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Introduction to C. M. Scarfe Memorial: Special Section on Silicate Melts and Mantle Petrogenesis

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In the summer of 1988 it was decided to commemorate Chris's career with a special session at an international meeting and a publication containing contributions volunteered by his former friends and associates. The 1989 Spring Meeting of the American Geophysical Union was chosen for the memorial session and the *Journal of Geophysical Research* was chosen for the publication of contributed scientific papers. This section would not have been possible without the active encouragement, advice, and direction provided by Bob Liebermann. I also extend my thanks to the participants and to the reviewers.

Silicate melts have played a crucial role in the differentiation of the Earth via igneous processes. Thus the study of such melts is as fundamental as mineralogy to the earth sciences. The physical properties of silicate melts provide valuable information for modeling the behavior of silicate magmas during igneous petrogenesis. Transport properties, such as diffusivities and viscosity, are especially important in igneous petrogenesis because of the possibility of kinetic control of many igneous processes at depth within the Earth. In this section, physical properties of silicate melts are investigated in papers by White and Montana; Dickinson, Scarfe, and McMillan; Dunn and Ratliffe; and Webb and Dingwell. White and Montana have determined the effects of H_2O and CO_2 on the viscosity of KAlSi₃O₈ liquid at high pressure and temperature. Dickinson, Scarfe, and McMillan have determined the liquid viscosities and quench glass densities of $K_2Si_4O_9$ subjected to pressures up to 2.4 GPa. Raman spectra on the same glasses are used to infer the effects of pressure on melt speciation. Dunn and Ratliffe have investigated chemical diffusion of ferrous iron in a peraluminous sodium aluminosilicate melt at high temperature and pressures to 1.0 GPa. Webb and Dingwell have investigated the onset of non-Newtonian rheological behavior in geological melts.

A comprehensive understanding of silicate melt properties can only come from a model for the structure of such liquids and glasses. For some time, such a consideration has prompted the investigation of short range order in silicate melt within the geological community. A large number of spectroscopic methods continue to be employed in the characterization of the coordination of the large number of chemical components present in natural melts and their analog systems. In this section, Brearley; Ellison and Hess; Sherriff and Fleet; Mysen; and Sykes and Scarfe investigate melt structure by spectroscopy. Brearley has performed a ⁵⁷Fe Mössbauer investigation of the effect of pressure on the coordination state of ferric iron in highly oxidized melts of

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Paper number 90JB01794. 0148-0227/90/90JB-01794\$02.00 the Na-Fe-Si-O system. Ellison and Hess have obtained perpendicular and parallel-polarized Raman spectra on lanthanide-bearing silicate glasses. Sherriff and Fleet present ²⁹Si, ²⁷Al, and ²³Na MAS NMR spectra for gallium and germanium-substituted silicate glasses. Mysen has studied the Raman spectra of peralkaline alkali aluminosilicate glasses. Sykes and Scarfe present a Raman spectra form glasses on the NaAlSiO₄-CaMgSi₂O₆ join.

The development of multianvil techniques for the generation of high pressures acting on large volumes has opened a new chapter in the experimental investigation of geological materials. Papers by Gasparik; Presnall and Gasparik; Herzberg, Gasparik, and Sawamoto; Canil and Scarfe; Wei, Trønnes, and Scarfe; Pacalo and Gasparik; and Rubie, Tsuchida, Yagi, Utsumi, Kikegawa, Shimomura, and Brearley illustrate the growing body of high-pressure phase equilibrium and kinetic data on silicate systems. The most immediate impact of such studies is constraints on the petrogenesis of the Earth's mantle.

Gasparik has investigated phase relations in the MgO-Al₂O₃-SiO₂ and CaO-Al₂O₃-SiO₂ systems at temperatures up to 2500°C and pressures to 22.6 GPa. Presnall and Gasparik have determined the melting curve of enstatite from 10 to 16.5 GPa and the forsterite-majorite eutectic at 16.5 GPa. Herzberg, Gasparik, and Sawamoto have investigated the melting of komatiite, peridotite, and chondrite compositions from 5 to 16.5 GPa. Canil and Scarfe report phase relations in the peridotite-CO₂ system to 12 GPa. Wei, Trønnes, and Scarfe have investigated the phase relations of aluminum depleted and undepleted komatiites between 4 and 12 GPa.

Rubie, Tsuchida, Yagi, Utsumi, Kikegawa, Shimomura, and Brearley have performed an in situ X ray diffraction study of the kinetics of the Ni_2SiO_4 olivine-spinel transformation. Pacalo and Gasparik have reversed the orthoenstatite-clinoenstatite transition at 7–11 GPa.

The oxidation state of the upper mantle is currently the subject of much discussion. In this section, Wood has experimentally tested a spinel peridotite oxygen barometer based on the Fe_3O_4 content of spinel coexisting with olivine and orthopyroxene.

Ultramafic nodules are the most direct source of petrological, isotopic and geochemical on the upper mantle. In this section, Liang and Elthon present a major and trace element characterization of spinel lherzolite xenoliths from Xalapasco de La Joya, San Lius Potosi, Mexico. Xue, Baadsgaard, Irving, and Scarfe have obtained major, trace, and whole rock Sr and Nd isotopic data for spinel periodotite xenoliths from West Kettle River, British Columbia.

Volcanological studies provide tests of petrogenetic hypotheses and raise questions for further experimental investigations. In this section, Trønnes has presents a geological, petrographic and geochemical synthesis of basalts from the Hengill Volcanic System of SW Iceland. Gunter, Hoinkes, Ogden, and Pajari describe and interprete centimeter-scale intraflow layering of orendite and wyomingite from the Leucite Hills, Wyoming.

Ultimately, the goal of experiments and observations on rocks and synthetic analogs is a synthesis of the petrological, geochemical and geophysical constraints on geologic processes. Two syntheses, by Kushiro on island arc petrogenesis and by Takahashi on Archaean mid-ocean ridges, complete this memorial section. Kushiro presents the results of "sandwich" experiments bearing on the melts produced during partial melting of a hydrous peridotite at pressures of 1.2–2.0 GPa. These results are combined with seismic velocity and crustal xenolith data to yield a synthesis for the evolution of the crust in the NE Honshu arc. Takahashi uses high-pressure peridotite melting data and the geochemistry of depleted garnet peridotites and peridotitic komatiites to generate a speculative model for the nature of mid-oceanic ridges in the Archaean.

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