2-4 Stratigraphy and Geological Structure

(1) Stratigraphical Correlation (Fig. I-5)

The basement rocks in this area mostly have pelitic and carbonatic rocks and judging from the rock facies and the geological structure, the pelitic semischist, the lowermost succession found in the eastern part of the surveyed area, is estimated to be correlated to the pelitic schist which is the uppermost succession in the western part of the area. The acidic volcanic rocks distributed in Amzourh area and Frizem area are thought to be different in view of their ages.

(2) Geological Structure

The surveyed area is located along the axis of the great synclinal structure developed along the northern margin of the Haut Atlas mountain range, which extends in the direction of WSW-ENE.

The Guemassa fault is the fault developed along the axis of this great synclinal structure and different geological structures are recognized bounded by this fault. In the south side of the fault, the trend of the strata is in NW-SE direction, while it is NNE-SSW in the north side of the fault.

With the development of many drag folds, intrafolial folds and schistosity faults, quite complicated composit folding structure has been formed in the basement rocks in this surveyed area. However, it can be said that the basement rocks are dipping toward the east or northeast as a whole, and that the older strata are exposed in the west while the younger layers are accumulated in the east.

The Hajar horizon, mostly covered with the Quaternary sediments, is estimated to extend in WNW direction to the Oukhribane block and the Amzourh block to the west and then toward the Rial area changing the trend to the north. It is estimated that the horizon extends to the Souktana Block to the west.

2-5 Chemical Properties of Rocks

The results of chemical analysis of rock samples in total 20 are shown in the Ap. I-3. The values of SiO_2 of the igneous rocks excluding gabbro are 70 % to 80 % which contents are classified in the range of rhyorite, though the values of Na_2O and K_2O are fairly small.

The values of SiO_2 of the sedimentary rocks are 57 % to 64 % in the pelitic rocks and 53 % to 57 % in the green rocks. The values of K_2O are varied and up to 6 % in the green rocks. The clear difference of the main chemical contents is recognized between green rocks and pelitic rocks. The difference of SiO_2 contents seems to reflect the difference of each original rock and the variation of K_2O contents in the green rocks seems to be caused by the alteration after sedimentation.

The chemical and mineral components of the schist or semischist have been changed in the term of metamorphism. To examine the mineralogical paragenesis, A-C-F diagram and A-F-M diagram are drawn up as shown in the Fig. I-6. In the A-C-F diagram, the pelitic rocks of this area are plotted in the small sphere. The ratios of $A(=Al_2O_3-3K_2O-Na_2O)$, F(FeO) and M(MgO) elements are similar to each other and the ratio of A-F-M elements corresponds to the ratio of chlorite. It means that chlorite is the most common secondary mineral in the pelitic rocks of this area.

The igneous rocks and the green rocks in this area show the different A-F-M ratio to the pelitic rocks and are plotted in the sphere of high $(3K_2O + Na_2O)/(Al_2O_3 + 3K_2O + Na_2O)$ ratio or high $MgO/(MgO + FeO)$ ratio. It shows a differentiation of chemical components in each igneous rock and green rock.

In the A-C-F diagram, all the rock in this area are plotted in the sphere of abounding CaO and Al_2O_3 compared with FeO. This sphere means to be liable to occur calcite, actinolite, and epidote.

