



LABORATOIRE D'OcéANOGRAPHIE DYNAMIQUE ET DE CLIMATOLOGIE

UNITE MIXTE DE RECHERCHE 121

CNRS / ORSTOM / UNIVERSITE PIERRE & MARIE CURIE

A.R.A.M.I.S. 1

à bord du

"LA FAYETTE"

21 septembre - 14 octobre 1988

(B. Piton, chef de mission - C. Peignon)

par

Sabine ARNAULT

Jacques MERLE

Lionel GOURDEAU

Christophe PEIGNON

Yves MENARD

Bernard PITON

*Rapport interne LODYC 90/09
Septembre 1990*

*UNIVERSITÉ PIERRE & MARIE CURIE
PARIS VI*

(Tour 14 - 2^e étage) 4, place Jussieu 75252 PARIS CEDEX 05

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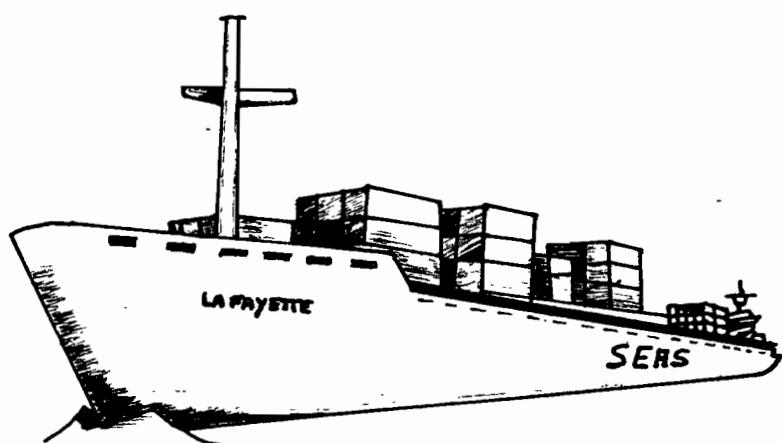
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1. INTRODUCTION ET OBJECTIFS SCIENTIFIQUES.

La prochaine décennie va pour la première fois voir apparaître de grands projets spatiaux directement liés à l'océanographie. L'avantage de telles données réside dans leur couverture globale et quasi synoptique inégalée par celle des mesures à la mer.

Parmi les capteurs embarqués sur satellite, l'altimètre mesure la distance satellite-surface de la mer ainsi que la hauteur des vagues et la vitesse du vent en surface. L'altimètre est un radar qui permet donc de déterminer la distance (avec une précision centimétrique!) entre la surface de la mer et la position du satellite sur son orbite (généralement 800 km). Si la position de la surface de l'océan homogène, sans vent et au repos (géoïde) est connue, l'altimétrie donne les écarts (liés aux mouvements marins) de l'océan par rapport à cette position et permet donc une première approche des courants marins. La difficulté d'un tel travail consiste à extraire un signal faible (de l'ordre de la dizaine de centimètres dans la région considérée) par rapport à la mesure altimétrique initiale.

En prémisses du projet altimétrique franco-américain TOPEX/POSEIDON auquel ils participent par la "Study of Mass and Heat Transport of the Tropical Atlantic Ocean Using Models and Altimeter Data" (Principal Investigator J. Merle, LODYC), Jacques Merle, Sabine Arnault (LODYC/ORSTOM) et Yves Ménard (CNES) ont demandé auprès de l'ATP télédétection spatiale, le financement d'une action thématique programmée intitulée "Validation géophysique des produits altimétriques". Cette action s'appuie sur l'utilisation de l'altimètre américain GEOSAT. L'altimètre du satellite de la NAVY américaine, GEOSAT, qui effectue des mesures sur une large partie du globe (jusqu'à 72° de latitude Nord ou Sud), a été lancé en mars 1985. Les données, d'abord classées et réservées aux militaires américains, ont été rendues accessibles à l'ensemble de la communauté scientifique depuis novembre 1986, quand l'appareil a été placé sur une orbite répétitive à 17,05 jours. Une des traces au sol de GEOSAT se superposant parfaitement à la route maritime d'un bateau marchand dans l'Atlantique tropical, il a donc été proposé une expérience de validation du satellite par des mesures in-situ quasi simultanées.

II. ROUTE ET DEROULEMENT DES OPERATIONS

La campagne A.R.A.M.I.S. 1 (Altimétrie sur un Rail Atlantique et Mesure In Situ) s'est déroulée à bord du M/S LA FAYETTE, du 21 septembre 1988 au 14 octobre 1988, dans l'océan Atlantique tropical. Le cargo porte-conteneurs LA FAYETTE de la Compagnie Générale Maritime relie régulièrement (1 à 2 fois par mois) l'Europe (dernier port touché Anvers) à l'Amérique du Sud (premier port touché Buenos Aires).



Un transit a donc été choisi de façon à ce que le satellite GEOSAT survole le bateau lors de sa traversée de l'Atlantique tropical.

L'appareillage "XBT" sur le LA FAYETTE est habituellement installé dans une petite pièce située derrière la timonerie pour permettre les lancers toutes les 6 heures par l'officier de quart à partir de l'aileron, bâbord ou tribord selon la direction du vent, situé à environ 25 mètres au-dessus de la mer. Devant le taux d'échecs relativement élevé (20 à 40%) vraisemblablement lié à la trop grande hauteur sur l'eau, il n'était pas envisageable de travailler de façon intensive à partir de cette installation. Un autre local a donc été choisi, plus grand et plus près de l'eau.



Les balises ARGOS ont été fixées sur une rembarde de passerelle de grue à l'avant bâbord de la timonerie,



et les 2 lanceurs sur la lisse tribord, sous le vent dominant, à l'arrière du pont supérieur.



L'installation du matériel s'est faite du 22 au 25 septembre.

Un lâcher intensif de sondes thermiques et un échantillonnage serré de mesures de salinités de surface ont alors été effectués, de même qu'un relevé systématique des

conditions météorologiques lors du croisement intervenu le 2 octobre lorsque le bateau se trouvait à 3°40'S (Fig. 1 p5).

L'espacement entre les tirs a été de:

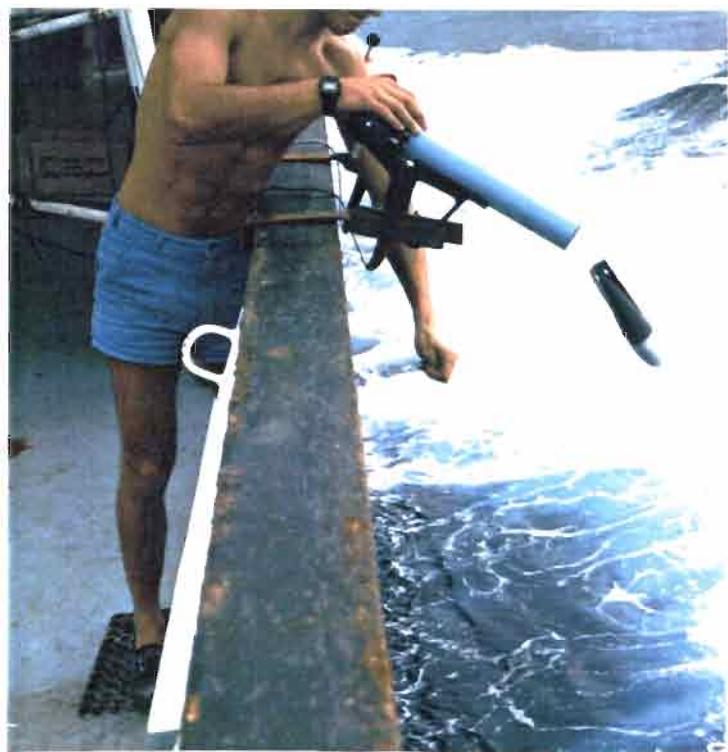
- 2° de latitude entre 40 à 30°N,
- de 1° environ jusqu'à 10°N ,
- de 30' de 10 à 8°N .

Le lâcher s'est en suite accéléré:

- une sonde toutes les 4' de latitude jusqu'à 5°N,
- toutes les 2' jusqu'à 3°N,
- toutes les 1' près de l'équateur

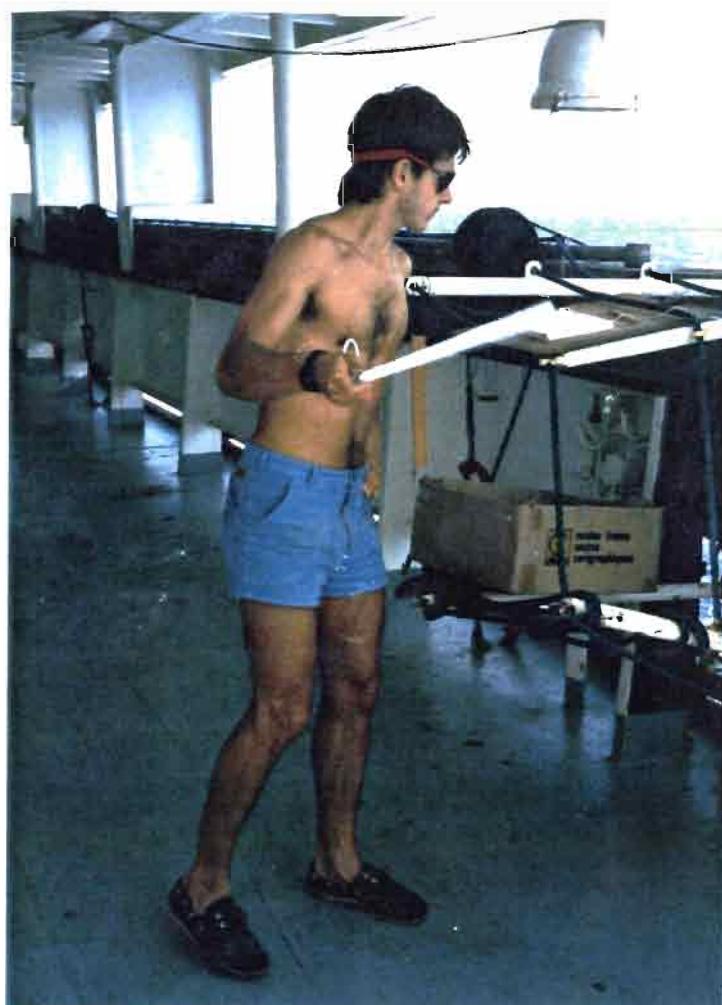
pour se relâcher à nouveau

- à 2',
- puis 3' jusqu'à 2°S,
- 4' jusqu'à 4°S,
- puis 1° jusqu'à 18°S.



Le premier lancer a eu lieu le 25 septembre par 40°00N/11°41W et le 308ème et dernier, le 4 octobre par 17°32S/38°05W.

Les lectures des thermomètres sec et humide ont été faites à l'ombre de la coursive tribord durant la descente de la tête XBT (2 minutes 30' environ jusqu'à 900 m) (Fig. 2 p6).



