Giant magnetocaloric effect and magneto-crystalline coupling

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Outlook

Magneto-crystalline coupling

How to change the coupling: Fe_2P

chemical pressure x physical pressure

Fe_2P to $(Fe,Mn)_2(P, ?)$

similarities and differences

What information can we obtain from it?

Conclusions

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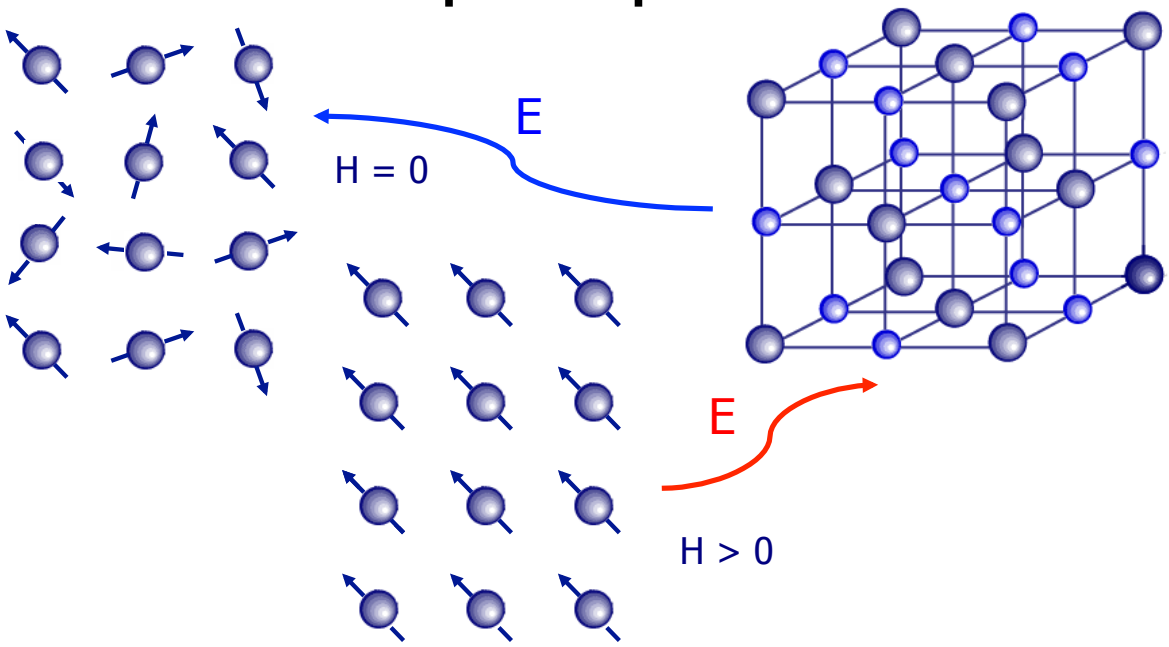
Magneto-crystalline coupling

magnetic interaction is dependent on interatomic distance

Pauli's exclusion principle



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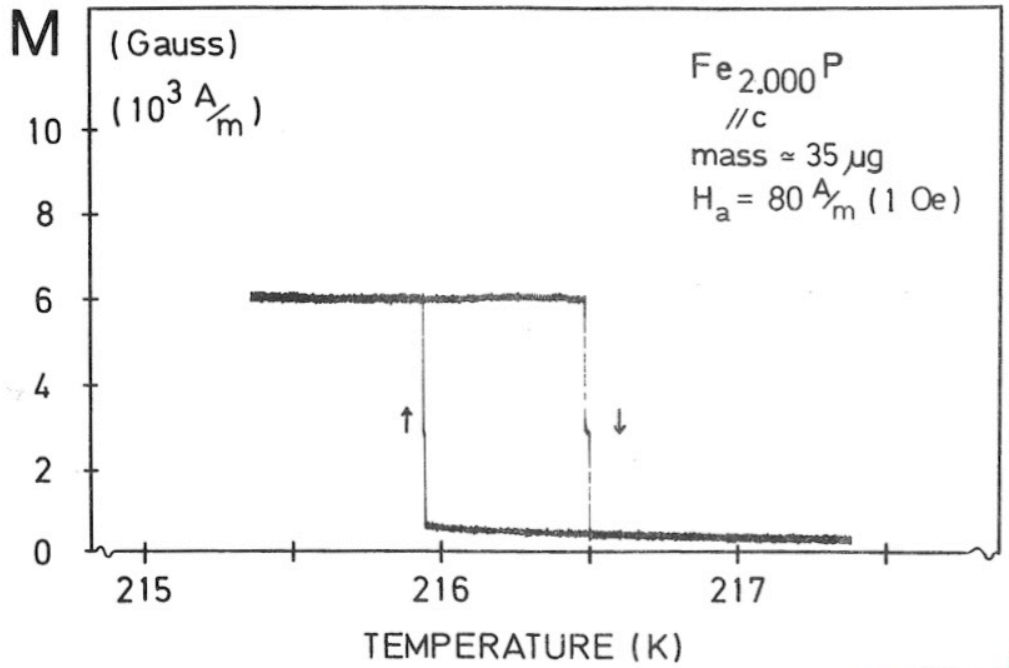
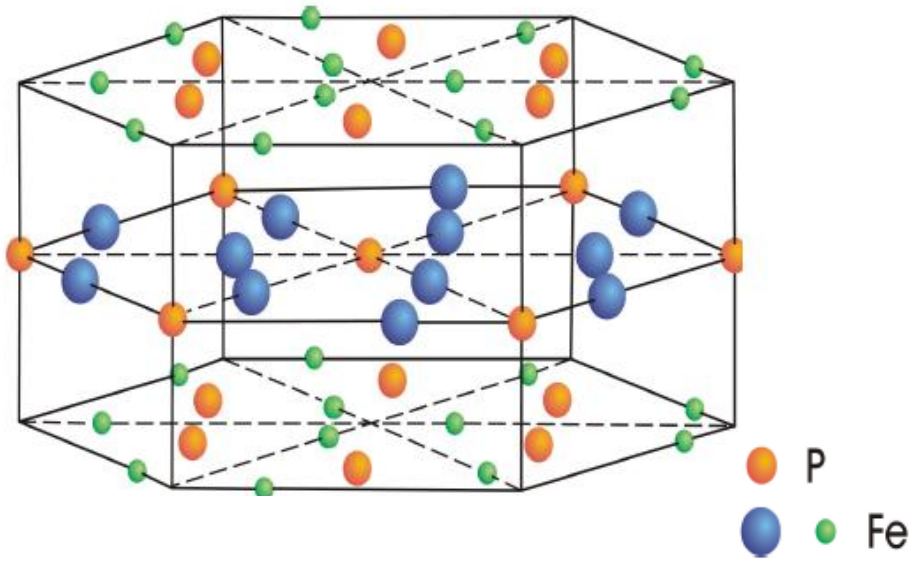
Chemical pressure: Fe_2P





