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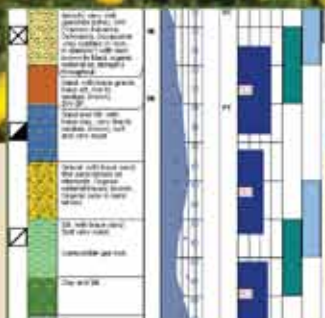
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Chronostratigraphy and geochronology: A proposed realignment



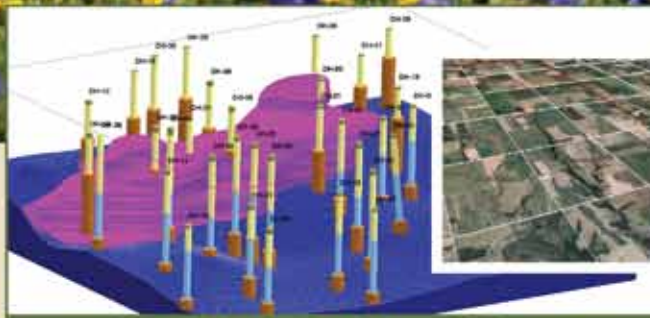
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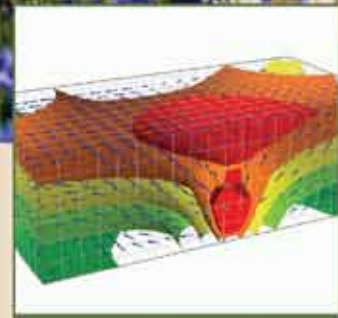
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Cover: The monument at Klonk, Czech Republic, to the Silurian/Devonian boundary stratotype, which was defined in a section in the adjacent hillside. The people in the photograph formed part of a meeting of the International Commission on Stratigraphy in Prague in 2010. See related article, p. 4–8.



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Chronostratigraphy and geochronology: A proposed realignment

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ABSTRACT

We propose a realignment of the terms *geochronology* and *chronostratigraphy* that brings them broadly into line with current use, while simultaneously resolving the debate over whether the Geological Time Scale should have a “single” or “dual” hierarchy of units: Both parallel sets of units are retained, although there remains the option to adopt either a single (i.e., geochronological) or a dual hierarchy in particular studies, as considered appropriate. Thus, geochronology expresses the timing or age of events (depositional, diagenetic, biotic, climatic, tectonic, magmatic) in Earth’s history (e.g., Hirnantian glaciation, Famennian-Frasnian mass extinction). Geochronology can also qualify rock bodies, stratified or unstratified, with respect to the time interval(s) in which they formed (e.g., Early Ordovician Ixex Group). In addition, geochronology refers to all methods of numerical dating. Chronostratigraphy would include all methods (e.g., biostratigraphy, magnetostratigraphy, chemostratigraphy, cyclostratigraphy, sequence stratigraphy) for (1) establishing the relative time relationships of stratigraphic successions regionally and worldwide; and (2) formally naming bodies of stratified rock that were deposited contemporaneously with units formally defined at their base, ideally by a GSSP (Global Boundary Stratotype Section and Point = “golden spike”) that represents a specific point in time. Geochronologic units may be defined and applied generally by either GSSPs or—as currently in most of the Precambrian—by Global Standard Stratigraphic Ages (GSSAs). Geochronologic units would continue as the *time* units eons/eras/periods/epochs/ages, and chronostratigraphic units as the *time-rock* units eonothems/erathems/systems/series/stages. Both

hierarchies would remain available for use, as recommended by a formal vote of the International Commission on Stratigraphy in 2010. Geological context helps determine the appropriate usage of the component units.

INTRODUCTION

Geology is the natural science in which time plays a central role. The passage of that time and its events (small and large) and intervals (short and long) are recorded in Earth’s rocks, particularly in stratigraphic successions and by the various lithologic, paleontologic, magnetic, and chemical signals within them. Study of these rocks has yielded the 4.6-billion-year history of Earth—study that is ongoing and is now being extended to other planets. Stratigraphy is the means of analyzing and ordering these phenomena, with chronostratigraphy and geochronology dealing explicitly with the relations of rock and time.

The primary means by which geological time information is conveyed is by the use of the Geological Time Scale (GTS = International Chronostratigraphic Chart [ICC] of the International Commission on Stratigraphy [ICS]) and its units. The most familiar of these units are the geological periods of geochronology, *sensu stricto*, or, more simply, of time (e.g., Jurassic, Cambrian) and the corresponding systems of chronostratigraphy, *sensu stricto*, or time-rock on which they are based. Historically, the systems were built from, or subdivided into, series and stages; the periods, epochs, and ages were then used to refer to the intervals of time in which the strata encompassed were deposited. Thus, conceptually, there has been a “dual and parallel hierarchy” of chronostratigraphic (time-rock) units used to designate rock bodies that formed contemporaneously and geochronologic (or time) units used to designate intervals in which they formed¹ or during which other events occurred (e.g., evolution, extinction, deformation, transgression). Many of these units were originally set up as (and remain fundamentally) relative time-rock units. These are typically of the last half billion years (the Phanerozoic Eon), where there are good fossil assemblages (i.e., biostratigraphy) that remain key to their definition, recognition, and correlation. Wherever feasible, additional tools, such as magnetostratigraphy, chemostratigraphy, sequence stratigraphy, cyclostratigraphy, and radiometric dating are employed (e.g., Strasser et al., 2006; Weissert et al., 2008; Langereis et al., 2010; Catuneanu et al., 2011; Gradstein et al., 2012). Most of the Precambrian units of the GTS, which largely lack useful fossil assemblages, remain defined by Global Standard Stratigraphic

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¹ By “formed” we mean when the main fabric of the rock was constructed; in sedimentary rocks, this is taken as when the sedimentary particles were deposited; in igneous rocks, this typically means intrusion or crystallization (although these processes may not be precisely synchronous). The “timing of formation” of any individual metamorphic rock is often more problematic, because such a rock commonly includes components that crystallized at different times along a pressure-temperature-time path.

Ages (GSSAs); the Archean–Proterozoic boundary, for instance, is set at 2500 Ma. However, the Ediacaran System/Period was defined by a GSSP in 2004 (Knoll et al., 2006), and the Ediacaran and Cryogenian subcommissions are considering a GSSP for the Cryogenian and subdivision of the Ediacaran by GSSPs. Furthermore, the ICS Subcommittee on Precambrian Stratigraphy is initiating efforts to define GSSPs for subdividing the Archean and Proterozoic by their rock record (e.g., Bleeker, 2004) rather than by arbitrarily chosen numerical ages. These projects will result in a Precambrian time scale that likely will be very different from that presently used.

At the other end of the geologic time scale, the recognition of long oceanic successions with effectively complete Milankovitch signatures has led to the revival of the unit-stratotype concept (Hilgen et al., 2006). Neogene stages (Zanclean and Piacenzian) with upper and lower boundaries defined by GSSPs in the same section have within them all significant biostratigraphic and magnetostratigraphic signals for the time encompassed and numerical ages that are integrated and precisely dated at high resolution through astronomical tuning. The Holocene, until recently defined only numerically, has been redefined with a GSSP in a Greenland ice core (Walker et al., 2009), and this epoch in turn leads to the present. Here geologic events are observed, recorded, and dated as they occur using human time (year, month, day, hour). Superposition in deposits analyzed at such high time resolution may commonly be compromised, for example, by the blurring effects of bioturbation (cf. Zalasiewicz et al., 2007), and this complicates the application of chronostratigraphy in such instances.

Early versions of the GTS were created, and functioned effectively, in the days before radiometric dating (e.g., Jukes-Brown, 1902). Today, considerable effort is expended to calibrate the GTS with numerical ages. Nevertheless, it remains more common to convey geological time information in terms of GTS units rather than by numbers of years. This is partly because of the familiarity and convenience of the units (to geologists at least) and partly because it is usually easier and more useful to establish relative correlations than to establish the numerical ages of rock phenomena. More importantly, however, the rocks formed during a time unit often encompass (and record) distinctive, time-constrained global environments (e.g., the Hirnantian Stage). They provide a convenient and practical method of reference to the events and time intervals they represent, just as with human history, when terms are used for a distinctive time interval (e.g., Renaissance) and its human products (e.g., art, architecture, literature, banking). Even informal terms, such as Caledonian and Grenvillian, are widely used in the same way in geology. For circumstances in which global units are difficult to apply, regional ones have been established (see Gradstein et al., 2004, 2012).

While traditionally chronostratigraphic units consist of rocks, whereas geochronologic units are spans of time, there has been debate over the necessity of retaining a dual and parallel time scale with the same formal names. This leads to terms such as “Jurassic” having two meanings, one an “intangible” unit of time and the other a physical unit of rock (which also means that the geochronologic term “age” may be confused with the word “age” used more generally). Some (e.g., Zalasiewicz et al., 2004a, 2004b, 2007; Gong et al., 2004; Odin et al., 2004; Carter, 2007; Jensen, 2004) have argued for unification of the geochronologic and

chronostratigraphic hierarchies, while others (e.g., Heckert and Lucas, 2004; Bassett et al., 2004; Narkiewicz, 2004; Walsh, 2004; Aubry, 2007; Hilgen et al., 2006) have argued for retention of the long-established dual hierarchy.