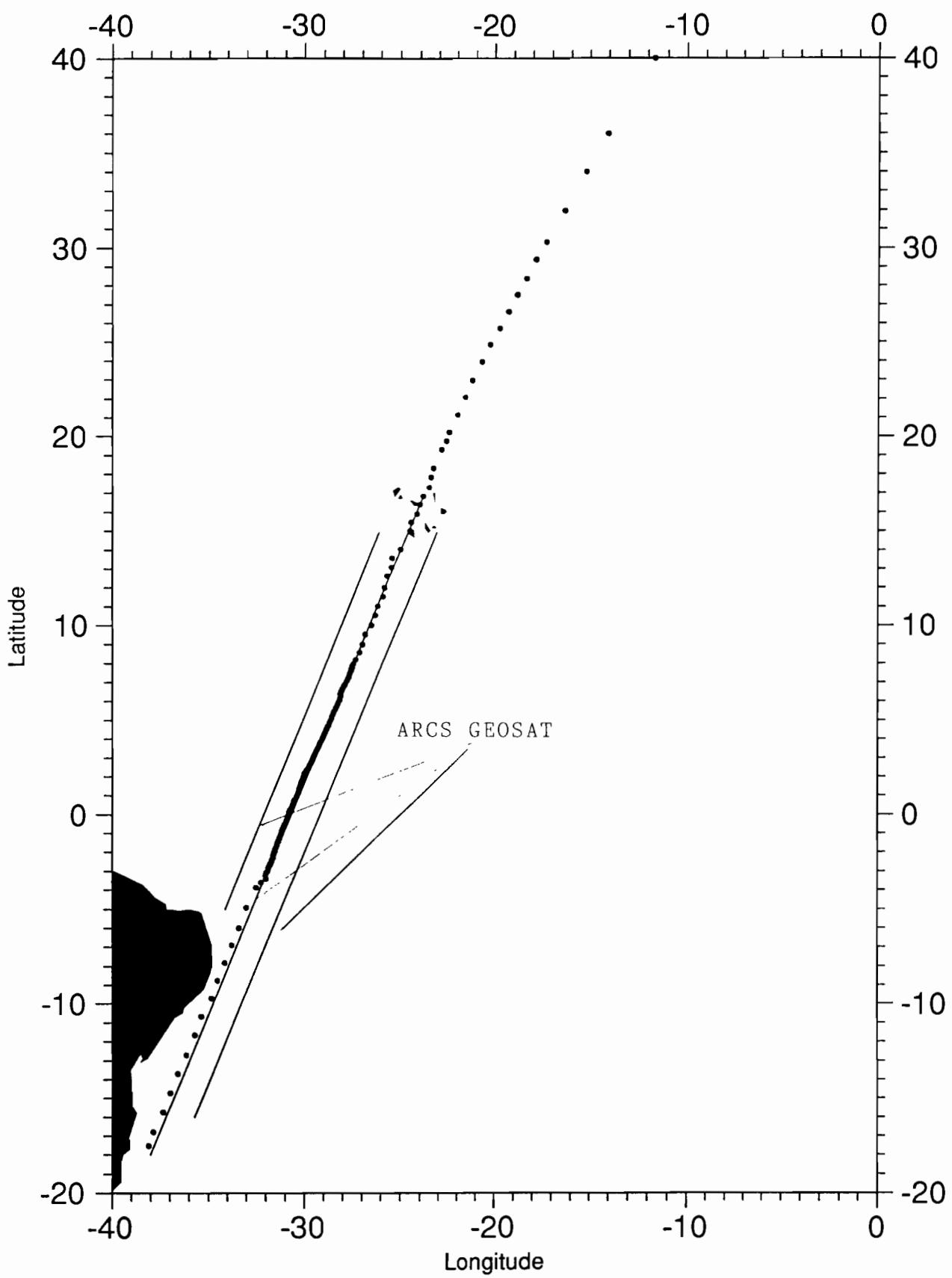
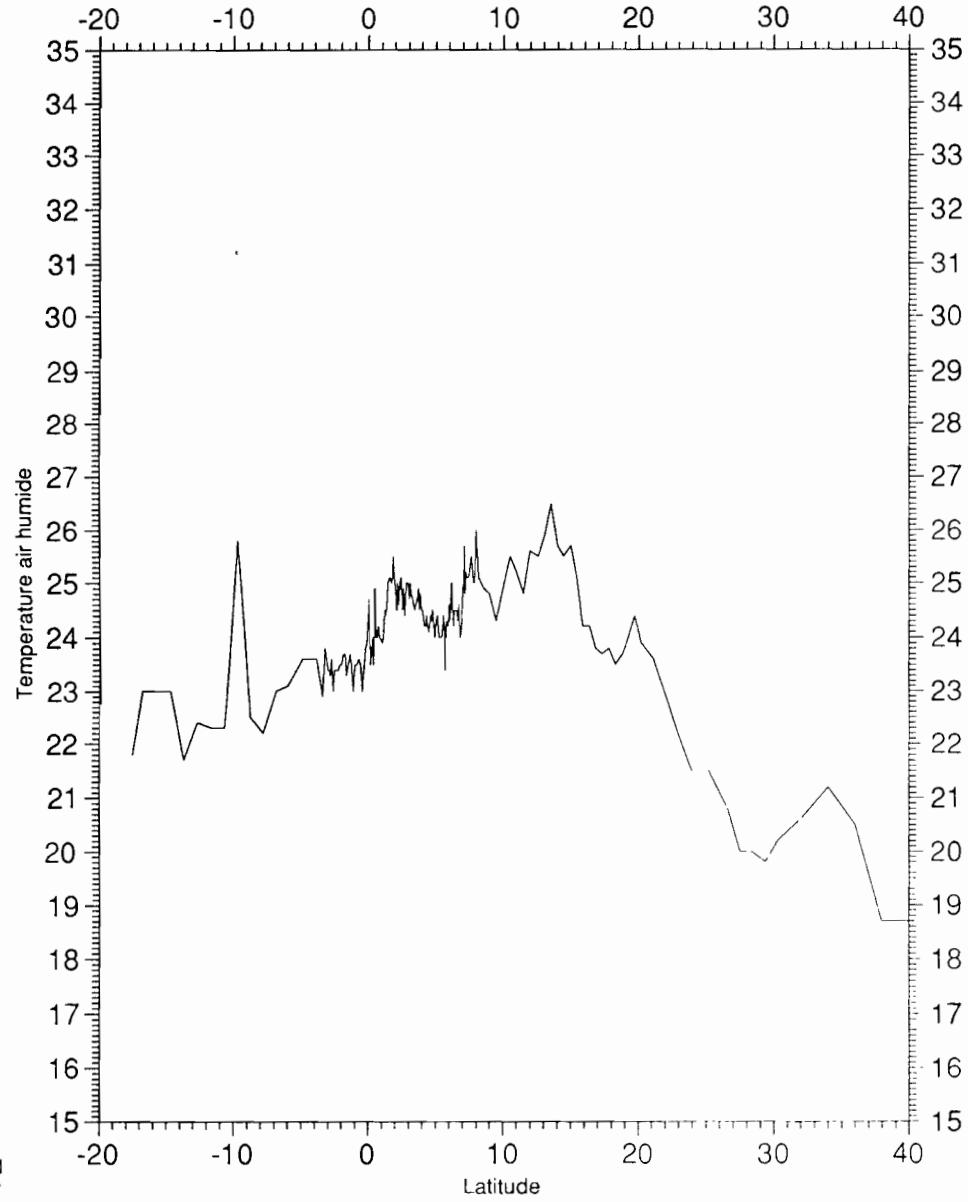
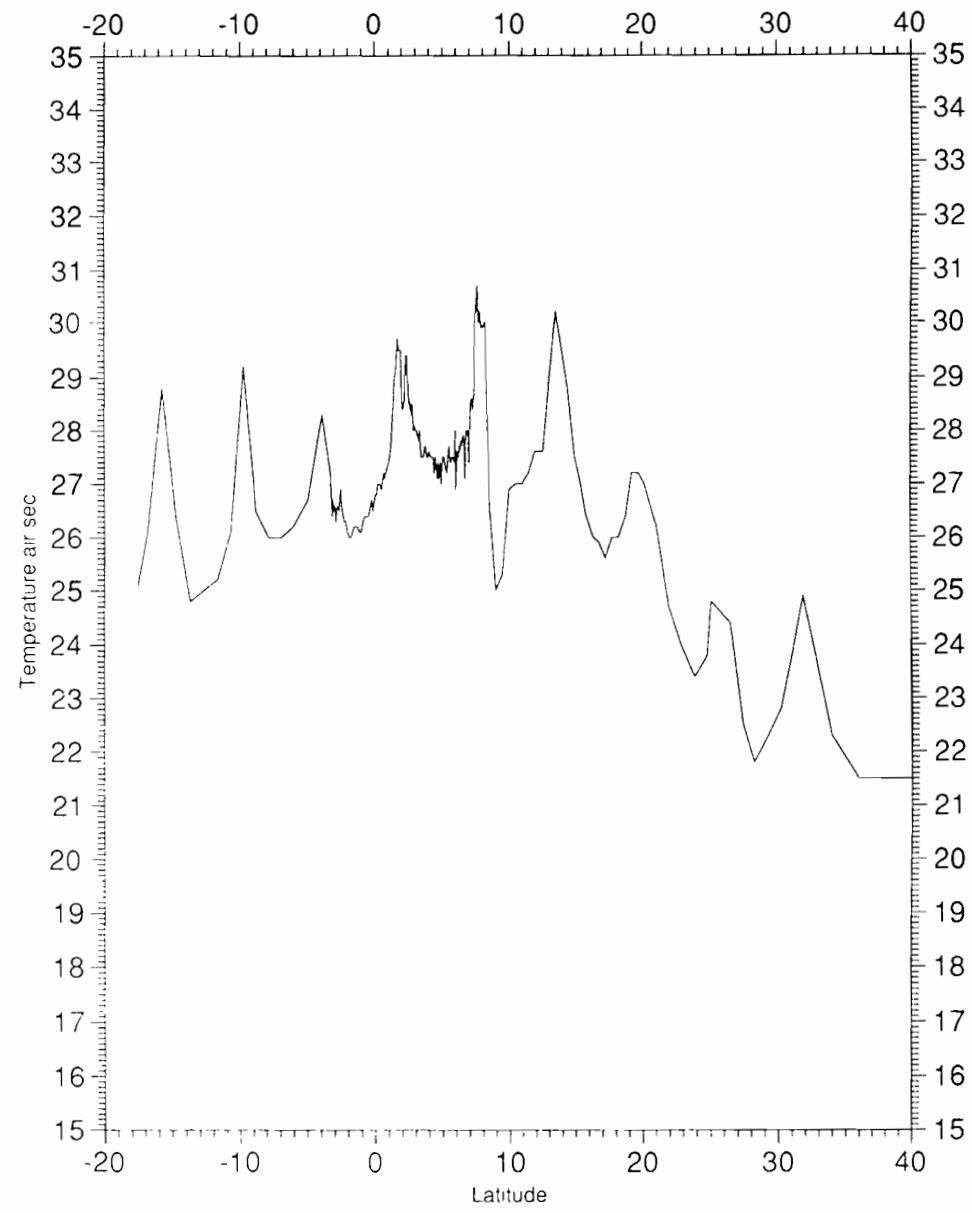


