Oxygen Fugacity in the Laboratory and in Terrestrial Systems

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REDOX - BUFFERS

- $2\,Ni + O_2 = 2\,NiO$ NNO
- $4\,Fe_3O_4 + O_2 = 6\,Fe_2O_3$ MH
- $3\,Fe_2SiO_4 + O_2 = 2\,Fe_3O_4 + 3\,SiO_2$ FMQ
- $6\,FeO + O_2 = 2\,Fe_3O_4$ WM
- $2\,Fe + O_2 = 2\,FeO$ IW
- $2\,Fe + SiO_2 + O_2 = Fe_2SiO_4$ IQF

After H. Eugster et al. (1957)

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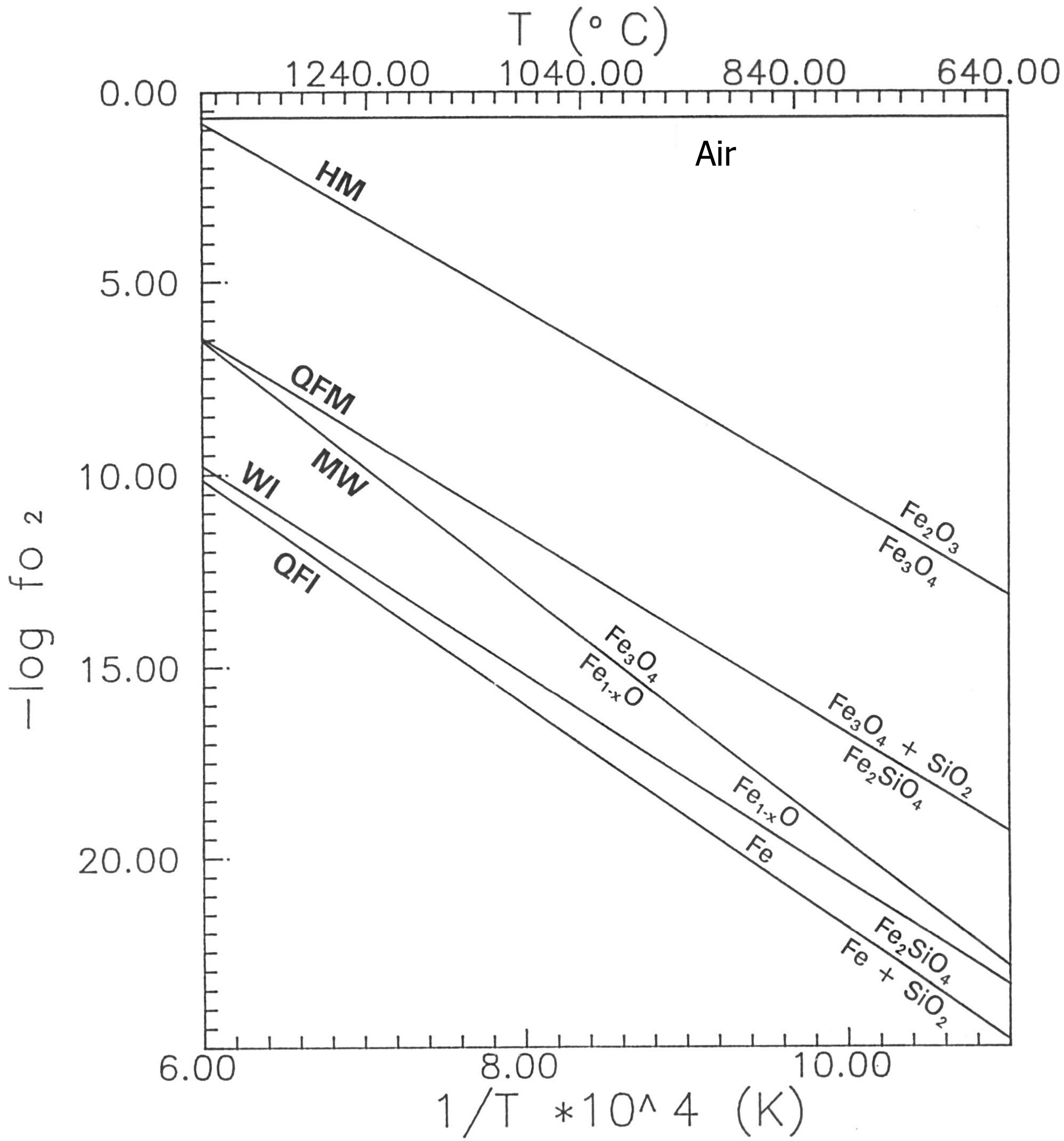
Explanation of the buffer acronyms

