**Anomalous Atmosphere?**

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<th>Earth</th>
<th>Mars</th>
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<td>$\text{H}_2\text{O}$</td>
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<td>0.00001</td>
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Gas Exchange Between Leaves and the Atmosphere
Evolution of the atmosphere and land plants in the Paleozoic


Root Systems

FIGURE 9-10 Forms of roots and root systems.
Rooting Depth

Effect of Compaction on Root Growth
Roots Growing in a Forest Soil
More Roots
CO2

O2

Diffusion

Mass flow

Root interception

Soil particle

(Diagram courtesy of R. Weil)
Soil Air

• In general, soil air contains more CO₂ and less O₂ than the atmosphere. These differences are seasonal and increase with depth.

• Soil air is almost saturated with water vapor (relative humidity ~100%). It may also contain variable amounts of volatile contaminants.
Air Movement in Soils

Figure 7.2 The process of diffusion between gases in a soil pore and in the atmosphere. The total gas pressure is the same on both sides of the boundary. The partial pressure of oxygen is greater, however, in the atmosphere. Therefore, oxygen tends to diffuse into the soil pore where fewer oxygen molecules per unit volume are found. The carbon dioxide molecules, on the other hand, move in the opposite direction owing to the higher partial pressure of this gas in the soil pore. This diffusion of O2 into the soil pore and of CO2 into the atmosphere will continue as long as the respiration of root cells and microorganisms consumes O2 and releases CO2.
Field Measurements: CO$_2$ and Temperature
Concentration of CO$_2$ in the Soil Atmosphere

• Related to respiration by bacteria, fungi, protozoa and other chemo-heterotrophs.
• Several experiments found that temperature is between 2-5 times more important than water content in determining concentrations of CO$_2$ in soils.
• An empirical equation relates log (PCO$_2$) and Actual Evapotranspiration (AET):
Empirical Prediction of PCO$_2$

- The model predicts that at AET~0 the PCO$_2$ is atmospheric.
- At high values of AET of about 2000 mm the model predicts a log PCO$_2$ of about -1.50.

Figure 4.12. Map of soil CO₂ pressure produced with the relationship shown in Figure 4.11 (Brook et al., 1983. Reprinted by permission of John Wiley & Sons, Ltd).