Fig. 1

HUMIDE



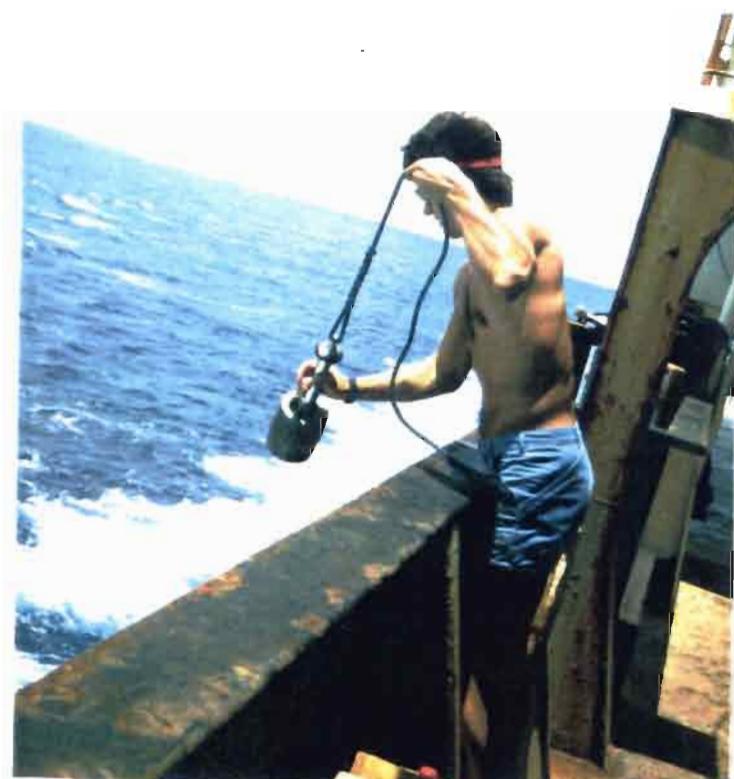
SEC

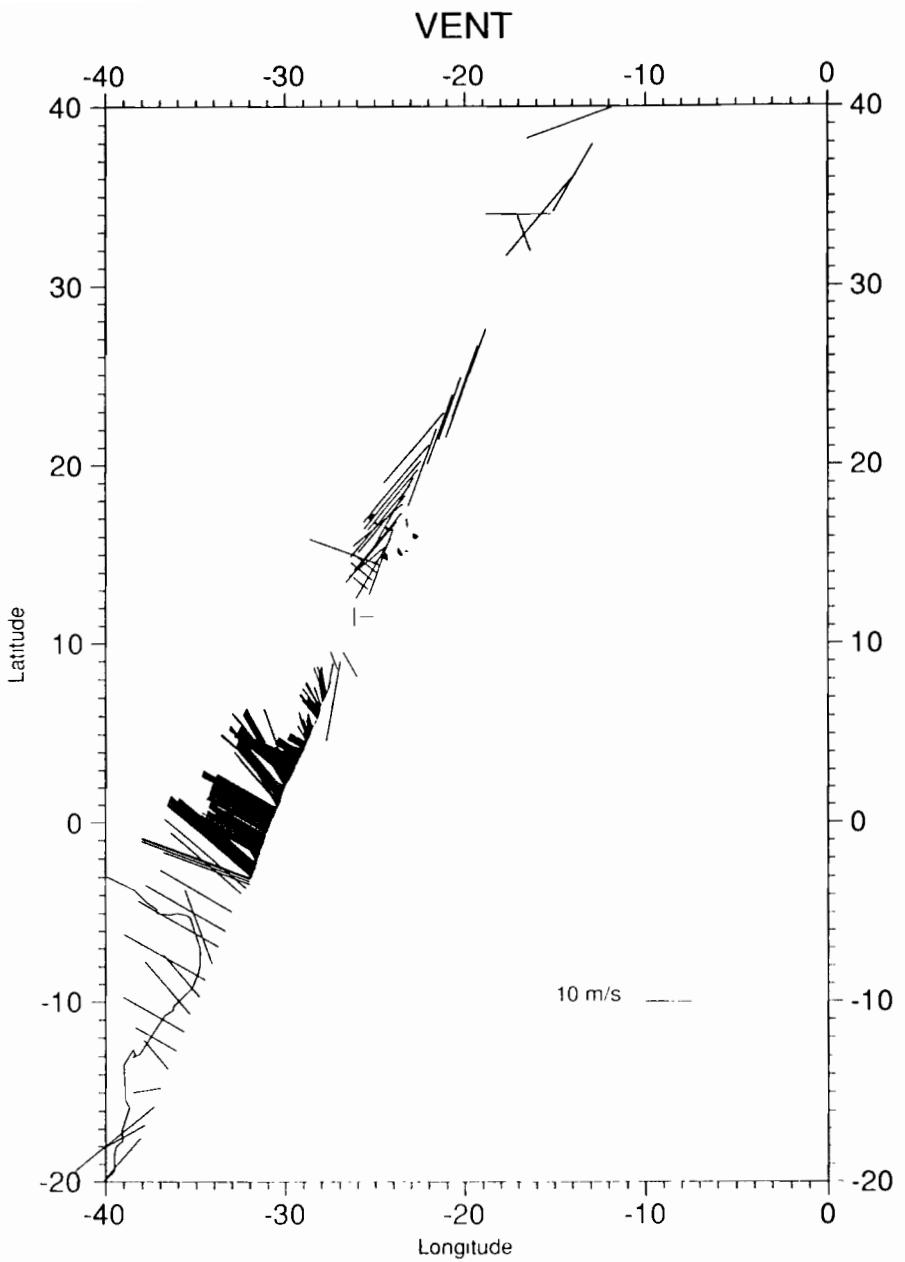
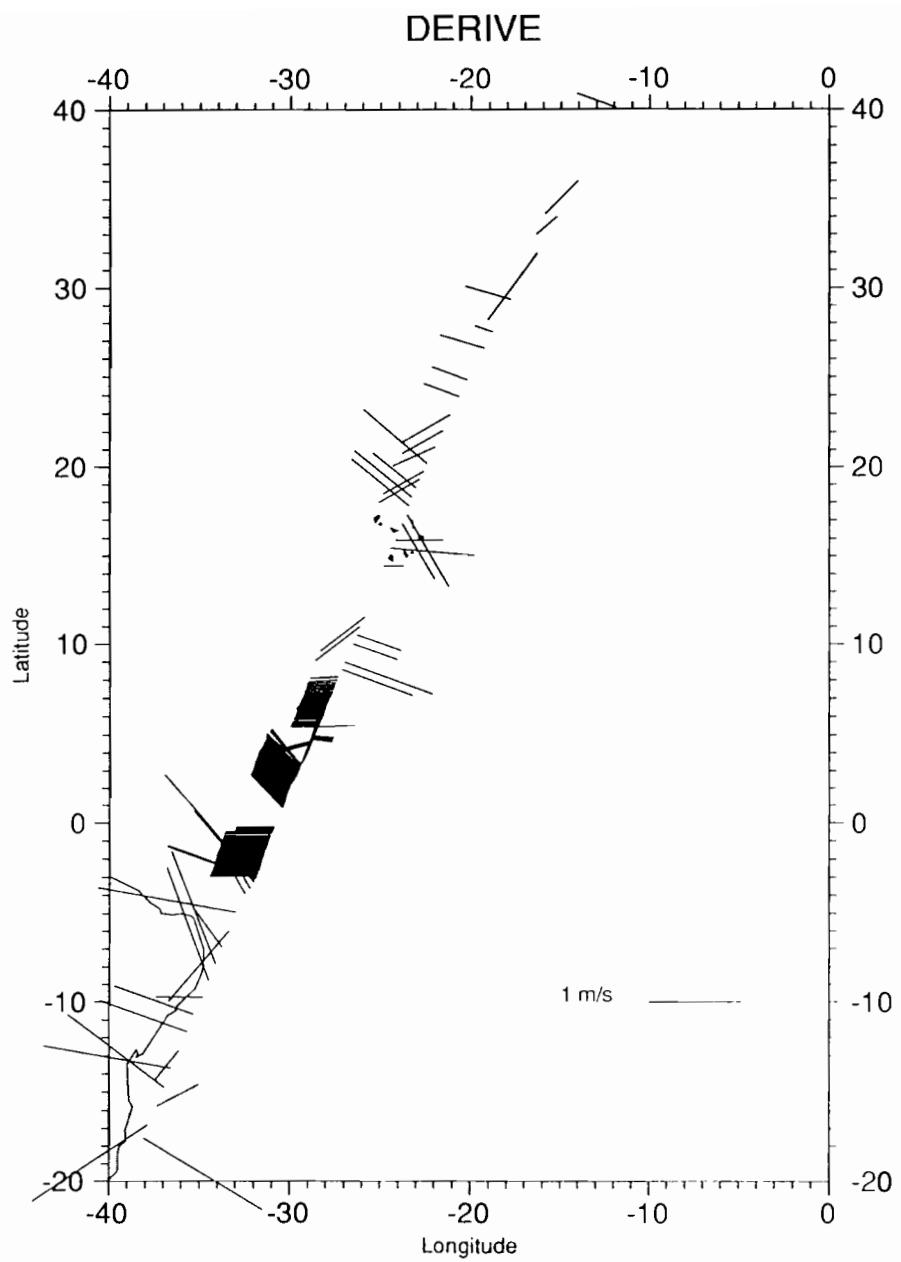


Les positions, dates, heures, vents, nébulosité ... étaient notées à chaque tir par les officiers de quart (Fig. 3 p8 et 4 p9).

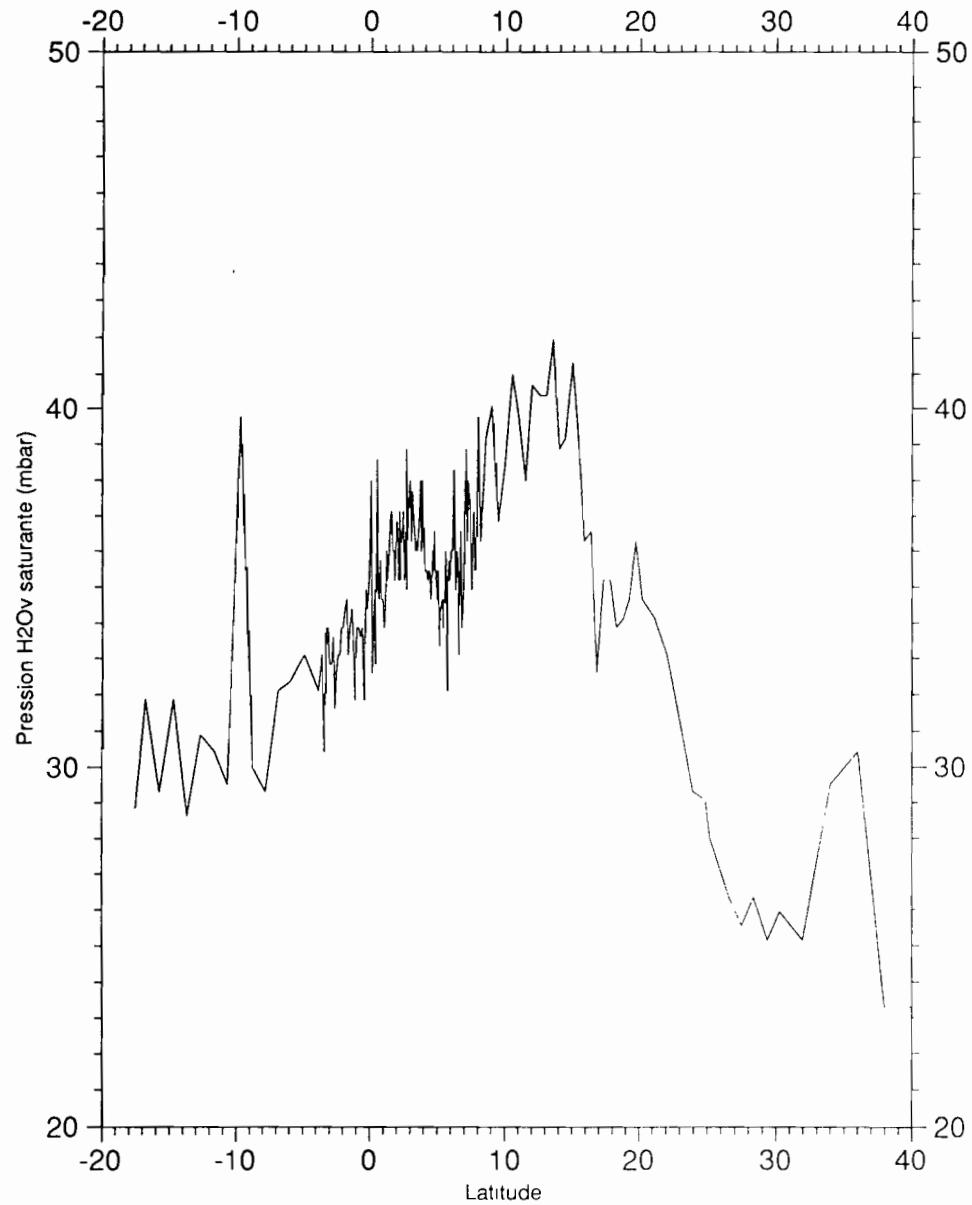
Le calcul de l'humidité relative, de la température du point de rosée découlait des observations citées ci-dessus (Fig. 5 p10).

Lors de certains lâchers, des prélèvements au thermomètre seau ont été effectués à une vingtaine de mètres plus en avant des lanceurs.