Fe1 - tetrahedral 1.03 μ_B

Fe2 - pyramidal 1.91 μ_B

Per Nordblad, PhD thesis Uppsala University 1982

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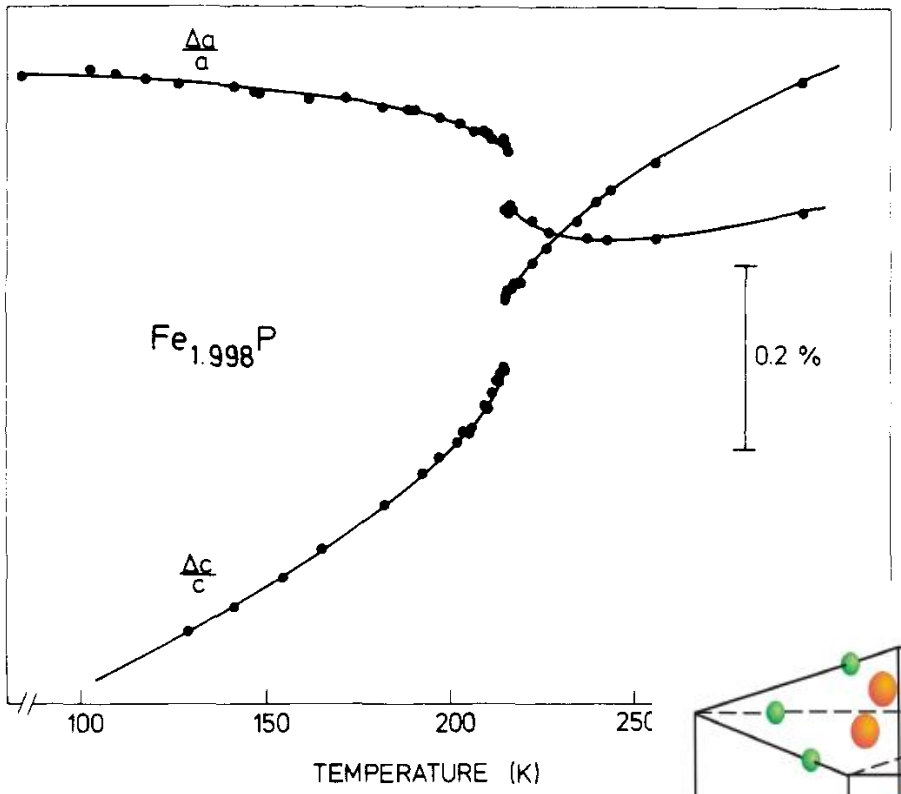
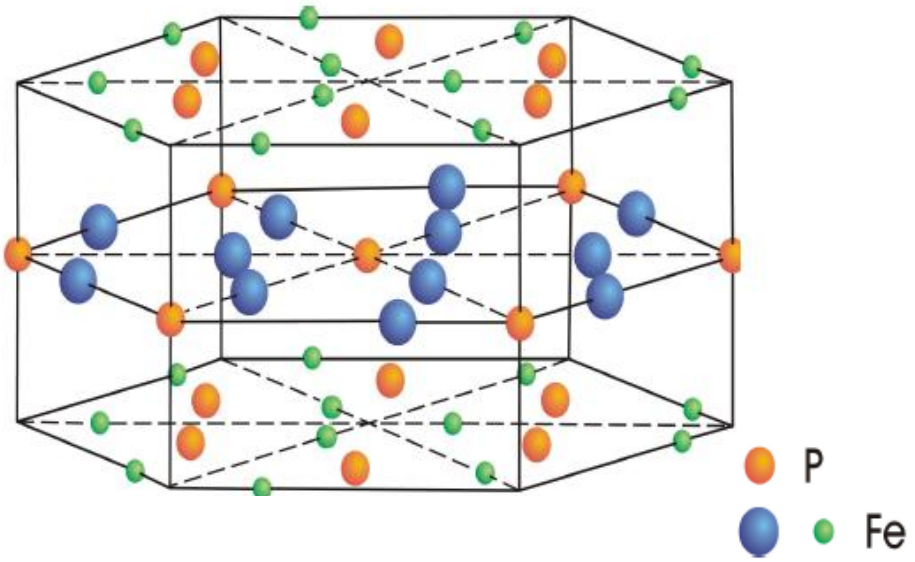
Chemical pressure: Fe_2P





Lundgren et al. Physica Scripta 1978

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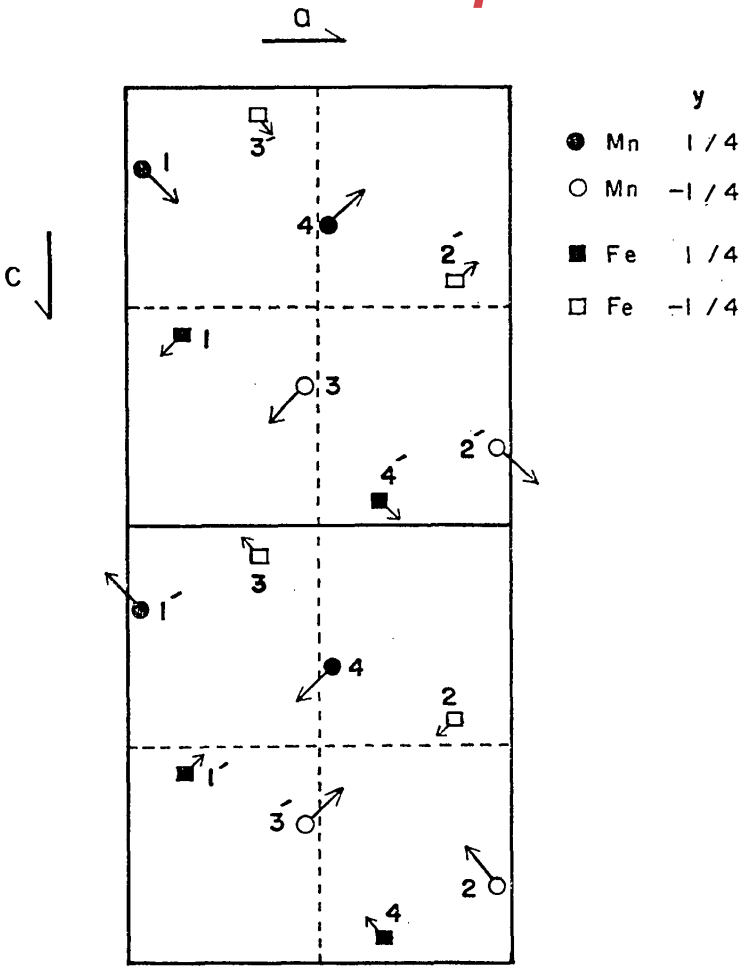
Chemical pressure: FeMnP



