# DOWNLOAD PDF 4.4. MAGMATIC ARC

## Chapter 1 : The Geology of Indonesia/Java & Java Sea - Wikibooks, open books for an open world

*magmatic arc Quick Reference Where an oceanic plate is sinking beneath a less dense continental plate at a subduction zone, the region of raised elevation between the fore-arc and back-arc basins, where magma is rising.*

Part 1 An Introduction Mt Rainier is one of the premier examples of the "top" of a magmatic arc hydrothermal system and has been extensively studied. Magmatic Arc Hydrothermal Systems: Part 1 An Introduction Posted by: Andrew Watson in Geology , Knowledge Base , The Basics Introduction A magmatic arc hydrothermal system is a class of hydrothermal systems that interlink major styles of precious metal and base metal deposits. These deposits include well known types like epithermal gold-silver , low sulfidation and high sulfidation , polymetallic silver-gold, sediment hosted replacement gold carlin-type , carbonate gold-silver base metal, porphyry copper gold , skarns , and various styles of breccia hosted mineralization. There are several basic concepts needed to fully understand magmatic hydrothermal systems. The first is that all rocks are full of water. It exists in faults, in pore spaces and within and between minerals even deep within the mantle. The second concept is that despite their relatively solid appearance, rocks are actually quite permeable, and water can move relatively freely through them on geologic time scales. The third concept is that metals and minerals can be transported and concentrated in aqueous solutions, which will solidify under the right chemical and pressure changes. Finally, systems need a heat motor to propel all the constituent parts. These intrusions propel fluids through the rock, first by exolving mantle derived aqueous solutions volatiles and by drawing the existing water down down, heating it up and then pushing it back up to the surface in massive convective cells. Digging Deeper Figure 1 Magmatic Arc Hydrothermal Systems â€" Schematic 1 The diagram above illustrates the essence of the four concepts and how they apply to the magmatic arc hydrothermal systems. The blue is a limestone-marl bed. The light green shown throughout is generalized wallrock, yellow green is a volcanic pipe, and the dark green is breccia pipes. Along the top, dotted yellow and horizontal lines are hot-spring related alteration products. Red areas are zones of economic mineralization. On the left there are series of stacked intrusives which end in a breccia close to surface. The up arrows indicate rising magamatic-volatiles that follow along faults and permeable horizons. The yellow speckled zone, is steam heated alteration, while the gradation from red to green charts the progress from hot-acid to cool-neutral alteration types. This setting would be typical of high sulphidation systems. The middle of the diagram represents the meat of the magmatic hydrothermal system: In the base there is a large pink intrusion. It is exolving volatiles squiggle arrows and fluids solid arrows and is driving the whole system. Branching off of it is a large breccia zone to the lower right, with the breccia progressing from chaotic at the base to jigsaw at the top. To the left the intrusion has crosscut a bed of limestone and marl blue , cut by faults half arrows. Rising up from the intrusion to the right are series of faults, and in the center a series of sub-intrusions ending a surface diatreme. To the right the intrusion is exolving fluid into a slightly different setting, which will be discussed later. Rising up are the exolved volatiles and mineralizing fluids, coming down short thick arrows are descending fluids. These are fluids that originally came from the intrusion but have cooled and their chemistry has changed. They are acidic fluids, bicarbonate fluids, and oxygenated fluids. Without getting into too many details, they influence the styles of alteration and mineralization found. Finally there are the styles of mineralization. At the deepest levels there are porphyry copper systems both within and beside wallrock the intrusion. Skarn deposits progress from endoskarns within the intrusion to exoskarns adjacent to the intrusion. Farther away, but along the fault, the limestone hosts replacement mineralization, and even farther away the marl hosts replacement breccia gold. On the far right, there is the final hydrothermal system. A small intrusive is exolving volatiles up a series of faults , and in this case is driving a large convection cell of meteoric water. Again as fluids rise, their chemistry changes and they descend when cooled, as bicarbonate, oxygenated or acidic fluids. Close to the intrusive polymetallic gold-silver is present, while farther away it is polymetallic silver-gold. While the diagram is in two dimensions these systems operate in three dimensions. The relationship can be further obscured by post mineral deformation. In the Guichon batholith both the Highland Valley Cu porphyry and Craigmont Fe-Cu skarn are related to the intrusion but they are many kilometers apart. Though presented as mutually exclusive styles of hydrothermal system, the reality is more complex. Different styles can overlap at different times or phases of mineralization. Systems can overprint or telescope, so that epithermal mineralization is found within a porphyry copper, or be far above it. Both high and low sulphidation can co-occur in the same place but separated by time. At the Comstock Lode an early high sulphidation phase was overprinted by a later low sulphidation. At the Maroto prospect in New Zealand early porphyry veins are crosscut by later epithermal veins created as the system was rapidly tectonically uplifted. How do we know the architecture of system that is spread out over 7 vertical kilometres of crust? In other areas, ancient systems are preserved in the geologic record by circumstance. In the Yerington district of Nevada, for example, the whole hydrothermal system is exposed from porphyry to paleo-surface. This is because the whole system was tilted by faulting rather than being exposed by erosion. The figure below is from Yerington Nevada and shows how these systems look in the real world. Figure 2 Yerington District, Nevada 2 The principles discussed in the first diagram are laid out in their full glory above and below. Figure 3, Figure 2 annotated for clarity A final example relates comes from the Cadia Porphyry system in Australia. This example has been deeply eroded, but it shows the same principles. Had less been eroded, there would have been the more distal parts preserved, and maybe even an epithermal deposit or two. This preservation is common in older terrains, where a few eons have removed kilometers of rock exposing the deeply buried roots. Fluid pathways between them. Hence they have been well studied for hundreds of years, and form the preferred targets for many exploration companies. Still, it is interesting recursive loop, in that as geologists get a greater understanding of these systems there is a bias towards exploring for them, thus generating an even better understanding and increasing their attractiveness. This was a lot to handle for a introduction. Further Reading Corbett, G. Magmatic to nonmagmatic sources of hydrothermal fluids: Their flow paths and alteration effects on rocks and Cu-Mo-Fe-Au ores. Link Forster, David B. Seccombe, and David Phillips.

