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The analysis of magnetization curves with model functions is a valuable tool for identifying magnetic mineral sources in sediments and sedimentary rocks. The method is limited by two main factors: the ability of the model function in reproducing appropriately the magnetic properties of an individual component, and its extreme sensitivity to measurement errors. Both factors influence the number of components, which are needed to fit a magnetization curve within the measurement error. Recent investigations on the shape of coercivity distributions (Heslop, 2003; Egli 2003) support the use of model functions introduced by Egli (2003). Extremely detailed measurements of alternating field (AF) demagnetisation curves of isothermal (IRM) and anhysteretic (ARM) remanent magnetizations have been performed on a wide variety of sediments and sedimentary rocks including sediments from rivers, lakes and oceans, recent soils, paleosols, loesses, red clays, limestones and also on atmospheric dusts, urban pollution and magnetotactic bacteria. The component analysis allowed the identification of several magnetic components with specific properties, which reflect different magnetic mineral sources: extracellular, bacterial and pedogenic magnetite, lithogenic minerals transported by water or in air, and magnetic minerals associated to anthropogenic pollution sources. Each magnetic component is described by nine parameters: four for the shape of the IRM, four for the shape of the ARM coercivity distribution, and one for the ratio of the ARM to the IRM. By comparing similar components occurring in different samples, empirical relations can be established between different parameters, which reflect fundamental physical processes that control the shape of coercivity distributions. As a consequence, only four parameters, so-called magnetic fingerprints, are necessary to characterise a magnetic component. The effect of environmental changes on the magnetic properties of specific magnetic components has been investigated in detail for sediments from lakes and oceans, highlighting the complex and non-linear behaviour of such natural systems. Heslop, D. and G. McIntosh, The influence of initial state, interaction and thermal relaxation on the isothermal remanent magnetisation curves, IUGG 2003 (GAI.03/03A/A14-007). Egli, R., The analysis of demagnetisation curves with skewed generalized functions (SGG): a novel method for the identification of magnetic sources in sediments, IUGG 2003 (GAI.03/03A/A14-008).

GP41B-0050 0830h POSTER

Environmental magnetic records of core sediments for the past 100 ka from Erhai Lake in China and Sogwipo Maar in Korea

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In order to detect high-resolution records of environmental changes in East Asia, we made environmental magnetic study of core sediments from Sogwipo Maar in Cheju Island, Korea (9.4 m long), and Erhai Lake in Yunnan Province, China (10.0 m and 42.6 m). Measurements of initial susceptibility (k), natural remanent magnetization (NRM), anhysteretic remanent magnetization (ARM) and isothermal remanent magnetization (IRM) were made by pass-through method using u-channel samples from both cores. Results of AMS radiocarbon dating suggest that the Sogwipo core is dated from 5 ka to 30 ka, and that the upper 16 m of the Erhai core is dated from 2 ka to 30 ka. Variation of NRM intensity of both cores, when normalized by ARM and IRM, showed similarity with paleointensity stack Sint-800 between 15 ka and 100 ka. Variation of magnetic concentration parameters of the Sogwipo core was consistent with lithological changes. In particular, magnetic minerals in the upper part seem to be diluted by increased biogenic productivity after 15 ka. The topmost part of the Erhai core showed rapid downcore decrease of magnetic concentration associated with increase of magnetic grain size, suggesting reductive environment before 3 ka. Negative correlation between magnetic concentration and magnetic grain size may indicate a gradual change in degree of the reductive diagenesis. In both cores, significant increases of ARM susceptibility were observed at several horizons, which can be correlated to interstadial periods of the Dansgarrd-Oeschger cycles. The increase of ARM susceptibility suggests that input of fine magnetic minerals were enhanced under increased precipitation due to activity of the Monsoon activity during the warm periods.

