

maximum payment of both interest payment and amortization occupy a small part of the recurrent budget of the government of Madagascar.

In summary, it could be safely argued that both the cost recovery of the water associations and the foreign loan disbursement of the government of Madagascar verify the financial soundness of the Project.

The Project was socially assessed in terms of the distribution of benefits among various social groups. The Project was evaluated from the viewpoints of gender and equity, two major groupings of the society.

As the implementation of the Project will make the beneficiary villages be conveniently located for fetching water, a great deal of women's time for fetching water will be saved. The Project, which shall benefit the region where the mortality rate by waterborne diseases are worse off than any other region, will mitigate inequitable distribution of health resources among regions, thereby giving favourable social impacts on the regional socio-economic situation.

Although the economic viability of the Project is not so high compared with the opportunity cost of capital in Madagascar, the following has been concluded:

- 1) the Project is financially sound in terms of both the cost recovery of the water associations and the foreign loan disbursement of the government of Madagascar, and
- 2) the Project will have favourable social impacts on gender and equity together with other social benefits.

## 13.2 Recommendations

### (1) Project implementation

Although the economic internal rates of return of the Project are quite low, there is no doubt that the critical shortage of potable water in the villages of the south-western region requires a swift solution, also there is no question that the social benefits from the project would be great, especially in the 60 prioritized villages.

Therefore, in consideration of the social benefits and associated favorable effects, the immediate implementation of the Project is highly recommended, provided that a soft loan or a grant can be obtained.

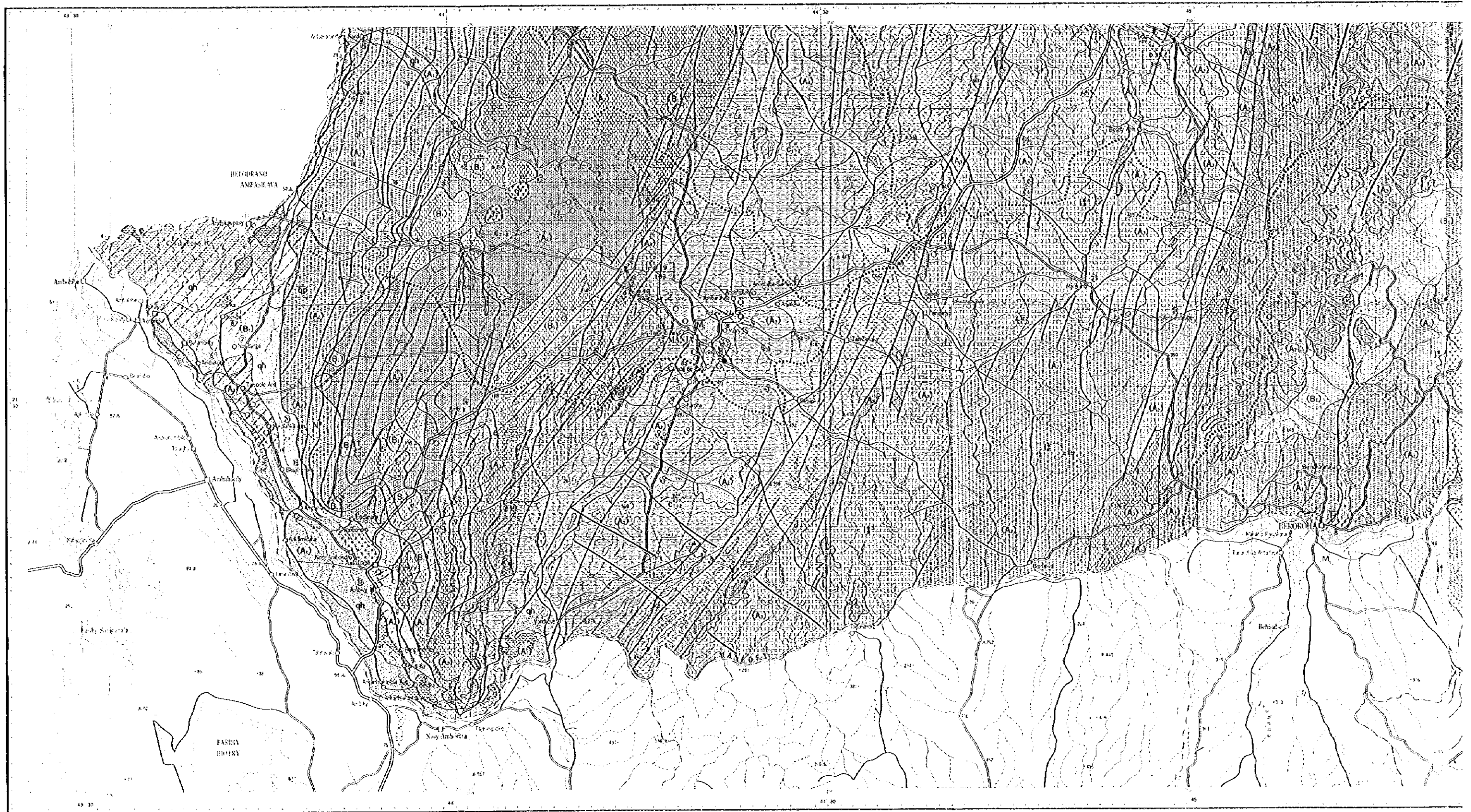
### (2) Operation and maintenance

Many of the candidate villages in the Study Area have, in the past, been involved in rural water supply projects, but the periods which these supply facilities remained

functioning were generally very short ranging from 2 to 4 years. After the supply facilities broke down, people were obliged to return to primitive water collection practices, due mainly to the poor operation and maintenance methodology. In addition, many of the candidate villages have never benefited from water supply services, therefore, it is difficult to establish a good sense of operation and maintenance in a short period.

As seen in the Phase I Project area, some of the benefited villages have preferred economizing running costs rather than providing adequate supplies of safe water through out the year, thus reducing the effectiveness of the Project. Since there is a limitation in the autonomous management at each of the villages caused by the long established tradition of not paying for water, great assistance and guidance from the concerned authorities should be extended to the villages. Thus, it is highly recommended that MEM, not only as the implementing body of the Project but also as the body responsible for the management of the Project, should strengthen the maintenance system by opening a management office at Morondava as a branch office to the Toliara Regional Office.

It is believed that the project will not be effective without conducting the patient enlightenment and encouragement of the villagers on the use of supplied water through periodic patrol. It is also recommended that MEM acts as the coordinating body in the Morondava area for involving the decentralized administrations and JIRAMÁ in maintenance related matters. Because, even if MEM opens the branch office in Morondava, patrol services or countermeasures against any troubles in the villages located to the south of the Kabatomana River would become somewhat difficult during the rainy season.



LEGENDE DE LA CARTE HYDROGEOLOGIQUE  
 LEGEND OF THE HYDROGEOLOGICAL MAP

A. Lithologie  
 Lithofacies

B. Temps géologique  
 Geologic time

C. Potentiels des eaux souterraines  
 Groundwater potentiality  
 Intergranular Apéters : Apéters intergranulaires

D. Structure géologique  
 Geological structure

F. Indices des eaux de surface  
 Occurrence of surface water

H. Stations d'observation hydrologique existantes  
 Existing hydrological observation station

I. Au  
 Out



C. Potentiâtes des eaux souterraines  
Groundwater potentiality

Intergranular Aquifers - Aquifères intergranulaires

(A) 1:100,000 scale map No. 1000, 1971, published by the Ministry of Geology, Japan. The map shows the geological structure of the area.

D. Structure géologique  
Geological structure

1:100,000 scale map No. 1000, 1971, published by the Ministry of Geology, Japan.

F. Indices des eaux de surface  
Occurrence of surface water

1:100,000 scale map No. 1000, 1971, published by the Ministry of Geology, Japan.

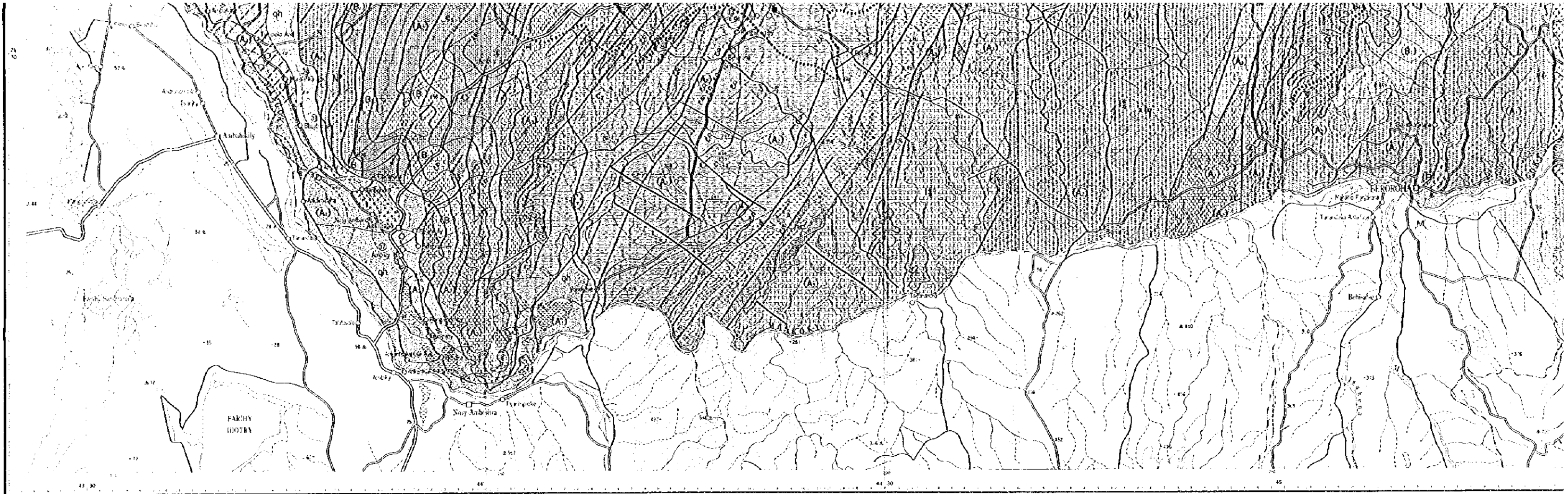
H. Stations d'observation hydrologique existantes  
Existing hydrological observation stations

1:100,000 scale map No. 1000, 1971, published by the Ministry of Geology, Japan.

I. Autres  
Others

1:100,000 scale map No. 1000, 1971, published by the Ministry of Geology, Japan.

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JAPAN INTERNATIONAL COOPERATION AGENCY



LEGENDE DE LA CARTE HYDROGÉOLOGIQUE  
LEGEND OF THE HYDROGEOLOGICAL MAP

A. Lithologie  
Lithofacies

- Substratum: Archaïque / Basement complex: Precambrian
- Grès: Grès / Sandstone
- Grès calcaireux: Grès calcaireux / Calcareous sandstone
- Grès argileux: Grès argileux / Clayey sandstone
- Marnes: Marnes / Marls
- Calcaires: Calcaires / Limestones
- Calcaires fissurés: Calcaires fissurés / Fractured limestones
- Calcaires et grès: Calcaires et grès / Limestones and sandstone
- Basaltes: Basaltes / Basalts
- Sphère de basalte: Sphère de basalte / Basaltic spherule
- Micas: Micas / Micas
- Fines de basaltes: Fines de basaltes / Basaltic fines
- Trachyte: Trachyte / Trachyte
- Diorite: Diorite / Diorite
- Gabbro: Gabbro / Gabbro
- Basalte: Basalte / Basaltic rock
- Trachyte: Trachyte / Trachyte
- Diorite: Diorite / Diorite
- Gabbro: Gabbro / Gabbro

B. Temps géologique  
Geologic time

Époque / Epoch	Substratum / Substratum	Pré-Cambrien / Precambrian	Paléozoïque / Paleozoic	Mésozoïque / Mesozoic	Cénozoïque / Cenozoic	Quaternaire / Quaternary
Quaternaire / Quaternary	q	qh	qo	q1	q2	q3
Paléozoïque / Paleozoic						
Mésozoïque / Mesozoic						
Cénozoïque / Cenozoic						
Pré-Cambrien / Precambrian						

C. Potentialités des eaux souterraines  
Groundwater potentiality

- Intergranular Aquifers / Aquifères intergranulaires
- 
- Intergranular or fissured rocks / Roches intergranulaires ou fissurées
- 

D. Structure géologique  
Geological structure

- Direction de l'inclinaison: Direction de l'inclinaison / Strike and dip
- Faille: Faille / Fault
- Élévation: Élévation / Elevation
- Axe de pliure: Axe de pliure / Axis of downwarping
- Axe de bas fond: Axe de bas fond / Axis of upwarping

E. Indices des eaux souterraines  
Occurrence of groundwater

- Puits / Spring
- Direction de mouvement des masses d'eau: Direction de mouvement groundwater flow
- Cote de niveau souterrain des masses d'eau: Line depth line of groundwater table
- Zone de saturation: Zone de saturation / Zone of water saturation area

F. Indices des eaux de surface  
Occurrence of surface water

- Cours d'eau permanent: Cours d'eau permanent / Permanent river
- Cours d'eau saisonnier: Cours d'eau saisonnier / Seasonal river
- Lac permanent: Lac permanent / Perennial lake
- Lac saisonnier: Lac saisonnier / Seasonal lake
- Marais ou zone marécageuse: Marais ou zone marécageuse / Marsh or swamp area
- Égout principal de drainage des eaux: Main surface water drain