## Chapter 2 : Back-arc basin - Wikipedia

*Continental Arc Magmatism The dip of the subducting slab has an important role in controlling the amount of magmatic activity (if any) in a continental arc.*

Characteristics[ edit ] Back-arc basins are typically very long several hundreds to thousands of kilometers and relatively narrow a few hundred kilometers. The restricted width of back-arc basins is probably because magmatic activity depends on water and induced mantle convection and these are both concentrated near the subduction zone. These ridges erupt basalts that are similar to those erupted from the mid-ocean ridges ; the main difference is that back-arc basin basalts are often very rich in magmatic water typically  The high water contents of back-arc basin basalt magmas is derived from water carried down the subduction zone and released into the overlying mantle wedge. Additional source of water could be the eclogitization of amphiboles and micas in the subducting slab. Similar to mid-ocean ridges, back-arc basins have hydrothermal vents and associated chemosynthetic communities. The islands of Japan were separated from mainland Asia by back-arc spreading Asymmetry[ edit ] Back-arc basins are different from normal mid-ocean ridges because they are characterized by asymmetric seafloor spreading , but this is quite variable even within single basins. General ideas invoke asymmetries relative to the spreading axis in arc melt generation processes and heat flow, hydration gradients with distance from the slab, mantle wedge effects, and evolution from rifting to spreading. This is the backward motion of the subduction zone relative to the motion of the plate which is being subducted. As the subduction zone and its associated trench pull backward, the overriding plate is stretched, thinning the crust which is manifest in the back-arc basin. Therefore, back-arc basins form when the overriding plate is under extension. In some cases, extension is triggered by the entrance of a buoyant feature in the subduction zone, which locally slows down subduction and induce the subducting plate to rotate adjacent to it. This rotation is associated with trench retreat and overriding plate extension. As the lithosphere stretches, the asthenospheric mantle below rises to shallow depths and partially melts due to adiabatic decompression melting. Sedimentation is strongly asymmetric, with most of the sediment supplied from the active magmatic arc which regresses in step with the rollback of the trench. The active back-arc basins of the world Location[ edit ] Active back-arc basins are found in the Marianas, Tonga-Kermadec, S. Fiji, and Tyrrhenian Sea regions, but most are found in the Western Pacific. Not all subduction zones have back-arc basins, some like the central Andes are associated with rear-arc compression. The Black Sea formed from two separate back-arc basins. History of thought[ edit ] With the development of plate tectonic theory, geologists thought that convergent plate margins were zones of compression, thus zones of strong extension above subduction zones back-arc basins were not expected. The hypothesis that some convergent plate margins were actively spreading was developed by Dan Karig while a graduate student at the Scripps Institution of Oceanography.

## Chapter 3 : Continental arc - Wikipedia

*The diagram above illustrates the essence of the four concepts and how they apply to the magmatic arc hydrothermal systems. There's a lot going on here so let's break it down: Intrusions are squares (fine grained quick cooling) and x's and +'s (coarse grained slow cooling).*