This debate represents subtle but distinct perspectives on the stratigraphic record. The issue was discussed extensively at the GSA Penrose Conference “Chronostratigraphy: Beyond the GSSP” held in Graz, Austria, in June 2006 and at a workshop of the International Commission on Stratigraphy in Prague, Czech Republic, in June 2010. In a formal ballot following the workshop, the ICS voting members recommended overwhelmingly (15 yes, 2 no, 0 abstain) to maintain the dual usage. Furthermore, the terms “geochronology” and “chronostratigraphy” have acquired a variety of wider meanings. Next, we consider the definition and application of these terms and of their units, discuss their proper usage, and provide examples and explanations of good practice.

CHRONOSTRATIGRAPHY AND GEOCHRONOLOGY: PREVIOUS DEFINITIONS

According to the latest versions of the International Stratigraphic Guide (Salvador, 1994; Murphy and Salvador, 1999), these two terms are defined as

Chronostratigraphy—“The element of stratigraphy that deals with the relative time relations and ages of rock bodies.”

Geochronology—“The science of dating and determining the time sequence of events in the history of the Earth.”

In this approach, chronostratigraphy deals explicitly with relative time relations of bodies of rock, typically stratified rocks, while geochronology rather more ambiguously suggests numerical dating to determine “absolute” ages (and indeed most specialists in radiometric dating consider themselves to be “geochronologists”). There is also a focus in this definition of chronostratigraphy on the rock bodies—for example, on tangible physical evidence, or material—and in the definition of geochronology on the temporal history derived from that evidence.

Today, certainly, the clear separation that used to exist between relative and absolute dating methods is now considerably blurred by methods such as astrochronology, which simultaneously provide *both* numerical and relative dates, once calibrated by biostratigraphy, at all levels within a stratigraphic succession. Thus, it seems timely to reexamine these terms and their conceptual value.

PROPOSED REALIGNMENT

One might consider here whether stratigraphy should be restricted to stratified rocks (as in the first edition of the International Stratigraphic Guide [Hedberg, 1976]) or be extended to cover *all* rocks (as in the second edition, in which the change in philosophy was introduced with little explanation or discussion [Salvador, 1994]). Nowadays, there is value in a term that refers to all rock-related time relations, not least because of the increasing interdisciplinary nature of the Earth sciences. Yet, there also remain considerable differences between the fundamental geological properties of stratified and non-stratified rocks, and hence of the means of their study and classification. For example, biostratigraphy and astrochronology are only possible in sedimentary strata, where superpositional relationships are present. Furthermore, the time of formation of plutonic and metamorphic rocks is determined with numerical dating, whereas, before the wide application of

radiometric dating, it was determined by cross-cutting relations with stratified rocks. This suggests a means of sharpening the distinction between the two terms, as follows:

Chronostratigraphy, consistent with its general use today, is *the establishing of time relations in stratified rocks*. The term is generally restricted to deposition-related processes in which the superpositional properties are present, and hence the detailed historical record is accessible. Chronostratigraphy is the application of disciplines such as biostratigraphy, magnetostratigraphy, chemostratigraphy, cyclostratigraphy, sequence stratigraphy, and numerical dating to stratigraphic successions in order to interpret temporal correlations. Furthermore, it involves the development of formally named and defined chronostratigraphic units and hierarchies, which comprise the ICS as well as regional chronostratigraphic classifications. On Earth, chronostratigraphy effectively starts in the Archean, ca. 3.8 Ma, when a stratal record begins.

Geochronology denotes *time relations in all rocks*, specifically *when they formed*, whether stratified or non-stratified. It also denotes the time of processes in which rocks not only formed but also were eroded (unconformities) and deformed (structural and cross-cutting relationships). It is used to denote the timing of events throughout all of Earth's history that are interpreted from the rock record (e.g., climatic, biotic, tectonic, and oceanographic). The geochronologic units for much of the Ediacaran to Quaternary are the intervals in time during which corresponding chronostratigraphic bodies of strata were deposited. Thus, the boundaries of chronostratigraphic units defined by GSSPs, chosen for their potential for precise global correlation, mark the beginnings and ends of the respective geochronologic units. Furthermore, geochronology is commonly used to denote the practice of radiometric dating (the term "geochronometry" is available to separately denote the process of numerical dating, though it has not been widely adopted). Thus, geochronology can be expressed in numerical ages and durations, though the dating of geologic events and intervals is most often expressed in terms of the geochronologic units.

The succession of global geochronologic units, equivalent to the units of the ICC, comprise the GTS, and these are calibrated by numerical ages. In some instances, ash layers associated with GSSP sections have provided high-precision ages for boundary levels (e.g., Brack et al., 2005, for the Ladinian Stage of the Triassic). Astronomical tuning of complete, continuous Neogene and Quaternary sections that include GSSPs provides very precise ages for boundaries as well as for enclosed stratal packets within the sections, but these may be subject to revision with alternative tunings and/or new astronomical solutions. Most GSSPs lack such ash layers and need be calibrated with numerical ages (themselves subject to revision and refinement) from elsewhere. For these reasons, boundaries of the chronostratigraphic units are not defined by numerical ages; instead, they are defined by GSSPs chosen within intervals with stratigraphic signals that offer the most reliable and most widespread time correlation. The age of a GSSP is estimated using mainly a radioisotopic age determination in its stratigraphic vicinity. In contrast, the Archean and Proterozoic were first defined as, and subdivided into, geochronologic units defined by numerical ages chosen as large round numbers (3600 Ma, 2500 Ma, 1200 Ma) rather than to reflect accurately the Precambrian rock record and the global events it records. Now, though, the ICS Subcommittee on Precambrian Stratigraphy has

embarked on a program of defining new chronostratigraphic units and corresponding geochronologic units in the Precambrian stratigraphic record, to be defined by GSSPs for which numerical ages will then be calculated.

Accordingly, a *formal chronostratigraphic unit* is the *material stratal (time-rock) body* interpreted to have been deposited contemporaneously and with lower and upper boundaries defined by GSSPs that afford the most reliable stratigraphic signals for their temporal correlation. A *formal geochronologic unit* is the continuous time interval between the deposition of the lowest and highest strata within the unit. In the case of non-stratified rocks, the rock body is referenced in terms of the time it formed (e.g., Early Cretaceous El Capitan Granite). This does not mean that the rock is part of a time unit, for rock and time are separate and distinct phenomena: It simply conveys that a dominant event in the granite's formation (crystallization of the component minerals) took place during a particular time unit, as deduced, for instance, from radiometric ages. The boundaries of the time unit in this example, the Early Cretaceous Epoch (and simultaneously of the equivalent Lower Cretaceous Series), are established using chronostratigraphic methods at GSSP sections and numerically calibrated, for example, by radiometric dating of volcanic ash layers within fossiliferous, correlatable successions.

Thus, detailed analysis and correlation of the stratal record establishes both the chronostratigraphic framework and the equivalent and parallel geochronologic units, while, as noted earlier, for much of the Precambrian, geochronologic units are currently defined by GSSAs.

Chronostratigraphy (time-rock)	Geochronology (time)
Eonothem (e.g., Phanerozoic)	Eon (e.g., Phanerozoic)
Erathem (e.g., Mesozoic)	Era (e.g., Mesozoic)
System (e.g., Cretaceous)	Period (e.g., Cretaceous)
Series (e.g., Upper Cretaceous)	Epoch (e.g., Late Cretaceous)
Stage (e.g., Cenomanian)	Age (e.g., Cenomanian)

Series for several systems have been formally named with the adjectives Lower, Middle, and Upper added to the system name; the respective epochs have been formally named with the adjectives Early, Middle (Mid in the UK), and Late added to the period name. For some systems/periods (e.g., Cambrian, Silurian, Permian, Paleogene, Neogene, and Quaternary), the series/epochs are given formal names without adjectives added to the system/period name. If used informally for any chronostratigraphic or geochronologic unit, the adjectives (lower, middle, upper, early middle, late) are not capitalized. We omit, for the time being, formal subdivisions of stages/ages (i.e., chronozones/chrons). This is a complex question beyond the scope of this paper. Such small-scale units now dominate the chronostratigraphy of younger strata (e.g., the numbered oxygen isotope stages of the Quaternary calibrated by astrochronology—but see Cita and Pillans, 2010), but the necessity or means of formally defining them as higher-order chronostratigraphic units remains unresolved.

That aside, the schema outlined here reflects the current standard meaning and use in practice of these units, both chronostratigraphic and geochronological, although the emphasis has been modified to be more clearly expressed in terms of the fundamental stratified/non-stratified divide. Strata and the stratigraphic signals they contain can be assigned to chronostratigraphic units, which can be mapped, studied, and sampled. However, they (or more precisely the events that shaped them) can also be referred

to geochronologic units that identify them by the time during which they formed. Thus, the Ibex Group can form part of the Lower Ordovician Series and can also be referred to the Early Ordovician Epoch (the phrase “Early Ordovician Ibex Group” means that these strata were deposited during the Early Ordovician Epoch, and not, we emphasize, that they form *part* of that epoch). Then, the history of events interpreted from the study of all rocks, whether stratified or non-stratified, and the relationships between them, would be made in terms of the geochronologic hierarchy (e.g., trilobite species evolving or an orogeny occurring during the Early Ordovician Epoch).

