What's Your Delta? EarthRates--A New NSF Funded Research Coordination Network for Linking Scales Across the Sedimentary Crust

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WHAT IS EARTHRATES?

In the Anthropocene, which is characterized by rapidly accelerating rates of change and multiple interacting physical-social-biological feedback loops, understanding Earth as a system has never been more critical. Broad-based interdisciplinary research focusing on geological records of earth system dynamics is foundational to understanding Earth processes, governing feedback loops, location of tipping points and tipping elements, sensitivities of critical Earth system components, and the behavior of the earth system under forcings analogous to those expected in the near future (NRC, 2011). The need for multidisciplinary approaches to determine Earth boundary conditions and past and present states lies at the forefront of the major grand challenges outlined in numerous National Academy and community-driven reports (NSF 2009, NRC, 2011, NRC, 2012; Parrish et al., 2012). Building the capacity within the scientific community to address these challenges requires coordination and efforts to integrate a disparate community of researchers. The sedimentary crust community is large and diverse and includes sedimentologists, stratigraphers, geochemists, geochronologists, paleontologists, paleoecologists, modelers, and many others. Nearly one-third of Earth science faculty employed at U.S. universities work within one of these discipline areas (Wilson, 2013). National Academy and community-based reports have called for increased coordination and collaboration across these disciplines (Badgley et al., 2011; NRC, 2012; Parrish et al., 2012).

To address these needs and aims, we have established a National Science Foundation (NSF) funded Research Coordination Network (RCN) called **"EarthRates: Linking Scales Across the Sedimentary Crust."** This RCN will provide the framework and opportunity to engage critical communities and forge synergistic collaborations in order to foster transdisciplinary research in the sedimentary crust. EarthRates brings together community-led research science and outreach resources such as the Paleobiology Database, Neotoma, Macrostrat, EarthTime, EarthChem, IEDA, Earth-Life Transitions, Flyover Country, and the Continental Scientific Drilling Coordination Office to strategize, leverage and build partnerships, all to enable the community to address major grand challenges in Earth system science (Figure 1). These would include: 1) how have climate, the oceans, the Earth's sedimentary crust, carbon sinks and soils, and life itself evolved together, and what does this tell us about the future trajectory of the integrated Earth-life system? 2) what are the ranges of ecosystem response, modes of vulnerability, and resilience to rapid changes between Earth-system states? 3) how can we link together all geological observations into a common spatiotemporal framework, dynamically updated by the best available geochronologies? By bringing these groups together and building stronger partnerships and alliances, we will move towards the goal of **developing a fully integrated four-dimensional digital Earth to fully understand dynamic Earth system evolution**.

The EarthRates RCN builds on the recent activities of the former STEPPE Office (Smith and Iler, 2012) and facilitates efforts to grow and interlink the sedimentary crust community to 1) hold workshops, 2) develop working groups, 3) provide training opportunities, 4) launch data mobilization campaigns, 5) strengthen community ties, 6) discover new partners and opportunities and 7) promote with social media and strong web presence, with the ultimate aim to **build the capacity of the sedimentary crust community to further contribute to earth system science research**.

WHO IS EARTHRATES?

EarthRates was initiated and organized by the lead

PI, Lisa Park Boush (University of Connecticut) and the EarthRates Steering Committee, which currently is comprised of Kerstin Lehnert (Lamont-Doherty/Columbia University), Amy Myrbo (University of Minnesota), Anders Noren (University of Minnesota), Shanan Peters (University of Wisconsin), Bradley Singer (University of Wisconsin) and Jack Williams (University of Wisconsin). The Steering Committee will be expanded in the coming year to include additional members from across the community. With all of the workshop participants, working group members and others engaged with EarthRates, we consider everyone who studies the sedimentary crust to be a part of EarthRates!

