Available online at www.sciencedirect.com

ScienceDirect

Solid Earth Sciences 2 (2017) 41–42

www.elsevier.com/locate/SESCI

Research Highlight

Carbon recycling through alkali basalts

Carbon is one of the most important elements that control life and the environment of Earth. The atmosphere and biosphere, however, are very small C reservoirs. By contrast, the mantle has 27,000 examoles C, whereas the total Earth surface (mostly sediments including fossil fuels) has ~7350 examoles C, with only 0.07 in the atmosphere and 0.13 in the biosphere and 3.3 in the hydrosphere (Hayes and Waldbauer, 2006). Therefore, carbon exchanges between the mantle and the surface, which are dominated by magmatism (outgassing) and plate subduction (down going), are the keys that strongly influence long term climate changes and the inhabitability of Earth. The C fluxes and the detailed pro-

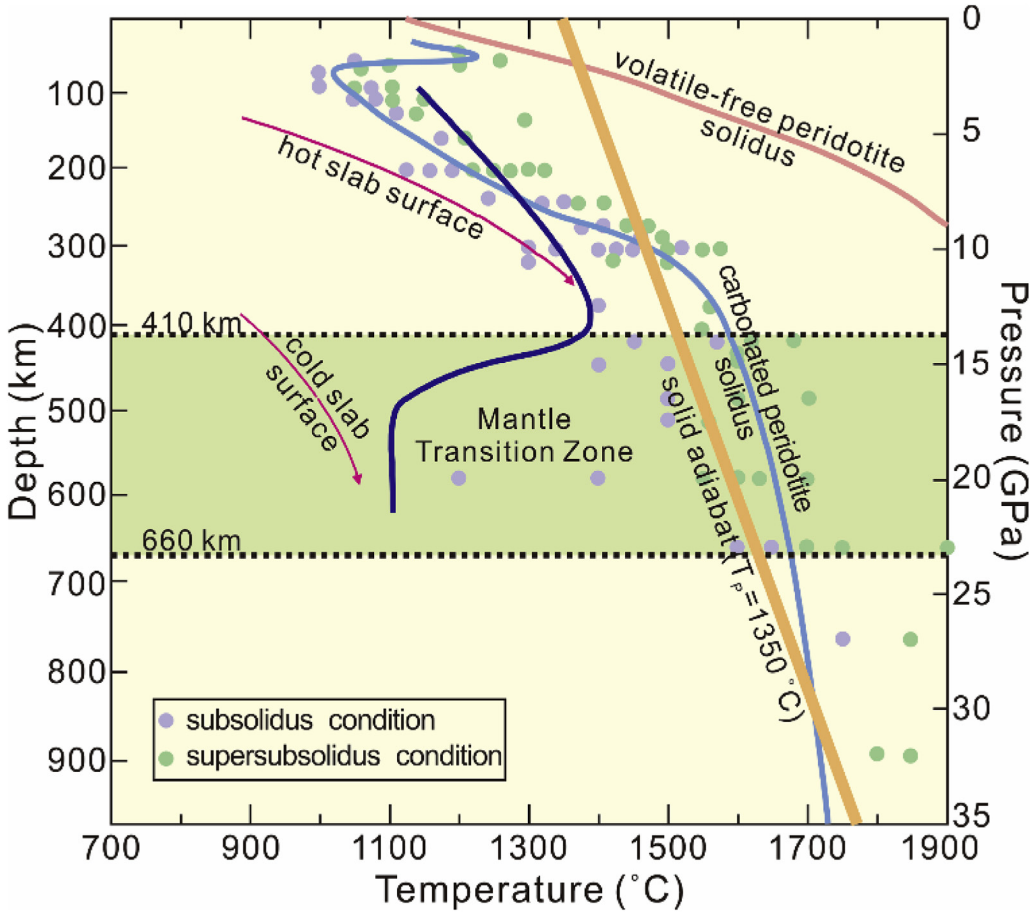

Fig. 1. The solidus line of silicate is dramatically lowered once carbonated, modified after (Dasgupta et al., 2013; Thomson et al., 2016): solidus lines of dry carbonated peridotite (light blue curve), volatile-free peridotite (thick pink curve) (Dasgupta and Hirschmann, 2010) and carbonated MORB (dark blue curve) (Thomson et al., 2016). Also shown are solid adiabat line (Tp = 1350 °C, thick orange line) (Dasgupta and Hirschmann, 2010), and the range of subducted slabs bounded between hot and cold slabs (thin red curves with arrow) (Thomson et al., 2016). Most of the carbonated MORB get melted before it goes across the Upper–Lower Mantle boundary (Thomson et al., 2016), whereas carbonate peridotite is stable between 300 and 800 km. Therefore, the transition zone may have played a major role in carbon recycling.

Peer review under responsibility of Guangzhou Institute of Geochemistry.

http://dx.doi.org/10.1016/j.sesci.2017.03.002

cesses that release C from deep in the mantle into the atmosphere remain obscure.