THE DISTINCTION BETWEEN TIME AND TIME-ROCK UNITS

A distinction may be made between a geological time unit and the stratal successions assigned to it—most obviously between geochronologic (time) and chronostratigraphic (time-rock) units, say between the Cenomanian Age and the Cenomanian Stage of the Late/Upper Cretaceous (Fig. 1). Thus, the beginning and base, respectively, of these units are fixed by the GSSP at the type section, while the end/top are fixed by the GSSP of the overlying Turonian Age/Stage, which usually is at another location, far removed, often on a different continent than that of the base/beginning. At any one place, the sedimentary record of the Cenomanian Age is almost invariably incomplete because hiatuses at some level or scale will be present, and there may be more significant non-sequences or unconformities at the base or top or within the succession. Furthermore, many GSSPs are within short stratigraphic sections representing a very small part of the global stratigraphic succession of the unit. In addition, elsewhere in the world and far away from these typically geographically separated GSSPs, the recognition of the Cenomanian Stage depends on the uncertainty in correlation. In practice today, correlation is normally by paleontologic means, because fossil evolution essentially possesses a unidirectional trajectory, but it usually involves uncertainty of a substantial fraction of a million years. Thus, there is an incompleteness omnipresent in the recording of Cenomanian time by deposited

sediment at any place and an imprecision in identifying Cenomanian events in rock. However, the span of geological time encompassed by the Cenomanian Age remains identical everywhere on Earth, by definition. This distinction holds true whether one classifies the strata in chronostratigraphic terms (i.e., Cenomanian Stage, employing the dual hierarchy) or as a geochronologic unit (strata deposited during the Cenomanian, or simply Cenomanian strata). Regardless, recognition of temporal gaps in the Cenomanian stratigraphic record is generally only possible through chrono-correlation.

SUGGESTIONS FOR BEST USAGE

We offer the following suggestions for consistent and effective usage of chronostratigraphic and geochronologic units in geological writing. A simple method is to use a chronostratigraphic unit when referring to stratified rocks and a geochronologic unit when referring to time and to phenomena associated with non-stratified rocks. This presents no problem when most units are used as adjectives (e.g., Hirnantian glaciation, Hirnantian strata in the Vinini Creek section) or in a sentence in which the proper name but not its rank is used (e.g., occurred in the Hirnantian, ranges upward from the base of the Hirnantian). More troublesome units are those with superpositional or time modifiers as part of a formal name or when used informally. Lower and Upper (e.g., Lower Ordovician, Upper Cretaceous) and lower and upper (e.g., lower Paleozoic, lower Silurian) should be used when referring to rocks and positions within stratigraphic successions (e.g., the Lower Ordovician of North America primarily consists of carbonate strata; the isotope excursion is recorded in samples from the Lower Ordovician of Scandinavia; the magnetic-polarity reversal occurs in the lower part of the Upper Ordovician series or lower part of the Hirnantian Stage). Early and Late and early and late are used when referring to time of events and processes (e.g., “the Middle [or Mid in UK English] to Late Ordovician Taconic orogeny”; “this species evolved in the Early Cretaceous”; “the isotope excursions in the early

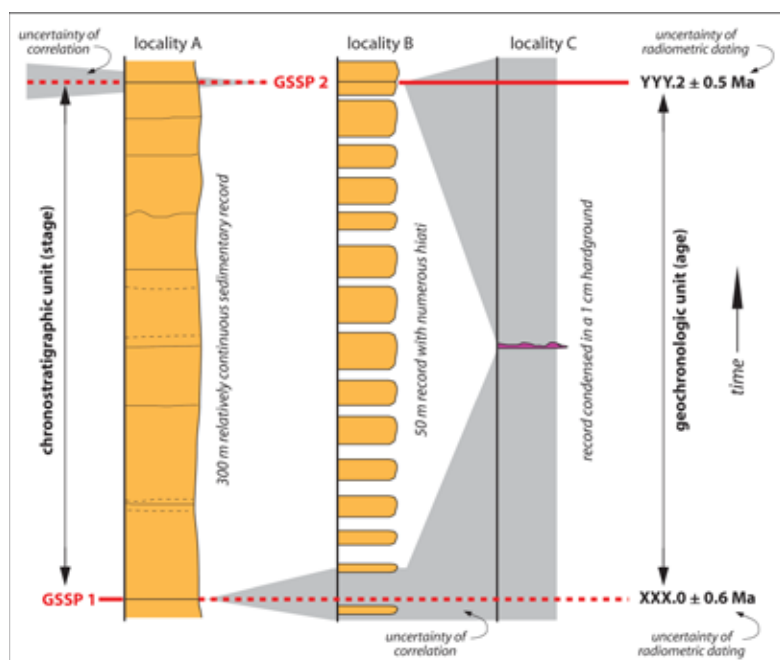


Figure 1. Diagram illustrating the relation of time and rock. Locality A shows a near-continuous succession that includes a GSSP near the base. Locality B shows a succession with sporadic gaps that includes the GSSP of the succeeding time unit near the top. Each of the GSSPs is precisely located at its type section, but there is uncertainty (shown as the gray shading) in locating each away from its respective type section. Locality C shows a highly condensed deposit that is poorly stratigraphically constrained, although best placed within the stage (and thus probably deposited within the age) defined by GSSPs 1 and 2. Radiometric dates provide numerical age estimates for the two GSSPs and hence of the time interval that they define. If taken from immediately adjacent to their respective GSSPs, then the uncertainty relates essentially to the levels of analytical precision obtained; if taken from elsewhere, then uncertainty in correlation/interpolation to the GSSPs is added to the analytical uncertainty.

Neogene”). However, rocks can also be referred to by the time at which they formed (e.g., the Early Ordovician Windfall Formation), but superposition and time terms should not be mixed in the same modifier group, sentence, or paragraph (thus “early Calabrian Stage,” “lower Eocene Epoch,” and “early Upper Ordovician strata” are incorrect). If one is concerned about the proper unit rank term to use or if one is not comfortable using age as the equivalent geochronologic unit for stage, then one can either not use the rank term or use “rock” or “time” instead (e.g., the species evolved in the Hirnantian or during Hirnantian time; the fossil occurrences in the Hirnantian or low in the Hirnantian succession). Although meaning is often clear from context, appropriate usage of chronostratigraphic and geochronologic units can help, for instance, express succinctly the distinction between data and observations and interpretations (e.g., “the successive, closely spaced lowest occurrences of species of *Normalograptus* in the lowest Hirnantian Stage worldwide succeeding the abundant and diverse assemblages of diplograptid-dicellograptid-orthograptid species in the upper Katian Stage reflects a major faunal turnover associated with the Hirnantian glaciation that began in the latest Katian”).

CONCLUSIONS

The scheme outlined in this paper seems a reasonable way to retain the two widely used terms chronostratigraphy and geochronology in both an informal and a formal (classificatory) sense, establishing a clear and practical difference between them more or less in line with current practice and also in line with their etymology. Both parallel sets of units are retained, though there remains the option to adopt either a single (i.e., geochronologic) or a dual hierarchy in particular studies, as considered appropriate. Within the framework proposed here, this question may be allowed to be effectively determined, ultimately, by future majority usage. Nevertheless, clarity and precision of stratigraphic expression seem currently achievable, within the guidelines we suggest.

ACKNOWLEDGMENTS

We thank Stan Finney for his thoughtful and constructive input toward the construction of this paper, although he does not necessarily agree with all of our proposals. We also thank two anonymous reviewers for their comments, which have helped improve this paper.

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2014–2015 COMMITTEE VACANCIES

Deadline to apply or submit nominations: 15 July

GSA invites you to volunteer or nominate one of your fellow GSA members to serve on a Society committee or as a GSA representative to another organization. Learn more about each committee and access the nomination form at www.geosociety.org/aboutus/committees/. You can also download the form and send a hardcopy nomination to Pamela Fistell, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA; fax: +1-303-357-1074; phone +1-303-357-1044 or +1-800-472-1988, ext. 1044; pfistell@geosociety.org. **Terms begin 1 July 2014** (unless otherwise indicated).

COMMITTEE, SECTION, AND DIVISION VOLUNTEERS:

Council Thanks You!

GSA Council acknowledges the many member-volunteers who, over the years, have contributed to the Society and to our science through involvement in the affairs of the GSA. Your time, talent, and expertise help build a solid and lasting Society.

