

EVOLUTION OF THE LITHOSPHERE:

From the Early Earth to Modern Processes

Organized by the State Key Laboratory for Mineral Deposits Research, Institute of Energy Sciences, Institute of Geophysics and Geodynamics

Coordinator: Prof. Dong JIA, Institute of Energy Sciences

Prof. Xiaodong SONG, Institute of Geophysics and Geodynamics

Time: May 16-18, 2013

Lectures presented by Profs. Alfred Kröner, An Yin and Walter D. Mooney

This course will present a comprehensive overview of lithospheric evolution through time, integrating data from geology, geophysics, geochemistry, geochronology, petrology, and paleomagnetism. Students will be introduced to the basic concepts and methods used by scientists in these disciplines to study the lithospheric structure and evolution, including how we can use present day lithospheric structure as determined through geophysics and geology to interpret the past history of different parts of the Earth. This will be followed by examples using the results of high-level research in lithospheric structure and evolution from around the world, including the Himalaya-Tibetan Plateau.

The course will cover aspects of the early formation of the Earth, such as the question of when the modern style plate tectonics began, and when did the first large continents form. Different models for the thermal history of planet Earth will be presented, with active discussion about the constraints and implications of the different models.

This will be followed by discussion on geophysical and geological characteristics of the Earth's cratons, mountain belts and continental margins. The significance of cover sequences that lie over the older crust will be discussed.

The role of supercontinents in the evolution of continental lithosphere will be covered, as well as the formation and matching of passive margin sequences from different continents, that aids supercontinent reconstruction.

The short course will end with a panel discussion of hot and controversial topics in lithospheric evolution. Participants are encouraged to be actively engaged with questions during the course, and there will be many opportunities for extended discussion following each session.

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Day 1

08.30 - 08.50 Welcome by Prof. Dong JIA;

Kröner, Yin & Mooney: Introduction: Purpose, scope and structure of course

08.50 - 9.00: Questions and discussion

09.00 - 09.45 Kröner: Some definitions and methods used in understanding crustal evolution
(Components of the lithosphere; geology; paleomagnetism, isotope geochemistry, petrology)

09.45 - 10.45 Yin: Modes of continental deformation: distributed deformation versus discrete microplate tectonics

10.45 – 11:00 Questions and discussion

11:15 - 11.30 Tea/coffee break

11.30 - 12.00 Mooney: Geophysical definitions and components of the lithosphere: seismic, magnetic, electrical, elastic, and thermal properties.

112:00 - 12.15: Questions and discussion. Video: The Early Earth

12.00 - 13.30: Lunch

13.30 - 14.15 Kröner: Early Earth formation (Hadean): Magma ocean, hot or cold beginning? The first crust, the oldest rocks, crust formation: juvenile vs. reworking, the first continents.

14.15 - 14.30: Questions and discussion

14.30 - 15.30 Yin: Vertically coupled and decoupled continental lithosphere: constraints from field, petrogenic and seismic observations.

15.30 - 15.45: Questions and discussion

15.45 – 16:00: Tea/coffee break

16:00 - 16.45 Mooney: Thermal history of the Earth; plate motion; mantle convection, plume tectonics in the early Earth?

16.45 - 17.00: Question time and general discussion on the day's topics and important literature: Where are the major disagreements and the best approaches for future studies?

Day 2

08.30 - 09.15 Kröner: Archean gneiss-granite greenstone terranes in southern Africa and western Australia. Early plate tectonics and/or plume tectonics? Formation and deformation of TTGs, Archean subduction and accretion, stabilization of Archean cratons.

09.15 - 09.30 Questions and discussion

09.30 - 10.15 Yin: Key differences between continental and oceanic lithospheric deformation.

10.15 - 10.30 Questions and discussion

10.30 - 10.45 Tea/coffee break

10.45 - 11.30 Mooney: Geophysical and modeling constraints on lithospheric structure and composition, geophysical images of the oldest crust.

11.30 - 12.00 Questions and discussion

12.00 - 13.30: Lunch

13.30 - 14.15 Kröner: Cratonic cover rocks: Witwatersrand, Pongola, Fortescue, the Palaeoproterozoic and speculations on the supercontinent Nuna or Columbia, palaeomagnetic evidence.

