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## Materials Sciences Division

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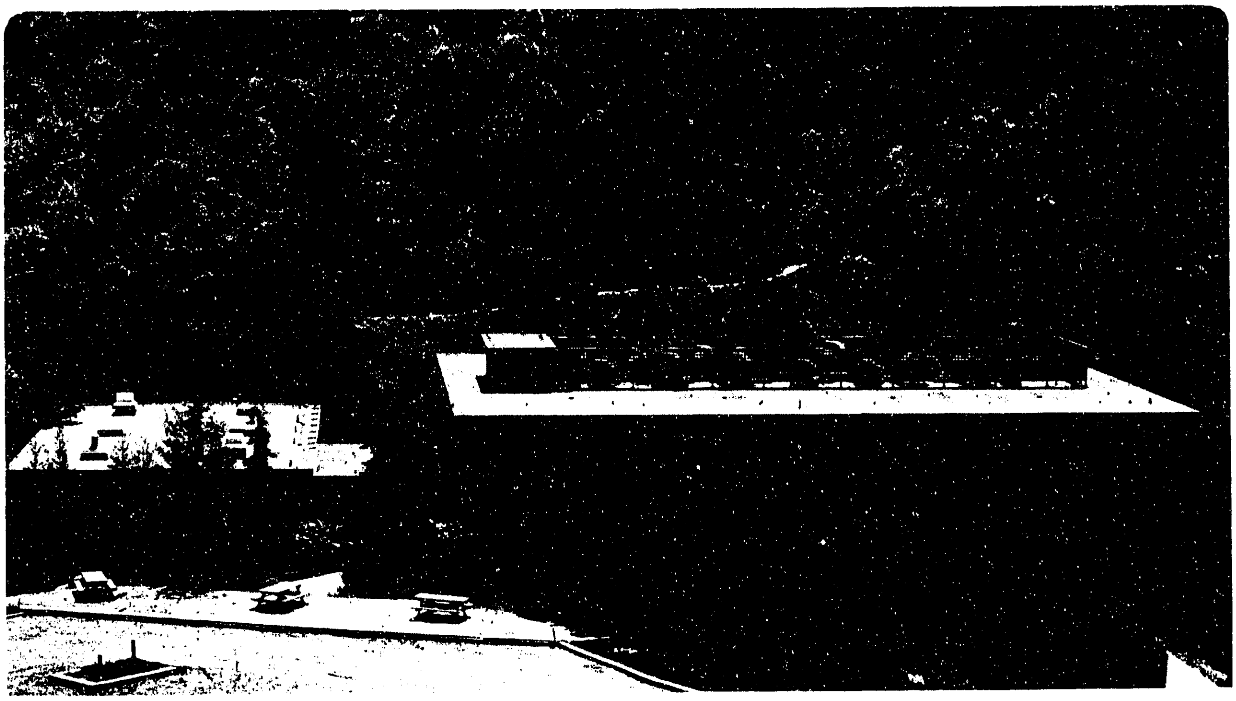
April 1993



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# THE LOW-TEMPERATURE SPECIFIC HEAT OF $CeCu_2Ge_2$ AT 0 AND 9.5 KBAR

by

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# The Low-Temperature Specific Heat of $CeCu_2Ge_2$ at 0 and 9.5 kbar

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$CeCu_2Ge_2$ orders antiferromagnetically, $T_N$~4K, and $\gamma(T)$ ~200 mJ/K$^2$·mole near 0.5K and P=0. A pressure of 9.5 kbar has no measurable effect on $T_N$; reduces slightly the specific-heat anomaly at $T_N$; and reduces slightly $\gamma(T)$ below 0.7K. These effects of pressure are in striking contrast to the much stronger effects on other heavy-fermion compounds, e.g., $CeAl_3$, $URu_2Si_2$ and $CeCu_2Si_2$.

$CeCu_2Ge_2$ is isostructural with $CeCu_2Si_2$, the first heavy-fermion superconductor [1]. Although $CeCu_2Ge_2$ is not superconducting at zero pressure (P), it is superconducting for P>70 kbar [2]. Previous specific-heat (C) measurements [3] for P=0, 0.05≤T≤30K, and magnetic fields (H) to 8T, showed antiferromagnetic ordering at $T_N$=4.2K, and an anomaly in C at 0.45K and H=0 that was interpreted as a maximum in $\gamma(T)$. The anomaly was suppressed, but not shifted in temperature, with increasing H and disappeared at H=8T. This paper reports new data for C, 0.35≤T≤20K and P=0; and also data obtained at 9.5 kbar, the first for P≠0. The P=0 data are in excellent agreement with the earlier work [3] suggesting that the features observed are intrinsic properties and not subject to the uncertainties related to sample dependence that are associated with some heavy-fermion compounds.