This intrusion consists of quartz-monzogabbro, quartz-monzodiorite, granodiorite and granite that have intruded into the Eocene volcano-sedimentary rocks. This intrusion is medium to high-K calc alkaline, metaluminous, and I-type granitoid. Similarity of patterns suggests a comagmatic source for these rocks and demonstrates the role of magmatic differentiation in their evolution. Clinopyroxene classified as calcic type with varying from clinoenstatite-clinofferosillite to diopside and augite from quartzmonzogabbros to quartz-monzodiorite and granodiorite. Plagioclase composition varies from bytownite and labradorite in quartz-monzogabbros to andesine in quartz-monzodiorites and oligoclase in granodiorites and granites. Core of some plagioclases in granodiorites and granites shows the calcic composition which is labradorite and andesine in granodiorite and andesine in granites. Field investigations along with petrographic and geochemical studies indicate that all phases of the Neshveh intrusion derived from a common magma source as a result of mineral differentiation. Some elements such as Na2O, Sr, Eu and Y follow curves that reflect crystal fractionation of clinopyroxene, plagioc1ase and hornblende. Furthermore, large volumes of quartz-monzogabbros compared to granites, as well as the lack of mafic enclaves in more evolved rocks, are also indicative of crystal fractionation. Fractionation of opaque minerals and apatite throughout the sequence, and the continuous increase in K2O and Ba vs. SiO2 reflect the absence of significant fractionation of biotite and K-feldspar. Introduction Neshveh intrusion located at about 25 km in the northwest of Saveh city and is a small part of the Sahand-Bazman magmatic arc in the Alpine-Himalayan orogenic belt. The arc outcrops mainly consist of Eocene-Miocene volcano-sedimentary sequences and associated plutonic rocks typical of calc-alkaline magmatism developed at active continental margins. The arc developed during the closure of the Neotethyan Ocean between Arabia and Eurasia e. However, little is known about the magmatic activity of the Sahand-Bazman magmatic belt, which was active from Tertiary to Pliocene-Quaternary times Figure 1 [4] [10] [11]. Volcanic rocks are so common in this magmatic belt. These rocks have varieties in composition and tectonic setting which is vary from acidic to basic and con-tinental to shallow marine environments. Acidic-intermediate volcanic and intrusive rocks are widespread in contrast to basic rocks. Intrusive rocks in this magmatic belt show a large range of rock types, dominated by granite and granodiorite but with small amounts of quartz diorite, diorite and gabbro. The Neshveh intrusion was intruded into the volcanic-sedimentary rocks of Eocene Figure 2 and constitute of quartz monzogabbro, quartz monzodiorite, granodiorite and granite Figure 3. Several studies have been carried out in the Saveh region, such as studies of [12] and [13] which were focused on the petrography and Petrochemistry of igneous rocks in the south west of Saveh, volcanic and plutonic rocks in the south of studied area. Previous petrological studies have concentrated mainly on the petrology and tectonic setting of the intermediate-acidic volcanic-plutonic rocks [12] - [15]. In this paper, we combine field and petrography studies with EMPA analysis of the main constitute minerals and whole-rock geochemical data to test whether these various rocks were generated by crystal fractionation or by mixing between basaltic and felsic magmas. Research Methods Our researches in this study consist of two parts: Field studies include identifying the different phases of intrusion, relationship between them and host rock and finally sampling of different phases for laboratory studies. Laboratory investigations include preparing of 90 thin section and petrographic studies. After detailed optical inspection, 8 fresh samples selected for electron microprobe analysis. The major oxide compositions of the minerals e. Detection limits range 0. Regional Geology Neshveh region which is located in the northwest of Saveh is a small part of the Sahand-Bazman magmatic belt within the Central Iranian zone. Based on Saveh geological map 1: These rocks composed of conglo- Figure 1. Schematic geological map of Iran, showing the distribution of the sedimentary and structural units and plutonic igneous rocks [after 16]. SahandBazman magmatic arc and studied area is shown on the map. Several granitoid intrusions were intruded into the Eocene volcanic-sedimentary rocks. Dating of some of these intrusions by [12] using K-Ar method on the amphibole, biotite, K-feldspar and whole rock indicate 28 - 42 Ma Table 1. The Selijerd granodiorite, Khalkhab tonalite-diorite, Neshveh intrusion this study and Neivesht micro-granite are the most important intrusions in the northwest of Saveh. Neshveh intrusion composed of quartz monzogabbro, quartz monzodiorite, granodiorite and granite. In addition to mentioned intrusives, some subvolcanic domes also exist in different parts of the northwest Saveh that have acidic-intermediate composi- Figure 2. The geological map of studied area based on 1: Simplified geological map of NW Saveh intrusions based on satellite data and the geological map of Saveh in1:

## Chapter 4 : Magmatic Arc Hydrothermal Systems: Part 1 An Introduction â€“ Geology for Investors

*Cross-section through the shallow part of a subduction zone showing the relative positions of an active magmatic arc and back-arc basin, such as the southern part of the Izu-Bonin-Mariana Arc. Back-arc basins are geologic basins, submarine features associated with island arcs and subduction zones.*

