GSA TODAY

Vol. 11, No. 6 A Publication of the Geological Society of America June 2001

Boston 2001:
A GEO-ODYSSEY
November 1–10, 2001

Annual Meeting and Exposition

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CONTENTS

Vol. 11, No. 6 June 2001

science article

A Moderate Translation Alternative to the Baja British Columbia Hypothesis

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ABSTRACT

The Baja British Columbia (Baja B.C.) hypothesis derives primarily from observed discordant paleomagnetic directions of Insular and Intermontane terranes interpreted to indicate post–mid-Cretaceous northward transport by up to 4000 km with respect to the continental interior. Recent paleomagnetic results from near Prince Rupert, British Columbia, document that discordant directions in plutonic rocks of this area are primarily due to local deformation rather than transport from a Cretaceous location along the southwest margin of North America. Expanded paleomagnetic studies of Cretaceous rocks at Duke Island and MacColl Ridge, Alaska, have led to much smaller estimates of latitudinal motion for Insular terranes than previously concluded. Recognition of likely chemical remagnetization of Cretaceous sequences in the Tyaughton and Methow basins, along with effects of compaction shallowing on marine sediments of the Nanaimo Group, indicate that paleomagnetic data from these rocks may not require the magnitude of northward transport suggested by the Baja B.C. paleogeography. Instead, the paleomagnetic observations are consistent with a Cretaceous paleogeography that limits post–mid-Cretaceous northward motion to ~1000 km. The resulting paleogeography has the appealing feature of an Andean-like, continuous subduction-related magmatic arc along the Cordilleran margin during Cretaceous time.

INTRODUCTION

One may quibble over the details, but the general picture on paleomagnetism is sufficiently compelling that it is much more reasonable to accept it than to disregard it.

—H.H. Hess, 1962

It is clear that much of the North American Cordillera is composed of terranes of oceanic affinity that were added to and shuffled along the continental margin during Mesozoic and Cenozoic time (Coney et al., 1980). Paleomagnetism contributed to the realization that some terranes experienced large-scale latitudinal motion prior to or following accretion to the continental margin (Hillhouse, 1977). But Cordilleran geologists now find themselves struggling with the Baja British Columbia (Baja B.C.) hypothesis, which many perceive as a fundamental conflict between paleomagnetic data and geologic observations. We view the controversy as growing pains in attempts to decipher the tectonic evolution of an orogen where supracrustal rocks have largely been removed and those remaining are complexly deformed. The remark by Hess (1962) reminds us of the apparent conflict between paleomagnetism and conventional geological wisdom regarding continental drift (Irving, 1988). In his celebrated article, Hess laid out concepts of plate tectonics resolving that apparent conflict. A more recent example of perceived conflict between paleomagnetism and geology resolved to the benefit of both disciplines is vertical-axis rotations of parts of the Cordilleran margin (Kamerling and Luyendyk, 1979; Beck et al., 1986). This history suggests that apparent conflicts between paleomagnetism and geology can lead to significant insights that neither discipline alone could have delivered.

The Baja B.C. controversy is focused on the magnitude of post–mid-Cretaceous northward transport of segments of the North American Cordillera. Did southeast Alaska, western British Columbia, and the North Cascades experience northward transport during the last 100 m.y., limited to 500–1000 km, as interpreted from the geologic record of inboard strike-slip faults (Price and Charmichael, 1986)? Or was this region, in mid-Cretaceous time, situated adjacent to the continental margin in the position now occupied by Baja California (Cowan et al., 1997)? The Baja B.C. hypothesis remains controversial and was the focus of a recent Penrose Conference (Mahoney et al., 2000). The primary motivation for the Baja B.C. hypothesis comes from discordant paleomagnetic directions interpreted to favor post–mid-Cretaceous northward transport up to 4000 km (Beck, 1980; Irving et al., 1996; Ward et al., 1997). However, the magnitudes of northward transport interpreted from paleomagnetic data in Cretaceous rocks range from ~500 km (Vandall, 1993) to ~4000 km (Panuska, 1985). So the paleomagnetic data do not provide a unified and simple signal to interpret. In addition to northward transport, part of the paleomagnetic discordance must result from geologic deformations such as faulting or folding of crustal panels. But between transport and structural disturbance, which is the signal and which is the noise?

In this paper, we offer ideas and observations that permit understanding of paleomagnetic observations from Insular and Intermontane terranes (Fig. 1) with much less northward transport than suggested by the Baja B.C. model. Our approach is conservative and we are sometimes pushing the confidence limits on paleomagnetic observations toward lower displacement estimates. The resulting Cretaceous paleogeography avoids many of the geological conflicts of the Baja B.C. hypothesis but still requires ~1000 km post–mid-Cretaceous northward motion for large segments of the North American Cordillera.

CHANGES IN LATITUDE OR CHANGES IN ATTITUDE?

The majority of discordant paleomagnetic results have been obtained from intrusive igneous rocks for which interpretation is complicated by lack of control on paleohorizontal at the time of magnetization. The general pattern of shallow inclinations and clockwise-deflected declinations observed in the Cretaceous plutonic rocks can be explained either by northward transport coupled with clockwise vertical-axis rotation or by systematic northeast-side-up tilt during uplift. A "translation versus tilt" controversy has ensued (Butler et al., 1989; Ague and Brandon, 1997). A central issue is the plausibility of plutonic rocks experiencing tilt of sufficient magnitude and correct geometry to explain the discordant paleomagnetic directions.

A bias towards shallower inclinations results from the steep expected direction in Cretaceous time when the paleomagnetic pole was located in northern Alaska, at its closest approach to the Cordillera. The steep expected direction results in high probability that a deflection will result in a shallower rather than steeper direction (Fig. 2A). Because the expected declination is aligned with the structural grain of the Insular terranes and Coast Mountains, tilting of crustal panels about axes subparallel to the structural grain will always produce shallower observed inclinations.

End-member translation and tilt interpretations of the discordant paleomagnetic direction from the Spuzzum pluton of southern British Columbia are illustrated in Figure 2. On the assumption that present horizontal approximates paleohorizontal, the 17° flattening of observed inclination indicates ~2500 km of northward motion while the discordant declination indicates 58° of clockwise vertical-axis rotation (Fig. 2B). Alternatively, the expected direction can be deflected to the observed direction by ~30° northeast-side-up tilt of the pluton about a horizontal axis with azimuth ≈330° (Fig. 2C). This northwest-southeast axis is subparallel to the structural grain of the Coast Mountains and consistent with structures that could tilt panels of crust. Barometry of metamorphic assemblages surrounding the Spuzzum pluton indicates that this panel of crust tilted northeast-side-up by 33° about an axis with azimuth of 332° (Brown and Burmester, 1991).

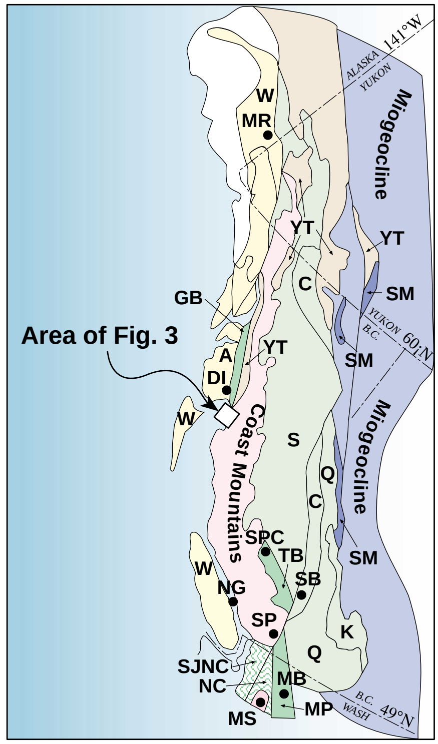

Figure 1. Generalized geological map of Coast Mountains and terranes of northern Cordillera. Prince Rupert area is outlined by box. Adapted from Gehrels and Kapp (1998). Geologic terranes: A—Alexander; C—Cache Creek; K—Kootenay; MP—Methow-Pasayten basins; NC—high grade rocks of North Cascades; Q—Quesnel; S—Stikine; SJNC—San Juan–North Cascades thrust belt; SM—Slide Mountain; TB—Tyaughton Basin; YT—Yukon-Tanana. Paleomagnetic studies: DI—Duke Island; MB—Methow Basin; MR—MacColl Ridge; MS—Mount Stuart; NG—Nanaimo Group; SB—Spences Bridge; SP—Spuzzum pluton; SPC—Silverquick–Powell Creek.

EXAMPLES OF TILTING AND FOLDING FROM THE PRINCE RUPERT AREA

The Quottoon plutonic complex was emplaced into eastern parts of the Coast shear zone (Fig. 3), considered by some workers to have accommodated ~2000 km of strike-slip motion between the Insular terranes and Intermontane terranes (Hollister and Andronicos, l997). Paleomagnetic data were obtained from more than 200 sites distributed from the Skeena River to Willard Inlet. U-Pb crystallization ages range from 72.3 to 55.5 Ma (Klepeis et al., 1998). K-Ar hornblende dates indicate Eocene cooling and magnetization after the proposed northward motion of Baja B.C. However, locally, the Quottoon plutonic complex yields paleomagnetic directions that are shallow and rotated clockwise, similar to plutons within Baja B.C. to the west. Eocene extension of the Coast Mountains tilted crustal panels that are bounded by northwest striking east-side-down normal faults and northeast-striking transfer faults (Fig. 3; Butler et al., 2001b). Based on a tilting domino model, ~30% extension can produce the 40° maximum tilts.

