On the structural evolution of Central and Eastern Afghanistan

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Abstract. The Central and Eastern Afghanistan are constituted by blocks of continental basement separated by depressions associated with strike-slip faults showing present-day activity. There are W-E to SW-NE faults converging in the Kabul region. One may distinguish 4 main blocks: Hindu Kush, Band-e-Bayan, Central Ranges and Balouch Province. They are separated by: the Bameyan trough associated with the Herat fault; the Panjaw trough is connected with the Helmand fault and the Kandhar trough connected with Chaman-Argandeh fault.

EVOLUTIONARY HISTORY OF THE FAULTS

Each of the three faults described here have evolved differently:

A– The Bamyan trough was active during the late Tertiary. It is the result of a rift-like collapse, of a zone of Middle Tertiary thermoplutonic activity (volcano-plutonism of Hindu Kush to the north, Yakaolong volcanism within the trough and Koh-e-Baba volcano-plutonism to the south). The study of early Paleozoic faunas indicate the presence, in the trough, of the contact between the northern warm formations of the Hindu Kush and the southern cold formations of Band-e-Bayan. This disposition is the result of a converging movement of the blocks. The Herat fault is then superimposed on a Paleozoic suture.

B– The Panjaw (Farah Rud) trough was an oceanic region from the Trias to the Middle Cretaceous and subsequent to an orogeny, an epicontinental region. But its south-eastern border is a narrow band of strongly metamorphosed Precambrian sediments, with migmatites and granites. Geochronometric datations give 480-450 M.Y. (Rb-Sr). It is the first notification in Afghanistan of a thermometamorphic event similar in age to the Panafrican episode. The Helmend fault was then superimposed on an Ordovician structure.

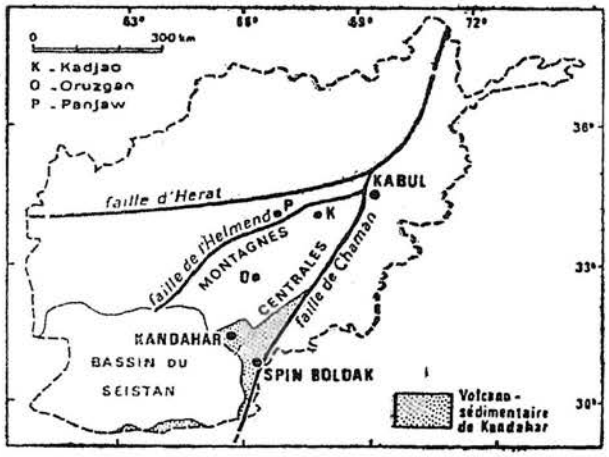
C– The Kandahar trough is situated on the south-eastern border of the Central Ranges. It is constituted from north-west to south-east by an oceanic fore-trench, a volcanic arc and an oceanic deep-trench associated with the subduction of the Indian border under the continental basement of the Central Ranges. The trench was active from the Trias to the Middle Cretaceous; subsequently, it was covered by the neritic Orbitolina (Middle Cretaceous) and Rudist (Upper Cretaceous) formations.

The volcanic arc is accompanied north-westwards by a granitic zone (100 M.Y.), and to the south-east by another granitic zone (50 M.Y.). At the end of the Precambrian, exactly the same stratigraphic sequences occur in Iran, Afghanistan and India. They were then connected.

The beginning of the resorption of oceanic basement along the active margin of Kandahar is Triassic, but the genesis of this basement is much older, perhaps as old as 400 M.Y.

Therefore, the major Afghan faults are connected with structural features as old as Paleozoic, and the strike-slip faults are the reactivation of very old structures during the Alpine orogenesis.

Central and Eastern Afghanistan are composed of continental blocks separated by strike-slip faults, which are still active today, and which led to progressive displacement of the blocks relative to each other (Lapparent, 1977).



Localisation géographique.

Fig. 1. Geographic location

The faults lie on sutures which show complex geologic evolution. Analysis of the history of faulting leads to the opinion that individualization of the blocks is not a recent phenomenon associated with the Alpine orogeny, as could have been surmized, but is a very ancient history and are superposed on faults of various

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types of Paleozoic or even at an end Precambrian age. To describe them only as faults is to omit a major part of their truly complexe developments.

— The Herat fault separates in the north the Hindu Kush and Band-e-Bayan-Koh-e-Baba from the Panjaw trough in the south.

— The Helmand fault separates the Panjaw trough in the north-west from the Central Ranges in the south-east.

— The Chaman-Argandeh fault separates the eastern border of the Central Ranges from the Balouch ranges (Paktia) which represent the western edge of the Indian continent.

A — The Herat fault is well-known in the west of Kabul. It continues eastwards into the Ghorband-Panchir-Pamir zone.