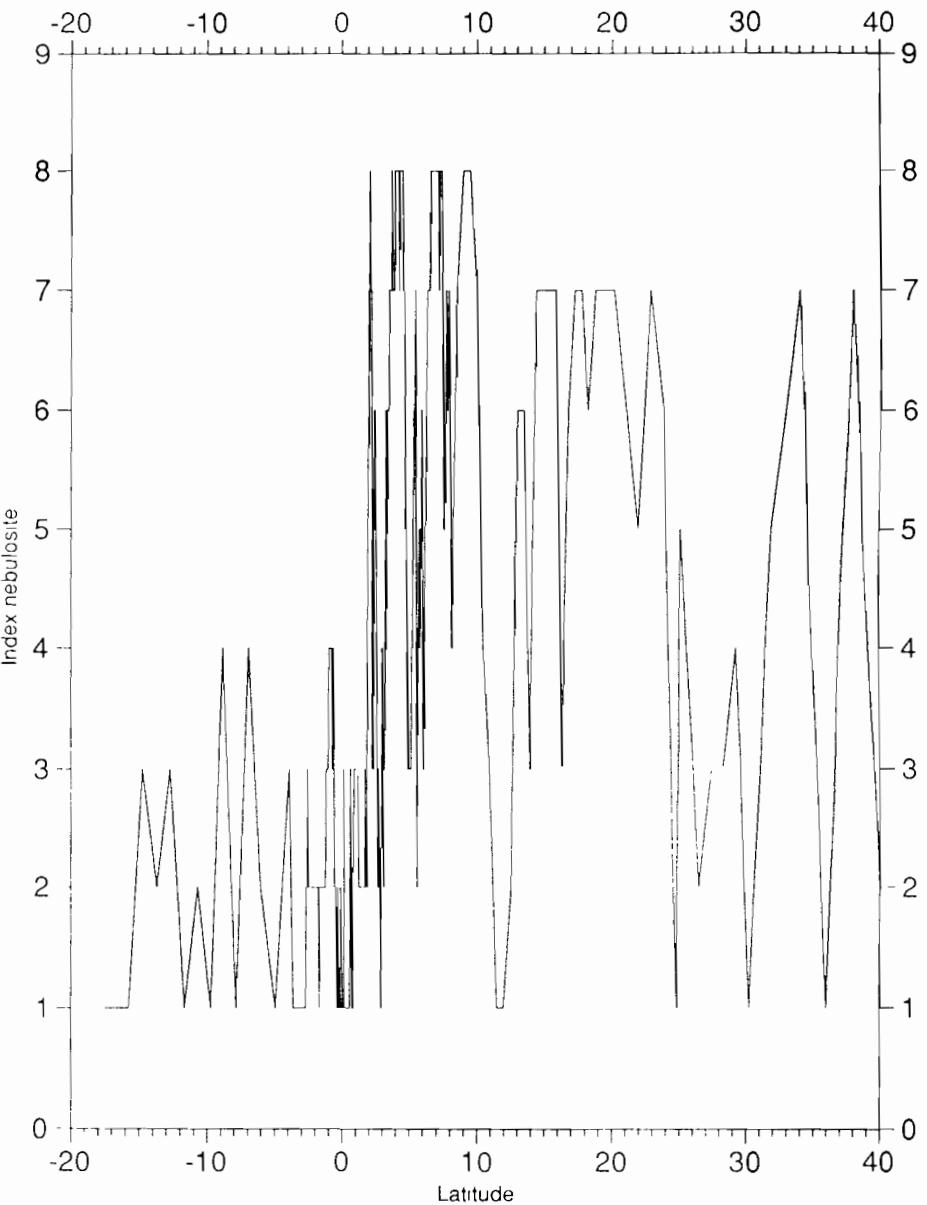




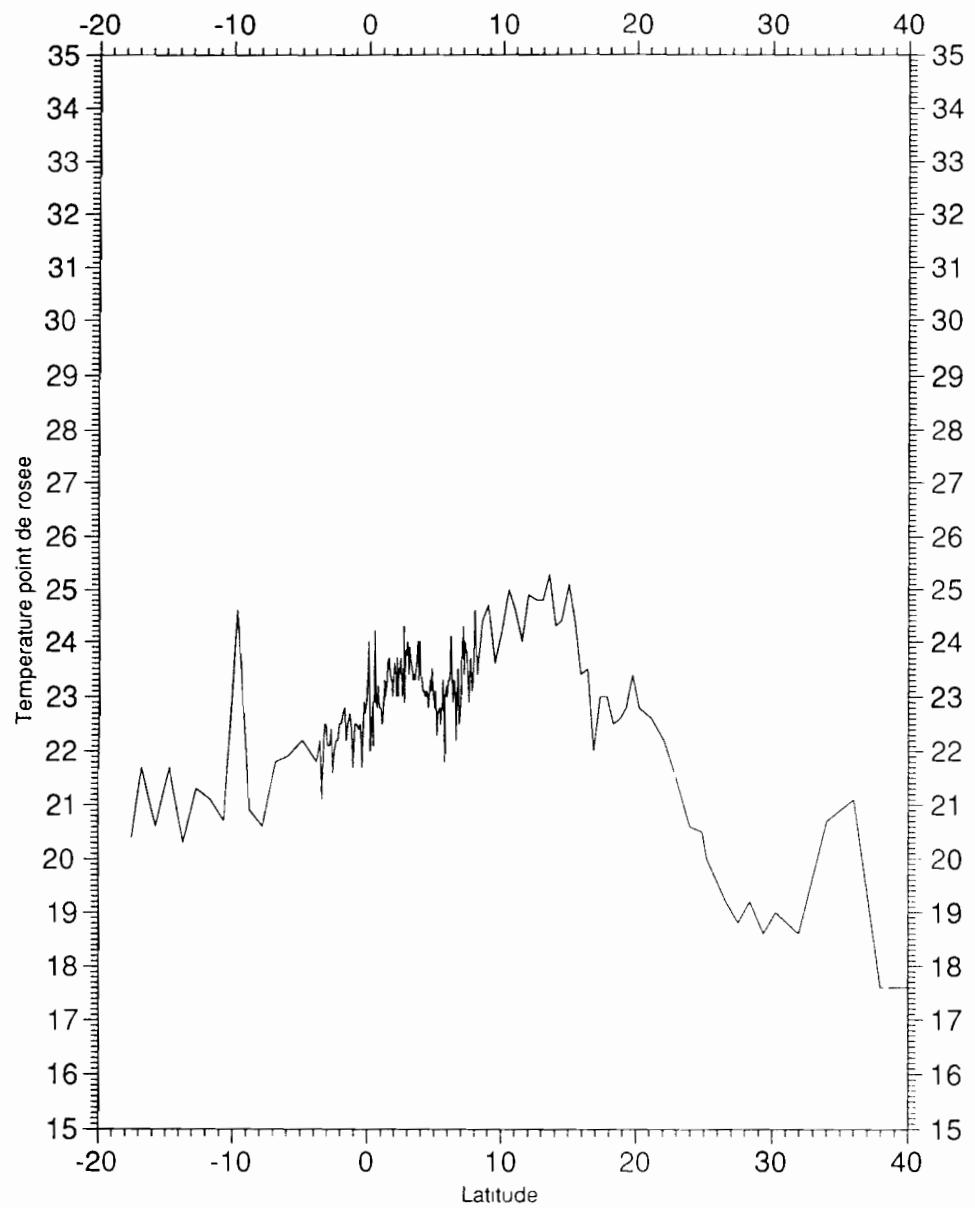
Pression H₂O Vapeur Saturante



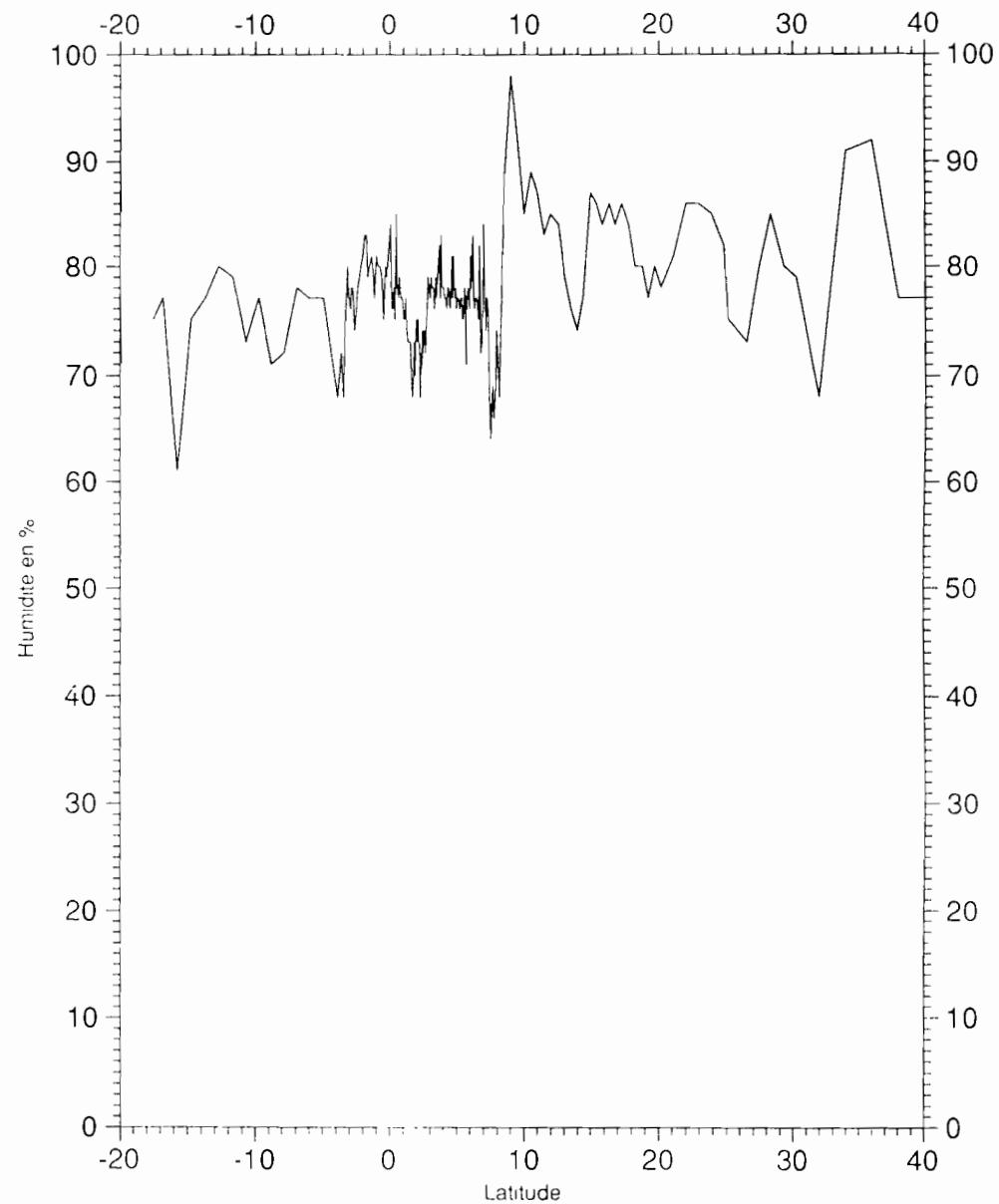
NEBULOSITE



ROSEE



HUMIDITE



La température de surface était ainsi indiquée pour noter le décallage éventuel de la mesure de la sonde. La salinité était mesurée à bord à l'aide d'un salinomètre GRUNDY.



Enfin, un dépouillement succinct: reprise des positions en fonction des "fix", pointage en fonction de la latitude de la température et de la salinité de surface, de la pression atmosphérique et de l'humidité relative ainsi que des immersions des isothermes 10, 15, 20 et 25° lues sur les graphes T/Z permettait de suivre la bonne évolution de la campagne et le bon fonctionnement du matériel.

III. INSTRUMENTATION

Navire sélectionné météorologie (mais sans centrale POMMAR) et XBT-TOGA, le LA FAYETTE est donc équipé d':

- une balise XBT-ARGOS avec antenne CIT,
- un câble coaxial de 20m,
- une liaison RS232,
- un interface
- un micro-ordinateur ZENITH
- un logiciel d'acquisition des données.
- un lanceur.

La longueur des câbles reliant les lanceurs aux interfaces est d'une trentaine de mètres.

Un deuxième système complet XBT-ARGOS a été acheté pour la campagne de validation.

Les 2 systèmes XBT-ARGOS étaient doublés par un système ETSM2/PET COMMODORE mis en alerte en cas de défaillance des autres.

Une imprimante graphique IBM était reliée à l'un des micro-ordinateurs pour suivre graphiquement la descente de certaines sondes.

600 sondes XBT (Expendable BathyThermograph) du type "Deep Blue" de la marque SIPPICAN ont été embarquées. Elles descendent jusqu'à 800-900 m.



Un thermomètre-seau a servi aux prélèvements hydrologiques.

Un salinomètre GRUNDY permettait la mesure à bord des salinités de surface.

Des thermomètres sec et humide fournissaient la température de l'air.

Une station SUN 110 assurait la maintenance des opérations à terre.

IV. PRELEVEMENTS HYDROLOGIQUES

207 prélèvements ont permis la mesure de la température et de la salinité de surface.

V. VALIDATION DES DONNEES

Les données de la campagne ARAMIS 1 ont été validées à Brest, grâce à une collaboration active avec l'équipe ORSTOM physique locale.

Les 308 sondes lâchers étaient reparties en 3 fichiers informatiques.

Une visualisation systématique de tous les profils thermiques élimine 20 profils des 308 initiaux soit environ 20%.

Parmi les 288 profils restants, seuls 280 atteignaient où dépassaient 500m, immersion de référence pour nos calculs.

VI. PRESENTATION DES RESULTATS

Les profils thermiques obtenus pas les XBT le long de la route suivie sont présentés pp15-88. Ces profils sont caractéristiques des eaux rencontrées:

- * Entre 40°N et 30°N, épaisse couche homogène (50m) relativement froide et peu de gradient thermique (10-12° sur 750m) entre la surface et le fond.
- * Entre 30 et 10°N les couches profondes se refroidissent, les températures de surface augmentent et la couche de mélange diminue (25m).
- * A partir de 10°N, les profils deviennent caractéristiques des régions tropicales avec une thermocline vers 100m bien marquée qui sépare des eaux superficielles chaudes et homogènes (plus de 25°C) des eaux plus profondes et froides (5-10°C).
- * Au Sud de 6°S, la thermocline devient beaucoup moins "pincée" et affecte une épaisseur d'eau d'au moins 400m tandis que la couche homogène de surface refroidit tout en s'épaississant.

Les températures et salinités de surface (p89) présentent entre 7 et 8°N une étroite bande d'eaux chaudes ($T > 29^\circ\text{C}$) et dessalées ($S < 36\text{‰}$). Les eaux de surface présentent donc par rapport à la climatologie des anomalies de plus de 2°C et de 2‰. C'est une des rares fois où, grâce à l'importante densité des mesures effectuées, on a pu mettre en évidence l'étroitesse et l'intensité du contraste thermo-salin sur cette région. On pensait auparavant que des eaux relativement chaudes et dessalées (27°C 35.5‰) s'étendaient sur une large zone entre 0 et 10°N.

Les coupes de températures le long de la ligne du bateau (pp90-91) dénotent la présence d':

- un courant vers l'Est entre 25 et 40°N, sans doute le courant des Ascores,
- un courant vers l'Ouest entre 10-12°N et 25°N, le Courant Equatorial Nord

- un courant vers l'Est entre 2-3°N et 10°N, le Contre-Courant Equatorial Nord
- un courant vers l'Ouest en surface autour de l'équateur, le Courant Equatorial Sud, tandis que l'éclatement de la thermocline vers 150m montre la présence du Sous-Courant Equatorial vers l'Est.

La hauteur dynamique 0/500 dbar (p92) a été calculée à l'aide de courbes T-S climatologiques mensuelles. Cette méthode avait été précédemment utilisée avec succès par les auteurs dans l'océan Atlantique tropical. Les T-S ont été reajustées en surface à l'aide des mesures effectuées lors de la campagne.