We collected paleomagnetic sites along a northeast-southwest transect across the northern part of the Ecstall pluton (Butler et al., 2000). Geobarometry and U-Pb analyses indicate 91 Ma crystallization at a depth of ~25 km. $^{40}Ar/^{39}Ar$ dates on hornblende from the western margin indicate cooling and magnetization at 84 Ma while hornblende from the central part yields a cooling age of 76 Ma. Crawford et al. (1987) interpret the Prince Rupert shear zone as a west-directed thrust with the Ecstall pluton in the upper plate (Fig. 3). For the central part of the pluton, paleomagnetic directions are concordant with the expected Cretaceous direction while observed directions from the western margin are discordant by >70°. Observed directions are distributed along a small circle with subhorizontal axis at ~340° azimuth. These directions cannot record northward flight of Baja B.C. because this would require ~7000 km of transport in ~8 m.y. at a velocity of ~1 m/yr! Our tectonic interpretation of the paleomagnetic, geochronologic, and barometric data from the Ecstall

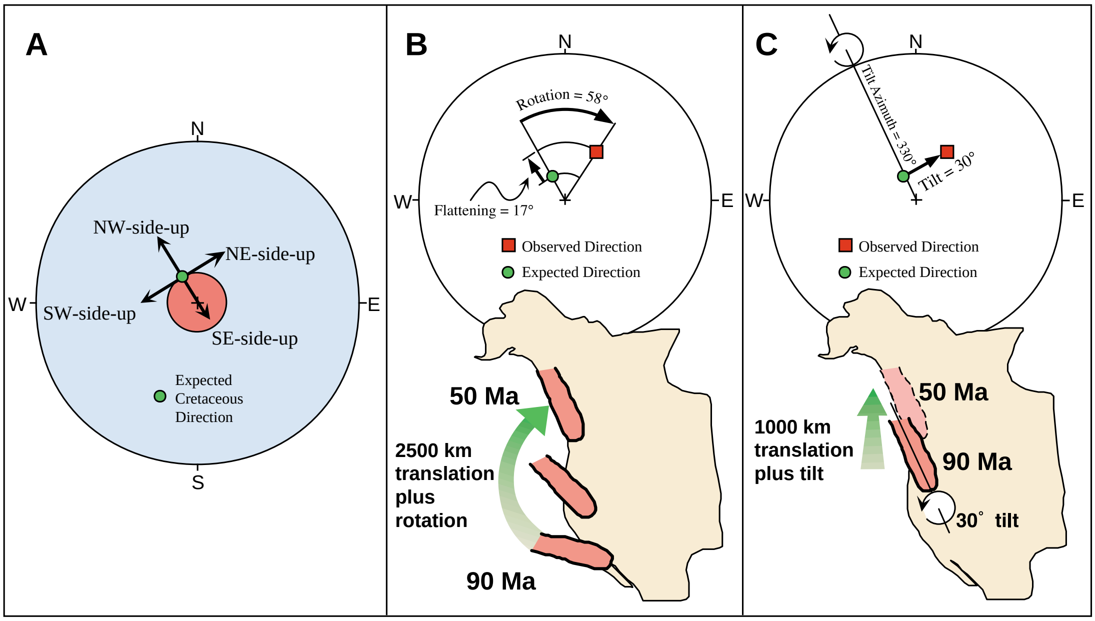

Figure 2. A: Equal-area projection showing expected Cretaceous direction at location of Spuzzum pluton in southern British Columbia. Directions with inclinations shallower than expected direction occur within blue area; directions with inclinations steeper than expected direction occur within red area. Arrows indicate deflections from expected direction resulting from 20° tilt of a pluton in directions indicated. Only a southeast-side-up tilt can yield an inclination steeper than expected direction; all other tilt directions yield shallower inclinations. **B:** Translation plus rotation interpretation of observed (red square) and expected (green circle) paleomagnetic directions for Spuzzum pluton of southern British Columbia (Irving et al., 1985). Observed inclination is 17° shallower than expected inclination and is interpreted to indicate ~2500 km of northward translation from a Cretaceous location adjacent to southwestern North America. Observed declination is clockwise of the expected declination and is interpreted to indicate 58° of clockwise vertical-axis rotation. **C:** Tilt interpretation showing deflection of expected direction (green circle) to observed direction (red square) by 30° northeast-side-up tilt of Spuzzum pluton about a horizontal axis with azimuth ≈ 330°.

pluton involves thrust displacement above the upward convex Prince Rupert shear zone (Fig. 3). We conclude that local folding with ~1000 km of northward transport produced the paleomagnetic discordance in the Ecstall pluton. These examples show that local folding and tilting are the dominant cause of discordant paleomagnetic directions at least in this part of the Insular terranes and Coast orogen.

THE MODERATE TRANSLATION ALTERNATIVE

A full synthesis of paleomagnetic data relevant to the Baja B.C. controversy is beyond the scope of this paper. Nevertheless, we provide alternative interpretations of key paleomagnetic studies (Fig. 1) considered by proponents of the Baja B.C. paleogeography to require ~3000 km post–mid-Cretaceous northward transport (Irving et al., 1996; Cowan et al., 1997). Our alternative interpretation is consistent with the suggestion that the combined effects of ~1000 km northward translation with tilting of crustal panels about axes parallel to the Coast orogen and compaction shallowing of paleomagnetic inclination in sedimentary rocks can explain the paleomagnetic observations. Note that we do not reject any paleomagnetic data. Instead, we offer alternative interpretations of these important observations.

Bogue et al. (1995) reported a paleolatitude based on paleomagnetic results from the mid-Cretaceous layered ultramafic intrusion of Duke Island in southeast Alaska. They argued that unplunging of fold axes followed by unfolding could restore cumulate layering and paleomagnetic vectors to paleohorizontal. We recently obtained paleomagnetic directions from sites where the attitude of cumulate layering was directly measured (Butler et al., 2001a). These data fail a fold test and indicate that cumulate layering was highly contorted at the time of magnetization. Observations of cumulate layering in other ultramafic intrusions indicate that layering can depart from horizontal by 10°–20°, even on the kilometer scale (Irvine et al., 1998). We conclude that use of such cumulate layering as a proxy for paleohorizontal is not justified and paleomagnetic data from Duke Island cannot be used to infer a Cretaceous paleolatitude for the Insular terranes.

Based on paleomagnetic data from only 20 specimens of sedimentary rock from the Upper Cretaceous MacColl Ridge Formation in the southern Alaska fragment of the Wrangellia terrane (Fig. 1), Panuska (1985) reported a paleolatitude of 32°N. This result suggested a dramatic 4000 km of post-Cretaceous northward transport. However, Trop et al. (1999) resampled the MacColl Ridge Formation, concentrating on volcanic tuff layers, and arrived at a much-reduced estimate of displacement. The data from 15 sites (129 samples) yield an inferred Late Cretaceous paleolatitude of 53°N ± 8°, indicating 1650 ± 1100 km of northward displacement.

The paleomagnetic results from the Cenomanian to Campanian Silverquick Conglomerate and the Powell Creek volcanic rocks in the Tyaughton Basin were interpreted by Wynne et al. (1995) to require 3000 km of northward translation. The conflict of this interpretation with geological correlations and estimates of offset between the Methow and Tyaughton basins has been described by Monger and Price (1996). In the Silverquick–Powell Creek sequence, there is evidence for authigenic magnetite in the sedimentary rocks, suggesting the magnetization could be of secondary chemical origin. Indeed, the maximum clustering of paleomagnetic directions occurs at 70% unfolding. Further, considering the evidence for remagnetization of equivalent rocks in the Methow Basin (Bazard et al., 1990), we conclude that the Silverquick–Powell Creek strata contain a synfolding remagnetization which cannot be used to infer its motion history. Recently, Haskin et al. (2000) obtained paleomagnetic data from 104 Ma volcanic rocks that unconformably underlie the Silverquick Conglomerate and Powell Creek volcanics. The mean paleomagnetic direction is indistinguishable from that of the correlative Spences Bridge Group (Irving et al., 1995), and the combined results provide a strong indication that this assemblage was 1100 ± 600 km south at 104 Ma.

The paleomagnetic direction from the Mount Stuart batholith is discordant, again with shallow inclination and clockwise declination compared with the expected Cretaceous direction (Beck et al., 1981). Butler et al. (1989) argued that southwest dipping sedimentary rocks of the Swauk Formation adjacent to the southwestern part of the batholith require post–early Eocene northeast-side-up tilt which largely explains the discordant paleomagnetism. However, that interpretation was challenged by Miller et al. (1990). Ague and Brandon (1996) applied aluminum-in-hornblende barometry to infer a tilt of 8° northwest-side-up. Anderson (1997) criticized the pressure estimates of Ague and Brandon (1996), concluding that their pressure estimates are not reliable. That conclusion was, in turn, refuted by Ague and Brandon (1997). Perhaps the most secure conclusion to reach about the Mount Stuart batholith is that the postmagnetization history of deformation is disputed and complex.