It is underlined by the Tertiary to Recent troughs of Yakao-lang-Bamyan (Lang, 1972 where mainly Neogene subsidence is observed, associated with volcano-plutonic activity which occurs not only in the troughs but also on their margins with volcanoes and granite plutons dated at about 35 M.Y. (Bordet at al., 1971). Thermomineral sources occur along the bordering faults.

Information on the possible Middle and Upper Paleozoic movement along the Herat fault is scanty, for outcrops of these ages are scattered. Permo-Carboniferous occurs on the southern lip of the trough and the most distant outcrops seem to indicate a biostratigraphic unity which shows that the two lips were side by side, and knew the same peri-Gondwana paleogeographic conditions of cold seas during the Carboniferous and of warm Fusulina seas during the Permian. Lower Paleozoic formations (Cambrian, Ordovician, Silurian, Devonian) occur within the trough and on its slopes. Recent study of the microfauna and their associations (Vachard, in press) show a clearly different paleoclimatic environment: warmer on the northern slope (Hindu Kush) and colder on the southern one (Band-e-Bayan). This leads to the conclusion that a considerable distance separated the slopes in those days, amounting to at least several degrees of latitude. This supports the tectonic hypotheses proposed for the Hindu Kush (Boulin *et al.* 1977) and the paleogeographic reconstitution of Termier and Termier, 1977. This further implies the existence of a major Lower Paleozoic discontinuity along the fault. The date of its initiation is as yet unknown, and may be Precambrian (?); it was sutured at the start of the Carboniferous and reactivated during two alpine orogenic phases with activity still continuing at present.

B — The Helmand fault separates the Panjaw tectonic trough and its SW extension in the Farah Rud from the northern border of the Central Ranges. It has been well studied in the N.E. between Argandeh and Delkundi. It extends S.W. to reach the Quaternary depression of Registan some 150 km west of Kandahar. This region is unfortunately of difficult access and study has not made much progress.

The Panjaw trough contains a flysch series of Triassic to Upper Jurassic age. To the south-east was a continuous band of metamorphic rocks with an ophiolite suite with reactionary glaucophane and containing large calcareous olistoliths probably of Permian age. A Lower Cretaceous phase of compression was followed by an unconformable post-orogenic series, attributed to "Red Grit" followed by Middle Cretaceous Orbitolina beds (Blaise *et al.*, 1978).

Evolution took place therefore between the Trias (micro-faunas) and the unconformable basal Cretaceous. Little is known on its later evolution: for a cover of possibly Tertiary formations can only be differentiated by geochronology. The north-west border of the Central Ranges — wherever it has been studied — comprises a Precambrian basement: the Beshud Series which is flyschoid volcano-sedimentary and epimeta-morphic. Plutons of light porphyroid granite cut the basement and extend far to the south-west (Helmand alignment of Debon *et al.*, 1980). The overthrust Beshud schists, above the Panjaw series, are bordered by anatectic gneiss (Rah Kol gneiss) some ten kilometers wide. Recent dating both on the granites and the gneiss gives ages of 480-450 M.Y. It is remarkable that the Paleozoic series of the Central Ranges, to the south-east, commence with the Cambrian and show no Devonian stratigraphic discontinuity (Blaise *et al.*, 1977); only a progressive north-western transgression of successive stages of the Paleozoic over the Beshud basement has been observed (the Upper Carboniferous and the Permian are directly transgressive on the Beshud basement). The latter formed, in the north-west of the basin, an eroding ridge since at least the Lower Ordovician. On the axis of this ridge took place the rupture that gave rise to the overthrusting of the Central Ranges over the Panjaw trough and then to the Helmund fault. It is not as yet known whether the other margin of the structure constitutes the basement of the Panjaw Series (which does not outcrop) or it lies in the southern border of the Band-e-Bayan.

The 450-480 M.Y. age indicates a Lower Paleozoic date for the initial movement along the fault. This age is well-known in Gondwana territory (India-Africa: Panafrican episode) (Crawford, 1977, Hurley 1974). This age has been reworked by 20 M.Y. in the Maydan — Argandeh region.

C — Joining the Helmand and the Chaman faults, the Chaman-Argandeh fault lies on the eastern border

of the Central Ranges, separating them from the Cenozoic Paktia formations (Balouch ranges).

The former show the back-land features of an orogeny and the latter fore-land features. Between them, the Kandahar basin (sensu lato) has the curious particularity of having its original structure preserved, little or not deformed by the Tertiary orogeny and without the generally occuring thrust sheets. An active continental margin and foredeeps and volcanic arc and main trench can be recognized at the base of which lay a subduction surface, now replaced by the Chaman fault.

The ocean which delimited the structure was directly connected to the south and west with the Mesosea of which the characteristic Upper Jurassic-Cretaceous fauna can be found.