- NNO: Nickel-Nickel Oxide
- MH : Magnetite-Hematite
- FMQ: Fayalite-Magnetite-Quarz
- WM : Wüstite-Magnetite
- IM : Iron-Magnetite
- IQF : Iron-Quarz-Fayalite



Oxygen fugacities of the various buffers at 1 bar total pressure (after H. Eugster)

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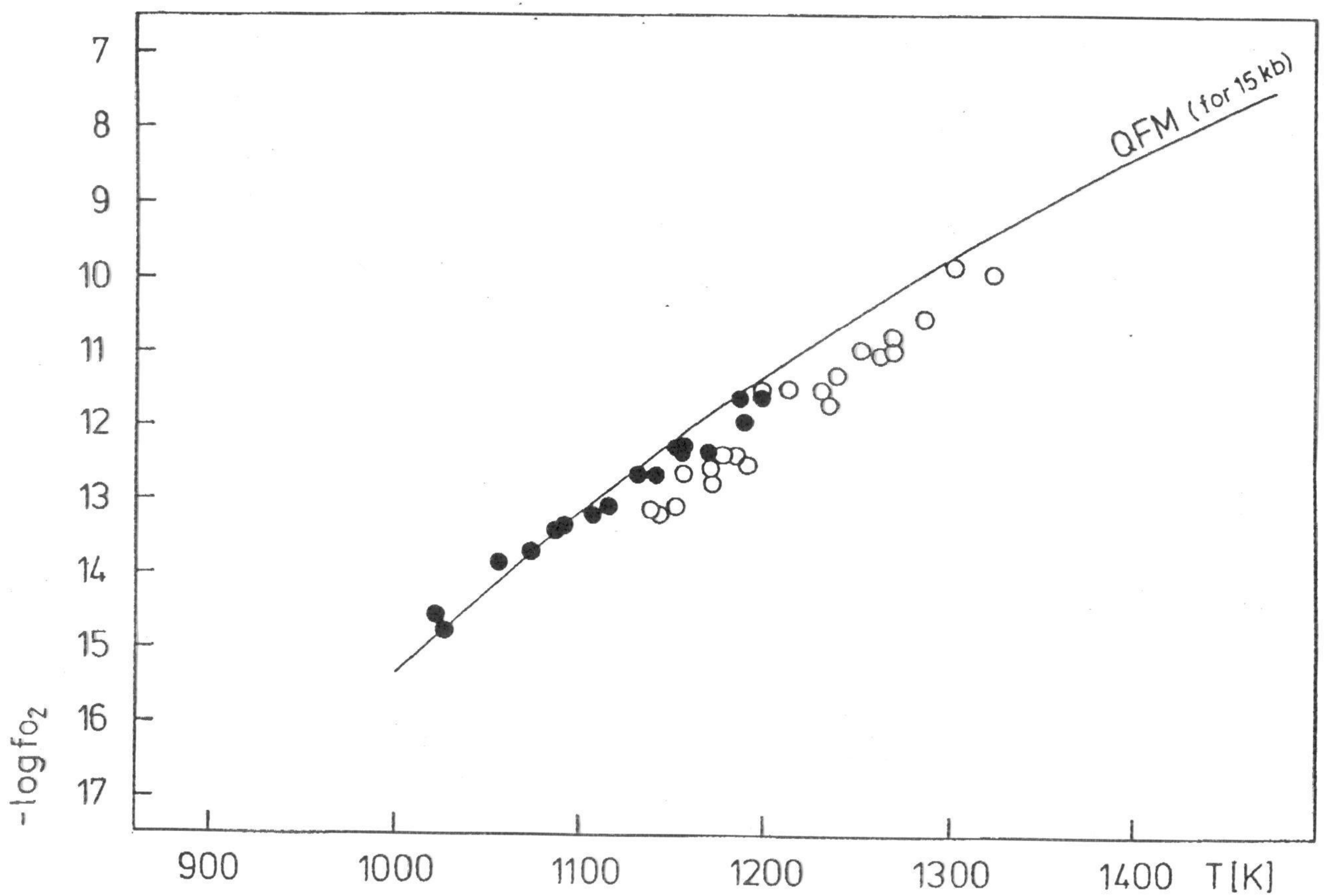
Experimental determination of oxygen fugacities of Eifel basalts compared with QFM buffer