Paleomagnetic data from marine sedimentary rocks of the Upper Cretaceous Nanaimo Group have been interpreted by Ward et al. (1997) to support the Baja B.C. model. However, the clay content of the Nanaimo sedimentary rocks likely made them susceptible to inclination shallowing by burial compaction. Laboratory experiments with synthetic and natural clay-rich sediments indicate that detrital Fe-oxide particles become attached to clay particles and rotate toward the horizontal during fabric development accompanying compaction, thus shallowing the inclination (Sun and Kodama, 1992). The remanence anisotropy of paleomagnetic samples can be used to correct for inclination shallowing caused by compaction (Kodama, 1997). Kim and Kodama (1999) showed that Nanaimo rocks, including some of the calcite concretions sampled for paleomagnetism, have a magnetic fabric characteristic of burial compaction, indicating ~15° of inclination shallowing. Correcting for the effects of compaction reduces the latitudinal displacement by 1500 km indicating that the Nanaimo rocks were slightly south of the Intermontane terranes in Late Cretaceous time.

The above discussion presented viable alternatives to the Baja B.C. paleogeography for interpreting the paleomagnetic observations. In some cases, these “tilt plus moderate translation” interpretations are well supported by the geology. In other cases, this explanation is speculative and requires further study. Housen and Beck (1999) argued that tilting of Cretaceous plutonic rocks, compaction of Cretaceous sedimentary rocks, and synfolding remagnetization of Cretaceous volcanic rocks could never conspire to produce the shallow observed paleomagnetic inclinations from the Insular terranes and Coast Mountains. If these processes resulted in both steeper and shallower inclinations with equal probabilities, we would agree with their assessment. But compaction of sedimentary rocks will shallow paleomagnetic inclinations, tilting of the plutonic rocks strongly favors shallowed inclinations, and the same bias affects rocks that experience tilting or folding subsequent to remagnetization.

It is worth recalling that early conclusions of 2500 km northward transport for coastal and Baja California were based on paleomagnetic data from a half dozen Mesozoic and Cenozoic formations. When about 20 studies had been published, the implied motion histories became complex with internal inconsistencies begging alternative explanation. Dickinson and Butler (1998) concluded that Neogene offset on the San Andreas fault system is sufficient to account for the paleomagnetic data, when compaction shallowing in sedimentary rocks and tilting of plutonic rocks are taken into account. Might history repeat in the case of the Baja B.C. hypothesis once

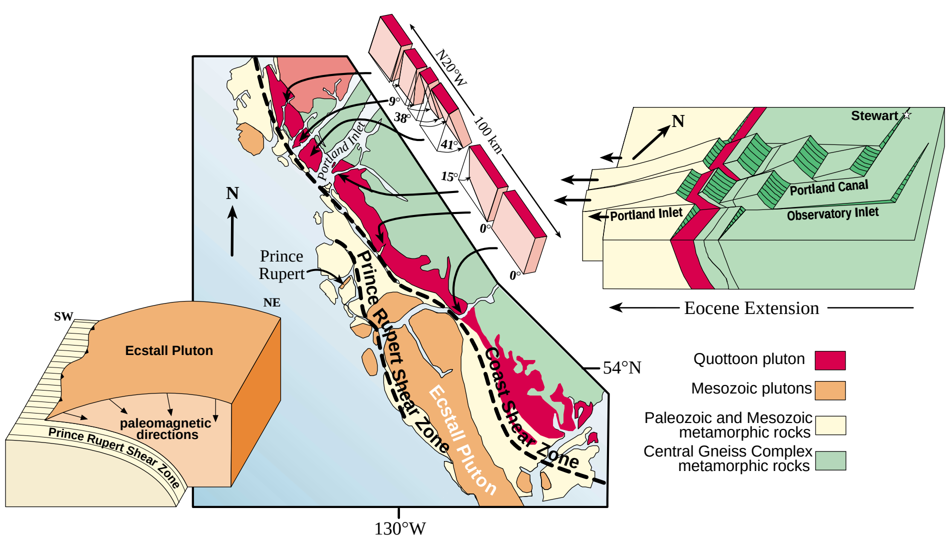

Figure 3. Summary of paleomagnetic observations of tilting and folding of plutonic rocks in Prince Rupert area. Diagram at upper right shows along-strike variation in amount of northeast-side-up tilt that affected Quottoon plutonic complex. Illustration at right is tectonic model for tilting of crustal panels containing Quottoon plutonic complex during Eocene extension. Folding model for Ecstall pluton is shown by block diagram at left with arrows indicating paleomagnetic directions. Ecstall pluton is shown above west vergent and convex upward Prince Rupert shear zone. View is toward north. Geologic map is from Hutchison (1982) while geologic structures are adapted from Crawford et al. (1987).

additional paleomagnetic data and a supporting array of geologic observations are acquired?

TOWARDS A MID-CRETACEOUS PALEOGEOGRAPHY

Reinterpretation of paleomagnetic data from Insular and Intermontane terranes allows for the construction of a simplified Late Cretaceous paleogeographic map of western North America that is consistent with both geologic relations and with conservative estimates of displacement based on paleomagnetism (Fig. 4). The likely positions of Cordilleran terranes, magmatic belts, and first-order strike-slip fault systems at ~90 Ma differ significantly from the "Northern Option" reconstruction of Cowan et al. (1997). We incorporate ~1000 km of northward translation of Insular terranes and ~800 km of northward motion of Intermontane terranes, most of which occurred during Late Cretaceous through Eocene time. These transport values are generally at the low end of the translation estimates based on paleomagnetic studies from the Insular and Intermontane terranes. An appealing aspect of this reconstruction is the existence of a continuous, subduction-related magmatic arc along the Cordilleran margin.

The inboard strike-slip fault (Fig. 4) is interpreted to include a broad zone of structures related to the Tintina–Rocky Mountain trench system in the northern Cordillera, and their cryptic continuations into southern British Columbia and northern Washington (Gabrielse, 1985). The fault shown between Insular and Intermontane terranes is interpreted to have ~200 km of dextral slip. Expressions of this structure would include the Denali fault in Alaska (north of the intersection with the Chatham Strait fault), the Coast shear zone and related structures within the Coast Mountains (Lanphere, 1978; Hollister and Andronicos, 1997) and the Yalakom, Harrison Lake, and related faults in southern British Columbia and northern Washington (Umhoefer and Schiarizza, 1996).

If we are relieved of the necessity to move Baja B.C. 3000 km north during the Late Cretaceous and Paleogene, some aspects of plate kinematics and North American continental dynamics

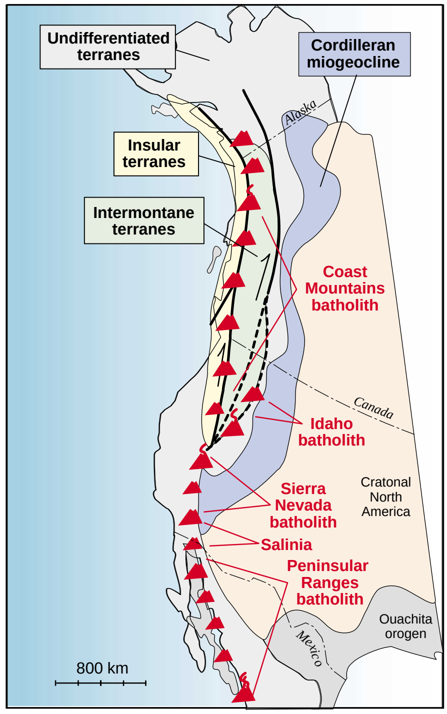

Figure 4. Generalized paleogeography of western North America at ~90 Ma, based on geologic relations and the reinterpreted paleomagnetic data (adapted from Oldow et al., 1989; Burchfiel et al., 1992; Plafker and Berg 1994; and Nokleberg et al., 1998). Restorations include 325 km of Basin and Range province extension, 500 km northward motion of Salinia, 300 km opening and offset in Gulf of California, 800 km offset on Tintina–Rocky Mountain Trench fault system and possible continuations to the south, and 200 km offset on Coast shear zone and related structures and their possible continuations. Known and inferred trace of main locus of subduction-related magmatism is represented by red "volcanoes."

are more easily understood. Dickinson and Snyder (1978) suggested that onset of flat subduction of the Farallon plate under North America could explain the inland migration of magmatism and foreland deformation during the Laramide orogeny which commenced at 75 Ma. Geodynamic models confirm that basal traction from flat slab subduction is required to account for foreland deformation far inboard from the continental margin (Bird, 1998). Models depending on interactions at the subduction margin, such as the hit-and-run collision of Baja B.C. with the southwestern margin (Maxson and Tikoff, 1996), cannot transmit compressional forces sufficiently far inboard. Proponents of the Baja B.C. model have often appealed to the southern option for the Kula-Farallon ridge (Engebretson et al., 1985) so that Baja B.C. could be moved northward on the Kula plate. Instead, the northeast direction of foreland shortening south of 49°N between 75 and 50 Ma and the contrast with Rocky Mountain deformation closer to the continental margin farther north is readily understood using the simpler northern option for the Kula-Farallon ridge. Indeed, the northern option is strongly favored by seismic tomography of the subducted Kula-Farallon plate boundary, which is imaged under the Great Lakes region (Bunge and Grand, 2000).