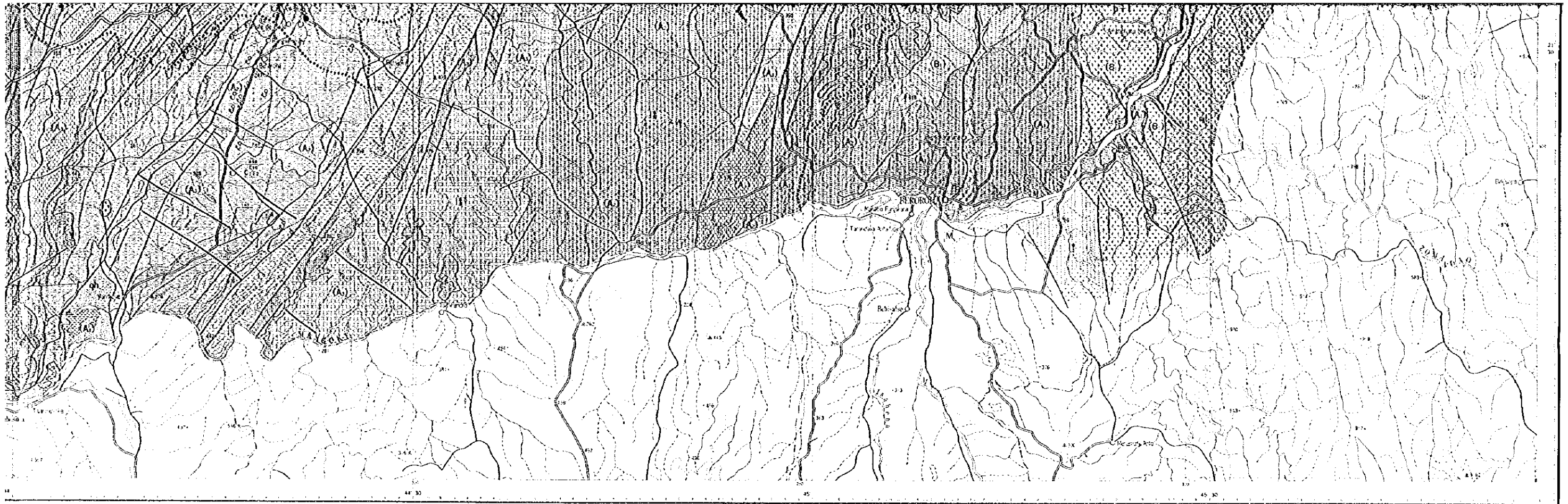
G. Installations existantes exploitées  
Existing facilities for water use

- Puits / Well
- Puits / Well
- Puits / Well
- Puits / Well
- Puits / Well
- Puits / Well

H. Stations d'observation hydrologique existantes  
Existing hydrological observation station

- Station de mesure hydrologique: Station de mesure hydrologique / River gauging station
- Base ligne: Base ligne / Base line
- Station de mesure pluviométrique: Station de mesure pluviométrique / Rainfall station
- Station de mesure de niveau d'eau souterraine: Groundwater level gauging station

I. A  
O



**C. Potentialités des eaux souterraines**  
Groundwater potentiality

- Intergranular Aquifers / Aquifères intergranulaires**
- (A) Eau libre (niveau profond) Q: 200 - 600 m<sup>3</sup>/an/secteur (20 - 50% de producteur) - Classe A  
Haute productivité aquifère Q: 200 - 600 m<sup>3</sup>/an/secteur (20 - 50% de producteur) - Classe A
  - (A) Eau libre (niveau profond) Q: 200 - 600 m<sup>3</sup>/an/secteur (50 - 100% de producteur) - Classe A  
Haute productivité aquifère Q: 200 - 600 m<sup>3</sup>/an/secteur (50 - 100% de producteur) - Classe A
  - (A) Eau libre (niveau profond) Q: 200 - 600 m<sup>3</sup>/an/secteur (100 - 250% de producteur) - Classe A  
Haute productivité aquifère Q: 200 - 600 m<sup>3</sup>/an/secteur (100 - 250% de producteur) - Classe A
  - (B) Eau libre (niveau profond) Q: 50 - 150 m<sup>3</sup>/an/secteur à moins de 10% de producteur - Classe B  
Faible productivité aquifère Q: 50 - 150 m<sup>3</sup>/an/secteur (à moins de 10% de producteur) - Classe B
  - (B) Eau libre (niveau profond) Q: 50 - 150 m<sup>3</sup>/an/secteur (100 - 200% de producteur) - Classe B  
Faible productivité aquifère Q: 50 - 150 m<sup>3</sup>/an/secteur (100 - 200% de producteur) - Classe B

- Fissured Aquifers / Aquifères fissurés**
- (A) Eau libre (niveau profond) Q: 200 - 600 m<sup>3</sup>/an/secteur (20 - 50% de producteur) - Classe A  
Haute productivité aquifère Q: 200 - 600 m<sup>3</sup>/an/secteur (20 - 50% de producteur) - Classe A
  - (A) Eau libre (niveau profond) Q: 200 - 600 m<sup>3</sup>/an/secteur (50 - 100% de producteur) - Classe A  
Haute productivité aquifère Q: 200 - 600 m<sup>3</sup>/an/secteur (50 - 100% de producteur) - Classe A
  - (B) Eau libre (niveau profond) Q: 50 - 150 m<sup>3</sup>/an/secteur (à moins de 10% de producteur) - Classe B  
Faible productivité aquifère Q: 50 - 150 m<sup>3</sup>/an/secteur (à moins de 10% de producteur) - Classe B
  - (B) Eau libre (niveau profond) Q: 50 - 150 m<sup>3</sup>/an/secteur (100 - 200% de producteur) - Classe B  
Faible productivité aquifère Q: 50 - 150 m<sup>3</sup>/an/secteur (100 - 200% de producteur) - Classe B

- Intergranular or fissured rocks / Roches intergranulaires ou fissurées**
- Eau libre (niveau profond) Q: 200 - 600 m<sup>3</sup>/an/secteur (20 - 50% de producteur) - Classe A  
Haute productivité aquifère Q: 200 - 600 m<sup>3</sup>/an/secteur (20 - 50% de producteur) - Classe A
  - Eau libre (niveau profond) Q: 50 - 150 m<sup>3</sup>/an/secteur (à moins de 10% de producteur) - Classe B  
Faible productivité aquifère Q: 50 - 150 m<sup>3</sup>/an/secteur (à moins de 10% de producteur) - Classe B
  - Eau libre (niveau profond) Q: 200 - 600 m<sup>3</sup>/an/secteur (100 - 200% de producteur) - Classe A  
Haute productivité aquifère Q: 200 - 600 m<sup>3</sup>/an/secteur (100 - 200% de producteur) - Classe A

**D. Structure géologique**  
Geological structure

- Direction de plissement  
Strike and dip
- Fault  
Faille
- Entassement  
Emplacement
- Synclinal  
Synclinal
- Anticlinal  
Anticlinal

**E. Indices des eaux souterraines**  
Occurrence of groundwater

- Écoulement  
Flow
- Niveau souterrain  
Water table
- Direction des écoulements des aquifères  
Direction of groundwater flow
- Chambre de recharge  
Recharge chamber
- Contour de la zone d'alimentation  
Boundary of the recharge zone

**F. Indices des eaux de surface**  
Occurrence of surface water

- Cours d'eau permanent  
Perennial river
- Cours d'eau intermittent  
Seasonal river
- Lac permanent  
Perennial lake
- Lac intermittent  
Seasonal lake
- Marsouin (ou autre) temporaire  
Marsh or temporary water
- Égout géologique (ou autre) des eaux  
Geological (or other) water discharge

**G. Installations existantes exploitées**  
Existing facilities for water use

- Puits (sans profondeur) 200 - 400 m<sup>3</sup>/an/secteur (20 - 50%)
- Puits 10 à 20 m  
100 - 200 m<sup>3</sup>/an/secteur
- Puits 20 à 50 m  
200 - 500 m<sup>3</sup>/an/secteur
- Puits plus profond que 50 m  
500 m<sup>3</sup>/an/secteur ou plus
- Puits artésien  
Artesian well

**H. Stations d'observation hydrologique existantes**  
Existing hydrological observation station

- Station de mesure hydrologique  
Hydrological station
- Station pluviométrique  
Rain gauge station
- Station météorologique  
Meteorological station
- Station de mesure pluviométrique  
Rainfall station
- Station de mesure de niveau d'eau souterraine  
Groundwater level observation station

**I. Autres**  
Others

- Carte de réseau  
Cadastral map
- Point géodésique  
Geodetic point
- Point de vue  
Viewpoint
- Route nationale  
National road
- Route régionale  
Regional road
- Route locale  
Local road
- Limite de l'ancien  
Ancient boundary
- Limite de l'actuelle  
Current boundary
- Ville plus de 4 000 habitants  
City with more than 4 000 population
- Village (plus de 1 000 à 4 000 habitants)  
Village (1 000 to 4 000 population)
- Canton rural (500 à 1 000 habitants)  
Rural canton (500 to 1 000 population)
- Centre de village  
Village center
- Bois  
Forest
- Parc  
Park

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DIRECTION DE L'EAU  
MINISTÈRE DE L'ÉNERGIE ET DES MINES  
REPUBLIQUE DE MADAGASCAR  
DEPARTMENT OF WATER  
MINISTRY OF ENERGY AND MINES  
REPUBLIC OF MADAGASCAR

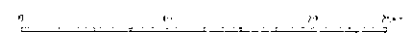
ETUDE DE L'EXPLOITATION DES EAUX SOUTERRAINES  
DANS LA REGION DU SUD-OUEST  
DE  
LA REPUBLIQUE DE MADAGASCAR

