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Long-term Controls on Eustatic and Epeirogenic Motions by Mantle Convection

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ABSTRACT

Computational geodynamics is leading to the synthesis of plate tectonics and mantle convection into a unified dynamic model. Coupled models of plates and thermal convection quantitatively show both eustatic and epeirogenic controls on long-term uplift and subsidence of Earth's surface from regional to global scales. Eustasy and epeirogeny can no longer be viewed as mutually exclusive hypotheses explaining continental stratigraphy—both arise with nearly equivalent amplitudes, but with complex phase offsets, by the same system of global convection. Dynamic models assist in the interpretation of the stratigraphic record, which has long been known to show that continents undergo both eustatic and epeirogenic motions.

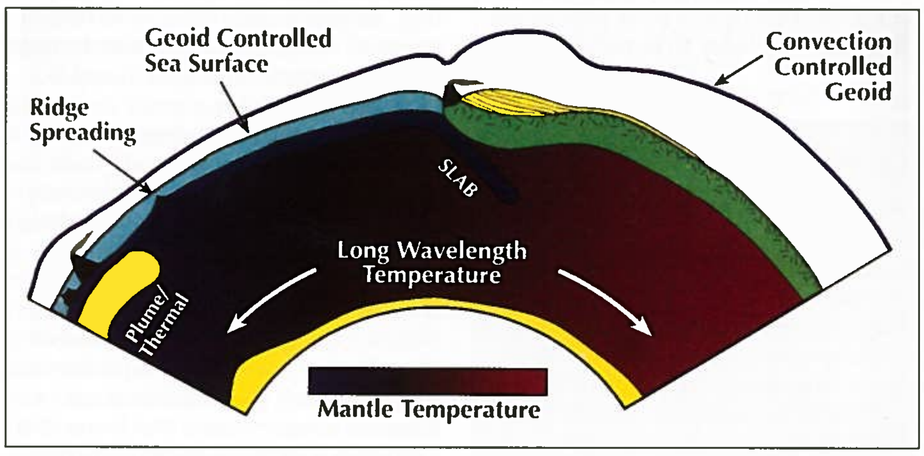

Figure 1. Summary diagram showing shallow and deep mantle convection controls on sea-level change and regional vertical motion discussed in the text. The influence of all mechanisms, except plume-lithosphere interactions, has been studied with dynamic models of plates, convection, and the geoid.

INTRODUCTION

"The explanation of the causes of transgression cycles in the history of the earth will represent one of the most important, but also one of the most difficult tasks of future geological and geophysical research." This statement is as true now as it was in 1929 when Alfred Wegener wrote these words in *The Origin of Oceans and Continents*. For although plate tectonics has been immensely successful at providing a kinematic framework of large-scale horizontal motions, it cannot explain vertical motions of continents. Stratigraphers have long appreciated the fundamental role that vertical motion must play in the development of the stratigraphic record of continental interiors (Sloss and Speed, 1974).

An entirely new frontier has opened in our effort to understand the causes of long-term sea-level fluctuations and the flooding of continental platforms by shallow seas. Over the past decade, the field of computational geodynamics has emerged, in which computer models of mantle convection are used in the interpretation of contemporaneous geophysical observations like seismic tomography and the geoid as well as of time-integrated observations from isotope geochemistry (see Davies and Richards, 1992, for a comprehensive review). We have now reached a point where we can use these techniques of computational geodynamics to make testable predictions of sea level and stratigraphy. The field of geodynamics is likely to benefit immensely from observational constraints on the time evolution of mantle dynamics from stratigraphy; this is particularly important, because traditional seismological and gravity observations do not provide any time-history constraints.

In the past decade, there have been important technical advances in our ability to understand mantle convection. From the perspective of craton and margin dynamics, these relevant advances range from the ability to partly simulate the dynamic interaction between tectonic plates and mantle convection (Gurnis, 1988; Weinstein et al., 1992) to the formulation of simple viscous flow models that allow us to calculate topography and geoid signatures from seismic anomalies in the mantle (Parsons and Daly, 1983; Richards and Hager, 1984). Here, I provide an overview of recent attempts at exploiting geodynamics to understand long-term controls on eustasy and epeirogeny (various mechanisms are summarized in Fig. 1). This paper is not intended to be a balanced review of sea-level change—the purpose is to highlight recent research at the boundary between sedimentary geology and geodynamics.

EUSTASY AND EPEIROGENY

No two concepts are probably as important for continental geology but so misunderstood as eustasy and epeirogeny. A eustatic sea-level rise is one that is globally uniform, whereas an epeirogenic motion is a broad, gradual rise of one continental region relative to another, or even the motion of an entire continent relative to others. Epeirogenic motions are unaccompanied by significant folding and faulting. Although seismic stratigraphy (Christie-Blick et al., 1990) has received widespread attention in recent years, it has never been clear if either mechanism of sea-level change can be tested directly by this method. The major problem with seismic stratigraphy is that the deposits studied are located on passive margins, where the lithosphere is thinned and thermally altered during rifting (Watts, 1982); so it is difficult to deconvolve deep mantle processes from shallow lithospheric ones.

The place to look for the influence of mantle convection on sea-level fluctuations is within vast sedimentary deposits covering the stable platforms of continents. Sedimentary geologists have long tried to determine if platform flooding can be explained solely by either eustasy or epeirogeny or if a combination of both processes is required. This problem was most clearly addressed by Bond (1978, 1979), who used a relative flooding–hypsometry technique. The difference in height between the sea surface and a continent can be determined from the intersection of the fraction of a continent covered by marine deposits with the continent's distribution of elevation vs. area (hypsometric curve). If there were only eustatic fluctuations, then at each geologic time each continent would have the same elevation difference. But Bond (1978, 1979) showed that the apparent sea level as seen by individual continents (North America, Africa, South America, Europe, Australia, and India) has differed by as much as an inferred eustatic signal since Early Cretaceous time (Fig. 2). Bond inferred a eustatic signal by noting that continents form distinct clusters—like the cluster of Australia, Europe, North and South America, and Europe during the Miocene (Fig. 2A)—and by making just four vertical translations since the Early Cretaceous, he showed that all the continents could be brought into clumps (Fig. 2B). These observations strongly suggest that distinct epeirogenic changes have been superimposed onto a clearly defined eustatic curve.

The large scatter between individual relative sea levels which we see in Figure 2 requires that the hypsometry of continents has changed (Bond, 1978). This means that either continental crust has thinned or thickened or that the continents have been tilted or vertically translated by mantle processes. Because sediments were laid down on flat, stable platforms, Bond suggested that changes in hypsometry were due to epeirogenic motions. An important aspect of the vertical motions evident in Figure 2 is that the amplitude of the regional epeirogenic motions are comparable to the amplitude of the inferred eustatic signal (both are about 100 to 200 m). As we will see, this near equality in the amplitude of eustatic and epeirogenic motions is what would be expected from a simple model of mantle convection.

Mantle Convection
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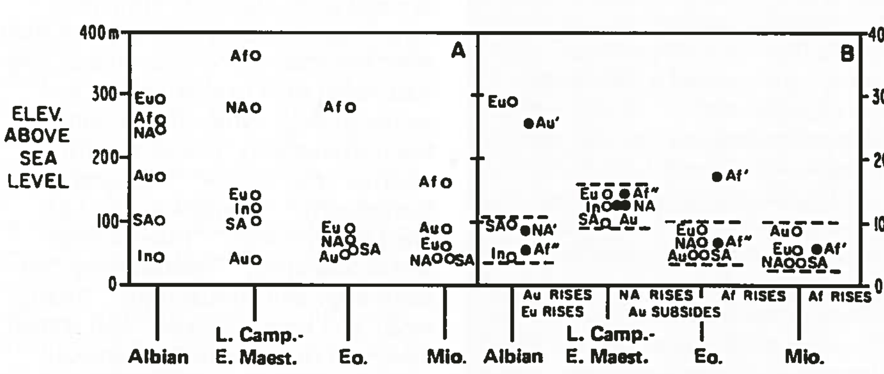

Figure 2. Sea-level elevations derived from the fraction of a continent flooded and its hypsometric curve. A: Uncorrected sea levels. B: Sea levels corrected by making individual vertical translations (corrected points indicated with primes). Reproduced from Bond (1976), with his permission.

Editor's Note:
This is the third article by a Packard fellow in earth science (see June 1991 and July 1991 issues of *GSA Today*). Each year the David and Lucile Packard Foundation awards 20 fellowships ($100,000 per year for five years) to promising young scientists and engineers working in fields less publicized than are high-energy physics, space, and medicine.
—Eldridge Moores

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The Teaching of Stratigraphy—Replies to a Questionnaire

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Concern about the proper teaching of stratigraphy in North American universities led me to mail in December 1991 a questionnaire on this subject to 100 universities in the United States and Canada. For several years I had become increasingly worried that stratigraphy was being eliminated or steadily curtailed from the curriculum of geological studies, that it was not being given the importance it deserves in the education of geoscientists. And I knew I was not alone—other colleagues had expressed similar alarm. But perhaps nobody had expressed it better than David Love as quoted by John McPhee in his most enjoyable book *Rising from the Plains*: "In order to know the anatomy of each mountain range, you have to know the details of sedimentary history. To know the details of sedimentary history, you have to know stratigraphy. I didn't know until recently that stratigraphy is dead. Many schools don't teach it any more. To me, that's writing the story without knowing the alphabet. The geologic literature is a graveyard of skeletons who worked the structure of mountain ranges without knowing the stratigraphy."

> *Editor's Note:*
>
> The science article by Michael Gurnis and the survey report by Amos Salvador both bear upon the importance of continental stratigraphy and its relation to global tectonic activity. I have long felt that a good deal of information about global tectonic history is present in the continental stratigraphic record (e.g., J. W. Valentine and E. M. Moores, 1970, Plate tectonic regulation of biotic diversity and sea level: A model, *Nature*, v. 228, p. 657–659; 1972, Global tectonics and the fossil record, *Journal of Geology*, v. 80, p. 167–184), if only one could "learn the language" needed to interpret that record properly. Gurnis's and Salvador's contributions provide two perspectives on this issue. Gurnis provides us with an introduction to the way in which eustatic and epirogenic fluctuations revealed in continental stratigraphy arise from global convection systems. At the same time, Salvador chronicles the decline and fragmentation of stratigraphy in the geological curriculum in the United States and Canada.
>
> Gurnis's approach should lead to rejuvenation of stratigraphy as a vital part of a modern geological curriculum, because in his approach we see the outlines of the "language" about global dynamic processes that the stratigraphic record "speaks." Gurnis argues the need for progress in two areas: (1) improved and more realistic models of mantle convection incorporating tectonic plates, and (2) better predictions of sedimentary packets that might result from the geoid fluctuations caused by thermal convection patterns. Surely, one can add a third area—testing of the predicted sedimentary packets against the real rock record—which leads back to the need for stratigraphers who not only are competent in all aspects of field observation and techniques (Salvador's plea), but who also are conversant with the geodynamic modeling and its consequences that Gurnis outlines.
>
> *—Eldridge Moores*

Is stratigraphy indeed dead or dying? A very disturbing thought to those who, like me, strongly believe that stratigraphy is the "guts of geology," as one respondent put it, the essential foundation upon which most other geological studies are based. So I decided to find out.

The selection of universities to be included in the survey—81 in the United States and 19 in Canada—was not random. With the invaluable help of the American Geological Institute *Directory of Geoscience Departments* I chose the 100 geoscience departments with the largest faculties (the total of assistant, associate, and full professors), those in which the broadest range of interests is represented, and those that I believed were more likely to include stratigraphy in their geoscience curriculum. The resulting roster represented a very broad geographic coverage.

Seventy-six replies were received, and the response was for the most part encouraging: it appears that, in one way or another, stratigraphy is being taught in almost all the universities that answered the questionnaire. A few respondents cheerfully and reassuringly affirmed that stratigraphy is not dead, that it is "alive," "kicking," and "prospering" in their departments. But there were many who sent word that they share my concern for the teaching of stratigraphy, who see a progressive decline in the amount of time devoted to stratigraphy, who deeply regret the dismembering of stratigraphy and the scattering of the fragments into various other courses, who deplore the passing of stratigraphy as a separate field of study and the decrease in emphasis on the teaching of basic stratigraphic principles.

At the undergraduate level, stratigraphy is being taught in most of the geoscience departments that answered the questionnaire. In 33 of them, it is offered as courses titled "Stratigraphy" or "Principles of Stratigraphy"; in another 27 as part of courses on "Sedimentology and Stratigraphy" or "Stratigraphy and Sedimentology." The portion of these latter group of courses devoted to stratigraphic principles varies from less than 25% to more than 50%; the majority of these courses dedicate equal time to stratigraphy and sedimentology. Nine other schools teach stratigraphy in courses with assorted other names: "Sedimentary Stratigraphy," "Stratigraphy and Applied Paleontology," "Paleontology and Stratigraphy," "Paleontology, Sedimentology and Stratigraphy," "Stratigraphy and Basin Analysis," and several others. In these courses the amount of time devoted to stratigraphy varies from 10% to 30% or 40%. The four among these courses that devote less than 20% to the teaching of stratigraphic principles probably cover the subject inadequately.

Several of the respondents from departments where stratigraphy and sedimentology are combined in a single course commented that such a grouping has been the result of compromises that did not please anybody because it does not provide enough time to teach effectively either of the two topics. Other respondents thought that sedimentology and stratigraphy are inseparable and should be taught jointly. One department has recently revised its curriculum to replace a one-semester course called "Sedimentation and Stratigraphy" with a two-semester sequence including separate courses in "Sedimentary Petrology" and "Stratigraphy." Perhaps course sequences such as this one, combining stratigraphy and sedimentology (and possibly also paleontology), may be the most satisfactory way to approach the teaching of stratigraphy.

Of the 76 questionnaires returned, 51 state that a course specifically devoted to stratigraphy (25 replies), or one combining stratigraphy and sedimentology (26 replies) are required for graduation with an undergraduate degree in geology. In another four geoscience departments, undergraduates can choose between taking stratigraphy and taking other courses, preferably sedimentology. Thirteen respondents indicated that their departments do not include stratigraphy among the requisites for granting an undergraduate degree in geology, and eight others did not answer this particular item of the questionnaire. One respondent stated that he finds it "difficult to believe that any legitimate degree-granting department of geology does not require stratigraphy for graduation." I, of course, agree with him.

Stratigraphy courses *at the graduate level* are less common: Only 28 geoscience departments offer graduate courses in stratigraphy, and five have graduate courses combining stratigraphy and sedimentology, many of them in the form of seminars.

Differences of approach to the teaching of stratigraphy were not unexpected. In preparing the questionnaire, I was acutely aware that not all geologists are in agreement concerning what should be included in—or excluded from—a course on stratigraphy. There are, in fact, considerable differences of opinion about the definition of stratigraphy. These differences were clearly reflected in the responses to the questionnaire. It is obvious, for instance, that, as mentioned before, many consider the boundary between the fields of stratigraphy and sedimentology quite blurred. Several respondents expressed the opinion that many aspects of sedimentology and stratigraphy are inseparable and that these two fields are too intimately related to be set apart and taught in separate courses. Courses listed as "Stratigraphy" may, and undoubtedly do, deal to a great extent with topics that some may consider clearly within the realm of sedimentology. Some of the results of the questionnaire reported above should, therefore, be viewed with considerable flexibility, because they reflect qualitative rather than quantitative opinions. Advocacy and bias cannot be put aside entirely.