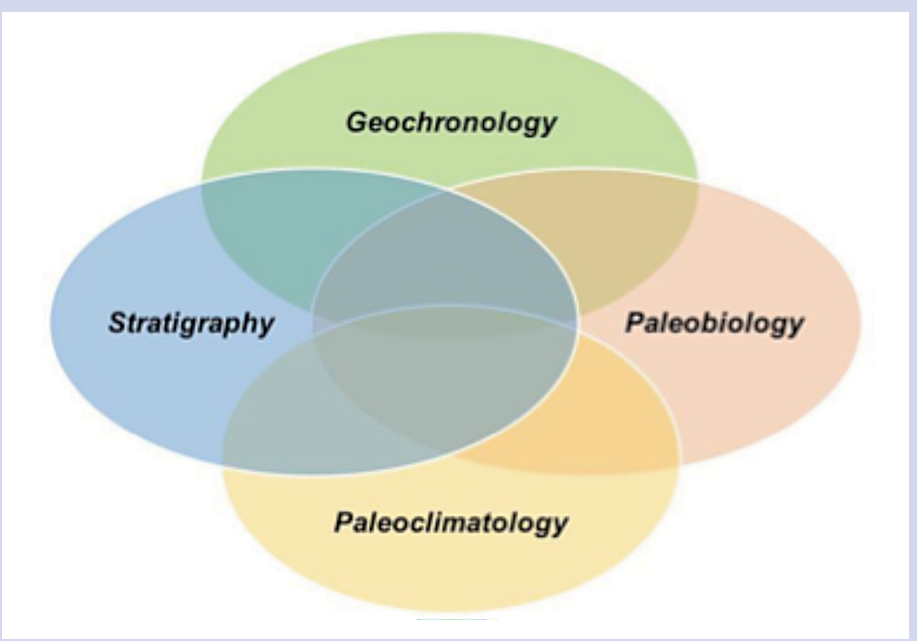

Figure 1: The EarthRates community

WHAT IS EARTHRATES GOAL AND MISSION?

EarthRates addresses the critical need to increase our understanding of surface Earth processes and rates of environmental change (NRC, 2011) by leveraging, coordinating and stimulating our diverse community of deep-time sedimentary crust researchers and informatics. We are building capacity by facilitating greater interaction between sedimentary crust scientists and creating new partnerships with other Earth and biological scientists to generate new tools and a community that are able to respond to the pressing research challenges of today and into the future, serving as a link among the many different ongoing activities.

EarthRates' vision is consistent with the vision of **EarthTime-EarthChem**, the **Paleobiology Database, Neotoma, Macrostrat, Flyover Country** and the **Continental Scientific Drilling Coordination Office** as well as the **Earth Life Transitions** PI community. Through EarthRates, these groups are being brought together to focus on the goal of building the framework for **a fully integrated four-dimensional Digital Earth to fully understand dynamic Earth system evolution as well as the research capacity to utilize a 4D Earth systems model and thus utilize this framework to understand rates of change in the geologic record (Figure 2).**

ON-GOING AND FUTURE ACTIVITIES

The focus of this RCN is to:

1. **Connect** established and emerging research communities
2. **Leverage** existing efforts in cyberinfrastructure to develop new capabilities
3. **Engage** new community members in collaboration and participation
4. **Build** overall capacity in sedimentary crust research
5. **Train** community members in using existing databases, their associated tools and services, and conduct data mobilization campaigns
6. **Create** a roadmap towards building a 4D Digital Earth

WORKSHOPS

One of the important functions of EarthRates is to bring scientists together. Thus far, we have supported two focused workshops—one for paleolimnologists interested in engaging with NEOTOMA, one on Conservation Paleobiology-- as well as one large, all hands workshop: **Setting Scientific Priorities for the Sedimentary Crust** (Figure 3). Based on proposals from an open call in September, 2017, we will sponsor 4 more small workshops in 2018 (Table 1). Our next call for small workshop proposals will be March 1, 2018. We anticipate the focus of these workshops to be on deep time.

For the **Setting Scientific Priorities** workshop, held November 9-11, 2017, EarthRates convened a large, all-hands meeting that included approximately 60 participants. This workshop brought together members of the EarthRates network to discuss updates to the major grand challenges (NRC, 2011) regarding **rates of change in the geological record** with respect to paleoclimate (e.g., tipping points and ecosystem thresholds), paleobiology (e.g., critical transitions of the past, extinction and evolution), crustal evolution and dynamics (e.g., modeling basin evolution, crustal tectonics and variability in sedimentary fill and paleoclimate indicators), and resources for humanity (e.g., the