GP41C MCC: Level 1 Thursday 0830h

Tectonic and Geochronologic Applications of Sedimentary Paleomagnetism I Posters *(joint with T)*

Presiding: **K P Kodama,** Lehigh University**; B M Clement,** Florida International University

GP41C-0051 0830h POSTER

A Synthesis of Cretaceous Paleomagnetic Data From South Korea and its Tectonic Significance in East Asia

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South Korea is tectonically divided into the Gyeonggi massif, Ogcheon belt, Ryeongnam massif and Gyeongsang basin from northwest to southeast. The Cretaceous strata are mainly exposed in the Gyeongsang basin, a southeastern part of Korea, and in several small basins along the boundaries of the Ogcheon belt and on the Gyeonggi massif. A total of 43 Cretaceous paleomagnetic poles from 33 published studies in South Korea were collected and reviewed to elucidate the geodynamic evolutions of the Korean Peninsula in the tectonic framework of East Asia during Cretaceous. As a result, 24 paleopoles from 17 studies have satisfied more than four reliability criteria of Van der Voo (1990). Paleomagnetic pole positions from the Gyeongsang basin and from small basins in the Gyeonggi massif and the Ogcheon belt show a good agreement, indicating that the Korean Peninsula was a single terrane since Cretaceous. Within the Gyeongsang basin, the paleomagnetic pole of the geographically northern area (Yeongyang block) is displaced westward from those of southern area (Milyang and Uiseong blocks). Also, the late Early Cretaceous paleolatitude of the Yeongyang block is similar to or slightly lower than those of the Milyang and Uiseong blocks. These paleomagnetic results and some geological features in the Gyeongsang basin suggest that the Yeongyang block underwent counter-clockwise rotations accompanied by northwestward protrusion with respect to the Milyang and Uiseong blocks during the Late Cretaceous. These relative tectonic movements within the Gyeongsang basin were probably due to the northwestward subduction of the proto-Pacific plate during the Late Cretaceous. The average paleopole positions of the Korean Peninsula for the middle Early, late Early and Late Cretaceous are Lat./Long.=59.6°N/194.7°E (A_{95}=4.6°), 68.1°N/207.7°E (A_{95}=3.2°) and 70.9°N/215.4°E (A_{95}=5.3°), respectively, showing the gradual eastward displacement with respect to the Cretaceous mean pole of Eurasia as the age of rock units is getting older. This result indicates that the Korean Peninsula underwent clockwise rotations with respect to Eurasia during the Cretaceous Period. The clockwise rotation of Southwest Japan with respect to Eurasia is ascribed to the Miocene opening of the East Sea, and has no connection with the Cretaceous clockwise rotations of the Korean Peninsula. Thus, it is interpreted that the Korean Peninsula and Southwest Japan might not behave as a tectonically single terrane during Cretaceous.

GP41C-0052 0830h POSTER

Paleomagnetic Study for the Cretaceous Laiyang Basin in the Shandong Province, Northeast China: Tectonic Implications for East Asia