The questionnaire could have yielded more informative results concerning the nature of the stratigraphy courses offered and the topics covered if more specific questions had been asked concerning the content of the

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WASHINGTON REPORT

Bruce F. Molnia

Washington Report provides the GSA membership with a window on the activities of the federal agencies, Congress and the legislative process, and international interactions that could impact the geoscience community. In future issues, Washington Report will present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

National Geological Surveys in the 21st Century

As part of the celebration of its sesquicentennial, the Geological Survey of Canada (GSC) organized and hosted an International Conference of Geological Surveys (ICOGS). About 200 earth scientists (representing several state and provincial surveys, international scientific organizations, academia, industry, and 30 national surveys), participated in the conference, which was held in Ottawa, from April 12 through April 14, 1992. Specifically, the theme of ICOGS was the role and responsibilities of national geological surveys in the 21st century and in a changing world.

In his welcoming remarks, Assistant Deputy Minister Elkanah A. (Ken) Babcock, head of GSC, stated that, in this quickly changing world, the many national geological surveys could learn much from each other's activities, traditions, and experiences. He hoped that ICOGS would be an appropriate forum to stimulate interaction and exchange of ideas among the many national surveys. Babcock recognized the pressing need for "innovative and practical strategies for the future."

ICOGS was organized around five primary themes: (I) evolution of geological surveys; (II) reconciliation of resource development and environmental protection; (III) resources for society; (IV) new concepts and new technologies in the earth sciences; and (V) international communication, cooperation, and collaboration. Regional perspective on the status of geological surveys in China, Africa, and Latin America were also presented.

Babcock's opening remarks paralleled these themes. He stated, "On the economic front, shifting global markets and trade patterns are reshaping the exploration, mining and energy industries." He noted, "Pressures on the global environment are causing many organizations to re-examine their operations, procedures, and policies." He also discussed the need for incorporating geoscience knowledge and information into understanding our changing environment. Similar comments were made by many of the other speakers. A summary of "common themes" is presented in the box at right.

A keynote address by Raymond A. Price, past President of GSA and former

Washington Report
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ICOGS Themes

At the ICOGS meeting, many themes recurred in presentation after presentation. The following list summarizes the more important of these:

- Virtually all national, state, and provincial surveys have budget problems.
- Many surveys are concerned about their "relevance" as the world's focus changes. Virtually all surveys understand the importance of participating in environmental geology issues, but most are struggling to make this transition.
- Nearly all surveys have become involved in the "data management revolution," are using computer and digital data, and are interested in geographical information systems.
- All surveys are identifying customers, pushing "information," and packaging products to meet client needs.
- Most surveys are involved in waste-disposal issues.
- Many surveys are contributing, or trying to contribute, to land-use decisions.
- Nearly all surveys are engaged in outreach activities and are trying to educate their parent ministries or departments and the public as to what they do and why they are important.
- Most surveys rapidly embrace new scientific technologies. Surveys in developed countries have far less difficulty in acquiring and maintaining these new technologies than do surveys in developing nations.
- All surveys have a strong conviction that earth science is important to managing national domains. Many think that their present strained situation results from geologists not being attentive to societal needs, or because they have not done a good job of "selling" themselves.
- Most geological surveys arose as supporting bodies for the discovery of mineral resources. In countries where the mineral resource industry is declining or moving overseas, geological surveys are worried about their future.
- Many surveys are having a very difficult time "getting the attention" of the governmental agency to which they answer.
- Many surveys, or their parent ministries, have been recently reviewed by "high-level" panels to determine if they were pursuing the correct mission and if they were really needed by their nations. Many have been reorganized and downsized.
- All surveys see mapping as a fundamental task that they must perform. Many believe that 3-D or "deep mapping" is the next frontier.
- Most surveys are doing some type of contractual research. Some surveys perform a majority of their work under contract.
- Some countries have both national surveys and state or provincial surveys (i.e., Canada, USA, Germany, PRC, Australia). Coordination ranges in many instances from excellent to poor.
- Most surveys are forming alliances and partnerships. Some have joined regional groups, such as the Association of Western European Geological Surveys.
- Few surveys are involved in global change research programs.

Stratigraphy *continued from p. 142*

courses. Such an expanded questionnaire was given some consideration, but the idea was discarded because I thought that it would have made the questionnaire unnecessarily long and difficult to answer. It may have also resulted in fewer responses.

Questions were asked, however, concerning four specific topics: magnetostratigraphy, numerical dating (geochronometry), seismic and/or sequence stratigraphy, and the relation between the related but divergent concepts of biostratigraphy and chronostratigraphy. Were these topics taught as part of the courses on stratigraphy, or as parts of other courses? Were they taught at all? Following are the results of this inquiry.

Magnetostratigraphy is discussed as part of the courses on stratigraphy or sedimentology-stratigraphy in only 37 of the 76 earth science departments answering the questionnaire. In 17 others, magnetostratigraphy is included in a variety of other courses—geophysics, marine geology, plate tectonics, physics of the earth, etc. The topic is discussed only briefly in 11 schools, and not discussed at all in another 11.

Numerical dating by isotopic or other methods (geochronometry) is included in stratigraphy-related courses in only 27 cases, and in any of a variety of other courses in 28 other departments—"Isotope Geochemistry," "Geochronology," "Basin Analysis," "Historical Geology," and several others. The topic is discussed only briefly in nine geoscience departments, and not at all in 12 others.

Seismic and/or sequence stratigraphy is being given considerably more attention as an important stratigraphic subject. It is being satisfactorily taught in stratigraphy-related courses in 56 of the 76 geoscience departments answering the questionnaire, and only briefly in three others. Ten schools teach seismic and/or sequence stratigraphy as part of other courses, particularly in geophysics courses, and seven do not offer it at all.

Similarly, *biostratigraphic and chronostratigraphic concepts* and their mutual relations are discussed in nearly all stratigraphy-related courses, either those labeled "Stratigraphy" or other courses combining in various proportions stratigraphy, sedimentology, and paleontology.

The fact that magnetostratigraphy and geochronometry are either not taught or are taught in courses not directly related to stratigraphy, some of them undergraduate courses but others offered only at the graduate level, is somewhat disturbing. Some of the most important recent advances in stratigraphy have been made as a result of the integration of several different stratigraphic approaches—biostratigraphy, magnetostratigraphy, and geochronometry, for instance—and it is disheartening to see these different approaches to stratigraphy taught in separate courses and to witness stratigraphy being carved into sections and scattered.

The many respondents who share my concern for the apparent steady reduction in the teaching of stratigraphy attribute it to the compression of curricula and the consequent progressive pushing aside of this essential field to make room for "number-driven" courses, for courses involving instrumental analysis, or for more glamorous and trendy "hard science." One respondent pointed out that stratigraphy is no longer considered exciting by funding agencies; another lamented that students increasingly prefer to work in a laboratory or sit in front of a computer rather than to go out in the field to map and "do" stratigraphy. Some feared that geology is becoming more and more a laboratory science. Others traced the reduction or elimination of the teaching of stratigraphy to the fact that the professors who taught stratigraphy have retired, or will soon retire, and are being replaced by younger faculty members not interested in teaching what they consider a worn-out and unfashionable subject.

There are many others, fortunately, who believe that students are getting a good grounding in stratigraphy, who look at the future of the teaching of stratigraphy with optimism, who believe that new and promising approaches and techniques developed in the past few years—increasing use of reflection-seismology information in stratigraphic work, magnetostratigraphy, sequence stratigraphy, vastly improved geochronometric methods—and particularly the integration of these with the classic approaches to stratigraphy, assure a revival in interest in teaching stratigraphy in the academic institutions of North America. Several mentioned the proliferation of new texts on stratigraphy published in the past five years (Boggs, 1987; Brenner and McHargue, 1988; Schoch, 1989; Prothero, 1990; Lemon, 1990; Blatt, et al., 1991) as an indication of this revival. I sincerely hope their optimism will prove to be justified, and that geoscience students are indeed learning the basic geological alphabet so they can go on to make important contributions to the writing of the story of Earth.

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A most intriguing vertical motion evident in Figure 2 is that of Australia during the Cretaceous. The interior of Australia became flooded by nearly 50% between 125 and 115 Ma and then became progressively exposed between 100 and 70 Ma at a time when nearly all other continents reached their maximum Cretaceous flooding (Struckmeyer and Brown, 1990). Much of Australia must have vertically subsided by >100 m in the Early Cretaceous, but then must have been uplifted by hundreds of metres in the middle Cretaceous to counteract the effect of the eustatic rise in sea level. Because Australia did not undergo any significant faulting or folding during this time, the conclusion seems inescapable that the mantle pulled down and then pushed up this continent over a horizontal scale of thousands of kilometres.

DYNAMIC TOPOGRAPHY AND THE GEOID

Mantle convection controls continental vertical motion through dynamic topography. In a viscous medium, such as Earth's mantle (Cathles, 1975), flow is generated by internal mass anomalies (buoyancy forces). The flow transmits stress to the top of the mantle, where the vertical hydrostatic stress is balanced by the deflection of the interface, dynamic topography. Positive mass anomalies within the viscous mantle cause Earth's solid surface to be deflected downward. Dynamic topography often refers only to the topography generated by loads located deep beneath the lithosphere.

If mass anomalies within the mantle are known, then dynamic topography and the geoid can be computed from spherically symmetric viscous models of the mantle (Richards and Hager, 1984). The mass anomalies within the mantle have been inferred from body-wave (Dziewonski, 1984; Inoue et al., 1990) and surface-wave seismic tomography (Dziewonski and Woodhouse, 1987; Tanimoto, 1990). This technique shows that seismic anomalies drive a strong degree-two (i.e., a wavelength half the circumference of Earth) pattern in the geoid with ~100 m amplitude highs (mass excesses) located over Africa and the western Pacific—very similar to the observed long-wavelength nonhydrostatic geoid (Hager et al., 1985). Controlling this geoid are ~1-km-amplitude dynamic topography highs located again over Africa and the western Pacific. But do these large-scale topography anomalies really exist? Cazenave et al. (1989) has shown that when the subsidence caused by diffusive cooling of the lithosphere is removed from ocean bathymetry, a nearly identical pattern of global topography emerges (Fig. 3). This long-wavelength residual topography has been refined (Cazenave and Lago, 1991) and corroborated independently (Pribac, 1991).

The amplitude of sea-level change and the pattern of continental onlap associated with dynamic topography is not immediately obvious, because topography controls the geoid, which in turn controls the sea surface. Ignoring the geoid for the moment, it is quite clear that motion of continents relative to a topography undulation of ~1 km amplitude could play a dominant role in controlling the flooding of continents. But the ratio of geoid to dynamic topography (the admittance) must be considered when determining platform flooding (Gurnis, 1990a). Because admittances are small and positive for the longest wavelength mantle anomalies (Richards and Hager, 1984), continents will be relatively exposed over geoid highs and flooded over geoid lows (Fig. 4)—which is the reverse of what is expected without dynamic topography. With the small admittances, the geoid itself will have a relatively small effect on sea-level change, and if the continents do move over these observed 1 km undulations (Fig. 3), then the continents would flood by more than 75% (Gurnis, 1990a).

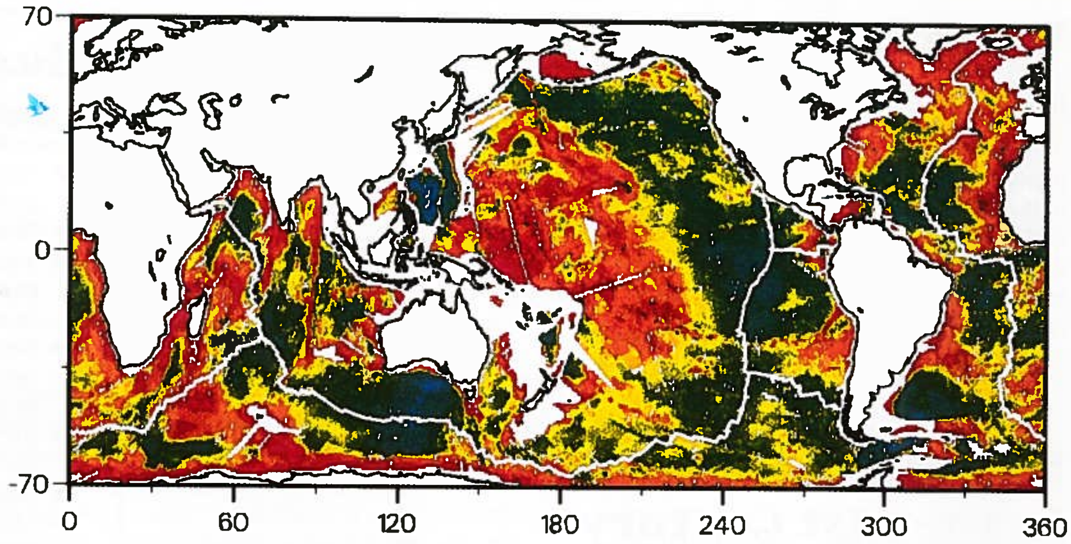

Figure 3. Residual topography obtained by removing the normal subsidence of the oceanic lithosphere. The topographically high areas are red and the low areas blue. The long-wavelength amplitude of this signal is 500 m. Figure courtesy of A. Cazenave.

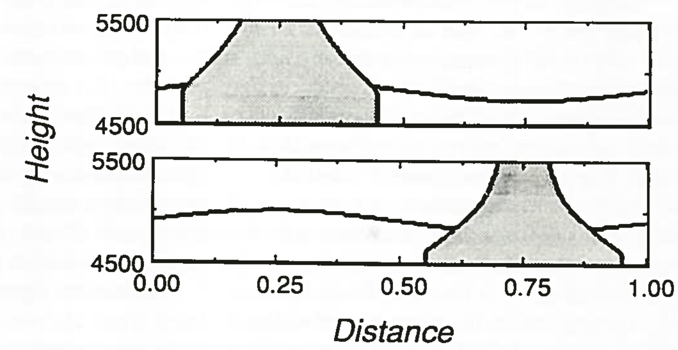

Figure 4. Total topography and sea surface for a one-dimensional continent passively moving over a dynamic topography undulation. The topography of the continent (shaded) is the result of isostatic topography (caused by crustal thickness variations), dynamic topography (with a 200 m amplitude), and sea-water loading. The continent becomes more flooded when positioned over a dynamic topography and geoid low (bottom). From Gurnis (1990a), reproduced from *Nature* by permission, copyright 1990 Macmillan Magazines Limited.

RIDGE SPREADING AND WHY SUBDUCTION CANNOT BE IGNORED

Since the acceptance of plate tectonics, variations in the rate of spreading of mid-ocean ridges have been thought to be the primary control on the Phanerozoic transgressions and regressions. According to this standard eustatic model, which was first proposed by Menard (1964), increased rates of plate spreading give rise to an increased volume of oceanic ridges, which in turn leads to a decreased volume of ocean basins. For a constant volume of water, continental platforms would flood during periods of increased spreading. Kominz (1984) has shown that the sea-level change computed from observed changes in the age of the oceanic lithosphere fits the post-Cretaceous inferred eustatic curve (Bond, 1978). But this model is incapable of explaining epeirogenic motions, which are as important as eustatic motions. The discrepancy may arise because the subduction of cold oceanic lithosphere into the mantle is ignored in the standard model (Hager, 1980; Gurnis, 1990b).