14.15 - 14.30 Questions and discussion

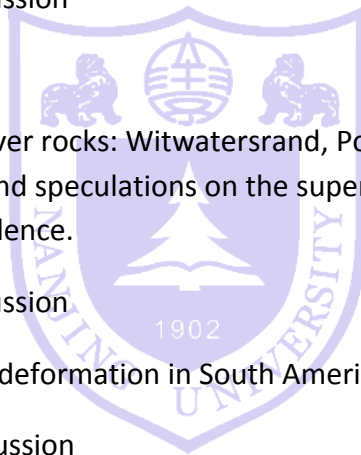
14.30 - 15.30 Yin: Active tectonic deformation in South America and the western USA.

15.30 - 15.45 Questions and discussion

15.45 - 16:00 Tea/coffee break

16:00 - 16.30 Mooney: Structure and evolution of the western USA (30 min. talk)

16.30 - 17.00 Question time and general discussion on the day's topics and important literature: major disagreements and what are the best approaches for future studies?



Day 3

08.30 - 09.15 Kröner: Geological evidence for the beginning of plate tectonics.

09.15 – 09.30: Questions and discussion

09.30 – 10.15 Mooney: Geophysical evidence for the beginning of plate tectonics

10.15 - 10.30 Questions and Discussion

10.30 – 10.45 Tea/coffee break

10.45 - 11.45 Yin: Amalgamation and dispersal of continents since the Neo-Proterozoic: assumptions, competing reconstructions and implications.

11.45 - 12.00: Questions and discussion

12.00 – 13.30 Lunch

13.30 - 14.15 Kröner: Crustal growth and tectonics of Central Asia.

14.15 - 14.30: Questions and discussion

14.30 - 15.30 Yin: Active tectonic deformation in Asia

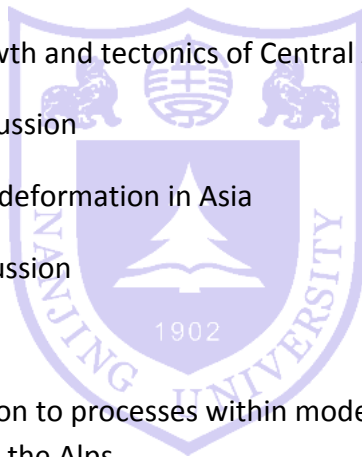
15.30 - 15.45 Questions and Discussion

15.45 – 16:00 Tea/coffee break

16:15 - 16.45 Mooney: Introduction to processes within modern orogens: Contrasting the South American Andes and the Alps

16.45 - 17.00 Panel discussion: Outstanding questions and debates in Earth evolution: Cratonization and decratonization, supercontinents, when did plate tectonics begin, rates of crustal growth through time, vertical growth via underplating, comparison of modern orogens with ancient orogens.

End of course.



About the presenters:

Alfred Kröner, Ph.D.



Professor Alfred Kröner was appointed full Professor of Geology in 1977 at the Johannes Gutenberg-University, and after retiring has continued to conduct his activities over several continents as a truly cosmopolitan geoscientist of overwhelming efficiency, recognized and appreciated worldwide in the Geoscience community. He now spends much of his time working out of the Beijing SHRIMP Center, Institute of Geology, CAGS.

Alfred has produced a continuously increasing flow of publications ranging from 2 to 7 per year at the beginning and rising to sometimes more than 10 annually. Most of his early papers dealt with the Precambrian of Southern Africa and consequences for general problems of the Earth's early evolution. Thus Alfred rapidly gained a reputation as an expert on the Precambrian in general.

