Mapping the periodic landscape of elements

When you stand too close to a painting by Monet or Van Gogh, the overall image seems to vanish in a thicket of individual brush strokes. Scientists who have habitually pressed their noses against chemistry's best-known icon — the flat periodic table of elements — may similarly have missed a third dimension that transforms the table into a more informative landscape, says theoretical chemist Leland C. Allen of Princeton (N.J.) University.

Allen's suggestion of a 3-D periodic table springs from his reinspection of a fundamental, much used, yet fuzzily defined chemical concept known as electronegativity, which Linus Pauling introduced in 1932. Pauling, who now heads his own research institute in Palo Alto, Calif., describes electronegativity as "the strength at which an electron is held by an atom in a bond." Chemists use the electronegativity values of various elements to determine whether atoms or groups of atoms will combine, and if so, what kinds of bonds — ionic, covalent or metallic — will form between them.

Allen prefers to think of electronegativities as "configuration energies" that collectively represent a third dimension of the periodic table. In the standard two-dimensional view, the table's row (horizontal) dimension specifies the number and arrangement of bonding electrons that occupy an element's outer, or valence, electronic shells, the region of all chemical bonding. The column (vertical) dimension corresponds to the size of these shells, which depends on the total number of shells an element has.

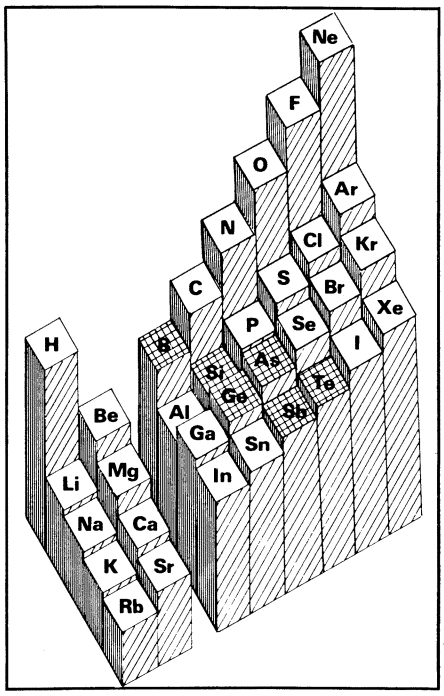
When configuration energies emerge as a third dimension, the periodic table "comprise[s] the small set of rules and numbers that help rationalize the observed properties of the 10 million known compounds," Allen writes in the Dec. 6 Journal of the American Chemical Society. The proposed conceptual integration should improve the table's performance as a chemical pattern recognition scheme, he says.

To determine an element's configuration energy, Allen uses readily available, high-precision values of the element's ionization energies. These values correspond to the amounts of energy required to remove bonding electrons from an atom's valence electron shells. Plugging them into an equation yields the element's configuration energy. Allen says scientists can use configuration energy in more complex calculations for predicting how specific chemical reactions might proceed.

Since Pauling first presented his electronegativity scale, others have proposed quantitative refinements of individual values or different definitions of electronegativity. Some of these amendments have stuck, but Pauling's values remain among the more widely used. Although several theoretical chemists say Allen's configuration-energy concept offers a thought-provoking perspective on electronegativity, they remain unconvinced that it will prove more useful than standard values and definitions of electronegativity.

"He has an interesting idea for extending the periodic table, but I'm slightly skeptical about it," comments Roald Hoffmann of Cornell University in Ithaca, N.Y. Robert G. Parr of the University of North Carolina at Chapel Hill also reserves judgment on Allen's arguments. Parr, who has developed a rival method for deriving electronegativity values, says the scientific community will eventually decide which definition of electronegativity reveals the most about chemical bonding.

Allen says he expects a rough reception for his idea because the concept of electronegativity is so central to modern chemistry. However, he stresses that his definition, unlike most others, explicitly recognizes the periodic table's intrinsic energy dimension. In practice, he adds, many chemists have culled information from this dimension without acknowledging its existence. — *I. Amato*



Allen/JACS

Three-dimensional depiction of an abridged periodic table, with the height of the elements corresponding to Allen's newly defined configuration energies.

Magnetic signal preceded October quake

Weeks and hours before the Loma Prieta earthquake ruptured the San Andreas fault on Oct. 17, a nearby instrument recorded highly unusual changes in the Earth's magnetic field, according to a group of atmospheric researchers led by Antony C. Fraser-Smith from Stanford University. The finding renews hope that scientists may one day provide short-term warnings of an impending earthquake.

The Stanford magnetometer monitors ultra-low-frequency (ULF) variations, between 0.01 and 10 hertz, in the intensity of the magnetic field. Ordinarily, these variations result from solar magnetic storms and other effects high in Earth's atmosphere, says Fraser-Smith.

On Oct. 5, the instrument detected an increase in ULF intensity. Then, three hours before the main shock, the signal suddenly gained strength, reaching about 30 times the normal level. Such levels were unprecedented in two years of measurement, Fraser-Smith and his colleagues reported last week at a meeting of the American Geophysical Union in San Francisco.

Fraser-Smith says the strongest signal is undoubtedly related to the quake. He speculates that water movement underground or pressure on certain minerals could have generated voltages that would alter the magnetic field in the ULF band. For years, researchers have searched for such magnetic signals before a tremor, but most have monitored other frequencies (SN: 9/12/87, p.167).

He cautions, however, that the weaker intensification 12 days before the main shock may represent something unconnected with the quake. Unusual atmospheric processes could have have caused those variations, he says, though he has not heard of any such events occurring at that time.

The magnetometer is located near Corralitos, a remote area about 7 kilometers from the epicenter of the magnitude 7.1 quake, which broke the San Andreas fault in the Santa Cruz mountains (SN: 12/9/89, p.374). The instrument's proximity to the fault was pure chance: In order to escape electromagnetic noise from cities, Fraser-Smith had moved it to a site near the home of the sister of one of his students.

The device did not record any signal preceding the magnitude 5.2 earthquake that struck the same section of the San Andreas in August. But that quake — which released roughly one-seven-hundredth the energy of the October main shock — may have produced a signal too weak to show up on the monitor. — *R. Monastersky*