Data Repository for: “Climatic and tectonic controls on sedimentation and erosion during the Pliocene–Quaternary in Qaidam Basin (China),” by Richard V. Heermance, Alex Pullen, Paul Kapp, Carmala N. Garzione, Scott Bogue, Lin Ding, and Peiping Song; doi: 10.1130/B30748.1

Magnetostratigraphy Analysis

Our section sampled the Plio-Quaternary part of the stratigraphic section, and previous work on similar strata within the Qaidam Basin documented sediment accumulation rates of 200–900 m/m.y (Liu et al., 1998; Fang et al., 2008; Zhang et al., 2012a). Assuming that Plio-Quaternary Qaidam strata accumulated at approximately same rate, each 17 m-interval spans between 0.018–0.085 million years (m.y.). The average duration of a polarity chron since the start of the Pliocene (the suspected maximum age of our strata) is 0.251 m.y. (calculated from Lourens et al., 2004), and so we anticipated that each polarity interval should be defined by three paleomagnetic sites on average. Excluding the two polarity intervals that span less than 20,000 years (Cobb Mountain and Reunion Subchrons at ~1.1 and 2.1 Ma), the shortest polarity chron in the interval lasted 0.084 m.y. and so should be represented by a least one paleomagnetic site.

Samples were analyzed at the paleomagnetic laboratory at Occidental College. Remanent magnetization was measured using a 3-axis DC-SQUID magnetometer system housed in a magnetically shielded room. The magnetometer has a background noise of <1 picoAm^2 and is equipped with a vacuum pick-and-put, computer-controlled sample handling system which can measure up to 180 samples automatically (Kirschvink et al. 2008). Alternating field (AF) demagnetization was performed with a computer-controlled, two-axis coil system. Thermal demagnetization was performed in a commercially built, magnetically shielded furnace.

Paleomagnetic Sample Analysis

One sample per site or stratigraphic level was initially measured for natural remanent magnetization (NRM), then subjected to AF demagnetization in four steps up to 20 mT to remove low-coercivity magnetizations, and subsequently treated with stepwise thermal demagnetization using 6–12 demagnetization steps between 200–680 °C, typically in 50 °C steps up to 500 °C and 30° steps from 500 °C to 680 °C.

Some samples, particularly from greenish-gray gypsiferous lacustrine beds near the top of the section, had very low NRM values (<10^{-4} A/m). For these samples, the typical thermal demagnetization sequence to at least 580° yielded erratic, uninterpretable results (Fig. 7E). Instead, these samples were submitted to three steps of AF demagnetization (3, 6, and 9 mT) and then small, 10–50 °C steps between 140° and 350°, after which the typical thermal demagnetization sequence was continued. This method was intended to isolate the magnetic remanence from iron-suphides that have lower unblocking temperatures but can carry primary magnetic remanence in some low-energy depositional environments (e.g., Husing et al., 2007).

To determine characteristic magnetic remanence (ChRM) directions, line-fit analysis (Kirschvink, 1980) was performed for each specimen based on data from a minimum of four but typically seven or eight thermal demagnetization steps using paleomagnetic software of Jones (2002). Samples were accepted as usable when the maximum angular deviation (MAD) of the line fit was less than 15°. In cases where all but the final HTC point clustered in a normal or reverse polarity position on an orthogonal vector plot, the ChRM direction was determined by forcing a line from the cluster through the origin. At each site, a second and third specimen from the block-sample was demagnetized if the first yielded unstable or overprinted directions or if a magnetostratigraphic interval of normal or reverse polarity was defined by only one specimen.

REFERENCES CITED

Fang, X., Zhang, W., Meng, Q., Gao, J., Wang, X., King, J., Song, C., Dai, S., and Miao, Y., 2007, High-resolution magnetostratigraphy of the Neogene Huaitoutala section in the eastern Qaidam Basin on the NE Tibetan Plateau, Qinghai Province, China, and its implication on tectonic uplift of the NE Tibetan Plateau: Earth and Planetary Science Letters, v. 258, no. 1, p. 293–306, doi:10.1016/j.epsl.2007.03.042.

Fang, X., Wu, F., Han, W., Wang, Y., Zhang, X., and Zhang, W., 2008, Plio-Pleistocene drying process of Asian inland—Sporopollen and salinity records from Yahu section in the central Qaidam Basin: Quaternary Sciences, v. 28, no. 5, p. 875–882.