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Academic and Applied Geoscience Relations (AM, T/E)	three	3 years
Annual Program (AM, B/E)	two	4 years
Arthur L. Day Medal Award (T/E)	two	3 years
Diversity in the Geosciences (AM, T/E)	four	3 years
Education (AM, B/E, T/E)	two	4 years
	one	2 years
eGSA (AM, T/E)	two	3 years
Geology and Public Policy (AM, B/E, T/E)	one	3 years
	one	2 years
Joint Technical Program (T/E)	two	2 years, starts 1 Dec. 2013
Membership (B/E)	three	3 years
Nominations (B/E, T/E)	one	3 years
Penrose Conferences and Field Forums (T/E)	one	3 years
Penrose Medal Award (T/E)	two	3 years
Professional Development (T/E)	two	3 years
Publications (AM, B/E, T/E)	three	4 years
Research Grants (B/E, C)	eleven	3 years
Young Scientist Award (Donath Medal) (T/E)	one	3 years
GSA REPRESENTATIVES TO OTHER ORGANIZATIONS		
GSA Representative to the AAAS Consortium of Affiliates for International Programs (CAIP) (B/E)	one	3 years, starts 1 Jan. 2014
GSA Conferee to the AAPG Publication Pipeline Committee (B/E)	one	3 years
GSA Representative to the AGI Environmental Geoscience Advisory Committee (EAGC) (AM, T/E)	one	3 years, starts 1 Jan. 2014
North American Commission on Stratigraphic Nomenclature (NACSN) (AM, possibly B/E)	one	3 years, starts 1 Nov. 2014

AM—Meets at the Annual Meeting • B/E—Meets in Boulder or elsewhere

C—Extensive time commitment required during application review period (15 Feb.–15 Apr. 2015) • T/E—Communicates by phone or electronically



Todd Anthony Bianco

A Perfect Placement

I am honored to serve as the 2012–2013 GSA-USGS Congressional Science Fellow. The fellowship program came to my attention at the first social gathering I attending during graduate school. It was at a celebration for a postdoctoral researcher who was leaving the University of Hawaii at Mānoa to serve as a Fellow. At the time I was very excited to begin as a graduate researcher but I also knew instantly that a fellowship in public policy was an opportunity that matched my wider interests.

Since that day, I would periodically research the different public policy fellowships available for scientists and read the fellow reports and biographies from different hosting groups, such as GSA-USGS, AGU, and AAAS. Learning more about the fellowship taught me that I had specific academic milestones that I wanted to reach before I applied for the Congressional Science Fellowship. A few years later, near the end of my NSF postdoctoral fellowship at Brown University, it was clear to me that it was the right year to apply for the GSA-USGS Fellowship. It was hard to stay calm when I received an invitation to interview for the fellowship. After more than a decade of research experience, I could finally see a viable and rewarding career in academia, so this first step toward at least a year of feeling a bit out of my element was exciting and intimidating. After a very enjoyable interview with the selection committee in March, I was lucky enough to be selected for 2012–2013.

Although my predecessors have already documented the two-week orientation in September that kicks off the fellowship year, my first report would be incomplete without giving my take on the program. This is truly an exceptional experience. The daily crash course in policy and politics is enough to excite anyone in attendance, but the many speakers deliver a sense of gravity and importance to the endeavor of bringing trained scientists to Capitol Hill that leaves all of the fellows more inspired with each passing day.

After orientation, I took full advantage of the open doors during the interview process, interviewing with a dozen offices in both the House and Senate and in both personal and committee offices. I also used the vast network of current and former fellows to help with my decision. After two weeks of running from appointment to appointment, I accepted an offer to serve in the personal office of Senator Sheldon Whitehouse of Rhode Island.

I was particularly interested in Senator Whitehouse's office, because he is a leader on environmental issues, serves on the Senate Committee on Environment and Public Works (EPW), and serves as the Chair of the Subcommittee on Oversight. Also, I am a native Rhode Islander, and it was important to me to be connected to the office I served. For some Congressional Science Fellows, this connection could be the focus the office has on an issue that would draw on their specific expertise, but I also wanted to know, on a personal level, the community I would be working for, the places they live, and the issues that they care about. Interest in serving in a home state office was actually a fairly common feeling among the other Congressional Fellows and many of the personal offices that were hoping to host a fellow.

On Senator Whitehouse's staff, I work mostly with the environment and energy legislative assistants, known affectionately as his Green Team. We work on a variety of issues that range from meeting with constituents to legislative planning. My colleagues also encourage me to attend the many interesting briefings on The Hill and include me in meetings with other congressional offices and government agencies.

The significance of having a home state connection came early in the fellowship. When Hurricane Sandy hit in late October 2012, it was motivating to know the places in Rhode Island that were affected by the storm and that were being discussed by Senator Whitehouse and office staff. I was also honored to serve as staff to the Senator for an EPW hearing that brought attention to the devastation the storm caused, and I was able to help identify what stories Rhode Islanders would want the nation to hear.

One of my main tasks has been drafting speeches. Senator Whitehouse delivers weekly remarks on the Senate floor about climate change, the environment, and related issues. I have had the opportunity to help draft these remarks and to staff the Senator when he delivers them on the floor. While climate science is not my area of expertise, it is rewarding to help raise awareness about climate change and to help the staff and Senator be very accurate in making the case for action.

I encourage any scientist, at any point in their career, to consider the Congressional Science Fellowship if they have an interest in public policy. I also hope that anyone who is interested will feel free to contact me if they have questions regarding the fellowship in general or my personal fellowship experience.

This manuscript is submitted for publication by Todd Anthony Bianco, 2012–2013 GSA-USGS Congressional Science Fellow, with the understanding that the U.S. government is authorized to reproduce and distribute reprints for governmental use. The one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. G12AP2 0120TDD. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government. Bianco is serving on staff for Senator Sheldon Whitehouse of Rhode Island and can be reached at Todd_Bianco@whitehouse.senate.gov.

GSA ELECTIONS

Elections begin 8 March 2013

GSA's success depends on you—its members—and the work of the officers serving on GSA's Executive Committee and Council.

In early March, you will receive a postcard with instructions for accessing your electronic ballot via our secure website, and

biographical information on the nominees will be online for you to review at that time. Paper versions of both the ballot and candidate information will also be available.

Please help continue to shape GSA's future by voting on the nominees listed here.

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Ballots must be submitted electronically or postmarked by 6 April 2013.

FUTURE GSA ANNUAL MEETINGS

Denver, Colorado, USA—125th Anniversary Event:
*Celebrating Advances in Geoscience—Our Science,
Societal Impact, and Unique Thought Processes:*
27–30 October 2013

Vancouver, British Columbia, Canada:
19–22 October 2014

Baltimore, Maryland, USA:
1–4 November 2015

Denver, Colorado, USA:
25–28 September 2016

Seattle, Washington, USA:
22–25 October 2017

Indianapolis, Indiana, USA:
4–7 November 2018

Denver, Colorado, USA:
October 2019 (dates TBD)

NOTICE of Spring 2013 GSA Council Meeting



Meetings of the GSA Council are open to Fellows, Members, and Associates of the Society, who may attend as observers, except during executive sessions. Only councilors and officers may speak to agenda items, except by invitation of the chair.

Council will meet next on Saturday, 27 April, 3–4:30 p.m.; and Sunday, 28 April, 8 a.m.–noon. The GSA corporate meeting will be Saturday, 27 April, 4:30–5 p.m. All meetings will be held in the Boulder, Colorado, USA, area with exact locations to be announced at a later date.



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Call for Nominations & Applications

GSA DIVISION AWARD

■ QUATERNARY GEOLOGY AND GEOMORPHOLOGY

Farouk El-Baz Award for Desert Research

Deadline: 2 April

Send your nominations, including (1) a statement of the significance of the nominee's research, (2) a curriculum vitae, (3) letters of support, and (4) copies of no more than five of the nominee's most significant publications related to desert research,

to Alan R. Nelson, anelson@usgs.gov. Please send electronically unless hardcopy previously approved. This award rewards excellence in desert geomorphology research worldwide, and any scientist from any country may be nominated. Monies for the award are derived from the annual interest income of the Farouk El-Baz Fund, administered by the GSA Foundation.

GSA STUDENT SCHOLARSHIPS AND AWARDS

■ ANTOINETTE LIERMAN MEDLIN SCHOLARSHIP IN COAL GEOLOGY

Deadline: 15 March

This GSA Coal Geology Division **scholarship** provides full-time students involved in coal geology research with financial support for their project for one year (~US\$2,000 for 2013–2014). In addition, the recipient may be provided with a stipend to present project results at the 2013 or 2014 GSA Annual Meeting.

For the academic year 2013–2014, the Coal Geology Division is also offering a **field study award** of ~US\$1,500. The recipient of this award will also be eligible to receive travel funds to present results at the 2013 or 2014 GSA Annual Meeting.

A panel of coal geoscientists will evaluate proposals for the scholarship and the field study award. Students may apply for both; however, only one award will be made to a successful applicant.

To apply, send five copies of the following to Mark Engle, Dept. of Geological Sciences, The University of Texas at El Paso, El Paso, TX 79968, USA, mercurous@gmail.com: (1) a cover letter indicating which award(s) is(are) sought; (2) a concise (no more than five double-spaced pages, including references) statement of objectives and methods and of how the scholarship funds will be used to enhance the project; and (3) a letter of recommendation from the student's immediate advisor that includes a statement of financial need and the amount and nature of other available funding for the research project.