Alfred is author and co-author of more than 230 research papers as well as a textbook on high-grade gneiss terrains. He is editor of *Precambrian Plate Tectonics*, *Precambrian Tectonics Illustrated*, and *Archaean Geochemistry*, editor of ten special journal volumes, co-editor of *Precambrian Research* and *Terra Nova*, associate editor of *Tectonics*, member of the editorial boards of *Geology*, *Geologische Rundschau*, and *Journal of Geodynamics*, Secretary of the IUGS Commission on Tectonics (1978-1989), Chairman of Working Group 3 of the International Lithosphere Program (1983-86), Leader of IGCP Projekt 280 "The oldest rocks on Earth" (1988-1993), President of the Geologische Vereinigung (1986-91), Vice-President of the European Union of Geosciences (1996-1999), and Program Director of EUG 9. Alfred's scientific achievements won him the Jubilee Medal of the Geological Society of South Africa in 1969. The Geological Society of America elected him a Fellow in 1981. In 1982 he was invited by the French Academy of Sciences to give a "Distinguished Lecture". In 1986, the Northwest University, Xian, China, awarded him the title "Honorary Professor", and in 1999, the Geological Society of South Africa invited him to deliver the renowned Du Toit Memorial Lecture. The Geological Society of Sri Lanka presented him with the Ananda-Coomaraswamy-Medal in January 2000. In the same year, he received the Emanuel-Boricky-Medal from one of the oldest universities, the Charles-University in Prague.

An Yin, Ph.D.



An Yin is Professor of at the University of California, Los Angeles, and at the China University of Geosciences (Beijing). He is a world-leading structural geologist and the author of more than 100 scientific papers, many of which as classics in their field.

For the past three decades he has focused his research on the Cenozoic tectonics of Asia. In the broadest sense, he has been trying to determine the role of two Cenozoic indentation events induced by the Arabia-Asia and India-China collision. These collisions have been accompanied by diffuse deformation and related igneous processes across Asia. An important research topic has been the determination of the timing and magnitude of motion on major Cenozoic faults (e.g., the Altyn Tagh Fault, Kunlun fault and Karakorum fault).

Current research on the Cenozoic tectonics of Asia includes: (1) investigations of the eastern Himalayan orogen and the northern Indo-Burma Range, (2) tectonic development of the Cenozoic Qilan Shan-Nan Shan thrust belt in northern Tibet, and (3) temporal and spatial development of Cenozoic fault systems and igneous activities in central Asia and their relationships to plate-boundary and deep-mantle processes.

Other research interests include : (1) the evolution and mechanics of low-angle normal faults, thrust systems, rift spacing and detachment faulting. (2) The tectonic evolution of the North American Cordillera; (3) contrasting styles of lithospheric structures and temporal development of Tibetan Plateau margins and implications for the formation mechanisms of continental plateaus; (4) dynamics of continental-lithospheric deformation using analogue experiments and quantitative numerical modeling; (5) surface processes and tectonic development of terrestrial planets and icy satellites; (6) interpretation of lithospheric scale deep-seismic reflection profiles and implications for basin evolution and development.

Walter D. Mooney, Ph.D.



Walter D. Mooney is a research seismologist and geophysicist at the U.S. Geological Survey, Menlo Park, California. He has been a member of the AGU member since 1974 (and Fellow since 1996). His major interest is global Earth crustal structure and tectonics, particularly of the continental lithosphere. Mooney was the Chief of Seismology at the USGS from 1994 to 1997. He has led field work throughout North and South America and participated in extensive research affiliations with colleagues worldwide.

Mooney has been a consulting Professor of Geophysics, Stanford University (1984-2008), and a visiting faculty at the following institutions: University of Karlsruhe and Kiel University, Germany; University of Paris and University of Strasbourg, France; Rice University, and the California Institute of Technology. He is the Program Leader for the USGS contribution to the Indian Ocean Tsunami Warning System and has extensive experience at leading training. He is a Fellow of the Royal Astronomical Society of London (U.K.), the Geological Society of America and the Indian Geophysical Union.

Mooney is the author or co-author of more than 150 research papers dealing with the deep structure, composition and evolution of the continental crust and sub-crustal lithosphere. He has also investigated the origins of intraplate seismicity, the thermal regime of the lithosphere, and the occurrence of great earthquakes and tsunamis. He has produced more than 20 scientific videos on a variety of Earth Science topics, as well as his personal field observations of earthquake effects in the USA, Chile, China, Italy, Haiti and elsewhere.

He is the author of the book “The Earth’s Crust” published in 2012 by the Geological Society of America, and in his lectures he will discuss the evolution of the crustal, from the Precambrian to the present. Young orogens will also be discussed, including the Central Asian Orogenic Belt, the Andes, Alpine system, and western North American Cordillera. A comparison of young orogens with ancient mountain belts and cratonic crust will provide a comprehensive view of lithospheric evolution through time.