However, the region has been continuously active tectonically since rifting in the Eocene. The Oligocene-Recent history is more dominated by subduction-related volcanism and limestone deposition. In general, West Java may be subdivided into the following tectonic provinces: A relatively stable platform area, part of the Sundaland Continent, with N-S trending rift basins offshore and adjacent onshore, filled with Eocene-Oligocene non-marine clastics, overlain by Miocene and younger shallow shelf deposits. Structurally complex, N-S trending block faults, E-W trending thrust faults and anticlines and possible wrench tectonism. South-West Java contains a number of sedimentary basins that formed within the axial ridge and in the area between the volcanic arc and submerged accretionary prism associated with the northward subduction of the Indian Oceanic Plate. The most western part of Java Island which may be subdivided into Seribu Carbonate Platform in the north, Rangkas Bitung sedimentary sub-basin, and Bayah High in the south. The northern part of this area is dominated by extensional faulting with very minimum compressional structuring. The basins were dominated by rift related fault which contain several depocentres. The depocentres are dominantly filled with Tertiary sequence with thickness in excess of 5, meters. The significant structures observed in the northern basinal area consist of various type of high trend area associated with faulted anticline and horst block, folding on the downthrown side of the major faults, keystone folding and drape over basement highs. Rotational fault blocks were also observed in several areas. The compressional structuring were only observed in the early NW-SE rift faults. These faults were reactivated during Oligocene time forming several series of downthrown structure associated with transpresional faulting in the Sunda area. Although the Northwest Java basin area is currently positioned in a back arc setting, the West Java Sea rift systems did not form as back-arc basins. Extension direction fault patterns and basin orientation of the Northwest Java basins suggest that the sub-basinal areas are pull-apart basins at the southern terminus of a large, regional, dextral strike-slip system; i. Two observations support the interpretations that these basins are not back-arc related; 1 the extension direction for the WJS rifts is nearly perpendicular to the present subduction zone, 2 a thick continental crust is involved Hamilton, The basin opens southward into the onshore Ciputat, Pasir Putih and Jatibarang Sub-basins, separated by the Rengasdengklok and Kandanghaur â€" Gantar Highs, respectively. The sub-basins are characterised by the presence of alternating highs and lows bounded by extensional deep-seated faults which were active during sedimentation. The Jatibarang Sub-basin is bounded by the Kandanghaur -Gantar- horst-block to the west, and the Cirebon fault, east and north-eastwards. This major growth-fault is responsible for an important accumulation of Tertiary rocks including the Jatibarang volcanics, in the Jatibarang Sub-basin. This sub-basin is bounded by some major faults, especially to the south. The Sunda-Asri basinal area consists of Sunda and Asri basin. This structural element is the westernmost basin of the northern basinal area of West Java. The Sunda Basin is a roughly northsouth depression with its main depocenter, the Seribu half graben, at its eastern edge, separated from the Seribu platform by steep flexures and faults. The Sunda Basin is the deepest basin in the northern basinal area of Java, where the basement is more than 3. A series of normal faults dissect the area in small horst and graben features. The Asri Basin, located to the northeast of the Sunda Basin, is the second deep basin in the region with basement as deep as 3. It is limited from the Sunda platform eastwards by a major normal fault. To the northwards and westwards, it is bordered by steep gradients and is dissected by normal faults. In the following discussion, the sediment sequences are divided into five different tectonostratigraphic units based on their tectonic origins Kohar et al, Basement[ edit ] The sedimentary sequence of the North West Java Sea basins rests on a multi-complexes of a Pre-Tertiary basement representing the continental crest of the Sundaland. The basement assemblage Fig. This melange of low-grade meta-sedimentary, igneous, and meta-igneous rocks is the result of subduction-related accretionary processes associated with the Meratus Suture Fig. Metamorphic grade varies widely throughout the sub-basins indurated limestones to low grade metamorphic philites. Based on basement dating, regional metamorphism ended during the Late Cretaceous, while deformation, uplift, erosion and cooling continued into the Paleocene. Late Cretaceous to Paleogene calc-alkalic magmatism occurred throughout onshore and offshore Java due to normal subduction related processes. Andesitic magmatism continued into the early Eocene. Another important igneous event in the West Java Basin, was a Pliocene phase of alkali basalt magmatism which is preserved as either sills or dikes or as volcanic edifices. Based upon the deep going, mostly extensional-fault series, the basinal area could be divided into alternating graben-like sub-basin and positive ridge or platforms. Early Rift Fill Paleocene? Continental and lacustrine systems dominated these sequences. The early rift fills are typically composed of immature clastics ranging from alluvial fanglomerate and conglomeratic sandstones to fluviatile sandstones and shales, culminated by anoxic lacustrine shales deposition in the Sunda Basin. Further east, in the Arjuna Sub-basin, the sequence is represented by alternating volcanic clastics and lacustrine clastics composed of andesitic volcaniclastics flow and tuff mixed with basement derived sediments Gresko et. The early rift fills overlie basement and present in most of the deepest part of the Sunda, Asri and Arjuna Sub-basins. The alluvial fan facies which composed mainly of conglomerates, coarse to medium grained sandstones associated with basin margin fault. Its thickness ranges from m to 30 m in a distance of 3 miles and until finally shales out to the south. It is interpreted that the alluvial fan deposition associated with a NW-SE trending basin margin fault, forms the early rift fill sediments, and progrades into a possible lake environment further south. The fluviatile sandstones and shales facies which onlap the alluvial fan facies. The fluviatile sandstones is interpreted as an axial channel fill if they are associated with alluvial fan and as a braided alluvial plain deposition on the western flank of the early rift graben hanging wall fill. The third facies is transgressive deep lacustrine facies composed of