■ HISTORY AND PHILOSOPHY OF GEOLOGY STUDENT AWARD

Deadline: 1 May

The History and Philosophy of Geology Division is offering a US\$1,000 award for proposals for a student paper to be presented at an upcoming GSA Annual Meeting. The topic of the proposed paper may be, but is not limited to, (1) the history of geology; (2) a literature review of ideas for a technical work or thesis/

dissertation; or (3) some imaginative aspect of the history of geology we have not thought of before. This award, established in 2004, is made possible by a bequest from the estate of Mary C. Rabbitt. Consideration will be given to both undergraduate and graduate students who are in good standing at the time of application, and the presentation at the GSA Annual Meeting may take place after graduation. Faculty advisor(s) may be listed as second author(s) but not as the lead author of the paper, and while both oral and poster presentations are acceptable, oral presentations are preferred.

Proposal guidelines and the application form are online at <http://gsahist.org/HoGaward/awards.htm>. If you have questions about the award, please contact the Division secretary-treasurer, Jane P. Davidson, jdhexen@unr.edu. Nominees need not be members of the History and Philosophy of Geology Division or of the Geological Society of America.

■ STEPHEN E. DWORNIK STUDENT PAPER AWARDS

GSA's Planetary Geology Division encourages applications for these awards, established in 1991 to provide encouragement, motivation, and recognition to outstanding future planetary scientists. Two awards are given each year—one for the best oral presentation, the other for the best poster presentation. Please go to www.lpi.usra.edu/meetings/lpsc2013/ for instructions, an application form, and further information. The 2013 award applies to papers presented at the 44th Lunar and Planetary Science Conference on **18–22 March 2013** in The Woodlands, Texas, USA. Student applicants must be (1) the senior author of the abstract; (2) a U.S. citizen; and (3) enrolled in a college or university, at any level of their education, in the field of planetary geoscience. This program is administered through GSA's Planetary Geology Division; the GSA Foundation manages the award funds.

Call for Nominations

John C. Frye Environmental Geology Award


Deadline: 31 March

GSA and the Association of American State Geologists (AASG) seek your nominations for **the best paper on environmental geology** published either by GSA or by a state geological survey during the last three full calendar years. Nominated papers must (1) establish an environmental problem or need; (2) provide substantive information on the basic geology or geologic process pertinent to the problem; (3) relate the geology to the problem or need; (4) suggest solutions or provide appropriate land-use recommendations based on the geology; (5) present the information in a manner that is understandable and directly usable by geologists; and (6) address the environmental need or resolve the problem. It is preferred that the paper be directly applicable to informed laypersons (e.g., planners, engineers).

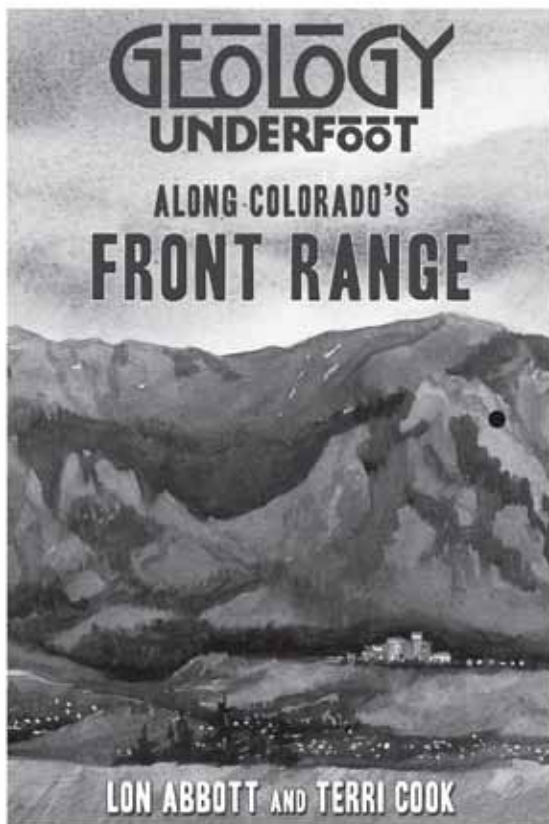
Please send your nominations (including a paragraph stating the pertinence of the paper) to GSA Grants, Awards & Recognition, P.O. Box 9140, Boulder, CO 80301-9140, USA.

2012 AWARD RECIPIENTS

John T. Neubert, Jeffrey P. Kurtz, Dana J. Bove, and Matthew A. Sares for their paper "Natural Acid Rock Drainage Associated with Hydrothermally Altered Terrane in Colorado," published in 2011 in *Bulletin 54* of the Colorado Geological Survey.



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Final Announcement

ROCKY MOUNTAIN

65th Annual Meeting of the Rocky Mountain
Section, GSA

Gunnison, Colorado, USA

15–17 May 2013

www.geosociety.org/sections/rm/2013mtg/



The Laramide Elk Range thrust north of Crested Butte. The thrust (to right) places Pennsylvanian and Permian strata on an overturned syncline (to left) of Permian and Mesozoic strata. Rocks of the Capital-Snowmass stock in background. Photo courtesy Robert Fillmore.

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LOCATION

The Geology Program at Western State Colorado University (WSCU) is pleased to host the 65th Annual Meeting of GSA's Rocky Mountain Section in Gunnison, Colorado, USA. The Gunnison Valley is positioned in a rich geologic environment featuring a broad age of geologic materials, structures, and surface and geologic processes. Features that dominate the upper valley include structures and stratigraphy of the high Colorado Rockies that are exposed by fluvial and glacial processes, which have created a complex and spectacular landscape. The upper valley is

also a key boundary between the stratigraphy and structures of the Colorado Plateau and West Elk Mountains to the west and the much more deformed rocks of Elk Range to the east.

REGISTRATION

Early registration deadline: 15 April

Cancellation deadline: 22 April

REGISTRATION FEES (all fees are in U.S. dollars)

	EARLY		STANDARD	
	Full Mtg.	One Day	Full Mtg.	One Day
Professional Member	\$180	\$85	\$210	\$95
Professional Nonmember	\$210	\$160	\$240	\$200
Professional 70+	\$70	\$50	\$70	\$60
Student Member	\$40	\$30	\$50	\$40
Student Nonmember	\$60	\$45	\$80	\$65
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Guest/Spouse	\$45	n/a	\$55	n/a
Field Trip/Short Course Only	\$35	n/a	\$35	n/a

ACCOMMODATIONS

Blocks of rooms have been reserved for meeting attendees at hotels in the area. The primary hotel is the Holiday Inn Express, located near campus at 910 E. Tomichi Ave., Gunnison, CO 81230, USA, +1-970-641-1288. Room rate: US\$89/night + tax; book online by 1 April at www.hiexpress.com/hotels/us/en/gunnison/gucad/hoteldetail?groupCode=RMG. Lodging is also available at the Quality Inn, 400 E. Tomichi St. Gunnison, CO 81230, USA, 1-970-641-1237, for \$65/night + tax, and at the Water Wheel Inn (~3 miles east of Gunnison), 37478 U.S. 50 Gunnison, CO 81230, USA, +1-970-641-1650, for \$70/night + tax.

THEME SESSIONS

- T1. 21st Century Geoscience Education for K–16 Students: Novel Approaches and Current Research.** Amy Ellwein, Western State Colorado Univ., aellwein@western.edu; Matt Nyman, Oregon State Univ., matt.nyman@oregonstate.edu.
- T2. Advances in Chronology, Correlation, and Stratigraphy of the San Luis Valley and the Rio Grande Rift Zone.** Andrew Valdez, Great Sand Dunes National Park, andrew_valdez@nps.gov; Cal Ruleman, USGS, cruleman@usgs.gov; Shannon Mahan, USGS, smahan@usgs.gov.
- T3. Quaternary Glaciations, Paleoclimates and Landscape Evolution of the Greater Rocky Mountains.** Keith Brugger, Univ. of Minnesota–Morris, bruggeka@morris.umn.edu; Dave Marchetti, Western State Colorado Univ., dmarchetti@western.edu.
- T4. Basement Structure in the Colorado Rockies: Assembly and Reactivation.** Colin Shaw, Montana State Univ., cashaw@montana.edu; Joseph Allen, Concord Univ., allenj@concord.edu.
- T5. Ancestral Rockies to the Laramide: Developing Structural Styles of the Southern Rockies.** Dave Lageson, Montana State Univ., lageson@montana.edu; Tim Wawrzyniec, Western State Colorado Univ., twawrzyniec@western.edu.