CONCLUSIONS

The Baja B.C. controversy is primarily the result of sparse and piecewise application of paleomagnetism and supporting geologic and geochemical methods to an orogen which experienced complex deformation and from which supracrustal rocks have largely been removed. The above analysis suggests that discordant paleomagnetic directions from the Cordilleran margin of North America are understandable within a paleogeography which limits post–mid-Cretaceous northward motion to ~1000 km. A necessary condition for embracing this smaller amount of latitudinal motion, as opposed to the ~3000 km displacements of the Baja B.C. hypothesis, is recognition that crustal panels of the Insular terranes and Coast orogen have experienced tilting or folding around axes subparallel to the continental margin. Dense paleomagnetic sampling along with U-Pb geochronology, $^{40}Ar/^{39}Ar$ thermochronology, geobarometric analyses, and structural geology have established that such tilting and folding has affected the margin near Prince Rupert, British Columbia. The utility of paleomagnetism in deciphering the tectonics of midcrustal rocks in extensional settings has been documented in the Omineca belt of southeast British Columbia (Wingate and Irving, 1994) and in the Basin and Range (Livaccari et al., 1995). These successful applications are traceable in part to tighter constraints on interpretation because large transport of these areas is not an option. We expect that resolution of the Baja B.C. controversy through wider application of interdisciplinary approaches will usher in a period of rapid advance in understanding of the northern Cordillera. Coordinated with the increasing array of sophisticated geological and geochemical methods applicable to elucidating crustal architecture, paleomagnetism will play a central role.

ACKNOWLEDGMENTS

We thank Bill Dickinson for stimulating discussions and Kathleen Koopman for assistance with figures. The manuscript was improved by careful reviews from David Evans, John Geissman, Paul Umhoefer, and Karl Karlstrom. Funding was provided by the Tectonics Program of the National Science Foundation.

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Manuscript received March 7, 2001; accepted April 9, 2001. ▲

What Do Penguins and Plate Boundaries Have in Common?

About as Much as Politics and Geologists

Sharon Mosher, *GSA President*

The most surprising thing I've learned as GSA president must be that dairy farmers are interested in Earth Science Week. It shouldn't surprise me, but like many geologists, I tend to overlook the less obvious connections with earth sciences. Conversely, we geologists often assume that what is so obvious to us is understood by the public and by public officials. When we hear severe budget cuts are proposed for the U.S. Geological Survey and National Science Foundation, we hope the public and public officials will recognize that such cuts are detrimental to society and the economy. Yet even our fellow scientists don't recognize the importance of the earth sciences. Two recent experiences have impressed on me the need to interact more with all scientists, both scientifically and politically.

I have been working on Macquarie Island, located 1500 km south of New Zealand. This World Heritage site is a sliver of oceanic crust uplifted at a restraining bend along the Pacific-Australian transform plate boundary and is a unique place to study plate boundary processes. But the island also is home to more than a million penguins, 70,000 elephant seals, numerous species of ground-nesting birds, and unusual vegetation. Most of the 40 scientists who come each year to study on the island are biologists or botanists. Working on the island turns you into a naturalist, if only to survive—for example, knowing the mating habits of elephant seals can save your life! Plus, my students will confirm that the close interaction with other scientists over many months generates a genuine interest in what others are studying. The obvious strong connection between the vegetation, animals, geology, topography, weather, and plate motion leads to scientific discussions on how various processes are linked. Here, penguins really are affected by plate boundaries, because their colonies are being uplifted at 5–16 mm per year, making their trek to the ocean longer every day. Not all of them have been willing to leave their established colony and move to lower elevations, causing unusual penguin living conditions!

So yes, penguins and plate boundaries have something in common, but what about politics and geologists? As GSA's president, I am a member of the Council of Scientific Society Presidents, a group very active in influencing science policy. I have found that although there is a strong interest among other scientists in interacting with us scientifically, our peers do not appreciate the relevance of our science. When scientists publish studies on the need for research in environmental sciences, and the words earth science, geology, or geoscience don't even appear, we all lose. Because of the striking and newsworthy effects that geologic processes have on people, earth sciences are probably the easiest to sell to the public, yet we don't capitalize on this. For example, every news article on a recent earthquake should mention the need to study plate boundaries through such initiatives as EarthScope. Other scientists are either not aware of what we do, or they can more easily see the value of biological, chemical, or physical sciences.

What can we do? We need to educate our fellow scientists—something we can all do in our day-to-day contacts with colleagues. We need to take every opportunity offered to spread the message that earth science research can provide answers to major scientific and societal problems. And, we need to work together with other scientists to increase public awareness of the importance of all sciences to society and to the growth of our economy, or we will be isolated just like those penguins on a plate boundary we don't understand.

Correction

The Council on Undergraduate Research—Geosciences Division, the National Association of Geoscience Teachers, and the Association of American State Geologists were listed incorrectly in the May "Dialogue" column. GSA apologizes to these societies and to their members for the errors.

Don't Just Make the Meeting—Make the Meeting Happen

Rob Young and Dave Bush, *Technical Program Co-Chairs, 2001 GSA Annual Meeting*

As the technical program co-chairs for this year's GSA Annual Meeting in Boston, we have been getting a great deal of input from friends and colleagues regarding the successes and failures of recent GSA meetings. There are some who feel that GSA has lost the "cutting edge" to another large, geological organization. (O.K., it's AGU.) One colleague went so far as to exclaim, "Not enough hard science. Too much education!" Of course, we still believe that field work constitutes science as much as computer models constitute science, so we are not prepared to apologize for our recent technical programs (and as an aside, Reno had the most abstracts ever submitted to a GSA meeting). But there is some truth to the laments of our digitally enhanced friends.

Due to the inherent reliance on technology within geophysical research, the American Geophysical Union (AGU) meeting has always been loaded with technological innovators and numerical modelers. But over recent years, the AGU meeting has expanded its umbrella to include the technologically inclined in fields that have been traditional GSA strongholds: hydrology, coastal and nearshore geology, and tectonics, to name a few.

Unlike some GSA loyalists, we don't believe that this trend threatens the health of our own meeting, nor does it threaten our organization. But we are concerned that, slowly but surely, we seem to be separating the modelers from the field geologists, and the technology from the data. If we all go to different meetings, the application of numerical models will continue to slide further away from reality (biased personal opinion), and the grizzled old field geologist will continue to be lost outside the technological loop (like our former doctoral advisor).

So what do we do? Should we all put our presentations on overheads and go to AGU? Noooooooooooo. Fortunately, our meeting format allows us to remedy this problem ourselves. Believe it or not, the GSA Annual Meeting technical program is proposed and assembled entirely by its participants. That's right, if you're reading this, you have the right to propose a technical session at any GSA meeting. Furthermore, if you have been displeased with some of the science at recent meetings, we would argue that you have the responsibility, as a GSA member, to do something about it. Rather than abandon the organization, how about helping us to bring some of our wandering sheep back into the fold? Propose a session. Undeniably, it would be good for us, and also good for science.

The new meeting format was designed to open the meeting up to the membership. There is no denying that it has done this successfully. We encourage all of you to seize this opportunity to improve and reinvigorate the technical program. If there hasn't been something there to interest you, put it there! If you have questions on how you can contribute to the content of the technical program, contact us at dbush@westga.edu or ryoung@wcuvaxl.wcu.edu. See you in Boston.

2001 GSA Annual Meeting, Boston

Abstract deadlines:
July 17 (paper); July 24 (online)

2002 GSA Annual Meeting, Denver

Topical Session proposal deadline:
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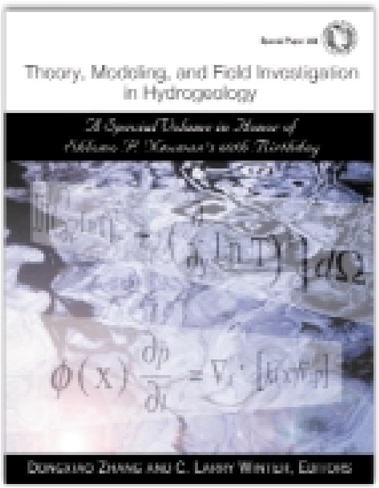

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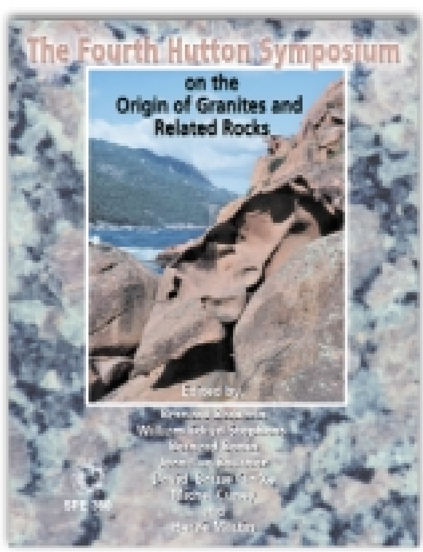

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Purchase an advance copy of the *Abstracts with Programs* volume (2001, vol. 33, no. 6) by September 28, and you should receive it before the Annual Meeting in Boston. This saves you the trouble of purchasing the volume at the meeting and gives you time to look over the abstracts ahead of time.