Limitations of the spreading-rate–sea-level hypothesis have been highlighted with convection calculations with an imposed oceanic plate (Gurnis, 1990b; Fig. 5). The convection models explicitly account for the effect of a slab returning to the deep interior. For example, when spreading rate is increased from 5 cm/yr to 7.5 cm/yr in the convection model (Fig. 6), sea level for the continental plate rises significantly faster than the rise predicted by the standard model, reaching a maximum 60 m.y. later, and finally falls to half the rise predicted from the standard model. The complex pattern of sea-level change is caused by changes in the thermal structure under plates: when plate spreading increases, cold fluid is dumped under the continent

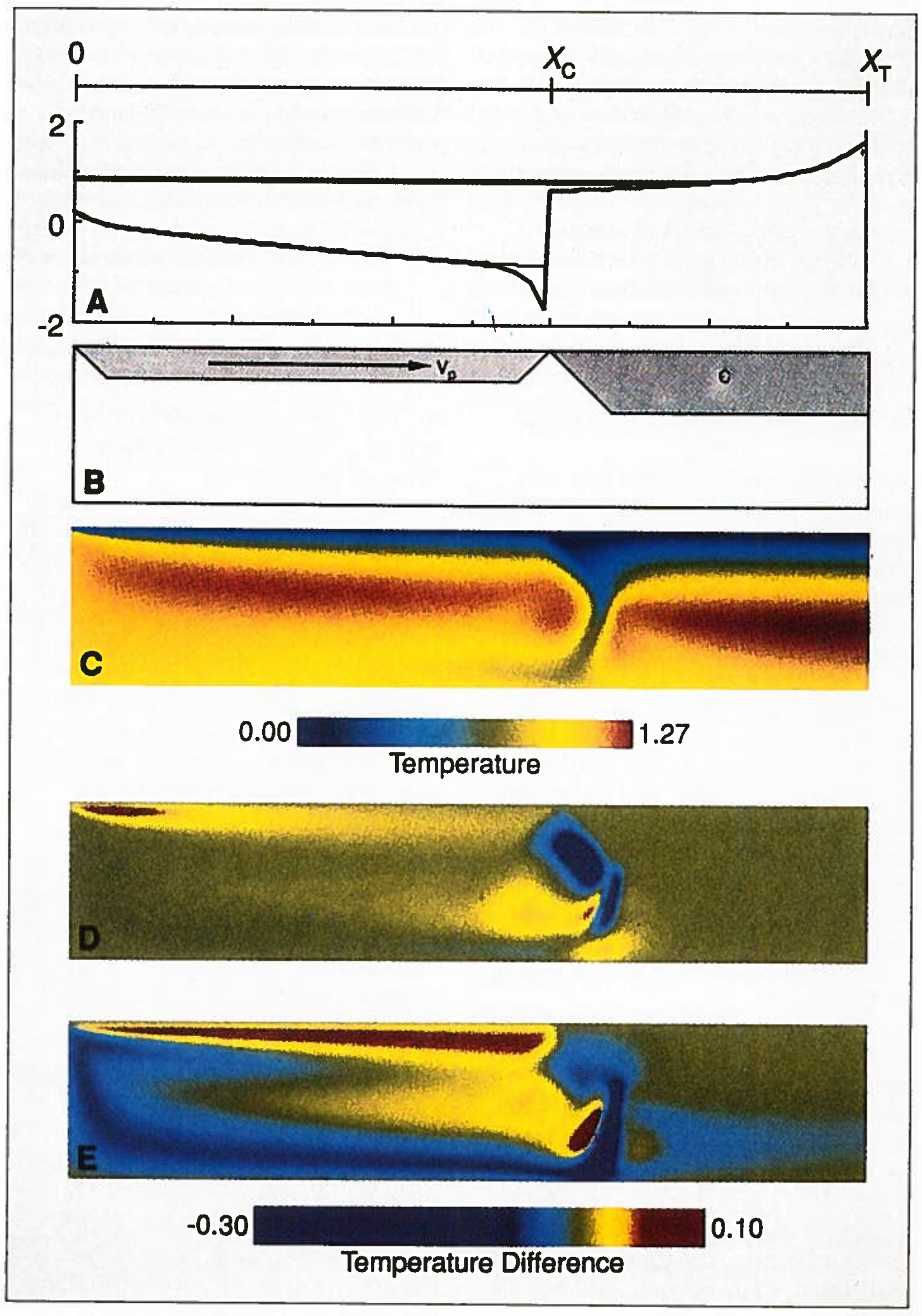

Figure 5. Convection model incorporating an oceanic and a continental plate kinematically. A: The total topography for the convection model at steady state. B: Schematic overview of model set-up showing the oceanic plate, which moves toward the right, and the stationary continental plate. C: The initial thermal structure. The temperature scale has been normalized by the constant basal temperature. D, E: Differential temperatures obtained by subtracting the temperature at time zero (the instant at which spreading increases) from the temperature after 10 m.y. (D) and after about 500 m.y. (E). The parts of the box that increase in temperature become red; those parts that cool become blue. Reproduced from Gurnis (1990c), copyright 1990 by the American Association for the Advancement of Science.

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GSA Council Actions—Spring 1992

Council announces the following actions taken at its meeting on May 8, 1992, in Boulder, Colorado.

New Honorary Fellows

Yang Zun-yi
Department of Geology
China University of Geosciences
Xueyuan Road 29
Haidian, Beijing, 100083
Peoples Republic of China

Hans Füchtbauer
Geologisches Institut der Ruhr,
Universität Bochum
Universitätsstrasse 150
W-4630 Bochum 1, Germany

Medal and Award Recipients—1992

Penrose Medal
John F. Dewey
Department of Earth Sciences
University of Oxford
Parks Road
Oxford OX1 3PR, England

Day Medal
Susan W. Kieffer
Department of Geology
Arizona State University
Tempe, AZ 85287-1404

Donath Medal (Young Scientist Award)
John P. Grotzinger
Department of Earth and Planetary Sciences
Room 54-1014
Massachusetts Institute of Technology
Cambridge, MA 02139

GSA Distinguished Service Award
A. R. (Pete) Palmer
445 North Cedarbrook Road
Boulder, CO 80304

Archaeological Geology Division Award
Fekri A. Hassan
Department of Anthropology
Washington State University
Pullman, WA 99164-4910

Gilbert H. Cady Award (Coal Geology Division)
Tom L. Phillips
Department of Plant Biology
University of Illinois
505 South Goodwin Avenue
Urbana, IL 61801

E. B. Burwell, Jr., Award (Engineering Geology Division)
George A. Kiersch
4750 North Camino Luz
Tucson, AZ 85718

George P. Woollard Award (Geophysics Division)
Rob Van der Voo
Department of Geological Sciences
1006 C. C. Little Building
University of Michigan
Ann Arbor, MI 48109-1063

History of Geology Division Award
Michele L. Aldrich
American Association for the Advancement of Science
1333 H Street, N.W.
Washington, DC 20005-4792

O. E. Meinzer Award (Hydrogeology Division)
Craig M. Bethke
Department of Geology
245 Natural History Building
University of Illinois
1301 West Green Street
Urbana, IL 61801

G. K. Gilbert Award (Planetary Geology Division)
John A. Wood
Harvard-Smithsonian Center for Astrophysics
60 Garden Street
Cambridge, MA 02138

Kirk Bryan Award (Quaternary Geology and Geomorphology Division)
R. Dale Guthrie
Department of Biology and Landlife
Institute of Arctic Biology
Irving Building, Room 211
University of Alaska
Fairbanks, AK 99775

Structural Geology and Tectonics Division Career Contribution Award
John C. Crowell
Institute for Crustal Studies
University of California
Santa Barbara, CA 93106-1100 ■

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(Fig. 5D), pulling the continent down and augmenting sea-level rise due to the shallowing ocean basin. But, as the age of the subducted plate decreases, the continent lifts and sea level falls. The models demonstrate that changes in mantle thermal structure occurring in response to spreading-rate changes cannot be ignored (Gurnis, 1990b). Furthermore, observed eustatic and epeirogenic effects are about equal in magnitude (Bond, 1978, 1979). The reason for this is apparently quite simple: eustatic fluctuations are generated by changes in the relative subsidence of the top thermal boundary layer of convection (the lithosphere), but these same changes in subsidence give rise directly to the dynamic topography fluctuations of a continent that overlies the subducted lithosphere. Thus, creation of a top thermal boundary layer and its injection into the interior is the simplest model of convection, and it directly predicts equivalent eustatic and epeirogenic effects (Gurnis, 1991a).

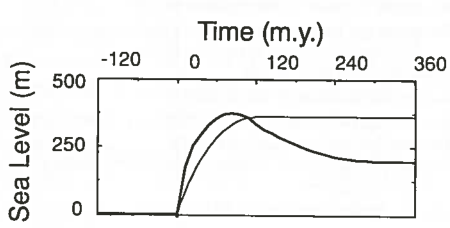

Figure 6. The sea-level curve that results from the convection model shown in Figure 5 (heavy line) compared to the sea-level curve expected from the standard spreading-rate hypothesis.

Details of the vertical motion associated with changes in slab configuration, with no eustatic fluctuations, have been explored in flow models with realistic viscosity variations (Gurnis, 1992). These models predict (Fig. 7) that during a Wilson cycle, dynamic topography resulting from slab subduction causes continental lithosphere to first rapidly subside following the start of subduction (Fig. 7A). As the dip of slab dynamically shallows, the continent will continue to subside, with a basin depocenter and forebulge migrating toward the continental interior (Fig. 7B). Finally, as the ocean basin closes, the continent will regionally uplift (Fig. 7C). The models show that the overriding continental plate can have apparent subsidence rates of up to 200 m/m.y., and they provide a simple explanation for the rapid subsidence of the eastern Laurentian margin which occurred in the mid-Ordovician before the development of the Taconic orogeny (Shanmugam and Lash, 1982). Excessive Cretaceous subsidence of the western interior seaway of North America (Bond, 1976; Cross and Pilger, 1978) is well explained by the second phase as the slab dynamically shallows (Fig. 7B). Finally, the uplift evident during the last phase is applicable to the Cenozoic uplift of western North America following the consumption of the Farallon plate (Damon, 1979; Mitrovica, et al., 1989). The models also predict a close spatial correlation between epeiric seas and subduction zones; generally, this may be the case for the Cretaceous (Bond, 1979), and even the enigmatic motion of Australia may be related to subduction (Veevers and Evans, 1973). At present there is a strong correlation between flooded continent and slabs in the western Pacific (Gurnis, 1991b).

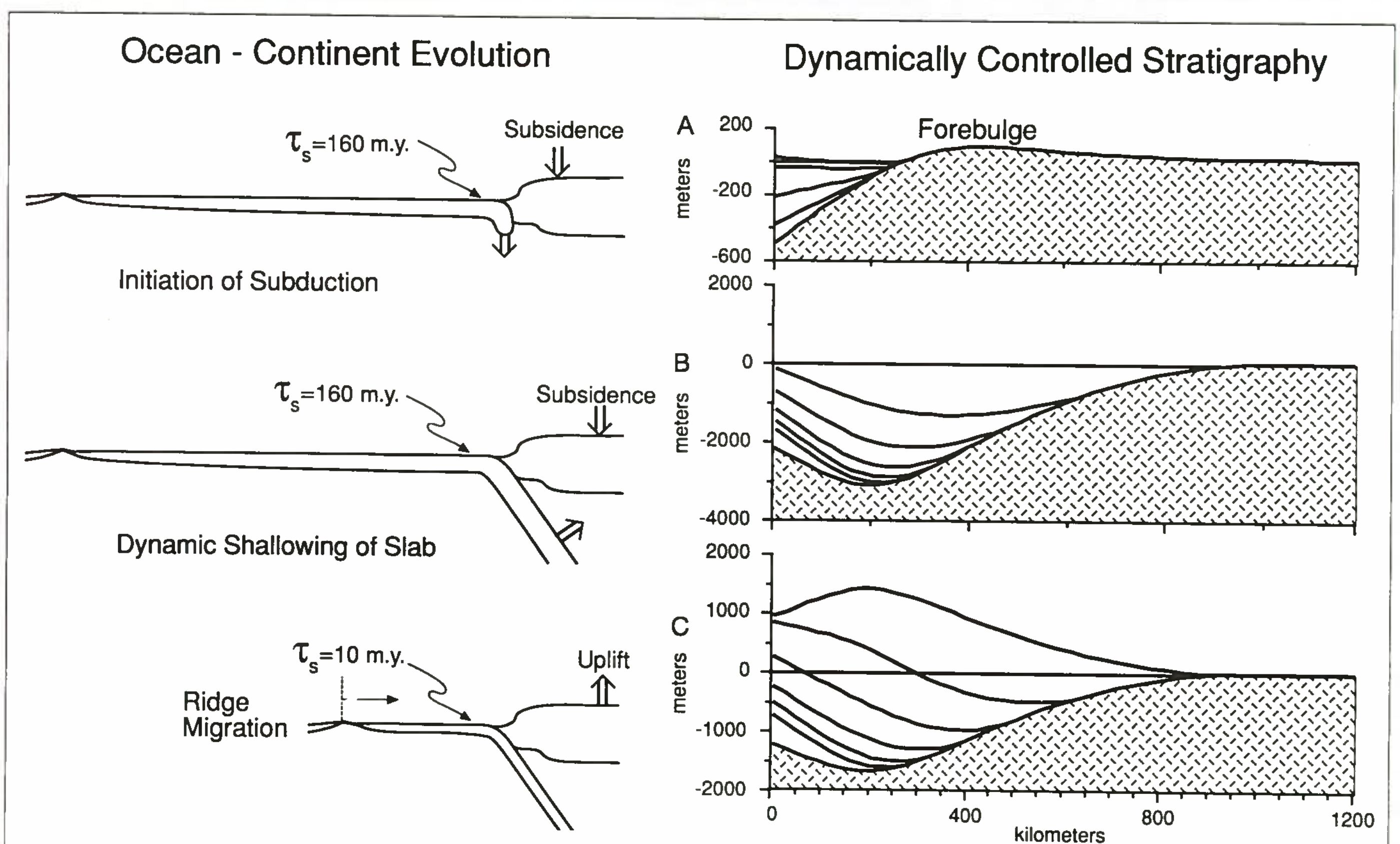

Figure 7. Left: The configuration of oceanic plate and slab during three stages in the evolution of a subduction zone. Right: The stratigraphy that results from subduction, computed from a finite-element model with realistic viscosity variations in the mantle. Thick solid lines on the right are chronostratigraphic surfaces; the line underlain by the stippling is the original land surface. The forebulge results from viscous flow in the mantle and not from the bending of the elastic lithosphere. During the first phase (A) chronostratigraphic surfaces are shown for a slab that successively deepens by 100 km . For a slab that descends at 5 cm/yr, these 100 km slab depth intervals correspond to 2 m.y. chronostratigraphic surfaces. During the second phase (B), the vertical distance between chronostratigraphic surfaces increases for each 10° decrease in slab dip. Reproduced from Gurnis (1992), copyright 1992 by the American Association for the Advancement of Science.

LARGE-SCALE MANTLE CONVECTION AND SUPERCONTINENTS

Bott (1964) was the first to suggest that thick continental lithosphere may inhibit cooling of the underlying mantle and generate large-scale mantle temperature anomalies which in turn cause continental drift. Anderson (1982) suggested that insulation under Pangea may have given rise to the long-wavelength geoid. The importance of insulation can easily be shown: if heat is added (per unit volume) throughout the depth of the mantle under a supercontinent at the same rate heat is being lost from the entire mantle, then the overlying supercontinent would have an uplift rate of ~5 to 10 m/m.y. A global pattern of dynamic topography with an amplitude of 500 m to 1 km could be generated in about 100 m.y.

Would continental fragments simply move with respect to these anomalies once they are generated via insulation? We can now address this question with fully dynamic models of plates

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Edward E. "Dr. Ed" Geary, Educational Programs Coordinator

Before We "CESE to Exist"

Historically, earth science is a diverse group of sciences encompassing geology, meteorology, hydrology, oceanography, space, and astronomy. More than 70 different societies, government agencies, and teacher organizations, plus numerous private sector companies, are currently at work on earth science education activities. Many of these groups work on similar projects, develop similar resources and materials, and have very little knowledge of what other earth science groups are doing.

To improve communication, enhance coordination, and foster cooperation on earth science education activities between these diverse groups, a dynamic new organization, the Coalition for Earth Science Education (CESE), is being formed. CESE will combine the forces of the entire earth science community, a dedicated group of a quarter of a million earth scientists and earth science teachers, and will address national and regional policy issues that affect earth science education reform.

