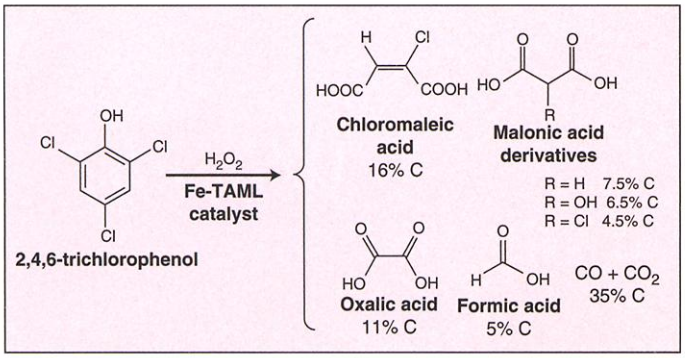

Efficient oxidation. The new catalyst described by Sen Gupta *et al.* breaks up the persistent pollutant TCP into smaller, acyclic products, which can be consumed by microorganisms. The catalyst shows similar activity for another persistent pollutant, pentachlorophenol.

tives are produced during this efficient oxidative degradation. (The remaining 13% are incorporated into other nonidentified minor products.) Furthermore, 83% of the chlorine atoms of TCP are released in the reaction mixture as (benign) free chloride. Another 12% of the chlorine atoms are incorporated into chlorinated products; 5% are unaccounted for.

These data confirm the efficiency of this catalytic method compared with degradation by microorganisms. Biodegradation of these chlorinated phenols is very slow, with only 20 mg/liter of TCP degraded by *Phanerochaete chrysosporium*, a white rot fungus, in 15 days (*6*). Slow microbial mineralization of TCP has also been observed in soil (*7*). An efficient catalytic chemical method for the oxidative degradation of chlorinated phenols, such as that reported by Sen Gupta *et al.*, is therefore highly welcome for treating industrial wastewater before it is released.

This catalytic method is complementary to other methods currently used in the elimination of wastes. Incineration requires high temperatures and long residence times for the full destruction of chlorinated aromatics. Supercritical water oxidation requires high temperatures (450° to 500°C) and high pressures (240 to 300 atmospheres). Wet air oxidation (partial oxidation), chemical or electrochemical treatments, and photodegradation processes (which usually occur with low quantum yields) must also be improved.

The fact that the simple, nontoxic iron complex of Sen Gupta *et al.* can, assisted only by hydrogen peroxide, catalyze the nearly complete degradation of recalcitrant chlorinated aromatic pollutants into biocompatible ring cleavage products makes it a true "green oxidant." Further work will elucidate details of the mechanism of the activation of hydrogen peroxide by these Fe-TAML complexes.

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PERSPECTIVES: PLANETARY SCIENCE

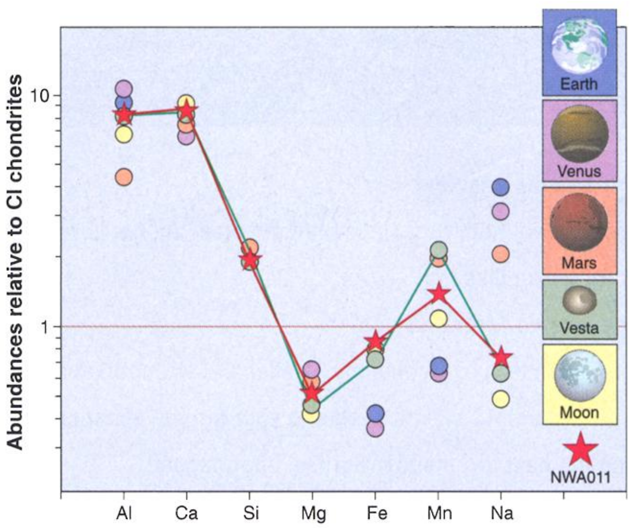
A New Solar System Basalt

Herbert Palme

The year 1969 was exceptional for research on extraterrestrial samples. On 8 February, the Allende meteorite fell. The Ca, Al-rich inclusions in this meteorite are the oldest objects known to date, preserving the signatures of the primordial solar nebula from which the planets formed. Analysis of samples from this meteorite prepared laboratories worldwide for the study of lunar samples brought back to Earth in July of the same year. On 28 September 1969, the Murchison meteorite was observed to fall in Australia, providing the first convincing evidence of amino acids of extraterrestrial origin. Also in the same year, a Japanese expedition recovered nine dark rocks, later identified as meteorites, from the ice fields of Antarctica.