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Price: $35 for GSA members; $42 for nonmembers. Price includes shipping. No additional discounts may be applied to this offer. Copies will be mailed about three weeks prior to meeting.

GSA Foundation Update

Donna L. Russell, Director of Operations

GSA Members Eligible for Subaru Benefit

Subaru of America has offered a great benefit to all members of the Geological Society of America: GSA members are able to purchase new Subarus at invoice cost. For every car sale recognized under this program, Subaru will make a $150 donation to the Foundation to be split between the Earth Science Educator Program and the Doris Curtis Women in Science Fund.

Any GSA member who has been a member for at least six months is now eligible to purchase or lease a new Subaru at dealer invoice cost. The qualified member must contact the VIP Partner Program Administrator at GSA and request a Dealer Visit Authorization form and letter of introduction before visiting their Subaru dealer of choice.

The letter of introduction must be presented to the participating dealer sales manager upon entry to your preferred Subaru dealership and before pricing negotiations are initiated. The savings will vary by vehicle, but may range from approximately $1,300 to more than $3,000.

Subaru of America and GSA are pleased to extend their partnership by providing this benefit to GSA members. For further details or to request a letter of introduction, contact the VIP Partners program administrator, Nancy Williams, at nwilliams@geosociety.org, 1-800-472-1988, ext. 1117.

Most memorable early geologic experience

Getting lost in Yellowstone Park during my first job in geology.

—Parker E. Calkin

A Subaru Update

The following ad announcing the sponsorship agreement between Subaru and GSA appeared in Subaru's *Drive* magazine.

Subaru Announces New Sponsorship

Subaru of America, Inc. recently signed a two-year sponsorship agreement with the Geological Society of America (GSA). The partnership assures funding for a portion of annual meeting expenses, enhances member services and provides funding for some GSA programs. The following are the general areas of support made possible by this relationship:

- Subaru was the title sponsor of the GSA annual meeting this past November in Reno, NV.
- The use of two decaled Subaru Outback vehicles at GSA Headquarters in Boulder, CO, for two years.
- Underwriting for two key programs within GSA's Science, Education and Outreach Department. Diana Stordeur, an award-winning science teacher from Denver, will work full time for one academic year on the Distinguished High School Earth Science Education in Residence Program. In addition, the Doris Curtis Women in Science Fund was enhanced by the Subaru-GSA partnership. An award was given at the GSA annual meeting last year to an outstanding woman in the geosciences, and additional dollars will be added to the endowment of this fund.

Science teacher Diana Stordeur in a Subaru Outback provided to the GSA.

By contacting Subaru of America within 60 days after purchasing a new Subaru, GSA members can ensure that Subaru of America will make a $150 donation to the GSA Foundation to support the GSA Distinguished Educator Program and the Doris Curtis Women in Science Fund.

For details about the GSA, visit **www.geosociety.org**.

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Sustainability Series Prompts Comments

Thanks for the Wake-Up Call

The dozen sustainability articles [in 2000] have been stimulating to those of us who have feared that "sustainability" may have become just another throwaway term in our faddish culture today.

However, since we have just experienced the debacle of a presidential election noted for its vituperation and divisiveness, George W. Fisher's Part XI (*GSA Today*, v. 10, no. 11, p. 19) appears to offer some hope for the political community in which we live.

Fisher's call for us earth scientists to engage our neighbors, to communicate our value systems as well as our scientific knowledge, and especially to recognize the global aspect of our cultural systems and our environment injects some much-needed wisdom into our thinking.

The sense of balance that he urges us to adopt—both/and rather than either/or—is what nature is more attuned to. Our philosophical discourse—and our legal systems—all too often are characterized by either/or. This change could speak volumes of self-awareness and healing, both of which will be very necessary if we are to bootstrap ourselves out of the political morass in which we are immersed.

It is time for us—earth scientists and all the other critters that we must interact with—to become more both/and in our contemplation, our communication, and our actions. Thanks, George Fisher, for the wake-up call!

Allen F. Agnew
Courtesy Professor
Oregon State University

Changing Cultural Values

GSA Today has taken a commendable stance in publishing the series "Toward a Stewardship of the Global Commons." However, in Part XII, "We have the Option of Choice: The Future is Up to Us" (*GSA Today*, v. 10, no. 12, p. 24), the authors appear to make some questionable assumptions regarding the difficulties involved in changing cultural values through appeals to reason and self-interest. For example, the enlightenment founders of European and American democratic nation-states expected a science-based, secular society of literate, deistic humanists to evolve out of the eighteenth century foundations of modernity. They did not anticipate such regressions from their secular political ideal as the romantic movement, religious revivalism, and totalitarian fanaticism. Likewise, the founders of the American environmental movement of the 1960s and 1970s did not expect the powerful anti-environmental forces of political conservatism, corporate propaganda, individual consumerism, and the wise use movement to undo many of the achievements of the movement to the point that today's growth mania, oversized homes and SUVs, unconstrained population growth, and ecologically destructive resource consumption are worse than ever after more than three decades of environmental education. Much has been accomplished through the creation of the National Environmental Policy Act, Environmental Protection Agency, and numerous public and private institutions, but these achievements have been overwhelmed by the voracious appetite of modern industrial society.

Appeals to altruism and self-interest in behalf of the environment today are falling on the deaf ears of a populace which continues to pursue the "American dream" of egoistic individualism leading to material abundance. For all of our recycling programs, we produce more waste per capita today than we did at the beginning of the environmental movement. The recommendations proposed by the authors of "The Future is Up to Us" already <u>have</u> been implemented (with the purpose of achieving environmental literacy and advocacy leading to political and social reform) relentlessly for decades and yet we stagnate. Why is our behavior so intractable? One reason is that modern western science, from Francis Bacon to Newton, developed in a crucible of belief to produce a humanistic arrogance toward nature. Ecosystems, in the popular mind, remain nothing more than aggregates of resources, which will continue to be used to build a technological utopia on a global scale.

If we are to seriously challenge the dominant anti-environmental social paradigm of the 21st century, we need to unmask publicly the underlying assumptions of our western culture (and their manifestation throughout the globe). Books such as Max Oelschlaeger's *The Idea of Wilderness* (1991) and William Ophuls' *Requiem for Modern Politics* (1997) have initiated this self-enlightenment, but only to an academic elite. Without the spread of such ideas to a larger public, however, the proselytization in behalf of building a sustainable society suggested by the authors of "The Future is Up to Us" will fall upon the barren ground of a collective world view, which can only lead to completion of the modern project (with its Judeo-Christian roots): the transformation of all of nature into a thoroughly controlled and managed planet supporting an increasingly technological society. This is not to say that we should abandon the goal of environmental literacy and action, but rather that we should pursue it with a realistic awareness of what we are up against.

Gilbert LaFreniere
Willamette University

Multidisciplinary Exchange Needed

I very much enjoyed the series "Toward a stewardship of the Global Commons: Engaging 'My Neighbor' in the Issue of Sustainability" in *GSA Today*. I believe the leadership of the Geological Society of America should be congratulated for opening up this controversial subject.

I would like to see other professions such as forestry or oceanography deal with their "commons." With oceans occupying such a large percentage of Earth's surface, what are the human ecological footprints and carrying capacity of the oceans and how can our impacts be measured? Would the guidelines be similar?

Then I would like to see these professions exchange and compare articles on a multidisciplinary basis. Perhaps a third party publication may be better but we tend to stay with our own profession's publications.

Bill Lukens
2860 Wrenco Loop
Sandpoint, ID 83864

Sustainability: It's Philosophy/Management, Not Science

During the last year, *GSA Today* has published a series of articles on sustainability as well as reports on meetings about sustainability. Although these articles contain scientific information, have the "look" of science, and are published in a journal read almost exclusively by scientists, I believe that in many cases, they have blurred the distinction between science and philosophy/management policy.

Sustainability is a new word that was first popularized in the environmental sense in 1987 when the United Nations Brundtland Commission defined sustainability as "the ability to meet the needs of the present generation without compromising the ability of future generations to meet their needs." Implicit in this definition is a series of value judgments regarding wealth distribution of "meeting the needs," and sounds similar to "… to each according to his needs and from each according to his abilities," another well-known philosophy of wealth distribution. Sustainability addresses some of the philosophical and management issues important to discussion of our resources and the environment; but as defined above, it is a management, not a scientific approach.

The scientific method is based on the principle that observation is the judge of whether something is true or not. It involves clever experiments, careful measurements, learning to ask the right question, and the application of a string of logical arguments. It is this approach in which observation is the arbiter that distinguishes the scientific method from all other approaches in addressing the mysteries of nature. A scientific observation will be the same for any observer: groundwater, for example, flows from areas of high potential to areas of low potential, regardless of race, religion, creed, form of government, economic model, or geographic location of the observer. These observations are indisputable, and there is no compromise. I recognize that the way we design experiments and interpret data may not be entirely free from bias, but there are ways to catch these transgressions, and they differ significantly from outright moral, ethical, and management issues.

