N 67-86524

Lunar Rocks as a Source of Oxygen

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A thermodynamic study of the thermal stability of conventional terrestrial minerals in a hypothetical lunar atmosphere has opened some interesting speculation.

Much of the Earth's crust is composed of oxides of silicon, aluminum, magnesium, and related compounds. These crust components may be as much a product of the Earth's atmosphere as vegetation and animal life. Though inanimate and long considered imperishable, these materials are stable under conditions of an atmosphere equivalent to 34 ft of water at sea level and persist under adverse conditions of moisture and temperature to altitudes of roughly 29,000 ft above sea level. The oxygen content averages 21%, and the oxygen partial pressure would be roughly 1/5 atm.

The question is posed as to the behavior of these minerals under varying temperatures and at 10^{-13} atm. A profusion of data on the thermal dissociation of many metal oxides and other compounds exists in the literature. These data have been concerned mainly with extrapolated free-energy–temperature diagrams based on formations from the elements.

In recent years, accumulated data on high-temperature stable suboxides, which often exist only in the gaseous phase, have been presented in the literature, with free-energy values based on spectroscopic measurements and calculation. These products, which are more familiar to technical personnel concerned with high-temperature vacuum installations, serve in effect to lower the dissociation temperature of many materials, as for example, quartz:

$$SiO_2 \rightarrow Si + O_2$$

$$SiO_2 \rightarrow SiO + \tfrac{1}{2} O_2$$

With the first dissociation, 1 atm of oxygen would be obtained at temperatures above 3900°K. The latter reaction provides 1 atm of oxygen at roughly 3100°K, about five times the oxygen pressure in the Earth's atmosphere. Under conditions of vacuum of upwards of 10^{-13} atm, quartz could dissociate at temperatures as low as 1000°K.

The first question becomes: What happens to quartz or other silicates exposed to high vacuums and moderate temperatures over geologic periods of time?

One answer would expect the lunar crust to be deprived of silica and silicates and be composed of spinels and other alumina-bearing materials. Magnesia could also be lost. This crust could be superficial and not persist to any great depth.

The second question might be of critical significance. If quartz persists at moderate depths, can it be mined, introduced into solar furnaces, gases compressed, and used as a source of oxygen to support life in the lunar environment?

Again, one answer would be a qualified yes, without consideration of the competitive cost of shipping liquid oxygen around the universe in tank cars. Other oxides might be added to silica as potential oxygen source material.

The real question still to be answered would be related to the Moon's origin. Are the Earth's crust minerals a product of the atmosphere and is the Moon a fragment of the Earth?

If the Moon was once part of the Earth, perhaps the odds in favor of oxygen mines on the Moon would be improved.

Perhaps the metallic meteorites are in a more stable form for high-vacuum space travel and the silicate forms are created during atmosphere traverse.

Figs. 1–7 illustrate the behaviors and properties of various compounds and present other information pertinent to answering the question asked by the title of this paper.

