DOWNLOAD PDF LARGE IGNEOUS PROVINCES

Chapter 1 : What is a Large Igneous Province? (with pictures)

What are Large Igneous Provinces? Earth history is punctuated by short duration events (or dramatic pulses in longer duration events) during which large volumes of mainly mafic magmas were generated and emplaced by processes unrelated to "normal" sea-floor spreading and subduction.

Definition[edit] In researchers first used the term large igneous province to describe very large accumulationsâ€”areas greater than , square kilometers approximately the area of Iceland â€”of mafic igneous rocks that were erupted or emplaced at depth within an extremely short geological time interval: LIP is now frequently also used to describe voluminous areas of, not just mafic, but all types of igneous rocks. Sub-categorization of LIPs into large volcanic provinces LVP and large plutonic provinces LPP , and including rocks produced by normal plate tectonic processes, has been proposed but are not generally accepted. Motivations for study of LIPs[edit] Map showing the recognized continental large igneous provinces. Large igneous provinces LIPs are created during short-lived igneous events resulting in relatively rapid and high-volume accumulations of volcanic and intrusive igneous rock. These events warrant study because: The possible links to mass extinctions and global environmental and climatic changes. Michael Rampino and Richard Stothers cited eleven distinct flood-basalt episodes - occurring in the past million years - which created volcanic provinces and oceanic plateaus and coincided with mass extinctions. The study of LIPs has economic implications. Some workers associate them with trapped hydrocarbons. Thus the LIP-triggered changes may be used as cases to understand current and future environmental changes. Plate tectonic theory explains topography using interactions between the tectonic plates, as influenced by viscous stresses created by flow within the underlying mantle. Since the mantle is extremely viscous, the mantle flow rate varies in pulses which are reflected in the lithosphere by small amplitude, long wavelength undulations. Understanding how the interaction between mantle flow and lithosphere elevation influences formation of LIPs is important to gaining insights into past mantle dynamics. Earth has an outer shell made of a number of discrete, moving tectonic plates floating on a solid convective mantle above a liquid core. The surface of the Earth reflects stretching, thickening and bending of the tectonic plates as they interact. In this model, tectonic plates diverge at mid-ocean ridges , where hot mantle rock flows upward to fill the space. Hot mantle materials rising up in a plume can spread out radially beneath the tectonic plate causing regions of uplift. Formation theories[edit] The source of many or all LIPs are variously attributed to mantle plumes, to processes associated with plate tectonics or to meteorite impacts. Plume formation of LIPs[edit] Although most of volcanic activity on Earth is associated with subduction zones or mid-oceanic ridges, there are significant regions of long-lived, extensive volcanism, known as hotspots , which are only indirectly related to plate tectonics. The Hawaiianâ€”Emperor seamount chain , located on the Pacific Plate , is one example, tracing millions of years of relative motion as the plate moves over the Hawaii hotspot. Numerous hotspots of varying size and age have been identified across the world. These hotspots move slowly with respect to one another, but move an order of magnitude more quickly with respect to tectonic plates, providing evidence that they are not directly linked to tectonic plates. Others such as the Pitcairn , Samoan and Tahitian hotspots appear to originate at the top of large, transient, hot lava domes termed superswells in the mantle. The remainder appear to originate in the upper mantle and have been suggested to result from the breakup of subducting lithosphere. Images reveal continuous but torturous vertical paths with varying quantities of hotter material, even at depths where crystallographic transformations are predicted to occur. The high volumes of molten material that form the LIPs is postulated to be caused by convection in the upper mantle, which is secondary to the convection driving tectonic plate motion. Basalts from the Ontong Java plateau show similar isotopic and trace element signatures proposed for the early-Earth reservoir. The hotspot pairs include a large igneous province with continental volcanism opposite an oceanic hotspot. Oceanic impacts of large meteorites are expected to have high efficiency in converting energy into seismic waves. These waves would propagate around the world and reconverge close to the antipodal position; small variations are expected as the seismic velocity varies depending upon the route characteristics along which the waves propagate. As the waves focus on the antipodal position, they put the crust at the focal point under significant stress and are proposed to rupture it, creating antipodal pairs. When the meteorite impacts a continent, the lower efficiency of kinetic energy conversion into seismic energy is not expected to create an antipodal hotspot. This model has been challenged because impacts are generally considered seismically too inefficient [15], and the Deccan Traps of India were not antipodal to, and began erupting several Myr before, the end-Cretaceous Chicxulub impact in Mexico. In addition, no clear example of impact-induced volcanism, unrelated to melt sheets, has been confirmed at any known terrestrial crater. Most of these LIPs consist of basalt, but some contain large volumes of associated rhyolite e. Comprehensive taxonomies have been developed to focus technical discussions. In , Bryan and Ernst refined the definition to narrow it somewhat: They are dominantly mafic, but also can have significant ultramafic and silicic components, and some are dominated by silicic magmatism. Large igneous provinces LIP.