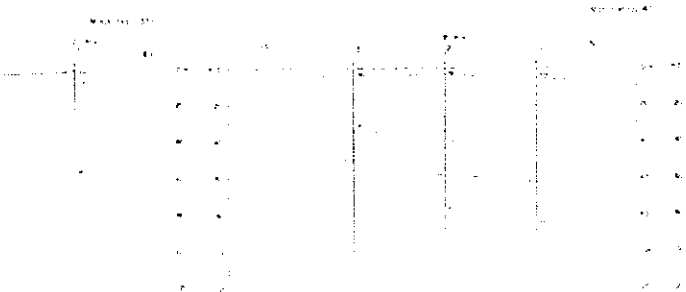
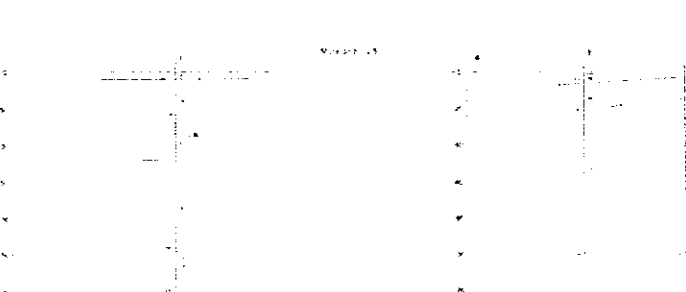
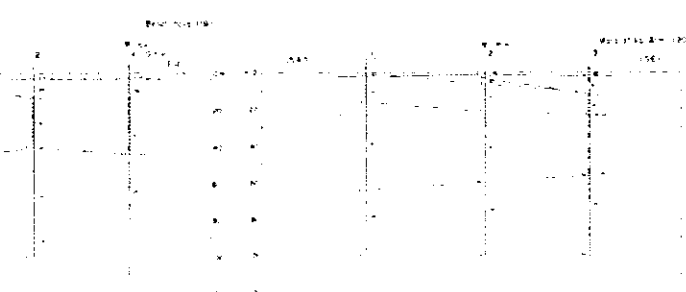
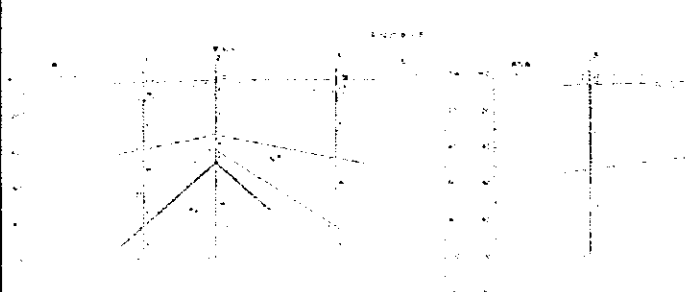
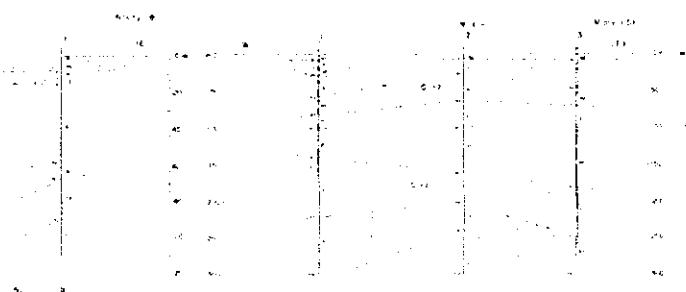
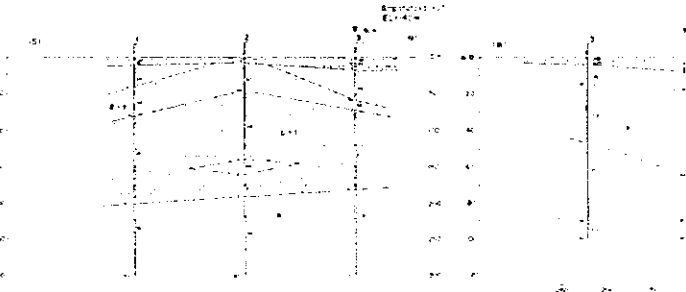
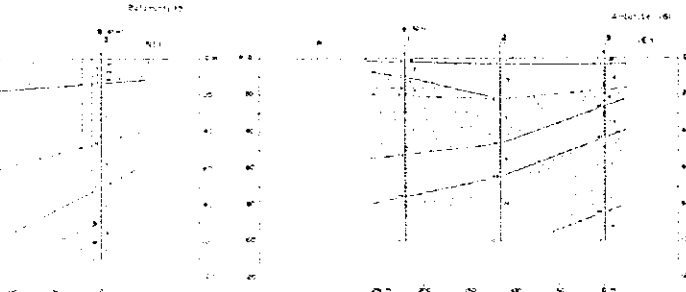
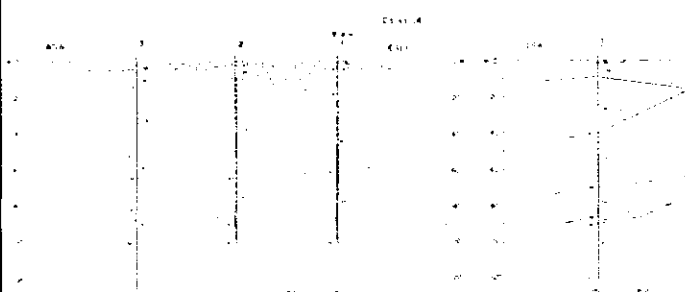
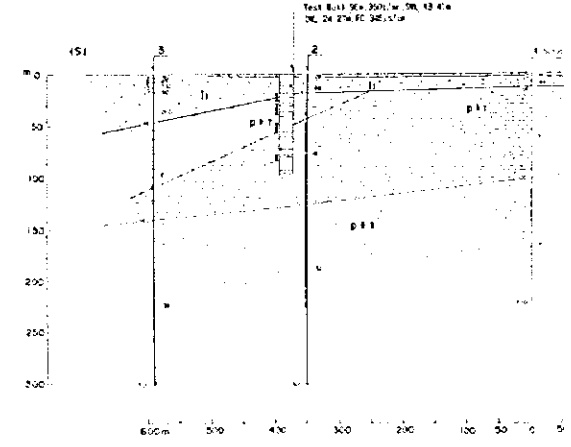
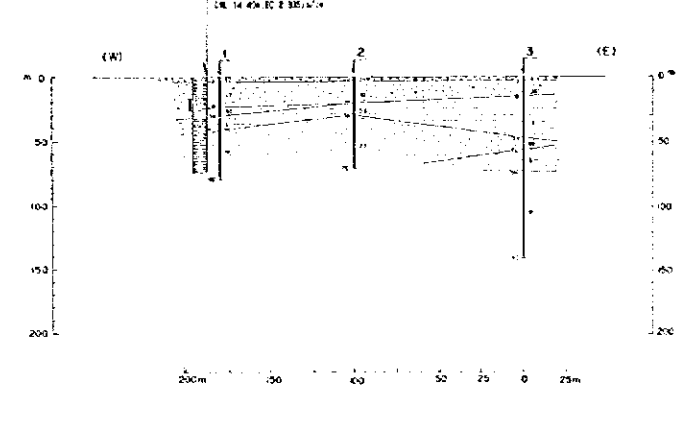
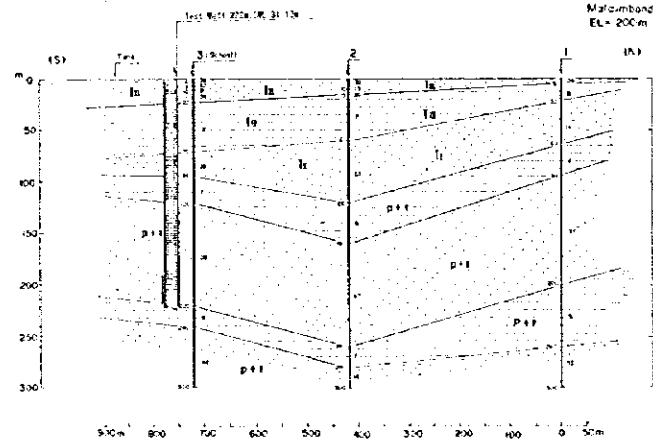
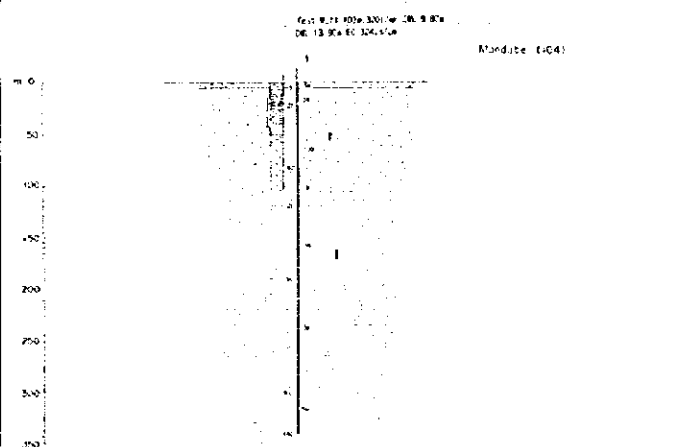
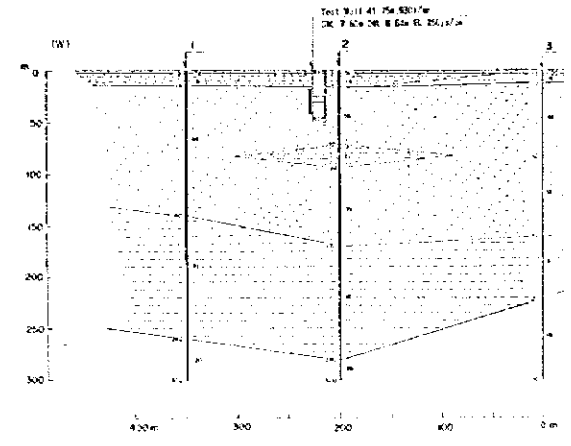
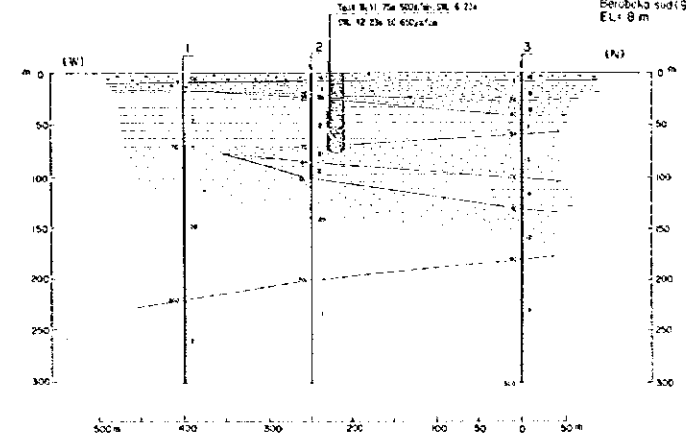
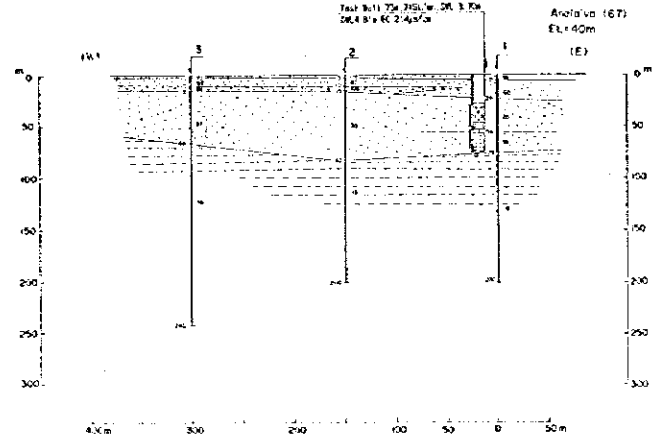
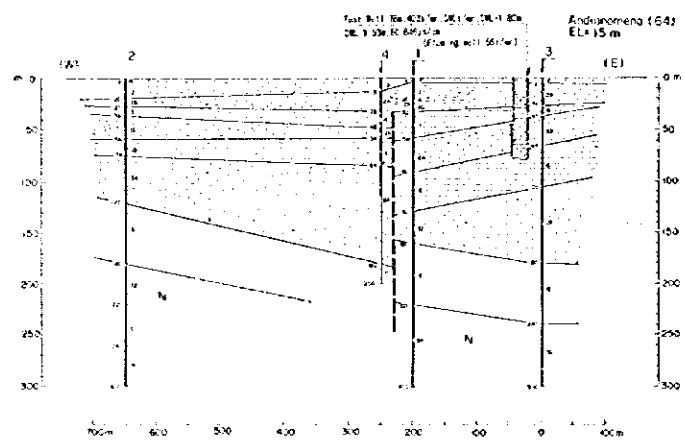
GROUNDWATER DEVELOPMENT STUDY  
IN  
SOUTHWESTERN REGION  
OF  
THE REPUBLIC OF MADAGASCAR

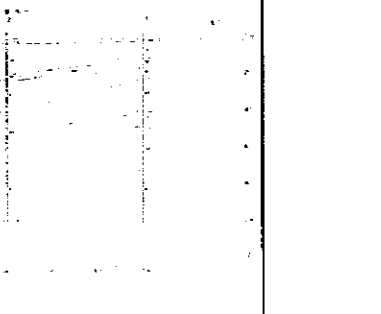
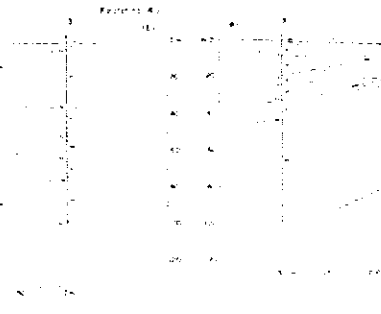
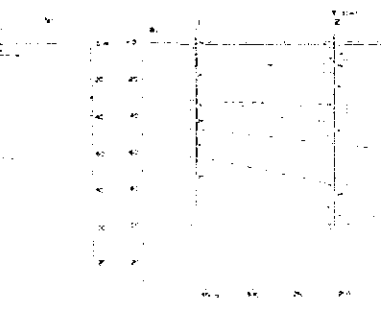
