reasonable agreement with the available microwave observations.

It can be seen on the expanded-scale inset of Fig. 1 that none of the models reproduces the high spectral gradient of the observations in the 5- to 20-cm band. If the observed 5- to 20-cm spectral gradient is accurate, this indicates that a large portion of the lunar regolith is characterized by either larger temperature gradients or longer absorption lengths. The observed spectral gradient between 5 and 20 cm can be matched if either 50 percent higher heat flow, 35 percent lower conductivities, or 50 percent longer electrical absorption lengths are utilized. The possibility of somewhat lower moonwide conductivities and longer absorption lengths seems the most plausible. Both effects could be produced if the regolith material, perhaps in the highland areas, is somewhat less compact than that found at the Apollo 15 and Apollo 17 heat flow sites.

The possibility of significant wavelength-dependent calibration errors in the Russian microwave emission data cannot be discounted. Errors in the observed 5- to 20-cm spectral gradient would lead to comparable errors in estimates of the mean thermal gradient of the lunar near side. A new set of remote measurements in the 5- to 100-cm band, with improved resolution and calibration techniques, is obviously needed. A set of measurements utilizing consistent calibration techniques would be most useful in minimizing wavelength-dependent calibration errors. The possibility of measurements at a few discrete wavelengths between 5 and 20 cm from a lunar orbiter should also be considered. The high accuracy and resolution of such a measurement would permit accurate assessments of the global variation of heat flow, regolith physical properties, and thickness to be made.

For the immediate future, additional electrical property measurements on the available lunar samples at wavelengths between 5 and 50 cm would be valuable for refining the interpretation of the available brightness temperature data.

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The Postspinel Phases in the Mg_2SiO_4-Fe_2SiO_4 System

Abstract. *Samples of olivine (Fo_0Fa_{100}, $Fo_{60}Fa_{40}$, $Fo_{80}Fa_{20}$, and $Fo_{100}Fa_0$) and of spinel ($Fo_{50}Fa_{50}$, Fo_0Fa_{100}, where Fo is forsterite and Fa is fayalite) were subjected to pressures up to 250 kilobars in a diamond anvil press and were heated in situ up to ~ 1700°C by an infrared beam from a continuous-wave YAG (yttrium-aluminum-garnet) laser. The brightness temperature was determined from the intensity of incandescence of the sample by means of an optical pyrometer. X-ray diffraction patterns of the samples, obtained after quenching and unloading, show conclusively that these compositions disproportionate to (Mg,Fe)O and SiO_2 (stishovite) under these conditions.*

Jeffreys (*1*) has reported velocity-depth curves for seismic waves in the earth's interior which show that the velocities of both P and S waves undergo marked increases at depths of from 200 to 900 km in the mantle. Birch (*2*) suggested that this rapid increase in velocities could be attributed to phase transitions in ferromagnesian silicates from their low-pressure modifications in the upper mantle to high-pressure modifications in the lower mantle, probably close-packed oxides.

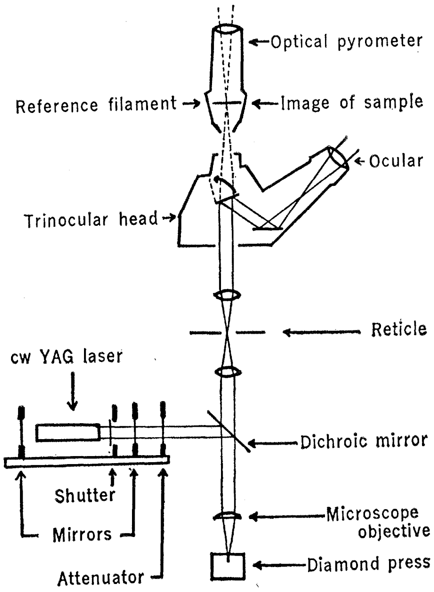

Fig. 1. An optical system for heating a sample under pressure in a diamond anvil press by means of a focused laser beam of a continuous-wave YAG laser. The brightness temperature is measured by an optical pyrometer when a sustained temperature is produced by the YAG laser.