black shales which covers the entire Banuwati area in the Sunda and Asri basins. The Talangakar is divided into two members, the lower member of Zelda member and the upper member so called Gita member. The sequence is Oligocene to Early Miocene in age and dominated by non marine sediments composed of interbedded fluviatile sandstones, shales and coals. Overbank mudstones and occasionally shallow lacustrine mudstones fill the interchannel area. In the Arjuna area coals, limestones and marine shales are also present in the upper part of the syn-rift unit. The coal and carbonaceous mudstones have been typed as the main hydrocarbon source rock for the Arjuna crude Gresko et. Age determination is problematic in the syn-rift fill unit as diagnostic pollen and fossils are absent. The age determination was based on the overlying post-rift unit Upper Talangakar and the underlying Banuwati lacustrine unit and a thought that this unit has an Oligocene to Early Miocene age. At this time the basin boundaries between the subbasins Sunda, Asri, Hera and Arjuna were not clearly defined. Basin bounding faults perhaps, were still active locally but subsidence had decreased significantly and rifting had ceased. Consequently, accommodation space was not entirely controlled by the movement of the faults for these post-rift sag successions. The overall depocentre shows a relatively symmetrical, work shape basin throughout the West Java Sea area. Non depositions continue to occur on paleohighs until Baturaja carbonate deposition commenced during Middle Miocene time, forming a bald area for the marginal marine deposition of the early syn-rift fills. The early sag basin fills post-rift include the previously described as Upper Talangakar Gita and marine Talangakar Formation and the carbonates of the Baturaja Formation and conformably overlie the syn-rift fills throughout the basin Fig. The lithology in the early sag basin fills is composed of interbedded sandstones, siltstones, mudstones and coal, and marine shales overlain by a continue succession of platform to reefal carbonates Baturaja. The sandstones and reefal carbonates of the early sag basin fill unit contain importance hydrocarbon reservoirs for most of the oil and gas fields in the area. The non marine clastics are dominated by channel, point bar and marine bar sandstones deposited in a wide range of environments from low sinuosity channel on alluvial plain, distributary channel to marginal marine bars. Coals and overbank mudstones and siltstones filled the interchannel area, form an intraformational seal for the prolific fluvial sandstones of the early sag fills unit. As transgressive process continues fluviatile and deltaic sandstones, coals and non marine shales deposition ceased, marine environment gradually advanced onto the highs. Reefal carbonates grew on basement highs i. Krisna, Bima, Rama forming a fringing reef complex around the highs. The lower part of the main sag fills occasionally onlaps the basin flank but by the end of Late Miocene shallow marine deposition covered the West Java Sea area. In the Sunda-Asri area the main sag basin fills are dominated by shallow marine clastics consisting of marine mudstones, calcareous and glauconitic sandstones and thin limestone stringers. The sequence is culminated by extensive platform carbonate deposition with some local carbonate build-up reef within the Air Benakat limestones. The Gumai-Air Benakat Formation sandstones are 10 to 70 feet thick and interbedded with shallow marine mudstones, they typically show a coarsening upward sequences. Locally, carbonate build-up also developed in the southern basin margin area. The carbonate build up consists of skeletal wackestone and packstone with the main grain constituents are corals, benthonic forminifera, bivalves, echinoderm fragments, red algae and minor quartz and glauconite grains. Shallow marine carbonate sedimentation continued of reefal build-ups in the upper part of the main sag basin fills, previously called the Pre-Parigi and Parigi Formation Shallow marine mudstones, shales and glauconitic sandstones filled the inter-reef and open marine area. The distribution of the Pre-Parigi and Parigi build-ups shows a N-S and NW-SE elongation, these build-ups commonly grew on a basement high or on an underlying Baturaja build-up which caused only a slight topographic elevations Fig. The carbonate build-up comprises a combination of skeletal packstone, wackestone, and grainstone interbedded with mudstone lithofacies. On seismic section the geometry and distribution of these build-ups were clearly identified as well defined sub-elliptical build-ups. Late Sag Basin Fills Pliocene-Pleistocene [ edit ] Late sag basin fills represent the latest sedimentary sequence below the present day sedimentation of the West Java Sea area that include the Cisubuh Formation. In the west, the late sag basin fills composed of marine claystone and mudstone and culminated in the continental deposits of conglomerate and volcanic clastic sediments. The continental deposition occurred during the sea level low of the Pleistocene time, approximately 1. Sandstones and conglomeratic sandstones interpreted as fluvitile sandstones and volcanic clastic are the main lithology of the Cisubuh continental. To the east, in the Arjuna basinal area, this unit is composed entirely of marine claystone and mudstone with thin sand stringers. Shallow marine deposition continued in the south eastern part of the Sundaland covering the western part of the North West Java Basin. The entire Bogor Trough is a thrust-fold belt and towards the north, the system is progressively younger in age, starting from Lower Miocene in the south to Plio-Pleistocene in the north. All sediments supplied from the North are shaling out here. Volcaniclastics were brought from the South. The Bogor Trough extends eastwards to the northern East Java region. Lower slope turbidites consisting of alternations of both volcaniclastics and conglomerates with fewer intercalations of volcanic and polymict breccia and claystone characterize the Ciletuh deposits. The second system consists of the transitional to shallow marine quartzose sandstones of the Bayah Formation which are also believed to be mainly Middle to Late Eocene in age. Intercalations of claystone and lignite are common. Marine sediments belonging to the Oligocene Batuasih Formation unconformably overlie this unit. These consists of marls, black claystones and shales which partly interfinger with the Oligo-Miocene Rajamandala Formation reefa1 limestones 90m. These are often thought of as equivalents of the Batu Raja Limestone. The third sedimentary system is characterized by volcanic sediment gravity flows. The lowermost of these is the Early Miocene Jampang Formation, consisting of breccias and tuffs up to m thick.