VII. EQUIPE SCIENTIFIQUE

Jacques MERLE Directeur de Recherche ORSTOM

Bernard PITON Directeur de Recherche ORSTOM

Sabine ARNAULT Chargé de Recherche ORSTOM

Yves MENARD Ingénieur CNES

Christophe PEIGNON Technicien ORSTOM

Lionel GOURDEAU Etudiant en thèse

VIII. REMERCIEMENTS

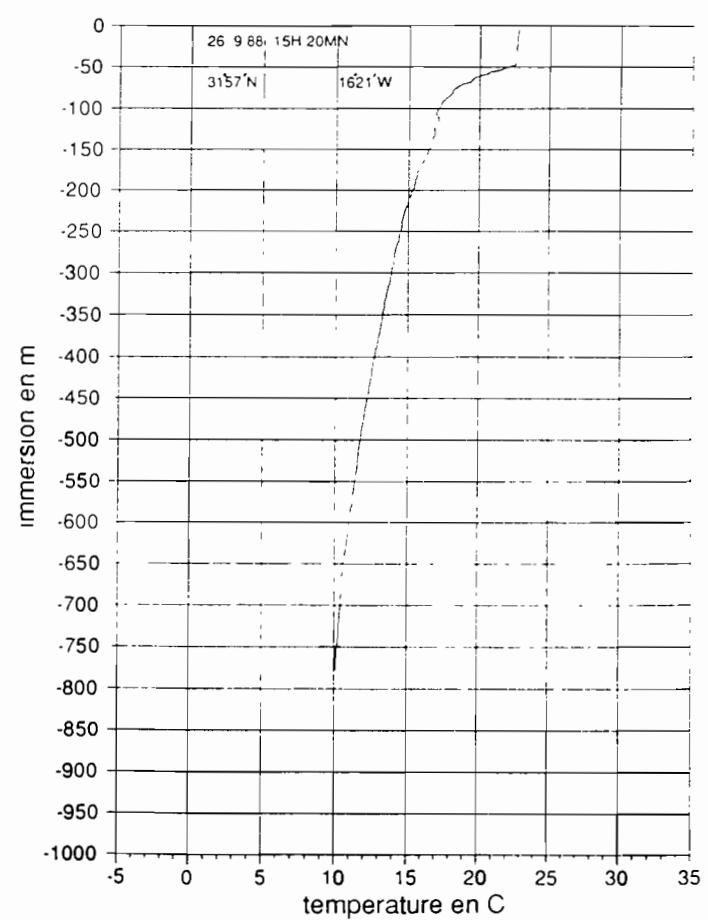
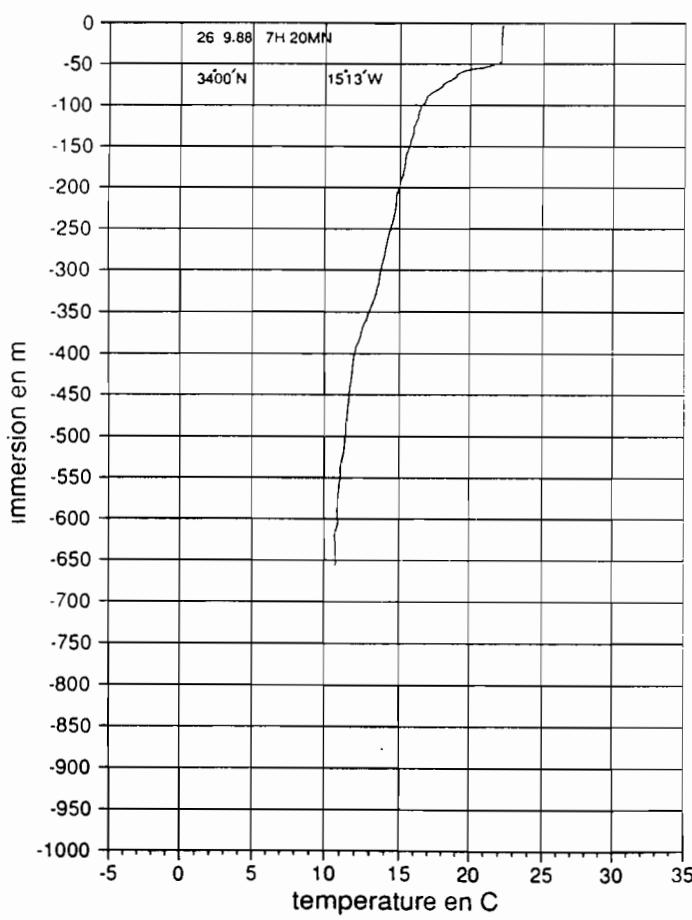
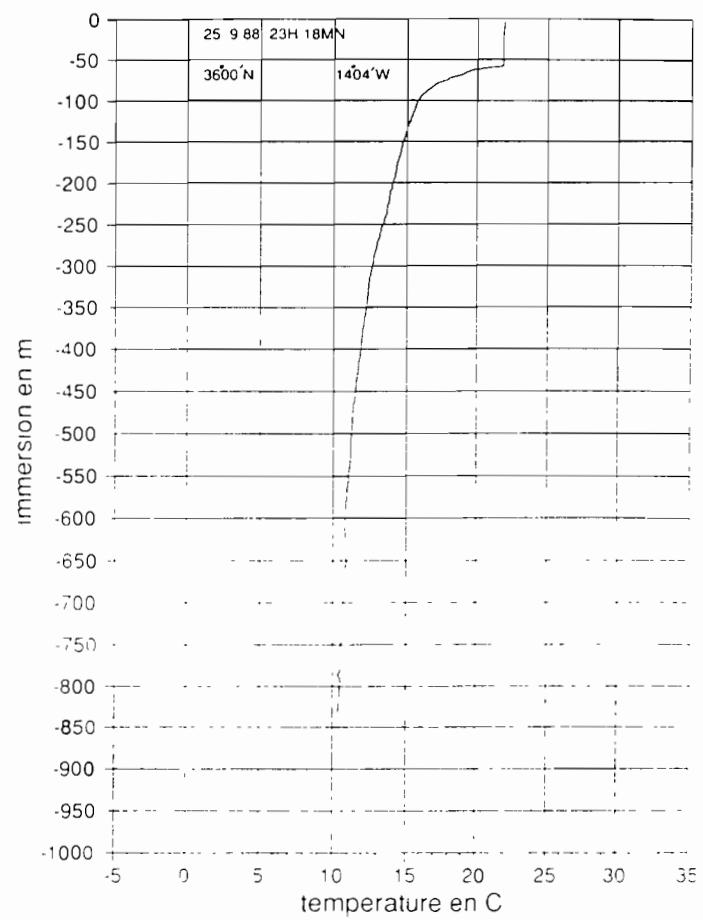
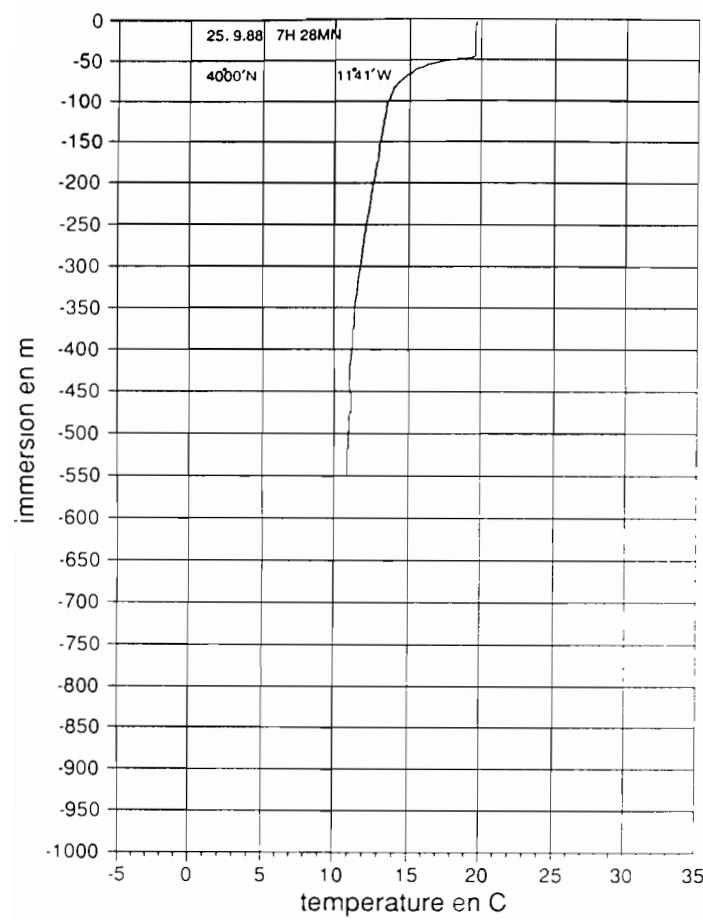
La préparation de cette campagne a été facilitée grâce aux interventions de :

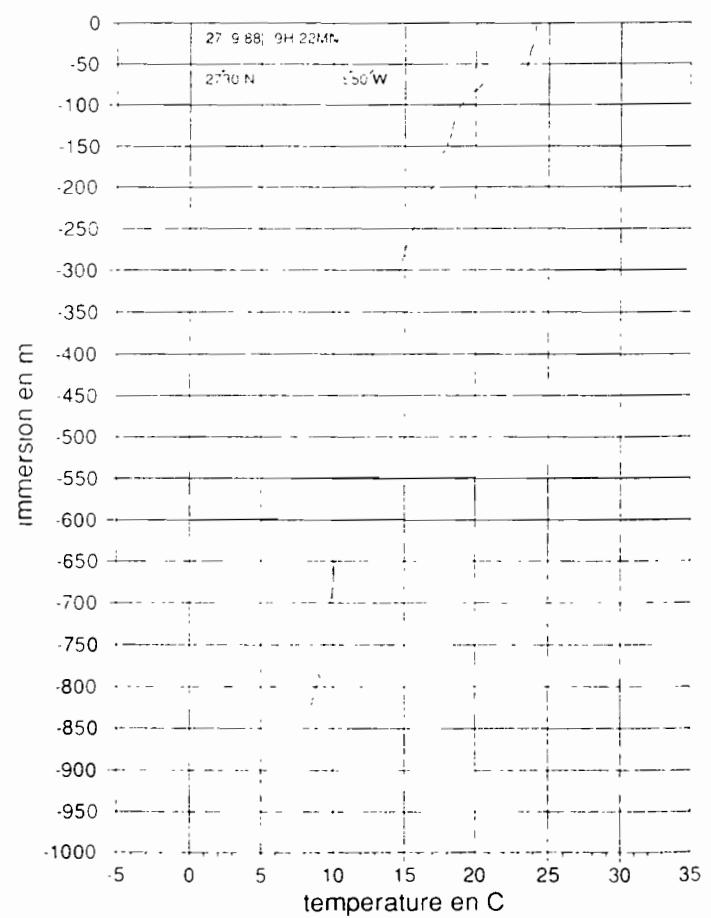
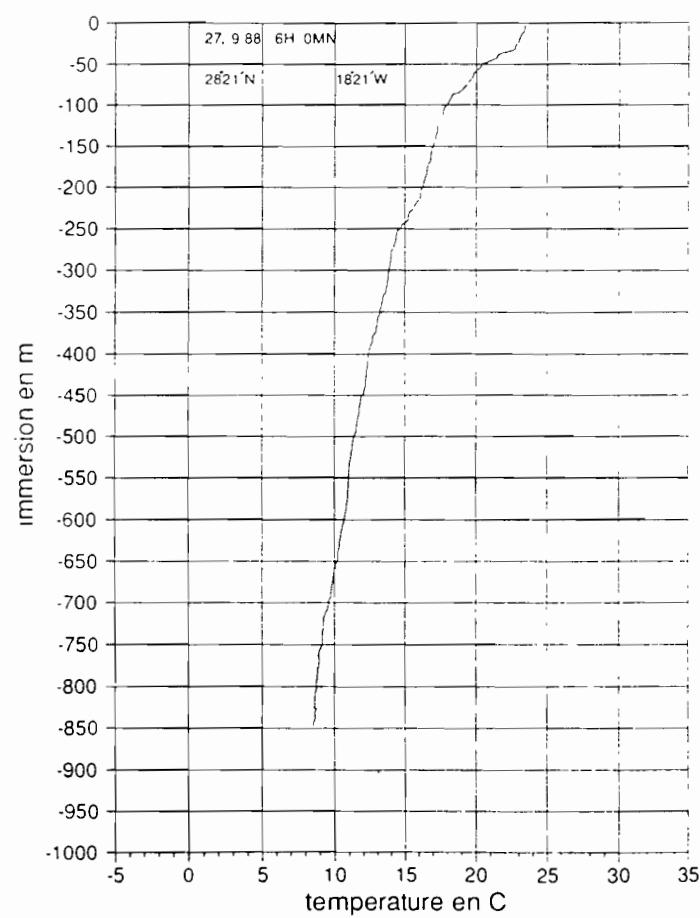
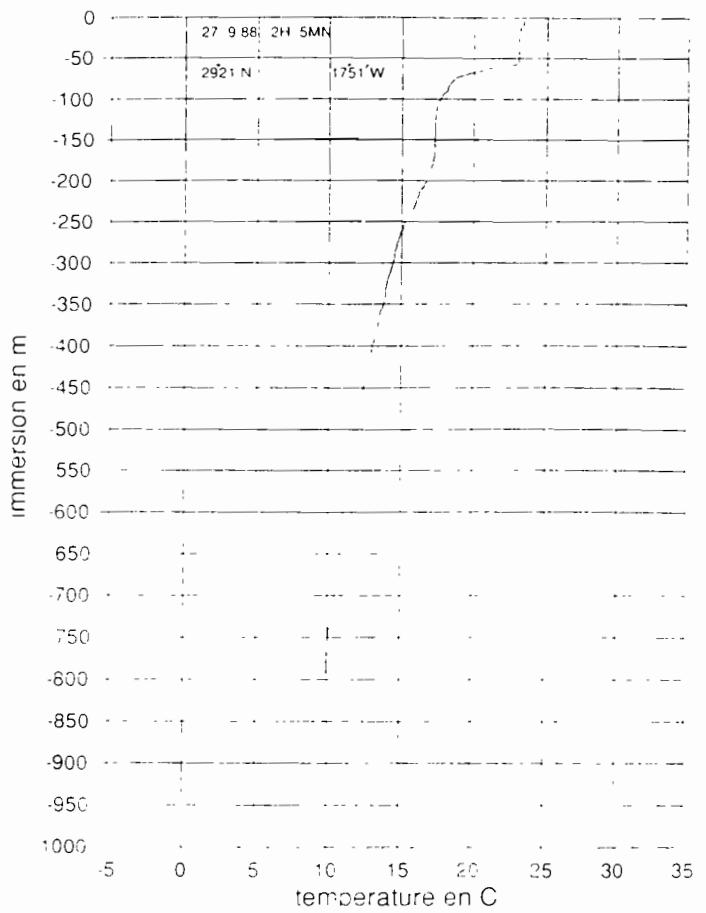
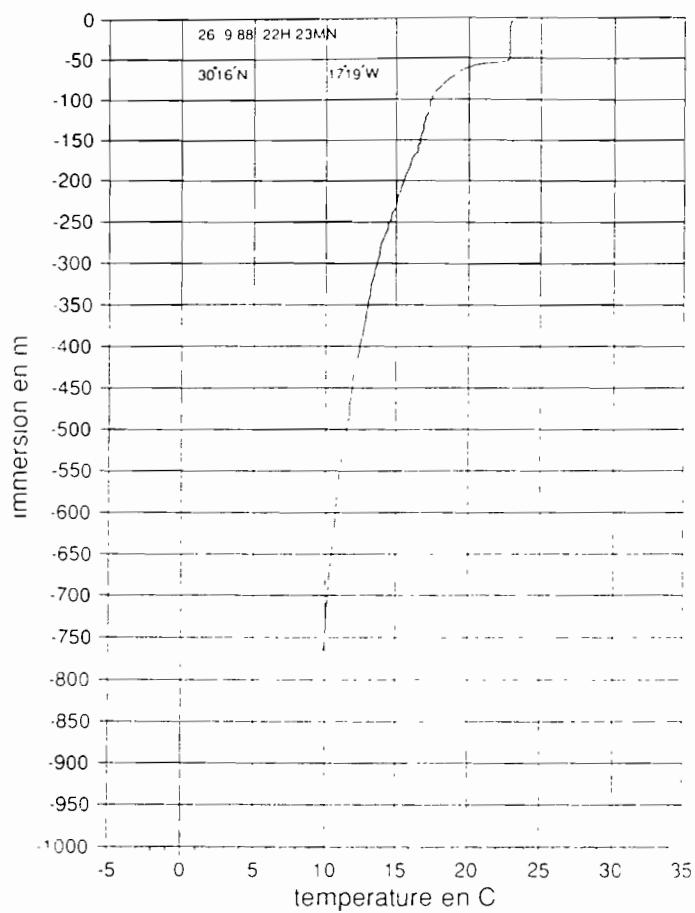
- Mr Ronin, CGM, dont l'aide nous a été précieuse pour établir les contacts avec les différents bureaux de la CGM,
- Mr Privé, ORSTOM, qui a assuré notamment la réception des sondes puis leur acheminement jusqu'au bateau, et nous a fait profiter de sa connaissance du LA FAYETTE,
- Mr Ortega, CLS ARGOS, qui nous a aidés à nous procurer le matériel informatique ARGOS.