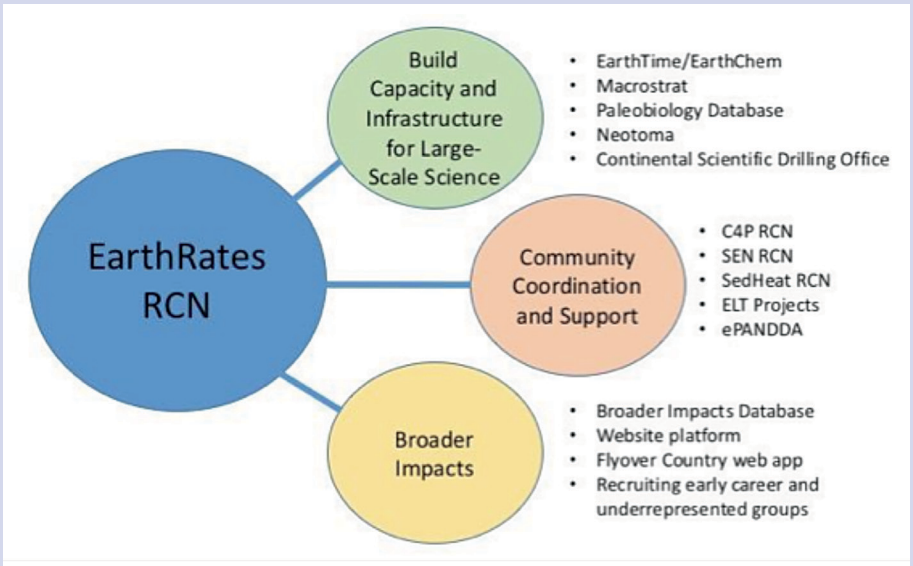

Figure 2: EarthRates-building a stronger community for the sedimentary crust.

coupling of key evolutionary events and environmental shifts, quantifying and managing energy stores for the future). During this workshop, participants began outlining a roadmap for broad-scale approaches to addressing these rates-based problems through vehicles--such as the 4D Digital Earth--as well as other transdisciplinary efforts. The outcomes of this workshop include 1) a series of 11 two-page documents that identify **key questions related to various topics and sub-disciplines and the major opportunities and approaches to addressing those questions**, 2) four responses to the NSF call for Mid Scale Infrastructure, and 3) the starting point for a community white paper that will focus on the **major science questions** of the sedimentary crust and develop a **strategic and action plan** for future activities to enable big-scale science. We anticipate the white paper will be available for community comment by late spring and presented to NSF in early Fall, 2018.

A **second large workshop** will be convened in 2019, which will include representatives of the working groups as well as community members identified in the EarthRates activities (e.g. webinars, demo camps, town halls, topical sessions, etc.). This workshop will be focused on dissemination of working group activities as well as further development of the strategic plan for building the 4D Digital Crust infrastructure. The outcomes of this workshop will rely heavily on those areas identified in the first workshop as priorities.

SMALL WORKSHOPS

Small, targeted workshops of ~10-20 people will be supported in the EarthRates RCN for the purpose of supporting RCN activities as well as the sedimentary crust community at large. Stand alone workshops will be supported at approximately $15,000 per workshop. In addition, we will explore the possibility of having multiple funding models, including the current levels of workshop support for stand-alone meetings and funding to support meetings that would occur in conjunction with larger professional society meetings or events. Calls for proposals will be approximately every 6 months (September, 2017; March, 2018; September 2018; March, 2019) and will be focused on various synergistic areas.

WORKING GROUPS

Working groups established through the large workshops or by other means will be supported by the EarthRates RCN via 1) hosting **virtual meetings**, 2) providing

Title	Location and Date
NEOTOMA/DIVA-GIS Database and Software Workshop	Santa Barbara, August, 2017
Conservation Paleobiology Workshop	Seattle, October, 2017
Speed Dating Pardee Session, Geological Society of America Annual Meeting	Seattle, October, 2017
All Hands Meeting-Setting Scientific Priorities for the Sedimentary Crust	Minneapolis, November, 2017
Developing a multi-proxy approach to reconstructing the climatic and environmental history of lakes in semi-arid India over the Common era	TBA
What forcing mechanisms sustained the large perennial North American Pliocene West	Minneapolis, January, 2018
Open and interoperable data standards in the paleogeosciences	TBA
Drilling Deeper for Connections Between Environmental Change and Evolution	TBA

Table 1: Workshops and Activities supported by EarthRates, Year 1.

Figure 3: EarthRates All Hands Meeting, November, 2017

online workspace and 3) **archiving of materials** generated by the groups. In addition, the RCN will help working groups apply for activities such as Goldschmidt and Penrose Conferences support and assist in convening topical or theme sessions at GSA or AGU meetings and will utilize GSA Divisions **(Sedimentary Geology, Limnogeology), as well as Society for Sedimentary Geology (SEPM), Paleontological Society, Society for Vertebrate Paleontology, the American Indian Science and Engineering Society (AISES), and Society for Advancing Hispanics/ Chicanos and Native Americans in Science (SACNAS)** to contact and target members of the community to participate in these workshops and working groups. An example of this type of support was the Geological Society of America Annual Meeting Pardee session called **Speed Dating!** which was partially supported by EarthRates. This highly successful and innovative method to convene a Pardee session—posters with flash talks and 2 page take-aways on almost every major geochronometer—is the type of activity that EarthRates envisions supporting in the future.