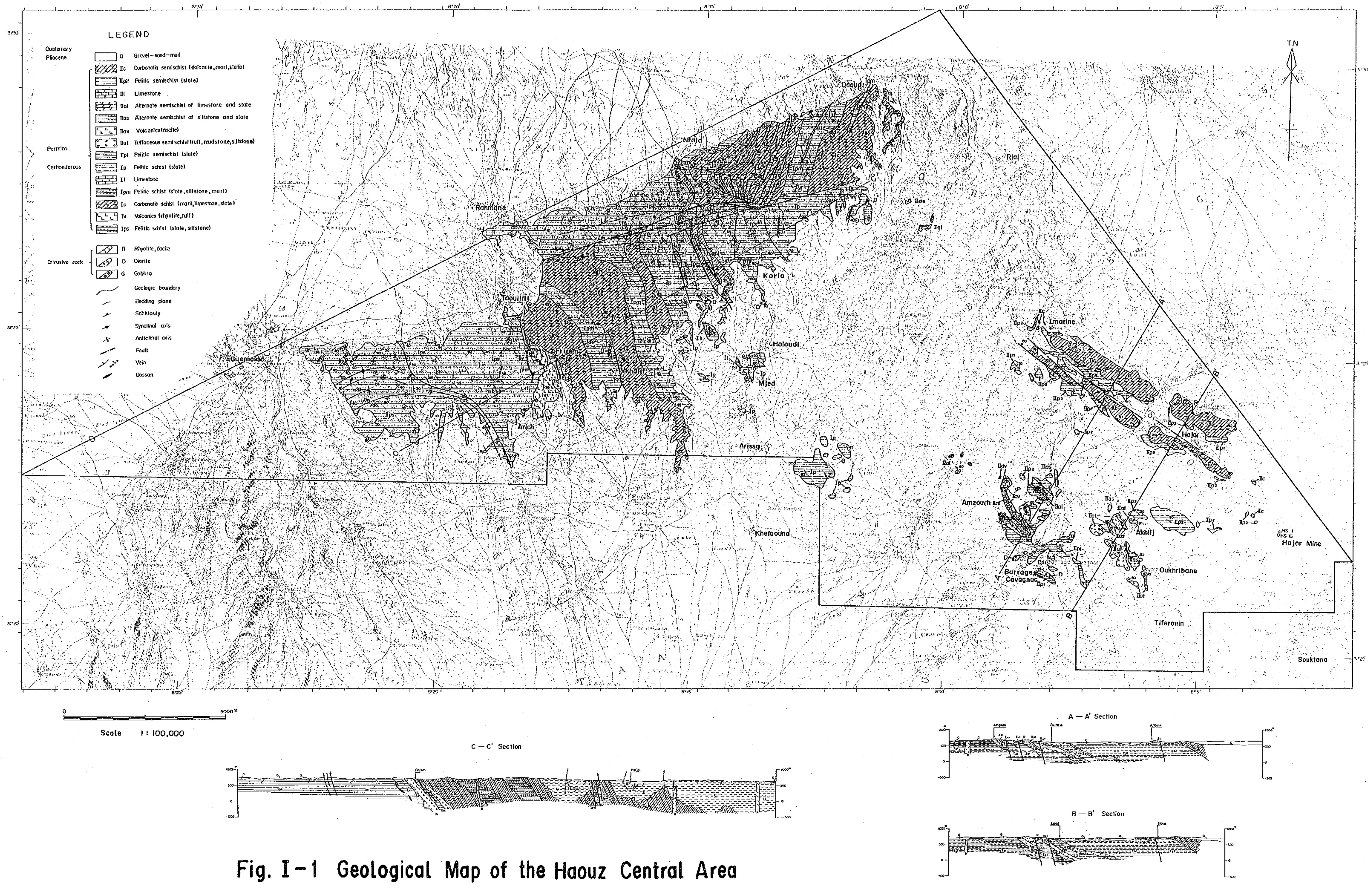


Fig. I-1 Geological Map of the Haouz Central Area

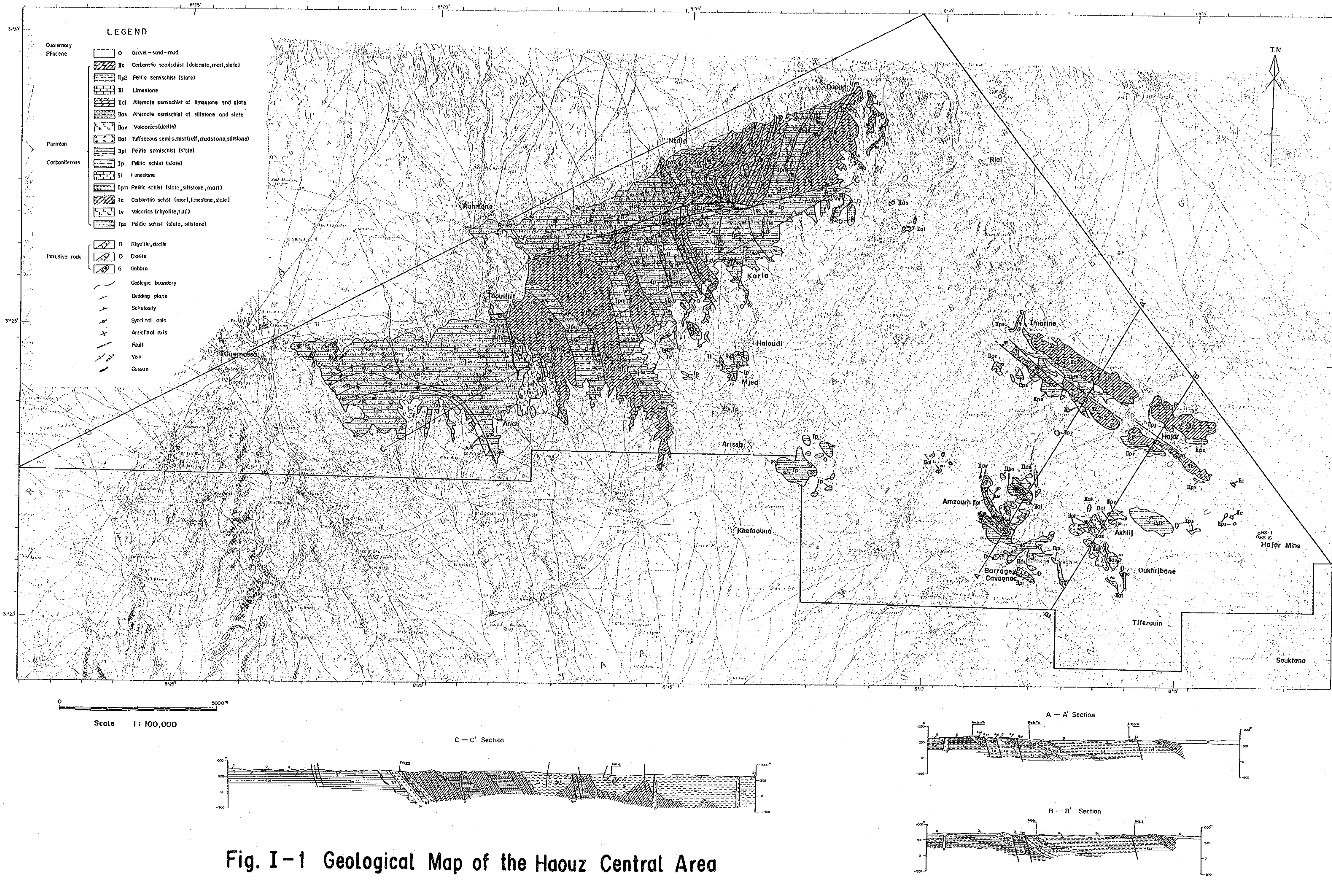


