

General geology of the Lao PDR

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A. The Precambrian and Palaeozoic

The Precambrian is not known in the Lao People's Democratic Republic from direct stratigraphic or geochronological evidence but high-grade metamorphic rocks which are found in certain areas in the northwest, northeast and southeast are believed to be Proterozoic. The Cambrian is known in the valley of the Nam Ma near the border with Viet Nam in the northeast (where it extends into Viet Nam to the northwest and southeast). The rocks comprise slightly metamorphosed limestone, shale (greenschists), sandstone (quartzite) and conglomerates. Similar rocks along the Viet Nam border in the southeast have been mapped as "Cambro-Ordovician". In the Middle Laos metamorphic rocks referred to Neoproterozoic-Lower Cambrian are limitedly exposed in the northern area, belonging to the Kham Keut district Bolikhamxay Province. They have been discriminated into the Sop Phan Formation of Neoproterozoic-Early Cambrian age.

There are a number of well-documented occurrences of fossiliferous marine Ordovician and Silurian (limestone, sandstone, shale etc.) in the north and east, notably in the mountains north of Phonsavan (Xieng Khouang) and along the border with Viet Nam to the east and southeast. The marine Devonian (similar facies) is also well known from many localities in the north and east. Rocks of Ordovician to Devonian age are also found in the area east of the Sekong River, in the southeast.

The Carboniferous and Permian were also times of predominantly marine deposition, mainly shale, sandstone and limestone. The latter forms and outstanding karst topography in parts of the north and east of the country. In a few areas, continental deposits of Carboniferous and Permian age have been found. These include coal near the Vientiane and Saravane (Carboniferous) and at Phongsaly in the far north (Permian).

B. Permo-Triassic Volcanicity

In the north of the country, and especially in the Pak Lay - Luang Prabang area and further northwest towards the Myanmar border, there are widespread occurrences of volcanic rocks which are believed to be mainly Permian and are thought to be the products of subduction-related volcanism. These are dominantly andesites and dacites, with some basalts.

The abundant rhyolitic and dacitic rocks of the Sam Nua area in the northeast are considered to be mainly Triassic. The rhyolites and tuffs which cover large areas in the Sekong valley and along the Cambodian border in the south (and form the Khone Falls on the Mekong) are also regarded as Triassic.

C. Marine Mesozoic

In general; there is evidence of widespread emergence by the late Permian. The marine Triassic is restricted to certain areas where sedimentary basins persisted into or developed in the Triassic. The best known of these is in the Sam Nua area where the marine Middle-Late Triassic (limestones, sandstones, siltstones etc.) is widely distributed, associated with the volcanic rocks referred to in the previous section. There are also occurrences of the marine Triassic in the northwest.

Occurrences of marine Liassic in the Sekong valley near the border with Cambodia constitute the youngest marine beds known in the Lao People's Democratic Republic.

D. Non-Marine Mesozoic

Late Triassic loading and uplift created a mountainous terrain which was subjected to intensive erosion. Much of the territory was covered with the products of this erosion, in the form of continental and paralic sandstones and conglomerates ranging in age from Late Triassic to Cretaceous. The Middle Cretaceous had reduced much of the land to a very subdued relief and there was widespread sedimentation in the form of muds, silts and fine sands, often red, interspersed with periods of deposition of evaporites.

E. Cenozoic

In the Lao People's Democratic Republic, the Paleocene is unknown. Freshwater deposits in numerous small -intermontane valleys in the north represent the Neogene. The deposits are mostly shale and sandstone, with some marls and, in places, lignite.

The late Cainozoic uplift was followed by rapid erosion of the highlands, entrenchment of the Mekong and other major rivers, and deposition of fluvial sands and gravels in the plains. There are fairly extensive flood plain deposits in parts of the lowland area through which the Mekong flows, but they are for the most part thin and intermittent.

The Quaternary is well developed in many separate localities in valleys in the mountainous area of the north, as well as on the Plain of Jars. It consists of fluvial terraces of gravels, sands and silts as well as loess and ash deposits. Erosion surfaces within and on top of the succession are commonly lateritised.

F. Quaternary Volcanicity

The Bolovens plateau east of Pakse and some other smaller upland areas in the east and southeast are made up of basaltic lavas resting upon Mesozoic sandstones. These lavas, like similar occurrences nearby in Viet Nam, Cambodia and Thailand, are Pleistocene, and perhaps partly Neogene, in age. Similar basalts are found in the extreme northwest near Ban Houei Sai, but these cover only a small area.