Ringwood (*3*), Sclar and Carrison (*4*), Ringwood and Major (*5*), Akimoto and Fujisawa (*6*), and Kawai *et al.* (*7*) have shown experimentally that olivines [$(Mg,Fe)_2SiO_4$] transform to the spinel structure (γ-phase) in the pressure range from 50 to 150 kbar at 1000°C. In the composition range between $(Mg_{0.8}Fe_{0.2})_2SiO_4$ and Mg_2SiO_4, experimental results show that olivines pass through an intermediate phase, the β-phase, before transforming to the γ-phase (*8*). Shock wave experiments (*9*) have been interpreted by a number of investigators (*10*) as indicating that olivines undergo further transformations to denser phases having densities generally consistent with a mixture of close-packed oxides. Ringwood (*11*) has found that a number of olivine and spinel analogs undergo phase transformations to a variety of structures including the following: strontium plumbate, the K_2NiF_4 structure, rock salt plus ilmenite structures, rock salt plus perovskite structures, rock salt plus corundum structures, and rock salt plus rutile structures as first suggested by Birch (*2*).

Bassett and Takahashi (*12*) observed the disproportionation of Fe_2SiO_4 (spinel) to FeO plus SiO_2 (stishovite) by heating a sample that was under a pressure of approximately 250 kbar in a diamond anvil cell with a light beam from a pulsed ruby laser. Mao and Bell

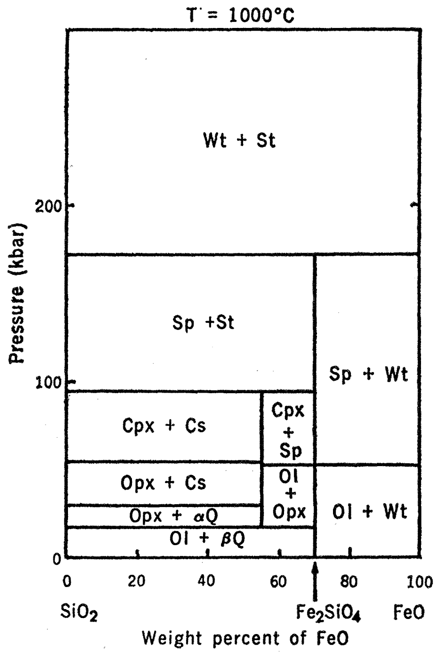

Fig. 2. A proposed pressure-composition phase diagram for the FeO-SiO_2 system: *Ol*, olivine; *Sp*, spinel; *Cpx*, clinoferrosilite; *Opx*, orthoferrosilite; *Cs*, coesite; *St*, stishovite; *αQ*, low quartz; *βQ*, high quartz; *Wt*, wustite.

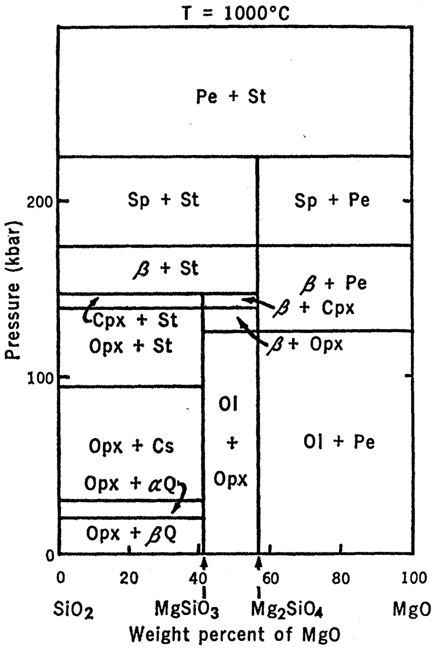

Fig. 3. A proposed pressure-composition phase diagram for the MgO-SiO_2 system: *Ol*, olivine; *β*, *β*-phase; *Sp*, spinel; *Cpx*, clinoenstatite; *Opx*, orthoenstatite; *Cs*, coesite; *St*, stishovite; *αQ*, low quartz; *βQ*, high quartz; *Pe*, periclase.

(*13*) and Bassett and Ming (*14*) also observed the disproportionation of Fe_2SiO_4 (both the spinel phase and the olivine phase) in the diamond anvil cell by means of static resistance heating at temperatures between 750° and 850°C.

Mao and Bell analyzed their quenched sample by both x-ray diffraction and electron microprobe techniques, whereas Bassett and Ming used x-ray diffraction only. Kumazawa *et al.* (*15*) reported the decomposition of pure forsterite (Mg_2SiO_4) to periclase (MgO) and stishovite at 330 kbar and 1000°C in a multiple-anvil sliding system. The purpose of the present investigation was to study the post-spinel phases of the whole range of compositions of olivine.

