OLFR2 is expressed by multiple cell types within the aorta but was found to be most highly expressed in vascular macrophages (*1*, *4*). Although only ~30% of vascular macrophages expressed OLFR2 in mice, deletion of *Olfr2* or its downstream signaling mediators *Adcy3* (adenylate cyclase 3) and *Rtp1* and *Rtp2* (receptor transporter proteins 1 and 2) in hematopoietic cells led to a reduction in markers of plaque vulnerability (e.g., necrotic core in the vessel wall) that predispose to fatal complications, and an increase in collagen content (linked to plaque stability), indicating the potent role of OLFR2 signaling in macrophages on the atherosclerotic plaque. Moreover, despite the relatively low frequency of OLFR2^{+} vascular macrophages, delivery of exogenous octanal to atherosclerosis-prone *Apoe*-deficient mice led to about a twofold increase in plaque area. Together, these data indicate that octanal may signal through other olfactory receptors expressed by lesional cells and/or that OLFR2-expressing macrophages release proatherogenic signals that cross-talk with other cells in the plaque. This study, along with high-resolution single-cell sequencing of atherosclerotic plaques (*11*), further contributes to our understanding of the function of macrophage subpopulations and their influence on atherogenesis.

There remain some key unknowns regarding how octanal and its receptors function in the vessel wall. Is there another role for octanal, in addition to promoting inflammasome activation? It is possible that, similar to how odorants act as attraction or repulsion signals in the olfactory epithelium or sperm cells, octanal acts as a chemoattractant in the vessel wall. Are there additional sources of octanal, perhaps derived from diet or the environment? As large-scale omics studies continue to be used to identify additional genes associated with risk of cardiovascular-related death, and as their functions in the vessel wall are characterized, there is an opportunity to better understand atherosclerosis progression and derive new treatments. ■

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PLANETARY SCIENCE

Molten iron in Earth-like exoplanet cores

Iron crystallization in super-Earth interiors plays a key role in their habitability

By **Youjun Zhang**[1,2] *and* **Jung-Fu Lin**[3]

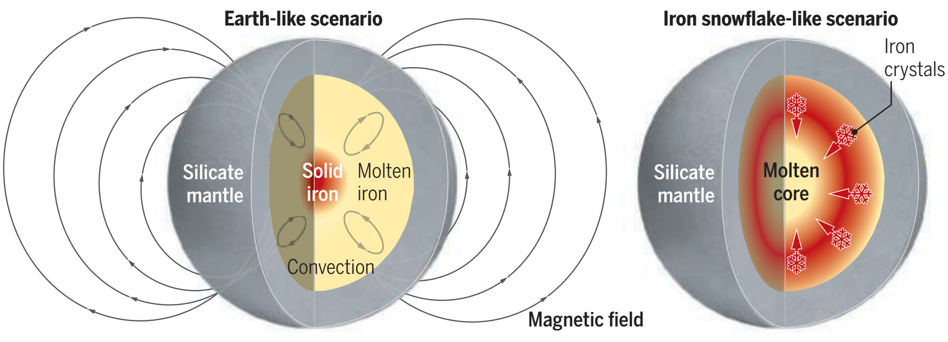
Earth, the only known habitable planet in the Universe, has a magnetic field that shields organic life-forms from harmful radiation coming from the Sun and beyond. This magnetic field is generated by the churning of molten iron in its outer core. The habitability of exoplanets orbiting other stars could be gleaned through better understanding of their iron cores and magnetic fields (*1*). However, extreme pressure and temperature conditions inside exoplanets that are much heavier than Earth may mean that their cores behave differently. On page 202 of this issue, Kraus *et al.* (*2*) used a powerful laser to generate conditions similar to those inside the cores of such "super-Earths" and reveal that even under extreme conditions, molten iron can crystallize similarly to that found at the base of Earth's outer core.

To date, more than 4500 exoplanets have been discovered, with approximately one-third of them categorized as Earth-like exoplanets (*3*). The discoveries of these exoplanets have raised hopes about finding habitable conditions beyond the Solar System and that exoplanetary habitability could be quite diverse in the Universe. Although surface water in a star's habitable zone has always been used as a qualifying condition for habitability, other key factors for habitability lie beneath the surface of the exoplanet, such as the property of its dynamo, a self-sustaining mechanism that generates a magnetic field (*4*).

Similar to Earth, super-Earths are thought to have formed through collisions and then differentiated into light silicate mantles and heavy iron cores. The iron cores were initially hot and molten but slowly lost heat to the silicate mantles. If core cooling is efficient, it can lead to iron crystallization, which releases energy. The cooling and solidification processes are thought to be the main sources of power that drives the convection of molten iron in the liquid core, generating magnetic fields through dynamo action, also known as magnetospheres. The pressure-temperature condition in which convection occurs is close to adiabatic, meaning that hot upwelling fluid follows a predictable temperature profile without heat gain or loss to the surroundings. Depending on the intersection relation between the iron melting temperature and the adiabatic profile under compression in a super-Earth's core, the molten cores can crystallize in two possible scenarios: either in an Earth-like "bottom-up" iron crystallization scenario or in an iron snowflake–like "top-down" scenario (see the figure). Bottom-up crystallization happens in the case of an iron melting curve steeper than the adiabatic pro-

Iron crystallization in super-Earth cores

Exoplanets with an Earth-like iron crystallization in their cores are more likely to possess and sustain a magnetic shield necessary for organic life-forms to exist. However, exoplanets with a higher content of light elements in the core may not have the internal condition necessary to sustain a solid core in the center and subsequently to sustain a magnetic shield over a long period.



