Lab 6: Oceanic Heat Flow and Bathymetry

Objective: To investigate the theoretical and observational relationship between age of the sea floor, ocean bathymetry, and heat flow.

Background: Simple 1-D cooling models are used to predict heat flow and bathymetry in terms of the age of the oceanic lithosphere. New and hot oceanic lithosphere is created at spreading ridges, and then proceeds to cool, lowering the heat flow. In addition, the oceanic lithosphere also contracts, increasing the depth of water or bathymetry. The theoretical relationships between these parameters, are as follows:

Heat Flow: $q_o = \dfrac{473}{\sqrt{age}}$

Bathymetry: $d = 2.5 + .35\sqrt{age}$

where *age* is in millions of years (My).

Exercises:

Following are to be conducted using the measurements of Age, Heat flow and Bathymetry given in Table 1. Note that the Heat flow values are based on the conductive heat loss from the ocean floor.

<u>1. Heat Flow vs. Age</u>

A. Make a scatter plot of oceanic heat flow as a function of age from the data in Table 1. Include error bars on each heat flow measurement.

B. On the same graph, compute and plot the theoretical relationship given above.

C. Discuss the agreement, or lack of agreement, between theory and observation in terms of age and other processes that might be occurring at mid-ocean
ridges.

D. See if you can find a better fit to the theoretical q_o equation by varying C_1 (C_1 = 473 in equation above). Plot these curves on the same graph as well.
Discuss your results.

E. Calculate the total heat loss (Watts) from the ocean floors, based on the area estimates in Table 1. Compare that to the global value.

<u>2. Bathymetry vs. Age</u>

A. Make a scatter plot of the depth of the sea floor as a function of age from the data in Table 1. Include error bars on each bathymetry measurement.

B. On the same graph, compute and plot the theoretical relationship between age and bathymetry.

C. Try to find a better fit to the bathymetry data by varying C_2 (C_2 = 2.5 km in the equation above). Plot these curves on the same graph as well.

D. Discuss the fit of the model and in particular, the sensitivity to a ridge depth of 2.5 km. How could the model be improved?

3. Extra Credit

1. Consider "Triangle World" – a flat world where one linear spreading ridge forms an angle relative to one linear subduction zone. The plate spreads from the ridge and has equal probability of being subducted at any age (some is immediately subducted, some exists out to a maximum age).
    a. What is the area - age relationship on this world if the spreading rate is constant?
    b. How does the curve change if the spreading rate speeds up or slows down for some period of time?
2. Examine area - age data in Table 1.
    a. To what extent do data show trends similar to "Triangle World"? What conclusions can be drawn?
    b. How appropriate is the analogy between "Triangle World" and Earth.
        1. What assumptions are likely valid?
        2. What changed assumptions might lead to alternate interpretations?

Table 1. Age and Heat Flow and Bathymetry data

Age (My) begin	Age (My) end	depth (m)	±depth (m)	heat flow mWm^{-2}	±heat flow mWm^{-2}	Area 10^6 km^2
0	2	2896	139	269	182	6.8
2	4	3176	162	138	118	6.8
4	6	3378	196	185	82	6.56
6	8	3568	208	101	66	6.56
8	10	3700	162	110	61	6.56
10	12	3832	187	87	35	6.36
12	14	3811	264	95	61	6.36
14	16	3898	207	77	51	6.36
16	18	4001	227	90	52	6.36
18	20	4065	198	67	41	6.36
20	22	4142	189	79	41	5.325
22	24	4244	194	50	37	5.325
24	26	4303	197	44	26	5.325
26	28	4388	188	56	27	5.325
28	30	4430	173	74	26	5.325
30	32	4547	183	75	47	5.325
32	34	4605	203	65	36	5.325
34	36	4652	226	66	32	5.325
36	38	4715	217	51	33	4.625
38	40	4769	224	47	29	4.625
40	42	4836	209	89	75	4.625
42	44	4871	193	67	18	4.625
44	46	4915	175	53	22	4.625
46	48	4967	208	53	41	4.625
48	50	5015	198	54	24	4.625
50	52	5056	225	54	22	4.625
52	54	5151	187	63	37	4.24
54	56	5181	212	58	17	4.24

56	58	5287	224	74	38	4.24
58	60	5306	221	61	31	4.24
60	62	5303	217	55	30	4.24
62	64	5358	237	77	52	4.24
64	66	5367	233	57	20	4.24
66	68	5374	236	53	29	5.32
68	70	5400	210	49	15	5.32
70	72	5436	204	64	20	5.32
72	74	5489	185	47	23	5.32
74	76	5466	236	53	17	5.32
76	78	5484	252	81	56	5.32
78	80	5496	262	66	34	5.32
80	82	5519	322	72	26	3.48
82	84	5519	304	62	17	3.48
84	86	5516	298	50	23	3.48
86	88	5482	380	93	117	3.48
88	90	5477	385	65	22	3.48
90	92	5514	338	59	12	3.48
92	94	5507	363	54	16	3.48
94	96	5542	321	69	27	3.48
96	98	5415	476	63	23	3.54
98	100	5417	460	55	12	3.54
100	102	5435	357	42	12	3.54
102	104	5416	333	49	7	3.54
104	106	5377	389	57	7	3.54
106	108	5305	496	54	7	3.54
108	110	5319	410	62	15	3.54
110	112	5320	479	68	42	2.17
112	114	5232	488	59	8	2.17
114	116	5177	487	54	8	2.17
116	118	5213	440	50	9	2.17
118	120	5249	466	50	19	2.17

120	122	5372	294	53	12	2.17
122	124	5355	330	55	7	2.17
124	126	5402	310	53	9	2.17
126	128	5446	331	42	14	2.38
128	130	5388	444	60	30	2.38
130	132	5495	436	49	11	2.38
132	134	5545	394	52	12	2.38
134	136	5628	252	44	16	2.38
136	138	5625	296	50	11	2.38
138	140	5639	319	50	9	2.38
140	142	5628	405	50	12	0.69
142	144	5558	427	54	14	0.69
144	146	5567	472	48	8	0.69
146	148	5470	505	55	21	0.69
148	150	5602	437	57	15	0.69
150	152	5555	455	50	6	0.69
152	154	5474	541	60	16	0.69
154	156	5449	565	49	15	0.69
156	158	5476	518	53	13	0.69
158	160	5456	450	46	16	0.69
160	162	5299	533	50	8	0.69
162	164	5229	465	54	14	0.69