	Interatomic distance Å	Sign of exchange interaction
Fe-Fe	2.631	antiferromagnetic
Fe-Mn	2.661	critical* (ferromagnetic)
	2.766	antiferromagnetic
	2.79	critical*
Mn-Mn	3.05	antiferromagnetic

* "critical" means that the interaction is in the region where the sign changes from antiferromagnetic to ferromagnetic.

Fe - tetrahedral 0.5 μ_B

Mn - pyramidal 2.6 μ_B

Watanabe et al. JPSJ 1973

antiferromagnetic

Co_2P - orthorhombic

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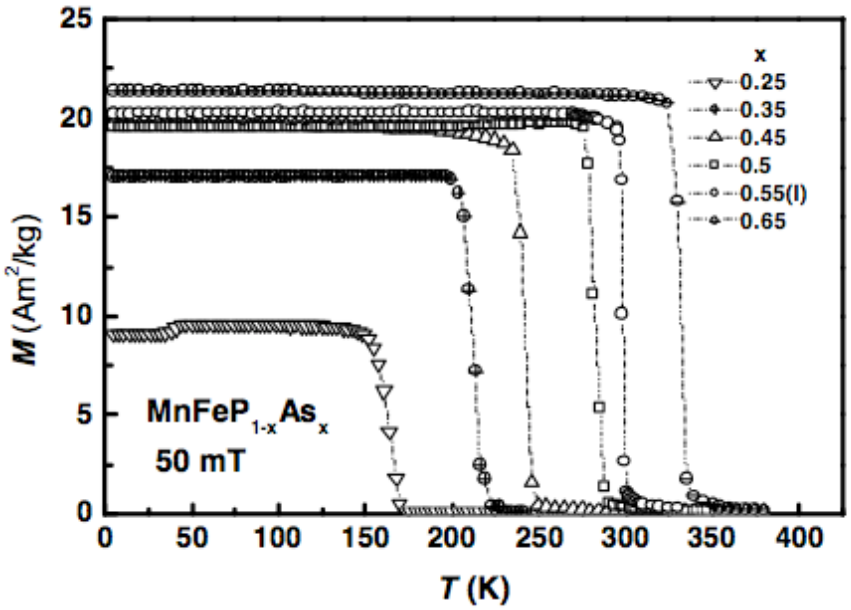
Chemical pressure $FeMnP_{1-x}A_x$

A = As, Ge, Si

Nominal, x	0.25	0.35	0.45	0.50	0.53	0.55(I)	0.65
a (Å)	6.0392	6.0677	6.1080	6.1290	6.1628	6.1739	6.2120
c (Å)	3.4870	3.4874	3.4900	3.4805	3.4946	3.4511	3.4633
c/*a*	0.5774	0.5748	0.5714	0.5679	0.5670	0.5590	0.5575
T_C(K)	168	213	240	282	290	300(I) 307(II)	332



$MnFeP_{1-x}As_x$

ferromagnetism and Fe_2P structure are recovered

Tegus, PhD thesis University of Amsterdam

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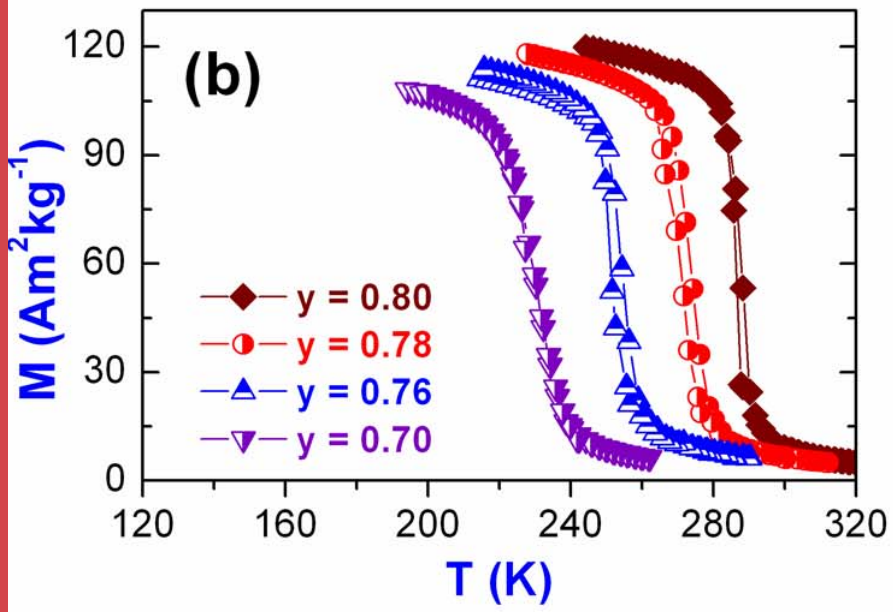
Chemical pressure $FeMnP_{1-x}A_x$

A = As, Ge, Si

y	c/a	ΔT_{hys} (K)	T_c (K)	$-\Delta S_{m,max}$ (J kg^{-1} K^{-1})	RCP (J kg^{-1})
0.80	0.5626	1	288	20.3	151
0.78	0.5638	2	274	15.3	162
0.76	0.5646	2	254	16.4	151
0.70	0.5651	0	230	9.8	155
Gadolinium[a]		0	293	4.2	166