- T6. **The Late Paleozoic Structural, Stratigraphic, and Climatic Evolution of Ancestral Rocky Mountain Basins.** Gary Gianinny, Fort Lewis College, gianniny_g@fortlewis.edu; Tim Lawton, New Mexico State Univ., tlawton@nmsu.edu.
- T7. **Tectonic Evolution of the Rio Grande Rift, Southern Rocky Mountains.** Rachel Landman, Univ. of Colorado Boulder, rachel.landman@colorado.edu; Daniel Feucht, Univ. of Colorado Boulder, dwfeucht@gmail.com.
- T8. **Cenozoic Evolution of the Rocky Mountains: Toward an Improved Understanding of Mantle-Surface Processes Interactions.** Andres Aslan, Colorado Mesa Univ., aaslan@coloradomesa.edu; Magdalena Sandoval-Donahue, Univ. of New Mexico, magdalena.donahue@gmail.com.
- T9. **Reconstructing the Paleogene Topography of the Rocky Mountains.** Emmett Evanoff, Univ. of Northern Colorado, emmett.evanoff@unco.edu.
- T10. **Cenozoic Magmatism of the San Juan Mountains: Plutons to Volcanoes.** Dave Gonzales, Fort Lewis College, gonzales_d@fortlewis.edu; Allen Stork, Western State Colorado Univ., astork@western.edu.
- T11. **REEs and Related Deposits in the Rocky Mountain–High Plains Region and Beyond.** Kevin Mahan, Univ. of Colorado Boulder, mahank@colorado.edu; Julien Allaz, Univ. of Colorado Boulder, julien.allaz@colorado.edu; Chuck Stern, Univ. of Colorado Boulder, charles.stern@colorado.edu; Lang Farmer, Univ. of Colorado Boulder, lang.farmer@colorado.edu; Rebecca Flowers, Univ. of Colorado Boulder, rebecca.flower@colorado.edu.
- T13. **Dust and Soil Geomorphological Research of the Intermountain West and Colorado Plateau: Applications and Approaches.** Les McFadden, Univ. of New Mexico, lmcfadnm@unm.edu; Amy Ellwein, Western State Colorado Univ., aellwein@western.edu.
- T14. **Climate Change, Water Resources, and Hydrologic Partitioning throughout the Upper Colorado River Basin.** Chris Shope, USGS, Shope@usgs.gov.
- T15. **Mapping in the Rocky Mountains: Results from STATEMAP and EDMAP Project (Posters).** Dave Noe, Colorado Geological Survey, dave.noe@state.co.us; Michael Timmons, New Mexico Bureau of Geology and Mineral

Resources, mtimmons@nmbg.nmt.edu; Grant Willis, Utah Geological Survey, grantwillis@utah.gov.

- T16. **Undergraduate Research in the Rocky Mountains (Posters).** Kim Hannula, Fort Lewis College, hannula_k@fortlewis.edu; Steve Semkin, Arizona State Univ., semken@asu.edu.

FIELD TRIPS

1. **The Geology and WPX Energy's Development of the Mesaverde Tight-Gas Petroleum System, Piceance Basin, Colorado, USA.** Mon.–Tues., 13–14 May. US\$195. Todd Dallegge, WPX Energy, todd.dallegge@wpxenergy.com.
2. **From Ignimbrite to Batholith, NE San Juan Mountains.** Tues., 14 May. US\$90. Peter Lipman, USGS, plipman@usgs.gov.
3. **Quaternary Glacial and Climate History of the Taylor River Basin, Gunnison County, Colorado.** Sat., 18 May. US\$75. Keith Brugger, Univ. of Minnesota Morris, bruggeka@morris.umn.edu.
4. **Geology and Mineral Deposits of the Iron Hill (Powderhorn) Carbonatite-Alkaline Complex, Gunnison County, Colorado.** Sat., 18 May. US\$45. Brad Van Gosen, USGS, bvangose@usgs.gov; Kevin H. Mahan, Univ. of Colorado Boulder, Kevin.Mahan@colorado.edu.

OPPORTUNITIES FOR STUDENTS

Mentor Programs

Cosponsored by GSA Foundation. Learn more at www.geosociety.org/mentors/, or contact Jennifer Nocerino, jnocerino@geosociety.org. These programs are so popular that they fill up quickly; come early to ensure your spot.

Roy J. Shlemon Mentor Program in Applied Geoscience Luncheon, Wednesday, 15 May. Students will have opportunities to discuss career goals, prospects, and challenges with professional geoscientists from multiple disciplines over a FREE lunch.

John Mann Mentors in Applied Hydrogeology Program Luncheon, Thursday, 16 May. Thinking about applied hydrology career? Network and discuss career prospects with hydrogeology professionals over a FREE lunch.



Curecanti National Recreation Area west of Gunnison, which includes Blue Mesa Reservoir, Colorado's largest body of water. Photo courtesy U.S. National Park Service.

Get into the Field with GSA & ExxonMobil

supported by



2012 Bighorn Basin Field Camp Awardees.

FIELD CAMP SCHOLAR AWARD

Seventeen students will be awarded US\$2,000 each to attend the field camp of their choice based on diversity, economic/financial need, and merit.

Who should apply?

Undergraduate students

Deadline to apply? 8 April

BIGHORN BASIN FIELD AWARD

A one-week, all-expenses-paid field seminar in the Bighorn Basin of north-central Wyoming emphasizing multidisciplinary, integrated basin analysis.

Who should apply? Undergraduate and graduate students, and faculty

Deadline to apply? 8 April

Camp dates? 3–9 August

FIELD CAMP EXCELLENCE AWARD

Field award for geology field camps—one field camp instructor/director will receive US\$10,000 to assist with his or her summer field season. This award is based on safety awareness, diversity, and technical excellence.

Who should apply? Anyone, but the award must be used toward field camp operations

Deadline to apply? 8 April

<https://rock.geosociety.org/ExxonMobilAward/index.asp>

Questions? Contact Jennifer Nocerino, jnocerino@geosociety.org, +1-303-357-1036.



Teacher Advocate Program (TAP)

"I walked away with knowing the relevance to implementing it into my curriculum."

"Great hands-on activities!"

The goal of GSA's Education & Outreach Teacher Advocate Program (TAP) is to promote geoscience to K–12 school students through active and enthusiastic teacher advocates. TAP accomplishes this goal by providing exciting, up-to-date, and curriculum-linked geoscience teaching resources to school teachers across the United States. These resources are developed by teachers with recent classroom teaching experience. TAP also provides opportunities for teachers to experience first-hand the importance, relevance, and wonder of geoscience through field and laboratory activities.

2012 was a very successful year for TAP. TAP was able to provide workshops at two regional conferences for the National Science Teachers Association and short courses at GeoTech, the Texas Science Teachers Conference (CAST), and GSA's Annual Meeting. These TAP courses provided teachers with engaging classroom materials that are easy to incorporate into their lessons. More than 2,000 teachers and 230,000 students benefited from the program.

TAP is also pleased to announce two "Explore! Earth Science Academies" for northern Texas teachers for 2013. Thanks to a grant from The Miles Foundation, TAP will be able to provide academies on fossils and energy. Academies will include workshops and field trips for teachers to gain a deeper understanding of the topics. Additional funds were made available to provide rural teachers with travel assistance.

Two teacher GeoVentures ran last year. The GeoVenture to Hawaii was completely booked. A wait-list was created to accommodate the number of teachers who wanted to attend, and now the 2013 trip to Hawaii is already full. The GeoVenture trip to Iceland that also ran last summer was completely booked as well. Learn more about GeoVentures at www.geoventures.org.

The best way to learn geology is to study it in the field. This year, GSA designed a field camp program to give teachers the chance to use scientific skills in the field. The first field camp will take place in June 2013 in central Colorado, USA. TAP is looking forward to expanding the field camps so each of GSA's regional Sections will be able to offer them to K–12 teachers.

The "Explore! Geoscience" CD-ROMs are in the process of being revised to include up-to-date science information and classroom activities that engage students while they explore different topics in the geosciences. Due to popular demand from teachers, TAP will introduce new topics for the "Explore! Geoscience" series. In addition to new and updated resources, the series will have a new look. As CD-ROMs are updated and developed, they will switch to an online format. This will allow teachers to have instant access to the materials and it will allow TAP to revise materials as new geoscience findings are made.



For more information about TAP, please e-mail Davida Buehler at dbuehler@geosociety.org, go to the Teacher Advocate Program website at www.geosociety.org/educate/tap.htm, or like TAP on Facebook at [facebook.com/GSAK12Education](https://www.facebook.com/GSAK12Education).

GSA's Teacher Advocate Program is supported by the GSA Foundation; to contribute to TAP, please contact Chris Tallackson at ctallackson@geosociety.org or +1-303-357-1007.



 Like us on Facebook!

www.facebook.com/GSAK12Education

Classified Rates—2013

Ads (or cancellations) must reach the GSA advertising office no later than the first of the month, one month prior to the issue in which they are to be published. Contact advertising@geosociety.org, +1.800.472.1988 ext. 1053, or +1.303.357.1053. All correspondence must include complete contact information, including e-mail and mailing addresses. To estimate cost, count 54 characters per line, including punctuation and spaces. Actual cost may differ if you use capitals, boldface type, or special characters. Rates are in U.S. dollars.