Chapter 2 : Talk:Large igneous province - Wikipedia

A large igneous province (LIP) is an extremely large accumulation of igneous rocks, including intrusive (sills) and extrusive (lava flows, tephra deposits), arising when magma travels through the crust towards the surface.

Their significance and potential global impact are related to the total volume of magma intruded and released during these geologically brief events peak eruptions are often within 1â€”5 m. Large igneous provinces thus represent important, albeit episodic, periods of new crust addition. However, most magmatism is basaltic, so that contributions to crustal growth will not always be picked up in zircon geochronology studies, which better trace major episodes of extension-related silicic magmatism and the silicic large igneous provinces. Much headway has been made in our understanding of these anomalous igneous events over the past 25 yr, driving many new ideas and models. Continental flood basalt provinces, such as the Deccan Traps, Siberian Traps, and Columbia River flood basalt province, are some of the best recognized examples of continental large igneous provinces Fig. While continental flood basalt provinces had been widely recognized prior to , it was not until the formative work of Coffin and Eldholm in the early s and the recognition of major igneous provinces submerged along continental margins and in ocean basins that a global record of episodic but relatively frequent catastrophic igneous events was identified and collated Coffin and Eldholm, , , a , b , , Much of this initial recognition of large igneous provinces focused on the relatively well-preserved Mesozoic and Cenozoic record Fig. Consequently, large igneous provinces have been critical to the development of the mantle plume hypothesis e. Many large igneous provinces have been attributed to deep mantle plumes e. However, observed geological inconsistencies with predictions of the mantle plume theory e. In the second part of the paper, we then discuss in more detail, one of the new classes of large igneous provinces recognized in the past 25 yrâ€”silicic large igneous provincesâ€”with the Sierra Madre Occidental of western Mexico used as an example to illustrate the inter-relationships between magmatism and continental rifting. Two topics that are not discussed in detail here are the substantial advancement in knowledge of the physical volcanology of large igneous provinces, particularly continental large igneous provinces, and magnitude of large igneous province basaltic and silicic supereruptions. These topics have recently been extensively reviewed by White et al. To summarize, it is now generally recognized that flood basalt eruptions are not the catastrophic and fast-flowing floods of lava originally envisaged Shaw and Swanson, , but instead, they are more analogous to the largest historic basaltic eruptions in terms of effusion rate, but where eruption life time is sustained for years or decades along very long fissures Swanson et al. Large Igneous Province Events in the Geologic Record The large igneous province record has now been extended back through the Paleozoic and into the Precambrian, with the oldest recognized large igneous province potentially as old as 3. For ancient examples, this task has been made more difficult due to the effects of erosion, burial, and tectonic fragmentation, where only the plumbing systems may now be preserved or remnants now exist on different continents e. As observed for the Mesozoicâ€”Cenozoic large igneous province record, many large igneous provinces have been deconstructed by subsequent tectonic fragmentation, reducing their size and preserved volumes such that it becomes unclear if the dispersed igneous rocks were originally part of a large-volume igneous event, and where its conjugate parts now reside. Establishing the full extent of Paleozoic and older large igneous provinces requires well-constrained plate reconstructions, and a precise knowledge of pre-Pangean supercontinental configurations is currently lacking Pisarevsky et al. Paleomagnetic, geochemical, and especially geochronological studies have been pivotal to show that widely distributed dikes, sills, layered intrusions, batholiths, and any erosional remnants of volcanic rocks were emplaced synchronously, have geochemical similarity, and, therefore, likely to belong to the same event. This is the large igneous province barcode approach of Bleeker and Ernst , Ernst et al. One successful example of the way in which an ancient, deeply eroded large igneous province has been reconstructed is the ca. Large Igneous Province Clusters Large igneous province events are not distributed evenly through geologic time, and from the Phanerozoic record, their frequency is clearly linked to the supercontinent cycle, being principally related to the period of Pangea breakup Fig. Based on the well-defined large igneous province record for the past m. As the record has been expanded and improved over the past 25 yr, principally driven by many, and higher-precision geochronology studies, researchers have