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Paleomagnetic investigation has been carried out for the Early Cretaceous Laiyang Group exposed in the eastern part of the Tan-Lu fault of the Shandong Province, Northeast China. A total of 224 independently oriented core samples were obtained from 12 sites for the study. The mean direction of high temperature/coercivity components (HC) in stratigraphic coordinates (D/I=16.0°/57.3°, k=140.5, α_{95}=3.7°) is more clustered than that in geographic coordinates (D/I=18.1°/56.7°, k=60.0, α_{95}=5.6°), yielding a positive fold test at the 95 % confidence level. Also, the parameter estimating fold test gives the maximum k value at 84.3 % unfolding. These results collectively indicate that the HC of the Laiyang Group might be a primary remanent magnetization component. The Early Cretaceous paleomagnetic pole position calculated from the mean direction of the HC is at Lat./Long.=77.1°N/198.8°E (A_{95}=4.7°). This pole position is not statistically distinguishable from coeval pole positions reported from the western part of the Tan-Lu fault within the North China Block (NCB). It indicates that the east of the Tan-Lu fault did not experience the relative movement with respect to the west of the fault since the Early Cretaceous. Thus, it is interpreted that the sinistral motion of the Tan-Lu fault, which was initiated by the collision between the North and South China blocks since the Late Paleozoic, might be ceased before Cretaceous or at least during the Early Cretaceous. To clarify the tectonic relationships of blocks in East Asia since Cretaceous, the reported Early Cretaceous pole positions of the South China Block (SCB), Mongolia, Siberia and Korea were compared with the coeval mean pole position of the NCB (78.0°N, 196.7°E, A_{95}=5.9°) calculated from paleopoles of the east and west of the Tan-Lu fault including this study. The paleopoles of the SCB (76.4°N, 211.2°E, A_{95}=6.8°) and Siberia (74.9°N, 205.6°E, A_{95}=1.9°) are indistinguishable from that of the NCB. On the other hand, the paleopoles of Mongolia (82.9°N, 249.5°E, A_{95}=5.7°) and the Korean Peninsula (65.2°N, 202.1°E, A_{95}=3.4°) are displaced westward by about 10° and eastward by about 17°, respectively, with respect to that of the NCB, indicating the rotations of opposite senses of the two blocks with respect to the NCB. Several previous paleomagnetic studies reported the Cretaceous clockwise rotations of the east of the Tan-Lu fault (e.g., Benxi area of northeast NCB and the Korean Peninsula), which were ascribed to the sinistral motion of the Tan-Lu fault. However, this study shows that the Tan-Lu fault did not experience any strike-slip motion since the Early Cretaceous, suggesting that another mechanism for the rotations might be involved. Recently, Lin et al. (2003) proposed that the clockwise rotation of the Korean Peninsula and the Benxi area might be caused by the fan-shaped intraplate rifting of the Cretaceous basins in the northeastern NCB and eastern Mongolia. The counterclockwise rotation of Mongolia and the no strike-slip motion of the Tan-Lu fault since the Early Cretaceous, identified in this study, could support the model by Lin et al. (2003) for rotations of blocks in East Asia.

GP41C-0053 0830h POSTER

Stratigraphic Correlation of Core Samples From the Osaka Bay off Kobe Based on Magnetic Properties and its Implication for Tectonic Activity of the Osaka-wan Fault for the last 6300 years

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Detailed correlation of bore-hole cores that collected around an active fault provides fundamental data for estimating vertical displacement of the strata generated by the fault movement. In order to recognize characteristic horizons for correlations, measurements of magnetic properties can be applied to core sediments, even if they seem homogeneous by visual inspections. For example, variation of initial susceptibility is often used for correlation of core samples, for its measurement can be made readily and rapidly. In this study, we have made detailed analysis of lithology and magnetic properties of bore-hole cores from sub-bottom sediments of Osaka Bay, central Japan, which were recovered from two sites at the both sides of the Osaka-wan fault off Kobe. These cores are composed of massive marine clay of the Holocene, intercalating a widespread tephra layer, K-Ah tephra, dated at 6300 14C years BP. We obtained u-channel samples from these cores and measured low-field magnetic susceptibility and anhysteretic remanent magnetization (ARM) by pass-through method. While we also measured natural remanent magnetization (NRM), reliable records of paleosecular variation were not obtained due to physical distortion of the core samples. The magnetic concentration parameters, however, show characteristic variations which are useful for stratigraphic correlations. The curve of ARM intensity corresponded to that of initial susceptibility. It is suggested that relative variation of ARM intensity supports the correlation obtained from the initial susceptibility measurement. The horizon of the K-Ah ash indicates a peak of initial susceptibility and ARM intensity, providing a key for correlation between the two sequences. The two parameters show increased value at the interval below the K-Ah ash at both sites, suggesting enhanced input of magnetic minerals into the Osaka Bay before 6300 yrs BP. Minor variations of the magnetic parameters were observed at several horizons, showing similar features at both sites. Based on these features and several radiocarbon dates, we established high-resolution correlation of the two sequences and compared accumulation history between both sides of the Osaka-wan fault. Our result delineates that the Osaka-wan fault has been active twice for the last 6300 years. It is also concluded that ARM intensity variation can improve the accuracy in correlating bore-hole cores based on initial susceptibility measurement.