G. Geological Structure and Intrusive Rocks

The geological structure of the Lao People's Democratic Republic is known only in broad outline. It may conveniently be described in terms of a number of tectonic elements, as shown on Fig. 2. Starting in the northwest, gneisses and associated granites of uncertain age are found along the Mekong River where it forms the border between the Lao People's Democratic Republic and Myanmar. Similar rocks occupy more extensive areas

in Myanmar and in Thailand, to the west and southwest. They are believed to represent a crystalline basement, which had remained a positive structural element throughout Phanerozoic time and as such formed the continental margin of an ocean basin, which lay to the east. From the Silurian to the Triassic (Fig. 2). Sediment in this basin was folded and the basin finally closed in the Triassic. The resulting fold-belt crosses western Lao People's Democratic Republic north-northeast and occupying most of the country west of latitude 103°. A southward extension of the belt crosses northern, central and southeastern Thailand, while to the north the belt extends into Yunnan province of China. Overlying the strongly folded Triassic and older rocks, in the northwest of the Lao People's Democratic Republic there are more gently folded continental sandstone, the oldest of which are believed to be Norian (Upper Triassic), and these give a minimum age for the strong folding.

The oldest known rocks in this NNE-trending fold belt are Devonian. Carboniferous and Permian strata are widely distributed throughout the belt but the marine Triassic seems to be restricted to relatively small areas. Continental beds appear in scattered localities from the Carboniferous onwards.

The Paleozoic and Triassic Rocks are moderately to intensely folded. Parts of the succession (e.g. in the Pak Lay area) consist of low-grade metamorphic rocks (phyllites, greenschists and quartzites). These are believed to be Devonian-Carboniferous rocks first folded (and metamorphosed) in the Carboniferous. The known Permo-Triassic part of the succession shows no sign of regional metamorphism.

In the Pak Lay area there are small granodioritic intrusions of Lower Triassic age; elsewhere there are some granite and granodiorite intrusions whose age is unknown. Gabbros occur near Sayaburi. Volcanic rocks of andesite-dacite composition are very widespread. Little is known about the distribution, field relations, or petrography of these rocks, which are thought to belong mainly to the Permian.

Occupying the north-centre of the country and extending southeast to the Vietnam border is a tract of folded Ordovician-Carboniferous rocks with major Pre-Carboniferous and Triassic granite intrusions and small areas of gneissic (? Proterozoic) basement. The structural trend in this area is generally NW-SE, curving to NNW-SSE towards the north. This zone extends southeastwards into central Vietnam (Fig. 2). It is believed to be essentially the result of early Carboniferous folding which was not however followed by any very marked uplift or emergence; throughout the Carboniferous and Permian limestones were deposited in shallow seas which extended across much of the area.

The extent to which the Lao part of this NW-trending belt may have been affected by regional Mesozoic tectono-magmatic events is not fully known; post-Devonian rocks in eastern Lao People's Democratic Republic are generally not strongly folded but it is believed that most of the many small granite and granodiorite intrusions are Triassic, as in the Vietnamese part of the belt. Some small granite intrusions near Sam Nua and in the Nam Pathene tin field east of Thakhek are believed to be Late Cretaceous or Palaeogene.

The NNW-trending structures in the east and the NNE-trending ones in the west converge towards the north, coming together along NNE-trending faults which extend into Viet Nam (close to latitude 103°) (Fig-2).

The Sam Nua Mesozoic basin in northeastern Lao People's Democratic Republic (Fig. 2) is essentially a much-faulted Triassic structure superimposed on older folded rocks. This basin is generally believed to be intra-continental, with a floor of continental crust formed by Paleozoic folding. Its origin may have been in rifting of the continental block; there was extensive volcanism (rhyolites, rhyodacites and basalts) in the area at about that time.

To the northeast of Sam Nua, part of an Early Paleozoic fold belt, which falls mainly in Viet Nam, crosses the territory of the Lao People's Democratic Republic. This NW-SE trending belt has discontinuous occurrences of basic and ultrabasic rocks aligned parallel to the axis of the belt which are thought to mark the position of a plate suture.

Turning to the southern part of the country, this region has a widespread cover of relatively little deformed rocks. These are for the most part Mesozoic continental deposits laid down partly across eroded "Hercynian" and older Paleozoic fold belts but largely on a basement of unknown, possibly in post-Precambrian age. Earlier platform cover on the Mid-Paleozoic fold belt occurs in the area east of Thakhek in the form of moderately folded Carboniferous and Permian limestone.

The only area in the southern part of the Lao People's Democratic Republic where there is definite evidence of strong Folding of post-Lower Carboniferous rocks is east of Salavan. Folding of a late Carboniferous coal-bearing formation and Permian limestone; in this area was certainly pre-Jurassic and presumably Triassic, at which time there was considerable eruption of acidic volcanic rocks in the area.

Post-orogenic deposition of continental sandstone and conglomerates -in the Jurassic and early Cretaceous has already been referred to. These deposits formerly blanketed most of the country. Warping block faulting and consequent partial removal of this cover took place in the Late Mesozoic-Cainozoic, presumably in response to tectonic forces acting peripherally, especially in western Myanmar and the South China Sea.

Tensional stresses are evidenced by the numerous small graben containing Neogene sediments in the north and by large expanses of Pliocene-Pleistocene basalts, including alkalic types in the extreme south. The Cenozoic structural history of the Lao People's Democratic Republic is, however, at present scarcely understood. There is some evidence from the drainage pattern and distribution of Quaternary fluvial deposits that there was pronounced epeirogenic uplift in the late Cenozoic (? Pliocene-early Pleistocene).