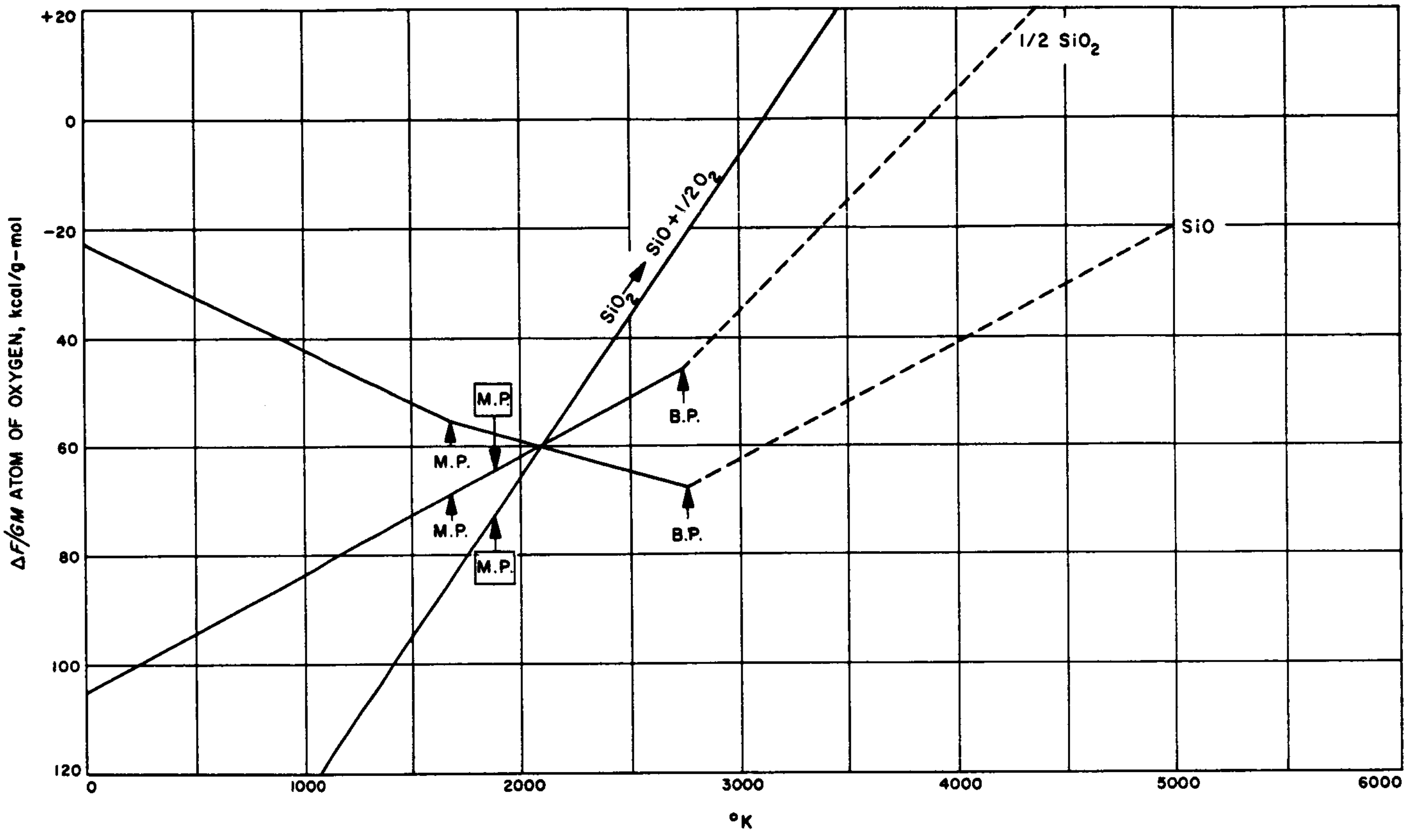

Fig. 1. Thermal stability of silicon oxides