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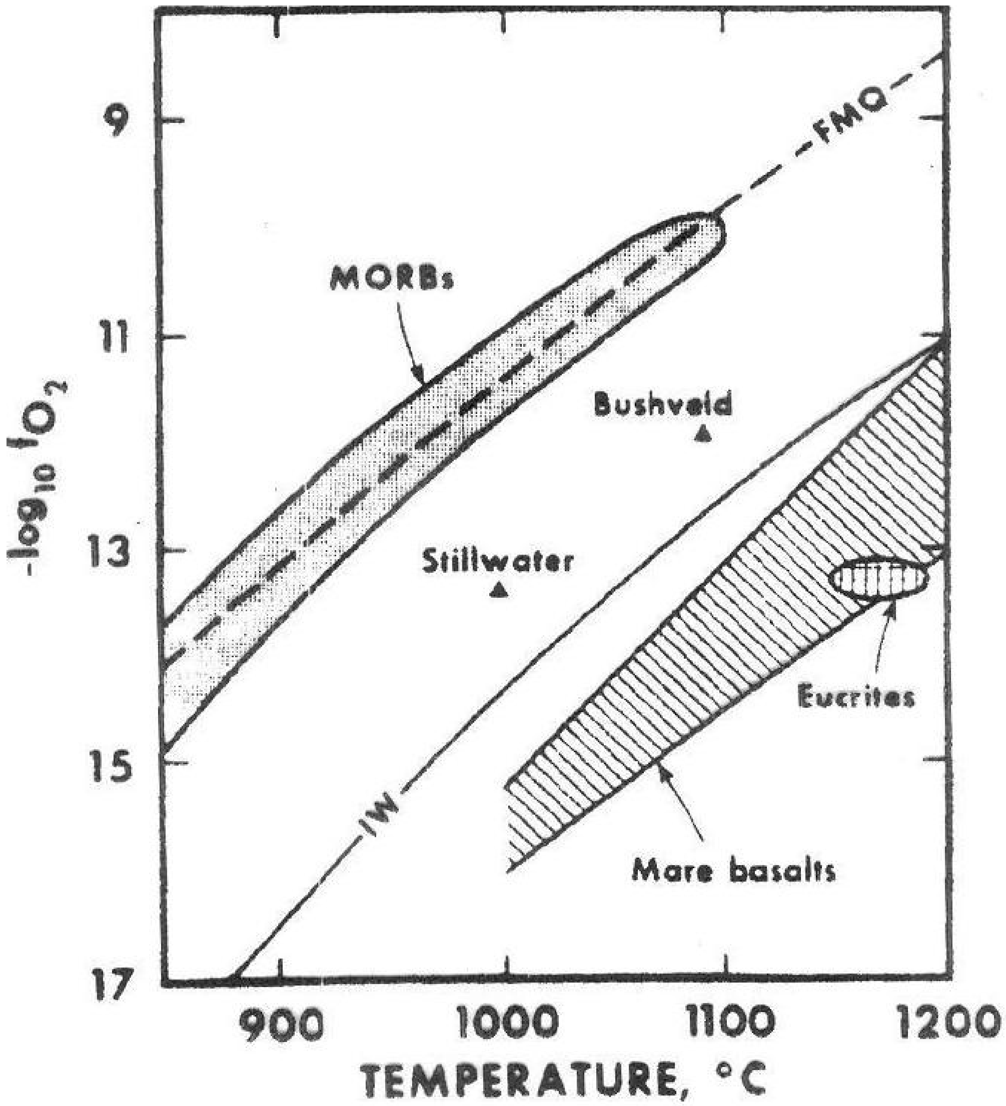

Comparison of oxygen fugacities for various planetary basalts with FMQ and IW buffers (after Ulmer, Stolper and Haggerty.
From
Basaltic Volcanism Study Project, 1981)