Fig. I-1 Geological Map of the Haouz Central Area

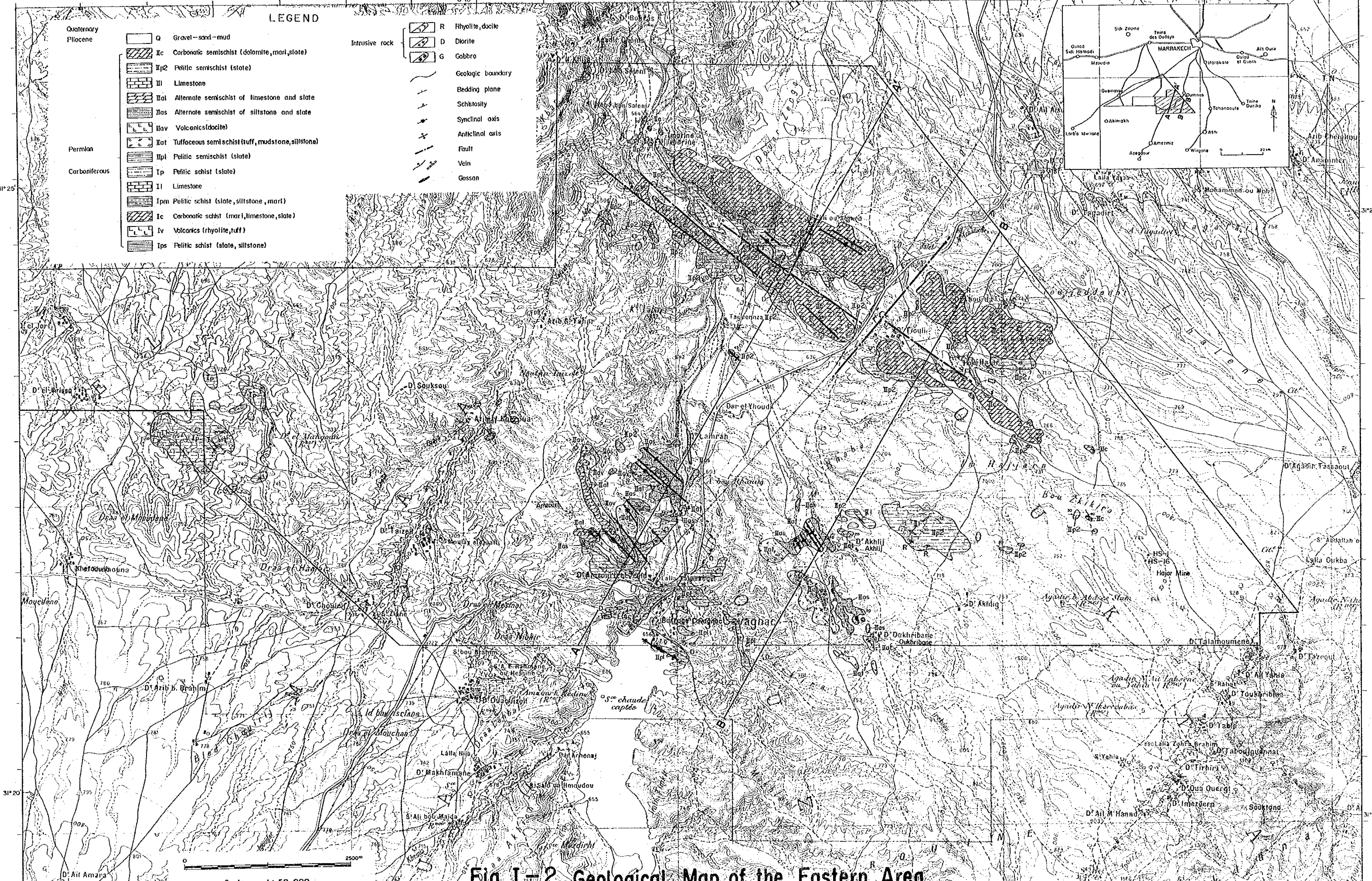