At the risk of sounding iconoclastic, I am concerned that some scientists in their enthusiasm to preserve the environment have jumped on the "sustainability" bandwagon without fully acknowledging the concept's philosophical/management nature. Scientists and engineers can provide answers to some of the questions that emanate from the sustainability philosophy, and we are well trained and equipped to supply those "what if" answers. We are not, however, moral or ethical leaders, nor are we elected officials for whom the responsibility exists for making value judgments. As geoscientists, we have a societal responsibility to protect the environment; but we must take great care that the philosophy is separated from the science in any statements that we make or concepts we embrace. If we are to make valued input into management of the environment, we must maintain our credibility as independent observers free from value judgments.

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LETTERS: *GSA Today* encourages readers to share their views on topics covered in the magazine or on topics of interest to members of the geoscience community. Letters should be no longer than 300 words; preference will be given to letters that meet this limit. Send letters to:

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NOTE: Comments and letters on science articles must be received within two or three weeks of publication of the article in order to be considered for publication.

COMMENTARY

Today's Reality—Professional Registration, Exit Examinations, and the National Association of State Boards of Geology

John W. Williams, *Professor and Chair, Department of Geology, San Jose State University, Past President of the National Association of State Boards of Geology, Past President of the Association of Engineering Geologists*

The ink is drying on the Ph.D. in geology diploma just earned from a prestigious university. The new Ph.D. is anxious to hang out her shingle, declaring her a geologist ready to assist the public on geologic issues. Belatedly, she learns that 29 states require geologic licensure in order to advertise as a geologist and to do work for the public without direct supervision. For this required licensure, in addition to the coveted degree in geology, she needs about 5 years of supervised experience, and must pass a written examination.

In 1988, the National Association of State Boards of Geology (ASBOG) was organized to link state geology licensing boards and to facilitate the preparation of uniform procedures. Twenty-four of the 29 states requiring geologic licensure are members.

Much of today's geological practice impacts engineered works, the health, safety, and welfare of the public, and the environment. These areas of geologic activity continue to expand and offer the greatest opportunities for employment. Inadequate and incompetent practice by a geologist can cause loss of life or property and can be expensive because of the need to redo work. Licensure by individual states helps provide protection for the public by establishing minimum standards in the discipline that individuals wishing to practice must meet and maintain.

In addition to being an advocate for licensure, one of ASBOG's principal services is developing standardized written examinations for evaluating the qualifications of applicants seeking licensure as professional geologists. The use of a common (national) examination enhances the ability of the geologist to be licensed in multiple states without the need to take examinations in different jurisdictions.

The ASBOG examination content is determined by periodic, detailed surveys of practicing professional geologists through out the United States to assess the geologic knowledge and skills needed to practice safely and effectively. The resultant two-part examination, "Fundamentals and Practice," tests academic knowledge of geology and practical skills. Over the decade of examination administration, on the average, 55%–60% of candidates have demonstrated successful performance. Thus, approximately 40% of the candidates, all of whom had the required geologic degree and requisite years of experience, did not demonstrate the geologic knowledge and skills believed by the profession to be needed in order to practice effectively.

Recently, the geology degree–granting universities in Mississippi began to require that all graduating geology majors take the "Fundamentals" portion of the examination. Two academic institutions in Kentucky also have adopted this procedure. The data generated about student performance over time in the various subject areas of the examination are employed as factors to provide direction in curricular adjustments. This use of the examination is not a pass/fail graduation requirement, but guides colleges and universities so that students receive the basics—the knowledge and skills essential for satisfactory performance in geological careers. ASBOG is encouraging other states and schools to consider using the "Fundamentals" examination in this manner.

The practice of geology is coming of age, utilizing techniques already adopted by many other scientific disciplines to ensure that qualified individuals are licensed to practice with the expectation that quality services and products will result.

If you would like to comment on this issue, please contact Dennis Goldman, Senior Director of Programs and Products, GSA, P.O. Box 9140, Boulder, CO 80301-9140, (303) 447-2020, ext. 1202, dgoldman@geosociety.org.

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Book Reviews

The Carbon Cycle

Edited by T.M.L. Wigley and D.S. Schimel, *Cambridge University Press, New York, 2000, $64.95.*

The Carbon Cycle represents a comprehensive attempt to summarize an enormous amount of interdisciplinary research into the carbon cycle and global change. The book's 21 chapters address three main questions—the "missing" carbon; past variations in CO_2; and using models to understand carbon dynamics in terrestrial and marine systems.

Despite its 2000 publication date, the volume is about 5 years out of date. Values for large-scale carbon fluxes are from the early 1990s (referencing papers from 1993 at the latest). Fossil fuel emission data and terrestrial exchanges are reported for the 1980s only. The lack of recent studies is most marked in the discussion, or lack thereof, of ecosystem manipulation studies—critical for understanding the CO_2 "fertilization" effect over the long term, as well as for understanding and modeling terrestrial carbon dynamics. Various authors consider results from controlled-environment CO_2 enhancement studies, but also acknowledge the need for long-term field studies. Results from ecosystem-level studies of CO_2 enhancement and ecosystem warming have been available for several years, but are not included here. Updates should be easily found, however, as just about every major scholar in the carbon cycle research community is represented or referenced here.

One of the volume's strengths is the thorough approach to quantifying the carbon cycle and understanding uncertainties in estimations of carbon fluxes and reservoirs, and in model parameters and results. This is most apparent in chapters dealing with terrestrial carbon flux and modeling of ocean carbon. Attempts to initialize models with observed data are well described and thorough, but occasionally there is insufficient detail given of model calibration and validation schemes, making it difficult to assess the value of model results. This is partly due to the aforementioned lack of inclusion of results from recent long-term ecological studies, which could provide relevant data for model calibration and testing.

The Carbon Cycle is a valuable resource for anyone working in the field of global change. Most figures are clear and easily understood (for example, excellent illustrations of carbon models), and would translate well to classroom use. Several chapters would be appropriate reading for upper-level undergraduate or graduate courses in climate change, ecosystem ecology, or earth system modeling. The chapters are similar in format, and occasionally in content, to the 1995 Intergovernmental Panel on Climate Change (IPCC) report on the science of climate change, and *The Carbon Cycle* may therefore be considered a companion volume to the 2000 update of the IPCC Scientific Assessment.

Karin P. Shen
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The Ecology of the Cambrian Radiation

Edited by A. Yu Zhuravlev and R. Riding, *Columbia University Press, New York, 2001, 576 p., $80.00 cloth, $40.00 paper.*

The Ecology of the Cambrian Radiation is the most recent addition to the "critical moments in paleobiology and earth history series" published by Columbia University Press. The book covers a broad spectrum of paleoenvironmental and paleobiological themes relating to the Precambrian-Cambrian transition in 21 chapters, with contributions by well-respected experts in the various fields.

One of the unique features of the Precambrian-Cambrian transition in comparison with other major events in biosphere history is the diversity of possible contributory factors that have been inferred to contribute towards the evolution and radiation of complex animal life around the Precambrian-Cambrian boundary. While this book does not aim to cover all of these debates, the first part of the book, "The Environment," provides excellent summaries of global tectonics and paleoclimate in the context of the Cambrian radiation event.

The second part of the book, entitled "Community Patterns and Dynamics," addresses aspects of the paleoecology of Cambrian plankton and the benthos of siliciclastic and carbonate environments with respect to their evolution during the Cambrian. Although much of the material is already published elsewhere, the reviews are well written and very much focused on the theme of the book. In particular, the review of Burzin et al. is broad reaching and represents a significant contribution to the field.

The third part of the book, "Ecologic Radiation of Major Groups of Organisms," covers most of the biological groups integral to the Cambrian radiation, including the often-overlooked algae, bacteria, and dinoflagellates that contributed the primary productivity that fueled the Cambrian radiation event. The higher orders of Cambrian taxa are also covered, with excellent discussions of the ecology of trilobite and non-trilobite arthropods by N. Hughes and G. Budd, respectively. This part of the book would have been significantly strengthened by adding an expanded section on the Cnidaria-Ediacara fauna, which is only treated in a cursory manner. In addition, the invaluable paleoecological information on the soft-bodied biota given by trace fossils probably also warranted a chapter to make this book a more rounded text.

The volume as a whole is well edited, with a consistent style and good quality reproduction of photographs and drawings. One feature of the book, however, is that in several of the more rapidly moving fields, the references are significantly out of date. Several of the authors seem to have rather neglected post-1998 references, which, unfortunately, detracts from what is otherwise an excellent resource text for students and professionals alike.

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Billion-Year Earth History of Australia and Neighbours in Gondwanaland

Edited by J.J. Veevers, *GEMOC Press, Sydney, Australia, 2000, 388 p., $40.*

This thorough but compact volume of two dozen chapters is a profusely illustrated (sketch maps and diagrams; no photographs) tectonic history of the Australian continent and its Gondwanan neighbors over the past billion years. Although a dozen contributors lent their technical expertise to some chapters, the bulk of the volume (~60%) was written solely by its editor, who has imparted to it a consistency of style and treatment uncommon for its genre. The format (page plats 7 × 10 in) makes for figures and tables packed with information. Passages that are not authoritative, in the sense of reflecting some widely held consensus, are nonetheless carefully crafted.