Since then, thousands of meteorites have been recovered from Antarctica. It was soon recognized that the large desert areas of the world are also huge reservoirs of meteorites. Today, more than 20,000 meteorites are known, about 10 times more than before 1969. Many are scientifically unexciting ordinary chondrites, but some represent extremely rare types. In 1981, an American expedition recovered an inconspicuous meteorite weighing just 31.4 g; it turned out to be a piece of the Moon. More than 20 lunar samples have now been found, and about as many are thought to be martian samples.

The author is in the Institut für Mineralogie und Geochemie, Universität zu Köln, Zülpicherstrasse 49b, 50674 Köln, Germany. E-mail: palme@gwp-min.min.uni-koeln.de



Similar, but not the same. The major element compositions of basalts from Earth, Venus, Mars, Vesta, and the Moon are compared to that of the new basaltic meteorite, NWA011 (*4*). The patterns for Al, Ca, Si, and Mg are remarkably similar. Low Fe in terrestrial basalts indicates a large core. Large variations in Na reflect differences in initial volatile element inventory. NWA011 data from (*1*), all other data from (*5*).

On page 334 of this issue, Yamaguchi *et al.* (*1*) further expand the list of unusual meteorites. They describe a new type of basaltic meteorite, NWA011 (*2*), recently found in the Sahara. Its texture, mineralogy, and chemical composition are similar to terrestrial or known extraterrestrial basalts, implying that this meteorite is a piece of a frozen melt flow on the surface of a planet or planetesimal. Yet, there are also some important differences.

The four inner planets—Mercury, Venus, Earth, and Mars—and the Moon were all more or less completely molten early in their history. They have FeNi metal cores, Mg-rich mantles, and Al-, Ca-, and Si-rich crusts. The first melt that forms when a planetary mantle is sufficiently heated is chemically different from the bulk mantle composition. It is rich in Al_2O_3, CaO, Na_2O, and SiO_2 and poor in MgO, and will rise to the surface of the planet to form the crust. Planets that underwent core formation and partial mantle melting are "differentiated." (Mantle melting is an ongoing process on a large planet such as Earth.)

Most iron meteorites are cores of differentiated planetesimals. Samples from the mantle or crust of these bodies are not known. There is, however, good evidence that we have meteorites representing the crust of the only known large differentiated object in the inner solar system apart from the terrestrial planets and the Moon: the asteroid Vesta (520 km diameter).

The major element composition of basalts from the Moon, Mars, Venus, Vesta, and Earth are quite similar, except for Na, and to a lesser extent Fe (see the figure). The large variations in Na among basalts of the terrestrial planets (see the figure) reflect a correspondingly large range in the initial volatile element endowment of the planets. Variations in FeO resemble different fractions of oxidized (FeO) and reduced (metallic) Fe in the planets. Comparison with NWA011 (*1*) shows that the major element composition of NWA011 resembles that of basaltic meteorites (eucrites) from Vesta (see the figure). On the basis of this evidence alone, one might conclude that NWA011 is a basalt from Vesta, but this conclusion would be premature.

Yamaguchi *et al.* report that the isotopic composition of oxygen in this meteorite is completely different from that of eucrites. Some variation in the oxygen isotopic composition of samples from a single planet is to be expected, but these variations follow certain trends and are predictable. For example, the increase in ^{18}O over ^{16}O relative to a terrestrial standard should be about twice that of the $^{17}O/^{16}O$ increase. The oxygen isotopic composition of NWA011 does not follow the trends expected for eucrites. The planet or planetesimal from which NWA011 originated has substantially more ^{16}O than does Vesta. Yamaguchi *et al.* conclude that the meteorite comes from an unknown, differentiated planetary object.

A closer look at the major and trace element composition of NWA011 and eucrites shows that despite the similarities, including relatively high Mn contents (see the figure), there are also important differences. NWA011 has a very different rare-earth element pattern, with low rare-earth element content but a pronounced positive Eu-anomaly. Furthermore, the NWA011 meteorite has the highest FeO content of all basalts shown in the figure, and its Ni and Co contents are higher than those of eucrites, while Cr is lower. The high Ir content of NWA011 is unique for a basalt and requires explanation.