TRAINING OPPORTUNITIES

DEEP-TIME DEMO CAMPS

Building on the successful models of iDigBio demo camps, the Community Surface Dynamics Modeling System (CSDMS) annual clinics, and the LacCore/CSDCO Drilling and Coring Summer Institute, the EarthRates RCN plans to provide targeted demo camps to help the community gain research and quantitative skills for using new tools and technology as well as big data to answer science questions. Deep-Time Demo Camps might include topics like: Applying ecological niche modeling to deep-time datasets; using geochronological and stratigraphic data to create basin sedimentation models; or generating models that incorporate disparate datatypes from both the geosciences and biosciences, learning analytical skills for collecting and analyzing geochronologic data. Demo camps will provide an opportunity for the community to learn new skills and will help identify needs for new tools development that can be the focus of future work (held in collaboration with ePANDDA, NEOTOMA, PBDB, etc.) and collaborative grants with partners to build new integration points with other large initiatives (e.g., Open Core Data, Flyover Country geoscience mobile app). All demo camps will have a webinar series, with speakers who are leaders in the field, followed by the Demo Camp. Webinars will be archived and available for later viewing/reviewing on the EarthRates website. Toolkits with software, code, etc. will be made easily accessible through this platform.

Figure 4: EarthRates affiliated organizations

DATA MOBILIZATION CAMPAIGNS

A number of data mobilization campaigns are planned for EarthRates. These would be in conjunction with the major databases and data platforms involved in the project: Paleobiology Database, Neotoma, Macrostrat, EarthChem, and IEDA. A particular focus will be on ways to expose radioisotopic age determinations and improve temporal resolution of earth history. These will be combined and coordinated with other efforts such as Deep-Time Demo Camps and workshops. The individual databases will be responsible for these efforts but the RCN will coordinate and support them.

DISCOVERING NEW PARTNERS AND INCREASING DIVERSITY

One of the major purposes of EarthRates is to develop the community and to recruit new partners and create new opportunities for collaborations. We will do this by targeting new PIs as well as underrepresented groups to invite to workshops, demo camps and other activities and ensure that we continue to strive to increase diversity in the geosciences.

EarthRates will also support projects such as ePANDDA, as well as the C4P, SedHeat, and SEN RCNs, and will work with these groups to build in a sustainable mechanism for the longer-term life of these projects that will allow them to continue even after NSF funding has ended. EarthRates will serve as the online repository of all associated documents (white papers/reports, papers, etc.) and provide continuing online virtual collaboration space for these groups when their project funding ends. EarthRates will act as an advocate for integrating and including these groups into ongoing activities and proactively provide support for their respective communities' development.

CONNECTING WITH EARTHRATES

EarthRates has an active website www.earthrates.org and Twitter feed @earthrates as well as a Facebook page. We also post information of interest on community listservs and in newsletters. You can contact EarthRates directly via email at earthrates@gmail.com (Figure 4).

SUMMARY

Never before has such a diverse community been poised to come together to begin building the capacity to do transdisciplinary research to address major science challenges. Because of individual efforts in databases like Neotoma, Paleobiology Database, Macrostrat, Flyover Country, IEDA and EarthChem and combined community building efforts like EarthTime, C4P, ePANDDA, SedHeat, the Continental Scientific Drilling Coordination Office (CSDCO) and the STEPPE Office, researchers interested in the grand challenges of understanding rates of processes within Earth's sedimentary crust will be able to come together in a series of workshops, working groups, and training opportunities to link and leverage their activities in order to build a 4D digital Earth. EarthRates will provide the means by which effective coordination and collaboration can take place to achieve that goal. We hope you join us in this effort!

REFERENCES

BADGLEY, C., BOTTJER, D., DOUGLAS, E., GINGERICH, P., JAHREN, H., KOCH, P., NORRIS, R., OLSZEWSKI, T., RAYMOND, A., SOREGHAN, G., 2011. DETELON Science Plan. National Science Foundation sponsored workshop, 32p.

NATIONAL RESEARCH COUNCIL, 2011. Understanding Earth's Deep Past: Lessons for our Climate Future. Committee on the Importance of Deep-Time Geologic Records for Understanding Climate Change Impacts, National Academies Press, Washington, D.C., 152p.

NATIONAL RESEARCH COUNCIL, 2012. New Research Opportunities in the Earth Sciences. National Academies Press, Washington, D.C., 117p.

NATIONAL SCIENCE FOUNDATION, 2009. GeoVision Report: Unraveling Earth's Complexities Through the Geosciences: NSF Advisory Committee for Geosciences, Arlington, VA., 44p.

PARRISH, J., 2012. Transitions: The Changing Earth-Life System – Critical Information for Society From the Deep Past. Final Workshop Report. 62p. www.uidaho.edu/sci/geology/sgpworkshop.

SMITH, D. M. AND D. ILER, 2015. STEPPE: Earth's Past, Our Future. The Sedimentary Record, 13(1): 4–9.

WILSON, C. (EDITOR), 2013. Directory of Geoscience Departments 2013, 48th Edition. American Geosciences Institute, Alexandria, VA., 460p

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