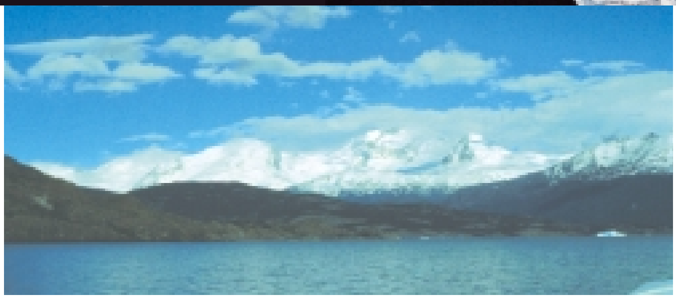
The book offers several kinds of rewards for overseas readers. Succinct overviews of Australian paleomagnetic poles and paleolatitudes through time, of patterns of seafloor spreading in the oceans around Australia, of the geophysical properties of Australian crust and lithosphere, and of Quaternary glacial-interglacial fluctuations in Australia are brought together for easy perusal. For those unfamiliar with key Australian geologic provinces, there are compact summaries of the Proterozoic assembly and subsequent Neoproterozoic history of interior Australia, the evolution of the Paleozoic Tasman orogenic belt (~25% of the total text), the development of post-Tasman Permian-Triassic basins and fold belts, and the morphotectonics of modern Australian continental margins.

Paleotectonic and paleogeographic syntheses address questions of global tectonics from a "down under" perspective that is important for a balanced appraisal of global relations. In this vein, the book considers the place of Australia and adjoining continental blocks within Gondwanaland, Gondwanan affairs during the assembly of Pangea, and salient drift episodes involving Australia and its Gondwanan neighbors during the breakup of Pangea. The treatment of Rodinia is unorthodox, but potential Australia-Laurentia crustal connections are explored thoughtfully.

Unique in my experience are provocative topical discussions, almost in the nature of expanded sidebars, on a topographic-bathymetric feature termed the Australian-Antarctic Depression aligned normal to the Australia-Antarctica spreading ridge, post-Jurassic vertical motions of the Australian platform akin to epeirogeny, and widespread sedimentary dispersal of Neoproterozoic-Cambrian zircons from the Transantarctic Beardmore-Ross orogen.

There is no more informative summary of Australian tectonic history in a regional and global context, something in the volume for almost everyone, and the price is right!

William R. Dickinson
Department of Geosciences
University of Arizona



Lago Argentino. Photo by J. Reynolds.

GeoTrip

New Year's at the End of the World: The Geology of Southern Patagonia, Including Tierra del Fuego
Dec. 26, 2001–Jan. 10, 2002
15 days, 14 nights
Scientific leaders: James Reynolds, Brevard College, Brevard, North Carolina; Dorothy L. Stout, Cypress College, Cypress, California.

Jim Reynolds has spent the past 15 years investigating the uplift history of the Andes. Using magnetostratigraphy, Jim and his colleagues are developing a relatively precise chronostratigraphy across the many tectonic provinces that we will visit. In addition to his work at Magstrat, LLC, and Brevard College, he holds an adjunct position at the University of Pittsburgh.

Since 1978, Dottie Stout has been leading geological expeditions around the world, including trips to China, South America, Africa, Europe, Indonesia, Australia, and Russia. Dottie is past president of the National Association of Geology Teachers and is temporarily on leave as a program director at the National Science Foundation.

Description

Our trip will start in Ushuaia, Argentina, the southernmost city in the world, at the base of the Cordillera Darwin on the Beagle Channel along the southern shore of Tierra del Fuego. The austral summer can be pleasant, but is seldom truly warm. We'll look at the glaciers, rocks, and the tectonic setting along the channel before we cross the mountains to the Patagonian steppes that comprise the northern part of the island. After crossing into Chile and taking the ferry across the Straits of Magellan to the South American mainland, we'll head eastward along the straits through the oil and gas fields to the penguin rookery near Punta Dungeness, Argentina. We'll observe the interplay between sea-level changes, glaciations, waves, currents, and extreme tidal ranges that shaped the coastline, while dodging the numerous rheas and guanacos on the plains. From there, we'll go to Río Gallegos and then to Glaciers National Park in the Patagonian Andes. We'll watch icebergs calve off of the Perito Moreno glacier into Lago Argentino, take a daylong boat trip on the lake, and slalom through the icebergs while Andean condors soar overhead. A low pass through the mountains will take us to Torres del Paine National Park in Chile to see the most spectacular mountains in the Andes. After a boat trip up the Ultima Esperanza fjord at Puerto Natales, we'll head to Punta Arenas and our flight home.

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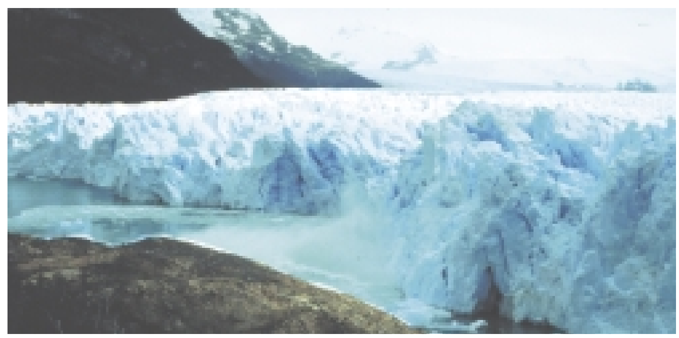
$4,200 for GSA members, $4,300 for nonmembers. A $300 deposit is due with your reservation and is refundable through Sept. 1, less a $50 processing fee. Total balance is due Sept. 1. Minimum: 20; maximum: 30. Included: Guidebook; airfare from Atlanta to Ushuaia via Buenos Aires; ground transportation; lodging for 13 nights (double occupancy); and meals for 14 days. Not included: Airfare to and from Atlanta, Georgia; and alcoholic beverages.



Perito Moreno glacier. Photo by J. Reynolds.

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The International Centre for Diffraction Data (ICDD) is seeking nominees for the 2001 J.D. Hanawalt Powder Diffraction Award for an important, recent contribution to the field of powder diffraction. The award is named for Professor J. Donald Hanawalt, whose pioneering work in the 1930s led to the development of the PDF® database structure and search and/or match procedures still in use today. Work eligible for consideration must have been published after January 1, 1996. The selection committee welcomes suggestions, nominations and documentation of accomplishments for possible recipients through June 30, 2001. The award will be presented at the 50th Annual Denver X-ray Conference to be held at Steamboat Springs, Colorado, USA, from July 30–August 3, 2001. The recipient's travel expenses to the meeting will be provided.

Send submissions to: Executive Director, International Centre for Diffraction Data, Newtown Square Corporate Campus, 12 Campus Boulevard, Newtown Square, PA 19073-3273, U.S.A., (610) 325-9814, fax 610-325-9823, information@icdd.com.

In Memoriam

David W. Blake
Battle Mountain, Nevada
September 13, 2000

Michael Fleischer
Washington, D.C.

Ronald C. Hirschfeld
Winchester, Massachusetts
March 7, 2001

Charles B. Sclar
Bethlehem, Pennsylvania
January 13, 2001

Robert L. Slamal
Wichita, Kansas
February 2001

About People

GSA Fellow **William A. Berggren**, senior scientist emeritus at the Woods Hole Oceanographic Institution and distinguished visiting professor at Rutgers University, was awarded a doctorate honoris causa by the University of Utrecht (The Netherlands) on March 26 in connection with its 365th anniversary. This doctorate was awarded to Berggren for his research on the construction of geological time scales based on "The integration of a broad spectrum of biological, chemical, and physical tools that can be applied to accurately date marine as well as terrestrial sediments presently exposed on land or recovered from the oceans through deep-sea drilling."

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WATERSHED HYDROLOGY
UNIVERSITY OF NEVADA, RENO

The Environmental and Resource Sciences Department of the University of Nevada, Reno, seeks candidates in the area of watershed science with emphasis on water quality, nutrient dynamics, and/or sediment transport. A Ph.D. in watershed science, hydrology, civil/environmental/agricultural engineering or related field is required at appointment. Experience with numerical methods and modeling of water quality dynamics in surface waters is required and expertise in field-scale experimentation, non-point source pollution, contaminant fate and transport, and limnology is preferred. Candidates must possess strong written and oral communication skills, capability to develop an externally funded research program, and a documented commitment to excellence in undergraduate/graduate teaching and advisement of graduate students. This full-time (12-month) tenure-track position is anticipated to involve approximately 70% research and 30% teaching. Starting salary will be commensurate with qualifications/experience with a starting date of January 1, 2002, or as soon as possible thereafter.

The successful candidate will be expected to collaborate on multidisciplinary research with faculty in the department on a broad range of activities, including watershed assessment, range and forest restoration, habitat rehabilitation and impacts of anthropogenic pollutants on microbial and vertebrate populations. He or she will develop a nationally competitive research program in the areas of watershed hydrology and water quality and teach undergraduate/graduate courses in hydrology.