Fig. I-2 Geological Map of the Eastern Area

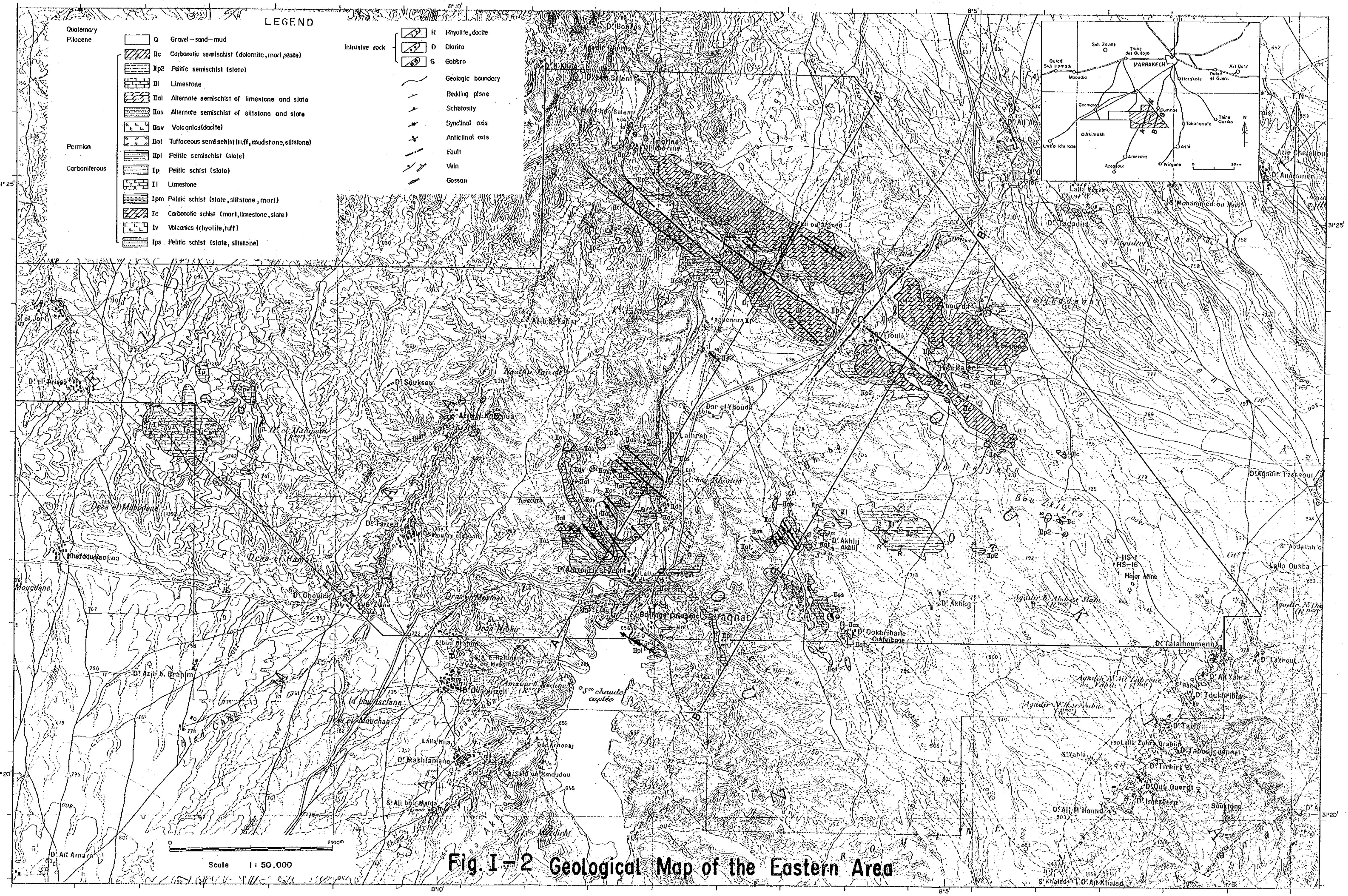


Fig. I-2 Geological Map of the Eastern Area

