PHASE DIAGRAM AND MELTING CURVE RESULTS OF IRON AND IRON-NICKEL ALLOY OF SHOCK-WAVE AND STATIC MEASUREMENTS IN THE EARTH'S CORE STATES

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Previous shock-wave measurement results of compressibility, sound speed and temperatures on adiabats of impact compression of iron and iron-nickel alloys in the range of pressure from 140 up to 350 GPa were used for calculations of distribution of density and temperature in the Earth's core and examinations of the appropriate model submissions. One of main directions here consists in determination of a melting curve of iron and temperature of outer liquid and inner solid core boundary, atpressure 330 GPa. The Earth's core consitsts mainly of iron, but there are nickel and light elements in outer core, that may be decreased melting temperature in this range states.

In the last years in connection with significant static technical measurement developments of diamond anvil cell with laser heating of sample was essentially extended pressure range (up to 200 GPa) and temperatures in the range of melting curve for iron that allowing to define the phase diagrams and to extrapolate this data to condition, achieved by shock compression.

Despite some inside disagreement of experimental data sets of static and shock-wave measurements, there is the essential divergence between these results, apparently, lying outside of observed errors of both sets of experiments, that caused to a various position of determined by these methods melting curve on the phase diagram and accordingly to various temperature estimates of internal region of the Earth [1]. So, on measurements of sound speed on shock adiabat [2] the melting on it answers pressure P = 240 GPa and temperature T = 5700 K, but interception of static melting curve [3] with shock adiabat - P = 155 GPa and T = 3600 K. The shock-wave dates of iron-nickel alloy will be agreeed with the similar data of iron, as a whole, allowed to expand the compare analysis of experimental data sets with results of static measurements. Some distinction of shock compression dates at larger pressure for the γ-phase alloy and iron is connected to $\alpha \rightarrow \varepsilon$ phase transition in it at pressure 13 GPa.

For consideration of the formed contradictions of these data sets we carried out some additional exsperiment determination of parameters of shock compression of iron and iron-nickel alloy (stainless steel) corresponding to a melting at normal pressure for want of expansion after shock compression [4]. The used method is based on establishment of attributes of a melting in the subjected to loading samples. The results of determination of shock-wave pressure are 140 and 175 GPa. Such data adequate the lower boundary of melting curve, can be used for reliable estimate of temperature relation on isentope by results of shock-wave experiment [5], and also for examination of adequacy of calculations on the equations of states of the phase diagram and melting curve. At the same time, receiving large reliability of static measurement results at initial pressure, these data allow also to extrapolate a melting curve to higher pressure.

For the initial point of these estimates of the curve melting of iron and alloy [6] is accepted triple point of interception of γ-ε phase boundary and melting curve of iron, determined on more accurate static measurements [3] at P = 60 GPa, T = 2800 K. This point answers also the data of static measurements of melting curve [7] and extrapolated γ-ε phase boundary [8] of iron-nickel alloy.

Using these data in γ-phase range of iron and alloy, also the appropriate isothermal compressibility data and Lindemann low of melting curve, were determined Gruneisen ratio from density, and on them isentope position, corresponding melting at normal pressure. Incidentally was taken into account discontinuty isentrope on phase boundary in γ-phase range.

Thus the isentrope states in the ε-phase range becomes known in two points - on γ-ε phase boundary and on the shock adiabat. Both points correspond rather small density change from 9.5 up to 11.5 g cm^{-3}. Assuming, as well as earlier for γ-phase range, that the Gruneisen ratio is back proportional to density, it was determined, using Lindemann low melting curves are received. In the range of pressure ~ 150 GPa the melting curve of iron-nickel alloy has appeared below (~100 K) by the appropriate curve for iron.

The melting curves for both materials, received under the isentrope expansions data, passing through the common triple point, have appeared are enough close to the data of melting curve of iron [3], though a little bit above it at P = 150 GPa, on 100-200 K. Received results for iron and alloy answer lower values of melting curve temperatures and do not eliminate the indicated contradiction between groups of static and dynamic measurements, though the appeared recently results [9, 10] a few pull together these data.

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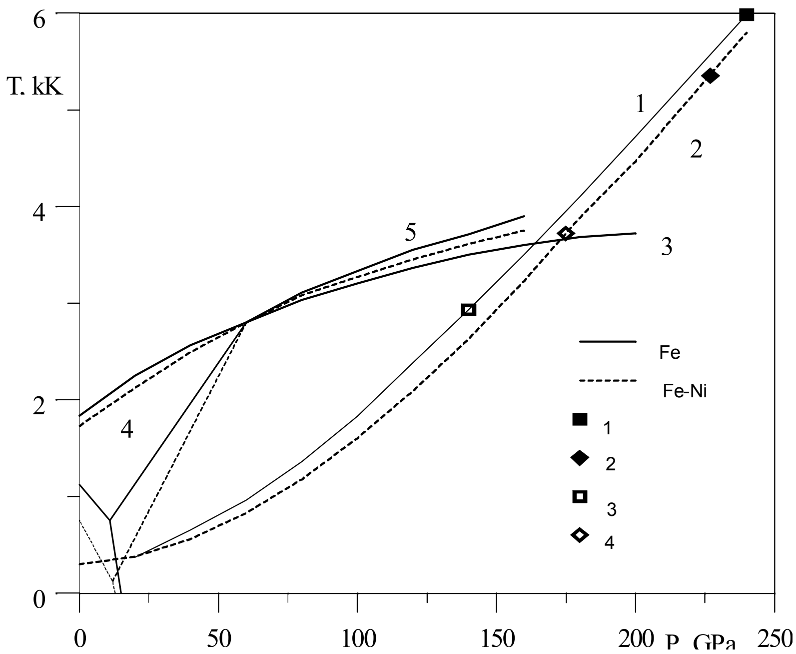

Fig. 1. Shock adiabates (1, 2), melting curves (3 [3], 4 [7] and 5 - present work) and phase boundares for iron and iron-nickel alloy; shock-wave measurements for the melting (1, 2) and isentope (3, 4)