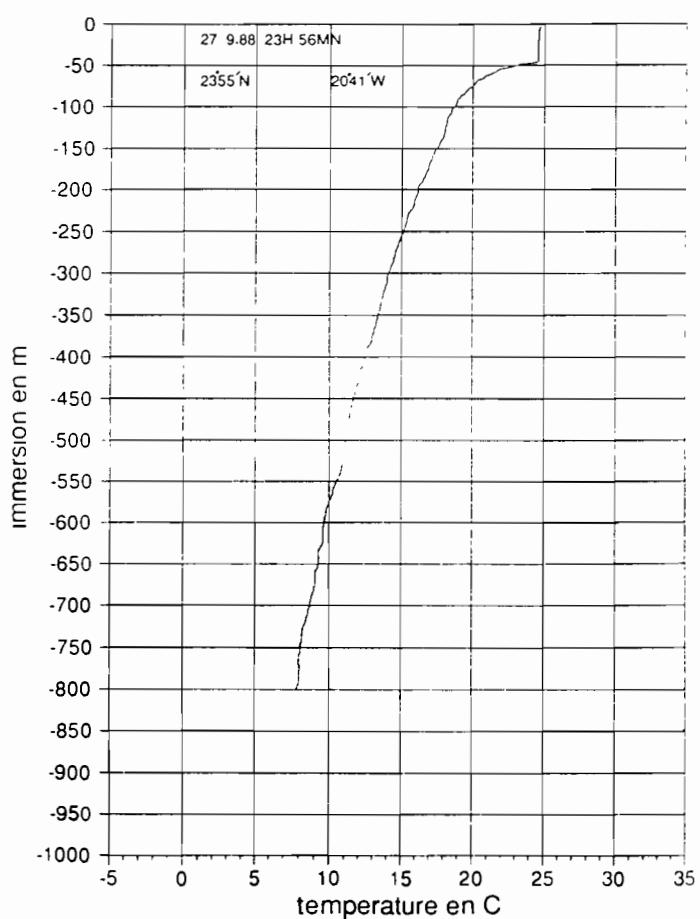
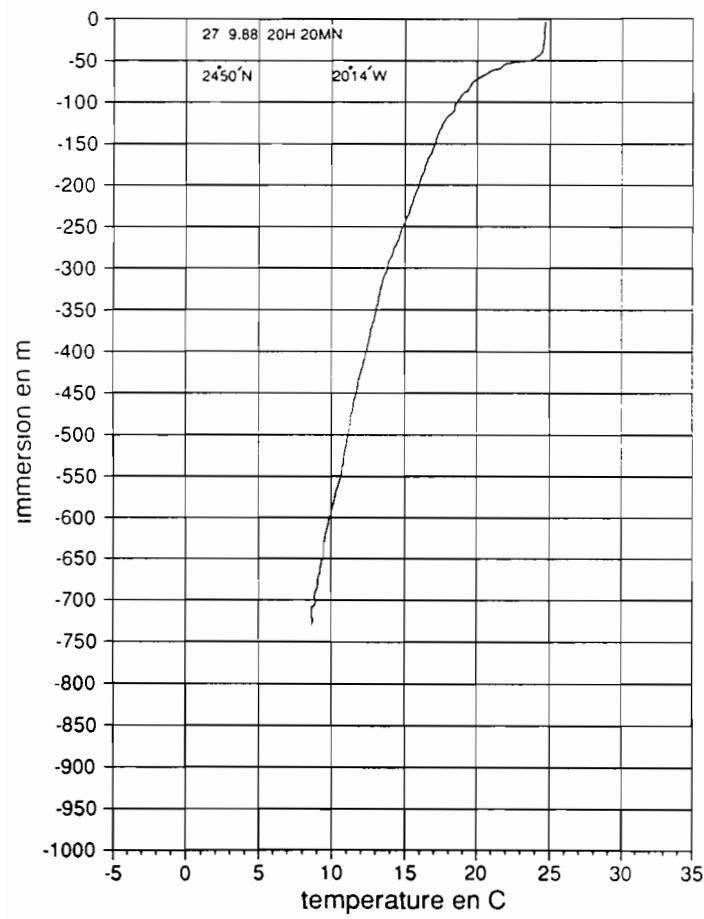
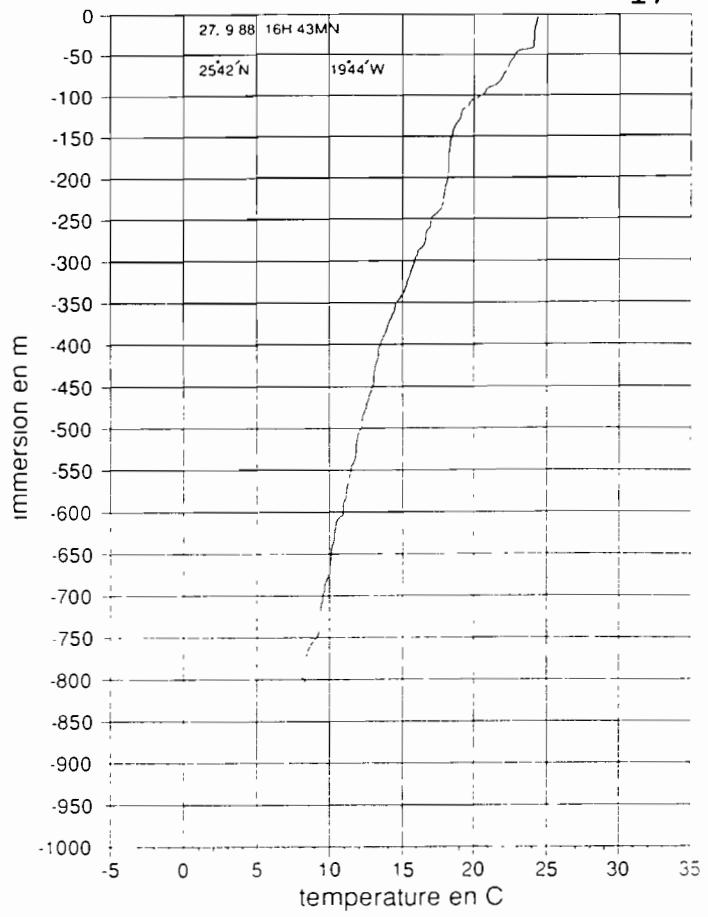
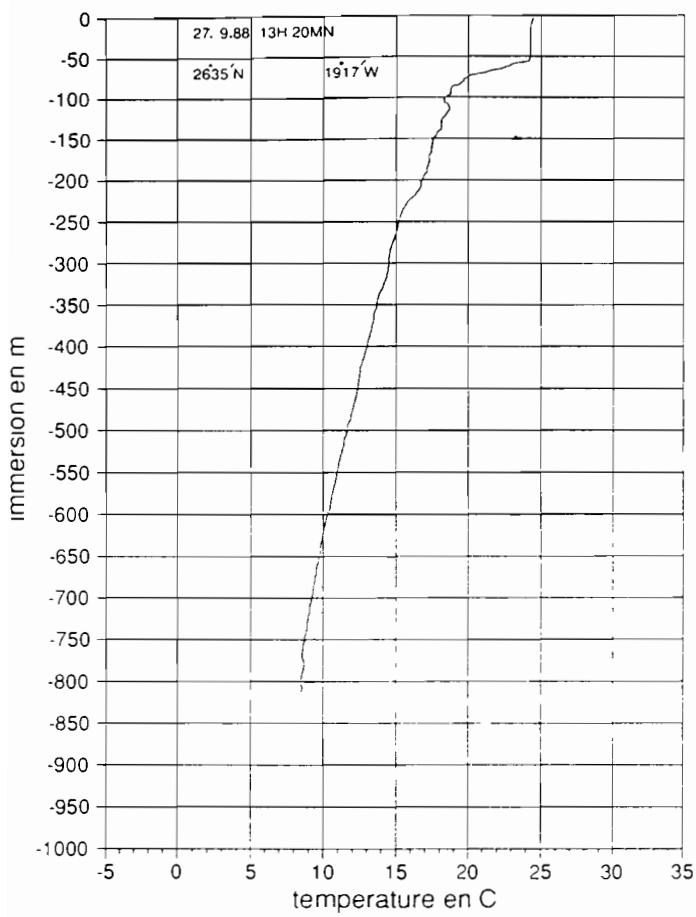
La coopération très efficace du commandant Soviche et de l'ensemble de l'équipage a été très appréciée.

