period. By Smith's theorem, such a diffeomorphism has a circle of fixed points if it has any at all. Of course, the idea is to prove that the circle is unknotted. The proof proceeds by study of the three-manifold that is the complement of the circle in the three-sphere. First, several reductions are made disallowing various possibilities if the circle were knotted. The proof then branches into two distinct considerations. One branch can be labeled algebraic and the other geometric. The algebraic branch begins with the deep and fundamental uniformization theorem for three-manifolds announced by Thurston. An algebraic interpretation of this theorem says that for a large class of three-manifolds the fundamental group, a principal algebraic invariant, can be represented by a very special group of 2×2 matrixes. It is at this point that the work of Bass and P. Shalen entered. Bass described the structure of these special groups of 2×2 matrixes, and Shalen, using classical methods of three-manifold topology, parlayed the algebraic statements into information about the structure of the three-manifold under consideration.

As all the preceding pieces were unfolding, it was the geometric branch of the argument that seemed to be the stumbling block. Some progress had been made on the problems occurring in this situation when a special case was understood by C. Gordon and R. Litherland. However, in completely independent work, primarily done by W. Meeks and S.-T. Yau, the methods and techniques of minimal surface theory were introduced to the study of three-dimensional manifolds. This work had an enormous impact on the understanding of three-manifolds, answering many questions. It also had an immediate application to the remaining gap in the solution of the Smith conjecture.

The Smith conjecture was solved. A circle of fixed points of a periodic diffeomorphism of the three-sphere can only be unknotted. In other words, any periodic diffeomorphism of the three-sphere having a circle of fixed points is precisely as one would imagine it to be.

Most of the material appearing in the papers in the book can be found in other publications in which the authors present their independent work in a broader context. The papers prepared for this volume provide the concise statements and supporting proofs applicable to the considerations of the Smith conjecture. Having papers written specifically for this volume certainly makes it easier to understand the logical structure and details needed for proving the Smith conjecture; moreover, it makes for a wonderful introduction to the various broader theories relevant to the study of three-manifolds.

The paper by Morgan on Thurston's uniformization theorem may be absolutely the best source there is on this subject and the closest approximation to a complete proof. It is based on lectures by Thurston and several personal conversations between Morgan and Thurston. Morgan has done an excellent job of giving logical organization to the proof of this important theorem. There are substantial exclusions; however, the exclusions are clearly acknowledged, and a remarkably clear picture appears in Morgan's presentation. One of the unusual and unfortunate phenomena resulting from the intense activity in low-dimensional topology is that such an important and fundamental result as the uniformization theorem has gone without a complete and written proof for such a long period of time. The paper by Morgan is a noteworthy attempt to correct this situation. Some of the exclusions remain; other gaps are being filled, and papers on them are appearing in the literature. These gaps will surely be filled and a complete and accessible proof will be available. But for now this book presents the best picture available of the uniformization theorem, and, in total, the material in the book represents the frontier of research in three-manifold topology.

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Fluvial Geomorphology

The Colorado River. Instability and Basin Management. WILLIAM L. GRAF. Association of American Geographers, Washington, D.C., 1985. viii, 86 pp., illus. Paper, $5. Resource Publications in Geography.

In October 1983 the Santa Cruz River of southeastern Arizona was the source of a major flood, the largest in over 70 years of continuous observation. As is the case with most urban communities in the United States, Tucson, Arizona, had prepared for such an event through engineering hydraulic surveys of its "floodplains." The surveys had clearly delineated zones of hazardous overbank flow to be expected from large, rare floods.

In the 1983 flood the Santa Cruz River did not overflow its banks as the surveys had predicted. Like other streams in the Colorado River basin, the Santa Cruz had experienced a complex metamorphosis over the past century. Water withdrawals, vegetation changes, climatic shifts, and basin development all induced instabilities in this arid-region river. In the late 1800's the Santa Cruz incised to form a classic arroyo. From 1920 to the 1960's it was relatively stable in a period characterized by unusually small floods. The 1983 flood encountered an incised channel that generated little overbank flow, but instead widened by spectacular scour of channel banks. Houses collapsed into the river as the flood flow undercut their foundations. Bridges were left on one bank as the river migrated into and beyond the opposite abutment.

Tucson's floodplain managers, indeed water-resource managers throughout the Southwest, would benefit from W. L. Graf's concise and lucid analysis of fluvial system complexities in the Colorado River basin. Graf provides a scientific analysis, emphasizing the important fluvial influences of flooding, riparian vegetation, incision, channel widening, high dams, and chemical changes. His conclusion is that engineering experience with the humid-region rivers of America is being grossly misapplied to the sensitive stream systems of the West. Too much emphasis is being placed on the design of the Colorado River basin to suit human whims without attention's being paid to the unique fluvial geomorphic processes of that region.

