Hence, bubble growth rate in undegassed Guinness beer is much lower, only about 1/50 that in undegassed Budweiser beer. Therefore, once released from a widget, the bubbles do not grow much at all in Guinness beer.

The rising velocity of bubbles depends strongly on the size of the bubbles. For example, a bubble with a radius of 0.5 mm rises in beer at 90 mm/s, but a bubble with a radius of 0.03 mm rises at only 1.0 mm/s. This is why in FIGURE 2, although bubble radius varies linearly with time, bubble speed increases with time. Because of their small size, the bubbles in Guinness beer rise slowly and hence can be entrained by downward flow if the downward flow velocity exceeds the small velocity of rising bubbles, which explains why in Guinness beer bubbles are often observed to sink.

The growth and rise of non-interacting bubbles are the focus of this article, but the growth and rise of interacting bubbles require more complex models. Furthermore, many bubbles in liquid can rise as a bubble plume. Bubbles can deform, oscillate, break up, and coalesce. The half-life of foam formed by collecting bubbles varies from beer to beer and from beer to champagne. The quantitative understanding of the rich phenomena will require much more work. Until then, enjoy your drink. Cheers!

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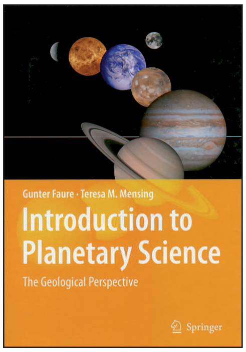
INTRODUCTION TO PLANETARY SCIENCE: THE GEOLOGICAL PERSPECTIVE[1]



Astronomy is rightfully abdicating much of the solar system to geology, as we learn more and more about the geological workings of planets and small bodies. This shift of a substantial quantity of scientific real estate is reflected in the appearance of planetary geoscience courses at many colleges and universities. The preface of this new textbook indicates that it is intended for use in capstone courses taken by senior undergraduate Earth science majors and possibly beginning graduate students. Until now, there has been no appropriate text available.

Introduction to Planetary Science: The Geological Perspective provides some historical background on solar system exploration, especially good sections on stellar evolution, nucleosynthesis, and orbital mechanics, and survey chapters on the solar nebula, the Sun, meteorites, and impact craters. Global-scale processes on the Earth are discussed very well (after all, Earth is a planet too). The terrestrial planets, the Earth's Moon, asteroids, the giant planets and some of their moons, Pluto–Charon and Kuiper Belt objects, and comets are all described in turn, as the chapters march through the solar system in order of increasing heliocentric distance (an organization that is logical and perhaps inevitable, but nonetheless feels encyclopedic). The book ends with interesting discussions of the origin and future of life on Earth and of the successful search for planets around other stars.

The authors, Gunter Faure and Teresa M. Mensing, have produced a book that is remarkably up to date, nicely illustrated, and written in an engaging style. An especially effective touch is that each chapter ends with one or more science briefs, introducing students to especially interesting topics in greater detail. I found no errors, except that refractory compounds in the nebula are described as having high melting temperatures rather than condensing at high temperatures from gas to solid form. Despite its strong points, and there are many, the readers of *Elements* may share some of my concerns. Contrary to the book's subtitle, its geologic perspective is not strong enough for my taste. Planetary mineralogy, petrology, and geochemistry are topics largely missing, although abundant data and interpretations are available for asteroids (meteorites), the Moon (lunar samples and orbital remote sensing), and Mars (meteorites, rover missions, and orbital data). The book contains few descriptions of the imaging, remote sensing, and geophysical techniques that have transformed planets into worlds shaped by familiar geologic processes. Planetary geomorphology fares much better, and there is little to criticize there, although additional information on planetary stratigraphic frameworks, crustal structures, and the methods of planetary geologic mapping would be of interest to geology students. The book's level is also uneven, given that the target audience is advanced geology majors; one might expect a capstone course to use mathematics of a higher level than rudimentary algebra, and might question whether explanations of the scientific method and Bowen's reaction series are necessary.

Those criticisms aside, the book presents an abundance of fascinating information about our cosmic neighborhood, in a form that is readily accessible to students majoring in Earth science. This text will significantly improve teaching and learning about planetary geoscience, and I will be using it for my own undergraduate course, supplemented with other readings.

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[1] Faure G, Mensing TM (2007) Introduction to Planetary Science: The Geological Perspective. Springer, Dordrecht, The Netherlands, 526 pp, ISBN-13 978-1-4020-5233-0, 79,95 Euros