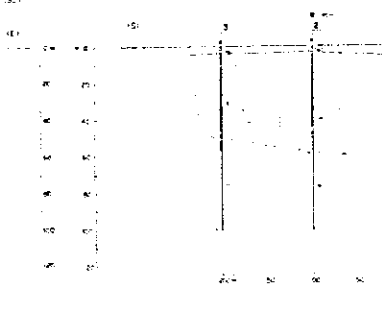
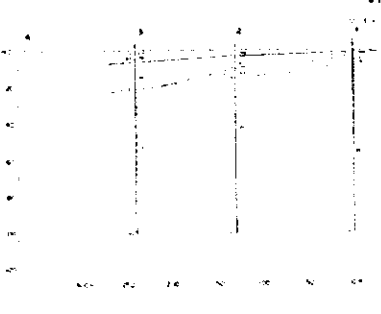
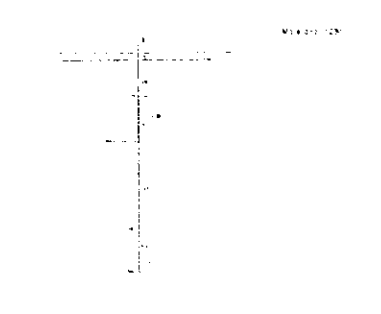
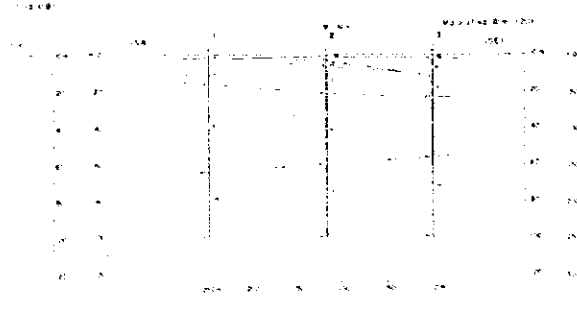
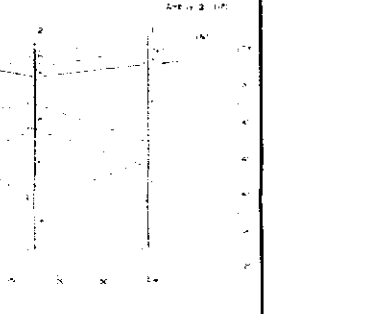
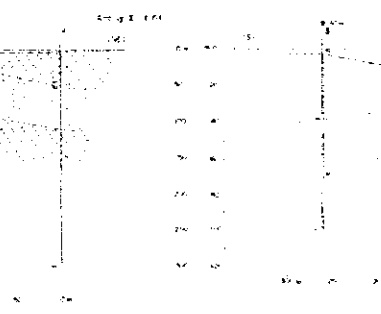
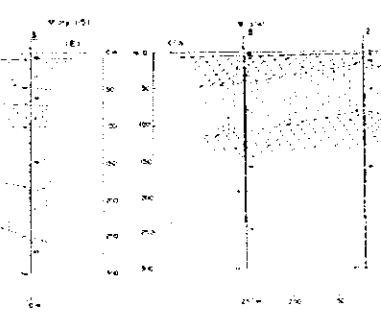
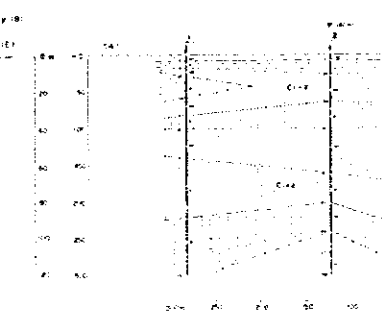
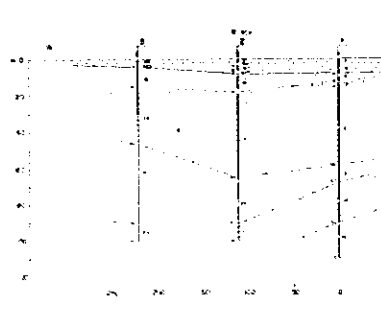
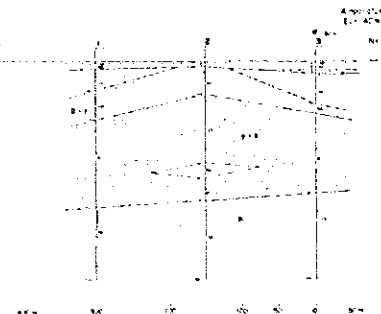
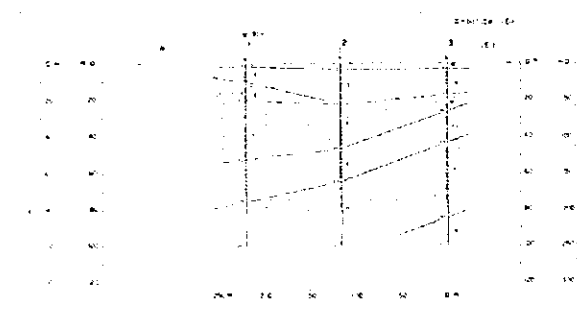
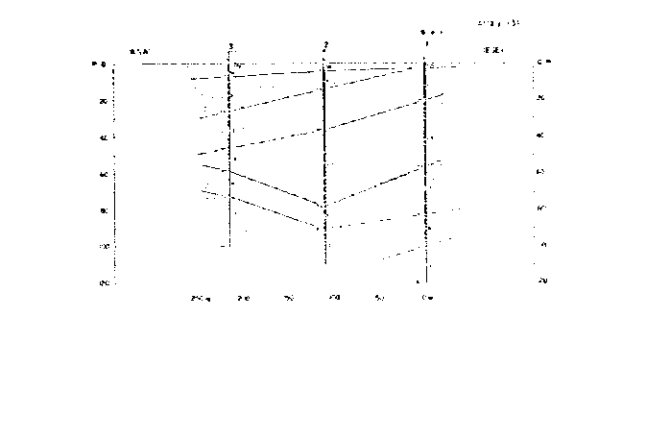
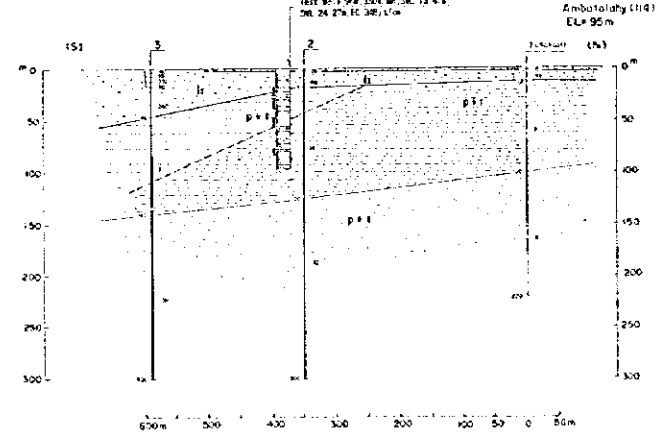
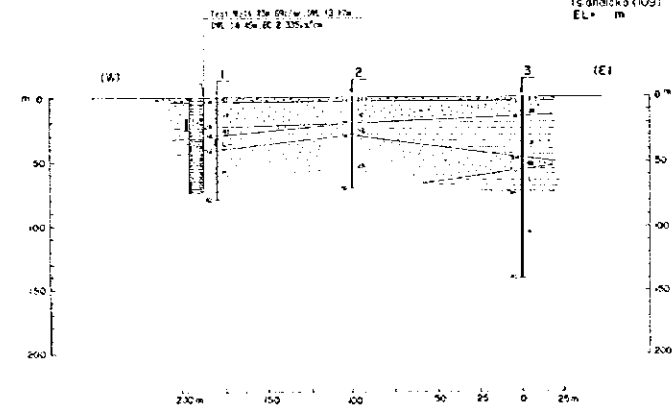
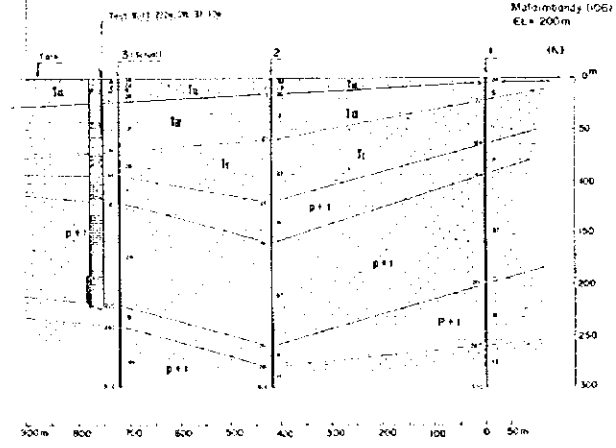
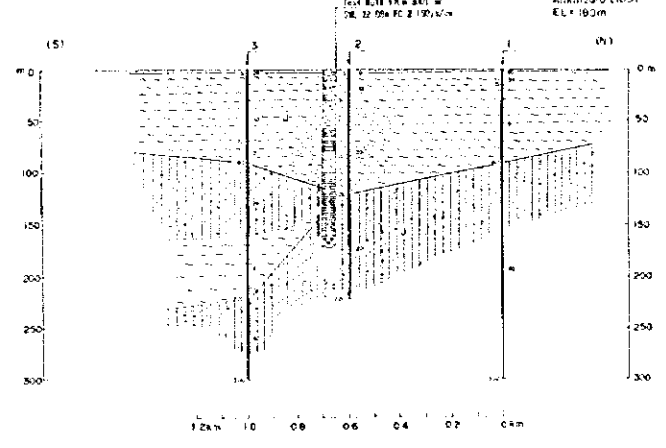
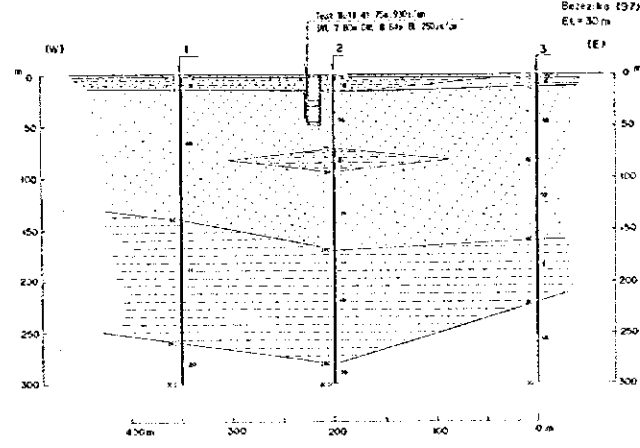
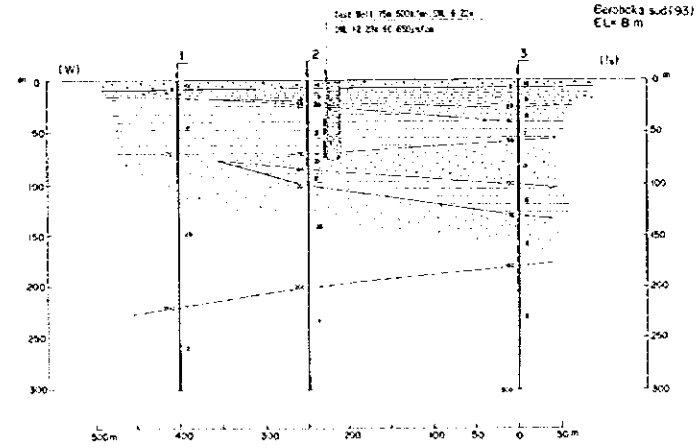
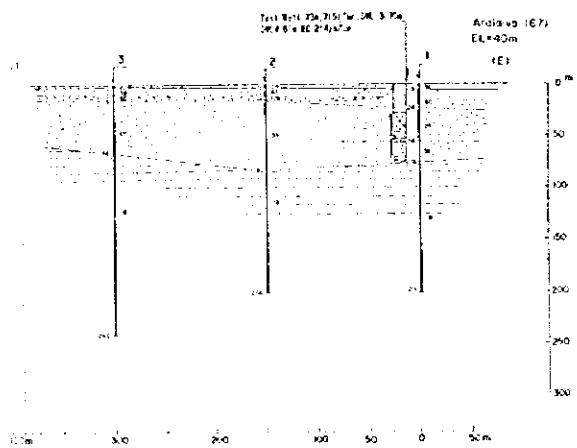
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SANYU CONSULTANTS Inc., TOKYO