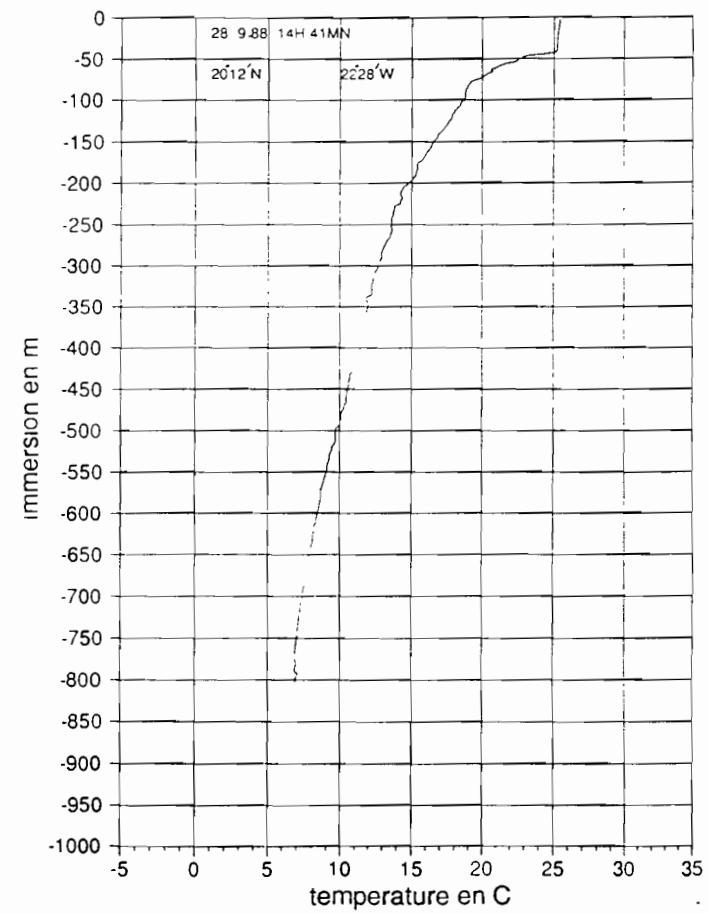
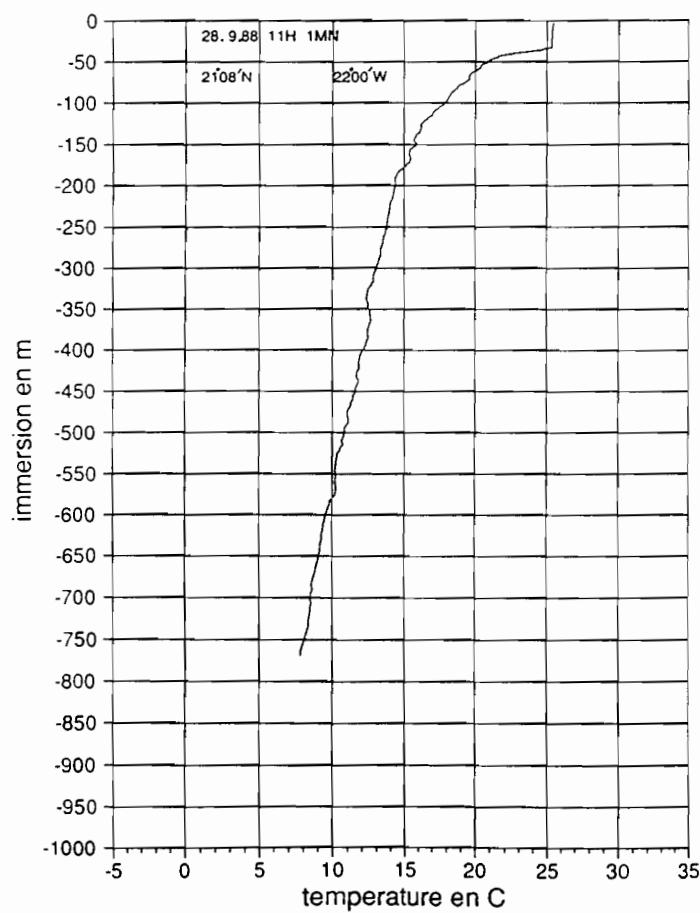
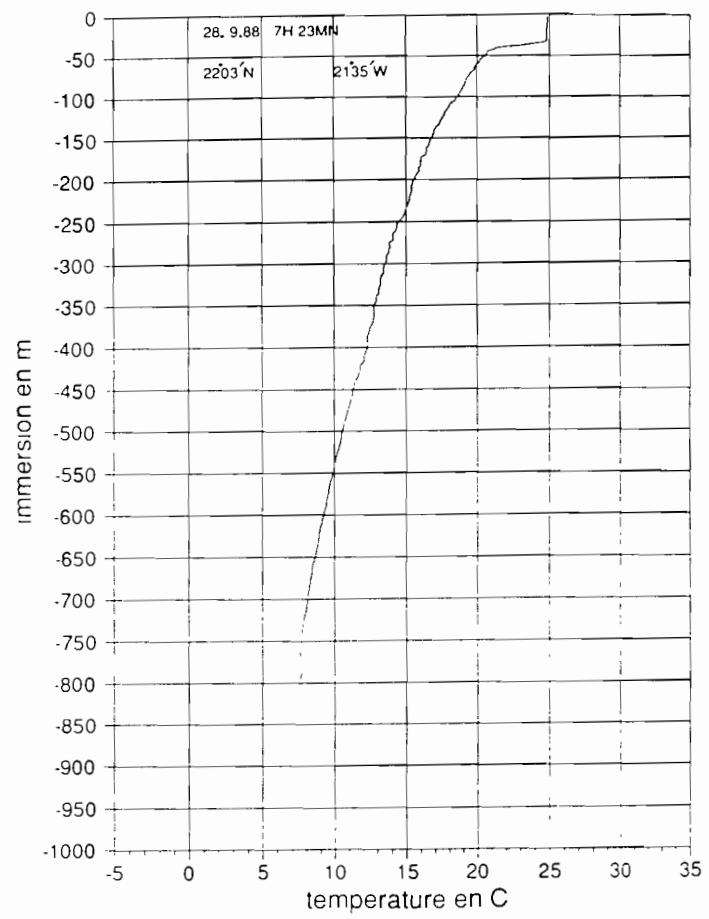
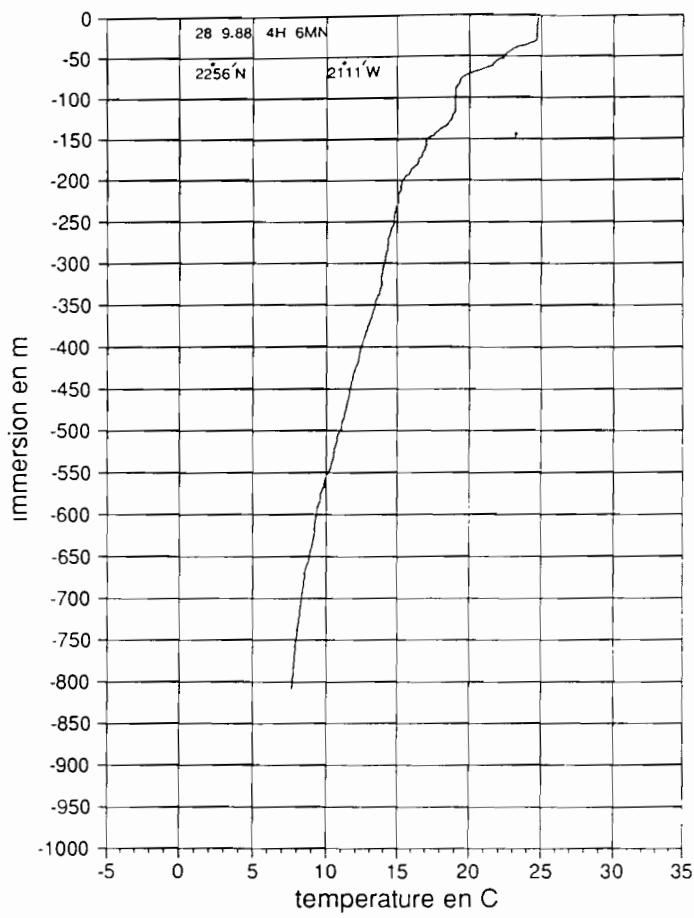
La validation des données s'est faite avec l'aide de R. Chuchla à Brest, qui a mis tous ses programmes à notre disposition.

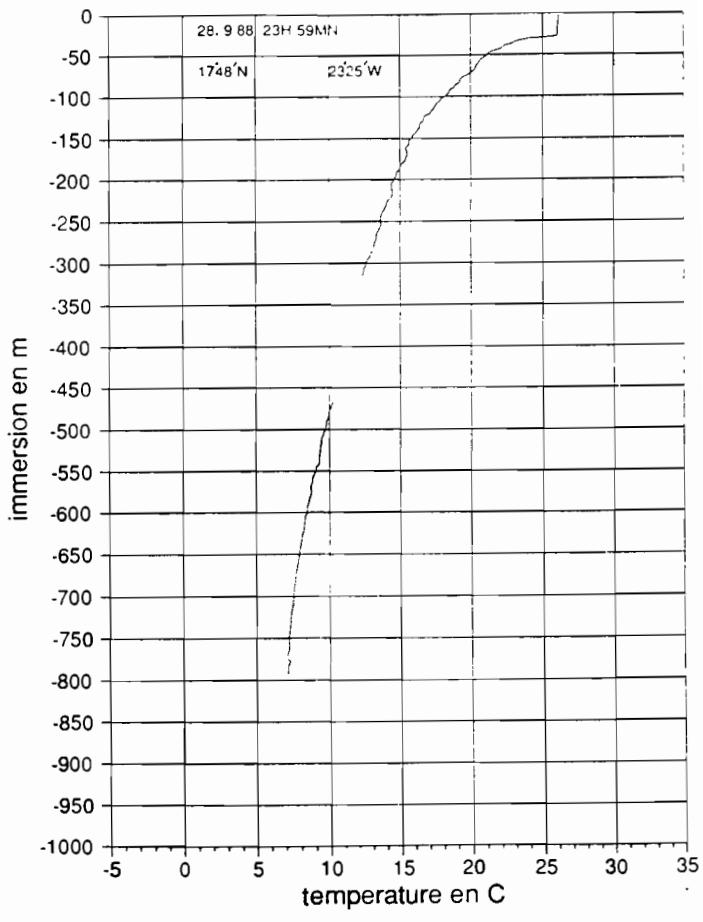
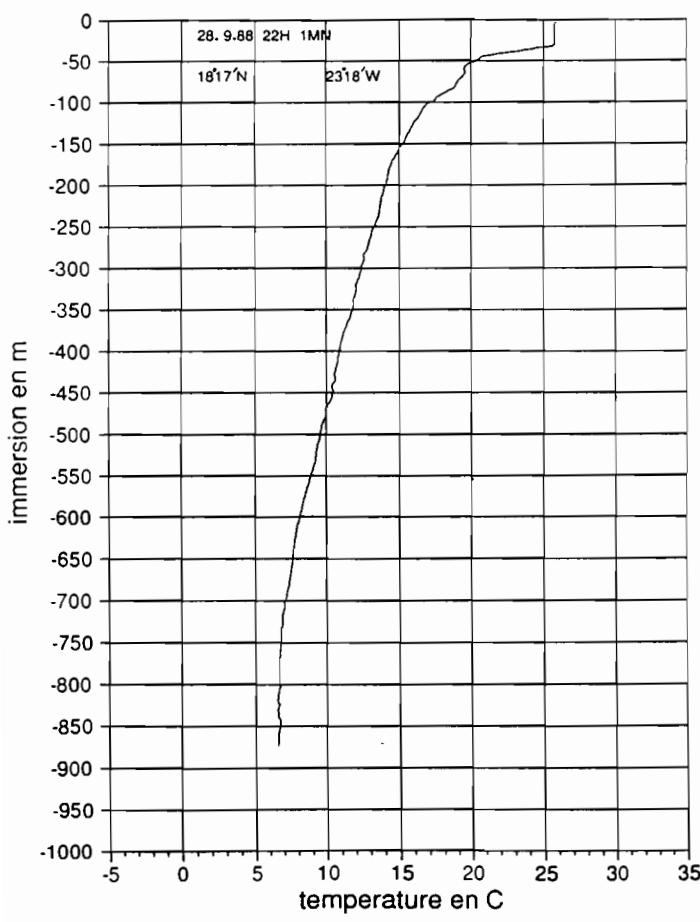
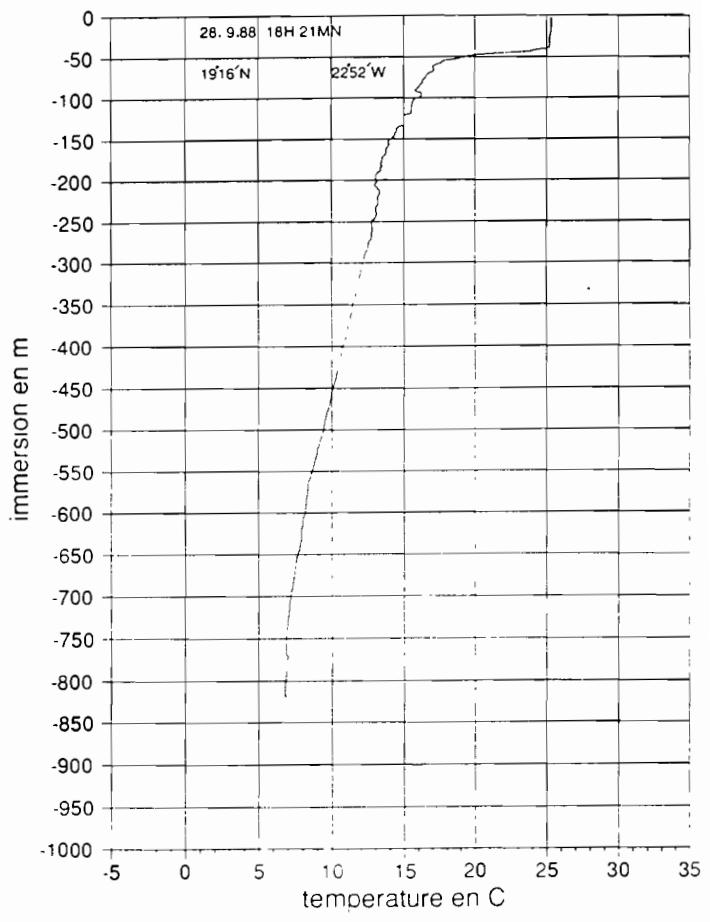
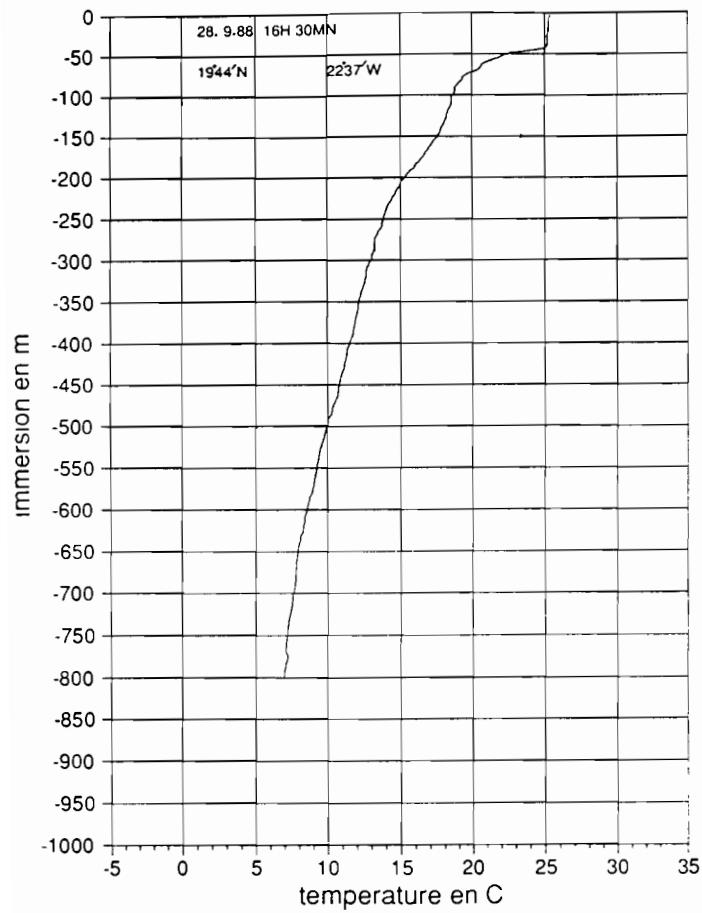
Cette campagne a bénéficié du support financier de l'ATP télédétection spatiale et de l'appui de l'ORSTOM.