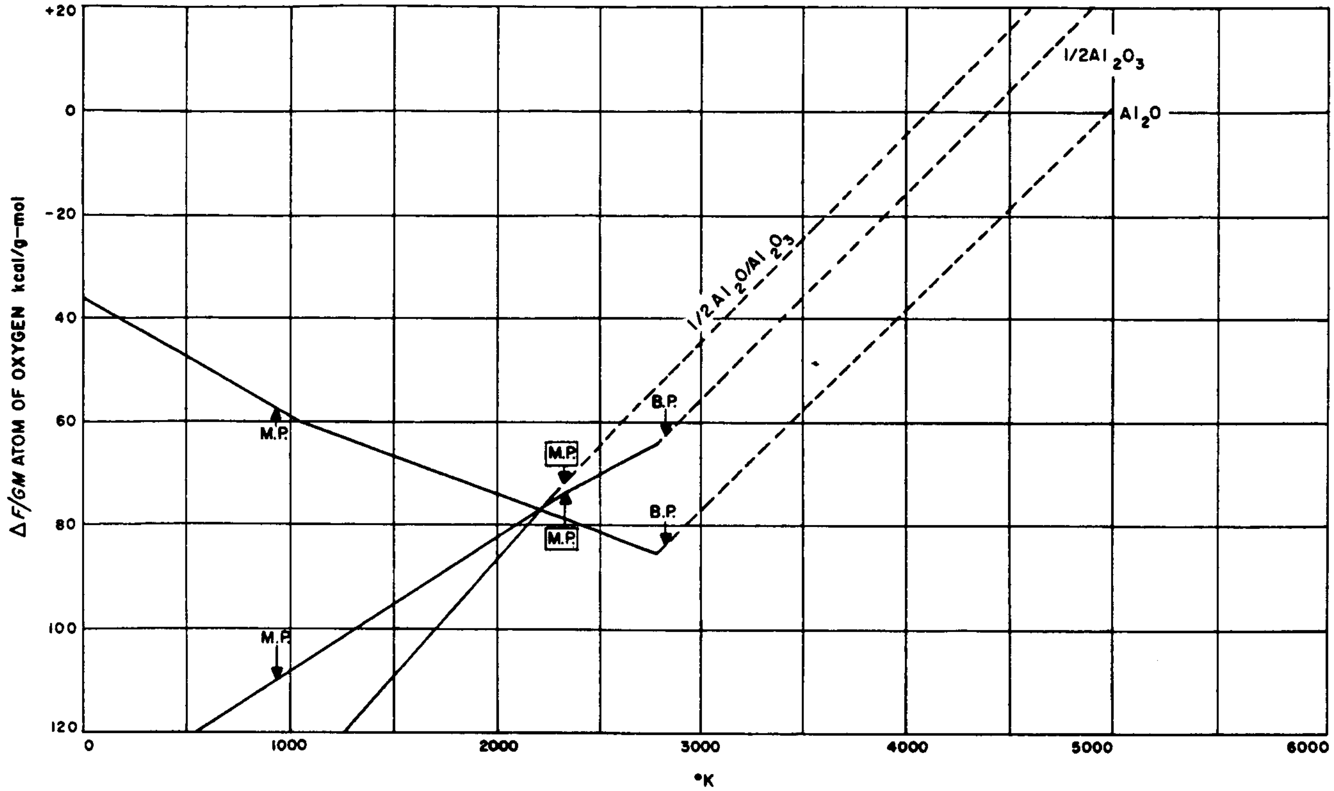

Fig. 2. Thermal stability of aluminum oxides

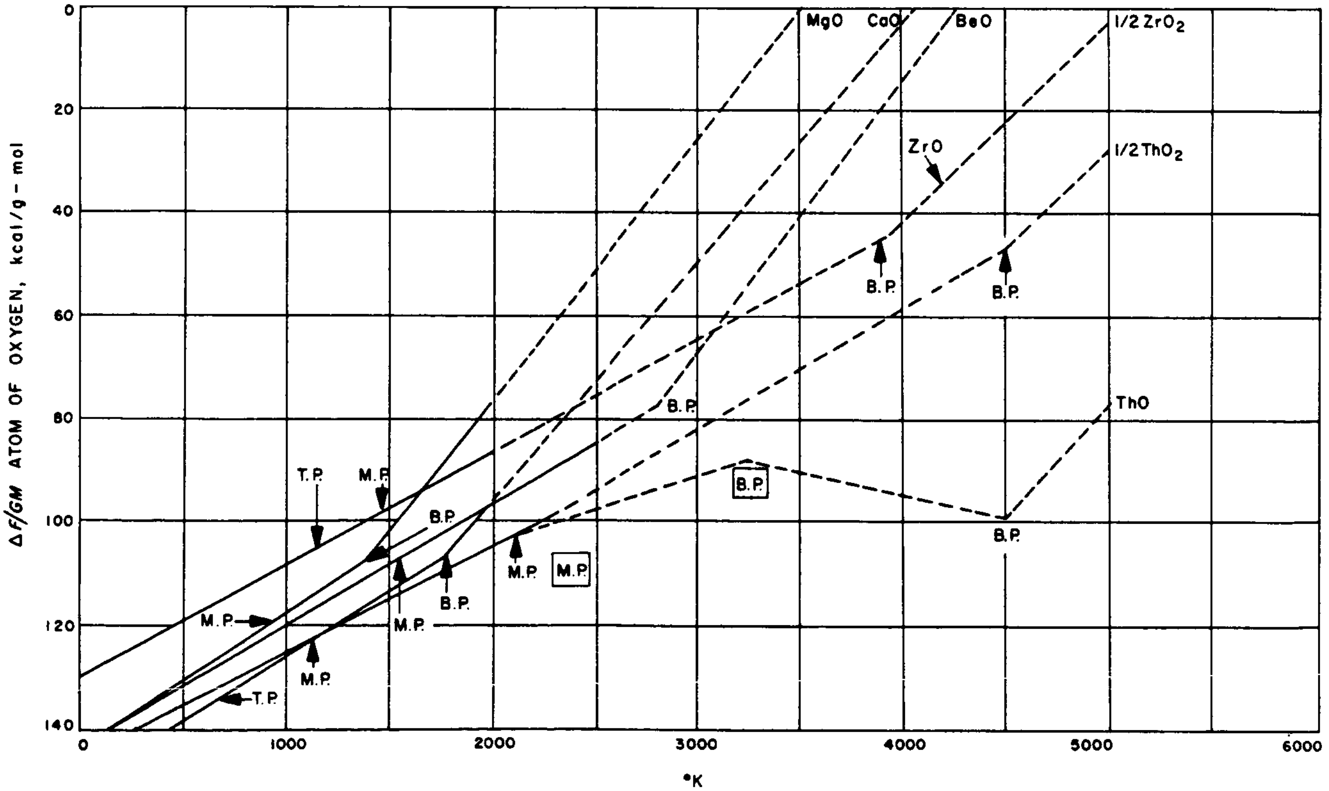