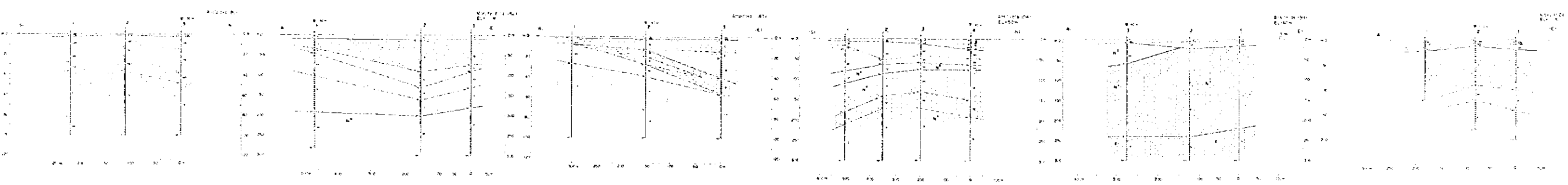
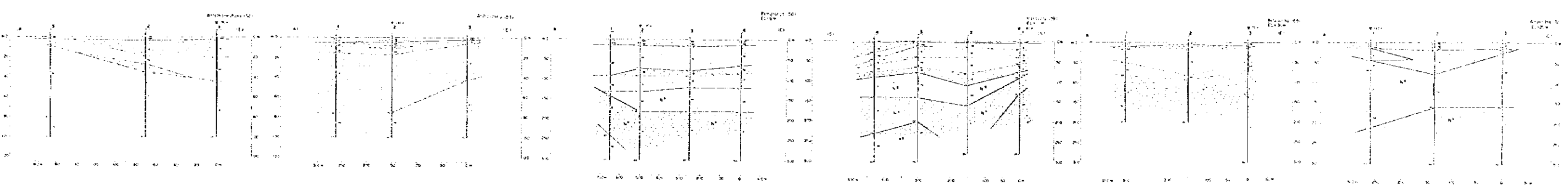
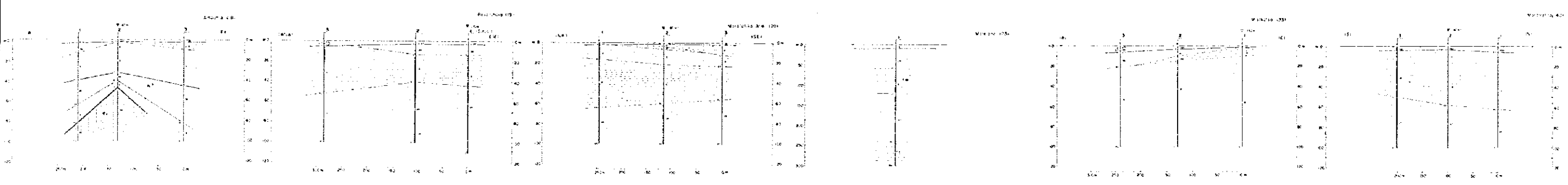
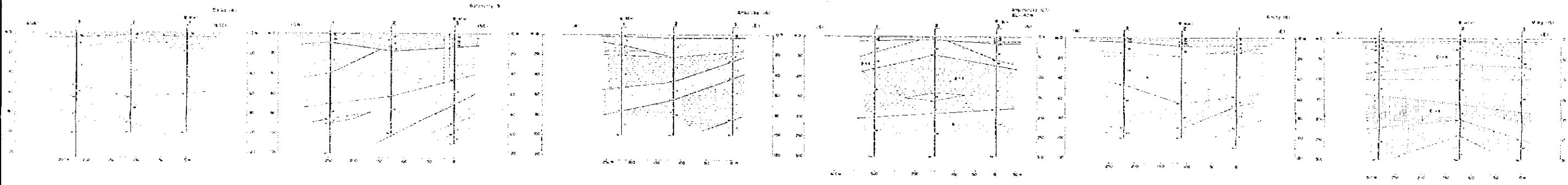
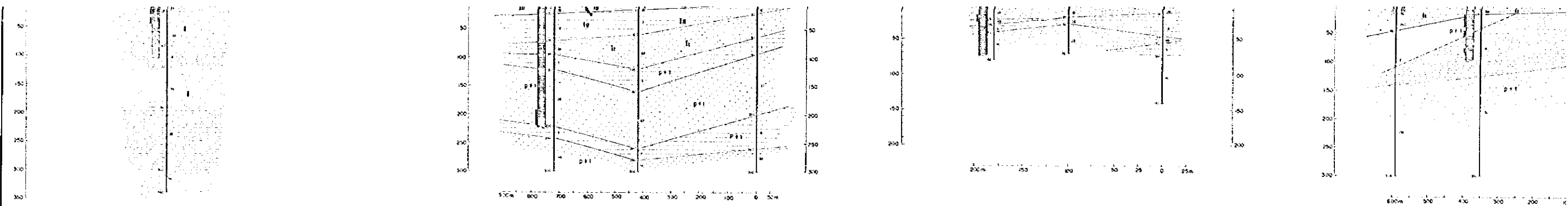
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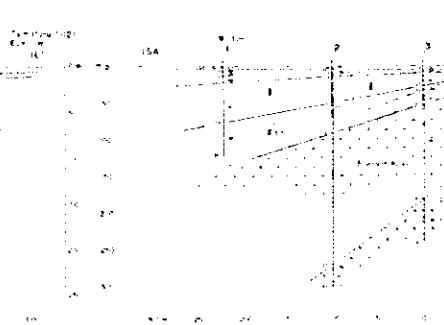
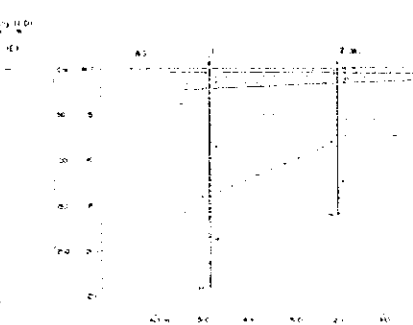
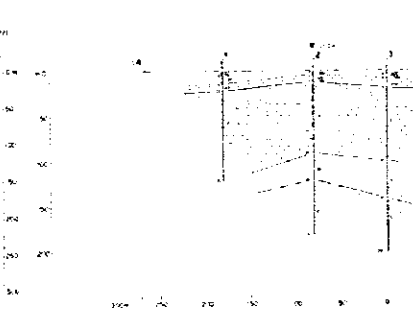
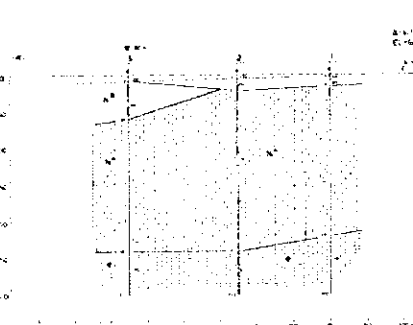
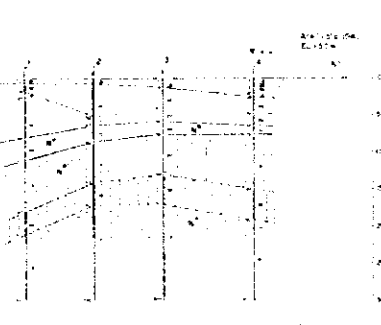
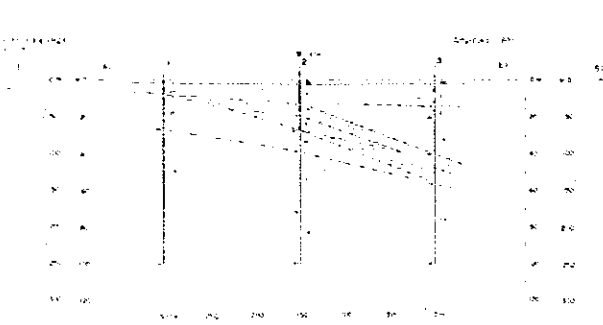
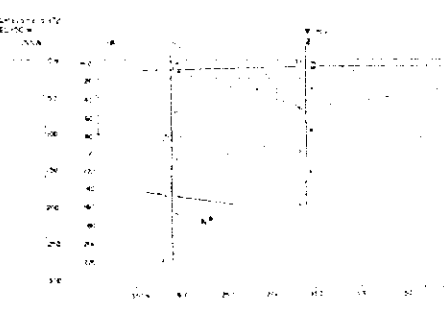
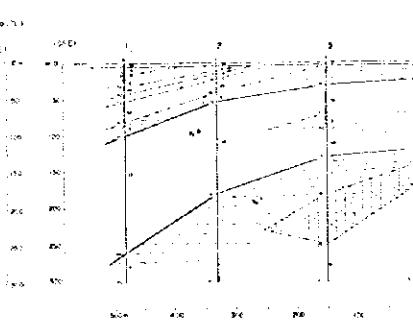
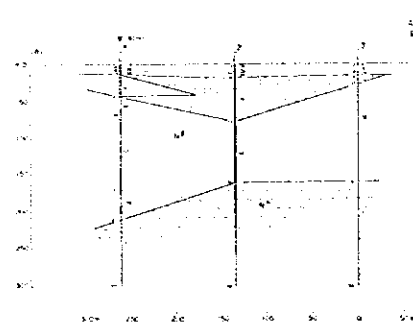
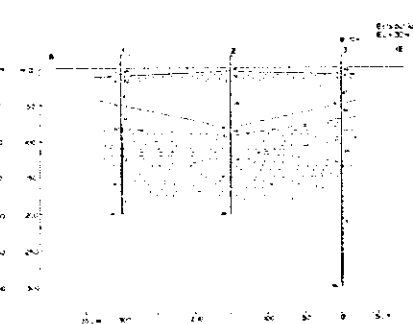
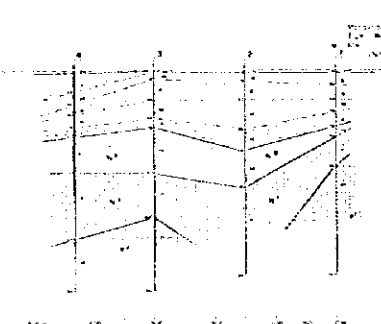
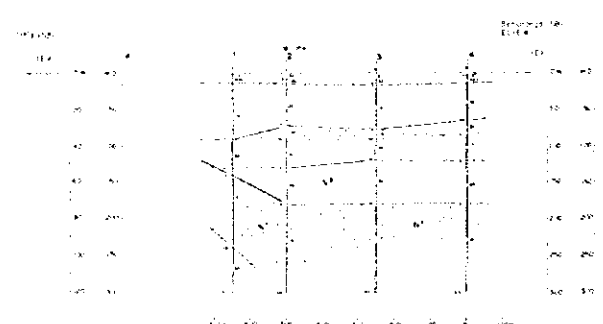
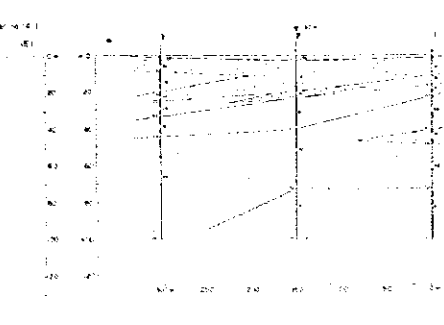
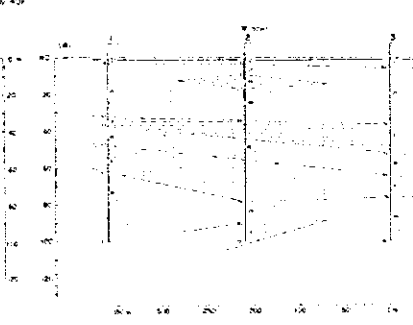
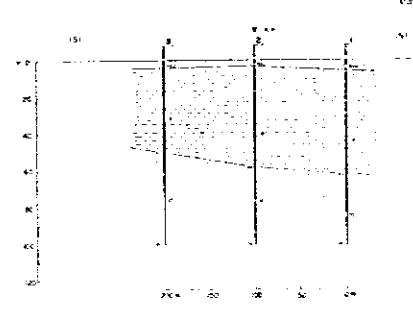
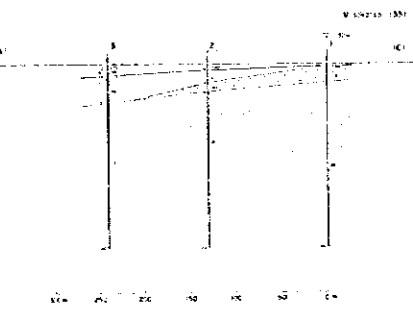
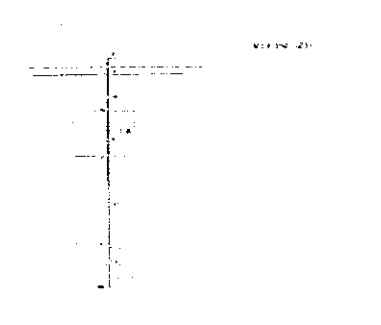
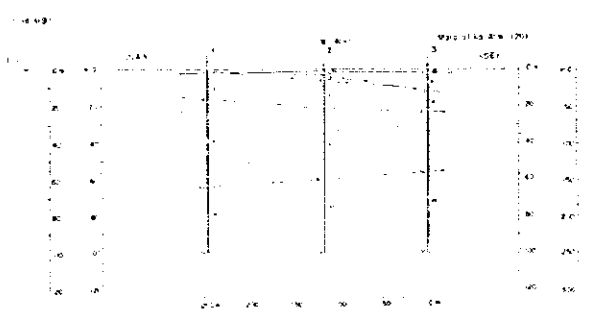
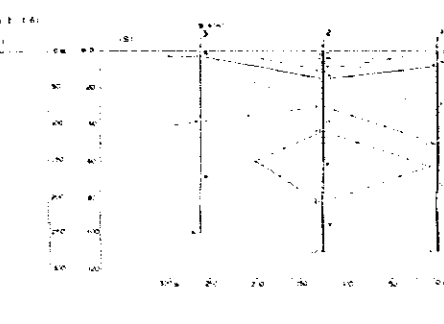
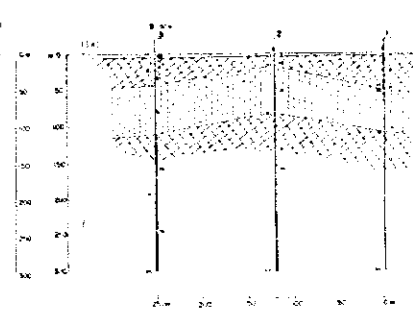
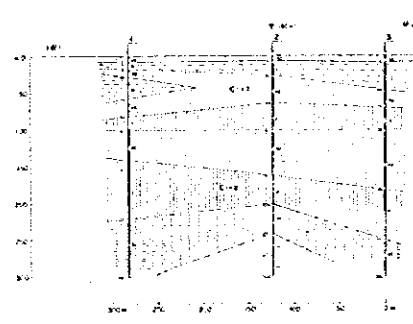
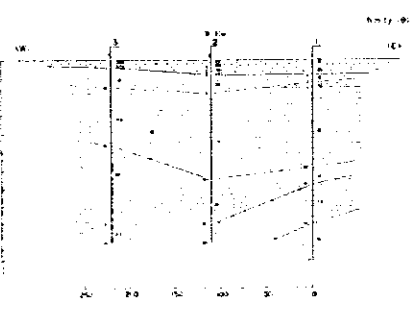
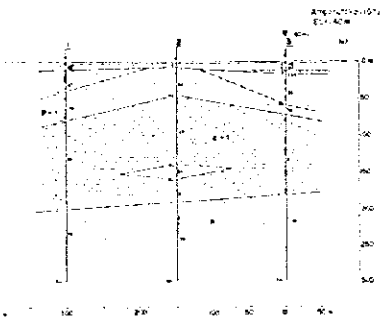
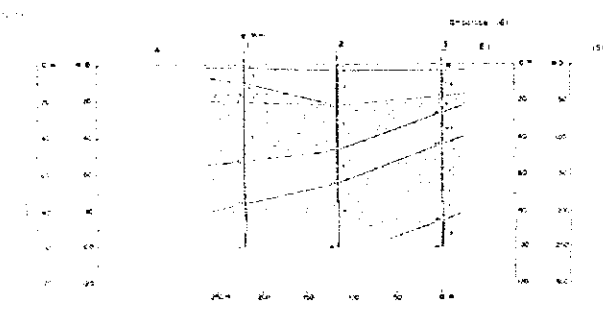
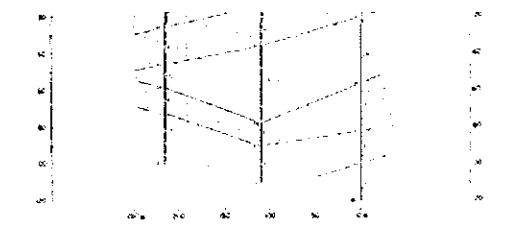
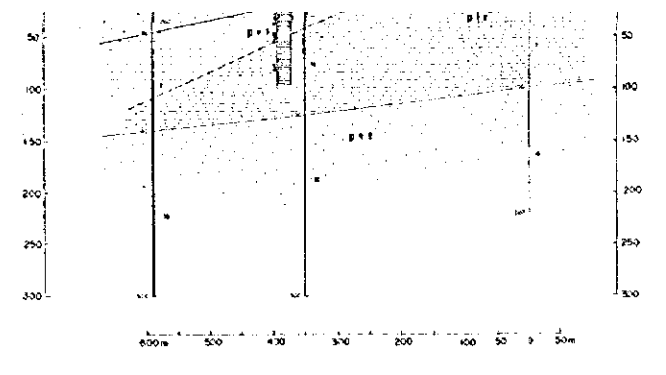
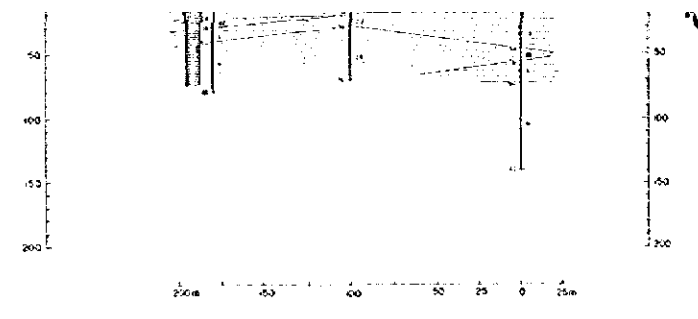
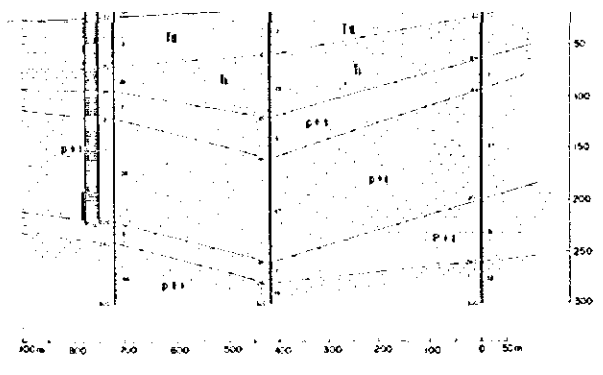