After We "CESE to Exist"

Individual organizations will continue to develop and run projects, but through a coalition clearinghouse each organization will be able to find out what types of projects other organizations are working on or have completed. This clearinghouse will also aid organizations as they design projects, and will afford opportunities for collaborative efforts. For earth science teachers this also means that they will finally be able to contact one source for information on the multitude of projects and resources in the earth and space sciences.

CESE has already begun working toward these goals by hosting a successful multiple society booth at the National Science Teachers Association annual meeting in Boston. CESE has also contacted the National Research Council to help with the development of national standards for science teaching, and joint CESE member-society activities are being planned in the areas of teacher preparation, teacher enhancement, curricular materials development, information collection and dissemination, and partnering between earth scientists, teachers, and students.

Listed below are the organizations that participated in earlier conferences and others that have been invited to participate in CESE. The Coalition invites other organizations and interested individuals to participate in CESE. ■

For further information about CESE contact:

M. Frank Ireton
American Geophysical Union
2000 Florida Avenue NW
Washington, DC 20009
(202) 462-6903

Ed Geary
Geological Society of America
P.O. Box 9140
Boulder, CO 80301
(303) 447-2020

GSA Announces The First Annual Biggs Earth Science Teaching (BEST) Award

ELIGIBILITY

All earth science instructors and faculty at 2- and 4-year colleges who have taught for 10 years or less.

AWARD AMOUNT

$500.00

NOMINATION PROCEDURE

See form below, or write to Ed E. Geary, Coordinator for Educational Programs, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

The Geological Society of America Biggs Earth Science Teaching (BEST) Award Nomination Form

Name ____________ Birthdate ____________
Home Address ____________ Telephone ____________
City and State ____________ ZIP Code ____________
College/University Attended ____________ Degree(s) ____________
Current Academic Institution ____________
Address ____________ Telephone ____________
Number of Earth Science Classes Taught/Yr. __ Graduate __ Undergraduate __
Name of Department Chair ____________
Name and Address of Local Newspaper ____________

Respond to the following, using no more than three typewritten pages. Support documentation in the form of course evaluations, letters of support, products, or publications may be attached if appropriate.

1. Teaching Ability: What techniques does this teacher employ? Is the course comprehensive, yet enjoyed by the students? What is the teaching philosophy?
2. Inventiveness: What new ideas are used? What new materials are produced? What new methods or devices are used?
3. Initiative: Be specific. How are new situations handled? How are students of varying abilities accommodated?
4. Cooperativeness: How does the teacher cooperate in the total school program and in other academic areas?
5. Strengths: What are the principal strengths of the candidate?
6. How is the teacher involved in community and youth activities?
7. Professional activities and noteworthy accomplishments.

Name of Recommending Person (Nominator) ____________
Address ____________
Nominator's Signature ____________

Send all forms with documentation to: Ed E. Geary, Coordinator for Educational Programs, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

Please feel free to copy this form for nomination purposes.

Participants in CESE Organizational Meetings

American Association for the Advancement of Science
American Association of Petroleum Geologists
American Association of Stratigraphic Palynologists
American Geological Institute
American Geophysical Union
American Institute of Hydrology
American Institute of Mining Engineers
American Meteorological Society
Association of American State Geologists
Association for Women Geoscientists
Association of Earth Science Editors
Association of Engineering Geologists
Bay Area Earth Science Institute—San Jose State University
Bureau of Land Management
Center for Science Education—University of South Carolina
Chevron USA
Geological Society of America
Geoscience Information Society
Earth Science Teachers Exploring Exemplary Materials—Harvard-Smithsonian Center for Astrophysics
Mineralogical Society of America
National Aeronautics and Space Administration
National Assessment of Educational Progress
National Association of Geology Teachers
National Center for Atmospheric Research
National Earth Science Teachers Association
National Oceanic and Atmospheric Administration
National Science Foundation
National Science Teachers Association
Program for Leadership in Earth Systems Education—Ohio State University
Royal Society of Canada
Society of Economic Geologists
Seismological Society of America
Society for Sedimentary Geology
Support Program for Instructional Competency in Astronomy
United States Geological Survey

Organizations Invited to Join CESE

American Association of Variable Star Observers
American Astronomical Society
American Chemical Society
American Ground Water Trust
American Institute of Aeronautics and Astronautics
American Institute of Professional Geologists
American Mining Congress
American Water Resources Association
Association for Women in Science
Association of Astronomy Educators
Association of Ground Water Scientists and Engineers
Astronomical Society of the Pacific
Canadian Geophysical Union
Department of Energy National Laboratories
Environmental Protection Agency
Geochemical Society
International Planetarium Society, Inc.
Lawrence Hall of Science
Mathematics, Engineering, Science Achievement
Mining Society of America
National Association for Research in Science Teaching
National Association for Science, Technology, and Society
National Center for Science Education, Inc.
National Geographic Society
National Marine Educators Association
National Middle School Association
National Science Supervisors Association
National Weather Service
North American Association for Environmental Education
Paleontological Society
Planetary Society
Project Catalyst—California State University at Fullerton
Royal Astronomical Society of Canada
Sigma Xi, Scientific Research Society
Society for the Advancement of Chicanos and Native Americans in Science
Society of Exploration Geophysicists
Soil Conservation Service
Soil Science Society of America
Triangle Coalition for Science and Technology Education

Earth Systems Education

Victor Mayer
Ohio State University, Columbus, OH 43210

National concerns about the quality and effectiveness of science teaching have resulted in two major efforts directed at restructuring the nation's science curriculum; Project 2061 of the American Association for the Advancement of Science (AAAS) and the Scope, Sequence, and Coordination project of the National Science Teachers Association (NSTA). A related effort is the Earth Systems Education program centered at Ohio State University and the University of Northern Colorado. Its philosophy and approach to science content are consistent with the larger and better known national projects, but differ in significant respects, especially in the focus on planet Earth.

Over the past two decades there have been tremendous advances in the understanding of planet Earth, in part through the use of satellites in data gathering and supercomputers for data processing. As a result, earth scientists are reinterpreting the relations between the various subdisciplines and their mode of inquiry. These changes are documented in the Bretherton Report, developed by a committee of scientists representing various government agencies with earth science research mandates. These advances also prompted the organization of a conference of geoscientists and educators in April 1988 to consider their implications for science curriculum renewal. The 40 scientists and educators, including many scientists from the agencies responsible for the Bretherton Report, developed a preliminary framework of four goals and 10 concepts about planet Earth that they felt every citizen should understand. Through subsequent discussions with teachers and earth science educators at regional and national meetings of the NSTA, a new focus and philosophy for science curriculum began to emerge.

In the spring of 1990, the Teacher Enhancement Program of the National Science Foundation awarded a grant to Ohio State University for the preparation of leadership teams in Earth Systems Education—PLESE, the Program for Leadership in Earth Systems Education. The program was designed to infuse more content regarding the modern understanding of planet Earth into the nation's K–12 science curricula.

In preparation for PLESE, a planning committee composed of 10 teachers, curriculum specialists, and geoscientists, met in Columbus in May 1990, to develop a conceptual framework to guide the program. Preliminary work includes the analysis of the Project 2061 report for content relating to Earth systems. The committee used this analysis, combined with the results of the 1988 conference, to develop a framework consisting of seven understandings. This Framework for Earth Systems Education now provides a basis for the PLESE teams to construct resource guides and to select teaching materials for use in infusing Earth systems concepts into the science curriculum in their areas.

The PLESE Planning Committee intentionally arranged the understandings into a sequence. The first emphasizes the aesthetic values of planet Earth as interpreted in art, music, and literature. By focusing on students' feelings toward Earth systems, the way in which they and others experience and interpret them, students are drawn into a systematic study of their planet. An aesthetic appreciation of the planet leads the student naturally into a concern for proper stewardship of its resources, the second understanding of the framework. A developing concern for conserving the economic and aesthetic resources of our planet leads naturally into a desire to understand how the various subsystems function and how we study those subsystems, the substance of the next four understandings. In learning how the subsystems function, students must master basic concepts of physics, chemistry, and biology. The last understanding deals with careers and avocations in science, bringing the focus back to the immediate concerns and interests of the student.

There is a national movement toward the integration of the K–12 science curriculum largely driven by Project 2061. What could be more natural than developing a science curriculum using the subject of all science investigations—planet Earth—as the unifying theme? Any physical, chemical, or biological process that citizens must understand to be scientifically literate can be taught in the context of its Earth subsystem. That is the thought that has guided individuals in considering the implications of Earth Systems Education for the nation's science curriculum reform efforts.

Several projects are underway to test aspects of Earth Systems Education. The major one is the PLESE program, which works with teams of teachers from each of the 50 states. Through three-week-long summer workshops offered by the University of Northern Colorado and Ohio State University, three-member teams representing elementary school, middle school, and high school developed resource guides based upon the Earth systems framework. Their purpose is to provide teachers with ideas and materials for infusing Earth systems concepts throughout the existing K–12 curriculum. After returning to their school systems, each team conducts at least two Earth Systems Education workshops at the state and local levels. During the last year of the project, the guides that have been developed will be edited and integrated into comprehensive Earth Systems Resource Guides for each of the grade levels and will be distributed nationally.

A second project testing aspects of the Earth Systems Education thrust is the development of an integrated Biological and Earth Systems (BES) science sequence for the high schools in the Worthington, Ohio, School District. It replaces earth science at 9th grade and biology at 10th. The sequence is organized around basic Earth system issues such as resource supply, global climate change, and deforestation. The program incorporates collaborative learning and problem-solving techniques as major instructional strategies. Current technology is also used, including the on-line and CD-ROM data bases for accessing current scientific data for use in course laboratory instruction.

A third effort is now underway, also in central Ohio. Ten school systems, including the two largest, have each designated a team of three to five middle school teachers to participate in a collaborative school-university program to consider the implications of Earth Systems Education philosophy and methods for the restructuring of their middle school science curricula. Four of the teams have already begun to develop a draft syllabus for their school districts. Other efforts are now underway in New York and Colorado.

The time appears to be ripe for the first total restructuring of the science curriculum since the current high school course sequence was established in the late 1800s. The dramatic changes that have taken place in science and in the understanding of how science is learned and the evolving demands of technology and the pressures it places on our environment require this restructuring. Earth Systems Education offers an effective strategy for restructuring. As a first step it provides for infusing planet Earth concepts into all levels of the K–12 science curriculum. For the long run it provides an organizing theme for a K–12 integrated science curriculum that could effectively serve the objectives of scientific literacy and at the same time provide a basis for the recruitment of talent into science and technology careers.

The comments in this article are from The Role of Planet Earth in the New Science Curriculum (*Journal of Geological Education*, v. 40, p. 66–73, 1992). ■

In Memoriam

Bennett F. Buie
Tallahassee, Florida
April 8, 1992

Mark P. Connaughton
Southport, North Carolina
April 7, 1992

Theodore H. Crook
Houston, Texas

Garth M. Crosby
Spokane, Washington
January 2, 1992

Walter M. Elsasser
Baltimore, Maryland
October 14, 1991

William H. Freeman
San Francisco, California
April 1, 1992

Mason L. Hill
Whittier, California
March 11, 1992

Floyd T. Johnston
Dallas, Texas
November 2, 1991

Chalmer J. Roy
Ft. Collins, Colorado

Ruth D. Terzaghi
Winchester, Massachusetts
March 2, 1992

James H. Zumberge
Los Angeles, California
April 15, 1992

Information Handling Inside Congress—How a Congressional Fellow Works Within the System

Kenneth B. Taylor
1991–1992 GSA Congressional Science Fellow

Many Washington insiders say the real coin-of-the-realm in Washington is information. People gather, trade, store, index, analyze, and manipulate it. There are in-town research services, both public and private, that can handle it for you. Even lobbyists and other interest groups will be happy to collect and process it for you. In Washington, there is no lack of information; rather, there is a glut of information, with the Members of Congress and their staffs rapidly approaching Information Overload.

Part of the job of being a fellow is to properly husband the technical information you have. The more compact *and* understandable you can make your information, the higher a value the Members of Congress as well as others will place on your information. Having accurate and relevant information is important, but having someone with a technical background to quickly analyze new information is essential. At present, my job consists of four types of information handling: information condensing, proposal processing, issue analysis, and technical translation.

Information Condensing. "Take this 300-page report, which has a 30-page Executive Summary, and condense the report to two pages," barks the Legislative Director to the Congressional fellow. "When you write it up, use bullets to list the highlights ... and by the way, the Senator needs it in one hour."

Such a request occurs more often than one would expect. Information condensing allows the Member of Congress to be informed without slogging through the examples, theory, or arguments present in a document. Fellows can go beyond the Executive Summary and examine the meat of the report. They have the experience and training to question both the methodology used in the study and the conclusions that the author drew from the data. Of greater importance, as a technical staff member, one has the responsibility to help his or her Member of Congress to avoid Information Overload. Should overload occur, it could result in basing the decision for a critical vote upon incorrect or incomplete knowledge of the issue.

Having independent sources of technical people to perform appraisal and analysis is essential to a Congressional office. In the office where I am working, there are four fellows: two detailees from government (DOD and BLM) and two from fellowship programs. Having in-house experts in several fields helps the Senator deal in depth with a wide range of issues. Several federal agencies such as the Nuclear Regulatory Commission, Environmental Protection Agency, U.S. Fish and Wildlife Service, and Minerals Management Service, for example, select and send their employees to help Members of Congress on particular issues. In addition, the in-house experts aid their agency by learning how the legislative process works, which helps make future dealings between the Executive and Legislative branches more productive.

Having accurate and relevant information is important, but having someone with a technical background to quickly analyze new information is essential.

Proposal Processing. The power of the purse rests with Congress. The President proposes a budget, but Congress appropriates the money. One tactic used to obtain money not in the budget is to forward dozens of proposals for funding various projects to the members of the appropriation committees. It is hoped that one of the members will take up one such proposal and champion that idea in the appropriation process. This is called working for an earmark, a process opposed by many Members of Congress but used by most.

Proposals come from constituents, lobbyists, and anyone with an interest in the dispersal of revenue from the U.S. Treasury. After arrival, the proposals are read by the staff, and summaries of both the type of proposed work and the cost estimate are made. If more information is needed, a staff member will meet with the constituent or interested parties. Finally, the staff members work this information into a coherent list for the Member to consider. The staff does not indicate to the Member which proposal to recommend; that's the Member's job.

Issue Analysis. Several thousand bills are introduced during every Congress; most are destined to go no farther. It is important to study the handful of bills that begin to move through the convoluted process of committee hearings, markup, and floor debate, for possible local impact to the State your Member represents. Examining the bill language can also indicate avenues to take in drafting possible amendments that could enhance or avoid economic impact. This means crafting ways to bring jobs to the State and/or prevent jobs from leaving. The Members of Congress, with rare exception, do not do anything against the greater good of the State they represent.

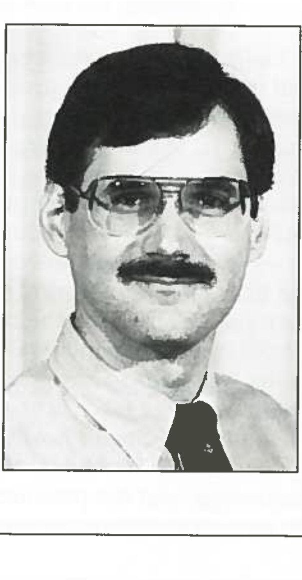
Technical Translation. As a scientist, one can talk to a wide range of technical people in their language and serve as a technical translator for the Member of Congress. One can help explain technical terms and complex processes. There is great need for more technical people in the Legislative Branch. Having experts on a Member's staff also highlights the importance that Member places on certain issues.