Fig. 3. Thermal stability of refractory oxides

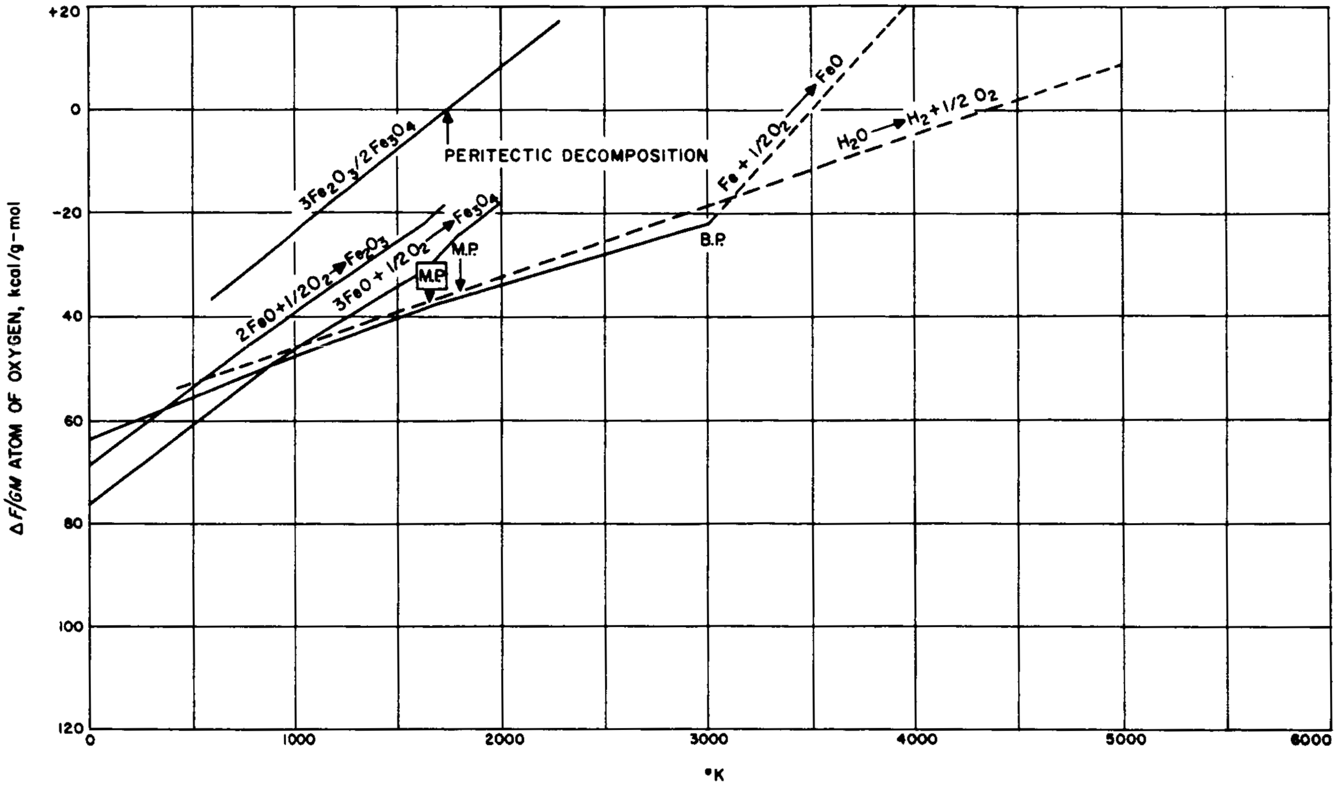