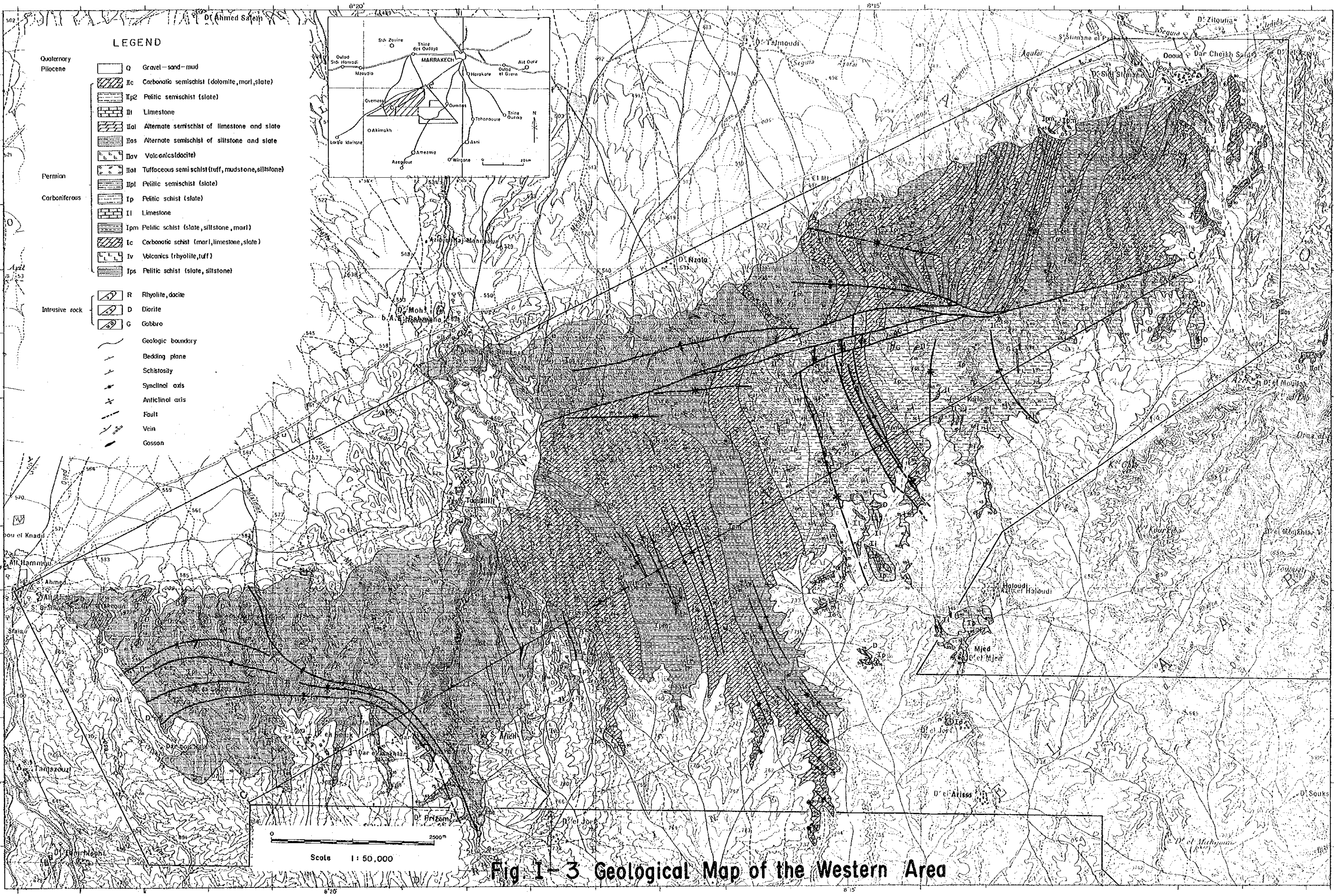


Fig. I-3 Geological Map of the Western Area

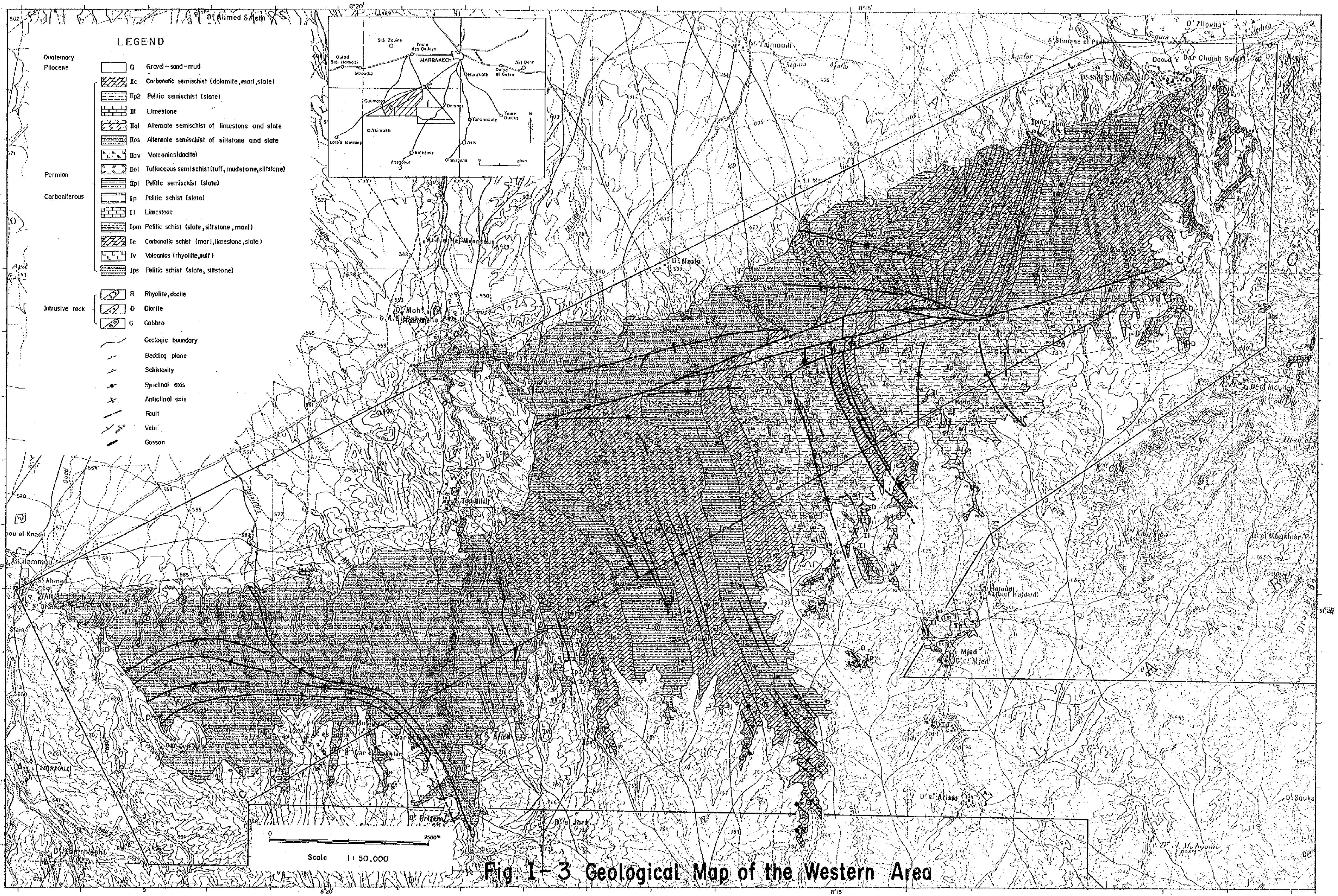