$Mn_{2-y}Fe_yP_{0.75}Ge_{0.25}$

ferromagnetism and Fe_2P structure are recovered

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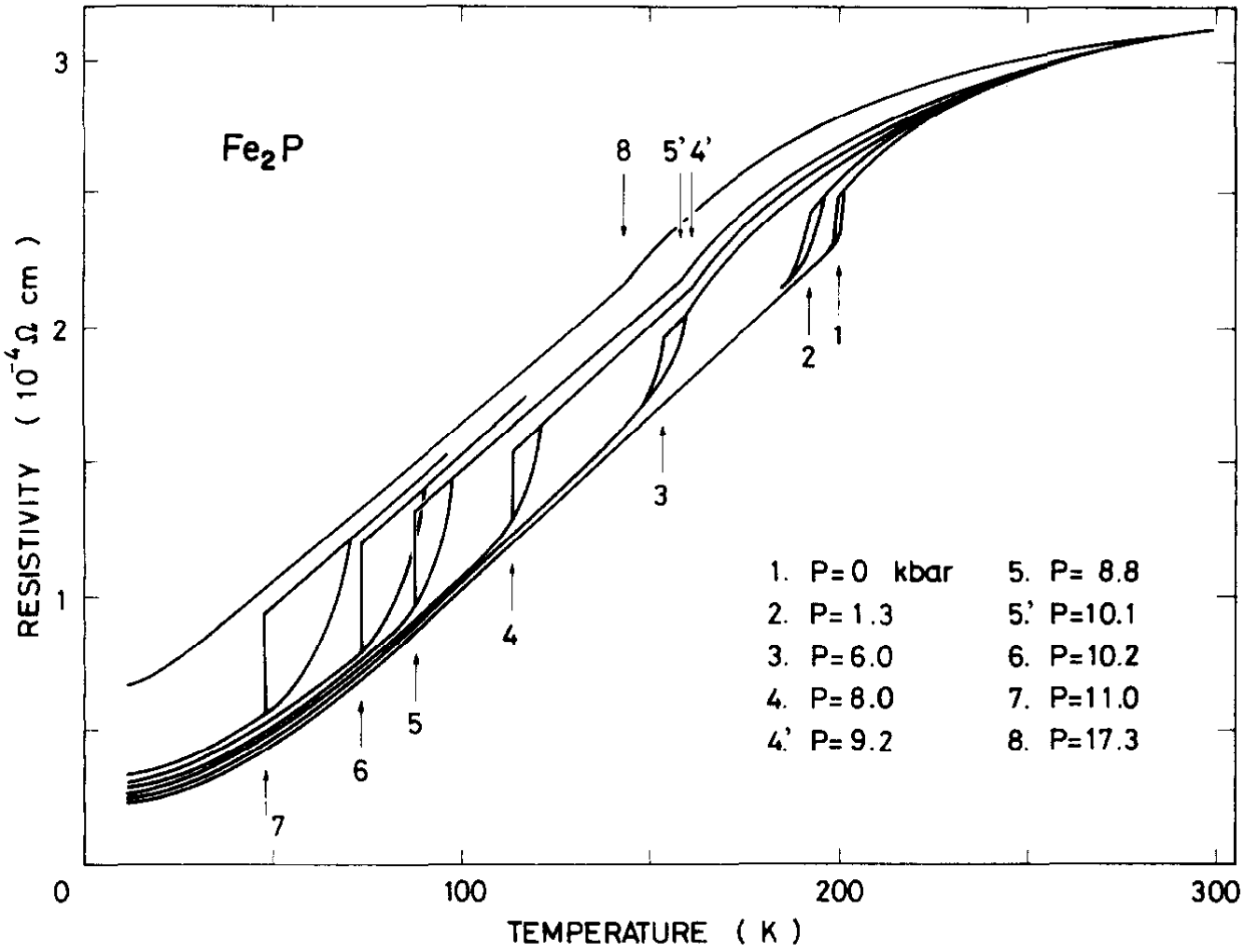
Probing the coupling with pressure



Fujiwara et al. JMMM 1980

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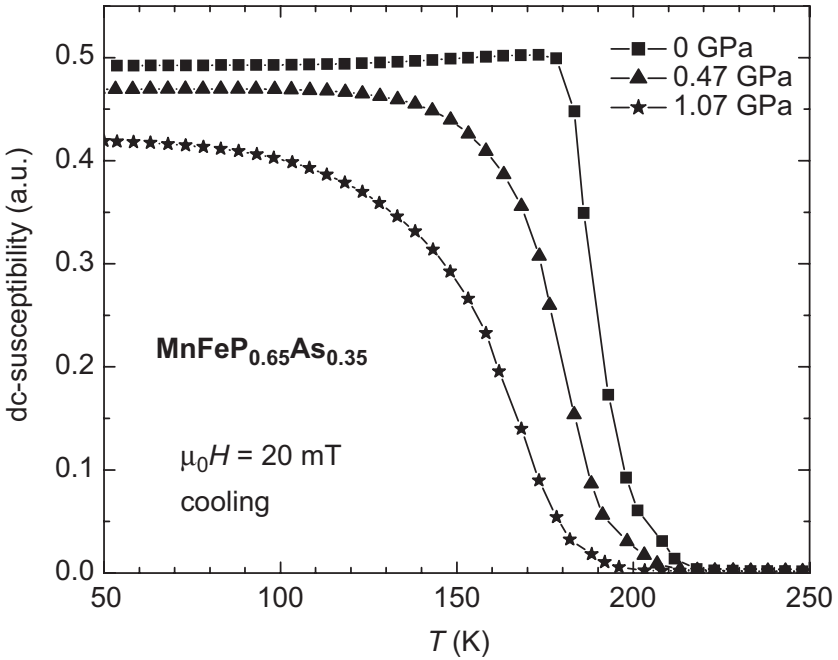