Hanson, A.D., Ritts, B.D., Zinniker, D., Moldowan, J.M., and Biffi, U., 2001, Upper Oligocene lacustrine source rocks and petroleum systems of the northern Qaidam Basin, Northwest China: AAPG Bulletin, v. 85, no. 4, p. 601–619.

Husing, S.K., Hilgen, F.J., Abdul Aziz, H., and Krijgsman, W., 2007, Completing the Neogene geological time scale between 8.5 and 12.5 Ma: Earth and Planetary Science Letters, v. 253, no. 3, p. 340–358.

Jones, C.H., 2002, User-driven integrated software lives: “PaleoMag”: Paleomagnetics analysis on the Macintosh: Computers and Geosciences, v. 28, no. 10, p. 1145–1151.

Kirschvink, J.L., 1980, The least-squares line and plane and the analysis of paleomagnetic data: Geophysical Journal of the Royal Astronomical Society, v. 62, p. 699–718, doi:10.1111/j.1365-246X.1980.tb02601.x.

Kirschvink, J.L., Kopp, R.E., Raub, T.D., Baumgartner, C.T., and Holt, J.W., 2008, Rapid, precise, and high-sensitivity acquisition of paleomagnetic and rock-magnetic data: Development of a low-noise automatic sample changing system for superconducting rock magnetometers: Geochemistry Geophysics Geosystems, v. 9, p. Q05Y01, doi:10.1029/2007GC001856.

Liu, Z., Wang, Y., Chen, Y., Li, X., and Li, Q., 1998, Magnetostratigraphy and sedimentologically derived geochronology of the Quaternary lacustrine deposits of a 3000 m thick sequence in the central Qaidam Basin, western China: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 140, no. 1–4, p. 459–473.

Lourens, L.J., Hilgen, F.J., Laskar, J., Shackleton, N.J., and Wilson, D., 2004, The Neogene Period, in Gradstein, F.M., Ogg, J.G., and Smith, A., eds., Geological Time Scale: Cambridge, UK, Cambridge University Press, p. 409–440.

Rieser, A., Neubauer, F., Liu, Y., and Ge, X., 2005, Sandstone provenance of north-western sectors of the intracontinental Cenozoic Qaidam Basin, western China: Tectonic vs. climatic control: Sedimentary Geology, v. 177, p. 1–18, doi:10.1016/j.sedgeo.2005.01.012.

Song, T., and Wang, X., 1993, Structural styles and stratigraphic patterns of syndepositional faults in a contractional setting; examples from Qaidam Basin, northwestern China: The American Association of Petroleum Geologists Bulletin, v. 77, no. 1, p. 102–117.

Wang, X., Qiu, Z., Li, Q., Wang, B., Qiu, Z., Downs, W.R., Xie, G., Xie, J., Deng, T., Takeuchi, G.T., Tseng, Z.J., Chang, M., Liu, J., Wang, Y., Biasatti, D., Sun, Z., Fang, X., and Meng, Q., 2007, Vertebrate paleontology, biostratigraphy, geochronology, and paleoenvironment of Qaidam Basin in northern Tibetan Plateau: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 254, no. 3–4, p. 363–385, doi:10.1016/j.palaeo.2007.06.007.

Wang, Y., Zhen, J., Zhang, W., Li, S., Liu, X., Yang, X., and Liu, Y., 2012, Cenozoic uplift of the Tibetan Plateau: Evidence from the tectonic-sedimentary evolution of the western Qaidam Basin: Geoscience Frontiers, v. 3, no. 2, p. 175–187, doi:10.1016/j.gsf.2011.11.005.

Zhang, W., Appel, E., Fang, X., Song, C., and Cirpka, O., 2012a, Magnetostratigraphy of deep drilling core SG-1 in the western Qaidam Basin (NE Tibetan Plateau) and its tectonic implications: Quaternary Research, v. 78, no. 1, p. 139–148, doi:10.1016/j.yqres.2012.03.011.

Zhu, L., Wang, C., Zheng, H., Xiang, F., Yi, H., and Liu, D., 2006, Tectonic and sedimentary evolution of basins in the northeast of Qinghai-Tibet Plateau and their implication for the northward growth of the plateau: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 241, p. 49–60, doi:10.1016/j.palaeo.2006.06.019.

Table S1. Summary of previous stratigraphic work and age assignments of late Neogene Qaidam Basin strata.