Fig. I-3 Geological Map of the Western Area

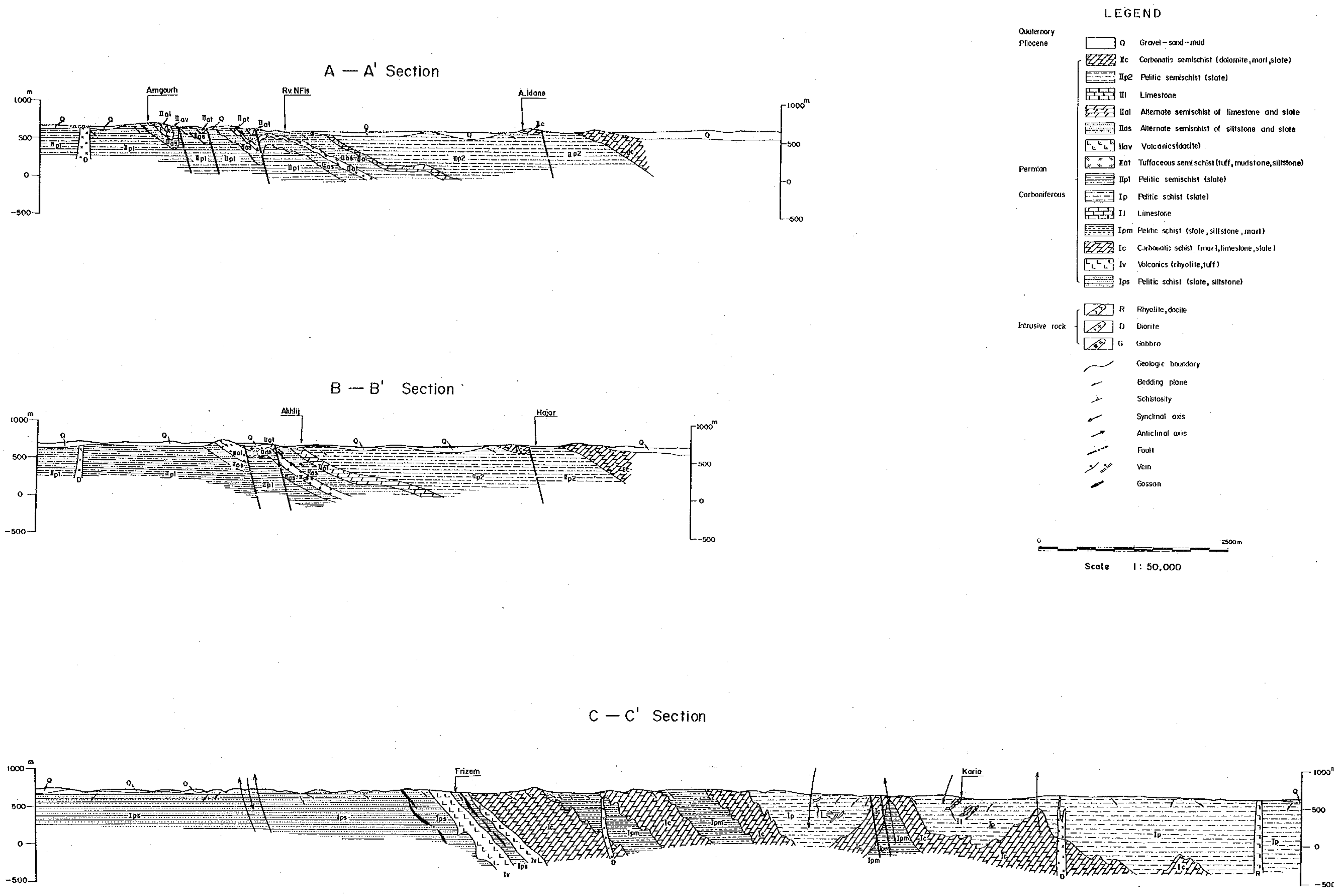


Fig. I-4 Geological Section