Congressional fellows try to avoid serving as spin doctors or political ramification experts. Fellows offer unbiased technical analysis. We brief the Member so that a very busy person is informed about the issues; we draft questions that reach to the heart of the matter during a hearing; and we help forge the compromises needed on the technical issues that are so often a part of controversial pieces of legislation. Fellows serve as support staff, helping with some of the heavy lifting and learning how the system really works. ■

Kenneth Taylor is the GSA Congressional Science Fellow for 1991–1992. He is serving in the office of U.S. Senator Harry Reid (D—NV). He can be reached at (202) 224-6996. The one-year fellowship is funded by GSA and the U.S. Geological Survey.

Meet the GSA Congressional Science Fellow

Ken Taylor will report about his experiences on the Hill at an informal lunch-hour session on Wednesday, October 28, during the GSA 1992 Annual Meeting in Cincinnati. This open forum is sponsored by the GSA Geology and Public Policy Committee. Room location to be announced in the Annual Meeting Program.



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Director General of GSC, at the opening plenary session, discussed the information requirements of governments and the concept of a "national geoscience knowledge base." Price described a national geoscience knowledge base as "an important national resource that will be depleted by the advancement of science if not continually updated." Price concluded that "Emerging global crises arising from growth in the human population, the per capita use of resources, and the resulting depletion of natural resources and deterioration of the environment for human habitation will present governments worldwide with urgent needs for geoscience and expertise...."

Presentations on theme I, evolution of geological surveys, were made by Peter Cook, Director of the British Geological Survey (BGS) and Zdenek Johan, Scientific Director of the French Bureau de Recherches Géologiques et Minières (BRGM), representing national surveys, and Philip E. Playford, Director of the Geological Survey of Western Australia, W. David McRitchie, Director of the Geological Services Branch of the Manitoba Department of Mines and Energy, and Arthur A. Socolow, former State Geologist of Pennsylvania. Cook described BGS's rapid evolution in the last decade, following a near fatal encounter with abolishment. Today, traditional mapping activities constitute a much smaller proportion of BGS activities, being replaced by activities related to waste disposal, ground-water resources studies, environmental geochemistry, petroleum resource studies, North Sea investigations, and similar projects. Cook stated that government long-term core funding now constitutes less than half of the BGS budget. Aside from undermining long-term planning, this has resulted in the necessity for strengthening marketing activities and vigorously attempting to "sell" BGS services to the public and private sector. Cook concluded, "In the 1830s Britain served as an example to the rest of the world in establishing a national geological survey. The modern British Geological Survey may not necessarily serve as an example for the future of all countries, but it is likely that as economic realities bite, progressively more countries will be forced to follow its example."

Johan reported that BRGM does not have a separate corps of scientific researchers, and that less than 25% of BRGM's annual budget is allocated for scientific research. Rather, BRGM is organized around three operational branches (the national geological survey, a soil and subsoil services branch, and a mining activities branch) and two strategic support branches (a scientific branch and a development branch). With this flexible structure, BRGM can undertake activities as a public service within the national geological survey, as a service corporation acting in the competitive sector, and as the parent corporation of an international mining group. Johan also described BRGM's activities as a center of training through research, with about 50 doctoral students, most supported by BRGM scholarships, preparing doctoral theses at BRGM's Orléans scientific and technical center.

Dallas L. Peck, Director of the U.S. Geological Survey (USGS) made the only presentations on theme II, reconciliation of resource development

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Robert L. Fuchs

3 For 1 Scholarship Challenge

The John T. Dillon Alaska Research Award Fund was established in 1988 by the Geological Society of America Foundation. Funds from the endowment support student field studies in structural geology and geochronology in Alaska. Since 1988, the fund has grown to about $20,000, and awards have been granted to three students. Field studies in Alaska are very expensive and the current awards cover only a small part of the students' expenses.

John Dillon's friends and family have set a goal of $30,000 for the fund by the end of 1992. To accelerate this effort, any contribution made by individual members of the Geological Society of America to the Dillon Fund before the end of the year will be *tripled.* For example, a contribution of $100 will be matched by a $200 contribution for a total contribution of $300. (Note: if your company matches your gift one-for-one, the total contribution will be $400.)

This offer will be honored through the end of 1992 or until the fund reaches the $30,000 goal, which ever comes first. Simply use the coupon below and send your tax-deductible contribution to the GSA Foundation. Please indicate on your check that your contribution is for the 3 for 1 Challenge.

This is a good opportunity to support geological research and expand our knowledge of Alaskan geology.

The BEST Award

You may have thought that the Penrose and Day medals are the preeminent awards that GSA presents to scientific notables. Now Ed Geary and SAGE have launched a new contender for lofty honors.

In March we announced in GSAF Update the Donald L. and Carolyn N. Biggs Excellence in Education Fund to support and enhance geoscience awareness and the education of young people. That news is now followed by the announcement that income from this fund will be used to provide an annual award to a faculty member who has been teaching for 10 years or less at a college or community college.

This award is to be known as the Biggs Earth Science Teacher Award—the BEST Award. In addition to establishing an appropriate acknowledgment that recognizes and encourages highest quality teaching, the BEST Award in itself may be a strong contender for acronym-of-the-year honors.

Pooled Income Fund Draws Large Response

The Foundation has received numerous requests for information about its Pooled Income Fund, which began in January 1992 with a gift from Carol G. McGill in honor of her late husband John T. McGill. This fund is open to all GSA members and families and is an estate-planning device since it provides the means of building investment income for retirement purposes.

If you would like to learn more about this form of planned giving, please send us the attached coupon or call the Foundation office and ask for the GSA Foundation Pooled Income Fund Offering brochure. Do yourself and Earth a long-term favor.■

Washington Report

continued from p. 148

and environmental protection. He described how many USGS scientists have shifted their research emphasis from traditional energy, minerals, and mapping topics to questions related to environmental issues, such as waste disposal, water quality, and global change. He stated that he believed the direction those USGS scientists were taking would be paralleled by other geological organizations as they approach the 21st century. He said, "This dual role of traditional energy, minerals, and mapping pursuits, coupled with a new emphasis on issues related to our environment, is the future of our geological surveys." He continued that "the function of the USGS has broadened and will continue to broaden in the future. We will see an ever-growing emphasis on environmental quality, balanced management of Earth's resources, and a better understanding of international earth-science issues. Developing better knowledge of domestic land, water, energy, and mineral resources will continue to be an important function. Because the United States is an integral part of the global economy, the gathering of information about world resources and the global environment *is* an important priority for the USGS. Our goal remains to provide unbiased earth-science information in the public service. More and more, we will accomplish this goal through a combination of in-house expertise and partnerships with others."

Presentations on theme III, resources for society, were made by Marten Kürsten, President of the German Federal Institute for Geosciences and Natural Resources (BGR) and Horst Czichos, Vice-President of the German Federal Institute for Materials Research and Testing (BAM). Kürsten described how modern society is becoming more and more dependent on new materials such as alloys, ceramics, polymers, and other "space age" compounds. He illustrated graphically that this demand for sophisticated resources is not at the expense of basic resources. That demand continues to increase.

Presentations on theme IV, new concepts and new technologies in the earth sciences, were made by Neil Williams, Associate Director of the Australian Bureau of Mineral Resources (BMR) and Katsuro Ogawa, Director General of the Geological Survey of Japan. Williams described the use of high-quality, systematic airborne magnetic and radiometric surveys for regional-scale geologic mapping, and Ogawa described the variety of earthquake-prediction techniques and investigations being conducted by the Geological Survey of Japan.

Presentations on theme V, international communication, cooperation, and collaboration, were made by Umberto Cordani, President of the International Union of Geological Sciences (IUGS), and Anthony Naldrett, Chairman of the Board of the International Geological Correlation Program (IGCP). Each described aspects of nongovernmental international cooperation and how the surveys and nongovernmental organizations can have a symbiotic relationship.

Zhu Xun, Minister of Geology and Mineral Resources for the People's Republic of China; Cornelius A. Kogbe, President of the Geological Society of Africa; and Carlos Oiti Berbert, President of the Brazilian Companhia de Pesquina de Recursos Minerais (CPRM) presented summaries of the status of geological surveys in their respective regions. Berbert stated that the geological agencies of Latin America all believe that international scientific cooperation is of the utmost importance toward the development of the geosciences. He described how many Latin American surveys maintain reciprocal exchanges with institutions in Europe, North America, and Asia.

At the closing plenary session, ICOGS attendees were asked if a permanent international association of geological surveys should be formed. There was no consensus. Some felt that regional associations would be more beneficial. Others favored an international approach as a mechanism to share problems and solutions. An ad hoc committee was appointed to pursue the question and to report at the 1992 International Geological Congress in Kyoto, Japan.■

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About People

GSA Fellow **Paul A. Catacosinos,** Delta College, University Center, Michigan, has received the Ormond E. Barstow and Ludo K. Frevel Award for Scholarly Achievement from Delta College, for his research on the stratigraphy, origin, and history of the Michigan Basin.

American Institute of Professional Geologists awards for 1992 go to GSA Fellow **R. H. Dott, Jr.,** University of Wisconsin, Madison (the Ben H. Parker Memorial Medal); Fellow **Kenneth N. Weaver,** Maryland Geological Survey, Baltimore (Martin Van Couvering Memorial Award); Fellow **Robert R. Jordan,** Delaware Geological Survey, Newark (Public Service Award); and Fellow **Richard J. Proctor,** Arcadia, California (Honorary Membership Award).

Officers for 1992 of the Association for Women Geoscientists include GSA Member **Cathryn Stewart,** Oklahoma City (Secretary) and Member **Sarah Stoll,** Sheboygan, Wisconsin (Editor).

Member **Kent Sundell,** Casper, Wyoming, has received the Wyoming Geological Association's 1991 Frank A. Morgan Award.

Schemes for Redistributing Geoscience Literature

Claren M. Kidd
University of Oklahoma, L. S. Youngblood Geology Library
100 E. Boyd R220, Norman, OK 73019-0628

Individuals and organizations occasionally need to eliminate books and journals from their collections. Described on the chart below are an individual and 15 selected Canadian and U.S. organizations that place geoscience literature in public or academic libraries domestically and internationally. A call to the contact person with a description of what you would like to donate will begin the process to affirm that the information contained in your personal library will continue to be used. Information summarized in this chart is part of a longer, more detailed paper (Kidd, C. M., 1992, Schemes for Redistributing Geological Literature, *in* Fracolli, D. M., Geoscience Information Society *Proceedings*, v. 22; an oral version was delivered at the GIS Symposium held October 22, 1991, in San Diego, California).

Organizations and an Individual Involved in Redistribution of Geoscience Publications

Organization	Address	Phone	Contact Person	Kinds of items accepted	Emphasis		Shipping paid by		Comments
					Subject	Part of world	donor	recipient	
AAAS Sub-Saharan Journal Distribution Program	1333 H St., N.W. Washington, DC 20005	(202) 326-6650	Lisbeth Levey	Journal subscriptions	Science, humanities, social sciences	38 sub-Saharan African nations			ACLS coordinates social sciences and humanities
AGID Book/Journal Donation Service	910 Avenue Road Toronto, Ont. M5P 2K6, Canada	(416) 481-4731	Owen White	Current textbooks, journal runs	Geoscience	Third World nations	To CODE (Ottawa)	Overseas requested	
Books for Asia (part of the Asia Foundation)	451 Sixth St. San Francisco, CA 94103	(415) 982-4640	Mathew King	Books—less than 10 yrs. old and in good condition; journal runs to current or previous year	Any	Asia and the western Pacific	To San Francisco		
Brother to Brother	19 W. Alameda Dr. #102, P.O. Box 27634 Tempe, AZ 85285-7634	(800) 642-1616 (602) 967-7871	Diana French	Books, journals	Any	Any	Arranged between donor and recipient		Computerized clearinghouse
Brothers Brother	824 Grandview Ave. Pittsburgh, PA 15211	(412) 431-1600	Greg Kearns	Books, journals	Medical, scientific, reference	Any	Arranged between donor and recipient		Solicits health and educational resources from producers
Canadian Book Exchange Center	85 Bentley Ave. Nepean, Ontario K1A 0N4, Canada	(613) 954-8904	Pierre Gamache	Periodicals, nonfiction monographs, Canadian publications, foreign publications	Any, but no fiction	Canada; secondarily, rest of the world	To Ontario	To recipient	Membership is free
CODE	321 Chapel St. Ottawa, Ontario K1N 7Z2, Canada	(613) 232-3569	Scott Walter	"Gently" used books	Any, publisher donation	Africa, Pacific, Caribbean	Suggestions for assistance can be requested		Emphasis is shifting to assistance with autonomous publishing
Center for Interamerican Mineral Resources Investigations (USGS)	210 E. 7th St. Tucson, AZ 85705	(602) 670-5510	Norman J. Page	Books, journal runs	Geoscience	Latin America	To Tucson		USGS geologists investigating Latin America identify libraries and place needed literature
Darien Book Aid Plan	1926 Post Rd. Darien, CT 06820	(203) 655-2777	Patricia Brown	Recently published books in *good* condition	Any	Any	To Darien		Center repackages to fill request of recipient
International Book Bank, Inc.	608-L Folcroft St. Baltimore, MD 21224	(301) 633-2929 (800) US-GRANT	Rosamaria Durand	New or barely used	American history and market economics	Eastern Europe	To Baltimore		Maintains computerized inventory from which recipients select
F. L. Klinger	5013 Alta Vista Ct. Bethesda, MD 20814	(301) 530-1985	F. L. Klinger	Books, journal runs	Geoscience	U.S. libraries	Arranged between donor and recipient		Occasionally distributes a duplicate list
Library of Congress	Room B03 Madison Bldg. Washington, DC 20540	(202) 707-9511 (202) 707-9512	Judy McDermott	Books, journals	Any	Any	Arrange shipping		Recipients select on-site from shelves of donations
SEPM Developing Countries Libraries Committee	Dept. Geol. Sciences Indiana University Bloomington, IN 47405	(812) 855-6654	Abhijit Basu	SEPM subscriptions to libraries of developing nations	Geoscience	Any accepted by Program Committee	SEPM ships from its printer		SEPM Newsletter advises its members of needs of libraries. Will assist program with use of SIES
SIES	1111 N. Capitol St., N.E. Washington, DC 20560	(202) 357-1964 (202) 357-2073	Thomas Matthews	Books, journals	Any	Any, but recipient must be identified	To Washington		Donations must come from institutions; be sure to carefully adhere to "Regulations Regarding Weight and Preparation of Packages for Overseas Mailing" from SIES
Sudan-American Foundation for Education, Inc.	c/o Guy Detrick 201 Davis Dr., Unit Z Sterling, VA 22170	(703) 525-9045	Lee Burchinal	Books and journal runs of past 10 yrs.	Any of college level	Sudan	To Sterling	Foundation arranges	Local representatives select in Sudan

Abbreviations:
AAAS—American Association for the Advancement of Science
ACLS—American Council of Learned Societies
AGID—Association of Geoscientists for International Development
CODE—Canadian Organization for Development through Education
SEPM—Society for Sedimentary Geology
SIES—Smithsonian International Exchange Service

Preliminary program appeared in April issue of *GSA Today*.
Full program appears in August issue of *GSA Today*.
Preregistration due: September 25
Housing deadline: October 3
For more information: Meetings Department (303) 447-2020, 1-800-472-1988, fax 303-447-0648

THE VOYAGE CONTINUES
From Columbus to Magellan

Symposia

Invited Papers (Symposia)

This format includes only abstracts that have been invited by the convener of a symposium. Abstracts are sent directly to the convener by July 8.

S1. **From Columbus to Magellan—Discovery.** 1992 Technical Program Committee. Nicholas Rast, University of Kentucky.

The impetus of geological sciences can only be sustained if new and pertinent discoveries are made and become widely known. These discoveries then become parts of the whole body of knowledge and can be employed both in the development of new ideas and in the utilization of these ideas in practice.

