LECTURE SERIES IN MISASA
"PROPERTIES AND STRUCTURE OF SILICATE MELTS AND GLASSES"
LECTURER: DR. BJORN MYSEN (GEOPHYSICAL LABORATORY, CARNEGIE INSTITUTION OF WASHINGTON)
September 5 (Wed) - 7 (Fri), 2007, at Institute for Study of the Earth's Interior, Okayama University, Misasa, Japan

The lecture series for researchers and advanced students has been planned as part of the COE-21 program at Institute for Study of the Earth's Interior, Okayama University, Misasa. The lecture series is open to people outside of Okayama University, either within Japan or overseas. Accommodation in the Misasa guesthouse will be available at reasonable charges (approx. 1600 yen / night per person). Those who wish to participate this lecture series should contact the coordinator of the lecture series via email (shigeru@misasa,okayama-u.ac.jp) **by July 31**.

An overview of the lecture series

Understanding structure and properties of silicate melts and glasses are as important in earth sciences as in glass and materials science. About 21km^3 silicate melt is extruded on to the Earth's surface every year as extrusive magmatic rocks. This is only a fraction, however, of the actual volume of rising magma serving as the principal medium for heat and matter within the Earth from its beginning some 4.5 billion years ago until today. The societal utility of glass and melts is much younger but no less important. From a feeble beginning as ornamentation some 4,500 years ago, the annual glass production of more than 100 million tons testifies to its importance in the modern industrial world.

Magmatic silicate melts and industrial glasses have many common features, including great compositional diversity requiring experimentation at high temperature wide a wide range of compositional and other variables. There are, nonetheless, also important differences. Understanding magmatic liquids and the magmatic processes requires experimentation not only at high temperature but also at high pressures that are irrelevant to industrial processes. In both cases, however, the methods of investigation are the same and the results obtained in one field are generally of direct relevance to the other.

In this lecture series, much of the experimental and theoretical work that has been made during the last decades will be presented and discussed with particular emphasis on recent advances that result from application of modern spectroscopic and simulation methods. Through these efforts, much understanding of the microscopic nature of melts and glasses has been gained. Such information is employed to characterize macroscopic properties.

The first lecture will focus on the principles governing the structure of silicate glasses and melts. This introduction will be followed by 6 lectures that will address properties and structure of chemically increasingly complex silicate melts and glasses with pure and slightly impure $Si0_2$ as a starting point. Effects of network-modifying cations are examined from the perspective of alkali and alkaline earth silicates. The specific influences of aluminum and iron on the structure and properties as a function of composition, temperature, and pressure.. With water, fluids of the system C-H-O-N-S, the importance of major volatile components in silicate melts also dealt with. Application of these property and structural results to complex systems such as natural melts will be addressed in the final lecture.

Date and time

September 5 (Wed):
10:30 Lecture 1 (Principles)
13:30 Lecture 2 (SiO_2 and SiO_2 with impurities (TiO_2, P_2O_5))
15:30 Lecture 3 (Binary metal oxide-SiO_2 systems)
September 6 (Thu):
10:30 Lecture 4 (Ternary aluminosilicate systems)
13:30 Lecture 5 (Iron-bearing silicate melts and glasses)
15:30 Lecture 6 (Volatiles I - H_2O in silicate melts)
September 7 (Fri):
08:30 Lecture 7 (Volatiles II - C-O-H-N-S volatiles in silicate melts)
10:15 Lecture 8 (Chemically complex natural melts - magmatic liquids)

A brief outline of each lecture

Lecture 1: Principles
1.1 Building blocks, connectivity, polymerization, order and disorder
1.2 Properties and principal structural features
1.3 Premelting, melting phase relations, and thermodynamics of melting
1.4 Glass versus melt - glass transition
Lecture 2: SiO_2 and SiO_2 with impurities (TiO_2, P_2O_5)
2.1 Melting and crystallization behavior
2.2 Thermodynamics of melting
2.3 Transport and thermodynamic properties
2.4 Structure (3-D networks, coexisting structures, temperature and pressure)
Lecture 3: Binary metal oxide-SiO_2 systems
3.1 Melting and crystallization
3.2 Transport and thermodynamic properties
3.3 Structure (Qn-speciation w/composition, temperature, and pressure)
3.4 Qn-speciation and melt property modeling
Lecture 4: Ternary aluminosilicate systems
4.1 Concepts of peralkaline, metaluminous and peraluminous systems
4.2 Metaluminous systems - Melting, transport and thermodynamic properties
4.3 Peralkaline systems - Melting, transport and thermodynamic properties
4.4 Structure - Al^{3+} with and without charge-balance, Al for Si substitution
4.5 Al^{3+} in peralkaline systems, distribution among Qn-species
4.6 Al-distribution, Qn-speciation, temperature, and pressure - structure and properties
Lecture 5: Iron-bearing silicate melts and glasses
5.1 Melting and crystallization
5.2 Redox relations - effects of composition, temperature, and pressure
5.3 Structural behavior of Fe^{2+} and Fe^{3+} in glasses and melts
5.4 Redox equilibria of iron and silicate melt structure
5.5 Structure and properties of iron-bearing silicate melts
Lecture 6: Volatiles I - H_2O in silicate melts
6.1 H_2O and silicate phase relations, transport, and thermodynamic properties
6.2 H_2O solubility in silicate melts - composition, temperature, and pressure
6.3 Structure of hydrous melts: H_2O solution mechanisms; OH groups and molecular H_2O

6.4 Structure of hydrous melts: OH groups and silicate structure
6.5 Structure and properties of hydrous silicate melts
Lecture 7: Volatiles II - C-O-H-N-S volatiles in silicate melts
7.1 Carbon species - CO_2, CO, and CH_4; effect on melt properties and melt structure
7.2 Hydrogen in silicate melts
7.3 Sulfur species - H_2S and SO_2; effect on melt properties and melt structure
7.4 Nitrogen species - N_2, NO, and NH_3; are these all relevant?
Lecture 8: Chemically complex natural melts - magmatic liquids
8.1 Property systematics in simple systems and their applications to natural systems
a Transport and thermodynamic properties
b Crystal-liquid equilibria and thermodynamics of mixing in silicate melts
c Modeling volatiles
8.2 Structure of natural melts
a Systematics of melt polymerization and Qn speciation
b Al^{3+} charge balance in natural melts
c Network-modifier distribution
8.3 What properties can be characterized, what cannot, and why

Contact information

For inquiries concerning the lecture series, please contact
Dr. Shigeru Yamashita, the coordinator of the lecture series
by email (shigeru@misasa.okayama-u.ac.jp).