In one of several in-depth discussions, Graf presents an excellent overview of the influence of vegetation on channel stability. With the advent of Anglo settlement in the 1800's, native vegetation growing on river banks was cut for lumber and fence posts. Large floods, which had had little effect on banks stabilized by plants, proved to be destructive in the absence of dense riparian vegetation. In the 1900's exotic species invaded the region, replacing the decimated native riparian communities and stabilizing banks. Concern over water loss by evapotranspiration then led to an expensive and unsuccessful program of eradication for the exotics during the last 40 years. The program became obsolete when rapid groundwater withdrawal destroyed both native and exotic riparian communities. Today major channel changes are occurring on rivers like the Santa Cruz, which flow in fine-grained unconsolidated alluvial fills.

Perhaps those who strive to control the modern environment of the Colorado basin would do well to study the experience of the prehistoric Hohokam, Mogollon, and Anasazi peoples of 1000 years ago. These inhabitants built irrigation systems, apartment houses, roads, and cities. Nevertheless, as Graf describes, they strove to adapt to the unique southwestern landscape rather than to dominate it. Whether or not this ethic is compatible with modern society is certainly debatable. There is no question, however, that in the long run neither adaptation nor dominance can succeed without sound scientific study of this sensitive landscape.

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Wave Dynamics

Ocean Wave Modeling. THE SWAMP GROUP. Plenum, New York, 1985. vi, 256 pp., illus. $49.50. From a symposium, Miami, May 1981.

The scientific prediction of surface waves may be dated from Sverdrup and Munk's 1947 *Wind, Sea, and Swell: Theory of Relations for Forecasting*. That report was stimulated by the need for the Allied forces to have sea and swell forecasts before the invasion of North Africa, and it appeared in classified form in 1943. The complete prediction comprises two essentially distinct parts, the prediction of the wind field, which is the province of meteorologists, and the prediction of the resulting response of the ocean surface, which is the province of oceanographers. The present monograph, like that of Sverdrup and Munk, deals with the latter problem.

The starting point is the transport equation

$$\frac{\partial F}{\partial t} + \mathbf{v} \cdot \nabla F = S_{in} + S_{nl} + S_{ds}$$

which governs the evolution of the surface-wave field in space ($\mathbf{x}$) and time (t); $F = F(f,\theta;\mathbf{x},t)$ is the two-dimensional spectral density in frequency f and direction of propagation θ, $\mathbf{v} = \mathbf{v}(f, \theta)$ is the group velocity, S_{in} is the input from the wind, S_{nl} is the nonlinear transfer through wave interactions, and S_{ds} is the dissipation. This approach is distinct from that of Sverdrup and Munk, which was based on quasi-empirical relations between characteristic parameters of the wave and wind fields and antedated the introduction of statistical concepts (by Pierson, Neumann, and James in 1955) in the treatment of ocean waves. It became practical only in the early 1960's, after the theoretical studies of Phillips (1957) and Miles (1957), which provided a basis for the representation of S_{in}, and the discovery of resonant interactions by Hasselmann (1960) and Phillips (1960), which provided the basis for the representation of S_{nl}; the representation of S_{ds} was, and remains, empirical. It should perhaps be emphasized that these predictions are for deep water and that to extend them to water of a depth that is half, or less than half, of the wavelength would introduce further complications, especially if (as in coastal regions) the depth varies significantly.

The SWAMP (for Sea Wave Modeling Project) Group, which comprises 25 scientists from 11 institutions in the Federal Republic of Germany, Italy, Japan, the Netherlands, Norway, the United Kingdom, and the United States, has carried out a comparison of ten different models for the integration of the transport equation, using various parameterizations of the input terms, for seven hypothetical test cases. The first half of the present monograph discusses the various types of models and the principles on which they are based and describes the test cases. The second half presents the individual models and describes their predictions for some or all of the test cases.

There are (not unexpectedly) striking differences among the predictions of the models for particular test cases, and it is evident that we are not yet able to provide reliable forecasts of the surface-wave field induced by a strong front, let alone a hurricane. This is due in part to limitations in our basic understanding of the physics (the air flow over waves is turbulent), but the principal shortcomings of the models appear to stem from limitations in the parameterization of the nonlinear interactions (S_{nl}) and in the assumed form of the dissipation (S_{ds}). Nevertheless, much progress has been made, and the present ("second generation") models represent a significant advance over earlier ("first generation") models, in which nonlinearity was either absent or crudely represented and in which it had been necessary to increase the linear input S_{in} by one or more orders of magnitude over the theoretical values. Future ("third generation") models, already under development, will incorporate more sophisticated parameterizations of S_{nl} and may exploit our theoretical knowledge to its present limits, after which the lack of a rational model of dissipation and the effects of finite, variable depth are likely to present barriers to further progress.

We have come a long way from Sverdrup and Munk, but much remains to be done if we are to take full advantage of the data soon to be (if not already) available from satellite technology. The present monograph provides a valuable survey of the state of the art as of 1981.

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