URL: http://www.geor.or.jp/

GP41C-0054 0830h POSTER

Paleomagnetism of the Upper Cretaceous Units of the Gold Beach Terrane, Southwest Coastal Oregon

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Latitudinal displacement of the Gold Beach terrane, southwest coastal Oregon, is enigmatic. Gold Beach terrane is composed of Jurassic vocaniclastic sandstone and Upper Cretaceous marine sandstone. Previously published paleomagnetic evidence using the Jurassic Otter Point formation indicates 1200 to 1400 km. of post-Jurassic northward displacement along the Cordilleran margin (Blake, et al. 1985). The Upper Cretaceous formations are the subjects of a new paleomagnetic study intended to quantify the amount of displacement, age of magnetization and effects of compaction. Initial results indicate well-defined, consistent directions in some samples, and a positive intraformational conglomerate test indicating an ancient magnetization. Using a combination of rock magnetic tests of partial anhysteretic remanence and the Lowrie (1990) method has shown a combination of coarse to medium-grained pyrrhotite and magnetite present in several samples. Pretreatment by cooling in liquid nitrogen significantly reduced the magnitude of NRM, consistent with presence of coarse-grained magnetite. It may be possible to show that pyrrhotite carries an ancient magnetization if vectors isolated between 160 to 320 degrees can pass a conglomerate test. If both pyrrhotite and magnetite carry a definable set of ancient directions, a detailed comparison between inclinations of both authigenic and presumably detrital remanence carriers can be made.

GP41C-0055 0830h POSTER

Paleomagnetic Vertical Axis Rotations Caused by Oblique Deformation Within the Grand Hogback Monocline, Colorado Plateau

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The monoclines of the Colorado Plateau, formed over reactivated Precambrian faults during the Laramide Orogen, locally absorb oblique deformation (e.g. Tinsdall and Davis, 1999; Bump and Davis, 2003). Thus it can be assumed that the distributed deformation in the overlying, folded strata from oblique slip would be in the form of a strike-slip shear zone with some unknown amount of vertical axis rotation. Paleomagnetic vertical axis rotations in the monoclines of the Colorado Plateau can constrain such a rotation from strike-slip motion on the underlying thrust-faults. This study focuses on new paleomagnetic work performed on the anticlinal hinges of the San Rafael monocline, central Utah, and the Grand Hogback monocline, Colorado. The San Rafael monocline is a large, curvilinear structure with oblique deformation from right lateral slip proposed on the southern, northeast-southwest oriented limb (Bump and Davis, 2003). The Grand Hogback monocline is a large, highly sinuous feature, with left-lateral strike-slip deformation proposed along the central, east-west oriented limb (Murray, 1966). Three sites sampled within the anticlinal hinge of the north and south limbs of the San Rafael monocline, yielded no vertical-axis rotations. Two sites were sampled along the northern, north-south oriented limb and the central limb of the Grand Hogback monocline. A minimum rotation of -15° ± 8° was determined from Upper Triassic strata sampled on the anticlinal hinge of the central limb (39.5 N, 107.4 W). The tilt-corrected direction for this site is D = -23.6°, I = 24.3°, α_{95} = 9.6°, N = 16. Correlative strata sampled on the north limb (39.8 N, 107.9 W) contain a clockwise rotation of 8.8° ± 4.5°. This paleomagnetic result provides a minimum constraint of 23° of differential tectonic rotation absorbed in this Laramide structure. Further work in the overlying pre-Laramide strata will provide further information on the amount and distribution of rotation, and thus constrain the mechanism of deformation for the Grand Hogback monocline. The presence of rotations at this monocline and the absence of rotations on the San Rafael monocline must be further investigated to understand how the Laramide Orogen formed the monoclines of the Colorado Plateau.

GP41C-0056 0830h POSTER

Testing for compaction-shallowing, and tectonic implications of the paleomagnetism of the late Cretaceous sediments of the Gualala Block, northern California