# DOWNLOAD PDF 4.4. MAGMATIC ARC

## Chapter 5 : Magmatic arc - Oxford Reference

*magmatic arc Java has often been referred to as a classical example of the relationship of calc-alkaline magmatism to subduction. Subduction of the Indian Ocean beneath the Sunda arc is considered to have been active since at least Eocene ~ time, according to geodynamic reconstructions (Hamil- ton , Katili , Rangin et al. ).*

Advanced Search Abstract The Laramide magmatic arc in the Arizpe-Mazocahui quadrangle of north-central Sonora, Mexico, is composed of volcanic rocks assigned to the Tarahumara Formation and several granitic plutons that intrude it. The arc was built over juxtaposed crustal basements of the Caborca and Mazatzal provinces. The lower part of the Tarahumara Formation is composed of rhyolitic ignimbrite and ash-fall tuffs, andesite flows, and interbedded volcaniclastic strata, and its upper part consists of rhyolitic to dacitic ignimbrites, ash-fall tuffs, and volcaniclastic rocks. The Tarahumara Formation shows marked lateral facies change within the study area, and further to the north it grades into the coeval fluvial and lacustrine Cabullona Group. The age of the Tarahumara Formation is between ca. Major and trace element composition of the Laramide igneous rocks shows calc-alkaline differentiation trends typical of continental magmatic arcs, and the isotope geochemistry indicates strong contribution from a mature continental crust. The Nd, Sr, and Pb isotopic values of the studied Laramide rocks permit comparison with the previously defined Laramide isotopic provinces of Sonora and Arizona. The El Gueriguito pluton and Bella Esperanza granodiorite in the northeastern part of the study area along with plutons and mineralization of neighboring northern Sonora have isotopic values that correspond with those of the southeastern Arizona province formed over the Mazatzal basement Lang and Titley, ; Bouse et al. These data permit us to infer that a covered crustal boundary, between the Caborca block with a basement of the Mojave or boundary zone and the Mazatzal province, crosses through the northeastern part of the area. These rocks formed in a continental, Andean-type magmatic arc related to subduction of the Farallon plate beneath North America during Late Cretaceous and early Cenozoic time Coney and Reynolds, ; Dickinson, , ; Damon et al. Based mostly on their own data set of predominantly K-Ar ages of plutonic rocks, Damon et al. The name Mesa formation Valentine, was first assigned to outcrops of this succession near the town of Cananea Fig. Wilson and Rocha applied the term Tarahumara Formation to the Laramide volcanic succession and it became a commonly used name for extensive volcanic and volcaniclastic outcrops in Sonora; they described it as consisting of highly altered, aphanitic intermediate volcanic rocks unconformably overlying Triassic strata in its type section near the town of Tecoripa, in central Sonora Fig. From that locality, McDowell et al. To avoid confusion and to provide uniformity in the terminology, we follow other authors in applying the formal, more commonly used name Tarahumara Formation to this succession throughout its region of exposure McDowell et al. In this paper we provide new constraints on the stratigraphy and geochronology of the Tarahumara volcanic succession and the petrology and geochronology of associated plutonic bodies that represent the Laramide magmatic arc within the Arizpe-Mazocahui area in north-central Sonora Fig. The area is located in a position that is transitional between the classic localities of the Tarahumara Formation to the south, and the Mesa formation to the north. Our work is based on geologic mapping conducted at that scale and illustrated here by a generalized geologic map Fig. Six measured stratigraphic columns and seven accompanying structural sections are included to illustrate the stratigraphic and tectonic relationships of the Laramide rocks with older and younger geologic units. We also dated detrital zircons from four sandstone units to constrain their maximum deposition ages. Two of these come from the Proterozoic basement and two others are from sandstone beds within the Laramide succession. All of the analyzed samples have age and stratigraphic control. The field and analytical data help to document the stratigraphic, tectonic, and temporal framework of the Laramide magmatic arc for this part of the Cordillera, and the new cartography and isotope data place constraints on possible delimitations of the Caborca and Mazatzal crustal blocks. Procedures are described in Appendix 3 and results are in Supplemental Table 4 4. A hornblende separate from sample 04ES-8 was analyzed by the resistance-furnace incremental-heating age spectrum method at the New Mexico Geochronology Research Laboratory. Details of the method and overall operation of the laboratory are provided at http: Radiogenic