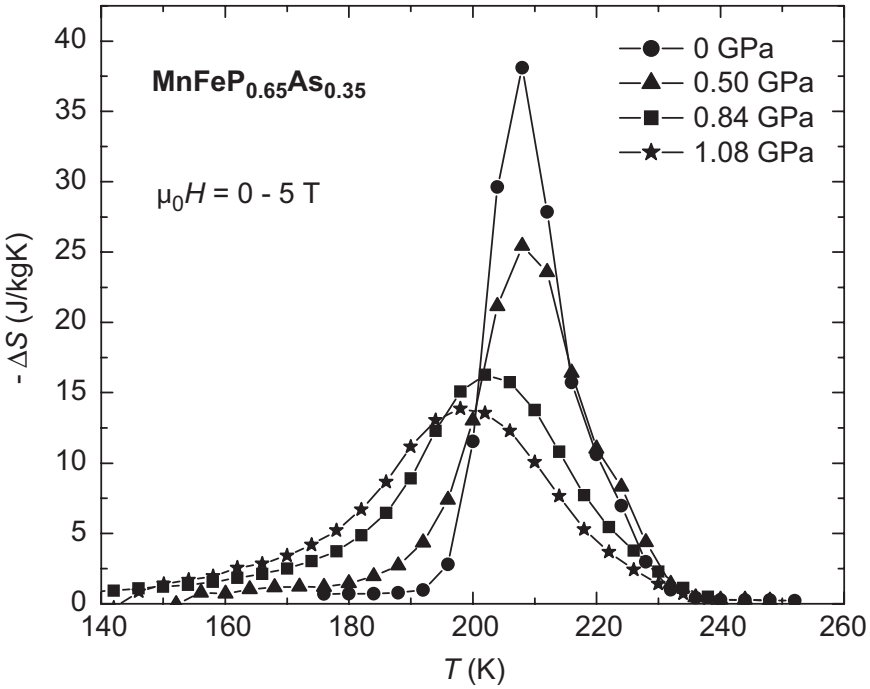

Fe_2P- like behavior

Brück et al. JMMM 2007

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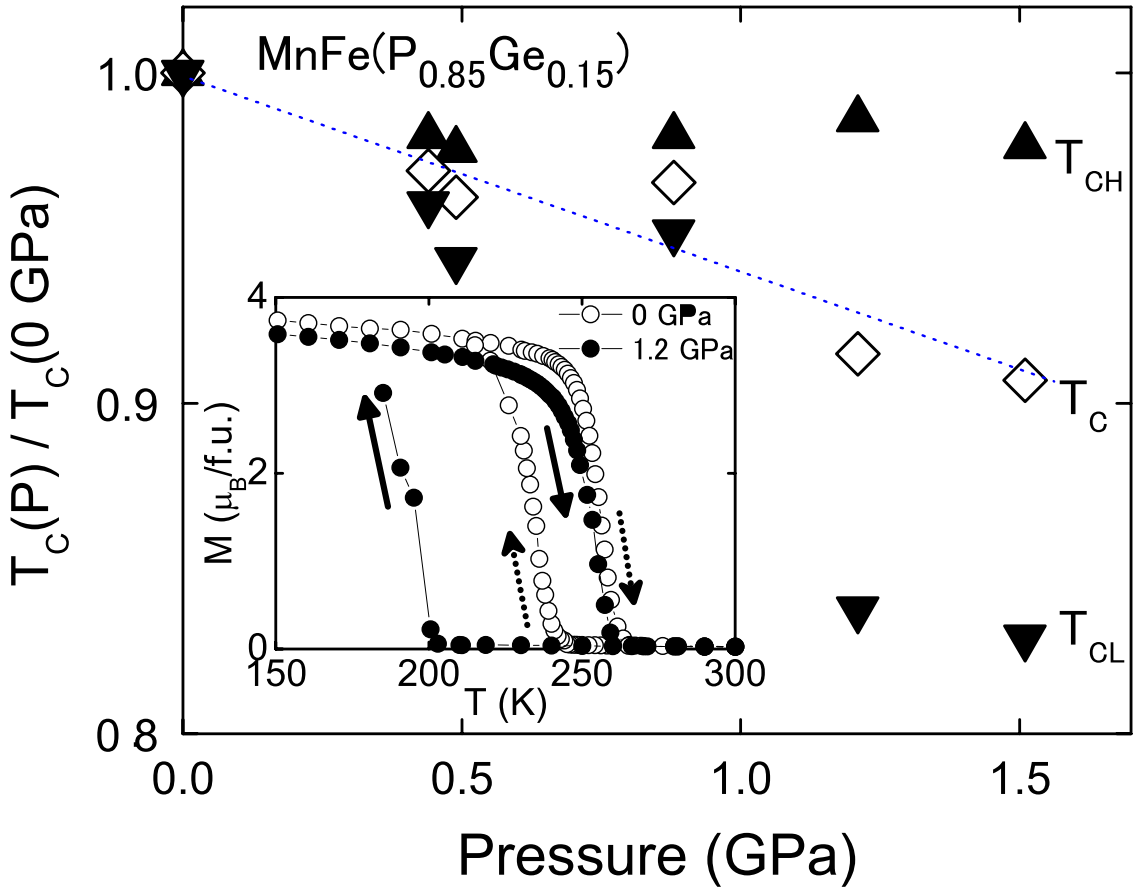

Yabuta et al. JMMM 2007

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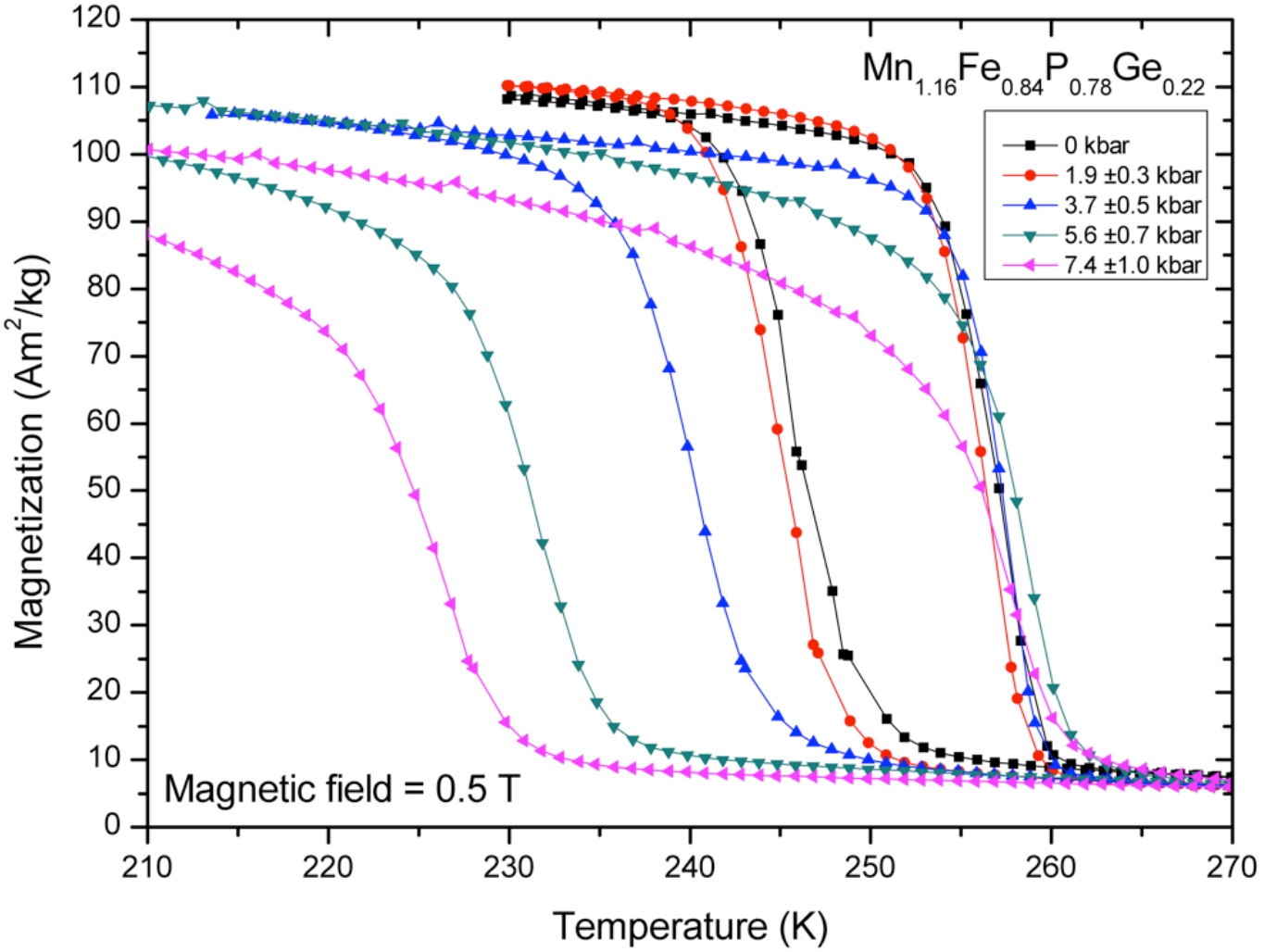