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The Gualala Block is a discrete package of sediments of late Cretaceous to Eocene age contained in the Point Arena Terrane. The terrane is located on the continental margin outboard of the San Andreas Fault in northern California. Rudistid bivalves were discovered in the late Cretaceous Anchor Bay member, suggesting a sub-tropical paleolatitude (Kodama and Ward, 2001). A paleomagnetic study will be undertaken to determine paleolatitude to provide an estimate of post-Cretaceous displacement with implications for Cordilleran margin paleogeography. A total of 395 specimens from 26 sites were collected from the Anchor Bay and Stewarts Point members of the Gualala Block. At present, 130 specimens have been demagnetized via several methods with varying results. Among the demagnetization methods employed are low temperature treatment with liquid nitrogen, alternating field, thermal, and combinations of alternating field and thermal. Most specimens so far exhibit a well-behaved first-removed component of magnetization. After removal of this magnetization component, the vast majority of the specimens do not display a well-defined primary magnetization. At present 4 of the sites exhibit the potential to contain definable second-removed components. The anisotropy of magnetic susceptibility will be measured for each specimen indicating the amount of magnetic fabric. The magnetic fabric will be compared with the inclination to evaluate for possible compaction shallowing. The results of the compaction shallowing study will be used to determine the paleolatitude of the Anchor Bay Formation.

GP41D MCC: 2000 Thursday 1020h

Tectonic and Geochronologic Applications of Sedimentary Paleomagnetism II *(joint with T)*

Presiding: **K P Kodama,** Lehigh University**; B M Clement,** Florida International University

GP41D-01 1020h

The Sedimentary, Isotopic, and Magnetostratigraphic Signature of a Pair of Pre-Sturtian (~850 Ma) Rapid True Polar Wander (TPW) Events in the Akademikerbreen Group, NE Svalbard

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Since the 1950's, rapid true polar wander (TPW) has been recognized as a physically viable process in which the entire silicate shell of the Earth may shift as much as 90° with respect to the spin axis in 10^6-10^7 years. Recently, numerous studies have suggested that rapid TPW occurred repeatedly in the latest Proterozoic and Cambrian and may have influenced patterns of climate change and the evolutionary radiation of animals. However, analyses have been plagued by uncertainties in the age, quality, and correlation of paleomagnetic poles collected from various types of rocks on different continents. Using an integrated sedimentary, isotopic, and paleomagnetic approach, we document two possible rapid TPW events of > 50° magnitude in the pre-Sturtian carbonate-dominated succession of East Svalbard. The nature of our carbonate magnetostratigraphy, extending through 650 m of coherent section and reproduced at five locations spread out over 160 km on a single craton, ensures that correlation, secular variation, inclination shallowing, tectonic rotation, and uncertainty of paleohorizontal do not contribute significant error. Rigorous AF and thermal demagnetization procedures and at least one semi-quantitative field test constrain each reported paleomagnetic result to date from the time of sedimentation or early diagenesis. Calculated paleomagnetic poles fall on a single great circle swath which is compatible with the occurrence of two rapid TPW events centered around a pole located in Ungava, Canada (after restoration of Eastern Svalbard to the northeastern margin of Laurentia). The older TPW event is marked by a karstic surface and a crash in δ^{13}C from +6 to -1 per mil PDB. Anomalously low δ^{13}C values are maintained for ~300 meters before they rise again sharply, at a second sequence boundary, to the strongly positive values characteristic of the rest of the Akademikerbreen Group. The younger TPW event is constrained to have occurred either within the isotope stage or very shortly thereafter, and likely corresponds to the sequence boundary that delineates the end of the low δ^{13}C interval. We tentatively interpret the stratigraphic and isotopic data in terms of the 'methane-fuse' hypothesis (Kirschvink and Raub, 2003), where TPW-induced sea level changes are manifested as sequence boundaries on continental shelves and destabilize frozen clathrates stored on continental margins, thus contributing isotopically light carbon to the ocean-atmosphere system. Because a rapid TPW event will affect every continent differently but predictably (depending on the continent's changing position relative to the Earth's spin axis), the TPW hypothesis is testable. The well-defined carbon-isotopic stage containing the rapid TPW event in Svalbard is matched in the Shaler Group of Arctic Canada and the Bitter Springs Formation of central Australia. Following correllations made by Walter et al. (2000), radiometric dates from Australia suggest that the isotopic stage ended by 830 Ma. In order to test the TPW hypothesis, we make model predictions about the sedimentary, chemostratigraphic, and paleomagnetic patterns we expect to see in contemporaneous basins of East Greenland, Arctic Canada, and Central Australia.