Classification	Per Line for 1st month	Per line each add'l month (same ad)
Positions Open	\$9.00	\$8.75
Fellowship Opportunities	\$9.00	\$8.75
Opportunities for Students		
First 25 lines	\$0.00	\$4.75
Additional lines	\$4.75	\$4.75

Positions Open

MULTIPLE POSITIONS DEPARTMENT OF GEOSCIENCES UNIVERSITY OF AKRON

The University of Akron is expanding its research and teaching strengths in the Dept. of Geosciences by opening multiple tenure-track and non-tenure track positions to complement the department's strengths in geography, GIS, and geology. These positions, combined with a search for a new Chair of the Dept. of Geosciences, will position this department for future growth. Candidates for this position will be expected to develop an externally funded research program in one or more of the following areas: structural geology, surface processes and/or tectonics. Responsibilities include a commitment to research and teaching. Teaching duties will include graduate courses in candidate's specialty, structural geology, introductory courses and summer field camp. Preferred qualifications include post-doctoral experience, a clear vision of future research endeavors and a plan for obtaining external funding. Candidate's specialty should enhance existing departmental core courses in geology. Additional information and the on-line application for job ID # 7749 are found here: <https://www.uakron.edu/hr/job-openings/openings.dot>. **Review of applications will begin 15 March 2013.** Competitive candidates will demonstrate the potential to augment existing expertise within the department as described below.

1. Assistant Professor—Geology (tenure track; Job # 7749): This candidate will be expected to develop an externally funded research program in one or more of the following areas: structural geology, surface processes, and/or tectonics. Responsibilities include a commitment to research and teaching. Teaching duties will include graduate courses in candidate's specialty, structural geology, introductory courses and summer field camp. Preferred qualifications include post-doctoral experience, a clear vision of future research endeavors and a plan for obtaining external funding. Candidate's specialty should enhance existing departmental core courses in geology.

2. Assistant Professor—Geography/Geographic Information Systems (tenure-track; Job # 7744): This candidate will be expected to develop an externally funded research program in geography-related geosciences and teach GIS and related geography

courses at the undergraduate and master's levels. The candidate must demonstrate the ability to teach three or more of the following upper-level and/or graduate courses: GIS, GIS database design, GIS programming and customization, and/or spatial analysis. Preferred qualifications include a research specialization in applications of GIS in the geosciences, strong potential to develop interdisciplinary collaborations, prior teaching experience, and the ability to teach cartography. Candidate's specialty should enhance existing departmental core courses in geography.

3. College Lecturer—Physical Geography (non-tenure track; Job # 7751): In addition to the criteria specified above, the candidate will be able to teach physical geography and/or maps and map reading and have an interest and aptitude for developing and teaching online courses. Preferred qualifications include a demonstrated record of teaching excellence and the ability to teach cartography and/or geomorphology.

4. College Lecturer—Geography (non-tenure track; Job # 7747): In addition to the criteria specified above, the candidate will be able to teach cultural diversity, introduction to geography and economic and world geography, and have an interest and aptitude for developing and teaching online courses. Preferred qualifications include a demonstrated record of teaching excellence and the ability to teach field research methods and a regional geography course.

Questions about job numbers 7749 and 7751 should be directed to Dr. LaVerne Friberg at lfribe1@uakron.edu. Questions about job numbers 7744 and 7747 should be directed to Dr. David Steer at steer@uakron.edu. Candidates must complete the online application and attach the following items: A curriculum vitae; a written statement describing your research, teaching experiences, and goals and how they will contribute to the growth and success of the department; and contact information for at least four references. The preferred start date is August 2013. Review of applications will begin on 15 March 2013. For complete details and to apply for this position, visit www.uakron.edu/jobs/.

RESEARCH GLACIAL GEOLOGIST INDIANA GEOLOGICAL SURVEY

The Indiana Geological Survey (IGS), a research institute of Indiana University, seeks applications for a glacial geologist to perform geologic mapping and basic and applied research related to the glacial stratigraphy and geomorphology of the state of Indiana. Significant duties include participation in the USGS-sponsored STATEMAP and Great Lakes Geologic Mapping Coalition projects. A master's degree, publications record, and 3 years' experience required. Complete job posting is on the IGS website: igs.indiana.edu. Application deadline: 15 April 2013. Anticipated starting date: 1 July 2013.

ONE-YEAR TEACHING POSITION CENTRAL MICHIGAN UNIVERSITY

The Dept. of Earth & Atmospheric Sciences at Central Michigan University invites applicants for a one-year teaching position beginning 15 August 2013.

Candidates must be able to teach Structural Geology and introductory geology classes. ABD Ph.D. candidates are encouraged to apply. Interested persons must submit their applications to www.jobs.cmich.edu. Position open until filled. CMU, an AA/EEO institution, strongly and actively strives to increase diversity within its community (see www.cmich.edu/aaeo/).

GEOHYDROLOGY/APPLIED GROUNDWATER RESOURCE ASSESSMENT, ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

The Alaska Division of Geological & Geophysical Surveys (DGGS) is seeking a senior-level geohydrologist to implement a new groundwater research program for important aquifers in the state of Alaska. The successful applicant will use advanced principals of geohydrology to provide professional scientific and operational leadership in conceiving, planning, and implementing applied projects relating to ground water resource assessment in high priority areas around the state, with a primary emphasis on ground water analysis and aquifer modeling and mapping in areas of high potential development and population growth. The successful applicant will work independently and collaboratively in all aspects of this work, from writing proposals and compiling published data to collecting new field data and preparing maps and reports for publication. Position will be located in either Fairbanks or Anchorage, Alaska, USA. For a detailed job description and to apply, please go to the Job Posting Board on Workplace Alaska at <http://notes3.state.ak.us/wa/main-entry.nsf/WebData/HTMLJob+Posting+Board/?open> and click on the Geohydrologist postings under the "Title" category. Application deadline is 15 March 2013. Inquiries regarding the position may be e-mailed to De Anne Stevens at deanne.stevens@alaska.gov. Additional information about DGGS may be found at www.dggs.alaska.gov.

TENURE TRACK POSITION GEOLOGICAL SCIENCES UNIVERSITY OF SASKATCHEWAN

The Dept. of Geological Sciences at the University of Saskatchewan is accepting applications for a tenure-track position as the Murray W. Pyke Chair, which is a new named Chair in Geological Sciences. The appointment will be at the Assistant or Associate Professor level (depending on experience) in the broad area of hard-rock geology, with recognized expertise in one or more of the following areas: mineral deposit systems, petrology, mineralogy, geochemistry, and tectonics. The successful candidate will be expected to develop a vigorous, externally funded research program with a strong emphasis on field work, and to participate broadly in undergraduate and graduate student teaching and research, including introductory courses, field schools, core geology, and specialist courses in their area of expertise. The successful candidate must hold a Ph.D. when appointed, which is expected to be 1 July 2013.

Murray Pyke was a distinguished graduate of the department and a founder, executive, and director of Complex Resources and Bonterra Energy, both of Calgary. A prominent figure in minerals and

petroleum exploration in Canada, Murray spent many summers mapping the Precambrian Shield in northern Saskatchewan, the Northwest Territories, and Nunavut. This work reflected his love of the outdoors, satisfied his scientific curiosity, and nurtured a deep respect for the indigenous peoples of Canada with whom he worked and lived during those years.

The College of Arts & Science offers a dynamic combination of programs in the humanities and fine arts, the social sciences, and the sciences. There are over 8,000 undergraduate and graduate students in the College and 325 faculty, including 12 Canada Research Chairs. The College emphasizes student and faculty research, interdisciplinary programs, community outreach, and international opportunities.

The University of Saskatchewan is located in Saskatoon, Saskatchewan, a city with a diverse and thriving economic base, a vibrant arts community, and a full range of leisure opportunities. The University has a reputation for excellence in teaching, research, and scholarly activities. It offers a full range of undergraduate, graduate, and professional programs to a student population of about 20,000 and is one of Canada's leading research-intensive universities.

Applications, including a full curriculum vitae and statement of research interests and teaching philosophy, should be sent to Murray W. Pyke Chair Search Committee, Dept. of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, SK S7N 5E2, Canada; e-mail: jim.merriam@usask.ca.; fax: +1-306-966-8593.

Please arrange to have three letters of reference sent to the above address.

We will begin reviewing applications after 31 March 2013.

The University of Saskatchewan is strongly committed to a diverse and inclusive workplace that empowers all employees to reach their full potential. All members of the university community share a responsibility for developing and maintaining an environment in which differences are valued and inclusiveness is practiced. The university welcomes applications from those who will contribute to the diversity of our community. All qualified candidates are encouraged to apply; however, Canadian citizens and permanent residents will be given priority.

POSTDOCTORAL RESEARCH ASSOCIATE GEOCHEMISTRY, PRINCETON UNIVERSITY

We are accepting applications for a post-doctoral or more senior researcher in low-temperature geochemistry in the Dept. of Geosciences at Princeton University. Qualifications include a Ph.D. in geoscience or a related field. Areas of research include non-traditional stable isotope geochemistry, carbonate sedimentology, and numerical models of sediment diagenesis. The appointment is for one year with the possibility of renewal contingent upon satisfactory performance and funding. Applicants should include a cover letter, curriculum vitae, brief statement of research goals, list of publications, and contact information for three references by applying on the Princeton University jobsite at <https://jobs.princeton.edu/>, Requisition #1300012.

Princeton University is an equal opportunity employer and complies with applicable EEO and affirmative action regulations.

PETROGRAPHER/CONSULTANT SIMPSON GUMPERTZ & HEGER (SGH) WALTHAM, MASS.

