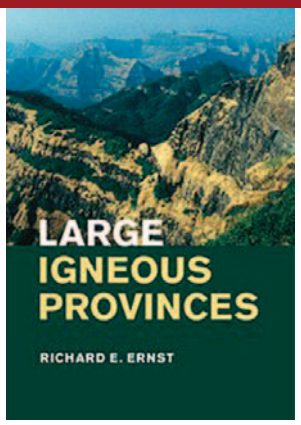
LARGE IGNEOUS PROVINCES[1]



The term "large igneous province" (LIP) was first introduced in 1992 to describe unusually large, short-duration volcanic episodes that are relatively rare throughout Earth's history and that are not easily explained by plate tectonics. The use of LIP has become widely accepted; however, there has been considerable debate as to what exactly a LIP is and how one originates. In his book *Large Igneous Provinces*, Richard E. Ernst has done an excellent job in reviewing these fascinating features and the controversies surrounding them, as well as providing an assessment of our current state of knowledge.

The first two chapters cover the historical context of LIPs and definitions that have previously been proposed. Ernst refines the earlier concepts and provides a new definition that integrates aerial extent, volume (e.g. >0.1 Mkm^3), eruption duration, number of pulses, geochemical signature, and tectonic setting. He makes it clear that intraplate mafic LIPs dominate but distinguishes between LIP and non-LIP magmatism, thus providing a clear separation of what is and is not a LIP. Ernst provides the most comprehensive look to date at what a LIP should include. This, then, provides a sound basis for subdividing LIPs and describing their characteristics, which forms the second part of the book.

Ernst's LIP classification includes the well-established continental, oceanic, and volcanic rifted-margin basalts types, but also the less obvious ones where only small remnants remain, as in Archean and Proterozoic ones, or even just the dike systems. For example, he classifies Archean, nonarc, greenstone belts that have tholeiite–komatiite affinities as LIPs that probably erupted from the hottest part of a mantle plume. His rationale for including areas where only dikes remain is that they must have fed LIPS that now are completely removed, leaving only the plumbing system for our inspection. One criterion for including dike systems into LIP classification is that LIP dikes are typically wider than 10 m, whereas dikes associated with volcanic edifices, mid-ocean ridges, and ophiolites are typically only a few meters wide. Of course, this is not a golden rule: many dikes feeding the Columbia River basalts are less than 10 m wide. Ernst points out that LIP dikes tend to be hundreds to a thousand kilometers long, which is undoubtedly a characteristic of LIPs. He also includes the planetary analog LIPs and silicic LIPs, which have received considerable attention in the last decade. After describing the main categories of LIPs, he then addresses links between LIPs and kimberlites, carbonatites, and lamprophyres.

Following his description and characterization of LIPs, Ernst examines LIP geochemistry. This chapter includes some material that might have been better placed with individual LIP descriptions, but it does provide a nice overview of the general geochemistry of LIPs in one coherent chapter. As such, it is a welcome addition for those wishing to have a summary of the geochemical aspects of LIPs without having to wade through the details of individual ones.

The next three chapters look at the broader aspects of LIPs. First, Ernst considers the role of LIPs in the supercontinent cycle. Then, he examines regional topographic changes associated with the initiation of LIP volcanism: this is an interesting subject because many researchers argue that the emplacement of a LIP is usually preceded by regional domal uplift as caused by the arrival of a mantle plume. Finally, he examines the role of geologic structures (e.g. wrinkle ridges) that are superimposed on many of these features.

The next chapter addresses the impact of LIPs on the environment. Here, Ernst presents an impressive argument for LIPs having played a significant role in effecting climate change through Earth's history and playing a major role in mass extinctions.

By far the most controversial LIP topic is their origin. Initially, the plume model was widely accepted; but in the past decade, this model has come under increasing attack. He begins by reviewing the principal models, including the bolide model, and then discussing the data that supports each. It is clear throughout the book that Ernst favors a plume origin, though he treats alternative models fairly.

The last chapter summarizes the influence that LIPs have had in providing Earth's resources: everything from platinum group elements to water and petroleum. This important topic is typically overlooked by other authors. Few realize how important LIPs are to civilization, especially in areas where flood basalts control regional groundwater supplies.

The book is well written and well referenced with abundant illustrations. Considering the cost and information contained, I consider it worth the price. Ernst developed the book, at least in part, from a course he taught, and this origin shows throughout. The chapter on the supercontinent cycle has a fascinating section that would provide excellent exercises for an introductory tectonic class. Ernst provides eight "Strategies" for using LIPs to constrain continental reconstructions. I could see students applying these strategies in an exercise to reconstruct former continents. Thus, the book would make a great reference for a graduate seminar in LIPs and could be used for other courses, including climate change and tectonics. Anyone with an interest in LIPs will want to have this book.

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1 Ernst RE (2014) Large Igneous Provinces. Cambridge University Press, New York, 666 pp, ISBN 978-0-521-187177-8, US$130.00