と噴煙観測システムの提案】
「火山活動が活発な時期でも、無人で運搬・設置でき、無人で長期間にわたって観測を続けられる簡易的な火山観測装置の開発」と「噴火の際、簡便かつ臨機応変に観測網を展開できる観測装置に実装可能で、小規模な噴火にも対応できる火山活動度推定手法の構築とそれを用いた噴煙観測システムの提案」を目的に、理学、工学分野の学生7名が協同する。
＜装置開発班＞
A:工学研究科 DC1 全体取りまとめ，筐体設計
B:工学研究科 DC2 制御設計
C:工学研究科 DC2 熱設計
D:工学研究科 DC1 Webシステムデザイン
＜情報解析班＞
E:理学研究科 DC2 応用アルゴリズム開発
F:理学研究科 DC2 火山観測応用デザイン
G:理学研究科 DC1 火山観測応用デザイン
装置開発班は前年度開発した独立電源（バッテリー）方式の撮影システムの制御の改善と、積雪や凍結への対策を施した外部電源方式の観測装置の開発を行い、現在、仙台管区気象台の協力を得て、蔵王山地蔵岳にて運用試験を行っている。
「簡便かつ臨機応変に観測網を展開できる観測装置」のコンセプトがあることで、情報解析班は、機材設置条件、使用可能電力量、経費などの制限が、画像の解像度、撮影頻度などに直結することなど、理学分野の学生にとっては、何を優先すべきかの取捨選択を迫られることとなり、工学分野の学生にとっては、取捨選択された優先事項と、機材の制限がどのような条件によるものか、的確説明することを迫られた。

キーワード：分野融合教育、火山観測機器
Keywords: Interdisipilinary Education, Development of Instrument for Volcano