In the work reported here, samples were subjected to pressure in a diamond anvil cell according to the following procedure (*16*): A polycrystalline sample is compressed between two flat parallel faces of single-crystal brilliant cut diamonds which are driven together by a mechanical screw. A beam of infrared light having a wavelength of 1.06 μm is introduced through one of the diamonds and focused onto the sample while it is under pressure (Fig. 1). The beam of infrared light is produced by a continuous neodymium-doped YAG (yttrium-aluminum-garnet) laser capable of emitting coherent light of 60 watts in multimode operation and 6 watts in single-mode operation. The more iron-rich samples are sufficiently absorbing so that they efficiently convert the electromagnetic radiation to heat. For the less absorbing magnesium-rich samples, approximately 1 percent graphite must be mixed with the sample to produce the level of absorption necessary for heating.

The brightness temperature of the sample is measured by means of an optical pyrometer placed above the third tube of a trinocular head as shown in Fig. 1. The brightness temperatures of the samples have been measured with a precision of ± 50°C, but, since the emissivities of the samples are very poorly known at present, we can only estimate that the true temperatures lie between 100° and 200°C higher than the brightness temperatures. The brightness temperatures in the samples studied range from 1300° to 1500°C. Therefore, all measurements were made at temperatures high enough to overcome kinetic barriers but well below the melting temperatures of the samples at those pressures. We measured the pressure by calibrating the diamond press, using the NaCl scale reported by Weaver *et al.* (*17*). The assumption that the pressure is unaffected by temperature was necessarily made.

During the heating of a sample at high pressure, visual changes can be observed by means of a microscope. When phase boundaries have stabilized and the transitions appear to have gone to completion, the sample is cooled and then unloaded from the press. It is then transferred to an x-ray powder diffraction camera for analysis as described by Bassett and Ming (*14*).

All of the x-ray diffraction patterns of the various compositions of olivine (Fo_0Fa_{100}, $Fo_{60}Fa_{40}$, $Fo_{80}Fa_{20}$, and $Fo_{100}Fa_0$) and of spinel (Fo_0Fa_{100}, $Fo_{50}Fa_{50}$, where Fo is forsterite and Fa is fayalite) subjected to laser heating in the diamond anvil cell reveal the presence of the separate close-packed oxides of iron, magnesium, and silicon. The iron-magnesium oxides appear as a solid solution MgO-FeO (magnesiowustite), and the SiO_2 is in the form of stishovite which has the rutile structure. The transition pressure for decomposing Fe_2SiO_4 at a brightness temperature of 1400° ± 50°C (~1600° ± 100°C, real temperature) is 160 ± 10 kbar, as determined by the lattice parameter of internal NaCl mixed with the sample. For other compositions, transition pressures at a brightness temperature of 1400° ± 50°C are estimated to be about 175 and 190 kbar for $(Fe_{0.4}Mg_{0.6})_2SiO_4$ and $(Fe_{0.2}Mg_{0.8})_2SiO_4$, respectively, based on the calibration of the diamond anvil press with the use of the NaCl scale of Weaver *et al.* (*17*). Univariant boundaries in the reactions of Fe_2SiO_4 (spinel) $\rightarrow$ $2FeO$ (wustite) + SiO_2 (stishovite) have been calculated as

$$P = 198 - 0.022T$$

where P is the pressure in kilobars and T is the temperature in degrees Celcius. The transition pressure at 1600° ± 100°C for this reaction is then 163 ± 2 kbar. The agreement between the experimental result and the thermodynamic calculation is thus excellent. But transition pressures in other compositions ($Fo_{80}Fa_{20}$ and $Fo_{60}Fa_{40}$) are somewhat lower, probably because of errors made in the calibration of the diamond anvil press.