realized the temporal coincidence of several large igneous province events large igneous province clusters of Ernst et al. Although with temporally overlapping igneous activity, these events have independently occurred on different tectonic plates large igneous province nodes of Bryan and Ernst, ; Ernst et al. Four clear examples of a temporal clustering of events include clusters at ca. Large igneous provinces with dated igneous activity at ca. The youngest large igneous province cluster at 30 Ma is represented by the overlap of peak activities in the Afro-Arabian continental flood basalt and Sierra Madre Occidental silicic large igneous provinces e. The occurrence of large igneous province clusters is significant for a number of reasons. First, it has led to the suggestion of superplumes, where large igneous province events are interpreted to record one or more large core-mantle boundaryâ€"derived mantle plumes, triggering increased convection in the outer core, halting the magnetic reversal process for tens of millions of years, and increasing oceanic crust production and mantle outgassing Larson, ; cf. Second, large igneous provinces are playing a key role in Precambrian supercontinent reconstructions e. These are then used as supporting evidence for those terranes being nearest neighbors during that time interval Ernst, a. Reconstruction is further enhanced by paleomagnetic studies, geochemical comparisons, and identification of intraplate compositions, and the use of the geometry of dike swarms linear, radiating to orient the terranes Bleeker and Ernst, ; Ernst, a. However, the Mesozoicâ€"Cenozoic record highlights the problem of deciding whether coeval magmatic units that are located on different cratons actually should be reconstructed into a single large igneous province or whether they represent simultaneous but independent events Bryan and Ernst, Temporal overlaps and geochemical similarities will not be sufficient for robust terrane reconstructions in the Precambrian see also Ernst et al. Third, large igneous province events have been considered important drivers of environmental change, coinciding with mass extinctions e. Therefore, the co-occurrence of multiple large igneous province events globally and both in the oceans and on the continents would be predicted to greatly enhance their capacity to drive mass extinctions. Interestingly, the and Ma large igneous province clusters, which represent in excess of million km3 of new, dominantly mafic igneous crust, and which account for the majority of new igneous rock produced by large igneous province events in the breakup of Pangea, do not correlate with the largest mass extinction events or extreme environmental changes see following. Instead, the largest mass extinction events have coincided with a single continental large igneous province event, and why a single large igneous province event may be more significant than global clusterings of events remains unclear. Large Igneous Province Events and Continental Breakup Large igneous provinces are intimately linked to continent and supercontinent plate breakup e. Large igneous provinceâ€"related breakup produces volcanic rifted margins, new and large up to km2 ocean basins, and new, smaller continents that undergo dispersal and ultimately, reassembly e. Most continental-scale rifts that proceed to seafloor spreading develop in association with large igneous provinces, and recent studies are recognizing the importance of magmatism and dike intrusion in rift evolution, such that large magma volumes can facilitate the transition to tectonic rifting Corti et al. More recently, large igneous province fragmentation has also been recognized as an important process in the oceanic realm, where propagation of mid-ocean-ridge spreading centers and ridge jumps break up oceanic large igneous provinces, as suggested for the Ontong Javaâ€"Manihiki and Hikurangi plateau fragments Taylor, Rifting apart of oceanic large igneous provinces by new oceanic spreading centers seems commonplace Fig. It remains unclear why thickened and strengthened oceanic crust of an oceanic plateau should be preferentially rifted apart, where crustal thicknesses may be up to 40â€"45 km Coffin et al. It is interesting to note that at the first-order, the sequence of events in lithospheric rupturing shows little difference between continental and thickened oceanic crust. However, not all continental large igneous provinces lead to continental rupture, and the controls on which large igneous provinces lead to breakup remain poorly understood. This is despite the fact that all Mesozoic to Cenozoic continental large igneous provinces were emplaced into regions of either prior or coeval extension Bryan and Ernst, One factor that may prevent continental rupturing is whether or not the adjacent continental margin is undergoing subduction, such that contractional forces are transmitted into the overriding plate. As discussed later herein, new research is now suggesting the Sierra Madre Occidental was the prerift large igneous province event to the Gulf of California

