

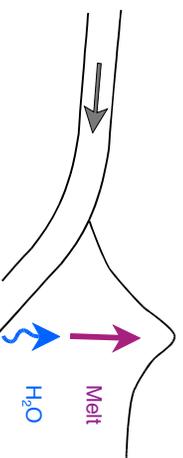
Origins of melts and magmas II

The diagram and text at right were used in Part I of this pair of pages to explain why most melts originate *where* they do. The aspect of the diagram least considered in Part I was the label “*partial melt*”. This page tries to redress that deficiency.

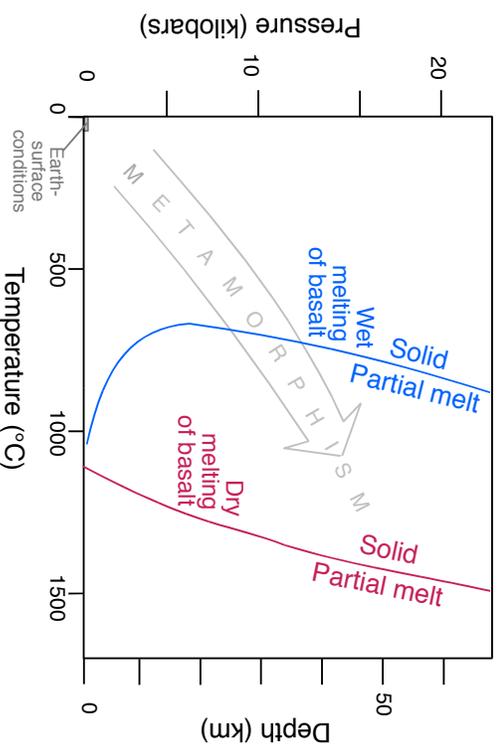
The table at right shows that the melting temperatures of silicic silicate minerals are generally less than those of mafic silicate minerals, especially when water is present. Thus, when a rock (an assemblage of minerals) is heated, not all of its minerals melt at the same time. Instead, those with lower melting temperatures melt preferentially to give a partial melt that is typically more silicic than the original rock.

That thought about the lower melting temperatures of silicic silicate minerals is especially true in “wet” melting conditions where H₂O is present (see the blue column at right). Thus, when dehydration of a subducting oceanic plate releases H₂O that induces melting in the scenario shown both in Part I and below, the result is a significantly more silicic magma than the original melting rock. It was this preferential production of silicic melt that led the University of Georgia’s Professor James A. Whitney, a famous igneous petrologist, to give one of his UGA colloquium lectures the succinct title “Why are there granites? Because there are oceans.”

H₂O-induced partial melting at convergent plate boundaries



Water released from the subducting oceanic plate at a convergent plate boundary induces melting that produces island arcs and continental arcs. In the former case, the result is largely basalt, whereas the latter produces both grano-dioritic intrusive rocks and basaltic to rhyolitic volcanics.



Along the dry-melting boundary, increased vibrational energy of atoms with increasing temperature breaks minerals apart to cause a transition to liquid (melting). Because these liquids are less dense than the corresponding solid minerals, decreasing pressure also favors melting, so that the boundary slopes as it does.

Compared to the dry melting boundary discussed above, the “wet”-melting boundary falls at a lower temperature because H₂O molecules bond to the cations of minerals and help liberate those cations, breaking down minerals to generate melt.

The curves at left are only schematic and would move with changing rock composition and/or changing water content.

Minerals	Melting temperatures (°C)		(Mg+Ca) / (Al+Si)
	T _m (P _{H₂O} = 5 kb)	T _m (1 atm) ^{Dry}	
Forsterite (Mg ₂ SiO ₄)	1622	1890	2.0
Diopside (CaMgSi ₂ O ₆)	1295	1391	1.0
Anorthite (CaAl ₂ Si ₂ O ₈)	1234	1553	0.25
SiO ₂ minerals (Quartz etc.)	1077	1722	0
K-feldspar (KAlSi ₃ O ₈)	876	1530	0
Albite (NaAlSi ₃ O ₈)	748	1118	0
			Stilic

Part I of this series draw on concepts presented in webpages by Prof. Jonathan Miller of San Jose State University (geosun.sjsu.edu/~jmiller/Geo1_Lec5_IgRocks.html) and by Dr. John W. Merck of the University of Maryland (www.geol.umd.edu/~jmerck/geol100/lectures/10.html). The table above is adapted from Table 4 of Railsback 2007 (*American Mineralogist*, v. 92, p. 356-369). These pages also draw on the comments of Drs. Robert Hawman and James Wright of the University of Georgia.