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REVIEWS

Gravity Currents: In the Environment and the Laboratory. By J. E. SIMPSON. Ellis Horwood, 1987. 244 pp. £35.

The great mathematician and explorer of nature Andrei Nikolaevich Kolmogorov used to say to his disciples: before making a mathematical picture of a certain geophysical phenomenon try always to find a person who knows how it occurs in reality ('na samom dele'). Reading this book I had the feeling that a reader interested in gravity currents, a geophysical phenomenon of high and ever growing importance, will recognize in its author just such a person.

Gravity-driven currents or simply gravity currents become most intriguing when the density variations throughout the flow are small, not exceeding several tenths of a percent. Although this density variation is so small its dynamical consequences are significant, sometimes tremendous due to the large value of the gravitational acceleration. Significant horizontal components of pressure gradient appear that would otherwise be absent; turbulence is suppressed, sometimes strongly. The latter effect leads to flow acceleration, sometimes large. For instance, owing to suppression of turbulence by suspended sediment the flow velocity in the great Chinese rivers redoubles, and mild winds in the atmosphere become sandstorms. So, the phenomena under consideration in John Simpson's book are of high interest, both fundamental and practical.

The book divides naturally into two parts. The first part (chapters 1–10) describes gravity currents of different kinds in, so to say, a nature explorer spirit. It seems worthwhile to mention here briefly the contents of each chapter. In chapter 1 there is a general description of gravity currents in their various manifestations. Some instructive photographs are given, including a colour photograph showing the front of the Sudanese 'haboob' – a typical gravity current in the atmosphere made visible by suspended sand – as well as a photograph of a laboratory suspension current in water in some sense simulating this haboob. It is instructive that the author has included bores, both surface and internal, in the first chapter, stressing that this phenomenon is fundamental. In fact, as can be shown, more detailed consideration of this phenomenon leads to a new generalized concept of shocks.

Many more examples of atmospheric gravity currents are presented in chapter 2, including thunderstorm outflows. Also, a first for this book, there is a description of the vortical frontal structure. Atmospheric bores are presented in a short chapter 3, including the beautiful 'Morning Glory', well-known to Australians. Chapter 4 discusses sea-breeze fronts, including their fine structure and internal bores formed by them (this time the example is from the Cambridge area of England). The growth of chemical pollutant concentration on the front is emphasized here by an instructive record. Peculiarities of the behaviour of birds and insects on atmospheric fronts are also discussed. In chapter 5 the influence of topography on the formation of fronts is discussed, including the 'southerly buster' – cold wind change in spring and summer along the coast – familiar to Australians as well as other coastal-trapped gravity currents. Chapter 6 deals with gravity currents involved in environmental problems in the atmosphere. I would like to mention here specially the section concerning the spread and dilution of a dense gas. A warning for all those who can read and extract the lessons from reading: not only is the explanation of this most

dangerous phenomenon given but also previous disasters from Meldrim, Georgia, USA to Bhopal, India are described. I had after reading these simply written several pages a terrible feeling that if responsible engineers had read them they could have prevented the Ufa disaster in Russia last summer. The 'inverse' of this phenomenon – gravity currents of light combustible gas in mines – is also described at some length. Chapter 7 deals with gravity currents in rivers, lakes and oceans, and raises many interesting points, such as the formation of a 'shelf-breaking front' and, again, bores. Instructive here are the observations of a bore in the Qiantang River in China and protection against it. Internal bores in the ocean are also described. It is shown that this phenomenon is by no means harmless – the breaking of submarine cables is only a mild example. In chapter 8 industrial problems related to gravity currents in the ocean are discussed, including oil slicks and out-flows from the cooling of power stations. Chapter 9 deals with avalanches and chapter 10 with volcanic gravity currents; both chapters contain impressive results of observations as well as qualitative explanations of phenomena.

The second part of the book (chapters 11–18) deals with semi-quantitative models of gravity currents. The phenomena are complicated and have many governing factors, so laboratory experiments are used as the basic tool in this part. Only a few of these governing factors are operative in each experiment. Nevertheless laboratory experiments play a definite role here, as well as in other geophysical phenomena, giving not only qualitative understanding of phenomena but also semi-quantitative estimates.