of the Eastern and Western Areas

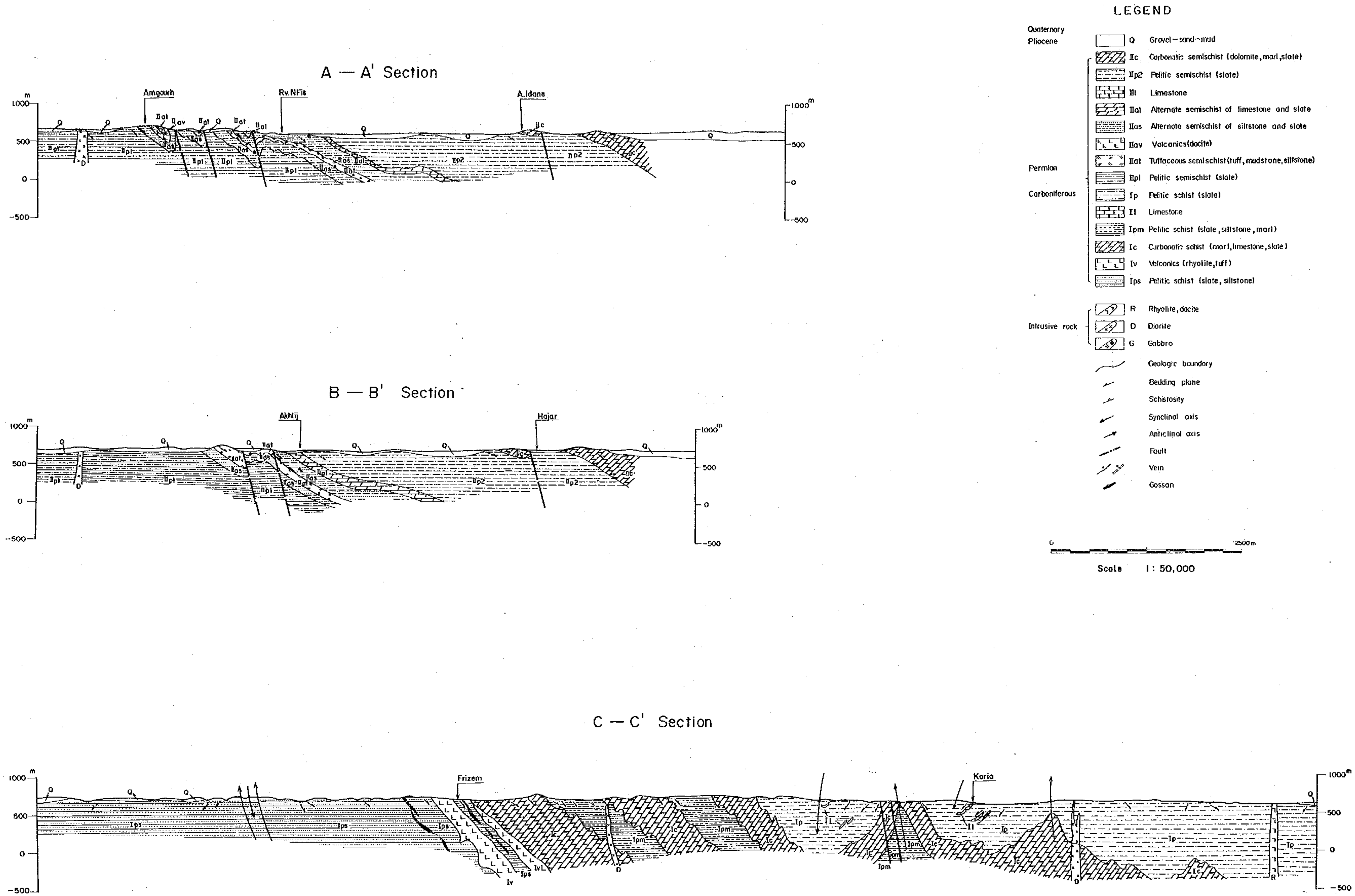
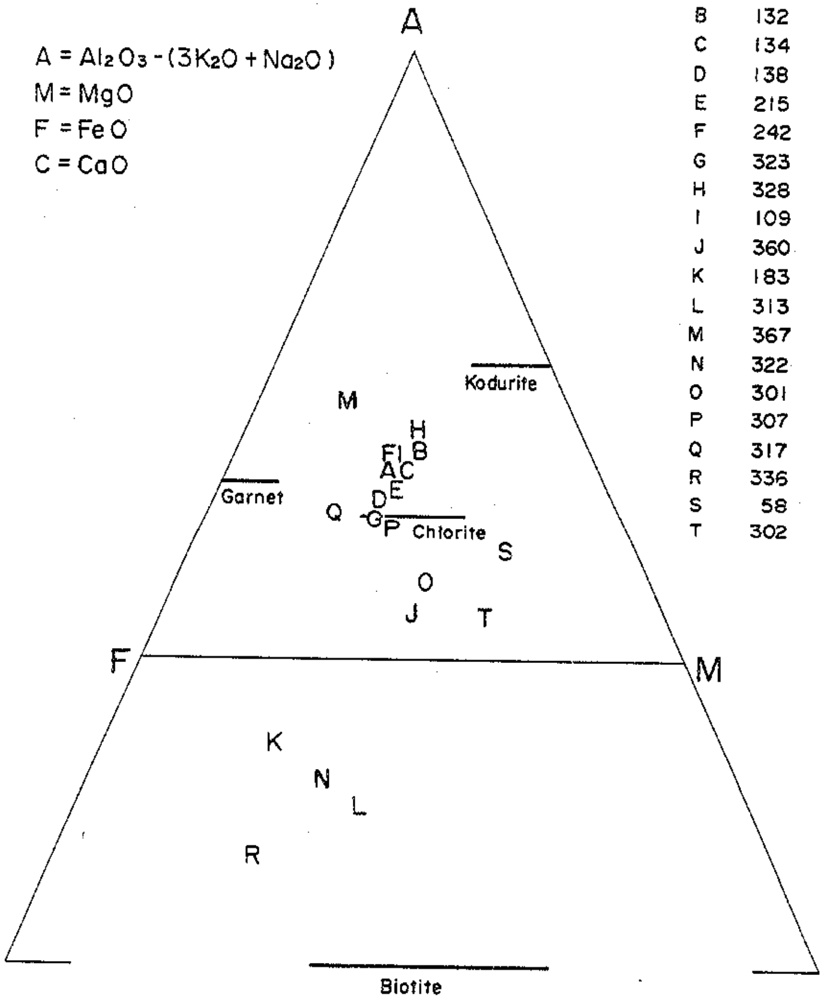