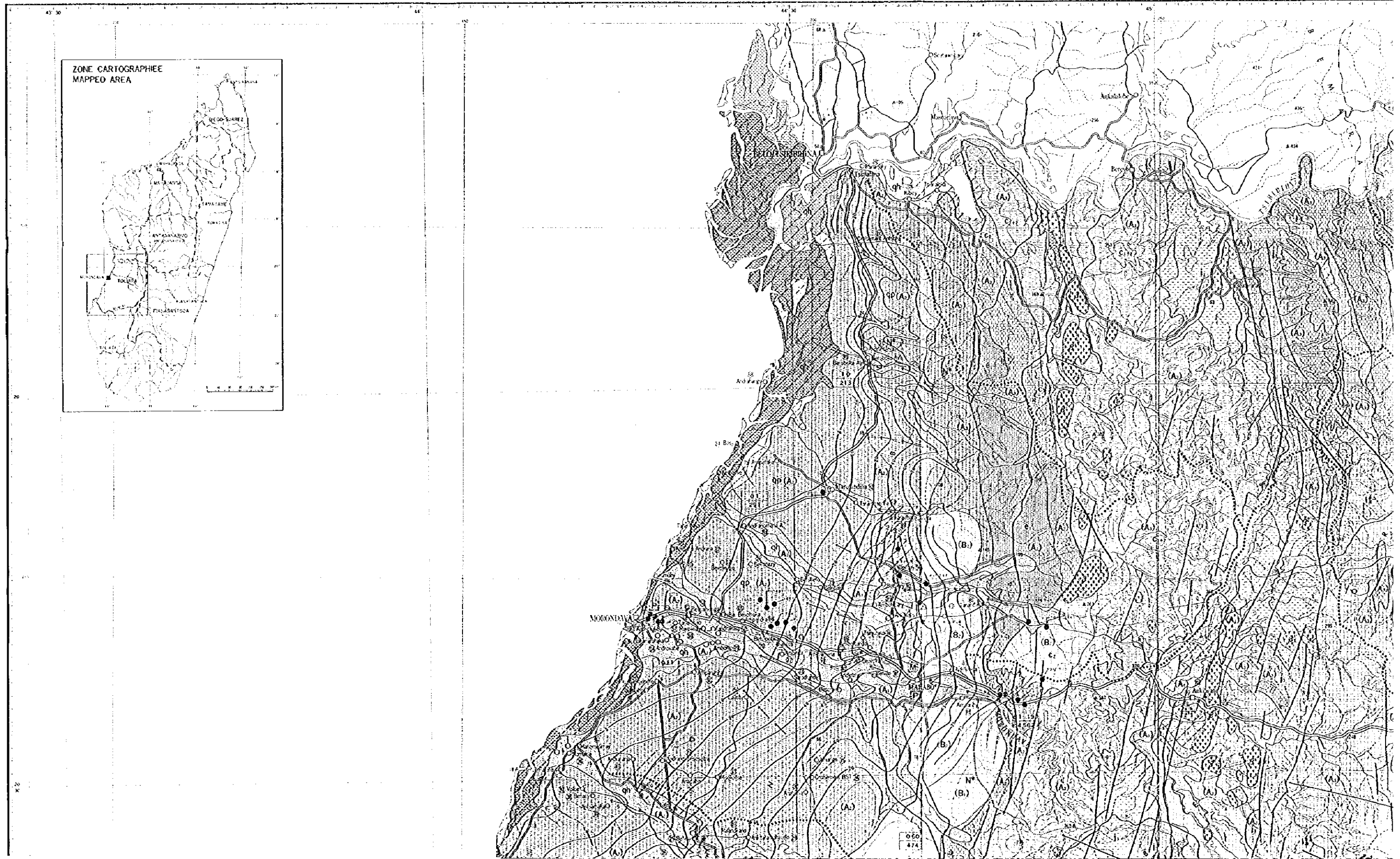




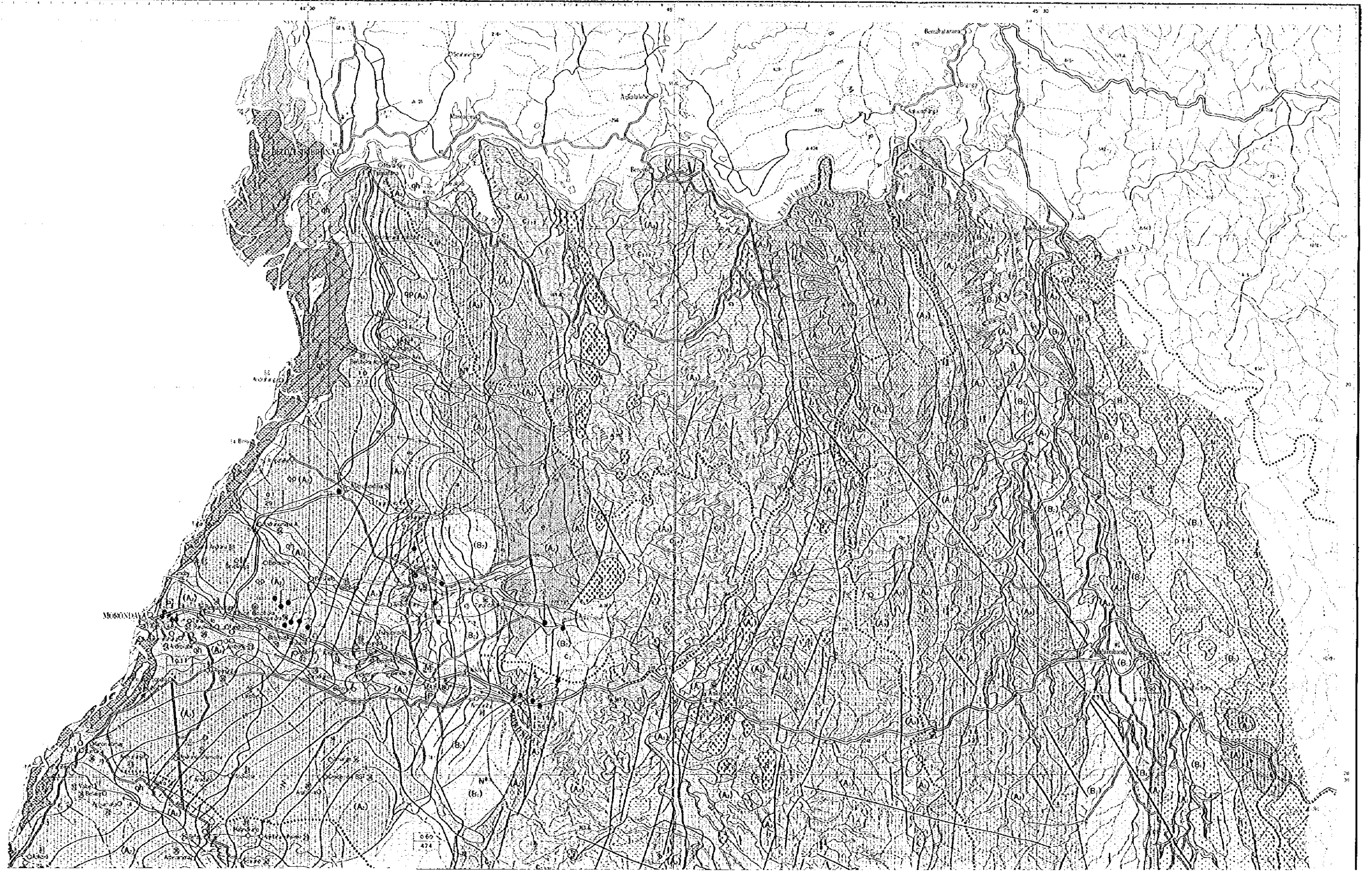


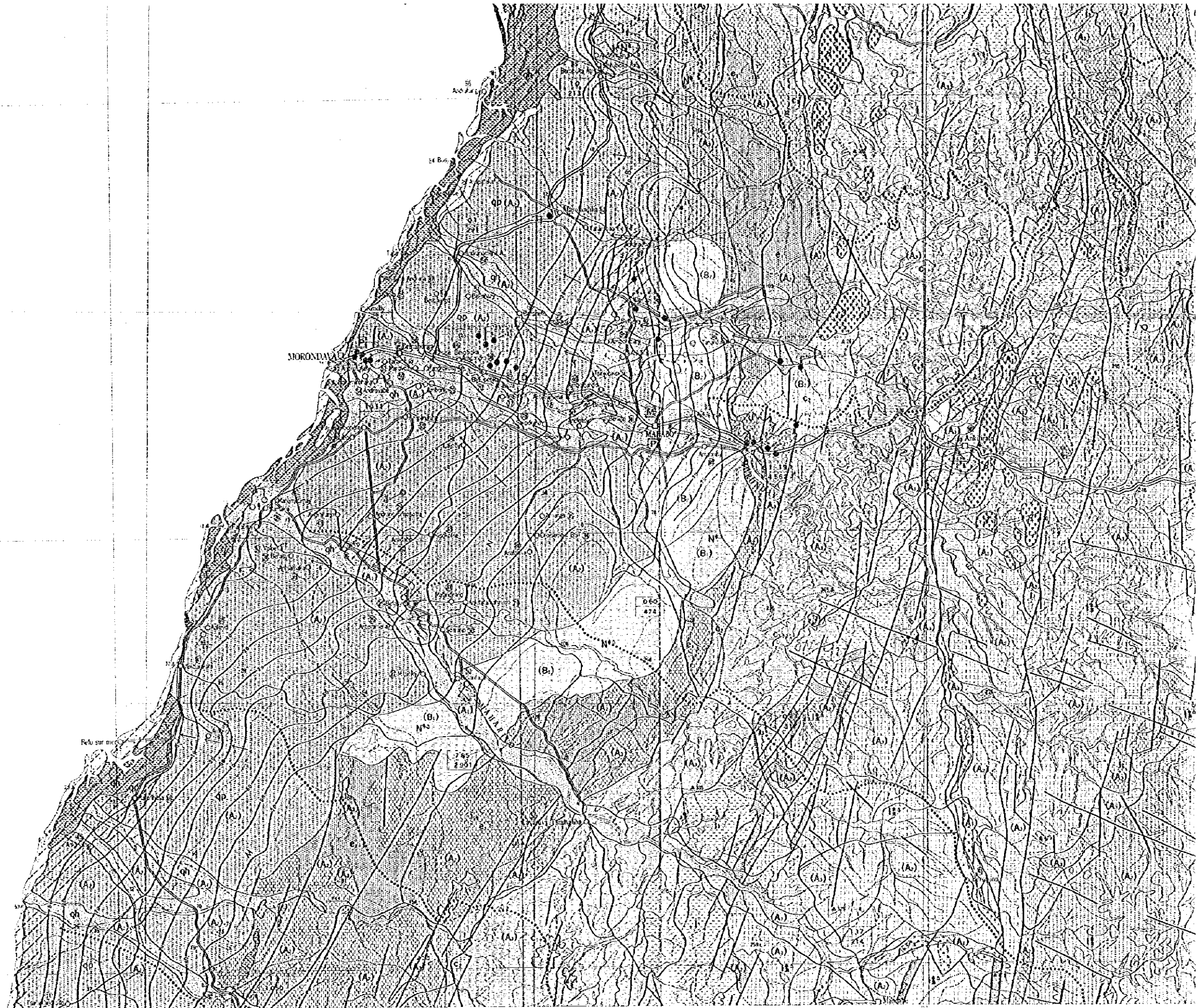
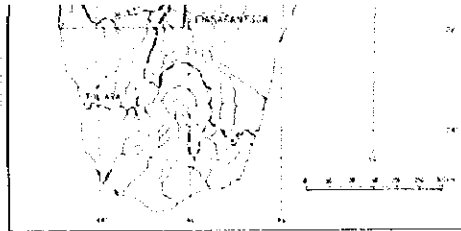


CARTE HYDROGEOLOGIQUE DE MADAGASCAR (2) REGION DU SUD-OUEST  
HYDROGEOLOGICAL MAP OF MADAGASCAR (2) SOUTH-WESTERN REGION

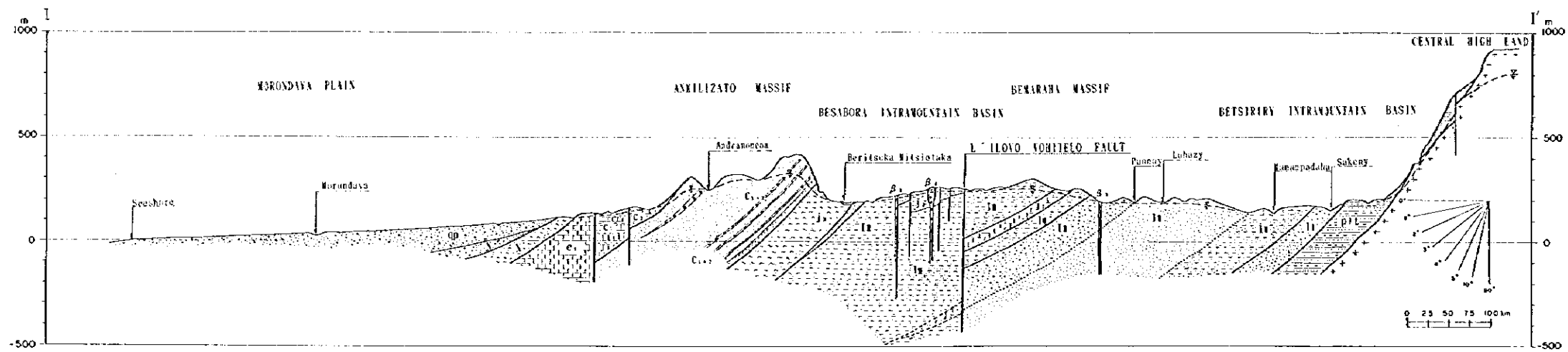


CARTE HYDROGEOLOGIQUE DE MADAGASCAR (2) REGION DU SUD-OUEST  
HYDROGEOLOGICAL MAP OF MADAGASCAR (2) SOUTH-WESTERN REGION





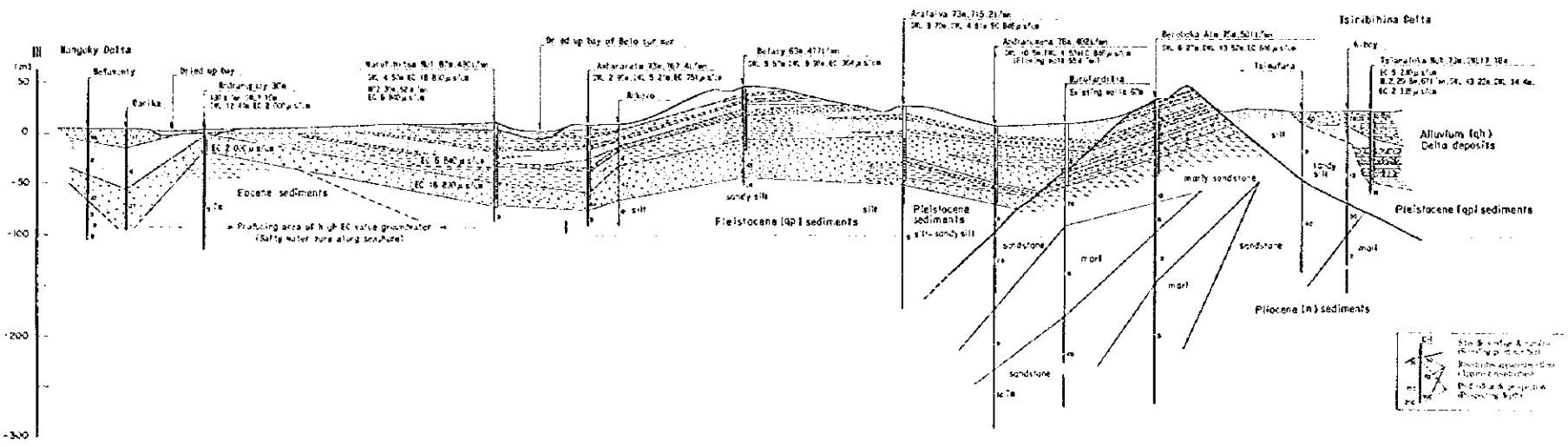
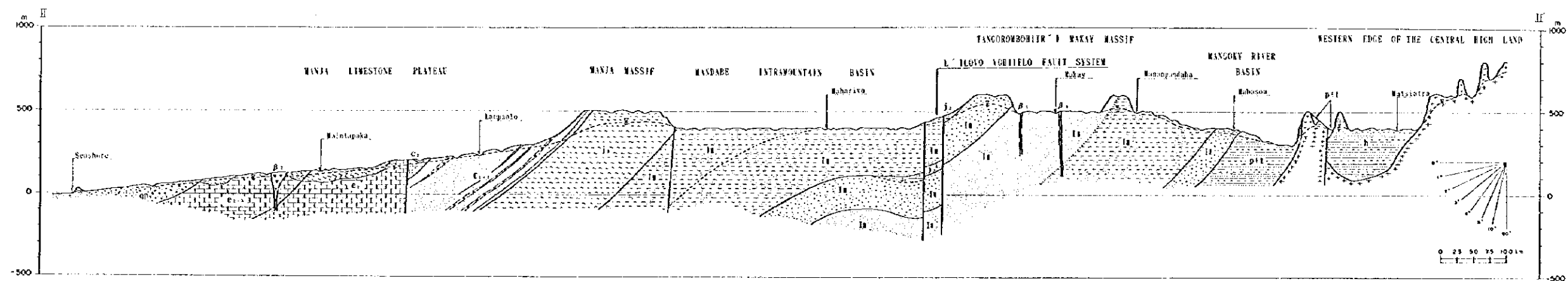