Bryan et al. The Central Atlantic magmatic province, emplaced at ca. This is a feature of most late Paleozoic to Cenozoic continental large igneous provinces Bryan and Ernst, ; see also Meyer et al. Several provinces also have synrift igneous pulses e. Ancient large igneous provinces are now being used to piece together the ancient supercontinents of Rodinia, Nuna, and Superior, and also constrain the timing of ancient supercontinent cycles e. Large igneous provinces are thus a critical component of the Wilson cycle, and the Atlantic, Indian, and Antarctic Ocean ridge spreading systems can therefore be considered as the consequence of large igneous province events Bryan and Ernst, Crustal Setting of Large Igneous Provinces Following recognition of large igneous province events throughout the geologic record, a clearer picture of the range of crustal settings cratons, continental margins, ocean basins has emerged Bryan and Ernst, Although a wide variety of large igneous province types were initially recognized by Coffin and Eldholm , , this was strongly influenced by Mesozoic to Cenozoic examples, and by volcanic features on the seafloor, such that seamount groups and submarine ridges dominated the initial large igneous province inventory. Many Proterozoicâ€”Paleozoic large igneous provinces occur as eroded flood basalt provinces, exposing their intrusive underpinnings, while the greenstone belts of the tholeiite-komatiite association most likely represent Archean large igneous provinces Ernst, a ; see also Campbell and Hill, Silicic large igneous provinces reflect their crustal setting along young, fertile continental margins Fig. However, a large proportion of the igneous volume generated during a large igneous province event does not reach the surface and remains stored at all depths in the lithosphere. Deeply eroded large igneous provinces, as represented by the giant continental dike swarms and mafic-ultramafic intrusive provinces Ernst and Buchan, ; Ernst, a ; Bryan and Ernst, ; Ernst and Bleeker, , provide windows into the plumbing system and subsurface storage of large igneous province magmas. Some estimates suggest that the ratio of extruded to intruded magma is 1: Oceanic plateaus are the largest large igneous provinces preserved on Earth in terms of area and igneous volume, and the Cretaceous marked a peak in oceanic plateau formation e. To emphasize the continental scale of some large igneous province events, the prerift reconstruction of the oceanic plateau fragments of Ontong Java, Manihiki, and Hikurangi Taylor, results in a single plateau originally the size of the Indian subcontinent. Due to their excess crustal thicknesses, oceanic plateaus are difficult to subduct e. Consequently, large igneous province events represent major, juvenile lithosphere-building episodes and are important to factor into crustal growth models e. The clustering of large igneous province events at times of supercontinent breakup, when hundreds of millions of cubic kilometers of magma are emplaced, and the substantial development of volcanic rifted margins during the breakup of Pangea e. However, because magmatism is fundamentally basaltic, large igneous province magmatism typically yields little to no age signature of new zircon growth except for silicic large igneous provinces , and their substantial mafic igneous contribution to crustal growth will largely go unrecorded in zircon-based crustal growth studies e. For example, 25 continental large igneous provinces are recognized from to 0 Ma, but only five have so far been recognized from to Ma, a period of Pangea assembly Bryan and Ernst, ; Groflin and Bryan, In contrast, six well-defined large igneous province events can be recognized for the relatively short breakup history of Rodinia between ca. This large igneous province episodicity is consistent with a more pulsed history to lithospheric growth. Large Igneous Provinces and Mass Extinction Events The origin of sudden mass extinction events has attracted substantial research effort, and extraordinary and geologically rapid events such as large igneous provinces and large, high-velocity impacts of asteroids or comets with Earth are widely considered to be the most plausible causes for the five major mass extinction events at the end-Ordovician, mid-Devonian Frasnianâ€”Fammenian , end-Permian, end-Triassic, and end-Cretaceous Hallam and Wignall, In particular, a near-perfect association exists between extinction events and large igneous province events over the last m. However, it has also been recognized that many large igneous province events do not coincide with major environmental