Fig. I-4 Geological Section of the Eastern and Western Areas

Geological Age	Fm.	Stratigraphic Column	Lithology	Thick. (m)	Area	Tectonic Movement	Igneous Activity	Mineralization
Quaternary	Q		Gravel · sand · mud	+ 120				
Tertiary						Alpine		
Cretaceous								
Jurassic							Rhyolite, Diorite, Gabbro	
Triassic						Hercynian		
Permian ~ Carboniferous	IIc		Carbonatic semischist (marl · dolomite · slate)	+ 400	Eastern Area			
	IIp2		Pelitic semischist (slate · limestone · siltstone)	± 900				
	IIa		Volcanics & alternation zone (dacite · tuff · limestone · siltstone · slate)	± 500			Dacite, Rhyolite	Massive sedimentary type
	IIp1 ~ Ip		Pelitic semischist (slate) Pelitic schist (slate · limestone)	+ 1500	Western Area			
	Ipm · Ic		Carbonatic & Pelitic schist (marl · slate · siltstone)	+ 1500				
	Iv		Volcanics (rhyolite · tuff · slate)	± 400			Rhyolite	Vein type
	Ips		Pelitic schist (slate · siltstone)	+ 1500				

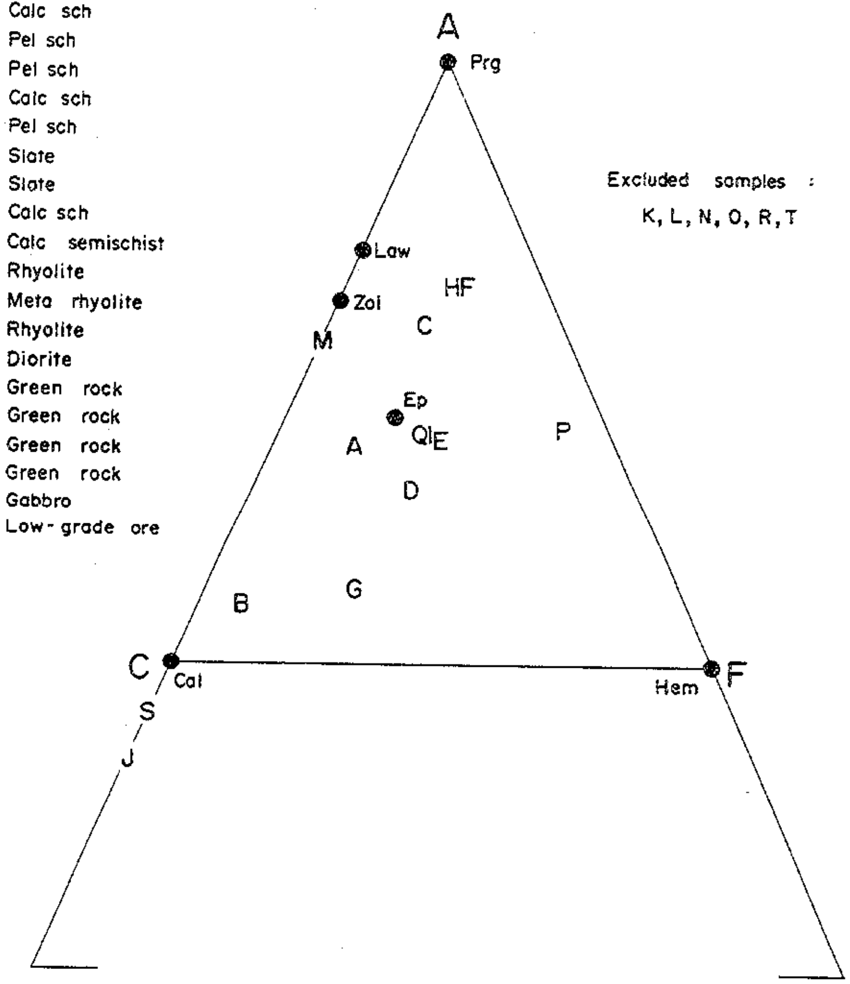
Fig. I-5 Schematic Geological Column of the Surveyed Area

A = $Al_2O_3 - (3K_2O + Na_2O)$
M = MgO
F = FeO
C = CaO



(1) A-F-M Diagram

Sym-bol	Sample No.	Type of sample
A	103	Pel sch
B	132	Calc sch
C	134	Pel sch
D	138	Pel sch
E	215	Calc sch
F	242	Pel sch
G	323	Slate
H	328	Slate
I	109	Calc sch
J	360	Calc semischist
K	183	Rhyolite
L	313	Meta rhyolite
M	367	Rhyolite
N	322	Diorite
O	301	Green rock
P	307	Green rock
Q	317	Green rock
R	336	Green rock
S	58	Gabbro
T	302	Low-grade ore



Excluded samples : K, L, N, O, R, T

(2) A-C-F Diagram

Fig. I-6 Paragenesis Diagram of Rock Samples

CHAPTER 3 MINERALIZATION

3-1 Outline of Ore Deposits

As for the mineral indication in the surveyed area, gossaneous indication of mineralization at Oukhribane, Amzourh and Frizem are noted.

The Hajar ore deposit is found to be emplaced in the Carboniferous-Permian system covered with the Pliocen to Quaternary sediments. The Carboniferous-Permian system is distributed discontinuously in the ESE direction from the area as an essential member of the Meseta Zone, although it is covered with Jurassic sediments and disappears in the east-southeast of the surveyed area. In the Jubilet mountain north of Marrakech, Kettara pyrrohtite deposit is emplaced in this system. Further to the north, the Carboniferous-Permian system appears again in the southern part of Spain, where it contains the Rio Tinto copper-pyrite ore deposit.

3-2 Hajar Ore Deposit (Fig. I-7)

The Hajar ore deposit is located at the eastern most corner of the surveyed area. At present, BRPM is carrying out diamond drilling and tunnel exploration.

Based on the BRPM data, the outline of the Hajar ore deposit is as follows.

(1) Form and Size

Quaternary overburden	:	approx. 120 m	
Depth of the orebody	:	150 - 400 m below surface	
Size of the orebody	:	laterally	300 m
		along shoot	400 m
		thickness	max. 100 m
Shoot of the orebody	:	20°NNE in shallow part	
		60°NNE in deeper part	

(2) Grade Distribution

The ore grade in the higher grade portion of the orebody reaches Ag 200 - 400 g/t, Pb 5 - 20 % and Zn 20 %, more or less. The Ag grade and Pb grade are higher in the upper portion and are decreasing toward the lower. The Cu grade has a tendency to increase in the lower portion. The higher grade part and the lower grade part are repeated with the width of

20 to 30 meters.

(3) Ore Minerals

The main ore minerals are pyrrhotite and sphalerite associated with galena and chalcopyrite. The ore types observed are those of banded ore, massive ore, brecciated ore, disseminated ore and vein ore, etc. Usually, the higher grade portion of the orebody is represented by the banded ore which is composed of either sphalerite and pyrrhotite or sphalerite and green minerals.

(4) Host Rock and Alteration

The hanging wall of the orebody is composed mainly of argillized pelitic rock while the horse rock and the footwall are constituted by green rock. The green rock occasionally contains white phenocrysts and the green rock is estimated to have been originated principally from volcanic rock and pyroclastic rock. The green rock is composed mainly of chlorite and quartz associated with sericite and biotite.

As to the alteration in relation to the mineralization, the most remarkable one is chloritization. Also, sericitization, silicification and argillization are recognized. It is noted that the upper part of the basement rock, about 20 meters, is oxidized zone.

(5) Ore Reserve Estimation

The data used for the ore reserve estimation are those from the 21 drill holes of the total length of 8,400 meters. The diamond drill holes were distributed with the spacing of every 70 meters.

The method employed in this case is Block Calculation Method and the ore reserve and the average grade were estimated by this method. Each block is drawn in the form of polygon with the vertex of a drill hole within the orebody, while, along the marginal area of the orebody, most appropriate polygons are established based on the estimation from the geological section.

The ore reserve and the average grade calculated by this method are roughly as follows.

Ore reserve :	16 million tons
Average grade :	Ag 74 g/t, Cu 0.86 %
	Pb 2.78 %, Zn 9.45 %, S 30.3 %