Discoveries have always been at the heart of geological sciences, and have always been promoted by GSA. In 1992, the quincentenary of Columbus discovering America, and a year in which the Magellan satellite is still mapping Venus from space, the theme is particularly pertinent. In 1492, Columbus journeyed to discover a new world on Earth. We are now discovering and charting a new world in space, and in the process we are exploring worlds of new ideas. To modern geoscientists the impact of new ideas is not only of theoretical importance, but also of practical and progressively more environmental importance.

S2. **History of Late Glacial Runoff from the Southern Laurentide Ice Sheet.** Quaternary Geology and Geomorphology Division. James T. Teller, University of Manitoba, Winnipeg, Canada.

The paleohydrological history of meltwater generation and its flow from the southern Laurentide Ice Sheet through varying drainage routes from Canada to the Gulf of Mexico can be found in the sedimentary and erosional records of proglacial lakes and valleys. Of concern is the late glacial record of ice-marginal lakes and their overflow to the oceans, from the region extending from the Canadian plains through the Great Lakes and south to the Gulf of Mexico. This session will describe the nature, magnitude, routing, and chronology of this discharge.

S3. **The History of the Use of Art and Photography in Geological Literature.** History of Geology Division. Donald M. Hoskins, Pennsylvania Geological Survey, Harrisburg.

The symposium will seek to examine the historical development and use of imagery and visual techniques that can be classed as "art" in the depiction and explanation of geologic phenomena. In addition, the development of photography used for similar illustrative purposes in the geological sciences will be explored.

S4. **Preserving Geoscience Imagery.** Geoscience Information Society. Louise S. Zipp, University of Iowa.

This symposium will focus upon preserving imagery that is of substantial importance to the communication of knowledge in geoscience. Art, photography, maps (conventional and digital) and other formats will be considered. Papers will deal with large-scale preservation efforts and needs, as well as those of the individual geoscientist.

S5. **Frontiers of Chemical Mass Transport in Contaminant Systems.** Hydrogeology Division, Institute for Environmental Education. Yu-Ping Chin and Frank W. Schwartz, Ohio State University.

Research in chemical reactions in controlling the transport of contaminants in groundwater spans two decades. Workers are examining complex problems such as colloid generation, properties and transport, the influence of microorganisms, interfacial reactions involved with mixed waste, surfactants and the stability of precipitated solids. In spite of progress in this field, challenges remain.

S6. **Reform in Science Education.** National Association of Geology Teachers. Charles Q. Brown, East Carolina University, North Carolina.

Leaders in the national science education reform movement will discuss (1) the role of science in the National Curriculum of England and Wales implemented in 1990, with emphasis on earth science, (2) progress and earth science content of two major national science curriculum efforts in the United States, the AAAS Project 2061 and the NSTA SCOPE, Sequence and Coordination, (3) involvement of the geoscience community in the national science education standards program of the National Research Council, and (4) the impact of reform on higher education curricula.

S7. **Mineralization Related to Continental Rifts** (full day). Society of Economic Geologists. Richard E. Beane, Oro Valley, Arizona.

This full-day symposium centers on the chemical evolution and mineralization of continental rifts. Presence of the Midcontinent Rift in the central United States makes this a topic of regional interest. This symposium contains three segments: formation and chemical evolution of continental rifts; mineralization in various rifts (Midcontinent, Connecticut River, Palisades, and Red Sea); and mineralization related to the currently evolving Salton Sea.

S8. **Black Shales and Related Ore Deposits.** Society of Economic Geologists. Richard I. Grauch, U.S. Geological Survey, Denver; Holly Huyck, Denver, Colorado.

Black shales commonly carry significant mineralization related to continental rifting. Presence of organic-rich, metalliferous shales in Ohio, Kentucky, Indiana, and beyond make this a topic of both regional and international interest. This symposium focuses on location and migration of metals in shales or sedimentary basins and on the interaction of organic materials with metals. This symposium is closely tied to the Sunday symposium on mid-continental rifts, as well as the premeeting field trip to the White Pine (shale-hosted) and Keweenaw copper deposits in Michigan.

S9. **Ground Truth: Geology of the Earth and Planets from Rocks and Analogs.** Planetary Geology Division. Harry Y. McSween, University of Tennessee, Knoxville.

This symposium will explore the constraints on planetary (including terrestrial) geology imposed by mineralogic and petrologic studies of planetary materials and by experimental, computational, and field-oriented analog studies. Included will be talks that focus on volcanism, metamorphism, structural deformation, cratering, and fluids. By concentrating on the geologic implications, the symposium should be of interest to structural geologists, volcanologists, and geomorphologists, as well as sample-oriented geologists.

S10. **Applications of Stable Isotope Geochemistry to Problems in High-Temperature Petrogenesis.** Geochemical Society. Theodore C. Labotka, University of Tennessee, Knoxville.

The stable isotopes of hydrogen, carbon, and oxygen are potent recorders of petrogenetic processes, including those involving the interaction between magmatic, oceanic, and meteoric hydrothermal fluids and igneous and metamorphic rocks and those involving the mixing, contamination, or assimilation of country rock with isotopically distinct magma. This symposium will focus on results from new and traditional analytical techniques and new experimental studies for the petrogenetic interpretation of the isotopic compositions of rocks and minerals.

S11. **Geologic Aspects of Development Projects in Latin America and the Caribbean Basin.** International Division, Engineering Geology Division. Jerome V. DeGraff, USDA Forest Service, Clovis, California; John S. Oldow, Rice University.

The symposium will explore the role of environmental and engineering geology in development, and how development has affected geologic processes. The quincentenary of Columbus represents an acceleration in human interaction with the geologic environment in Latin America

Symposia *continued on p. 152*

NEW GSA FELLOWS

The following 24 Members were advanced to Fellowship in May 1992.

Bill Bonnichsen
G. Robert Brakenridge
Carlton E. Brett
Dabney W. Caldwell
Patrick J. V. Delaney
William A. DiMichele
Ronald I. Dorn
Edward A. du Bray
John C. Eichelberger
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Martha M. Godchaux
John W. Hess
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Colin J. Paterson
Jarg R. Pettinga
Marith C. Reheis
Stephen J. Reynolds
George C. Stephens
Edward F. Stoddard
Pradeep Talwani
John W. Valley
John D. Vitek
Jane H. Wallace

Symposia *continued from p. 151*

and the Caribbean Basin, and reflects concerns that are global. Development projects have the potential for both positive and negative consequences. These issues provide a continuation of the Global Challenge theme from the 1991 Annual Meeting.

S12. **Instability on Clay and Shale Hillslopes.** Engineering Geology Division. William C. Haneberg, New Mexico Bureau of Mines, Socorro; Robert W. Fleming, U.S. Geological Survey, Denver.

Emphasis will be on advances in our understanding about how clay and shale influence slope instability, clay as a material, the effects on failure mechanisms, insights into potential clay-related instability problems in natural hazard zonation, and recent discoveries as a stimulus to future research. The well-known role that clay and shale play in slope instability around Cincinnati makes this city an appropriate setting for this symposium. However, the symposium will provide a broad view of this topic in both a geographic and a scientific sense.

S13. **Physical and Chemical Responses to Allocyclic Processes in Carboniferous Coal-Bearing Strata.** Coal Geology Division. Cortland F. Eble, Kentucky Geological Survey, Lexington; C. Blaine Cecil, U.S. Geological Survey, Reston.

Sedimentological responses to allocyclic processes (including climate, tectonics, and eustasy) as controlling factors on the Carboniferous rock record will be emphasized. This is a departure from historic emphasis on autocyclic (e.g., deltaic) processes and traditional depositional modeling. Invited papers will cover a wide range of topics and subdisciplines from Carboniferous basins throughout North America.

S14. **Controls on Carbon Preservation** (full day). Organic Chemistry Division of the Geochemical Society. Cindy Lee, State University of New York at Stony Brook.

The relation among primary productivity, O_2 levels, and organic carbon preservation in marine sediments has been a subject of great controversy among geochemists, sedimentologists, and paleoceanographers. Explanations for the enrichment of organic carbon that can occur in modern and ancient sediments include (1) anoxic conditions, (2) higher productivity, (3) higher sedimentation rate, and (4) lower animal activity than in oxic sediments.

S15. **The Role of Fluids in Crustal Deformation.** Structural Geology and Tectonics Division. Jan A. Tullis, Brown University; Terry Engelder, Pennsylvania State University, University Park.

Fluids have a profound effect on crustal deformation, and deformation plays an important role in channeling fluids through the crust. This symposium will highlight recent advances in our understanding of topics such as the anomalously low strength of major faults, crustal plumbing and seismic pumping, and fluids in ductile shear zones.

S16. **Synergism: Archaeological and Geological Sciences.** Archaeological Geology Division. Bonnie A. Blackwell, Purdue University.

This symposium will review the many contributions that archaeological geology and archaeology have made to scientific developments within geological sciences, including soil science; sedimentology; karst geomorphology; geochemistry through paleodietary, paleothermometry, and paleohumidity studies; geochronology with improved methods for $^{230}Th/^{234}U$, ESR, AMS ^{14}C and amino acid dating; paleontology; mineralogy and materials sciences; the development of geographic information systems (GIS); palynology; paleoclimatology; and geophysics.

S17. **Paleosols: Their Geologic Applications.** Sedimentary Geology Division. Mary J. Kraus, University of Colorado; David E. Fastovsky, University of Rhode Island.

Paleosols are an important but still under-used aspect of terrestrial sedimentology. The application of paleopedology to diverse geologic problems includes interpreting paleoclimates and paleoenvironments, determining the CO_2 content of ancient atmospheres, estimating sediment accumulation rates and stratigraphic completeness, and evaluating significant biologic events (e.g., immigrations, extinctions). This session will also address paleosol analysis and evaluate the interpretations that can be made from paleosols.

S18. **Speciation in the Fossil Record.** Paleontological Society. Douglas H. Erwin, U.S. Museum of Natural History, Washington; Robert Anstey, Michigan State University.

We will consider recent work, particularly in case studies, of speciation in the fossil record. Of particular interest are new procedures for analyzing speciation patterns and work on the limitations of the fossil record in studying speciation. This symposium comes at a particularly appropriate time in light of work by biologists, but studies of speciation in the Holocene lack the temporal depth that only paleontologists can achieve. In addition, this symposium will be held on the 20th anniversary of Eldridge and Gould's seminal paper on punctuated equilibrium. While we do not intend to reopen this controversy, this does provide an opportunity to look back and look ahead. ■

NEW GSA MEMBERS

The following 523 Members have been elected to Membership by Council action during the period from August 1991 through February 1992 (*indicates transfer from Student Associate to Member).

Ernesto Abbate
Ginette Abdo
Hamed H. Al-Harby
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*Joanne M. Alexandrovich
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*Laurie C. Anderson
Karin M. Andreassen
*Gary J. Axen
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*Karin M. Barovich
G. Robert Barry
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*Denise A. Battles
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*David R. Bazard
*Harriet G. Beale
Warren Beck
Diane Bellis
*Andrew T. Benoit
Richard C. Benson
Richard C. Berg
William Berglof
Stefano M. Bernasconi
*Erick A. Bestland
Lori Bettison-Varga
Keith H. Bettles
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*Henk Brinkhuis
Madeleine Briskin
*Daniel T. Britt
*Lynn D. Broede
Kevin M. Brown
Nancy E. Brown
*Nancy E. Brown
*Gregory H. Browne
*Jonathan R. Bryan
Philip A. Buchiarelli
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Hunter Butler
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*Kenneth G. Caldeira
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Thomas A. Chaimov
*Steven R. Chambers
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*Mark Chandler
*Mark A. Chandler
Gary S. Chulick
*Jean M. Chytil
*Dennis A. Clark
*Michael S. Clark
*Brooke P. Clements
*Burt G. Clothier
*C. A. Clowe
*Bernard J. Coakley
*Annette R. Colgan
Bruce C. Comstock
*Roger D. Congdon
*Richard M. Conrey
*Robert D. Cook
*Timothy K. Cowdery
*Patience A. Cowie
Troy T. Crain
Sharon S. Crowley
*Kenneth M. Cruikshank
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New Members *continued on p. 153*

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GSA Penrose Conferences

September 1992

Applications of Strain: From Microstructures to Mountain Belts, September 9–13, 1992, Liscomb Mills, Nova Scotia, Canada. Information: Mark Brandon, Dept. of Geology and Geophysics, Yale University, P.O. Box 6666, New Haven, CT 06511-8130, (203) 432-3135; Scott R. Paterson, Dept. of Geological Sciences, University of Southern California, Los Angeles, CA 90089-0740, (213) 740-6130.

Origin and Emplacement of Low-K Silicic Magmas in Subduction Settings, September 25–30, 1992, Chelan, Washington. Information: James S. Beard, Virginia Museum of Natural History, Martinsville, VA 24112, (703) 666-8611, fax 703-632-6487; George W. Bergantz, Dept. of Geological Sciences, University of Washington, Seattle, WA 98195, (206) 545-4972; Marc J. Defant, Dept. of Geology, University of South Florida, Tampa, FL 33620, (813) 974-2238, fax 813-974-2668; Mark S. Drummond, Dept. of Geology, University of Alabama, Birmingham, AL 35294, (205) 934-8130.

October 1992

Fluid-Volcano Interactions, October 4–9, 1992, Warm Springs, Oregon. Information: Steve Ingebritsen, U.S. Geological Survey, MS 439, 345 Middlefield Road, Menlo Park, CA 94025, (415) 329-4422, fax 415-329-4463; Bruce Christenson, Geothermal Research Centre, Private Bag 2000, Taupo, New Zealand; Craig Forster, Dept. of Geology and Geophysics, University of Utah, 719 W.C. Browning Building, Salt Lake City, UT 84112; Grant Heiken, Los Alamos National Laboratory, MS-D462, Los Alamos, NM 87545; Craig Manning, Dept. of Earth and Space Sciences, University of California, 405 Hilgard Avenue, Los Angeles, CA 90024.

Late Precambrian Tectonics and the Dawn of the Phanerozoic, October 18–23, 1992, Death Valley, California. Information: Ian W.D. Dalziel, Institute for Geophysics, University of Texas, Austin, TX 78759-8345, (512) 471-6156, fax 512-471-8844; Andrew H. Knoll, The Botanical Museum, Harvard University, Cambridge, MA 02138, (617) 495-9306 (on sabbatical in Cambridge, UK); Eldridge M. Moores, Dept. of Geology, University of California, Davis, CA 95616, (916) 752-0352 or 752-0350, fax 916-752-0951.

1992 Meetings

July

7th International Symposium on Water-Rock Interaction, July 13–22, 1992, Park City, Utah. Information: Yousif Kharaka, Secretary-General, U.S. Geological Survey, MS 427, 345 Middlefield Road, Menlo Park, CA 94025, (415) 329-4535, fax 415-329-5110.

Society for Industrial and Applied Mathematics Annual Meeting, July 19–24, 1992, Los Angeles, California. Information: SIAM Conference Dept., 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: siamconfs@wharton.upenn.edu.

International Committee for Coal Petrology 44th Meeting, July 20–24, 1992, University Park, Pennsylvania. Information: Alan Davis, Penn State University, 205 Research Bldg. E, University Park, PA 16802, (814) 865-6544, fax 814-865-3573.

Society for Organic Petrology, 9th Annual Meeting, July 23–24, 1992, University Park, Pennsylvania. Information: Jim Hower, Center for Applied Energy Research, 3572 Iron Works Pike, Lexington, KY 40511, (606) 257-0261, fax 606-257-0302.

Northeastern Science Foundation–History of Earth Sciences Society Meeting on the History of Geology, July 29–August 1, 1992, Troy, New York. Information: Gerald M. Friedman, Northeastern Science Foundation, P.O. Box 746, Troy, NY 12181-0746, (518) 273-3247, fax 518-273-3249.

