Magnetic Susceptibilities of Coals

Abstract. *Magnetic susceptibilities are reported for seven American coals of different rank. The susceptibilities were measured in magnetic fields parallel and perpendicular to the bedding planes. The coals have diamagnetic susceptibilities approximating* -0.5×10^{-6} *centimeter-gram-second unit. Only anthracite shows significant magnetic anisotropy.*

Air pollution has recently come under public scrutiny. Oxides of sulfur produced by combustion of coal are receiving special attention as a health hazard. Since the major portion of sulfur in coals rich in sulfur (more than 3 percent S) is in the form of sulfides of iron, mainly pyrite, removal of iron sulfides by magnetic separation is being studied by the U.S. Bureau of Mines. During these studies we measured the magnetic susceptibilities of several coals. Very few studies have been made of the magnetic susceptibilities of coals (*1, 2*), and none have been reported of American coals in particular. We now report the results of our studies of seven selected American coals ranging in rank from high-volatile C-bituminous to anthracite.

It is well known that many physical properties of high-rank coals [for example, refractive index, extinction coefficient (*3*), x-ray and electron-scattering intensities (*4*)] differ according to whether they are measured along the bedding plane or perpendicular to it. For this reason samples of vitrains (anthraxylons) were carefully cut, the direction normal to the bedding being noted; cubes measuring 5 ± 0.5 mm were obtained. The vitrain samples were selected from relatively wide uniform bands, and were examined microscopically to make sure that they were free from visible mineral matter. Final shaping was done by grinding with sandpaper to avoid ferromagnetic contamination.

Table 1. Magnetic susceptibilities of some American coals. Measurements: parallel (PAR) or perpendicular (PERP) to the bedding plane, or along another axis in the bedding plane (TA).

Coal	Magnetic susceptibility (10^{-6} cgs unit) PAR	PERP	TA
Anthracite, Luzerne County, Pa.	−0.56	−0.77	−0.53
Semianthracite, Northumberland County, Pa.	− .42	− .44	− .43
Low-volatile bituminous, Wyoming County, W.Va.	− .49	− .52	
Medium-volatile bituminous, Wyoming County, W.Va.	− .56	− .58	
High-volatile A-bituminous, Allegheny County, Pa.	− .54	− .55	
High-volatile B-bituminous, Saline County, Ill.	− .57	− .61	
High-volatile C-bituminous, St. Clair County, Ill.	− .45	− .50	

The magnetic balance used was a Faraday-type null instrument constructed at the Bureau of Mines for measurements of diamagnetic and low paramagnetic susceptibility. For diamagnetic measurements it was calibrated with water occupying the same volume as the coal specimens; measurements were made at room temperature under a field of 6000 gauss. The cubes were oriented so that the field was either parallel or perpendicular to the bedding plane. In the cases of anthracite and semianthracite, measurements were made along the third axis of the cube. The results appear in Table 1. No corrections were made for paramagnetic contributions. The data correspond to averages of at least two measurements on the same sample, the second measurement being made after measurements were made on at least one other sample. The average deviation of all repeated measurements was ± 0.02; root-mean-square deviation was ± 0.03 in the units specified.

Table 1 shows that coals are diamagnetic. Susceptibilities with the field parallel to the bedding plane indicate no special trend with rank. The perpendicular susceptibility of anthracite is significantly higher than its parallel susceptibility; that is, anthracite shows significant magnetic anisotropy, Measurements along two axes in the bedding plane, with anthracite and semianthracite, indicate no anisotropy. In every instance the perpendicular susceptibility is slightly higher than the parallel susceptibility, the difference being very small except for anthracite.

These results are in good agreement with others (*1*) from British coals.

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References

1. W. A. Wooster and N. Wooster, in *Proc. Conf. Ultrafine Structure of Coals and Cokes, London, 1943* (British Coal Utilization Research Assoc., London, 1944), p. 322.
2. H. Honda and K. Ouchi, *Fuel* **36**, 159 (1957).
3. J. T. McCartney and S. Ergun, *Fuel* **37**, 272 (1958).
4. ———, *Nature* **205**, 962 (1965).

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Radioactive Wastes from Fusion Reactors

Abstract. *Calculation of the amount of tritium released from a hypothetical fusion reactor shows that it is* 2×10^{4} *the amount released by generation of an equivalent amount of electricity by a fission reactor. Release of the tritium generated by a power economy, if the nuclear power were all fusion, would result in unacceptable worldwide dosages by the year 2000.*

Although fusion reactors are still far from being operational, the long-term future for power generation is in breeder-fission or fusion reactors, and "the prospects for economic fusion power seem brighter today than in recent years" (*1*). In addition to the limitless supply of fuel and the low cost of the energy produced, one of the most attractive features of fusion reactors is the promise that they "would be free of radioactive waste" (*2*). When one recognizes that the usual spectrum of fission products will not be present, and that induced activity in the structural components of the reactor will be minor compared with the fission-product activity produced in a fission reactor, the most important aspects with respect to wastes are those dealing with the neutron economy and the tritium inventory and losses in a D-T-type reactor.

The debate over the feasibility of generating sufficient tritium and neutrons internally seems to have been resolved with publication of the Massachusetts Institute of Technology studies (*3, 4*). For the configuration investigated, it is stated that "It is evident that tritium breeding with sufficient margin to allow for all anticipated losses can be achieved in physically practical blanket configurations by using present available materials and techniques. Thus the basic question of the feasibility of D-T fusion reactors from the point of view of tritium regeneration appears to be favorably re-