These chemical characteristics are inconsistent with NWA011 being a simple partial melt from any planetary mantle. It must have had a more complicated origin involving extensive melting, crystallization, and mixing, but without losing the basaltic major element composition. The high FeO content of NWA011 (see the figure) indicates that its parent planet can only have a small core. A large fraction of the bulk Fe content of the planet is oxidized, contrary to Earth with its large Fe core and its low FeO content in the mantle.

The NWA011 meteorite has basaltic major element composition, mineralogy, and texture, but oxygen isotopic compositions and trace element concentrations rule out a relationship to known basalts of the inner solar system. Perhaps NWA011 is a basalt from Mercury. This is dynamically possible, although the yield is less than 1% of that of martian meteorites (*3*). A better knowledge of the chemical composition of the surface of Mercury is a prerequisite to identifying mercurian meteorites. Alternatively, a much smaller asteroid may have produced basalts of compositions that are so far only known from the larger bodies of the solar system.

References and Notes

1. A. Yamaguchi *et al.*, *Science* **296**, 334 (2002).
2. Named by the nomenclature committee of the Meteoritical Society. NWA stands for Northwest Africa.
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4. For Earth, the composition of midocean ridge basalts is plotted. Basalt compositions from the Moon, Mars, and Vesta are taken from an Apollo 12 basalt, the Shergotty meteorite, and eucritic meteorites, respectively. Venus data are from the Russian Venera 13 and 14 missions. All data are normalized to average solar system abundances represented by CI-chondrites. It is therefore assumed that all planets have the same bulk composition.
5. K. Lodders, B. Fegley, *The Planetary Scientist's Companion* (Oxford Univ. Press, Oxford, 1998).

PERSPECTIVES: IMMUNOLOGY

Pathogen Surveillance—the Flies Have It

Ranjiv S. Khush, François Leulier, Bruno Lemaitre

The ancient origins of the battles between infectious microbes and their hosts are illustrated by the similarities in frontline defense adopted by insects and mammals. In mammals, the innate immune system defines a rapidly induced first response to infection that directly activates host defenses and also stimulates the adaptive immune system. Insects share features of the mammalian innate immune response. In both groups, pathogens are recognized through interactions of stereotypical microbial structures with host proteins called pattern recognition receptors (*1*). Mammalian pattern recognition receptors include the Toll-like receptors (TLRs), so-called because they resemble the Toll receptor of *Drosophila*. The Toll receptor and the TLRs activate immune responses to infection that are regulated by the transcription factor NF-κB. However, unlike the TLRs, Toll does not interact directly with microbial compounds such as lipoproteins or peptidoglycans. Consequently, the identity of pattern recognition receptors in *Drosophila* has posed a compelling puzzle. This puzzle has been partly resolved with the reports by Choe and colleagues on page 359 of this issue (*2*) and Michel *et al.* in *Nature* (*3*). These investigators identify two peptidoglycan recognition proteins (PGRPs) in the fruit fly that are probable pattern recognition receptors for the insect innate immune response.

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The *Drosophila* Toll receptor signaling pathway was initially implicated in the specification of dorsoventral polarity during embryonic development. Subsequently, several components of this pathway were found to be necessary for resistance to fungal infection. Upon fungal infection, Toll proteins on the surface of fat-body cells (the insect equivalent of the liver) are activated by a proteolytically cleaved form of an extracellular cytokine-like protein, Spaetzle, which is present in insect hemolymph (blood). Interactions between Spaetzle and Toll trigger an intracellular signaling cascade that culminates in the nuclear translocation of two NF-κB–like transactivators, Dorsal and Dif, which induce expression of genes encoding antimicrobial peptides (*4, 5*) (see the figure). Similarities between the Toll receptor pathway and the interleukin-1 receptor pathway, which regulates

R. S. Khush is in the Department of Microbiology and Immunology, Stanford University School of Medicine, Stanford, CA 94305, USA. F. Leulier and B. Lemaitre are at the Centre de Génétique Moléculaire, CNRS, 91198 Gif-sur-Yvette, France. E-mail: lemaitre@cgm.cnrs-gif.fr