In Fig. 1, C vs T, the solid line represents an estimate of the lattice specific heat ($C_\ell$) obtained for T>14K. The corresponding Debye temperature and $\gamma$ are ~240K and 10 mJ/K$^2$·mole, respectively. There are substantial uncertainties in these estimates, but it is clear that $C_\ell$ is a negligible contribution for T<$T_N$, and $\gamma$ is not large for T>14K. It follows that the quasiparticles acquire high mass only at lower temperatures.

Figure 2, a plot of C/T vs T, shows the antiferromagnetic transition centered at $T_N$=4.3K, and the anomaly. Relative to the P=0 data, there are small decreases in C/T just below $T_N$

and in the vicinity of 0.45K, but with no measurable change in $T_N$. The entropy (S) in Fig. 3 approaches $R\ell n2$ at higher temperatures consistent with a doublet ground state for $Ce^{3+}$.

To separate the 0.45K anomaly from that associated with antiferromagnetic ordering, the procedure described in Ref. 3 was used: The low-temperature antiferromagnetic magnon contribution, $\beta_3 T^3$, was derived from a plot of C/T vs $T^2$, which is linear for $0.85 \leq T \leq 1.5K$. Subtraction of that contribution, which is pressure independent, gives the "0.45K anomalies" shown in Fig. 4. Both the position and magnitude of the maximum for P=0 are in good agreement with those of Ref. 3. In 9.5 kbar, however, the maximum is shifted to 0.5K, and reduced in magnitude for T<0.7K, by ~30% at 0.35K.

The weak P dependence of C near $T_N$ is in sharp contrast to the relatively large change of C with P for, e.g., $URu_2Si_2$ [4] for which $T_N$=18K. $CeAl_3$ also shows a maximum in C/T near 0.4K, but it is rapidly suppressed with increasing pressure, disappearing completely for P<0.4kbar, and at P=8.2 kbar C/T at 0.4K is reduced to less than one third of its P=0 value [5]. $CeCu_2Si_2$ also shows a large change of C with P [6].

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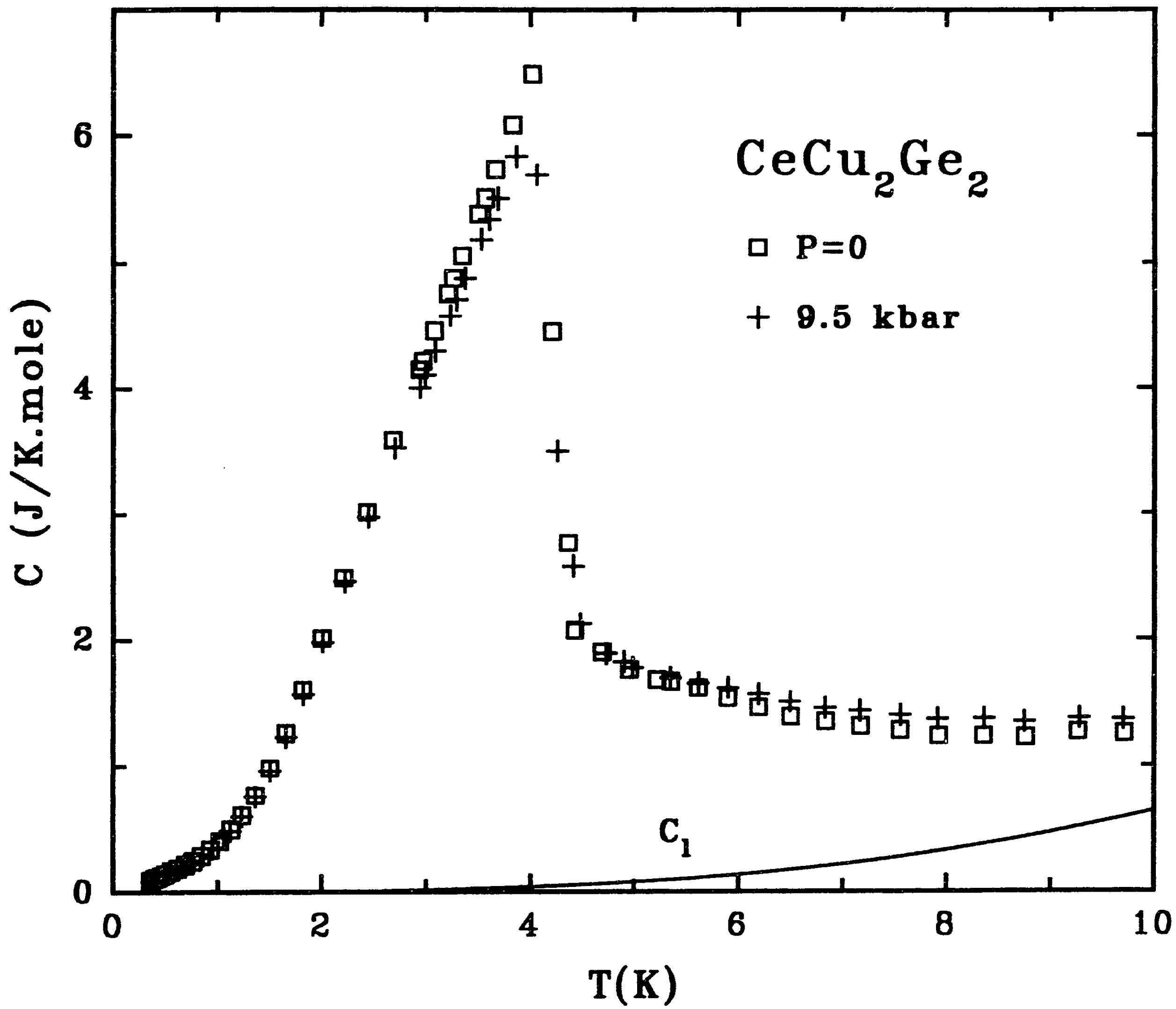


