with RNA polymerase II. Analysis of yeast Mediator bound to RNA polymerase II reveals intimate contacts between the two complexes, with RNA polymerase II in a globular conformation and Mediator covering it like a hat (*11*). Intriguingly, the carboxyl-terminal domain of RNA polymerase II induces a conformation in CRSP resembling that of CRSP-VP16 (*12*), suggesting a related effect of RNA polymerase II and VP16 on transcription. Moreover, despite their different structures, CRSP-VP16 and CRSP-SREBP performed identically in the Taatjes *et al.* transcription assay. Thus, the structures of ARC-L and CRSP do not disclose precise molecular downstream pathways. In addition, no data exist about the influence of the rest of the transcriptional machinery on the conformations of ARC-L and CRSP. It is also unclear whether ARC-L is a negative regulator of transcription like NAT (*12*) or a positive regulator that provides a docking site for RNA polymerase II (see the figure). Importantly, the new work suggests an unexpected level of specificity in transcriptional control that is established through conformational differences in Mediator-like complexes induced by activators. This points to versatile ways in which these cofactor complexes could exert effects on chromatin and on transcriptional activity.

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PERSPECTIVES: GEOCHEMISTRY

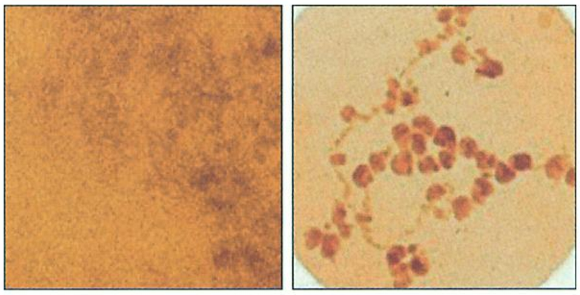
The Fate of Chlorine in Soils

W. H. Casey

The Irish noun "leannán" has two definitions: a lover or sweetheart and a chronic irritating affliction (*1*). Geochemists could use such a word to describe the degradation products of natural organic matter. These products are complicated polyelectrolyte macromolecules called humic and fulvic acids that control much of the reactivity of soil, including its fertility. Yet they also bind and disperse toxic metals such as plutonium in natural waters. Furthermore, large humic acids contain hydrophobic regions that dissolve aromatic organic compounds such as organohalogen pesticides, which are normally insoluble in water. They are thus key vectors for dispersing contaminants throughout natural waters.

Despite their obvious importance, little is known about humic and fulvic acids. They have no fixed stoichiometry or structure, cannot be crystallized, and are famously difficult to characterize reproducibly. In recent years, brilliant x-ray sources, in situ imaging methods, and nuclear magnetic resonance spectroscopies have begun to shed some light on their properties. On page 1039 of this issue, Myneni (*2*) elucidates their interaction with chlorine.

In 1999, Myneni *et al.* (*3*) used an x-ray microscope to provide the first in situ images of the macromolecules in various solutions and soils (see the figure). They showed how the molecules coil and relax depending on the composition of the solution and their proximity to a mineral surface. Myneni (*2*) now uses another synchrotron method to document changes in the chemical state of chlorine in humic materials and in leaf litter in soil throughout the year. He confirms the startling conclusion (*4*, *5*) that organochlorine compounds are common in soil and that there is a net transfer of chlorine from inorganic to organic forms with weathering. This stunning result has important social and scientific implications.


Fluvial fulvic acid in uncoiled (left) and coiled form (right) (*3*). The average sizes of globular coils are on the order of 300 nm^3.

Myneni's real breakthrough is the application of a simple, elegant, and nondestructive method to follow the reactions. Previous workers used extraction methods to show chlorination of aromatic moieities in soil, but their techniques were usually indirect and tedious. Myneni uses the position of the x-ray absorption edge for chlorine in the bulk soil or organic debris. This position is sensitive to the electronic structure and molecular environment of chlorine without extensive sample preparation. Applied to leaf litter, it records an evolution from inorganic chloride ion (Cl^-), which dominates in fresh leaves, to chlorinated hydrocarbons and aromatic products in decomposed (humified) material in soils.

The chlorination of aromatic organics by hydrogen peroxide is thermodynamically favored (*6*) but kinetically impeded. Myneni's results indicate that an abundant catalytic peroxidase facilitates this reaction in soils, as has been suspected (*4*, *5*). The results, when considered along with those of previous workers, clearly show that chlorination of organic compounds in humic materials is widespread and may account for the puzzling organochlorine concentrations found in unpolluted environments.

Myneni's results are not perfect. Because he cannot derive a mass balance for chlorine from the spectra, it remains unclear whether the organic molecules are really progressively chlorinated during humification or whether the signal from the chloride ion is simply reduced with time by aqueous leaching of the chloride ion from the plant material so that the relatively insoluble organochlorines, either natural or anthropogenic, become more conspicuous with time. This issue has been addressed before (*4*, *5*) and will be worked out soon by coupling x-ray spectrometry to traditional bulk methods of analysis.

The importance of understanding these reactions cannot be overstated. Halogenated organics are ubiquitous in our lives and are usually used to our benefit. Even DDT is still used in acutely malarious countries to reduce infant mortality (*7*), and it would be monstrous to deny populations use of a chlorinated pesticide without providing an effective replacement. Evident too, however, are the considerable environmental dangers of some of these compounds (*8*).