MORBs: Mid Ocean Ridge basalts
Mare basalts = Lunar basalts

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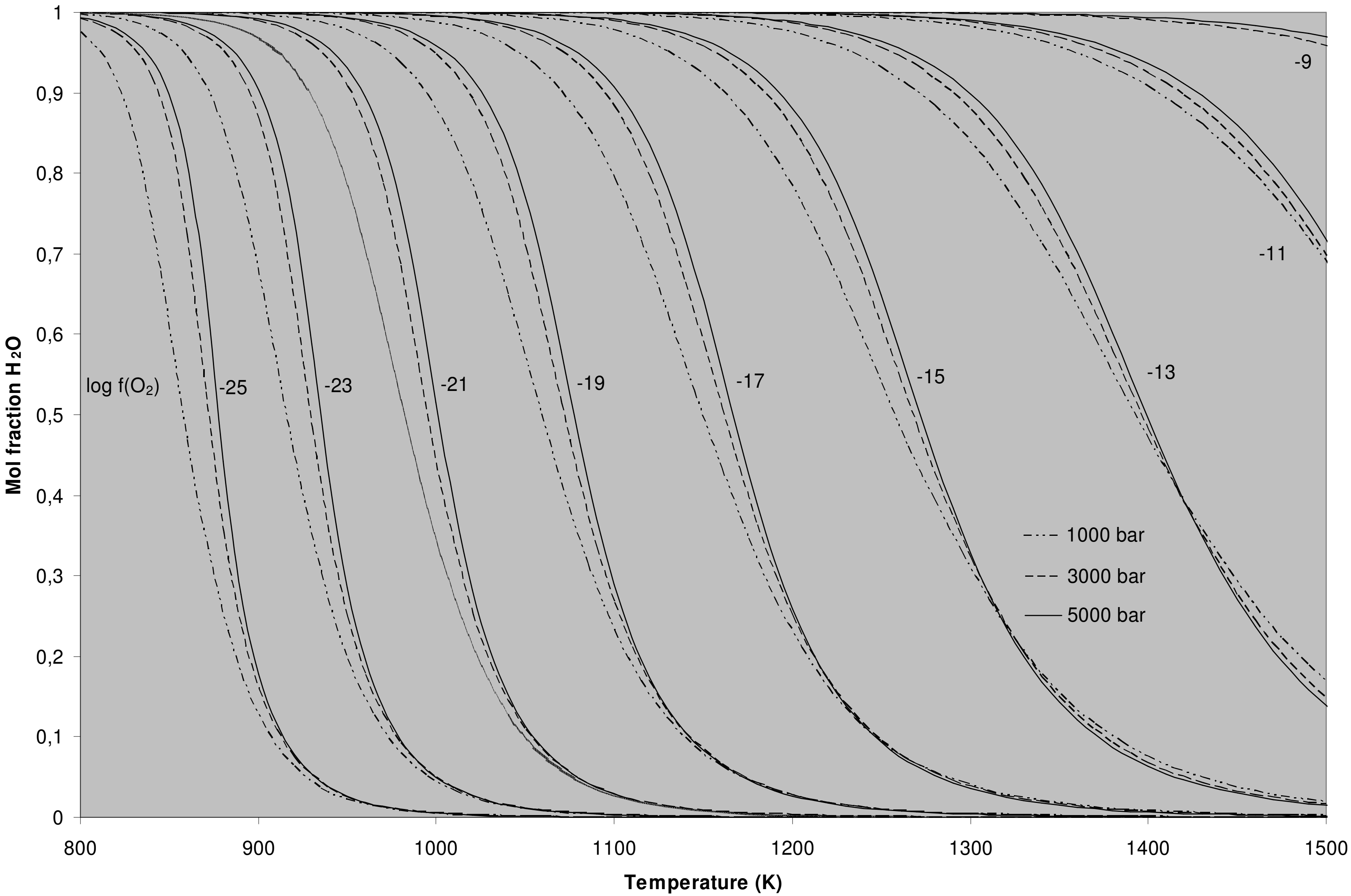
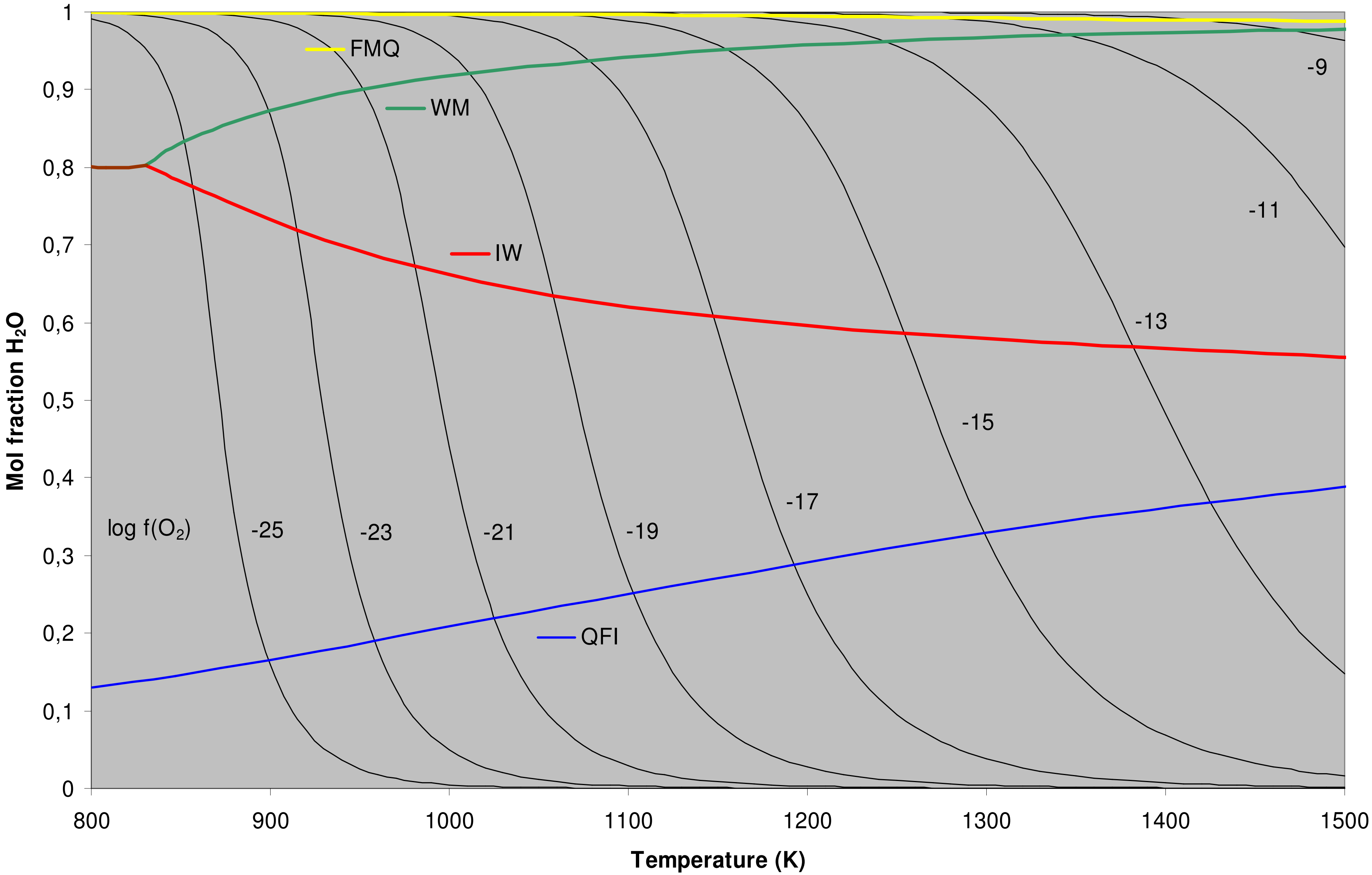
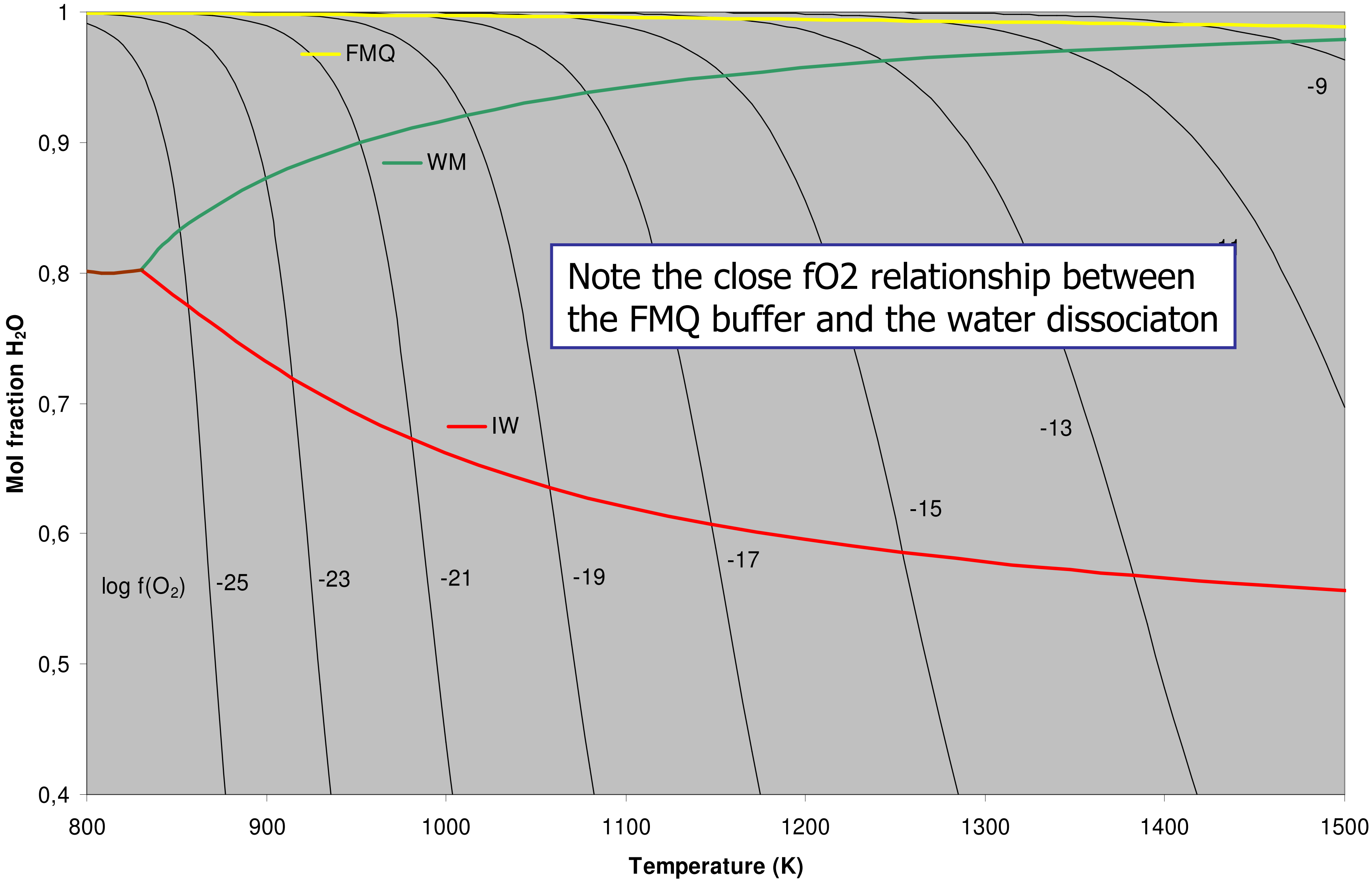
Oxygen fugacities for variable water molefraction (X(H2O)+X(H2)=1)
at various total pressures



Comparison of oxygen fugacities from water dissociation with various Eugster buffers



Comparison of oxygen fugacities from water dissociation with various Eugster buffers (high X(H2O) only)



Conclusions

- From the discussions above it is concluded that only the reaction 2 H_2O = 2 H_2 + O_2 may provide the "surviving" buffer. By thermodynamic calculations the oxygen fugacity of dissociating pure water close to FMQ is confirmed for temperatures above 800 K, kinetically above the closing temperature of a reaction between basaltic magma and water, *i. e.* for conditions prevailing for the eruption of MORBs (Mid Ocean Ridge Basalts).
- It must be noted that the calculations for the water dissociation require very high total pressures in the system. These can be incorporated thanks to the use of the fluid phase model for the C-H-O-S-Ar system that was developed by Belonoshko and Saxena (1992).
- The correlation between the oxidation state of a rock and the activity of water during its formation may be extended to further systems. Thus the fact that analyses of Nakhlites were showing an oxidation state close to FMQ indicates that during their formation on Mars water must have been involved – although at present neither water nor hydrous components in Mars minerals directly seem to support this conclusion.