There are four major forms of carbon in the mantle: diamond, graphite, carbide and carbonates, with minor CO_2 and CH_4 etc. Carbonate and also CO_2 are very active in the mantle. Experiments showed that the solidus line of silicate is dramatically lowered once carbonated (Fig. 1), whereas CO_2 can facilitate low-degree mantle-derived melt, reduce the SiO_2 and increase the alkalis in the melt, i.e. promote the formation of alkali basalts (Dasgupta et al., 2007). In this case, alkali magmatism is an important source of CO_2 emission from the mantle that must be considered sensibly.

A recent paper in Nature Geoscience reported for the first time, direct observation on the transition of carbonated magmas to alkali basalts in the South China Sea (Zhang et al., 2017). The authors argued that carbonated silicate melts reacted with the lithospheric mantle and were converted to alkali basaltic melts on their way up. They further proposed that the extremely thin lithosphere of less than 20 km in the South China Sea facilitates extrusion of the carbonated silicate melts.

Alkali basalts are widely distributed worldwide, e.g., significant portion of ocean island basalts are alkali basalts. The questions to be tackled in the future include: Is the transition from carbonated magmas to alkali basalt a normal phenomenon that controls the formation of all alkali basalts? What is the source of carbonates in the melt, i.e., newly recycled or previously stored in the transition zone (Fig. 1)?

Large scale Mg isotope anomalies of alkali basalts in eastern China indicate the incorporation of subducted carbonates, most likely during the westward subduction of the Pacific Plate (Li et al., 2017; Yang et al., 2012). In the case of the South China Sea basalt, the carbon may come from subducted Neo-Tethys oceanic crust (Sun, 2016) or paleo-Pacific plate. Nevertheless, the close association of CO_2 and carbonated magmas with alkali basalts opens a new window that enable us to have a better perspective on the deep carbon recycling.

Plate subduction is the main process that transports carbon down into the mantle. Carbonate is the predominant carbon spices in the subducted oceanic slab. As shown in Fig. 1, carbonated MORB get melted before it goes across the Upper−Lower Mantle boundary (Thomson et al., 2016). So, carbonate cannot be preserved in the mantle as residues of the subducted oceanic slab. In contrast, carbonated mantle peridotite is stable between 300 and 800 km, i.e. in the transition zone and the upper most Lower Mantle. Carbonate melts may be preserved there as carbonated peridotite after reacted with mantle peridotite. Therefore, the transition zone may have played a major role in carbon recycling.

References

Dasgupta, R., Hirschmann, M.M., 2010. The deep carbon cycle and melting in Earth's interior. Earth Planet. Sci. Lett. 298 (1−2), 1−13.

Dasgupta, R., Hirschmann, M.M., Smith, N.D., 2007. Water follows carbon: CO_2 incites deep silicate melting and dehydration beneath mid-ocean ridges. Geology 35 (2), 135−138.

Dasgupta, R., et al., 2013. Carbon-dioxide-rich silicate melt in the Earth's upper mantle. Nature 493 (7431), 211−U222.

Hayes, J.M., Waldbauer, J.R., 2006. The carbon cycle and associated redox processes through time. Philos. Trans. R. Soc. B Biol. Sci. 361 (1470), 931−950.

Li, S.G., et al., 2017. Deep carbon cycles constrained by a large-scale mantle Mg isotope anomaly in eastern China. Natl. Sci. Rev. 1−10. http://dx.doi.org/10.1093/nsr/nww070.

Sun, W.D., 2016. Initiation and evolution of the South China Sea: an overview. Acta Geochim. 35 (3), 215−225.

Thomson, A.R., Walter, M.J., Kohn, S.C., Brooker, R.A., 2016. Slab melting as a barrier to deep carbon subduction. Nature 529 (7584), 76−79.

Yang, W., Teng, F.-Z., Zhang, H.-F., Li, S., 2012. Magnesium isotopic systematics of continental basalts from the North China craton: implications for tracing subducted carbonate in the mantle. Chem. Geol. 328, 185−194.

Zhang, G.L., Chen, L.H., Jackson, M.C., Hofmann, A.W., 2017. Evolution of carbonated melt to alkali basalt in the South China Sea. Nat. Geosci. http://dx.doi.org/10.1038/NGEO2877, 229-U105.

Wei-dong Sun*
Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, China

Laboratory for Marine Mineral Resources, Qingdao National Laboratory for Marine Science and Technology, Qingdao, 266237, China

CAS Center for Excellence in Tibetan Plateau Earth Sciences, Chinese Academy of Sciences, Beijing, 100101, China

Chan-chan Zhang
Key Laboratory of Mineralogy and Metallogeny, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, 510640, China

University of the Chinese Academy of Sciences, Beijing, 100049, China

*Corresponding author. Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, China.