August

XVII Congress of International Society for Photogrammetry and Remote Sensing, August 2–14, 1992, Washington, D.C. Information: XVII ISPRS. Congress Secretariat, P.O. Box 7147, Reston, VA 22091-7147, (703) 648-5110.

10th International Conference on Basement Tectonics, August 3–7, 1992, Duluth, Minnesota. Information: Richard Ojakangas, Dept. of Geology, University of Minnesota, Duluth, MN 55812, (218) 726-7238, fax 218-726-6360.

International Geographical Union 27th Congress, August 9–14, 1992, Washington, D.C. Information: IGU Congress Secretariat, 17th and M Streets, NW, Washington, DC 20036, (202) 828-6688.

13th Caribbean Geological Conference, August 10–14, 1992, Pinar del Rio, Cuba. Information: Grenville Draper, Florida International University, Geology Dept., University Park, Miami, FL 33199, (305) 348-3572, fax 305-348-3877, Bitnet: DRAPER@SERVAX.

Phanerozoic Basins of Southwestern Gondwana: Tectonics, Stratigraphy, and Seismic Expression, August 12–16, 1992, Santa Cruz, Bolivia. Information: Ramiro Suarez Soruco, Casilla 727, Santa Cruz, Bolivia, fax 591-3-34-6472; A. J. Tankard, Petro-Canada, P.O. Box 2844, Calgary, Alberta, T2P 3E3, Canada, (403) 296-5808, fax 403-296-5875.

Second International Conference on Asian Marine Geology, August 19–22, 1992, Tokyo, Japan. Information: Shin'ichi Kuramoto, Ocean Research Institute, University of Tokyo, 1-15-1, Minamidai, Nakano-ku, Tokyo, 164 Japan, phone 03-3376-1251, fax 03-3375-6716, telex 25607/ORIUT, E-mail: kuramoto@tansei.cc.utokyo.ac.jp *or* kuramoto@jpnoriut.bitnet.

29th International Geological Congress, August 24–September 3, 1992, Kyoto, Japan. Information: Secretary General, IGC-92 Office, P.O. Box 65, Tsukuba, Ibaraki 305, Japan, phone 81-298-54-3627, fax 81-298-54-3629, telex 3652511 GSJ J.

GeoTech '92—Geocomputing Conference, August 29–September 1, 1992, Denver, Colorado. Information: Mark Cramer, GeoTech, Contract Station 19, P.O. Box 207, Denver, CO 80231-4952, (303) 752-4951, fax 303-752-4979.

IAS/SEPM Research Conference on Carbonate Stratigraphic Sequences: Sequence Boundaries and Associated Facies (Emphasis on Outcrop and Processes Studies), August 30–September 3, 1992, La Seu, Spain. Information: Toni Simo, Dept. Geology and Geophysics, University of Wisconsin, 1215 W. Dayton St., Madison, WI 53706, (608) 262-5987, fax 608-262-0693, E-mail: simo@-geology.wisc.edu; Mark Harris, Dept. Geosciences, University of Wisconsin, P.O. Box 413, Milwaukee, WI 53201, (414) 229-5452; Evan Franseen, Kansas Geological Survey, 1930 Constant Ave., Lawrence, KS 66047, (913) 864-5317.

International Conference on Large Meteorite Impacts and Planetary Evolution, August 31–September 2, 1992, Sudbury, Ontario, Canada. Information: B. O. Dressler, Ontario Geological Survey, 77 Grenville St., 9th Floor, Toronto, Ontario M7A 1W4, Canada, (416) 965-7046, fax 416-324-4933.

September

International Conference on Arctic Margins, September 2–4, 1992, Anchorage, Alaska. Information: David Steffy or Dennis Thurston, U.S. Minerals Management Service, 949 E. 36th Ave., Anchorage, AK 99508, (907) 271-6553, fax 907-271-6805.

5th International Symposium on Seismic Reflection Profiling of the Continental Lithosphere, September 6–12, 1992, Banff, Alberta, Canada. Information: R. M. Clowes, Lithoprobe Secretariat, 6339 Stores Road, University of British Columbia, Vancouver, BC V6T 1Z4, Canada, (604) 822-4202, fax 604-822-6958; A. G. Green, Geological Survey of Canada, 1 Observatory Crescent, Ottawa, Ontario K1A 0Y3, Canada, fax 613-992-8836.

■ **AAAS Arctic Division, Arctic Science Conference,** Environmental Change: Natural and Man-Made, September 8–12, 1992, Valdez, Alaska. Information: Cindy Wilson, (907) 474-7954, fax 907-474-7290.

International Symposium on the Geology of the Black Sea Region, September 7–11, 1992, Ankara, Turkey. Information: ISGB Sekreterliği, MTA Genel Müdürlüğü, 06520 Ankara, Türkiye, phone (90)-(4)-223 69 27, fax 90-(4)-222 82 78.

The Transition from Basalt to Metabasalt: Environments, Processes, and Petrogenesis, September 9–15, 1992, Davis, California. Information: Peter Schiffman, Dept. of Geology, University of California, Davis, CA 95616, (916) 752-3669, E-mail: PSchiffman@-UCDavis.edu.

Association for Women Geoscientists, 2nd National Convention, September 11–13, 1992, Denver, Colorado. Information: Pam Goode, 6103 Alkire Ct., Arvada, CO 80004, (303) 424-2045.

3rd International Conference on Plasma Source Mass Spectrometry, September 13–18, 1992, Durham, England. Information: Grenville Holland, Dept. of Geological Sciences, The University Science Laboratories, South Road, Durham DH1 3LE, England, phone 091-374-2526.

■ **El Paso Geological Society Fall Field Conference, Northern Sierra Madre Occidental Province, Mexico (Chihuahua/Sonora),** September 18–21, 1992. Information: Marty Brown, Economic Geology Publishing Company, 101 Vowell Hall, University of Texas, El Paso, TX 79968, (915) 533-1965 or 1966; fax 915-544-7416.

Federation of Analytical Chemistry and Spectroscopy Societies Annual Meeting, September 20–25, 1992, Philadelphia, Pennsylvania. Infomation: FACSS, P.O. Box 278, Manhattan, KS 66502, (301) 846-4797.

■ **Dallas Geotech '92 (Geoscience Oriented Computer Conference),** September 21–22, 1992, Dallas, Texas. Information: William Moulton, Enserch Exploration, Inc., 4849 Greenville Ave., Suite 1200, Dallas, TX 75206, (214) 599-9477.

4th International Conference on Paleoceanography, September 21–25, 1992, Kiel, Germany. Information: ICP IV Organizing Committee c/o GEOMAR, Wischhofstrasse 1-3/Bldg. 4, D-2300 Kiel 14, Germany.

23rd Annual Binghamton Geomorphology Symposium: Geomorphic Systems, September 25–27, 1992, Oxford, Ohio. Information: Bill Renwick, Dept. of Geography, Miami University, Oxford, OH 45056, (513) 529-1362, E-mail: BRENWICK@MIAMIU.BITNET; Jonathan Phillips, Dept. of Geography, East Carolina University, Greenville, NC 27858, (919) 757-6082, E-mail: GEPHILLI@ECUVM1.BITNET.

Underwater Mining Institute, Washington, D.C., September 27–30, 1992. Information: Charles Morgan, University of Hawaii, Look Laboratory, 811 Olomehani St., Honolulu, HI 96813-5513, (808) 522-5611, fax 808-522-5618.

American Institute of Professional Geologists Annual Meeting, September 27–October 1, 1992, Lake Tahoe, Nevada. Information: Jon Price, AIPG, P.O. Box 665, Carson City, NV 89702, (702) 784-6691.

October

■ **57th Annual Field Conference of Pennsylvania Geologists, Geology of the Upper Allegheny River Region in Warren County, Northwestern Pennsylvania,** October 1–3, 1992, Warren, Pennsylvania. Information: Field Conference of PA Geologists, P.O. Box 1124, Harrisburg, PA 17108-1124, (717) 787-2379.

Association of Engineering Geologists, Annual Meeting, October 2–9, 1992, Long Beach, California. Information: John W. Byer, 444 "A" East Broadway, Glendale, CA 91205, (818) 549-9959, fax 818-242-2442.

SEPM Midcontinent Section Annual Meeting: Paleosols, Paleoweathering Surfaces and Sequence Boundaries, October 9–11, 1992, Knoxville, Tennessee. Information: Steven G. Driese, Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-2366, fax 616-974-2368.

2nd International Congress on Energy, Environment and Technological Innovation, October 12–16, 1992, Rome, Italy. Information: Secretaria CPA: Comisión de Promoción Académica, Facultad de Ingeniería, Universidad Central de Venezuela, Edif. Decanato, Caracas 1050, Venezuela, phone 58-2-6627538/7612, fax 58-2-6627327.

Seismological Society of America, Eastern Section Annual Meeting, October 14–16, 1992, Richmond, Virginia. Information: John Filson or Henry Spall, U.S. Geological Survey, 904 National Center, Reston, VA 22092,

(703) 648-6078. *(Abstract deadline: September 11, 1992.)*

American Institute of Hydrology Conference: Interdisciplinary Approaches in Hydrology and Hydrogeology, October 17–22, 1992, Portland, Oregon. Information: AIH, 3416 University Ave. SE, Minneapolis, MN 55414-3328, (612) 379-1030.

Gulf Coast Association of Geological Societies and Gulf Coast Section of SEPM, Joint Annual Convention, October 21–23, 1992, Jackson, Mississippi. Information: Cragin Knox, GCAGS Convention 1992, P.O. Box 2474, Jackson, Mississippi 39225-2474.

Geological Society of America Annual Meeting, October 26–29, 1992, Cincinnati, Ohio. Information: GSA, Meetings Dept., P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, fax 303-447-1133. *(Abstract deadline: July 8, 1992.)*

Geological Association of New Jersey 9th Annual Meeting and Field Trip, October 30–31, 1992, New Brunswick, New Jersey. Information: Howard Parish, Jersey City State College, 2039 Kennedy Blvd., Jersey City, NJ 07305, (201) 200-3164, fax 201-200-2298.

November

28th Annual Conference and Symposia: Managing Water Resources During Global Change, November 1–5, 1992, Reno, Nevada. Information: Raymond Herrmann, NPS, WR-CPSU, WRD, Colorado State University, Ft. Collins, CO 80523, (303) 491-7825.

Joint Meeting of the Clay Minerals Society and the Soil Science Society of America, November 1–6, 1992, Minneapolis, Minnesota. Information: Jerry Bigham, Dept. of Agronomy, Ohio State University, Columbus, OH 43210, (614) 292-2001.

14th New Zealand Geothermal Workshop, November 4–6, 1992, Auckland, New Zealand. Information: 4th New Zealand Geothermal Workshop, University of Auckland, Private Bag 92019, Auckland, New Zealand, fax 64-9-373-7419. *(Abstract deadline: July 3, 1992.)*

Eastern Oil Shale Symposium, November 18–20, 1992, Lexington, Kentucky. Information: Geaunita H. Caylor, Coordinator, University of Kentucky/OISTL, 643 Maxwelton Court, Lexington, KY 40506-0350, (606) 257-2820, fax 606-258-1049.

Geological Society of New Zealand and New Zealand Geophysical Society Joint Annual Conference, November 23–27, 1992, Christchurch, New Zealand. Information: David Shelley, Dept. of Geology, University of Canterbury, Christchurch 1, New Zealand, phone 64-3-667-001, fax 64-3-642-769.

December

IGCP Project 274 Annual Meeting—Coastal Evolution in the Quaternary, December 7–15, 1992, Wellington, New Zealand. Information: Alan Hull, DSIR Geology & Geophysics, P.O. Box 30-368, Lower Hutt, New Zealand, +64(4) 569-9059, fax +64(4) 566-6168, E-mail: srlnagh@lhn.geo.dsir.govt.NZ. *(Abstract deadline: October 1, 1992.)*

1993 Meetings

February

9th Thematic Conference, Geologic Remote Sensing—Exploration, Environment, and Engineering, February 8–11, 1993, Pasadena, California. Information: ERIM/Thematic Conferences, Nancy J. Wallman, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123. *(Abstract deadline: June 8, 1992.)*

March

GSA South-Central Section Meeting, March 15–16, 1993, Fort Worth, Texas. Information: John Breyer, Dept. of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.

GSA Northeastern Section Meeting, March 22–24, 1993, Burlington, Vermont. Information: Vanessa George, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020.

Fluvial-Dominated Deltaic Reservoirs in the Southern Midcontinent, March 23–24, 1993, Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 East Boyd, Rm. N-131, Norman, OK 73019, (405) 325-3031.

GSA North-Central Section Meeting, March 29–30, 1993, Rolla, Missouri. Information: Richard Hagni, Dept. of Geology and Geophysics, University of Missouri, Rolla, MO 65401, (314) 341-4616.

April

GSA Southeastern Section Meeting, April 1–2, 1993, Tallahassee, Florida. Information: James Tull, Dept. of Geology, Florida State University, Tallahassee, FL 32306, (904) 644-1448.

25th International Symposium on Remote Sensing and Global Environmental Change, April 4–8, 1993, Graz, Austria. Information: Dorothy M. Humphrey, ERIM, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 2290, fax 313-994-5123.

Integrated Methods in Exploration and Discovery, April 17–20, 1993, Denver, Colorado. Information: SEG Conference '93, P.O. Box 571, Golden, CO 80402.

Canadian Quaternary Association (CANQUA), April 17–21, 1993, Victoria, British Columbia, Canada. Information: Environmental Geology Section, BC Geological Survey Branch, 553 Superior Street, Victoria, British Columbia, V8V 1X4, Canada, (604) 387-6249, fax 604-356-8153.

International Conference on Geoscience Education and Training, April 21–25, 1993, Southampton, England. Information: Dorrik A.V. Stow or Esther Johnson, Dept. of Geology, University of Southampton, Southampton, SO9 5NH, England, phone 0703-593049, fax 0703-593052, telex: 47662 SOTONU G.

May

■ Second USA/CIS Joint Conference on Environmental Hydrology and Hydrogeology, May 15–21, 1993, Washington, D.C. Information: American Institute of Hydrology, 3416 University Ave. S.E., Minneapolis, MN 55414-3328, (612) 379-1030, fax 612-379-0169. *(Preregistration deadline: September 11, 1992.)*

GSA Cordilleran/Rocky Mountain Section Meeting, May 19–21, 1993, Reno, Nevada. Information: Vanessa George, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020.

International Basin Tectonics and Hyrdrocarbon Accumulation Conference, May 25–June 15, 1993, Nanjing, People's Republic of China. Information: David Howell, U.S. Geological Survey, 345 Middlefield Road, MS 902, Menlo Park, CA 94025, (415) 354-5430, fax 415-354-3224.

Field Conference and GIS Workshop, INQUA Commission on Formation and Properties of Glacial Deposits: Work Groups on Glacial Tectonics and Mapping Glacial Deposits, mid-May, 1993, Regina, Saskatchewan, Canada. Information: D. J. Sauchyn, Dept. of Geography, University of Regina, Regina, Saskatchewan, S4S 0A2 Canada, (306) 585-4030, fax 306-585-4815; or J. S. Aber, Earth Science, Emporia State University, Emporia, KS 66801, (316) 341-5981, fax 316-341-5997. *(Abstract deadline: February 1, 1993.)*

June

■ International Symposium, Geology and Confinement of Toxic Wastes, June 8–11, 1993, Montpellier, France. Information: Michel Barrès, BRGM—Département "Environnement," BP 6009, 45060 Orleans Cedex, France, phone 33-38 64 34 14, fax 33-38 64 30 13, Telex BRGM 780 258 F.