GRAPHIC: N. DESAI/*SCIENCE*

file, which is expected to be very efficient in powering and sustaining a dynamo, whereas core dynamos driven by an iron snowflake–like regime may be more difficult to maintain over a long period (*5*).

Experimental determination of the crystallization scenarios in super-Earths' cores is critical in assessing their magnetic fields and habitability. However, previous laboratory techniques have been limited to relatively low pressure-temperature ranges so that extrapolation to super-Earth cores and theoretical predictions were used in existing models (*6*). Kraus *et al.* used a laser to mimic the high pressure-temperature conditions and monitored iron crystallization up to ~1000 GPa and concluded that the Earth-like "bottom-up" scenario is the more likely outcome for super-Earth cores with iron-rich Earth-like compositions. This crystallization can promote the convection of molten iron to generate magnetic fields surrounding super-Earths more readily than previously thought.

Iron in Earth's core is under extreme pressures that range from 136 to 360 GPa and temperatures from 4000 to 6000 K. The melting curve of iron was previously determined up to ~300 GPa by using static and dynamic compression techniques (*7–9*). The advance of ultrahigh-power lasers (such as the National Ignition Facility) allows scientists to create much higher pressure and temperature conditions. Controlling the duration of the laser power allowed Kraus *et al.* to generate higher pressures and moderate temperatures to reproduce iron melting and crystallization processes at super-Earth core conditions.

The melting curve of iron up to ~1000 GPa determined by Kraus *et al.* indicates a melting slope steeper than the expected adiabat in a super-Earth's core. For a super-Earth with ~1.5 times the radius and ~5 times the mass of Earth, the melting temperature at its topmost outer core is estimated to be ~8500 K at ~600 GPa (*2*). Considering a silicate mantle temperature of ~5000 K at its bottom (*10*), a big temperature gradient across the super-Earth's core-mantle boundary could be expected. Therefore, a large heat flow and thermal energy source are responsible for powering its molten iron convection (*11*). As the super-Earth cools, its adiabat first intersects the melting curve of iron at its center, resulting in a bottom-up core solidification. This is the same crystallization scenario happening in Earth.

The thermochemical and gravitational energy provided by these processes can sustain convection and dynamo within super-Earths for billions of years (*12*). By contrast, the iron snowflake–like scenario can occur in the cores of planets and exoplanets with possible substantial amounts of light element(s) that would lower its melting curve. In the snowflake-like scenario, a cooling planet's adiabat intersects the iron melting curve near the top-middle of the core, leading to iron crystals forming and sinking toward its center. This scenario has been proposed to occur inside Mars because of its lower melting temperature caused by the presence of lighter element(s) in its core (*5*, *13*).

When exoplanetary cores form, a certain amount of light elements—such as hydrogen, carbon, silicon, oxygen, and sulfur—make their way into the molten core (*14*). Their presence can depress the melting curve, influence the crystal structure stability of iron, and affect the output of thermochemical energy inside the core. Future experimental investigations of light element effects need to be taken into consideration in evaluating the dynamics of exoplanets at extreme conditions. Future investigation of the thermodynamic, transport, and rheological properties of silicate mantles and iron alloys at relevant super-Earth conditions can help us to better understand core dynamics, Earth-like mantle convection, and, potentially, plate tectonics. Detections of planetary magnetic fields outside of Earth's Solar System can be combined with laboratory measurements to infer exoplanetary interior processes and habitability. ■

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NEURODEGENERATION

A molecular view of human amyloid-β folds

Structures of amyloid-β fibrils suggest Alzheimer's disease–modifying strategies

By **Michael Willem[1]** *and* **Marcus Fändrich[2]**

One of the mysteries of Alzheimer's disease (AD) etiology is the folding of the amyloid-β 42 (Aβ42) peptide, which forms aggregates ranging from small soluble and likely neurotoxic oligomers to mature amyloid fibrils that form amyloid plaques (*1*). Aβ peptides are derived from sequential cleavage of amyloid precursor protein (APP). Two main types of Aβ deposits can be distinguished in patient tissue: parenchymal amyloid plaques consisting mainly of Aβ42 and vascular amyloid deposits containing the shorter Aβ40 peptide (*2*). Previous research using cryo–electron microscopy (cryo-EM) determined the structures of Aβ40 fibrils from post mortem human AD brain tissue (*3*). On page 167 of this issue, Yang *et al.* (*4*) describe the cryo-EM structures of Aβ42 fibrils that were extracted from the brain tissue of patients with different neurodegenerative diseases, including AD. These structures aid in understanding the development of amyloid diseases and may inspire strategies for disease-modifying therapeutic intervention or diagnosis.

Yang *et al.* discerned three fibril morphologies—types I, Ib, and II. Type Ib represents a dimeric version of the type I fibrils. Type I fibrils were found primarily in sporadic AD patient material, whereas the type II filaments were mainly associated with familial AD patients and other neurodegenerative disorders (e.g., frontotemporal dementia), as well as being found in an amyloidogenic mouse model. The three fibril morphologies were assumed to have a left-hand twist, which corresponds to that of in vitro fibrils from Aβ42 or Aβ40 peptides but differs from the right-hand twist of Aβ40 fibrils from AD brain tissue

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