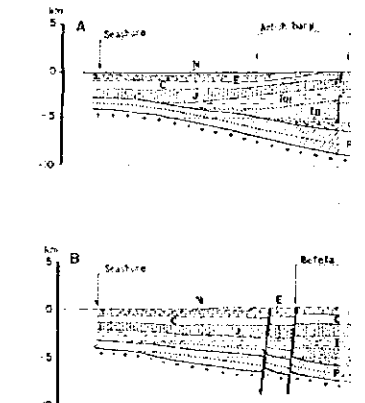
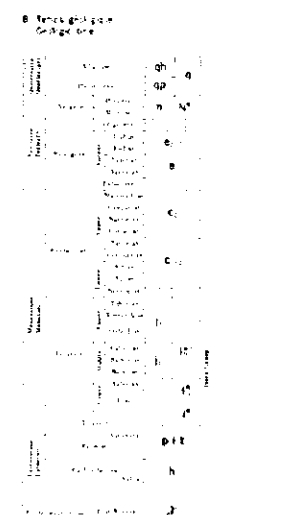
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7. AUSA	14. NORD
8. AUSA	15. NORD
9. AUSA	16. NORD
10. AUSA	17. NORD
11. AUSA	18. NORD
12. AUSA	19. NORD
13. AUSA	20. NORD
14. AUSA	21. NORD
15. AUSA	22. NORD
16. AUSA	23. NORD
17. AUSA	24. NORD
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45. AUSA	52. NORD
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47. AUSA	54. NORD

— Profil géologique  
 — Profil hydrologique  
 ● Site point Eau  
 Site of water

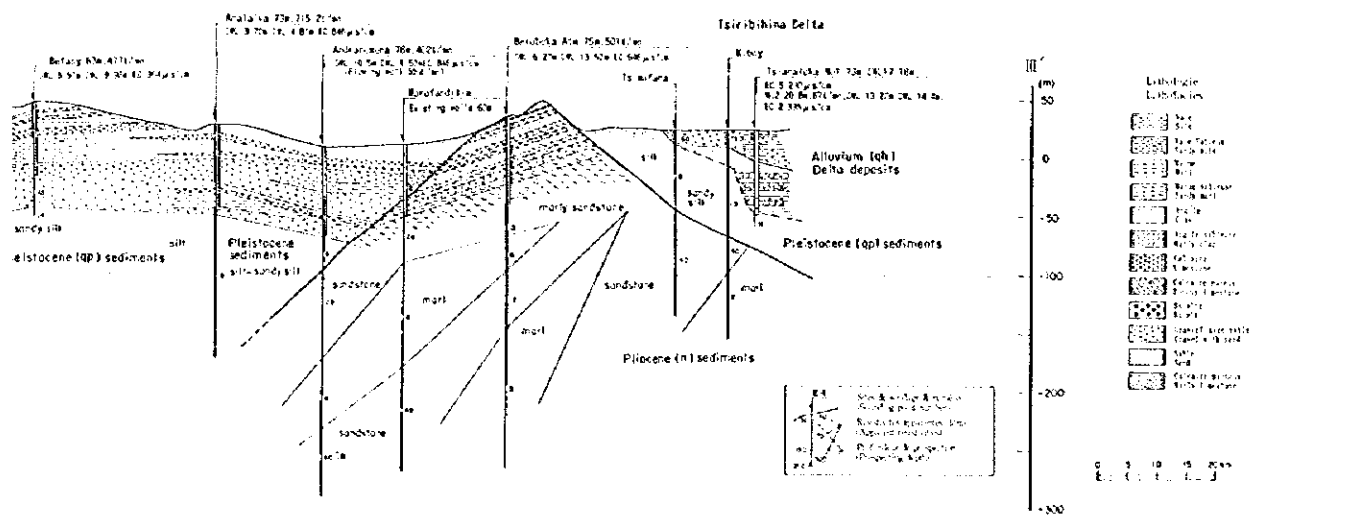
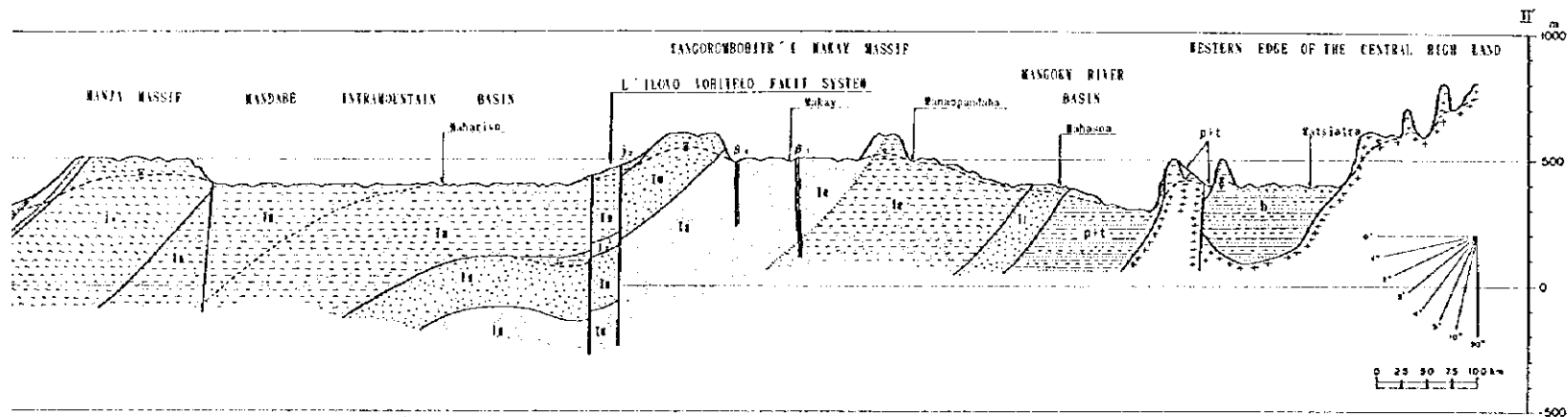
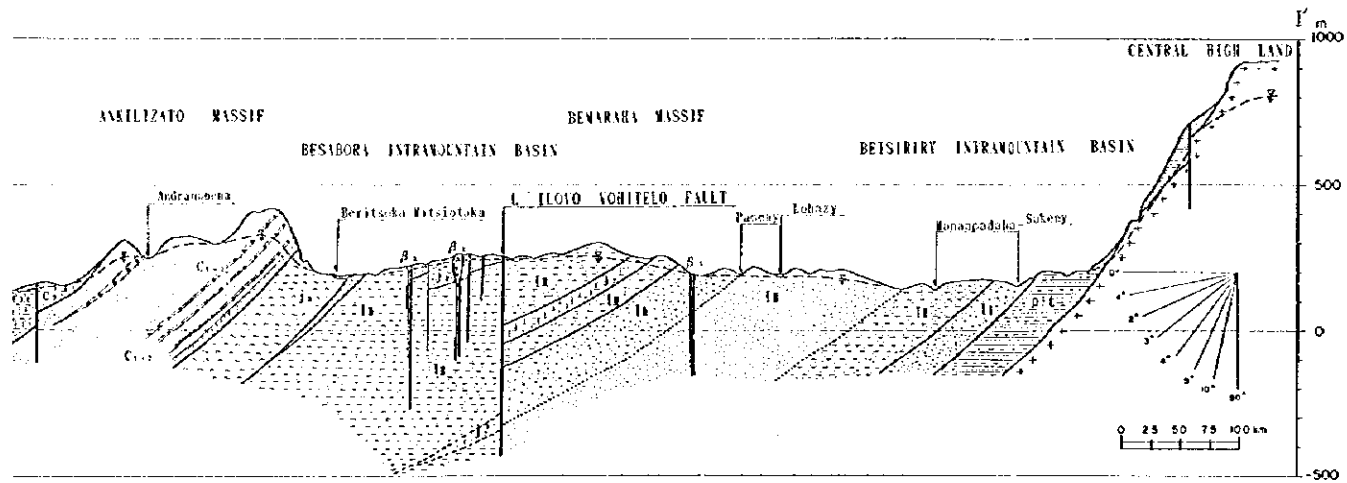
- [Symbol] Eocene
- [Symbol] Upper Cretaceous
- [Symbol] Upper Jurassic
- [Symbol] Middle Jurassic
- [Symbol] Upper Isalo Group
- [Symbol] Middle Isalo Group
- [Symbol] Lower Isalo Group
- [Symbol] Substratum
- [Symbol] Basement Complex



- [Symbol] Alluvium (q1) Delta deposits
- [Symbol] Pleistocene (Q1) sediments
- [Symbol] Pliocene (N3) sediments
- [Symbol] Sandstone
- [Symbol] Marl
- [Symbol] Silt
- [Symbol] Clay
- [Symbol] Shale
- [Symbol] Sandstone
- [Symbol] Marl
- [Symbol] Silt
- [Symbol] Clay
- [Symbol] Shale



Croquis hydrogéologique et géologique de la plaine de Marondava  
 Hydrogeological and Geological Section of the Marondava Plain



coupe géologique verticale de la plaine de Mandava  
 Geological Vertical Section of the Mandava Plain

1. M.1	2. M.2	3. M.3	4. M.4	5. M.5	6. M.6	7. M.7	8. M.8	9. M.9	10. M.10	11. M.11	12. M.12	13. M.13	14. M.14	15. M.15	16. M.16	17. M.17	18. M.18	19. M.19	20. M.20	21. M.21	22. M.22	23. M.23	24. M.24	25. M.25	26. M.26	27. M.27	28. M.28	29. M.29	30. M.30	31. M.31	32. M.32	33. M.33	34. M.34	35. M.35	36. M.36	37. M.37	38. M.38	39. M.39	40. M.40	41. M.41	42. M.42	43. M.43	44. M.44	45. M.45	46. M.46	47. M.47	48. M.48	49. M.49	50. M.50	51. M.51	52. M.52	53. M.53	54. M.54	55. M.55	56. M.56	57. M.57	58. M.58	59. M.59	60. M.60	61. M.61	62. M.62	63. M.63	64. M.64	65. M.65	66. M.66	67. M.67	68. M.68	69. M.69	70. M.70	71. M.71	72. M.72	73. M.73	74. M.74	75. M.75	76. M.76	77. M.77	78. M.78	79. M.79	80. M.80	81. M.81	82. M.82	83. M.83	84. M.84	85. M.85	86. M.86	87. M.87	88. M.88	89. M.89	90. M.90	91. M.91	92. M.92	93. M.93	94. M.94	95. M.95	96. M.96	97. M.97	98. M.98	99. M.99	100. M.100
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- A — Profil géologique Stratigraphic cross section
- B — Profil hydrogéologique Hydrogeologic cross section
- ⊙ Site ayant fait l'objet de forage d'essai en 1955  
 Site of test drill hole carried out in 1955
- [ Qh ] Relacene [ Qp ] Pleistocene
- [ N ] Néogène (Tertiaire) Neogene (Tertiary)
- [ E ] Eocene
- [ C1 ] Crétacé Supérieur Upper Cretaceous [ C2 ] Crétacé Inférieur Lower Cretaceous
- [ J ] Jurassique Jurassic
- [ T1 ] Trias Supérieur Upper Triassic
- [ T2 ] Trias Inférieur Lower Triassic
- [ P ] Paléozoïque (Pré-Cambrien) Paleozoic (Pre-Cambrian)

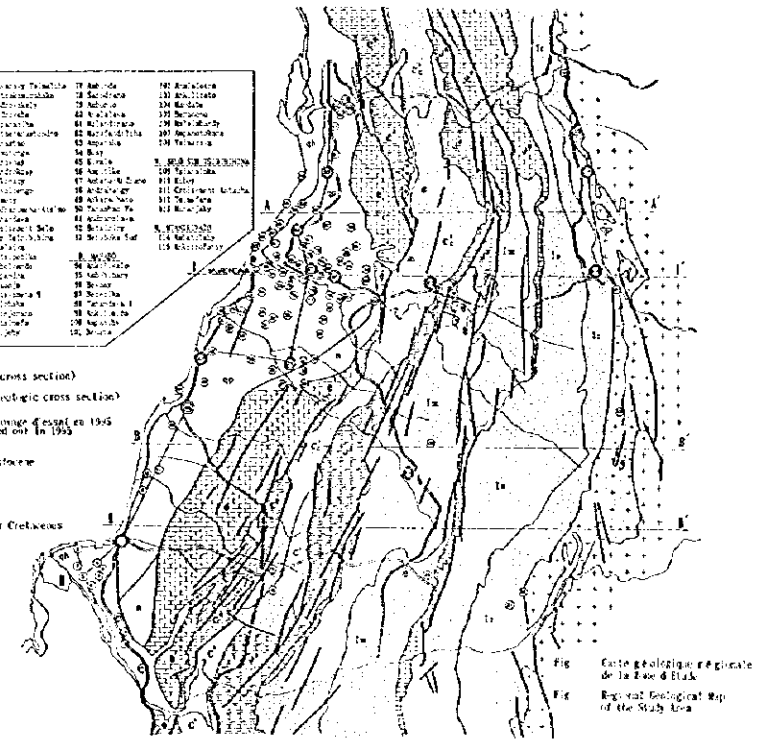
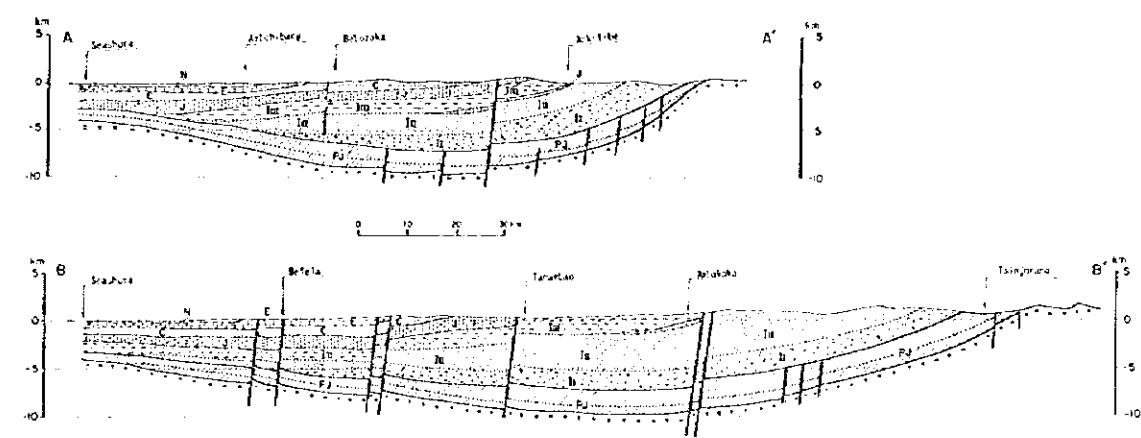