Ringwood and Major (*18*) showed experimentally that $FeSiO_3$ (ferrosilite) decomposes to form Fe_2SiO_4 (spinel) plus SiO_2 (stishovite) at 95 kbar and 1000°C. The decomposition of $(Fe,Mg)SiO_3$ (clinopyroxene) into $(Fe,Mg)_2SiO_4$ (spinel) plus SiO_2 (stishovite) has been demonstrated in the pressure range 80 to 180 kbar at 1000°C by Ringwood and Major (*19*) and at 800°C by Akimoto and Syono (*20*). Ito *et al.* (*21*) also reported that $MgSiO_3$ (clinoenstatite) decomposes to Mg_2SiO_4 (β-phase) plus SiO_2 (stishovite) at a pressure between 200 and 280 kbar at 1000°C and that β-Mg_2SiO_4 transforms into γ-Mg_2SiO_4 (spinel) at higher pressure. This last pressure reported by Ito *et al.* (*21*) seems to be overestimated. A pressure of 150 kbar is much more consistent with the other studies made on the phases in the MgO-SiO_2 system (*22*). Although recent studies (*19-21*) do not support the claim by Sclar *et al.* (*23*) that $MgSiO_3$ (clinoenstatite) decomposes to forsterite plus stishovite, they do confirm their conclusion that $MgSiO_3$ decomposes to Mg_2SiO_4 plus SiO_2. Sclar *et al.* (*23*) estimated the pressure for this transformation to be 125 kbar. With subsequent revision of the fixed point pressure scale, this value should perhaps be lowered 15 percent. This is generally consistent with our conclusion that Ito *et al.* (*21*) have overestimated the pressure. In any case, all of these results indicate that $(Mg,Fe)SiO_3$ decomposes to $(Mg,Fe)_2SiO_4$ plus SiO_2 under pressure at 1000°C.

On the basis of the experimental work on the olivines and pyroxenes described above and of work described elsewhere (*24*), pressure-composition phase diagrams for the FeO-SiO_2 and MgO-SiO_2 systems are proposed in Figs. 2 and 3, showing that separate oxides of $(Fe,Mg)O$ and SiO_2 (stishovite) are the stable phases in the system of FeO-MgO-SiO_2 under high pressure (>250 kbar) and high temperature (>1000°C). We believe that the mineralogy of the earth's mantle below 650 km consists mainly of magnesiowustite [$(Mg,Fe)O$] and stishovite.

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Deficient Ganglioside Biosynthesis: A Novel Human Sphingolipidosis

Abstract. *An unusual lipid storage disease is characterized by the accumulation of hematoside (G_{M3}) in the patient's liver and brain. In contrast to the other sphingolipidoses, the accumulation of G_{M3} is not the result of a defective catabolic reaction, but is the first disorder caused by a deficiency in ganglioside biosynthesis to be described in man.*

A group of clinically distinct disorders characterized by the accumulation of glycosphingolipids in various tissues have been described chemically and enzymatically (*1*). Several of these disorders (*2*) involve the accumulation of gangliosides G_{M1} and G_{M2} (*3*), and such storage has been shown to be due to defects in the catabolism of these compounds (*4*). Recently, it has been possible to document for the first time the accumulation of G_{M3} and the virtual absence of higher ganglioside homologs in the brain and liver of a patient with a presumed sphingolipidosis (*5*). We report here that the patient's G_{M3} (hematoside) accumulation was not due to the defective catabolic reaction

$$G_{M3} + H_2O \rightarrow CDH + NAN$$

but was the result of a deficient ganglioside biosynthetic enzyme, UDP-GalNAc : G_{M3} *N*-acetylgalactosaminyltransferase (*6*) which catalyzes the following reaction:

$$G_{M3} + \text{UDP-GalNAc} \rightarrow G_{M2} + \text{UDP}$$

This is the first description of a defect in ganglioside biosynthesis in humans.

The clinical and pathological aspects of this patient's disease have been described (*7*). When first seen at the University of Maryland Hospital, this 1-month-old male had poor physical and motor development and frequent seizures. The first child of young, unrelated, Jewish parents (mother 22 and father 25 years of age), he weighed 3.5 kg at birth after a 36-week gestation. He was limp and unresponsive, with coarse facies, macroglossia, gingival hypertrophy, squat hands and feet, flexor contractures of the fingers, thickened, loose hirsute skin, large inguinal hernia, hepatosplenomegaly, and normal fundi. Death at 3½ months followed a series of bronchopneumonic episodes. A maternal uncle had a similar disorder and died at 2½ months of age. These features suggested G_{M1} gangliosidosis, which was ruled out by the finding of normal β-galactosidase activity in leukocytes and in a liver biopsy. The activities of acid phosphatase, β-glucosidase, β-*N*-acetylhexosaminidase, α-fucosidase, α-mannosidase, and arylsulfatase A were normal. The diagnosis of G_{M3} gangliosidosis was established by an accumulation of G_{M3} (and G_{D3}) in postmortem samples of brain and liver, which was demonstrated by thin-layer chromatographic analysis. The content of G_{M3} and G_{D3} in the patient's brain tissue was 1.6 and 0.8 nmole per milligram of protein compared to values of 0.46 and 0.34 nmole per milligram of