Yabuta et al. JMMM 2007

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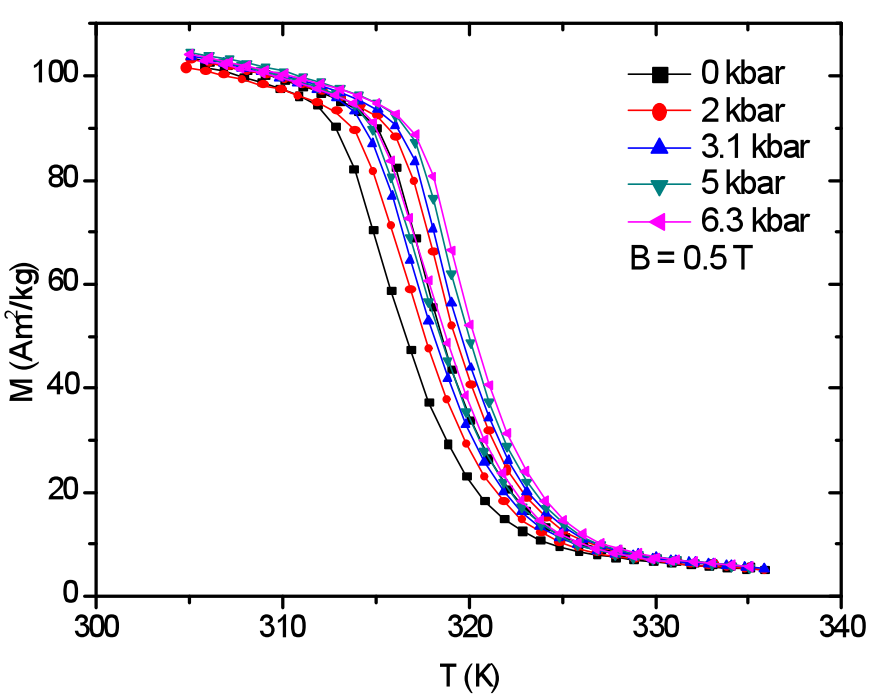
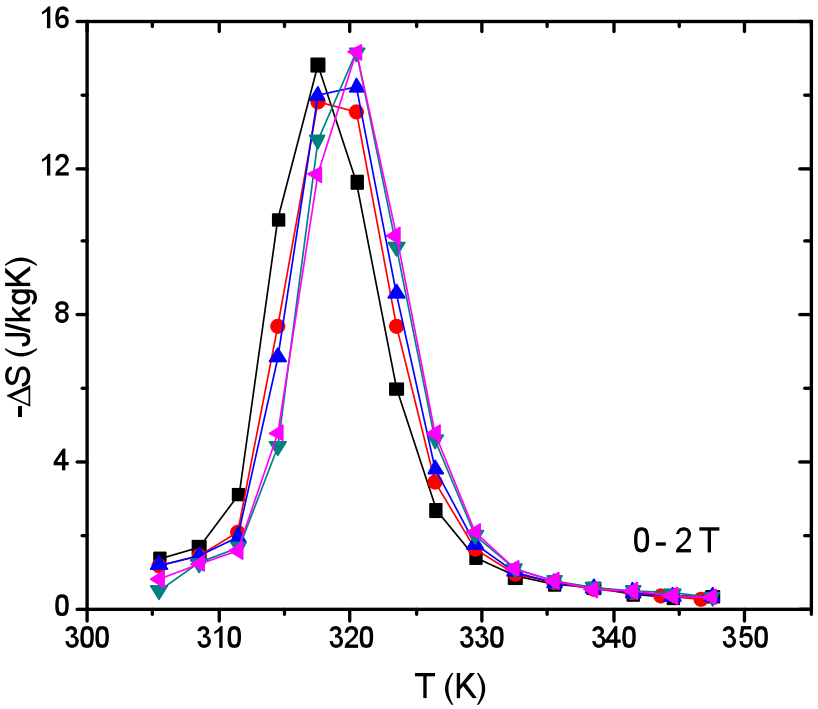
Probing the coupling with pressure