change or a mass extinction. This is also the case for large asteroid impacts White and Saunders, , with only the end-Cretaceous extinction event being clearly linked with an asteroid impact e. Additionally, no correlation exists between the magnitude of the large igneous province event and the corresponding mass extinction see Fig. In addition, large igneous province clusters e. Consequently, proof of the nature of the causal links between large igneous provinces and extinction events, and whether the juxtaposition of effects from large igneous province volcanism and an asteroid impact is required to cause the largest mass extinctions White and Saunders, , is far from resolved Wignall, There are three main issues in establishing a causal link between large igneous province event s and a mass extinction: Contemporaneity of Large Igneous Province Events and Mass Extinctions Linking mass extinction with the onset and tempo of large igneous province eruptions has proved difficult because of the geographic separation between large igneous provinces and stratigraphic sequences preserving evidence of the extinction Blackburn et al. Consequently, an accurate temporal relationship between the onset of eruption and the main pulse of large igneous provinces and a correlated mass extinction requires precise geochronology, but this remains unclear for a number of large igneous provinces see Fig. This includes the Siberian Traps Bowring et al. Early work, including sampling of flood basalt lava piles, assumed overly simplistic layer-cake stratigraphies for large igneous provinces, and much more complex lava stratigraphies and facies architectures are now apparent e. This is particularly the case for oceanic large igneous provinces, where, often, only the top few hundred meters in a few widely separated locations have been sampled by ocean drilling programs e. Furthermore, recent studies are now finding missing pieces to large igneous provinces where they had been rifted away following continental breakup e. For older large igneous provinces where significant erosion has removed much of the volcanic pile e. Studies of younger large igneous provinces such as the Afro-Arabian have shown that temporal differences can exist between extrusive and intrusive events, such that the exposed hypabyssal, plutonic rocks and dike swarms are younger and biased toward dating crustal extension Menzies et al. A further complication arises in that where flood basalt lavas do contain crystals, they can be recycled i. Dating stratigraphic boundaries has also been fraught with difficulties e. Other studies have drawn attention to issues regarding interlaboratory variability e. Consequently, while more recent studies are now illustrating that some key large igneous province events, based on the dated main phase of volcanism, may slightly either pre- or postdate the corresponding mass extinction event e. Kill Mechanisms of Large Igneous Province Events While large igneous province events are considered the trigger mechanism initiating reactions that lead to environmental conditions resulting in the death of organisms Knoll et al. This is because of the observation that only some large igneous province events have coincided with mass extinctions and others have not, and that little correlation exists between the magnitude of the large igneous province event and the corresponding mass extinction. The implications are that large igneous province events may not always be triggers, the coincidence with an asteroid impact may be required White and Saunders, , ecosystems may have already been under stress in those cases where mass extinction occurred, or large igneous provinces may lead to more than one type of kill mechanism. Several specific kill mechanisms have been identified e. Volcanic aerosol release associated with flood basaltic volcanism during large igneous province events is thought to have influenced the environment in two ways Self et al. For oceanic plateaus, CO_2 emissions are thought to be particularly important, contributing to ocean acidification, global warming, and potentially runaway greenhouse conditions see summary in Kerr, Oceanic plateaus are commonly related to periods of black shale deposition and evidence for oceanic anoxia e. In addition, the physical emplacement of the basaltic plateaus in the oceans is thought to have resulted in sea-level rises, disturbance of oceanic circulation systems and thus nutrient upwelling events, causing increased biological productivity in surface waters, and the catastrophic release of ocean-floor clathrates, all of which contribute to ocean anoxia Kerr, , ,