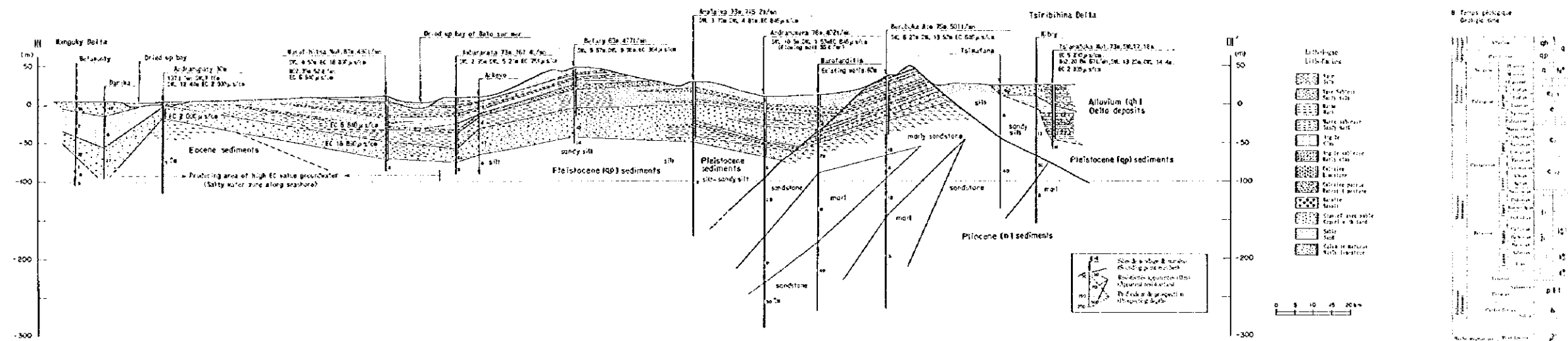
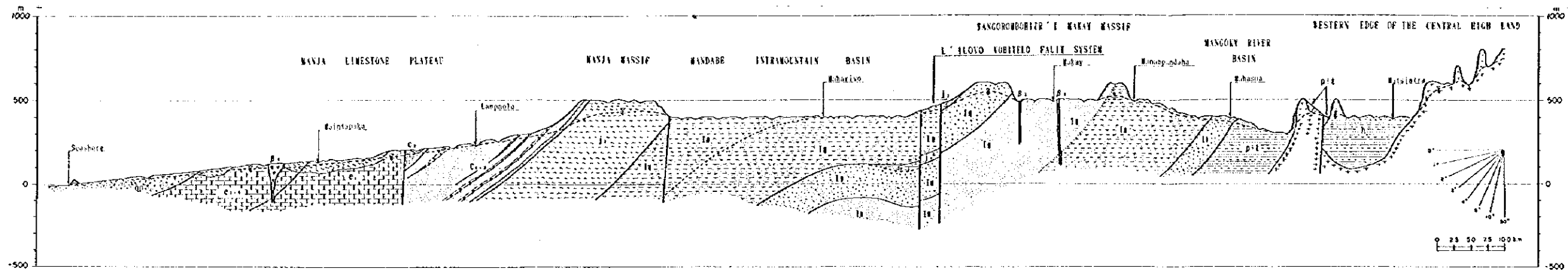
Fig. Carte géologique régionale de la Région d'Elak  
 Regional Geological Map of the Study Area



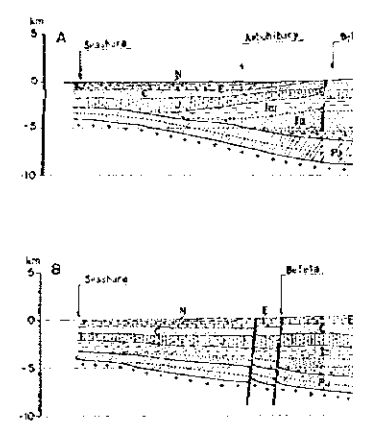
- [ N ] Néogène (Tertiaire) Neogene (Tertiary)
- [ E ] Eocène Eocene
- [ C1 ] Crétacé Supérieur Upper Cretaceous
- [ C2 ] Crétacé Inférieur Lower Cretaceous
- [ J ] Jurassique Jurassic
- [ T1 ] Trias Supérieur Upper Triassic
- [ T2 ] Trias Inférieur Lower Triassic
- [ P ] Paléozoïque (Pré-Cambrien) Paleozoic (Pre-Cambrian)

COPIE GÉNÉRIQUE TRAVAIL DE RECHERCHE  
 REPRODUCTION GÉNÉRIQUE DE TRAVAIL DE RECHERCHE

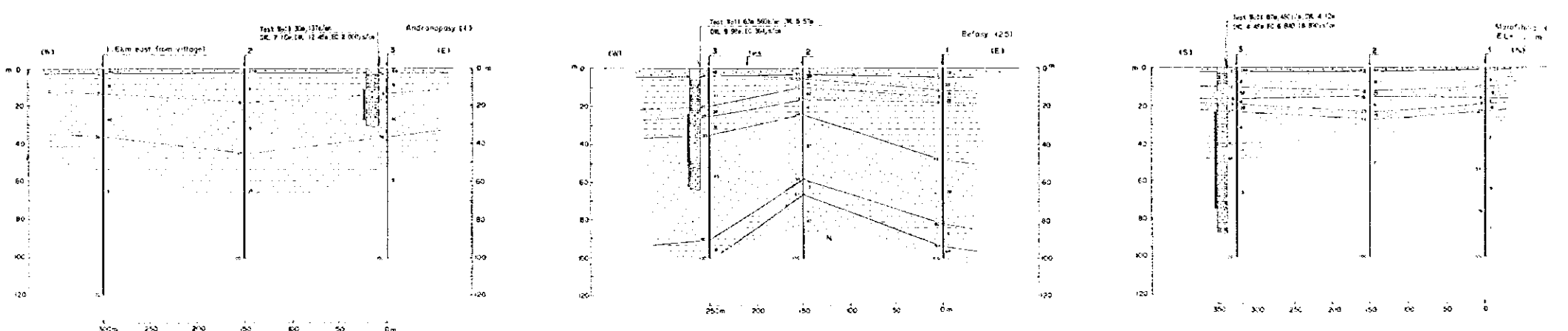
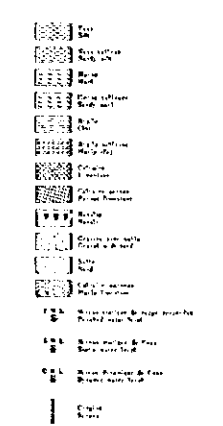
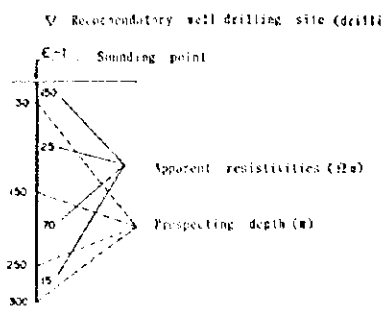


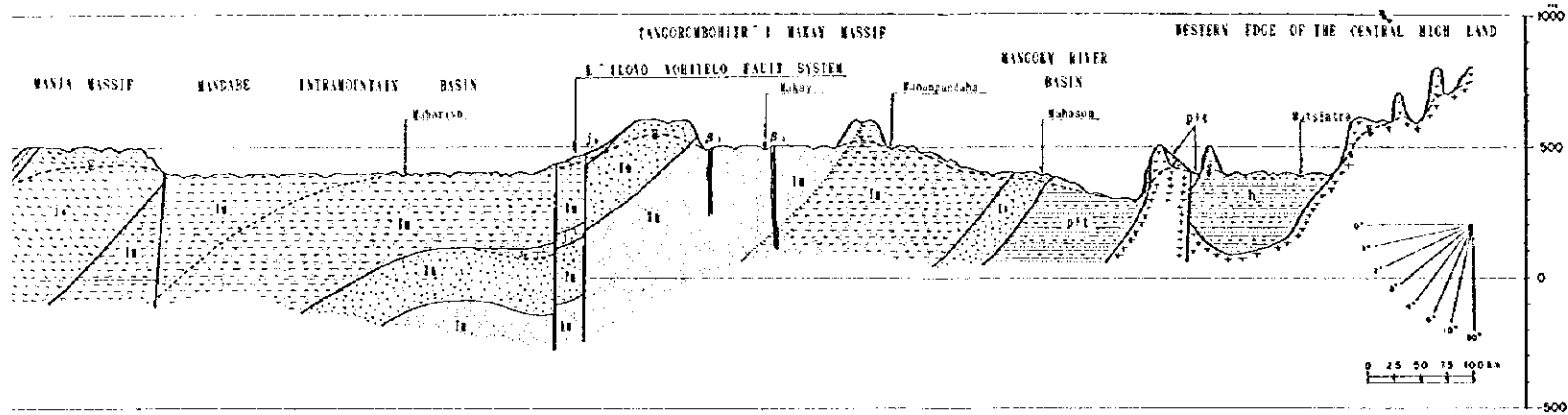


Coupe hydrogéologique verticale de la plaine de Mangoky  
Hydrogeological Vertical Section of the Mangoky Plain

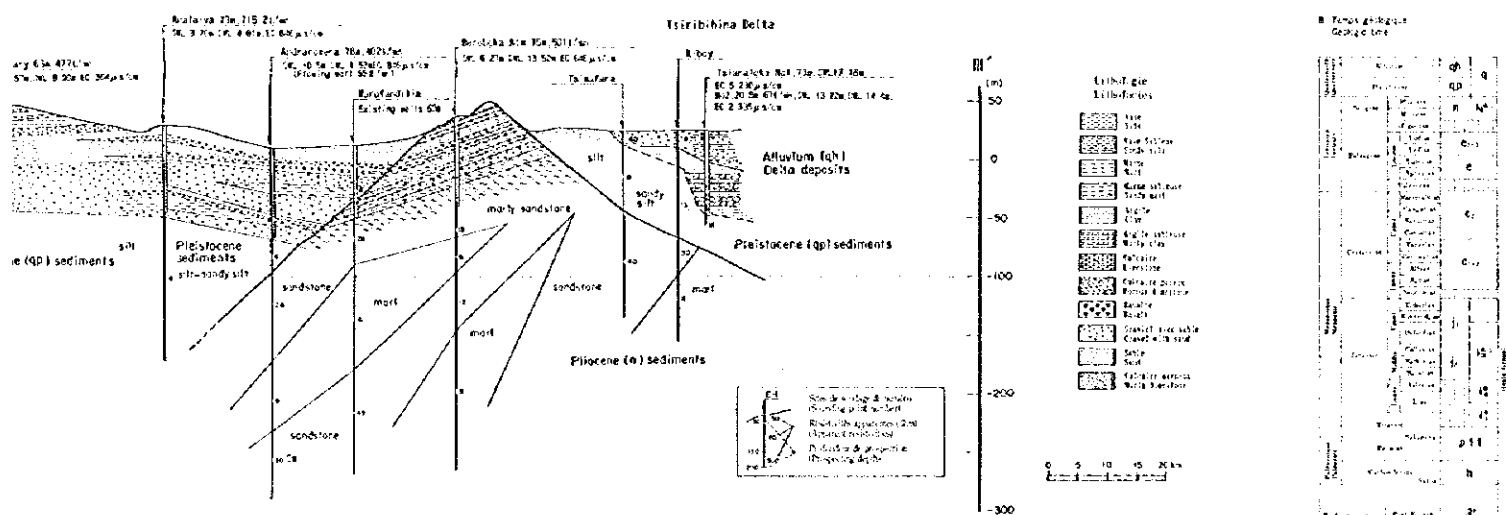


Coupe géophysique transversale  
Geophysical Cross Section  
(resulting from electrical resistivity sounding)

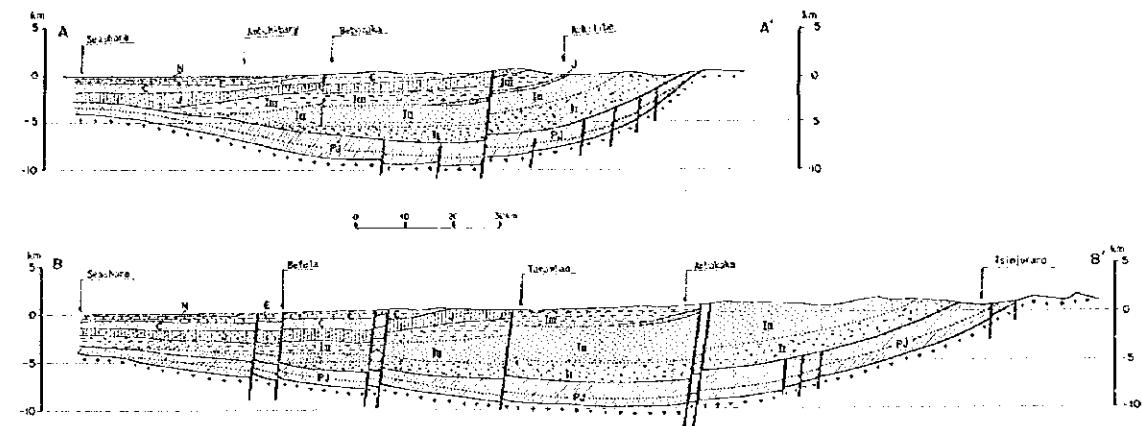




- [Iu] Upper Isalo Group
- [Im] Middle Isalo Group
- [Il] Lower Isalo Group
- [T] Tsiaribihina Belt (Jurassic)
- [K] Kousat (Quaternary)



Coupe hydrogéologique verticale de la plaine de Morondava  
Hydrogeological Vertical Section of the Morondava Plain



- [N] Neogene
- [C] Cretaceous
- [E] Eocene
- [J] Jurassic
- [Iu] Upper Isalo Group
- [Im] Middle Isalo Group
- [Il] Lower Isalo Group
- [T] Tertiary
- [K] Kousat (Quaternary)

Coupe géologique transversale régionale  
Regional Geological Cross Section