$Mn_{1.16}Fe_{0.84}P_{0.75}Ge_{0.25}$





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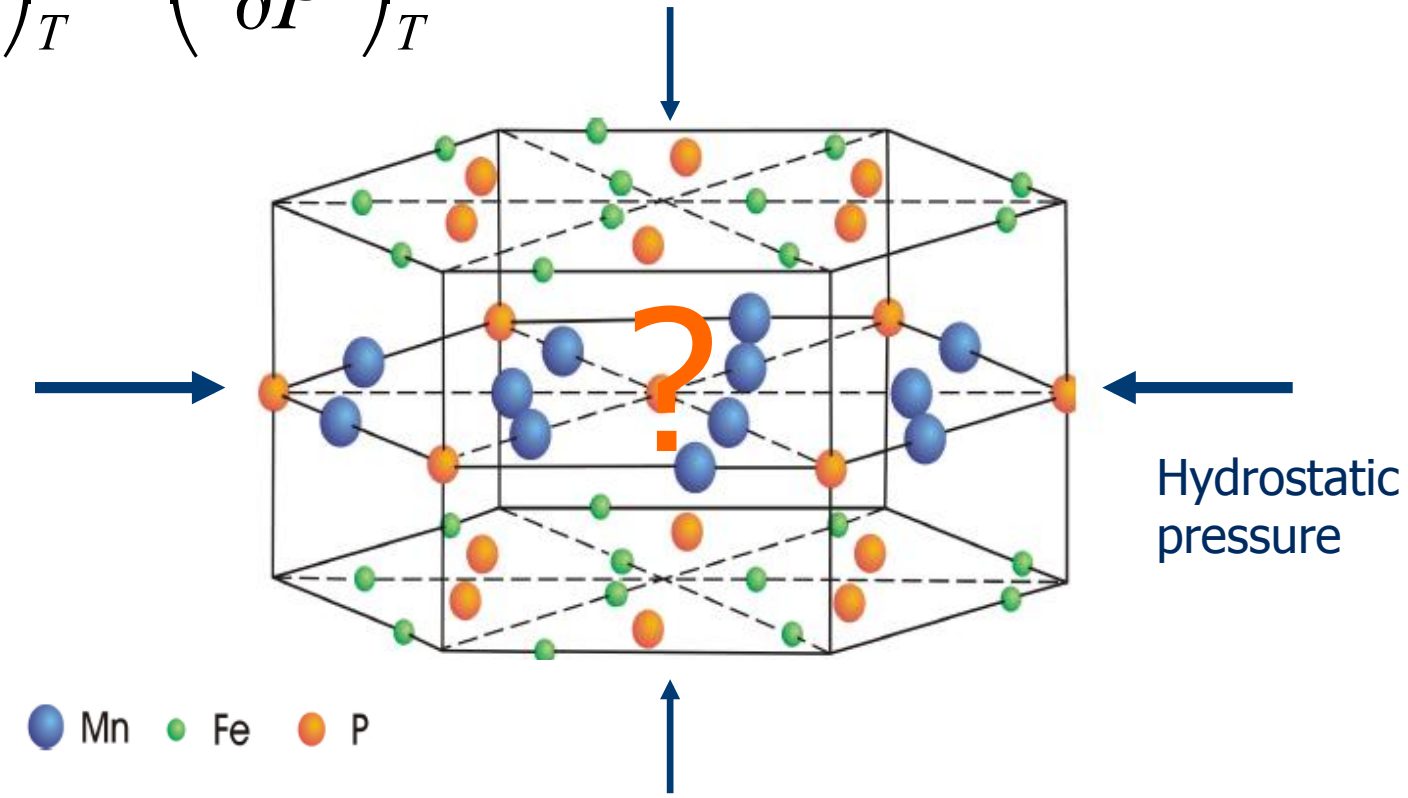
Probing the coupling with pressure

$$\left(\frac{\partial V}{\partial B}\right)_T = \left(\frac{\partial M}{\partial P}\right)_T$$

$Fe_yMn_{2-y}P_{0.75}Ge_{0.25}$

Why no change in T_C?



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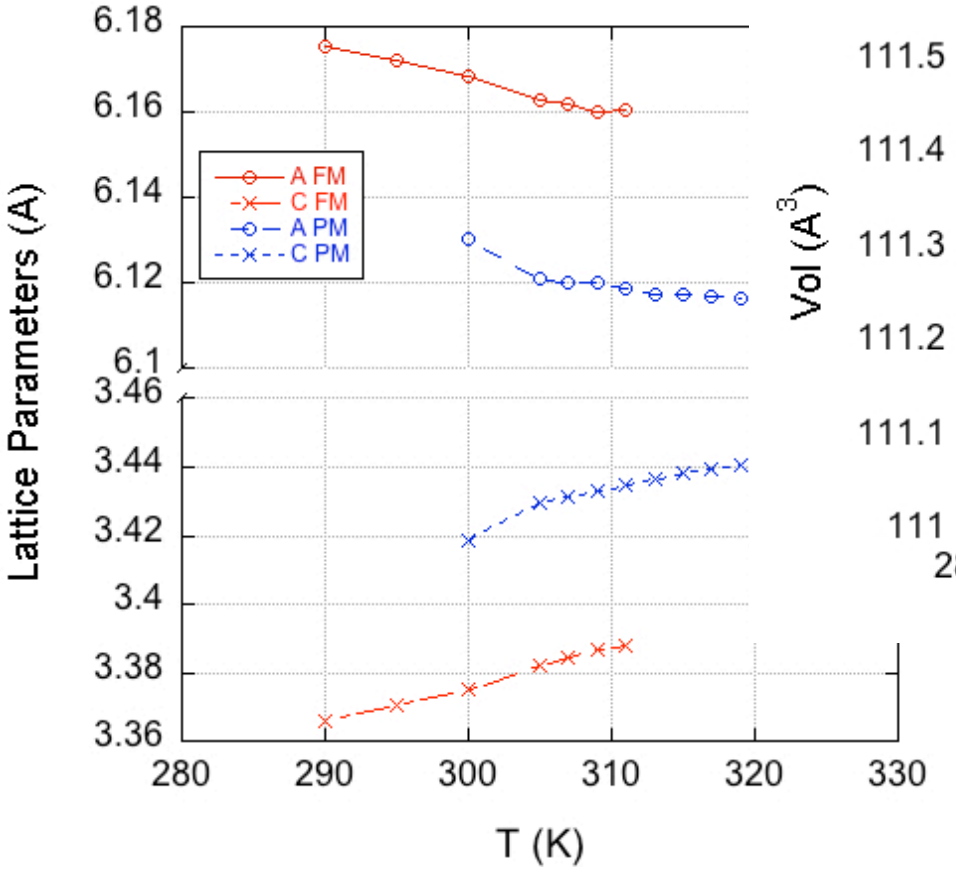
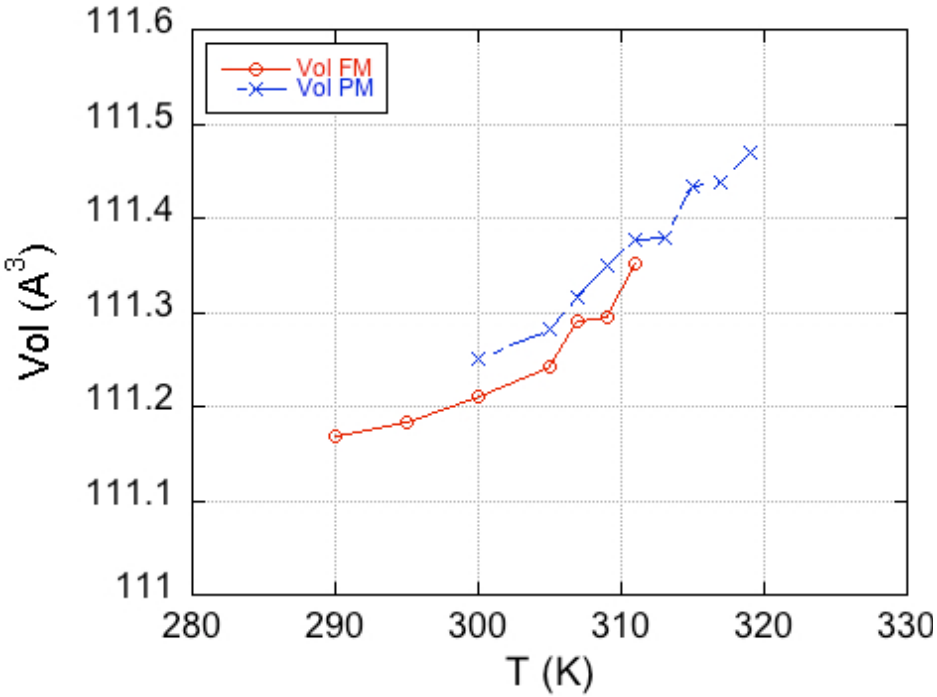
Why no change in T_C?