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FIGURE 1

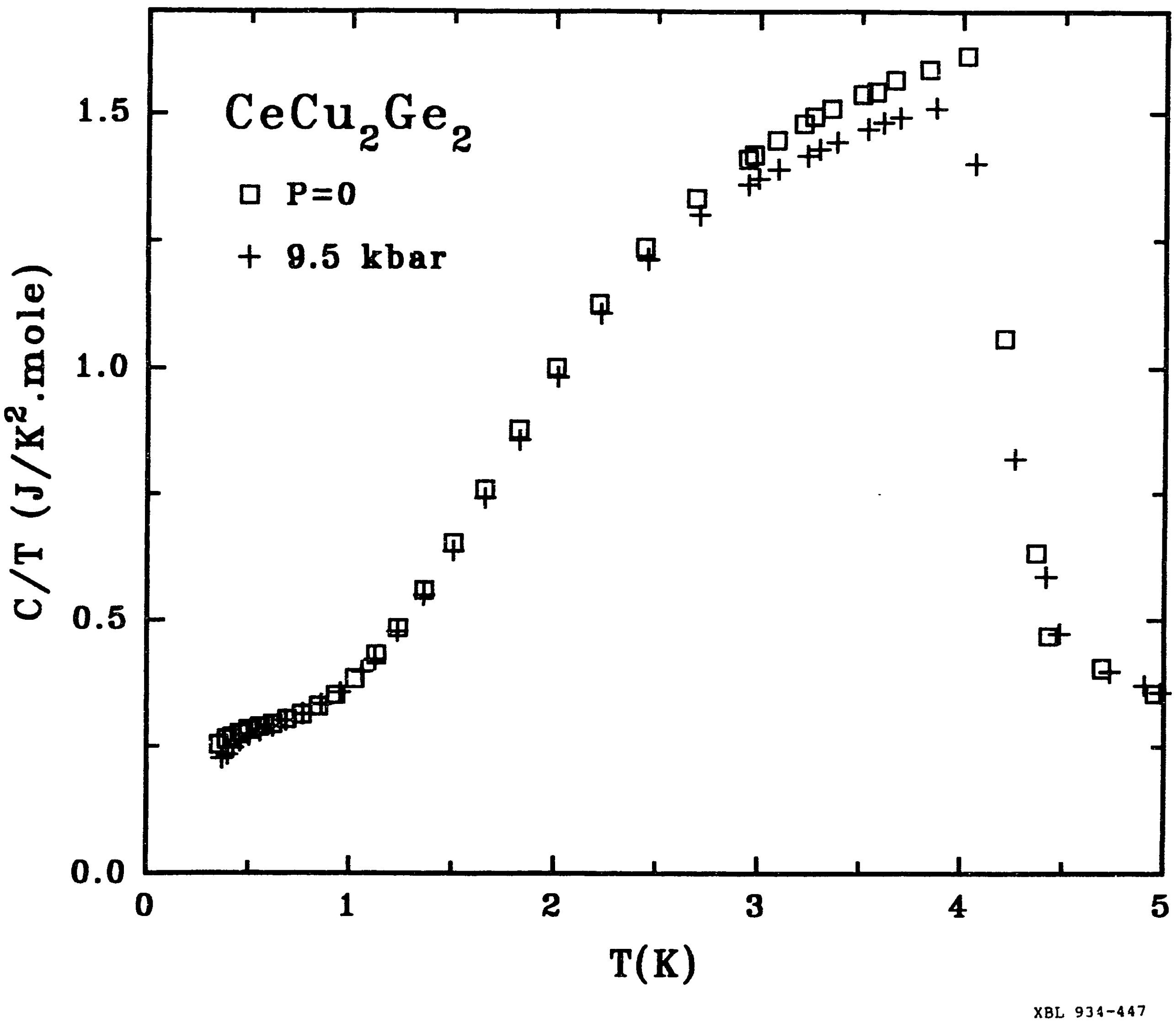
CeCu2Ge2
P=0
9.5 kbar
C/T (J/K2.mole)
T(K)
0.0
0.5
1.0
1.5
0
1
2
3
4
5
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FIGURE 2