Chapter 3 : Home | Large Igneous Provinces Commission

Large Igneous Provinces (LIPs) are increasingly recognized to have a significant global environmental effect on the atmosphere and ocean as monitored in the.

Large igneous province Save Only a few of the largest large igneous provinces appear coloured dark purple on this geological map, which depicts crustal geologic provinces as seen in seismic refraction data. A large igneous province LIP is an extremely large accumulation of igneous rocks , including intrusive sills and extrusive lava flows, tephra deposits , arising when magma travels through the crust towards the surface. The formation of LIPs is variously attributed to mantle plumes or to processes associated with divergent plate tectonics. LIPs are fundamentally different from any other currently active volcanoes or volcanic systems. Definition In researchers first used the term large igneous province to describe very large accumulationsâ€"areas greater than , square kilometers approximately the area of Iceland â€"of mafic igneous rocks that were erupted or emplaced at depth within an extremely short geological time interval: LIP is now frequently also used to describe voluminous areas of, not just mafic, but all types of igneous rocks. Sub-categorization of LIPs into large volcanic provinces LVP and large plutonic provinces LPP , and including rocks produced by normal plate tectonic processes, has been proposed but are not generally accepted. Motivations for study of LIPs Map showing the recognized continental large igneous provinces. Large igneous provinces LIPs are created during short-lived igneous events resulting in relatively rapid and high-volume accumulations of volcanic and intrusive igneous rock. 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Understanding how the interaction between mantle flow and lithosphere elevation influences formation of LIPs is important to gaining insights into past mantle dynamics. Earth has an outer shell made of a number of discrete, moving tectonic plates floating on a solid convective mantle above a liquid core. The surface of the Earth reflects stretching, thickening and bending of the tectonic plates as they interact. In this model, tectonic plates diverge at mid-ocean ridges , where hot mantle rock flows upward to fill the space. Hot mantle materials rising up in a plume can spread out radially beneath the tectonic plate causing regions of uplift. Formation theories The source of many or all LIPs are variously attributed to mantle plumes, to processes associated with plate tectonics or to meteorite impacts. Plume formation of LIPs Although most of volcanic activity on Earth is associated with subduction zones or mid-oceanic ridges, there are significant regions of long-lived, extensive volcanism, known as hotspots , which are only indirectly related to plate tectonics. The Hawaiianâ€"Emperor seamount chain , located on the Pacific Plate , is one example, tracing millions of years of relative motion as the plate moves over the Hawaii hotspot. Numerous hotspots of varying size and age have been identified across the world. These hotspots move slowly with respect to one another, but move an order of magnitude more quickly with respect to tectonic plates, providing evidence that they are not directly linked to tectonic plates. Others such as the Pitcairn , Samoan and Tahitian hotspots appear to originate at the top of large, transient, hot lava domes termed superswells in the mantle. The remainder appear to originate in the upper mantle and have been suggested to result from the breakup of subducting lithosphere. Images reveal continuous but torturous vertical paths with varying quantities of hotter material, even at depths where crystallographic transformations are predicted to occur. The high volumes of molten material that form the LIPs is postulated to be caused by convection in the upper mantle, which is secondary to the convection driving tectonic plate motion. Basalts from the Ontong Java plateau show similar isotopic and trace element signatures proposed for the early-Earth reservoir. The hotspot pairs include a large igneous province with continental volcanism opposite an oceanic hotspot. Oceanic impacts of large meteorites are expected to have high efficiency in converting energy into seismic waves. 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The magnitude of such igneous events is perhaps best illustrated by oceanic plateaus. The Ontong Java Plateau in the western Pacific, for example, consists of more than 50 million km 3 of mafic volcanic and plutonic rocks which form a ~30 km thick plateau encompassing an area equal to one third of Australia.