■ 34th U.S. Symposium on Rock Mechanics, June 27–30, 1993, Madison, Wisconsin. Information: Bezalel C. Haimson, Dept. of Materials Science and Engineering, 1509 University Avenue, Madison, WI 53706, (608) 265-3021, fax 608-262-8353, E-Mail: haimson-@macc.wisc.edu.

July

5th International Conference on Fluvial Sedimentology, July 5–9, 1993, Brisbane, Australia. Information: Continuing Professional Education, The University of Queensland, Queensland 4072, Australia, phone +61-7-365 7100, fax +61-7-365 7099, telex UNIVQLD AA40315.

August

■ International Workshop on Intraplate Volcanism: The Polynesian Plume Province, August 1993, Tahiti, French Polynesia. Information: Workshop Tahiti 1993 Organization Committee, H.G. Barsczus, Centre Géologique et Géophysique, Case 060, Université de Montpellier II, 34095 Montpellier Cedex 5, France, phone 33-67-634-983, fax 33-67-523-908.

■ 3rd International Symposium on Geochemistry of the Earth Surface, August 1–6, 1993, University Park, Pennsylvania. Information: Lee Kump, Dept. of Geosciences, Pennsylvania State Univeristy, 210 Deike Bldg., University Park, PA 16802, (814) 863-1274, fax 814-865-3191.

■ International Congress on Mine Design—Mining into the 21st Century, August 23–26, 1993, Kingston, Ontario, Canada. Information: Peter Scott, Public Relations, ICMD/Relations publiques, CICM, Department of Mining Engineering/Départment de génie minier, Queen's University/Université Queen's, Kingston, Ontario, Canada K7L 3N6, (613) 545-2212, fax 613-545-6597.

September

■ 2nd International Symposium on Andean Geodynamics, September 21–23, 1993, Oxford, England. Information: P. Soler, ISAG 93, ORSTOM, CS1, 213 rue Lafayette, 75480 Paris Cedex 10, France, fax 33-1 48 03 08 29. *(Abstract deadline: April 1, 1993.)*

October

■ Basin Inversion—International Conference, October 4–9, 1993, Oxford, England. Information: James G. Buchanan, British Gas Exploration and Production Limited, 100 Thames Valley Park Drive, Reading, Berkshire RG6 1PT, UK, phone 0734-353222, fax 0734-353484, telex 846231; or Peter Buchanan, Congniseis Development, Stanley House, Kelvin Way, Crawley, Sussex RH10 2SX, UK.

Send notices of meetings of general interest, in format above, to Editor, *GSA Today*, P.O. Box 9140, Boulder, CO 80301.

GSA Congressional Science Fellow Named for 1992–1993

Margaret Goud Collins has been selected as the seventh GSA Congressional Science Fellow. She will work as a special legislative assistant on the staff of a committee or Member of the U.S. Congress from September 1992 through August 1993.

As a Congressional Science Fellow, Goud Collins hopes to work on issues spanning science, education, the environment, and foreign relations, particularly with respect to developing countries. With the aim of strengthening local research and education capabilities in developing countries, her primary focus is to increase the involvement of the American scientific community in formulating and effecting environmental development aid.

Goud Collins received her Ph.D. in oceanography in 1987 from the Woods Hole Oceanographic Institution (WHOI)–MIT Joint Program in Oceanography. Her principal research interests are coastal processes, marine geology, and sediment transport. From 1988 to 1990, Goud Collins worked in Manila at the University of the Philippines Marine Science Institute, teaching and helping to set up graduate programs in marine geology and physical oceanography. She has been at WHOI since her return, investigating and instigating ways of increasing collaborative research between scientists in America and in developing countries. She also participated as a sedimentologist on Leg 134 of the Ocean Drilling Program. Goud Collins received her B.S. in geology from Stanford University in 1978.

The Fellowship

The Congressional Science Fellowship gives a geoscientist first-hand experience with the legislative process and the opportunity to view science policy issues from the lawmaker's perspective. At the same time, the fellow assists in the analysis of public policy issues by providing scientific and technical expertise.

Funded by GSA and by a grant from the U.S. Geological Survey, the fellowship is intended as a way to demonstrate the value of such science-government interaction, and to educate the earth science community about the need for informed involvement. The program places highly qualified, accomplished scientists with the offices of individual members of Congress or committees for a one-year assignment. Fellows perform in much the same way as regular staff members; they have the opportunity to be involved in varied legislative, oversight, and investigative activities. They offer their special knowledge, skills, and competence for the opportunity to acquire experience and the chance to contribute to the formulation of national policy. The GSA Congressional Fellow reports periodically to the GSA membership and to the USGS during the one-year period.

Requirements for the fellowship include exceptional competence in some area of the earth sciences, cognizance of a broad range of matters outside the fellow's particular area, and a strong interest in working on a range of public policy problems. Fellows attend a two-week orientation conducted by the American Association for the Advancement of Science.

Selection Committee

On the selection committee for the fellowship this year were Brian E. Tucker, Oyo-Pacific; William L. Fisher, Bureau of Economic Geology, University of Texas at Austin; Richard Witmer, USGS; and Craig M. Schiffries, AGI. ■

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and convection (Gurnis, 1988). In a fully dynamic model of a nonsubducting plate interacting with convection, it was found that the continent remained stationary for an extended period as the temperature beneath the continent increased (Gurnis, 1990c; Fig. 8 here). During this period when the plate was stationary, the continent was uplifted and the sea regressed from the continent. The continent then rapidly moved horizontally away from the long-wavelength hot and topographically high area toward the cold and topographically low area. The continent moved downward during this rapid horizontal translation such that a transgression followed a pulse of rapid horizontal motion. Finally, the continent again settled over the cold area and the process was repeated. (The physics of subplate heating, horizontal motion, and sea-level change are particularly well illustrated in three-dimensional animations appearing on the video tape accompanying Gurnis, 1990c.) The models demonstrate that it is plausible for supercontinents to

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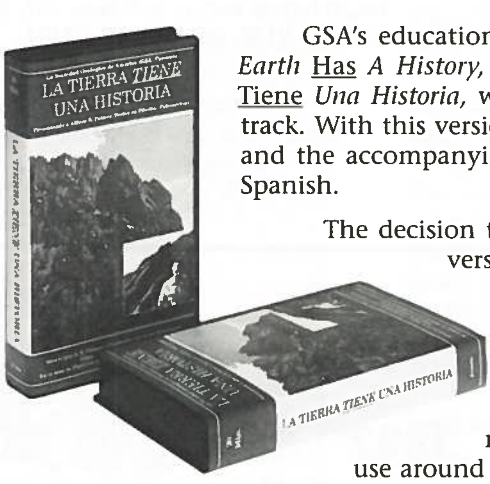
La Tierra Tiene *Una Historia*—¡Ahora disponible en Español!

The Earth Has *A History* Now Available in Spanish

Jim Clark, GSA Marketing Manager



GSA's educational video and 16mm film *The Earth* Has *A History,* is now available as *La Tierra* Tiene *Una Historia,* with a Spanish-language audio track. With this version, the cover of the video case and the accompanying teacher's aid is supplied in Spanish.

The decision to produce a Spanish-language version was prompted by the success of this study module and by requests from educators in Mexico. The English-language version was introduced in late 1989, and nearly 2000 copies are now in use around the world. The video has been highly praised by educators, and it carries an attractive price tag ($25 list) for a 20-minute study module of this quality.

The video demonstrates, in simple terms, the principals of geologic time—or "deep" time—by literally walking the viewer *through* time, as reflected in the geology of the Flatirons area of the Rocky Mountain Front Range near Boulder, Colorado. It is recommended as an opening module for the geology section of earth-science courses or for a biology section on the record of life on Earth. It is "...an excellent resource for introducing the concept of geologic time; an opportunity for a super field trip without the hassle," according to Betty Wade Jones, presidential award winning earth-science teacher from Clements Junior High School, Prince George, Virginia.

It is our hope that the Spanish-language version will encourage use of the video in schools throughout Mexico and other Spanish-speaking countries, as well as in areas of the United States where Spanish is a predominant language.

The video—in English or Spanish—is now available in either VHS or BETA cassette style, and in the three most popular electronic formats: NTSC—the standard in the United States, Canada, Mexico, Japan, and 42 other countries; PAL—the standard in the United Kingdom, Australia, western Germany, and 61 others; and SECAM—the standard in France, eastern Germany, and 35 others. When ordering copies of the video, be sure to specify all three of these options.

(1) **Language:** English or Spanish
(2) **Cassette style:** VHS or BETA
(3) **Electronic format:** NTSC, PAL, or SECAM. (Few people are aware that different electronic formats exist. Tapes produced in one format and played on a player using another will be distorted or have no picture, and the sound will be garbled.)

If you are unsure which format you need, follow this rule: if your player successfully plays the video tapes commonly available in your country, ask us for the format that is standard in your country. We have a guide that lists all countries and the standards used in each, and we will supply the correct one.

If your player cannot successfully play video tapes available in your country, then you need to specify which format it uses. Your user's manual should state the format. If it does not, write to the manufacturer of the player, providing serial and model numbers, or consult a local electronics repair shop.

Copies of the video may be ordered from GSA Publication Sales, P.O. Box 9140, Boulder, CO 80301-9140, 1-800-472-1988—toll-free from the United States (outside Colorado) or (303) 447-2020. ■

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break up and for the fragments to have little influence on the structure of long-wavelength thermal anomalies as they move horizontally—indeed, the continents seem to ride over a nearly immobile dynamic topography. Kominz and Bond (1991) suggested that rapid synchronous subsidence in marginal and interior basins of North America during middle Paleozoic time is consistent with the dynamic downwelling and compression that would affect continents as they assembled into a supercontinent.

These studies highlight a fundamental ambiguity in determining the causes of sea-level change. Because the average age of oceanic lithosphere decreases for tens of millions of years following supercontinent breakup (Heller and Angevine, 1985), we would expect the dynamic subsidence of continental fragments to be in phase with the eustatic sea-level rise associated with the decreased age of the sea floor (Gurnis, 1991a). In particular, even though an empirical correlation may occur between spreading rate and sea level, the sea level may not be primarily controlled by the "decreased volume" of the ocean basin—much of the change in sea level could be caused by dynamic subsidence. This was recognized earlier by Worsley et al., (1984) without the use of dynamic models.

SUMMARY AND FUTURE PROGRESS

The models reviewed here of mantle convection incorporating rudimentary oceanic and continental plates demonstrate that deep mantle convection can be a dominant control on long-term sea-level fluctuations. The oceanic lithosphere and in particular changes in the spreading rate of mid-ocean ridges are just one component of a globally coupled system. Changes in spreading lead directly to changes in the rate of subduction. Subduction can control the vertical motion and apparent sea level of the overriding continent. Longer term variations in spreading and continental insulation lead to the development of global scale variations in mantle temperature, and these fluctuations lead to changes in the relative height between one region and another elsewhere on the surface of Earth. A global scale undulation in dynamic topography, originally inferred from studies of the geoid but now observed directly, has an amplitude of about 1 km. Motion of the continents with respect to this topography could lead to the nearly complete flooding of platforms.

The major convection processes reviewed are summarized in Figure 1: ridge spreading, subduction, and the development of large-scale thermal anomalies. In comparison to dynamic topography, fluctuations in the geoid, which controls the sea surface, probably play only a small role in sea-level change. Mantle plumes, another important mode of mantle convection, may influence sea level via the impingement of a plume or diapir beneath the lithosphere, leading to the rapid dynamic uplift over a few thousand kilometres (Olson and Nam, 1986; Griffiths et al., 1989). The role of plumes has yet to be explicitly studied.

Unfortunately, the models of plates and convection have been illustrative rather than definitive. Enormous progress still must be made before we fully understand the interrelations between continental stratigraphy and mantle dynamics. Work must proceed in two areas. First, the modeled thermal convection drives dynamic topography and geoid fluctuations, and from these fluctuations we must make realistic predictions of the resulting sedimentary packages. Calculation of synthetic sequence stratigraphy resulting from plate bending and supracrustal loading is already well developed (see papers in Cross, 1990). Second, we need more realistic mantle convection models incorporating tectonic plates. For example, in the models with a nonsubducting plate and convection (e.g., Fig. 8), a realistic oceanic lithosphere now must be incorporated so that the relative importance of dynamic subsidence vs. spreading can be quantitatively explored. The dynamic balance between convection and oceanic and continental plates has been explored in other models (Gurnis and Hager, 1988), but these models incorporated plate margins in an ad hoc way. Recent progress with faults in viscous models of thermal convection (Zhong and Gurnis, 1992) will lead to much more realistic ocean-continent models. If we are to predict the three-dimensional pattern of stratigraphy and isopachs on a continent, then we must employ three-dimensional spherical models of convection with plates. Up to now, modeling of convection in spheres has been in isoviscous media without plates (e.g., Schubert, 1992), but with the rapid development of numerical algorithms, especially those for massively parallel supercomputers, spherical models with plates should be appearing within the next year.

The ability to model the dynamics of continental and oceanic plates, plate boundaries, and mantle convection will almost certainly lead to a new era of deciphering the ultimate causes of the longest term patterns in the sedimentary history of the continents. Inversion of continental stratigraphy may ultimately lead to important constraints on the evolution through time of mantle convection.

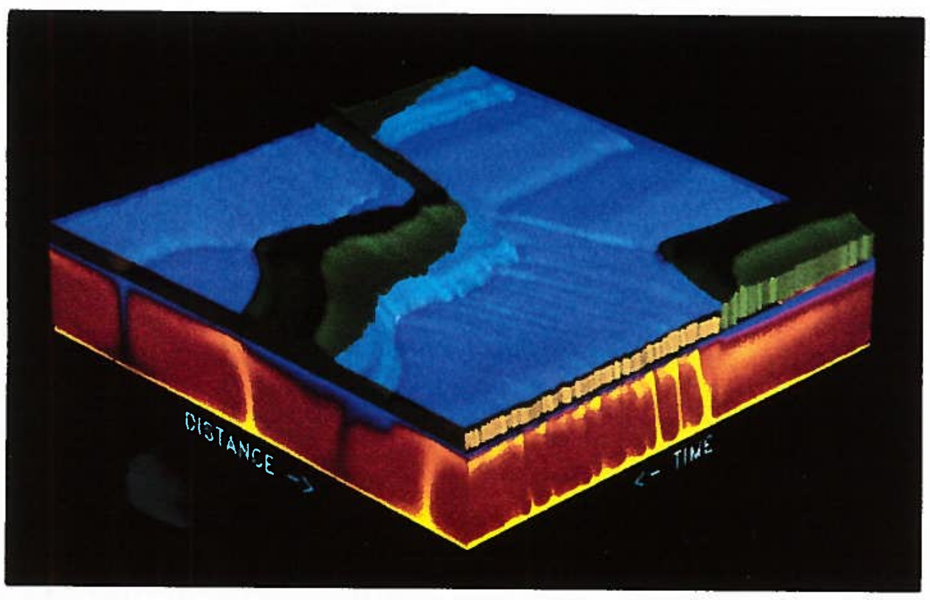

Figure 8. Three-dimensional visualization of a two-dimensional model of a nonsubduction continental plate interacting with thermal convection as a function of time. The front vertical face is the temperature field at the end of the simulation; yellow is hottest and blue is coldest. The side vertical face is the temperature field of a column that remains fixed relative to the center of mass of the system. From the back face toward the front face represents about 1 b.y. On the top surface the total topography and sea surface are displayed. One light illuminates the top from the upper right. The continental regions are green and the oceanic regions brown, and the water-surface is a transparent blue. At the start of the simulation, the continent is stationary and lies at the edges of the box (the model has periodic boundary conditions so that what flows out one side comes in the other). A third of the way through the progression of time, the continent rapidly moves horizontally and floods. Three-dimensional animations of this and other simulations can be found in Gurnis (1990c). Reproduced from Gurnis (1990c). Copyright 1990 by the American Geophysical Union.

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