Formation	General Description	Age Determination (Ma)	References
Qigequan	hyper-arid evaporite (gypsum, halite) and lacustrine (shale, mudstone)	Quaternary	Song and Wang (1993)
		1.8-0	Reiser et al. (2005)
		2.5-0	Fang et al. (2007)
		2.6-0	Zhu et al. (2006)
		2.65-0	Wang et al. (2012
		2.6-0	this study
Shizigou	evaporite/freshwater lacustrine (mudstone, shale, marginal lacustrine)	5.3-2.6	Wang et al. (2007)
		5.7-1.8	Reiser et al. (2005)
		5.3-2.45	Zhu et al. (2006)
		8.1-2.5	Fang et al. (2007)
		8.2-2.6	Zhuang et al. (2011b)
		8.2-2.65	Wang et al. (2012)
Shang Youshashan	freshwater lacustrine	12.1-5.3	Wang et al. (2007) Zhu et al. (2006) Reiser et al. (2005)
		14.9-8.2	Hanson et al. (2001) Wang et al. (2012)
Xia Youshashan	lacustrine/fluvial	early-middle Miocene	see Zhuang et al.(2011b) and references therein
Shang Ganchaigou	meandering fluvial	Oligocene-early Miocene	
Xia Ganchaigou	meandering fluvial	Eocene-Oligocene	
Lulehe	braided fluvial	Early-middle Eocene	

Table S2. Summary of magnetostratigraphic data.

Sites	total thickness spanned	sites used	sites not used	average site spacing used	average total site spacing	total samples used	total samples processed	magnetozones
100	1672	74	26	22.6	16.7	107	144	22

Table S3. Summary of paleocurrent analyses from the Northeast (NE) section. Trough cross-beds provide uni-directional measurements, whereas epsilon cross-beds, channel margins, and ripples provide bi-directional data. Overall directions are in Cartesian coordinates and are based on the combination of uni and bi-directional measurements.

Location	strat depth (m)	total measurements	trough cross-beds	epsilon cross-beds	channel margins	ripples	Overall Direction
Unit 3	1500-1725	14	8	0	0	6	SSW
Unit 3	1235-1500	37	18	17	2	0	S
Unit 2	920-1235	8	8	0	0	0	WSW
Unit 1	760-920	0	0	0	0	0	na
Unit 2	495-760	47	34	13	0	0	SW
Unit 1	175-495	18	14	2	2	0	WSW
Unit 1	0-175	9	7	2	0	0	E

Table S4. Carbonate phases observed in the carbon and oxygen istope samples.

OurLabID	Sample ID	**Phase**	**alteration**	OurLabID	Sample ID	**Phase**	**alteration**
C-3819	NE01	cement		C-3852	NE45	cement	
C-3820	NE02	cement		C-3853	NE47	cement	
C-3821	NE03	cement		C-3854	NE54	cement	
C-3822	NE04	cement		C-3855	NE59	micrite	
C-3823	NE05	cement		C-3856	NE62	micrite	
C-3824	NE06	cement		C-3857	NE65	micrite	
C-3825	NE07	cement		C-3858	NE67	cement	
C-3826	NE08	cement		C-3859	NE69	micrite	
C-3827	NE09	cement		C-3860	NE71	micrite	
C-3828	NE10	cement		C-3861	NE72	cement	
C-3829	NE11	cement		C-3862	NE73	micrite	
C-3830	NE12	cement		C-3863	NE75	cement	
C-3831	NE13	cement		C-3864	NE78	cement	
C-3833	NE14	cement		C-3865	NE81	cement	
C-3834	NE15	cement		C-3866	NE82	cement	
C-3879	NE16	cement		C-3867	NE83	micrite	
C-3835	NE17	cement		C-3868	NE84	cement	
C-3836	NE18	cement		C-3869	NE85	cement	
C-3838	NE20	cement		C-3870	NE86	micrite	
C-3839	NE21	cement		C-3871	NE88	cement	
C-3840	NE22	cement		C-3872	NE89	cement	
C-3841	NE25	cement		C-3880	NE92	cement	
C-3842	NE26	micrite	dolomite alteration	C-3873	NE93	cement	
C-3843	NE27	cement		C-3874	NE94	micrite	hematite/calcite
C-3844	NE29	cement		C-3875	NE95	micrite	
C-3845	NE31	cement		C-3876	NE98	micrite	
C-3847	NE34	cement		C-3877	NE99	micrite	
C-3848	NE39	cement		C-3878	NE100	cement	
C-3851	NE43	cement					