To maximize the displacement, the magnetic disturbance field is assumed perpendicular to the average or undisturbed field. Consider first the case where the disturbance at all levels equals its value measured at the surface ; this implies a very extensive current source in the ionosphere. In this case it can be shown that the displacement of a field line, in the auroral zone, at 1,000 km. above the conducting core, is about $0 \cdot 015\ \Delta$ km., where Δ is the disturbance in γ (10^{-5} gauss) units.

In the case of more localized ionospheric currents Δ increases with altitude, and the overall effect of this, for a given surface value of the disturbance, is to give a smaller displacement than that above. Consider an overhead cylindrical current causing the disturbance. Then Δ is (A/d), d being distance from the current and A a constant. Therefore, Δ is less than (A/h) where h is the vertical component of d. Taking Δ as (A/h) the desired displacement of a line in 1,000 km. height can readily be found, and it increases slowly as the current diameter is reduced. For a current of diameter greater than about $0 \cdot 1$ km. the calculated displacement is less than the $0 \cdot 015\ \Delta$ km. found before. But for such small diameters, replacing (A/d) by (A/h) causes a gross overestimate of the displacement ; and furthermore, ionospheric currents have a much larger scale than $0 \cdot 1$ km. Adding the disturbance due to the induced current in the core does not alter this result.

Thus the displacement of $0 \cdot 015\ \Delta$ km. (Δ in γ) is an upper limit to the movement of auroral phenomena due to field distortion. This distance is very small. It equals 50 km. (almost $\frac{1}{2}°$ of latitude) only if Δ has the extreme value of $3{,}300\gamma$; while if Δ is less than $1{,}300\gamma$, as in most magnetic storms when the K index does not exceed 7, the displacement is less than 20 km. Only by very slow changes, such as those with the period of the sunspot cycle, can the lines of force be moved through great distances at low altitudes.

Observations of the radiation points of auroral coronæ[4] show that the displacements of the field lines between the Earth's surface and the auroræ are well within the limits expected from the foregoing.

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GEOCHEMISTRY

High-pressure Phase Transformations in Laboratory Mechanical Mixers and Mortars

THE mechanical action of simple laboratory grinders, mortars and similar devices has occasionally been used to assist in chemical reactions in addition to performing their primary physical functions. Among these chemical reactions are phase transformations. That the effect is due to some kind of a pressure component in the mechanical action may appear obvious, but the magnitude of the pressures is not readily appreciated, nor can it be calculated or measured. However, in the course of work in this laboratory on the high-pressure polymorphism of lead dioxide (PbO_2), the information that a phase identical with the new high-pressure polymorph, which had been shown to be stable only in the region above 10,000 bars, had been formed by simple grinding[1] was noted with no little surprise. The observation was promptly confirmed by grinding a small amount (2 gm.) of the common rutile form (I) of lead dioxide in a mechanical mortar and pestle combination of laboratory pattern. Grinding in air for a few hours converted an estimated one-third to the denser orthorhombic form (II). After preliminary work, it transpired that nothing new in principle had been added to some similar results which had been reported by Burns and Bredig[2] on the transformation of calcite to aragonite by grinding in a mortar. The high-pressure phase was formed from the low-pressure one, the amount of change was dependent on time, and subsequent heating would form the low-pressure phase. A significant difference is that phase equilibrium and thermochemical studies[3] place the calcite–aragonite transformation at about 3,000 bars at room temperature, which is considerably lower than the 10,000 bars necessary for the lead oxide I⇌II transformation.

The obvious question that arises is whether or not the high-pressure types are actually being formed in their field of stability, or whether the shearing stresses so dominant in such an environment either alter the relative free-energy relations of the two forms or permit metastable nucleation of the high-pressure phase. Therefore, other substances with known *p–t* relationships between polymorphs (work in this laboratory, with L. Azzaria and W. B. White) were chosen for further study : MgF_2, BeF_2, SiO_2, PbO, Sb_2O_3, B_2O_3 and $BAsO_4$. Their transition pressures at room temperature (extrapolated from our equilibrium data obtained at higher temperatures) are near 9,500, 15,500, 13,500, 5,500, 10,000, 18,500 and 30,000 bars respectively. It was found that grinding for several hours in the mortar assembly under air or nitrogen (where oxidation was a possibility) would produce varying amounts (as determined in every case by X-ray diffraction) of the high-pressure phases of PbO, PbO_2, $CaCO_3$, MgF_2, Sb_2O_3 and BeF_2 (questionable) in decreasing order. Also of new but related interest is our finding that the 'quenchable' transitions in calcium carbonate and lead dioxide and in many other selected phases could be effected (partially), in a few minutes to 2 hr., by the action of a small rapidly vibrating mixer-grinder. The type used (trade name 'Wig-L-Bug') is common in spectroscopic laboratories and was used with a metal vial and ball and 50–100 mgm. of sample. Furthermore, it was found that the same (*vide supra*) relative effectiveness in forming detectable amounts of the high-pressure phases was evident in the action of the 'Wig-L-Bug'. Of the highest-pressure phase, BeF_2 (cœsite), only a trace was formed. Making allowances for the very sluggish nature of the quartz-cœsite transition of silica and the more complex relation[4] and serious hydration problem in the new high-pressure B_2O_3 polymorph, it appears that pressures in the region of 10–20,000 bars are being

(*Continued on p.* 71)