$$\left(\frac{\partial V}{\partial B}\right)_T = \left(\frac{\partial M}{\partial P}\right)_T$$

$Fe_{0.84}Mn_{1.16}P_{0.75}Ge_{0.25}$





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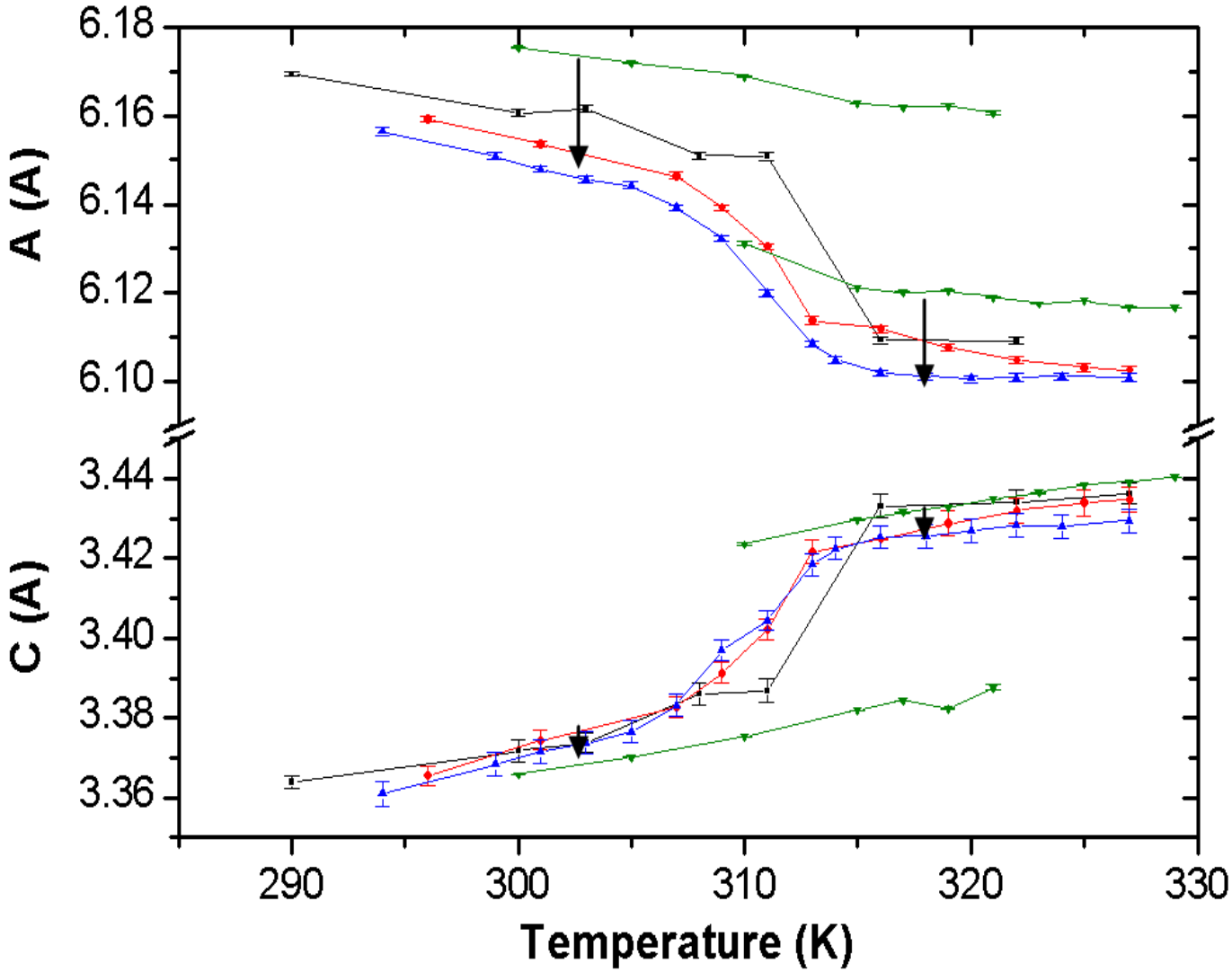
Why no change in T_C?

$Fe_{0.84}Mn_{1.16}P_{0.75}Ge_{0.25}$



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Conclusions?

- Fe_2P-based compounds present different behaviors under pressure
- chemical pressure is not always equivalent to physical pressure
- how to understand the entire picture?

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Thank you for your attention!