Large Igneous Provinces Millard F. Coffin, Institute for Geophysics. Among the terrestrial planets and moons of our solar system, however, global plate tectonics may well be unique to Earth. Even on Earth, current plate tectonic theory does not predict major crustal growth events termed large igneous provinces, LIPs Figure 3. LIPs are a continuum of voluminous magmatic constructions which include continental flood basalts and associated intrusive rocks, volcanic passive margins, oceanic plateaus, submarine ridges, seamount groups, and ocean basin flood basalts. They form in massive volcanic events that result from a mode of mantle convection different from that driving plate tectonics on Earth. Furthermore, unlike the magmatism associated with plate tectonics that creates new crust exclusively in the ocean basins or at ocean margins, LIPs form independently of plate setting; they form on the continents, in the oceans, and along margins between the two, and either wholly within plates or at plate boundaries. The alternative mode of convection manifested by LIPs is probably how other terrestrial planets and moons lose most, if not all, of their interior heat. Global LIPs, including oceanic plateaus, volcanic passive margins, continental flood basalts, submarine ridges, seamount groups, and ocean basin flood basalts. The CAMP is shown in red. Modified after Coffin and Eldholm, LIPs represent enormous outpourings of predominantly basaltic magma that commonly cover areas of km2 or more. The largest appear to occur in ocean basins, where giant plateaus such as the Ontong Java Plateau in the western Pacific and the Kerguelen Plateau in the Indian Ocean have formed. Similarly, flood basalts were erupted along many "volcanic passive margins" e. Primarily because of ease of access, continental flood basalts are the best sampled and documented type of LIP. Studies of continental flood basalts illustrate the evolution in thinking regarding the importance of such events for Earth evolution. Twenty years ago, when systematic studies of continental flood basalts began, flood volcanism was largely viewed as produced by continental rifting - a "standard" plate tectonic interpretation. Improvements in geochronology, however, have demonstrated that all well-dated continental flood basalt provinces initially thought to have formed over many tens of millions of years instead formed, for the most part, in a million years or less. The rapid melt production rates documented by the eruption of huge volumes of magma in such short time intervals implies a generation mechanism other than rifting, since passive rifting cannot produce such high melting rates. This realization has led to other models involving either the melting of a plume of hot, mantle that rises to the surface from a deep thermal boundary layer, such as that between the core and mantle, or upflow of deep upper mantle in areas where the plate thickness varies greatly. Neither the initial phase of activity that produces the LIPs "plume head" nor the subsequent volcanic activity that commonly produces trailing volcanic ridges and island chains "plume tail" in the ocean basins Figure 3. During Wilsonian periods left , the normal mode of plate tectonics prevails, with opening and closing of oceans and mantle convection with isolated upper and lower mantle. Plumes originate predominantly from the base of the upper layer, and continental growth is dominated by arc accretion. During MOMO episodes right , accumulated cold material descends from the knm boundary layer into the lower mantle, and multiple major plumes rise from the core-mantle boundary to form large igneous provinces LIPs at the surface, thus creating a major overturn. After Stein and Hofmann, The magnitude of such igneous events is perhaps best illustrated by oceanic plateaus. Events of this magnitude are unknown to human experience, but the consequences are dramatic. For example, 1 million km3 of basalt, the size of an average continental flood basalt province, would bury the area east of the Appalachians from Maine to Florida under more than a kilometer of basalt. Indeed, LIP formation correlates temporally with ecological changes and extinction of life forms. For instance, the eruption of the Siberian continental flood basalt province million years ago at the Permian-Triassic boundary coincided with the largest extinction of plants and animals in the geologic record. Ninety percent of all species became extinct at the boundary. On Iceland, the eruption of Laki provides the only human record of experience with the type of volcanism that constructs igneous provinces. If such a relatively small eruption happened today, all air traffic over the North Atlantic would likely be halted for three to six months. Observational and modeling efforts to understand LIP formation and development are at an early stage and are comparable to investigations of the mid-ocean ridge system prior to development of the plate tectonics paradigm, in that no one theory adequately explains large-volume basaltic magmatism on Earth and the other terrestrial planets and satellites. Because the scientific problems associated with LIPs range widely, scientists from many disciplines are involved in their study. These fields include geochronology, marine geophysics, petrology, geochemistry, mineral physics, rock deformation, oceanic and atmospheric chemistry, physical volcanology, paleomagnetics, tectonics, seismology, geodynamics, micropaleontology, paleoclimatology, paleoceanography, sedimentology, remote sensing, and planetary geology. Temporal correlations among geomagnetic polarity, crustal production rages, LIPs, sea water Strontium Sr , sea level, climate, black shales, and mass extinctions. After Coffin and Eldholm , Click on image for a more legible figure. Mantle plumes and episodic crustal growth, Nature, ,

