band. The solvent carries the solute downward as it moves along the axis of the column. It is assumed that a rapid equilibrium is established between the solute and adsorbent and that radial gradients are negligible.

Assume that a small volume of solvent, ΔV, is poured through the band, which carries the adsorbed solute downward in the column. A material balance on solute over a differential column height of ΔX yields

$$\begin{pmatrix}\text{total rate of}\\ \text{solute removal}\\ \text{from solvent}\end{pmatrix} = \begin{pmatrix}\text{rate of solute}\\ \text{removal in}\\ \text{void space}\end{pmatrix} + \begin{pmatrix}\text{rate of solute}\\ \text{removal in}\\ \text{solid phase}\end{pmatrix}$$

$$-\left[\left(\frac{\partial C_L}{\partial X}\right)\Delta X\right]\Delta V = \varepsilon A\,\Delta X\left(\frac{\partial C_L}{\partial V}\right)\Delta V + A\,\Delta X\left(\frac{\partial C_S'}{\partial V}\right)\Delta V \tag{11.74}$$

where C_S' is the amount of adsorbed solute per unit volume of column. Further simplification of eq. 11.74 yields

$$\frac{\partial C_L}{\partial X} + A\left(\varepsilon\frac{\partial C_L}{\partial V} + \frac{\partial C_S'}{\partial V}\right) = 0 \tag{11.75}$$

In the simplest case, the amount of solute adsorbed per unit volume of column is closely related to the adsorption isotherm of the solute.

$$C_S' = Mf(C_L) \tag{11.76}$$

where M is amount of adsorbent per unit volume of column (mg/ml) and $f(C_L)$ is the adsorption isotherm or amount of adsorbed solute per unit amount of absorbent, which is a function of C_L. By substituting the derivative of eq. 11.76 into eq. 11.75, we obtain

$$-\frac{\partial C_L}{\partial X} = A[\varepsilon + Mf'(C_L)]\frac{\partial C_L}{\partial V} \tag{11.77}$$

Substitution of $\partial C_L/\partial X = (\partial C_L/\partial V)(\partial V/\partial X)_c$ into eq. 11.77 yields

$$\left(\frac{\partial V}{\partial X}\right)_c = A[\varepsilon + Mf'(C_L)] \tag{11.78}$$

Integration of eq. 11.78 from $X = X_0$ to $X = X$ and $V = V_0$ to $V = V$ yields

$$\Delta X = \frac{\Delta V}{A[\varepsilon + Mf'(C_L)]} \tag{11.79}$$

Since ΔV, A, ε, and M are constants, ΔX is determined by $f'(C_L)$, which is the derivative of $f(C_L)$, or the adsorption isotherm. That is, the location of the solute band formed is mainly determined by the adsorption characteristics of a particular solute on an adsorbent. When the solvent contains two components, I and J, the solutes form two distinct bands at different axial distances, depending on their adsorption characteristics (see Fig. 11.29).

If we define L_I as the distance traveled by solute I, L_S as the distance traveled by solvent above the adsorption column ($\Delta V/A$), and L_C as the penetration distance of the sol-