Fig. 4. Thermal stability of iron oxides

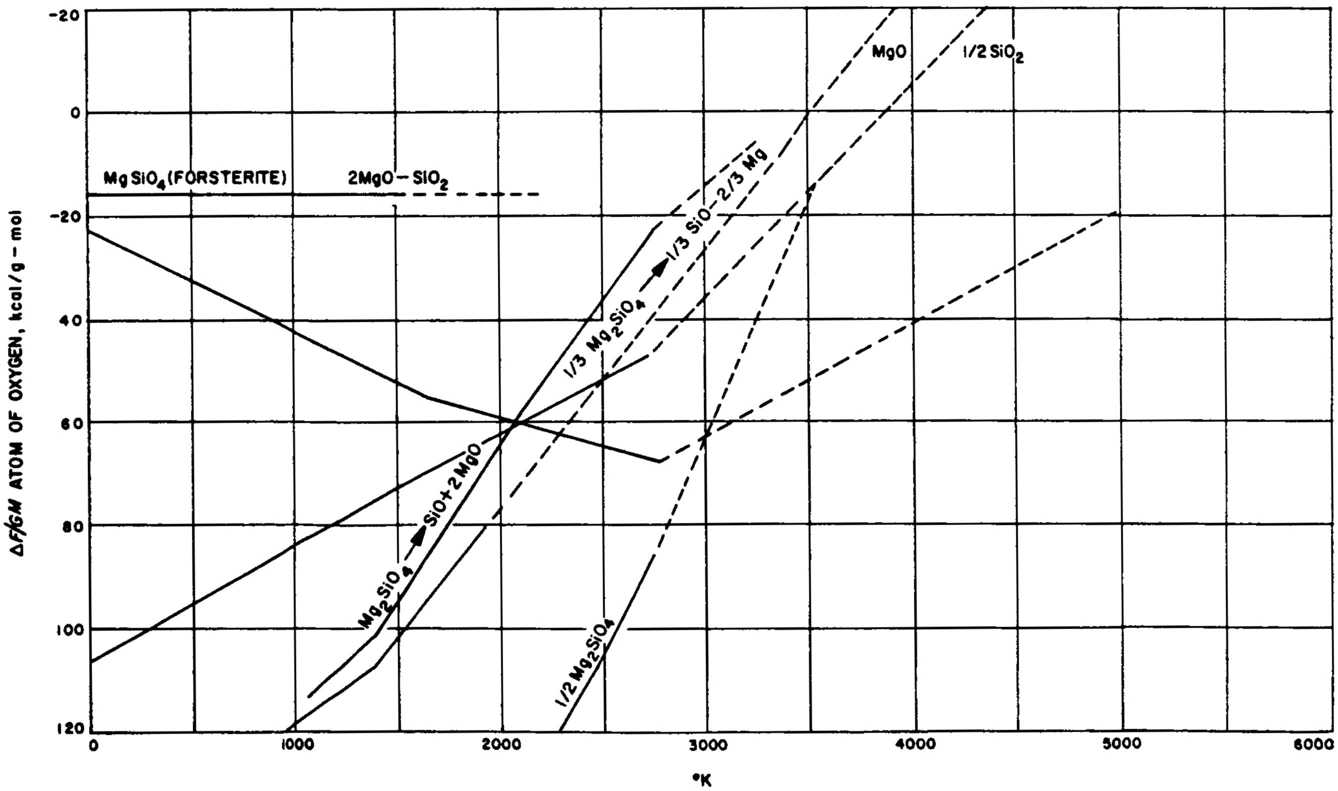