isotopic and select trace element concentrations were determined at the Isotopic Laboratory of the Geosciences Department of the University of Arizona following procedures reported in Appendix 4. Silver and Anderson noted that it could be divided into a northern block with ages between 1. However, the nature, age, and location of the crustal boundary are debatable. On one side, the Caborca block is interpreted as a piece of crustal southwestern USA translated to its present position by a major left-lateral fault assigned either to the Jurassic Mojave-Sonora megashear Silver and Anderson, ; Anderson and Silver, Fig. On the contrary, Poole et al. Similarly, Arvizu et al. Proterozoic granites with ages near 1. Other granites and gabbros that are assigned to the basement of the Caborca block because of their isotopic signatures and ages of ca. These units exceed a combined thickness of 3. Superjacent Paleozoic clastic and carbonate strata Stewart et al. This Proterozoicâ€”Paleozoic succession of the Caborca block is lithologically different from the Cambrianâ€”Permian sedimentary succession that unconformably overlies the basement of the Mazatzal province and that correlates with and resembles the Paleozoic formations of southeastern Arizona e. The nearby outcrops of this Paleozoic succession occur in the town of Bacoachi Stewart and Poole, and in the vicinity of Cananea, where the successtion is 1. These formations make up a clastic and volcanic succession that was deposited within a continental magmatic arc that developed in northern Sonora Riggs et al. The combined thickness of the Jurassic formations is at least 3. A major Middle to Late Jurassic tectonic event of extensional deformation formed a rift basin, termed the Altar-Cucurpe Basin, where the Cucurpe Formation was deposited Peryam, ; Mauel, ; Mauel et al. Alternatively, formation of this basin has been assigned to development of the left-lateral displacement of the Mojave-Sonora megashear Anderson and Nourse, ; Anderson and Silver, A younger, contractional tectonic event affected the Bisbee Group and older strata during early Late Cretaceous time Rangin, Following a period of uplift and erosion, deposition of the Laramide volcanic arc succession commenced. Regionally, the Laramide magmatic arc of Sonora has been documented mostly through a large geochronology database and geochemical and isotopic studies of the plutonic rocks Anderson and Silver, ; Anderson et al. Some ages are published for the Laramide volcanic rocks north of the study area, in the Cananea-Nacozari region Wodzicki, ; Valencia et al. Based on Sr and Nd isotopic variations and trace element compositions, Laramide granites of northern and central Sonora with ages between 57 and 68 Ma were assigned to northern and central granites by Valencia-Moreno et al. On the basis of Sr, Nd, and Pb isotope geochemistry, other granites with ages between 59 and 67 Ma were considered as belonging to provinces A and B by Housh and McDowell , who also included isotopic characteristics of Oligocene and Miocene volcanic rocks to define their provinces. Geographically, the Laramide granites of provinces A and B roughly occupy the same region as the northern and central granites of Valencia-Moreno et al. Basin and Range deformation structurally dismembered the Laramide arc and older basement Nourse et al. However, most of the area is occupied by outcrops of the volcanic and plutonic rocks of the Laramide magmatic arc; volcanic rocks, sedimentary strata, and a few rhyolitic domes of Oligoceneâ€”Miocene age; and by younger alluvial deposits Fig. Previously published geochronologic information of the Laramide volcanic rocks in the study area include a U-Pb zircon age of 76 Ma from the Santa Ana quadrangle McDowell et al. The Bella Esperanza granodiorite was also dated as Stocks of monzonite and diorite in the Cumobabi Mine Fig. Furthermore, in this work and based mostly on geochronology and geochemistry, we recognize the El Jaralito batholith as a plutonic suite that includes previously unrecognized plutons Fig. The older ages are interpreted as cooling ages of the plutons Mead et al. The Laramide and older rocks of the study area are intruded by rhyolitic and dacitic domes with ages between 23 and 25 Ma Fig. Stratigraphy and Structural Relationship of the Tarahumara Formation Structural relationships of the Tarahumara Formation with older and younger units are illustrated along seven cross sections Figs. Tarahumara Formation stratigraphy is described by means of six measured columns Fig. Samples from different stratigraphic levels of the Tarahumara sections were collected during field work for petrographic, geochronologic, and geochemical studies. Geochemical and isotope analyses were performed from samples collected at same stratigraphic levels of the dated samples and results are presented in Supplemental Table 5 5 and Table 2 , respectively. The main