# MELTING OF IRON SULFIDE AND IRON OXIDE AT HIGH PRESSURE

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Of the candidates for the primary light alloying element in the cores of the terrestrial planets, sulfur and oxygen are generally considered most reasonable. Until recently, little experimental data an the melting characteristics of FeO and FeS has existed. This paper compiles existing data for FeS to produce a melting curve for that compound. Also the first shock recovery data for porous samples of FeO which have been shock melted are presented.

The melting data for FeS come from static experiments [1,2] and reevaluated results from shock wave experiments [3,4] on pyrrhotite ($Fe_{1-x}S$). The approach to development of the melting curve was to first develop a curve for $Fe_{.87}S$ above 5.5 GPa, as this was the composition of material used in most of the experiments quoted, and then to correct that curve for the effect of nonstoichiometry. The composition correction is assumed to be proportional to the melting temperature [5], and the proportionality is assumed to be the same as for 1 bar [6]. Uncertainties introduced by using the 1 bar correction are probably about 4% of the melting temperature.

Questions have been raised as to whether FeS is stable at high pressures [7], but decomposition is not observed under static compression to 40 GPa [8]. A more difficult question arises as to the electronic behavior of S, which metallizes at 40 GPa [9,10]. Associated changes in bonding could affect the melting behavior, but there is no evidence in the existing data that this is the case.

The static melting data are used as is, except for correction for the composition of a point determined at 6.4 GPa [1]. Shock recovery results for porous $Fe_{.87}S$ [4] were reevaluated and found to indicate less melting at high pressure that previously thought, with the result that the temperature estimate for melting has increased. Hugoniot data obtained with crystal density $Fe_{.87}S$ [3] show characteristics which have been interpreted as melting between 120 GPa and 150 GPa. The data show some characteristics above 95 GPa which may be due to partial melting. Thus, a Hugoniot temperature estimate for the hpp at 95 GPa is used as a lower bound for melting at 95 GPa and, similarly, the Hugoniot temperature (corrected for estimated heat of fusion) at 150 GPa is used as an upper bound.

Table 1 gives the melting data for the $Fe_{.87}S$ high pressure phase. The data are fit very well by a Lindemann's Law extrapolation from the 6.4 GPa point (Fig. 1). The fit is good enough to allow extrapolation to higher pressures, with the resulting curve being presented in Fig. 2. The composition correction for to FeS is very small (~100 K at 330 GPa), so the curve presented is a good representation of the FeS melting curve. Also noted in Fig. 1 are the pressures at the core-mantle boundary (CMB) and inner core boundary (ICB) of the earth, and the center of Mars (MARS).

Published data for the melting of FeO extend to 3 GPa [11]. These are plotted in Fig. 2. Five shock recovery experiments have been performed on FeO samples with porosities near 35% (Table 2). The pressure range of the experiments is from 5 GPa to 20 GPa. Samples shocked to pressures above about 10 GPa were found to have experienced some degree of melting, with the highest pressure experiment yielding melting not only in the sample, but also in the steel container which held the sample during the experiment. From this observation, and the isentrope of steel, a minimum shock temperature of 2100 K at 20 GPa was estimated.

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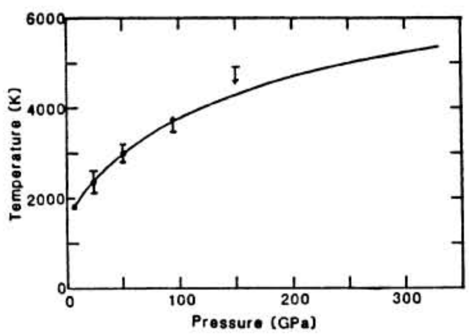


Fig. 1 - Melting Curve of $Fe_{.87}S$, plotted with the constraining data.

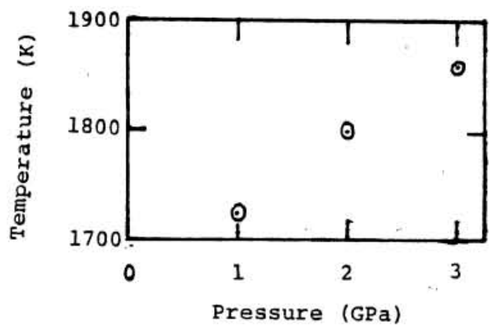


Fig. 2 - Melting data for FeO [11].

Table 1. Experimental data on melting of $Fe_{.87}S$.

| P (GPa) | T (K) | Ref. |
|---|---|---|
| 6.4±.3 | 1812±30 | 1 |
| 24±1 | 2370±250 | 4 |
| 50 | 3000±200 | 2 |
| 95 | >3490 | 3 |
| 150 | <4920 | 3 |

Table 2. Shock recovery experiments on 35% porous FeO.

| Impact velocity (km/s) | P (GPa) | Melting | Estimated T (K) |
|---|---|---|---|
| .88±.01 | 5.9±.1 | No | |
| 1.01±.01 | 7.3±.1 | No | |
| 1.3±.1 | 10.8±1.2 | Yes | 1880 |
| 1.71±.03 | 17.0±.45 | Yes | 1930 |
| 1.87±.01 | 20.0±.2 | Yes | 2150 |