Simpson Gumpertz & Heger (SGH) is actively recruiting an experienced candidate for a position as Petrographer/Consultant in our Waltham, Mass., USA, office. SGH is a nationally known civil and structural engineering firm that works in all aspects of design, investigation, and rehabilitation of structures. At SGH, petrographers provide front-line collaborative support to our investigative teams as well as for external clients, including other engineering firms. The successful candidate will work on investigations of concrete, masonry, stone, and related construction materials.

Applicants should have at least 10 years of experience with stone and concrete petrography; meet the requirements of ASTM C856 and C295; and understand the use of supplemental testing and analytical techniques such as XRD, IR, SEM/EDS, and chemical testing. Exceptional communication skills, experience in research and investigations, and a demonstrated ability for managing and developing staff are also required skills.

To learn more about SGH and to apply for this position, please visit our website at www.sgh.com or e-mail your resume to Stella Mereves-Carolan, Corporate Recruiter, at smereves-carolan@sgh.com, or apply online at www.sgh.com. Equal Employment Opportunities Employer.

Opportunities for Students

Doctoral Assistantships, Montclair State University. The Ph.D. program in Environmental Management at Montclair State University is seeking highly motivated individuals for doctoral assistantships starting Fall 2013. The Environmental Management program is a multidisciplinary platform that seeks to prepare environmental scholars who will recognize and analyze relationships among scientific, technological, societal and economic issues, and has multiple areas of specialization available, including but not limited to: environmental quality and remediation, environmental geochemistry, hydrology, environmental economics, environmental engineering, ecology, environmental policy, environmental conservation, environmental spatial analysis, environmental toxicology, global change, etc. The program currently has 40 doctoral students and 16 core doctoral faculty members. Details on the program and the application process can be obtained from the program's website at <http://csam.montclair.edu/enviro>. Deadline for Fall application is 15 March. For more information, please contact the program director, Dr. Dibs Sarkar (sarkard@mail.montclair.edu) or the program assistant, Jasey Araque (araquej@mail.montclair.edu). Montclair State University is the second largest university in New Jersey, which was named the Top Public University in New Jersey in 2009 by Forbes.

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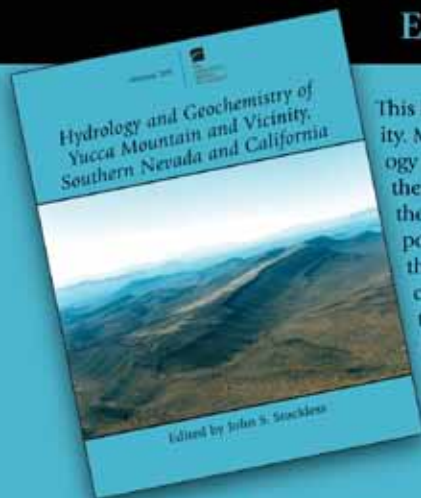
Be a part of GSA's
125th Anniversary!

www.geosociety.org/125/

Echo Lake with Mount Evans in the background, photo by Richard Grant. Used with permission from Denver Metro Convention & Visitors Bureau.

Hydrology and Geochemistry of Yucca Mountain and Vicinity, Southern Nevada and California

Edited by John S. Stuckless



This book summarizes nearly 30 years of intense research at Yucca Mountain, Nevada, and vicinity. Much of this work represents innovative approaches addressing the geochemistry and hydrology of the site, as well as the paleohydrology and transport of radionuclides under ambient and thermally altered conditions. This book is a companion to GSA Memoir 199, and together, the volumes present a comprehensive approach to characterizing a potential site for the disposal of radioactive waste. Memoir 209 includes state-of-the-art modeling of water flow in both the saturated and unsaturated zones, and through detailed isotope, geochemical, and paleoclimate studies, projects water flow back tens of thousands of years. These data, together with the previously reported climate models, make it possible to provide predictions of future performance of a repository for nuclear waste. Although the studies focused on Yucca Mountain, the methods and interpretations should be useful to any similar effort.

MWR209, 393 p., ISBN 9780813712093, \$60.00, member price \$45.00

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Memoir 209

Buy online at www.geosociety.org/bookstore

Explore the British Isles with GSA & GSL

The Geological Society (GSL) is pleased to present two field trips to the North West Highlands of Scotland, to be held in May and June 2013, as a contribution to the celebration of the 125th Anniversary of the Geological Society of America.

The Great British Tertiary Volcanoes: Exploring the Palaeogene Centres of Skye and Rum 27 May–1 June

This trip, based on the Isle of Skye, will visit two igneous centres which have provided the starting point for much of our understanding of petrology. It will look at layered igneous rocks, sills/dykes, lava flows, explosive volcanism, flood basalts, and beyond.

Structure and tectonics of the NW Highlands of Scotland: From Deep Crust to Hydrocarbon Reservoirs 2–8 June

This five-day trip will provide an overview of the geology and tectonics of NW Scotland, which is classic ground for structural geology, with a broad range of faults and shear zones, combining landscape views and hands-on outcrops.

Learn more at www.geosociety.org/125/events.htm#GSL
Deadlines are approaching soon.



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Check out GSA's 2013 GeoVentures!



Trips for K–12 Educators

- Iceland—Land of Fire and Ice: Reykjavik, Iceland, 30 July–5 August
- Ecuador and the Galápagos Islands: Quito, Ecuador, 13–23 August

Trips for Students

- Geology of Dinosaur National Monument—Yampa River Trip: Vernal, Utah, USA, 6–12 June

These 2013 GeoVentures are beginning to fill up! Register now to secure your spot on one of these amazing trips. For more information, visit www.geoventures.org or e-mail Gary Lewis at glewis@geosociety.org.

**Join GSA on amazing field experiences
to some of the world's greatest geologic sites.**

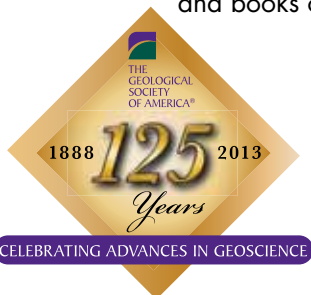
www.geoventures.org

publications highlights

Expanded E-book Archives at www.gsapubs.org

GSA is completing its e-book archive of **Special Papers, Memoirs, and Reviews in Engineering Geology** back to volume 1 for each series. You can now access all of our Special Papers, from volume 1 to present, at www.gsapubs.org. Memoirs and Reviews in Engineering Geology titles back to 1995 are available now, and the remaining volumes will be posted soon. The complete collection of **GSA Field Guides** also is available now.

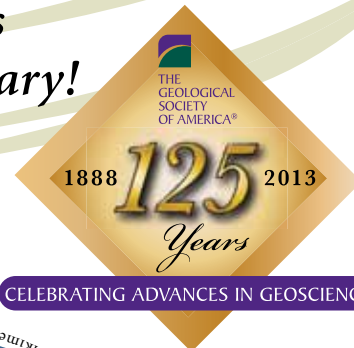
Institutional libraries can purchase subscriptions that provide full access to the archive. Individuals can use **Bloc of Docs** to access and download the chapters and books of their choice.



Start reading at www.gsapubs.org, or contact us at editing@geosociety.org for more information.

2013 GSA Section Meetings & Mentor Programs

Be a part of GSA's
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1



2

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7



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3

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4

Image Credit: Jeff Schmalz; courtesy NASA.



5

Photo courtesy Robert Fillmore.

U.S. Section Meetings

- | | | |
|--|--|---|
| <p>1. Northeastern • 18–20 March
Bretton Woods, New Hampshire, USA
Shlemon Mentors Luncheon*:
Monday, 18 March
Mann Mentors Luncheon**:
Tuesday, 19 March</p> | <p>3. South-Central • 4–5 April
Austin, Texas, USA
Shlemon Mentors Luncheon:
Thursday, 4 April
Mann Mentors Luncheon:
Friday, 5 April</p> | <p>5. Rocky Mountain • 15–17 May
Gunnison, Colorado, USA
Shlemon Mentors Luncheon:
Wednesday, 15 May
Mann Mentors Luncheon:
Thursday, 16 May</p> |
| <p>2. Southeastern • 20–21 March
San Juan, Puerto Rico
Shlemon Mentors Luncheon:
Wednesday, 20 March
Mann Mentors Luncheon:
Thursday, 21 March</p> | <p>4. North-Central • 2–3 May
Kalamazoo, Michigan, USA
Shlemon Mentors Luncheon:
Thursday, 2 May
Mann Mentors Luncheon:
Friday, 3 May</p> | <p>6. Cordilleran • 20–22 May
Fresno, California, USA
Shlemon Mentors Luncheon:
Monday, 20 May
Mann Mentors Luncheon:
Tuesday, 21 May</p> |

International Section Meeting

- 7. International
Roof of the World
17–19 June**
Chengdu, Sichuan Province, China

www.geosociety.org/Sections/meetings.htm

*Roy J. Shlemon Mentor Program in Applied Geology—FREE lunch for undergraduate and graduate students interested in a career in applied geology

**John Mann Mentors in Applied Hydrogeology Program—FREE lunch for undergraduate and graduate students interested in a career in hydrogeology

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Na	Mg	Al	Si	P	S	Cl	Ar										
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Uuq	Uup	Uuh	Uus	Uuo

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

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