Fig. 5. Thermal stability of forsterite

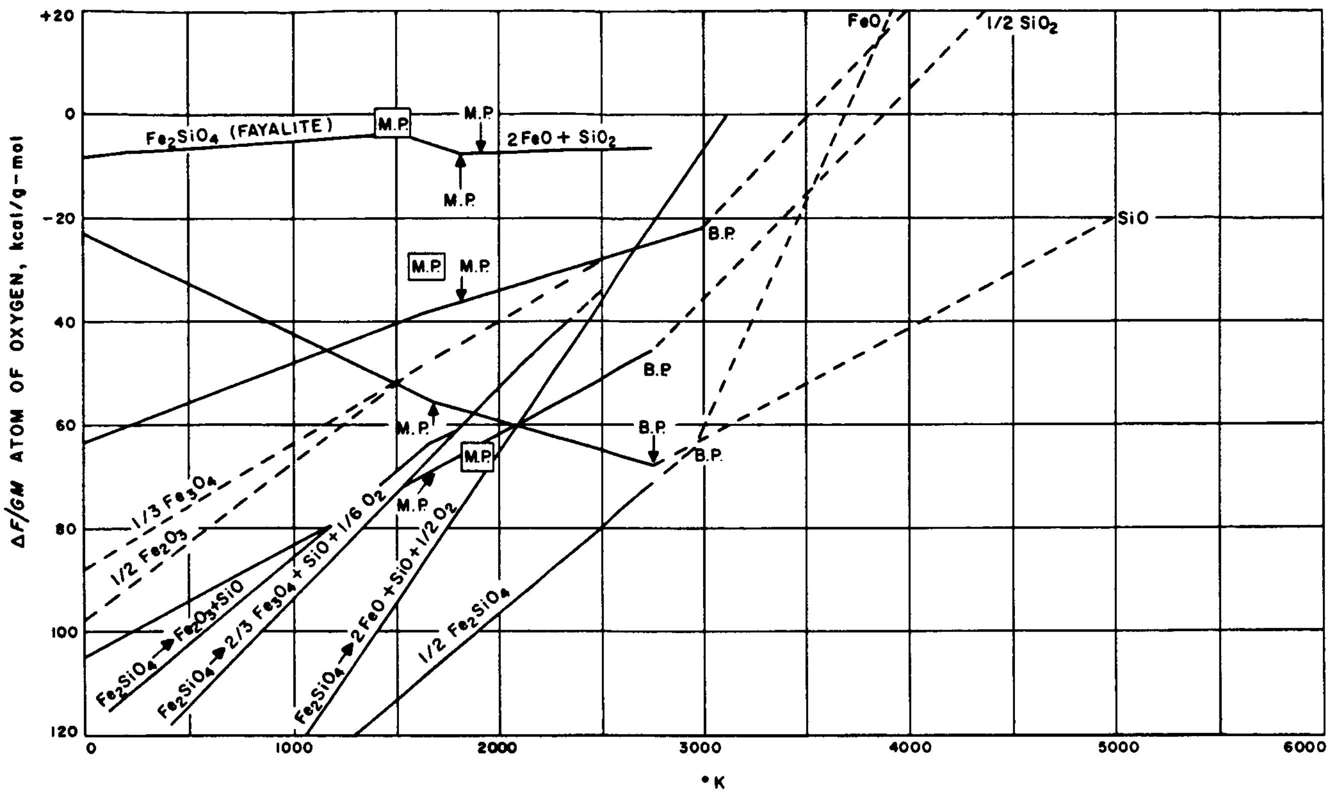

Fig. 6. Thermal stability of fayalite