In his exceptionally well-researched polemic against organochlorine molecules and the chlorine industry, Thornton (*9*) argues that anthropogenic organochlorine compounds should be banned outright because of their deleterious effects to health and because of their dispersion and persistence in the environment. Thornton's

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view is extreme, but it is clear that too little is known about halogenation of organic matter in soil and the fate (and toxicity) of the resulting compounds. Myneni accomplishes the redirection of the scientific focus away from the toxicology of anthropogenic chemicals toward understanding the natural cycle of this very common element, chlorine, which is both a sweetheart and an affliction.

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PERSPECTIVES: ASTRONOMY

Demotion Looms for Gamma-Ray Bursts

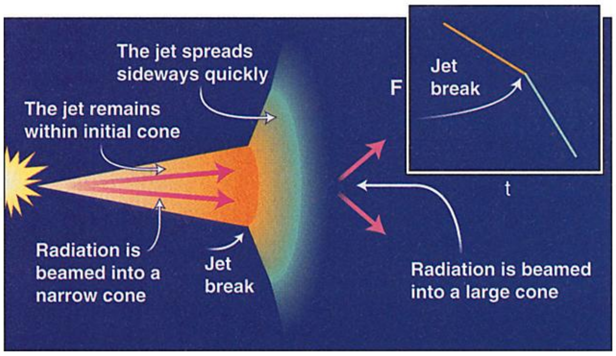
Tsvi Piran

Several times a day, a short burst of gamma rays (GRB) reaches Earth from outer space. The high-energy bursts last a few seconds and arrive from random directions in the sky. Because of their short duration, the exact location of the emitting sources could not be pinned down until the BeppoSAX satellite discovered in 1997 that GRBs are followed by an x-ray afterglow lasting several days. The exact positions given by the satellite enabled optical and radio astronomers to detect optical and radio afterglows lasting days to months. The host galaxies could be identified once the afterglows had faded.

Redshift measurements of the host galaxies revealed that GRBs are associated with an enormous energy output. In one extreme case, GRB990123, an energy output of more than 10^{54} ergs was estimated, comparable to the rest mass energy of a star. An energy output of this magnitude could not be explained with existing models, leading some researchers to talk about a GRB energy crisis.

It turns out that the reality is more mundane. Last November, three groups reported at a workshop at Woods Hole (*1*) that the initial energy estimates for GRBs were too high. The actual GRB energy is narrowly distributed around a "mere" $\sim 10^{51}$ ergs. The secret lies in beaming: The earlier energy estimates assumed isotropic emission, but GRBs form beams, some with an opening angle of only a few degrees. The wide distribution of observed fluxes and apparent luminosities results mostly from variations in these beaming angles.

According to the common fireball model (*2*, *3*), a GRB begins when a compact "central engine" accelerates relativistic flow to a velocity close to the speed of light. The kinetic energy of this flow is dissipated by shocks within the flow, producing the observed gamma rays. But these internal shocks do not dissipate all the available energy. External collisions with surrounding matter (interstellar matter or material ejected earlier from the progenitor) slow down the flow that still carries away a large fraction of the initial kinetic energy. The resulting external shocks produce the afterglow. Connaughton (University of Alabama, Huntsville) described observations showing the transition from a GRB phase to an afterglow phase in GRB991216, confirming this picture (*4*).



Beamed emission. A relativistic jet with a Lorentz factor γ and an opening angle θ moves forward until its Lorentz factor $\gamma = \theta^{-1}$. Then it expand sideways rapidly, resulting in a "jet break" in the light curve. A schematic light curve is depicted at the top right.

Relativistic time delays cause a jetted relativistic flow to move initially forward without sideways expansion. Later, during the afterglow phase, the flow slows down and then suddenly expands sideways (see the first figure). This transition produces a pronounced monochromatic "jet break" in the afterglow light curve, as observed in GRB 990510 (*5*, *6*). The timing of the jet break depends on the jet's opening angle—narrower jets have earlier jet breaks. Afterglows thus provide information on the opening angles of the jets.

An immediate prediction of this model is that we should observe orphan afterglows—optical or radio afterglows with no gamma-ray counterparts. This will happen when the narrow gamma-ray beam points away from us but the wider optical and radio emission can be seen on Earth. In fact, we expect to see far more orphan afterglows than bursts. Yet only one tentative observation has been reported so far. Vanden Berk (Fermilab, Batavia, IL) reported on the discovery of a mysterious optical transient in the Sloan Digital Sky Survey (*7*). The transient source was 100 times brighter than a supernova. It could be the first "orphan optical flash" because it was apparently not seen by the GRB detectors on the satellites BeppoSAX and Compton-GRO (which was still operational during this observation).

Sari (California Institute of Technology, Pasadena, CA) reported an analysis of the emitted gamma-ray energy for a sample of 17 bursts with known redshift. Sari and collaborators (*8*) have estimated the jet opening angles for these bursts from the afterglow data. When these angles were considered in the energy estimates, the gamma energy was narrowly distributed around $\sim 5 \times 10^{50}$ ergs. Panaitescu (Princeton University, Princeton, NJ) and Kumar (Institute for Advanced Study, Princeto, NJ) presented a different analysis (*9*). Using the multiwavelength afterglow light curves and spectra, they have modeled the afterglow emission and estimated the relativistic kinetic energy during the afterglow phase. They find that the kinetic energies are narrowly clustered around $\sim 3 \times 10^{50}$ ergs.

A third independent analysis supports these surprising results. Piro (Istituto di Astrofisica Spatiale, Rome) reported that the observed x-ray fluxes of 21 BeppoSAX afterglows at a given time after the burst are also narrowly distributed. We have found that according to the fireball model (*10*, *11*), these

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