Chapter 5 : Large igneous province | Revolvy

Modelling the location of large igneous provinces for the past million years shows that their eruptions and subsequent weathering modulate global climate. About million years ago, a.

How Large Igneous Provinces affect global climate, sometimes cause mass extinctions, and represent natural markers in the geological record. Palaeogeography, Palaeoclimatology, Palaeoecology, v. See Figures 1 and 2 for global distribution and barcode diagram. They comprise volcanic packages flood basalts , and a plumbing system of mafic dyke swarms, sill complexes, layered intrusions, and a lower crustal magmatic underplate. LIPs occur at a variable rate that averages approximately every 20â€"30 Myr back to at least 2. The rate of LIP occurrence in the Archean is less certain due to its poorer preservation. LIPs are systematically linked to continental breakup or attempted breakup events e. Bleeker and Ernst ; Ernst , ore deposits of a variety of commodity types Ernst and Jowitt , , have an effect on hydrocarbon and aquifers Ernst, , have implication for planetary analogues Ernst et al. Numbers are in Ga. Maps are in Robinson Projection. Global LIPs barcode record with selected labelling updated from Ernst, Each LIP name is followed by location information: Summary of environmental effect of LIPS Large Igneous Provinces LIPs are increasingly recognized to have a significant global environmental effect on the atmosphere and ocean as monitored in the sedimentary record e. Improved U-Pb dating with better than 0. The most dramatic climatic effect and kill mechanism is global warming due to greenhouse-gases from LIPs. An impressive example is the now robust link between the onset of the Sturtian glaciation ca. A link with the Gaskiers glaciation is also now proposed Ernst and Youbi ; Youbi et al. Correlation of LIP events with extinction events, updated from Ernst This figure shows the genus extinction intensity, i. The data are from Rohde and Muller , and are based on Sepkoski The curve is based on marine genera with the LIP record superimposed. Additional kill mechanisms that can be associated with LIPs include oceanic anoxia, ocean acidification, sea level changes, toxic metal input, essential nutrient decrease, producing a complex web of catastrophic environmental effects Figs. Notably, the size of a LIP is not the only important factor in contributing to environmental impact e. Of particular significance are the rate of effusion, and the abundance of LIP-produced pyroclastic material and volatile fluxes that reach the stratosphere. While flood basalt degassing CO_2, SO_2, halogens , and pyroclastic release are is important and is also from associated silicic volcanism; e. Feedbacks are important, such as global warming leading to destabilization of clathrates, consequent release of further greenhouse gases, and greater global warming. In the broadest sense LIPs can affect or even induce shifts between Icehouse, Greenhouse and Hothouse climatic states e. Kidder and Worsley, , However, the specific effects, their severity, and their time sequencing is specific to each LIP. Incorporates environmental data presentation style after Percival et al. Information mainly from Supplementary Table 1 of Ernst and Youbi Global temperature shifts between Hothouse, Greenhouse and Icehouse mostly after Kidder and Worsley, LIPs are marked by red bars, and their lower volume continuations, by pink bars. Flow chart showing environmental effects for both continental and oceanic LIP. Oceanic LIPs modified after Kerr , Link between LIPs and progressive oxygenation of the Earth. Oxygenation curve from Fig. Distribution of Paleoproterozoic glacial intervals from Gumsley et al. Source of information on other glacial intervals from other references discussed in text. Global LIP barcode shown with specific events relevant to the glacial and oxygenation record labelled. Paleoproterozoic glaciations after Gumsley et al. Location labels in parentheses after LIP names explained in Fig. Implications for the precambrian record and time boundaries Based on the robust array of environmental effects due to LIPs, as demonstrated in the Phanerozoic record, it is suggested that LIP events represent useful time markers in the Precambrian Era as proxies for some significant global environmental changes that are preserved in the sedimentary record Ernst and Youbi For instance, there is a potential correlation with black shale events notably at Ma e. While the LIP event itself may be regional, its environmental effects are global. As a contribution toward the identification of appropriate natural boundaries, the current Proterozoic LIP record Ernst, is canvassed for candidates to mark such boundaries. LIPs at â€", , , , â€", â€", , , , , , , â€", Ma are of particular significance for their scale and likely short duration of magmatic pulse s Figs. Short-lived mantle generated magmatic events and their dyke swarms: On the causes of mass extinctions. Large igneous provinces and mass extinctions: Geological Society of America Special Paper , pp. Climate forcing by iron fertilization from repeated ignimbrite eruptions: Cambridge University Press, Cambridge. Cambridge University Press p. Society of Economic Geologists Special Publication 17, pp. Multi-commodity, multi-scale exploration targeting using the Large Igneous Province record. Long-lived connection between southern Siberia and northern Laurentia in the Proterozoic. Timing and tempo of the Great Oxidation Event. A human-induced hothouse climate? GSA Today 22, 4â€" Initiation of Snowball Earth with volcanic sulfur aerosol emissions. Cycles in fossil diversity. Correlating theend-Triassic mass extinction and flood basalt volcanism at the ka level. Geology 38 5 , â€" U-Pb geochronology of the Deccan Traps and relation to the end-Cretaceous mass extinction. Science , â€" A compendium of fossil animal genera. Siberian gas venting and the end-Permian environmental crisis. Large igneous provinces and mass extinctions. The link between large igneous province eruptions and mass extinctions. A temporal and causal link between ca. Implications for geologic time scale and paleoenvironments. Resources for Future Generations conference http:

Chapter 6 : Large Igneous Provinces

The Mackenzie Large Igneous Province (MLIP) is a major Mesoproterozoic large igneous province of the southwestern, western and northwestern Canadian Shield in Canada. It consists of a group of related igneous rocks that were formed during a massive igneous event starting about 1, million years ago.

Chapter 7 : March LIP of the Month | Large Igneous Provinces Commission

Large igneous provinces, commonly referred to as LIPs, comprise mostly volcanic or near-surface intrusions, with outcrop areas â‰¥ km blog.quintoapp.com LIPs have volumes of > km 3 and maximum life spans of about 50 Ma (Bryan & Ernst,).

Chapter 8 : Large igneous provinces contribute to ups and downs in atmospheric carbon dioxide

Large igneous provinces (LIPs) are intraplate magmatic events, involving volumes of mainly mafic magma upwards of , km3, and often above 1 million km3. They are linked to continental break-up, global environmental catastrophes, regional uplift and a variety of ore deposit types.

Chapter 9 : Mackenzie Large Igneous Province - Wikipedia

The Siberian Traps are the largest of several floods of basalt, called Large Igneous Provinces (LIPs), that have occurred during Earth's history and that likely have played a role in regulating.