The fore-deep lay west of Kandahar: it consists of a thick series of dark schists, radiolarites and submarine volcanites with limestone olistoliths. It is cut by a line of granodiorites (called Arghandob line) of Upper Jurassic-Middle Cretaceous age.

The volcanic calco-alkaline arc was temporarily above sea level: (red conglomerate), it is overlain by Orbitolina limestones and rudist reefs of the Middle Cretaceous (Albian), overlain on their turn by massive Upper Cretaceous limestones. Volcanism was still active during deposition of the Orbitolina limestones. The olistoliths slid into both the fore-deep and into the main trench: some, with Orbitolina, indicate that infilling continued in the Middle Cretaceous. The main trench, filled with schists and radiolarites, is cut by granitic plutons of Upper Paleocene age.

Northwards, volcanism appears to have continued longer (Upper Cretaceous) and it is covered by Nummulite beds (Carbonnel, 1977); younger formations, which would have enabled the last stages of evolution to be described, are not known.

The Kandahar margin started its evolution in the Trias. Unfortunately, no Paleozoic formations are known in the region. The basement, locally outcropping, resembles the Beshud schists and is cut by basic dykes.

It is noteworthy that there exists, further north, in the Central Ranges (Zarkaran), a thick series that can be considered as infra-Cambrian (de Lapparent, 1977) which resembles closely both the series in Iran (Stocklin and Rutner, 1977) and those of the Salt Range in Pakistan (Stocklin, pers. comm.). During those times, there was a stratigraphic continuity between these areas. The opening of the ocean, of which the Kandahar series is the margin, is older for at that time it had already formed a structure which was subducted through the well-formed oceanic crust which originally separated Afghanistan from India. If this oceanic basement had required so long for its resorption, an age of over 400 M.Y. must be attributed to its inception. The relatively restricted width of this ocean did not prevent the cold influences of the Carboniferous Gondawana glaciation from extending as far as the Central Ranges. The appearance of the Chaman fault — which is still active today — moving several cm/year (Beun et al., 1979), followed upon the arrest of subduction: it commenced well after the Indian-Afghan collision (estimated at 40 M.Y.) and has been active only over the past 10 M.Y. It represents the present-day trace of a very ancient continental fault.

CONCLUSIONS

The geological history of the three major faults visible on the map of Afghanistan started in the Lower Paleozoic or even earlier.

These fragile zones were reactivated during the principal successive orogenies which affected the region (eo-Hercynian, eo-eventually neo-Cimmerian-Alpine). The structure of Afghanistan can be said to have been inherited from dispositions existing at the start of geological eras, though, obviously, it is impossible to estimate the displacements that affected the continental blocks along these faults. The paleogeography rests therefore obscure and will be the subject of future studies.

REFERENCES

Beun.N, Border P., Carbonnel J P., 1979. — C.R.Ac.Sc. France T. 288 p. 931-934

Blaise J., Border P., Carbonnel J.P., Montenat Ch., 1979 — Bull. Soc. Geol. France (7) T XX, p. 795-798

Blaise J., Bordet P., Montenat Ch., Desparmet R., Marin Ph., 1977 — Mem. h. ser. Sec. Geol France n°8. p. 117-144.

Bordet P., Lang J.,1974 — Rev. Geogr. Phys. Geol. dyn. (2), T XVI p. 351-60.

Bordet P., Bouyx-E., Lang J., 1971 — C.R. somm. Sec. Geol. France, p. 181-183.

Bordet P., Carbonnel J.P., Desmet A., Montenat Ch., Vachard D., 1979. — 7e R.A.S T. Lyon.

Boulin J., Bouyx E., 1977. — Mem. h. ser. Soc. Geol. France n°8 p. 87-106.

Carbonnel J.P., 1977. — Mem. h. ser. Soc. Geol. France n°8 p. 251-62.

Debon F., Le Fort P., Sonet J., 1980 — 8e R.A.S.T. Marseille.

Hurley P M., 1974. — Geology T2, p. 373-370.

Lang J., 1972. — Rev. Geogr. phys. Geol. dyn. France (2) T XIV, p 415-426.

Lapparent A.F. (de) 1977. — Mem. h. ser. Soc. Geol. France n°8 p 19-22.

Mattauer M., Proust F., Tapponier P., Cassaigneau C., 1978. — C.R.Ac Sc. France T. 287, p. 983.

Montenat Ch., Sornet J., Vachard D, Bordet P., Carbonnel J.P., Desmet A., 1979. — C.R.Ac. France T. 289, p. 651-654.

Sborshchikov et al., 1973. — Geol. Min. Res. Afghan.

Stockling J., Ruttner A., Nabavi M., 1964. — Geol. Surv. Iran, 20p.

Termier H, Termier G., 1977. — Mem. h. ser. Soc. Geol. France n°8, p. 309 324.

Wittekindt H.P., Weippert D., 1973. — Geological map Centr. South. Afghanistan Hannover.