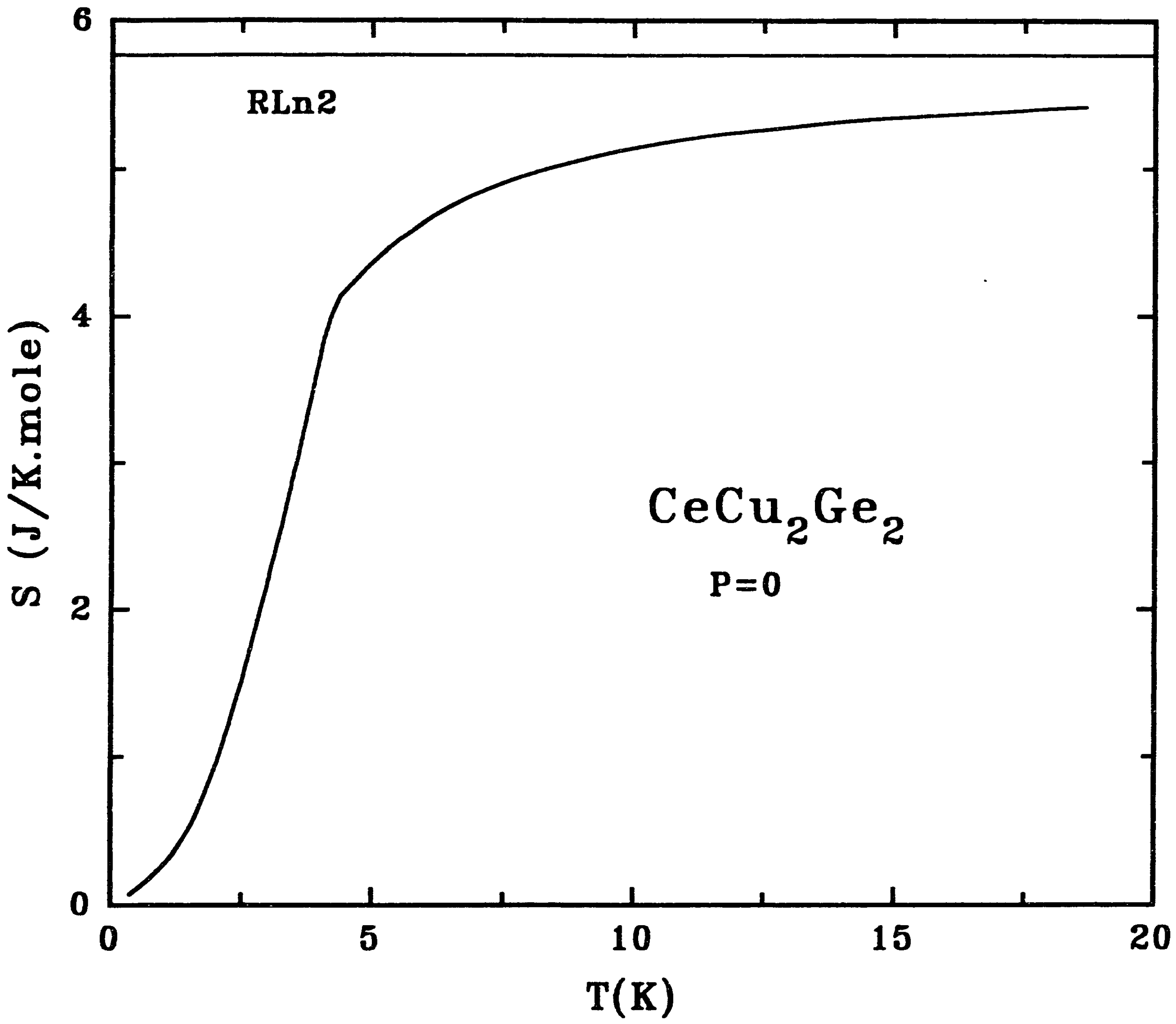


FIGURE 3

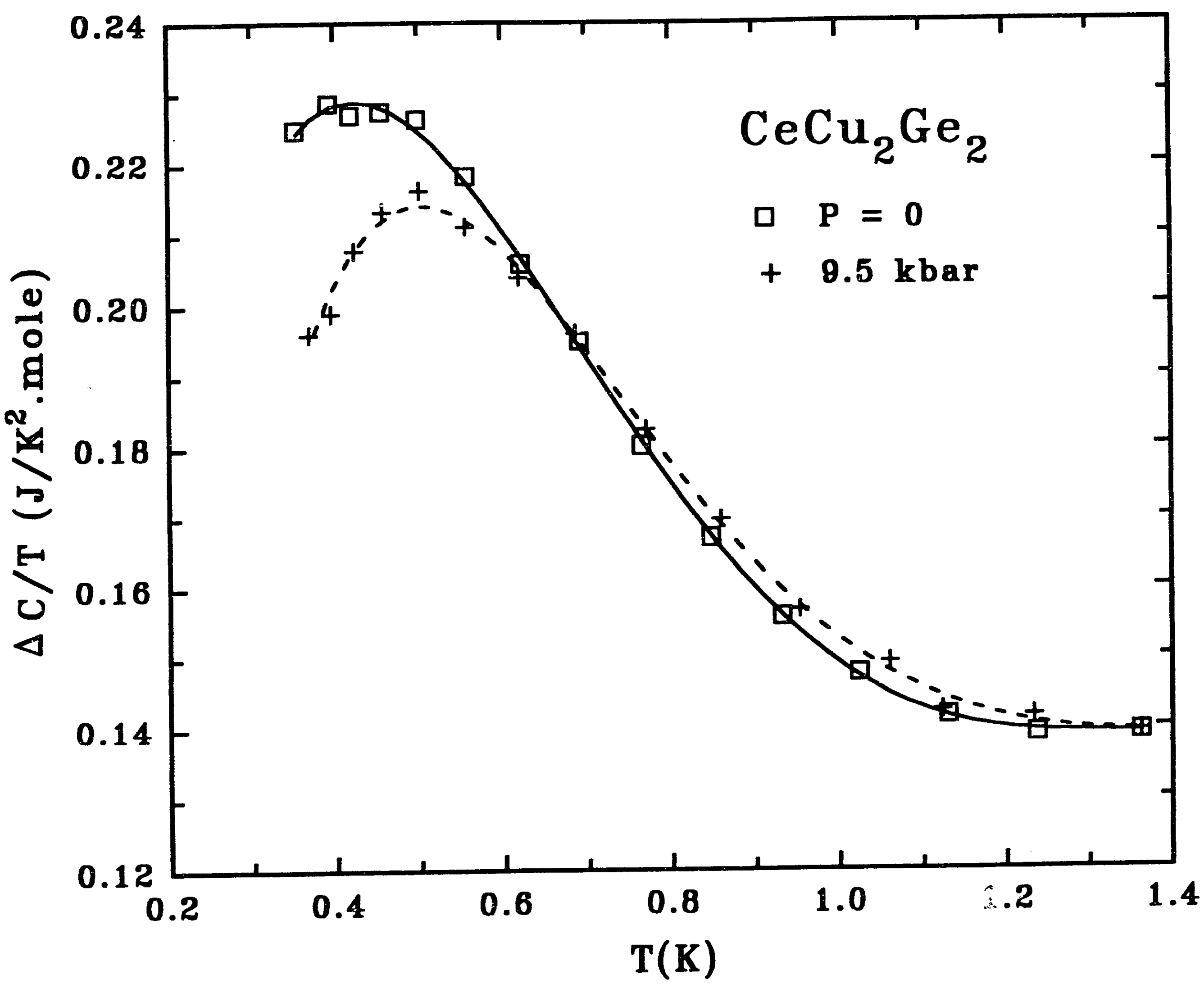


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FIGURE 4

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