The successful candidate will also have the opportunity to interact with several successful interdisciplinary graduate programs on campus, including: Environmental Science and Health; Environmental Engineering; and Hydrologic Sciences, a nationally recognized program at the University of Nevada, Reno, with more than 70 graduate students and 55 faculty members. The candidate will also have opportunities to participate in experimental watershed studies in the Lake Tahoe basin, the Great Basin and with the Desert Research Institute.

Applicants should send letter of application summarizing qualifications, curriculum vitae, statements of research and teaching interests, and names and contact information of 3 references to: Jean Freestone, Search Committee Secretary, Dept. of Environmental & Resource Sciences, University of Nevada, Reno, MS 186, 1000 Valley Road, Reno, NV 89512-0013. Applications received by July 1, 2001, will be given full consideration. For procedural clarification, contact: Ms. Jean Freestone, (775) 784-4020, freeston@ers.unr.edu, or Dr. Scott W. Tyler, Search Committee Chair, (775) 784-6250, styler@unr.edu. For additional information on the position and University, Department of Environmental and Resource Science and related programs, see: http://www.ag.unr.edu/naes/employ.htm and http://www.jobs.unr.edu. EEO/AA

UNIVERSITY OF MINNESOTA
DIRECTOR, MINNESOTA GEOLOGICAL SURVEY

The University of Minnesota seeks to fill the position of Director of the Minnesota Geological Survey (MGS). The director is the scientific and administrative leader of an earth science research and service organization and as such leads the MGS with considerable autonomy. The MGS is staffed by 30 professional geologists, hydrogeologists, geophysicists, and support personnel, and operates on an annual budget of approximately $2 million. Administratively, the MGS is a unit of the School of Earth Sciences in the Institute of Technology. The MGS director is a tenured faculty member in the Department of Geology and Geophysics and reports to the head of the school.

The Minnesota Geological Survey carries out an active program of basic and applied geological research and provides service and education in geological matters to the people of Minnesota. Principal activities include geologic mapping in (1) structurally complex Precambrian terranes, (2) essentially undeformed sedimentary strata of Paleozoic and Mesozoic age, and (3) varied glacial deposits of Quaternary age. Geologic mapping is integrated with vigorous programs in applied geophysics, applied stratigraphy and hydrogeology, and glacial geology. MGS staff, publications, and databases serve the needs of scientists, decision-makers, and resource managers at all public and private levels concerned with ground water, environmental issues, land-use planning, waste disposal, mineral discovery, and mineral-resource development.

The MGS is funded by a special appropriation from the State Legislature and in addition receives significant contract funding for special projects and research from various governmental agencies. The director is responsible for maintaining and augmenting the present programs of research and service to the state, maintaining records of the state's mineral and water resources data, and for providing geological information and evaluation to various governmental agencies and the public. The director is responsible for establishing and maintaining close working relationships with local, state and federal agencies as well as other university departments involved in geological research and the use of geological information in public policy and resource development.

The close connection between the MGS and the Department of Geology and Geophysics provides significant opportunities for collaborative projects of research, instruction and service. The director is expected to contribute to the educational role of the Department of Geology and Geophysics by teaching occasional courses and seminars.

Candidates for the position must hold a Ph.D. in geology or related fields, have at least 10 years professional experience, demonstrated management and personnel skills, and credentials qualifying them for a senior level academic appointment in the Department of Geology and Geophysics. The appointment as director is full time for an initial period of three years and is renewable.

Interested persons should send a resume and the names, addresses, and telephone numbers of three references to Professor James Stout, Chair, MGS Director Search Committee, Department of Geology and Geophysics, 108 Pillsbury Hall, University of Minnesota, Minneapolis, MN 55455. Inquiries may also be made to Dr. Stout at (612) 624-4344 or jstout@umn.edu. The position is available January 1, 2002, and the closing date for applications is July 31, 2001.

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KING FAHD UNIVERSITY OF PETROLEUM & MINERALS DHAHRAN, SAUDI ARABIA

College of Sciences
Earth Sciences Department

The Department of Earth Sciences at King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia invites applications for a faculty position at a professor rank in the field of Environmental and Engineering Geology. This position requires someone who is experienced in all aspects of environmental investigations and assessments. Areas of particular interest are interaction of humans with the geologic environment, waste and pollution management, assessing geological hazards and risks, toxic substance control and land use management. Additional requirements are a Ph.D. degree in Environmental Geology / Engineering Geology and at least ten years of industry experience. The successful candidate must be innovative and have the vision and ability to apply advanced scientific and computer techniques to environmental and geological engineering problems. Teaching at the undergraduate and graduate levels and maintaining a strong research program will be expected of the successful candidates.

Salary/Benefits: Two year renewable contract. Competitive salaries based on qualifications and experience. Free furnished air-conditioned on-campus housing unit with free essential utilities and maintenance. The appointment includes the following benefits according to the University's policy: air ticket to Dammam on appointment; annual repatriation air tickets for up to four persons; assistance with local tuition fees for school-age dependent children; local transportation allowance; two months paid summer leave; end-of-service gratuity. KFUPM campus has a range of facilities including a medical and dental clinic, an extensive library, computing, research and teaching laboratory facilities and a recreation center.

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VERTEBRATE PALEONTOLOGY POSITION
BRIGHAM YOUNG UNIVERSITY

The Department of Geology at Brigham Young University invites applications for a tenure-track position in vertebrate paleontology with an emphasis in dinosaur paleobiology. The successful candidate will be expected to teach courses (undergraduate and graduate) in this field along with Historical Geology and other general geology courses as needed. The successful candidate must have a Ph.D. and will be expected to initiate/maintain a productive research program that includes, but is not restricted to, development of the extensive dinosaur collections currently housed at BYU. The position will be available as early as July 1, 2002. Starting salary and rank will be commensurate with experience.

Applicants should send a letter of application and curriculum vitae including names of three references to Dr. Scott M. Ritter, Faculty Search Committee, Department of Geology-S 389 ESC, Brigham Young University, Provo, UT 84602. Application materials must be received on or before August 1, 2001, to be considered.

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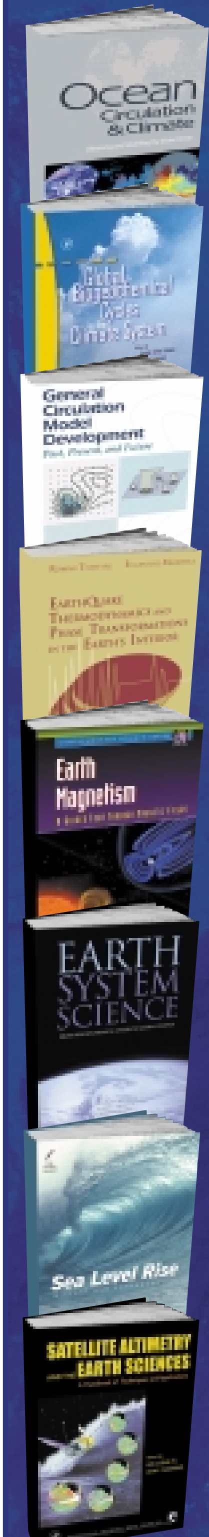

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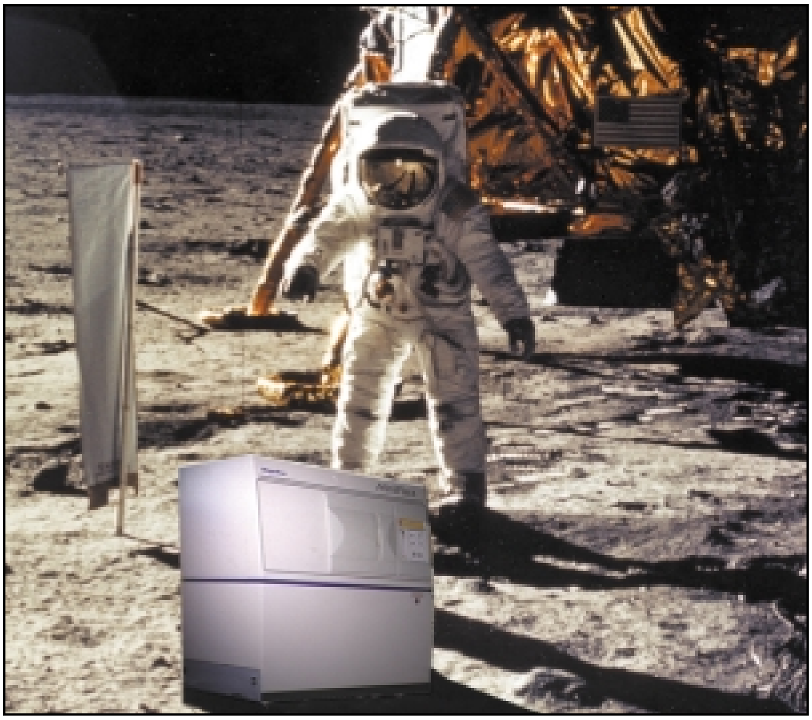

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