Chapter 11 is called 'The anatomy of gravity currents'; it is one of the central chapters of the second part. The advance of the gravity current front is considered here for the case when the current depth and density difference are already established. Also in this chapter the effects of mixing and friction are considered, as well as the head and tail ambient flows. In conclusion gravity currents on slopes are discussed. The technique of laboratory experiments is used to reveal the internal picture of flows, and visualization methods are also demonstrated. A hydrodynamic model is also discussed, viz. Benjamin's inviscid one. Some examples of dense fluid spreading, making a useful addition to chapter 11, are considered in the next chapter, 12. The phenomena of this class have found application recently in various branches of geophysical hydrodynamics, from fine structure of oceanic hydrodynamic fields to models of modern plate tectonics. Chapter 13 deals with the effects of ambient stratification. Interesting phenomena of flow blocking are discussed there as well as intrusive gravity currents and the collision of gravity currents. A short chapter, 14, presents some effects of a turbulent environment, including formation and dissipation of fronts. Viscous (low Reynolds number) gravity currents are considered in chapter 15 with their elegant similarity laws. Suspension flows are discussed, although very briefly, in chapter 16, and even fluidization is touched on there. Gravity currents in rotating systems are considered in chapter 17.

The final chapter, 18, stands on its own, and gives hints on the computer simulation of gravity currents.

To sum up, this is a very unusual and well-done book. To those who may try to do even better, I suggest the gathering of more available information for the second part from both the American and Soviet literature. It is unnecessary to discuss some minor shortcomings and misprints (in the basic text and also in errata, etc). I regret only that the publication of this book has come too late for A. N. Kolmogorov, who was deeply interested in gravity currents, to be able to read it.

G. I. Barenblatt

Natural Gas: Basic Science and Technology. By A. MELVIN. British Gas, 1988. 221 pp. £27.50.

This book is produced by British Gas with the cooperation of Adam Hilger, the publishing house of the Institute of Physics. In his preface the author identifies his objective as the presentation of aspects of basic science, mainly within a context of gas-industry operations. The text has been written with the physical scientist in mind although the author expresses the hope that engineers will also find it useful as a basic course on special topics.

In the reviewer's opinion these objectives have been admirably met. Interest in energy topics seems destined to remain high in the foreseeable future and this well-conceived monograph will be useful both to physical scientists and to engineers. There is also much to interest the specialist in fluid mechanics.

Wisely, the approach is sometimes selective, with some topics treated in detail while others get only a brief mention and one or two references. The text is enlivened with interesting comments and asides, and the result is a book which is generally enjoyable as well as informative.

There are seven chapters. The first discusses natural gas reserves and their origin and distribution. Subsequent chapters describe gas-industry operations, seismic exploration techniques, the thermodynamics of natural gas at high pressures, the measurement of high-pressure flows, the calorific value of natural gas and, lastly, its combustion. There are also two appendices, the first of which describes corresponding-states methods for predicting thermodynamic properties while the second presents empirical equations of state.

Fluid mechanics is discussed in almost every chapter; for example, flow through porous rocks, two-phase flows, problems of metering high-pressure flows in gas pipelines with the desired accuracy, the design of air guns for use as sources for seismic exploration, the stability of density-stratified cryogenic fluids and the sudden pressure rise due to 'rollover' instability.

The longest chapter and the one containing most discussion of fluid mechanics topics is the last, which is concerned with the combustion of natural gas. This chapter includes a section on laminar premixed flames, a useful discussion of flame stabilization and blow-off and a good section on laminar diffusion flames. There are also short sections on flame stretch, on catalytic combustion, on turbulent flames and on ignition. The piece on flame stretch is confusing to this reviewer.

The author is often quite critical of combustion scientists for not addressing questions of relevance to gas-industry operations. Faced with the task of reviewing approaches to turbulent combustion modelling he disarmingly hopes that most or all of them will disappear, sooner rather than later. His hopes for the future appear to be directed to bifurcation theory and the transition to deterministic chaos. The reviewer has yet to be convinced that these admittedly exciting developments will quickly reach a stage where turbulent combustion models can be dispensed with in the planning of natural-gas operations.

The book is to be recommended as a wide-ranging and stimulating appraisal of the role of the physical sciences in the gas industry.

K. N. C. BRAY