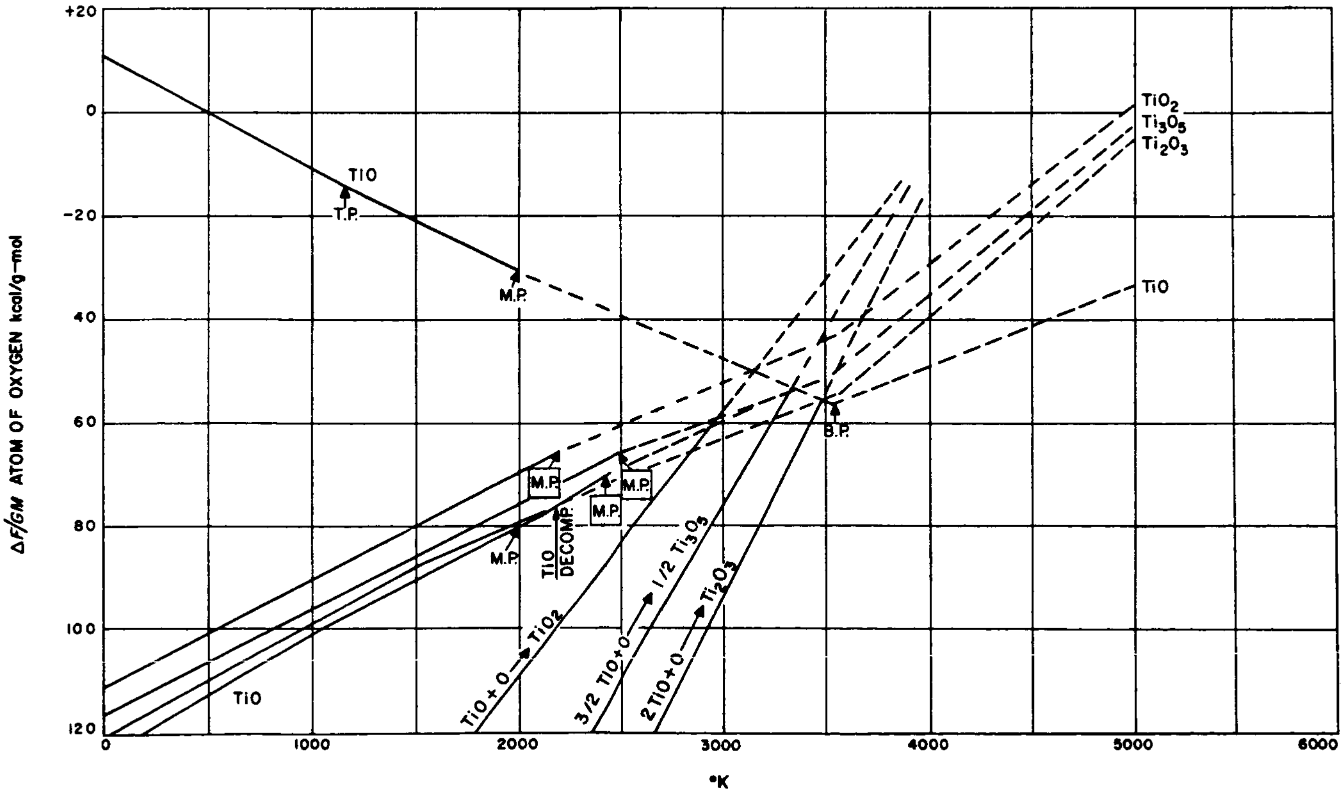

Fig. 7. Thermal stability of titanium oxides