structural and the stratigraphy characteristics of the Tarahumara Formation along the cross sections are described next. The measured thickness of the Tarahumara is m Fig. Its lowermost part consists of crystal-poor rhyodacitic welded tuff and crystal-rich porphyritic dacite. Zircons from the rhyodacite gave a U-Pb age of  The remainder of the section is composed of well-bedded rhyolite ash-fall tuff and brown to reddish volcaniclastic sandstone and siltstone. In the southern part of this section the Cintura and Tarahumara Formations are normally faulted against each other across the Los Alisos fault. It has an incomplete thickness of m and its lower part is occupied by a basal, m-thick conglomerate that grades upward to interbedded volcaniclastic strata, rhyolitic to dacitic ignimbrite, ash-fall tuff and lacustrine limestone. The overlying unit consists of andesitic breccia, rhyolitic ash-fall tuff, and ignimbrite. A normal fault at the top of this unit omits part of the stratigraphic column, and its upper part was measured in the southern flank of Sierra Los Juparos. It is composed of bedded ash-fall tuff, rhyolitic breccias, sandstone, and conglomerate, and its upper part is composed of ignimbritic rhyolite and subordinate interbedded rhyolitic ash-fall tuff. Zircons from the upper ignimbritic rhyolite gave a U-Pb age of  Its basal unit is a m-thick conglomerate with subordinate coarse-grained sandstone and ash-fall tuff beds that grade upward to volcaniclastic sandstone and ash-fall tuffs. Its middle part is composed of dacite to rhyolite ignimbrite and subordinate ash-fall tuffs and its upper part consists of volcaniclastic sandstone, siltstone, andesite breccia, fiamme-rich rhyolite ignimbrite, and dacite ignimbrite. A tuff bed from the lower part of this column did not yield zircons, but McDowell et al. Concordant detrital zircons separated from a tuffaceous sandstone collected m above the base of the formation yielded a younger U-Pb peak age of  A rhyolite from this section yielded a  In the western foothills of the Sierra El Oso, the Tarahumara is offset by the northwest-southeast El Saucito normal fault that dips steeply to the southwest. Because of the El Saucito fault offset, we measured the stratigraphy of the Tarahumara in two columns, named Cerro Colorado and Sierra El Oso, located west and east of the El Saucito fault, respectively. The Cerro Colorado stratigraphic column Fig. Its basal unit is a m-thick conglomerate composed of quartz-rich sandstone clasts that grades upward to a volcaniclastic succession with interbedded rhyolite and dacite ignimbrite. Zircons from a m-thick, fiamme-rich rhyolite tuff located m above the base of the formation yielded an age of  Upward, the succession is composed of rhyolite ignimbrite and ash and lapilli tuff, whereas its middle part consists of andesite flows and breccia, rhyolitic and dacitic ignimbrite, volcaniclastic sandstone, and well-bedded ash-fall tuff. Its upper part is composed of rhyolitic and dacitic ignimbrite, interbedded volcaniclastic sandstone, conglomerate, and andesite ash-fall tuff. The lower part of this column located between the measured section and the Santa Elena Mine Fig. The exposed lower part of the m-thick Sierra El Oso stratigraphic column Fig. Most of the lower part of this succession is composed of rhyolitic to dacitic ignimbrite and interbedded ash-fall tuffs, whereas its middle part consists of volcaniclastic strata, minor ash-fall tuffs, dacite, and andesitic breccia. Its upper part is andesitic and rhyolitic ash-fall tuff, trachyandesite flows, and rhyolite. Zircons from a rhyolitic tuff of this upper part yielded a U-Pb age of  Outcrops of its exposed lower part are interbedded andesitic volcaniclastic sandstone, conglomerate, and andesite flows that are overlain by crystal- and lithic-rhyolite ignimbrite and an interbedded porphyritic dacite that was dated as  The middle part of the Tarahumara Formation is occupied by andesitic flows and its upper part is composed of stratified, crystal- to lithic-rich rhyolite ignimbrite with subordinate rhyolitic and andesitic ash-fall tuff and breccias. A rhyolite from the uppermost part of this succession was dated as  At the southwestern end of this section, the Tarahumara Formation is intruded by the La Aurora tonalite discussed in the following. A rhyolite from the lower part of this succession was dated as  A dacitic ignimbrite from the lower part of this section yielded an age of  Other U-Pb ages of the Tarahumara succession in the study area come from samples that are not located on a measured section. From the Santa Ana quadrangle Fig. A reworked, tuffaceous rhyolite from the Aconchi quadrangle Fig. Based on field observation of well-exposed outcrops, most of the plutons are apparently fresh and homogeneous in texture and mineralogy, although detailed examination could reveal subtle variations in these characteristics.