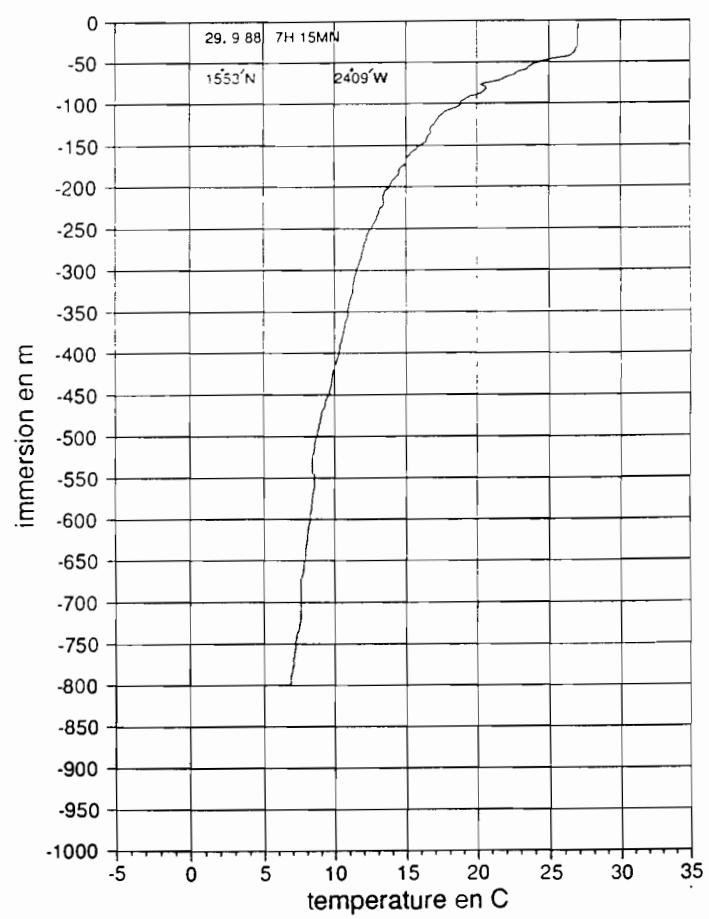
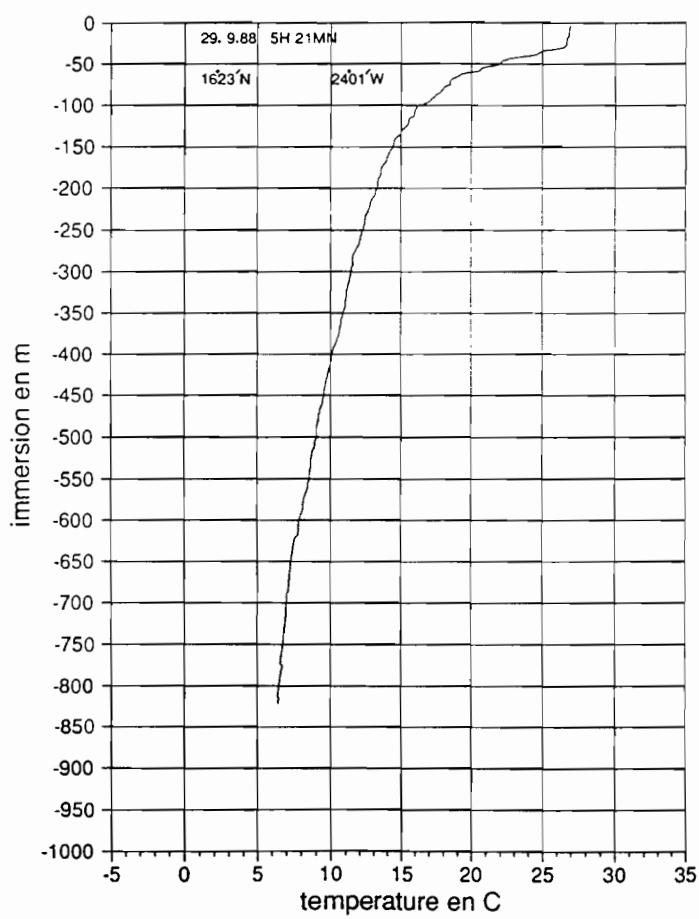
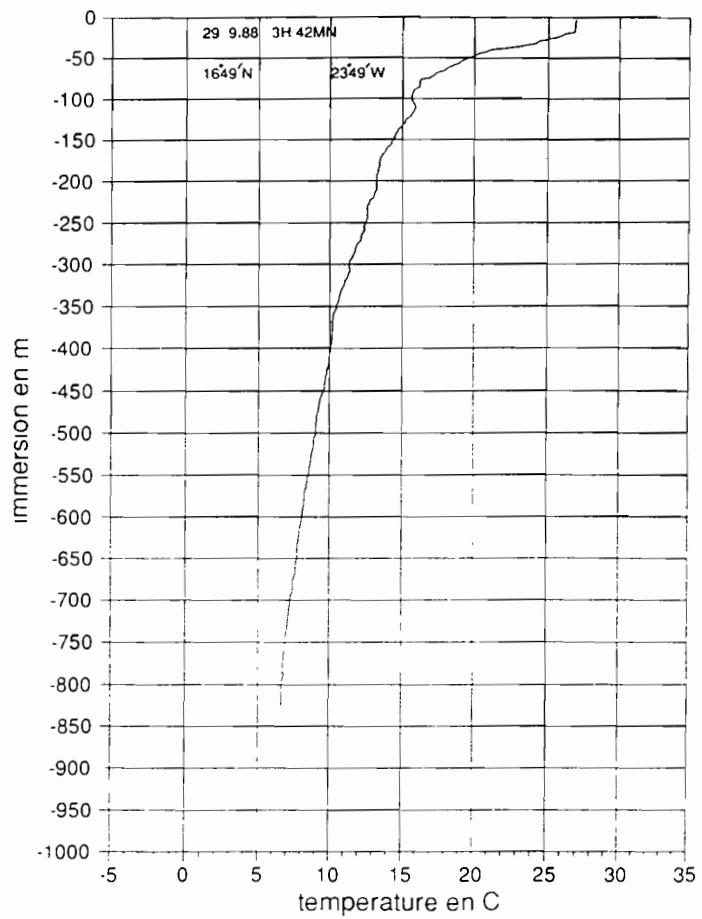
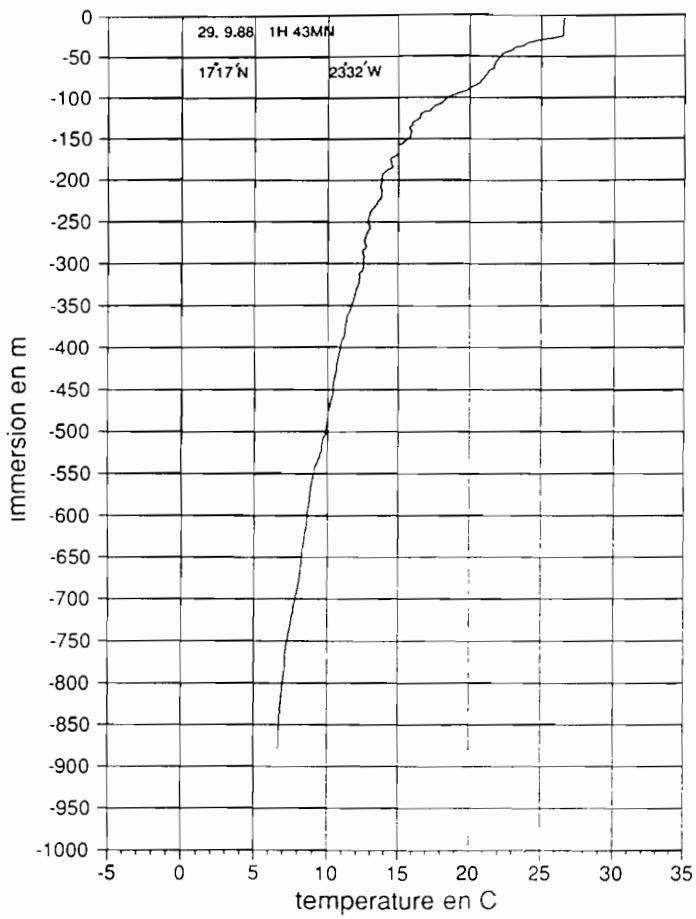


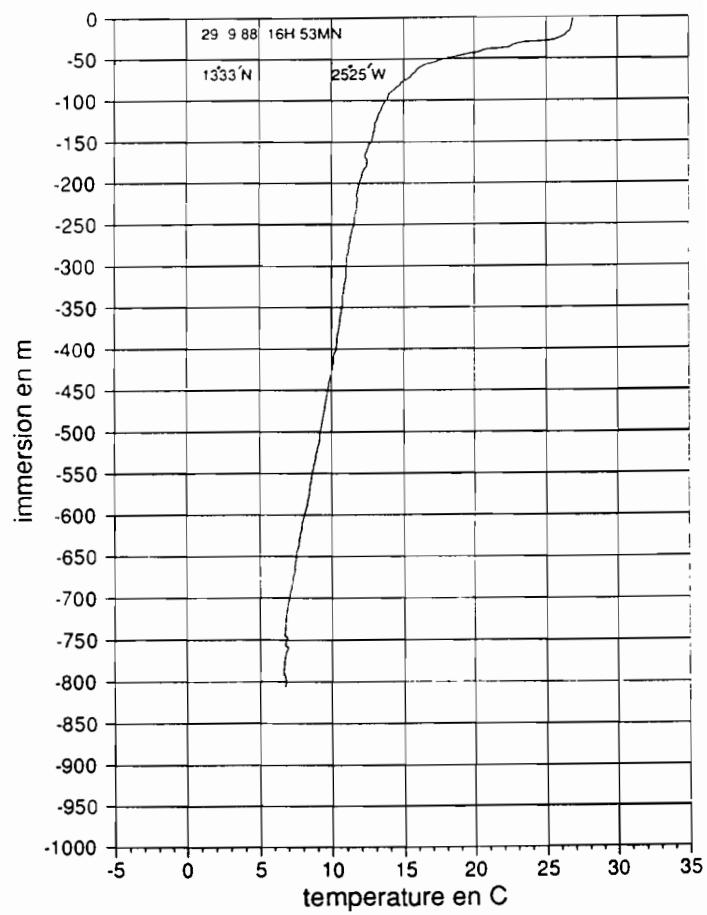
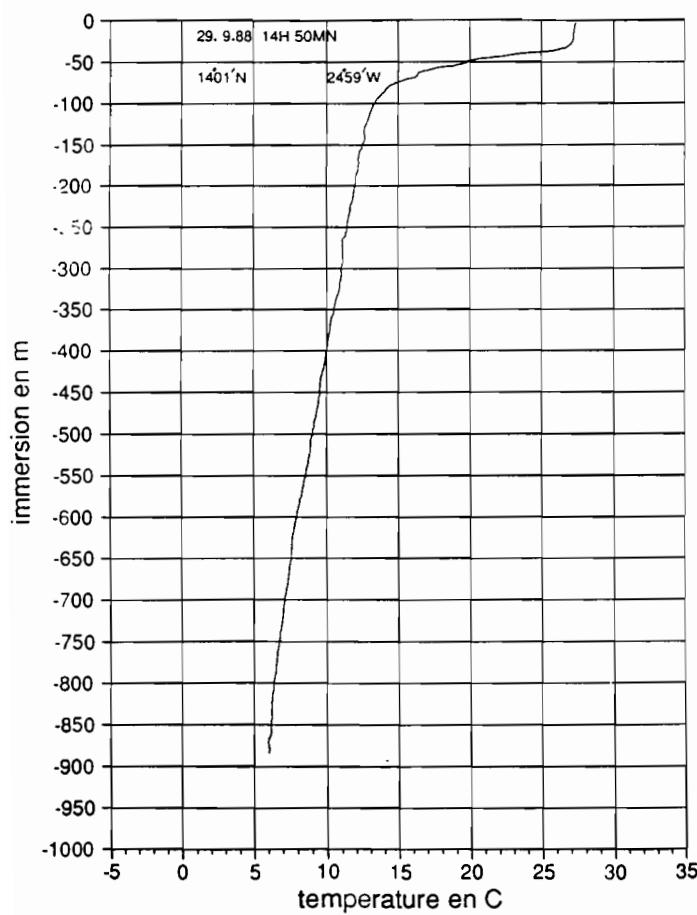
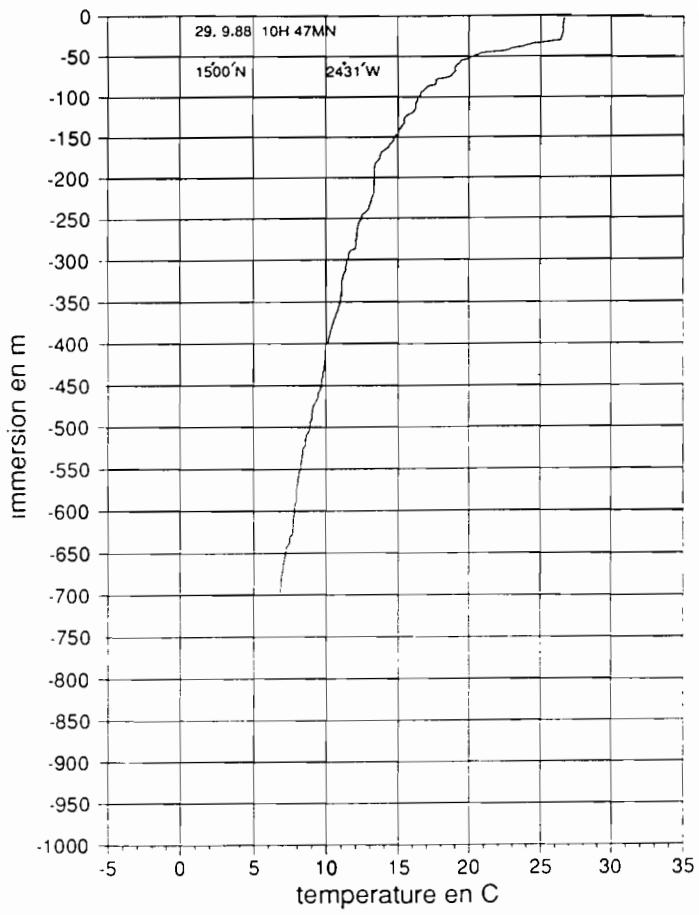
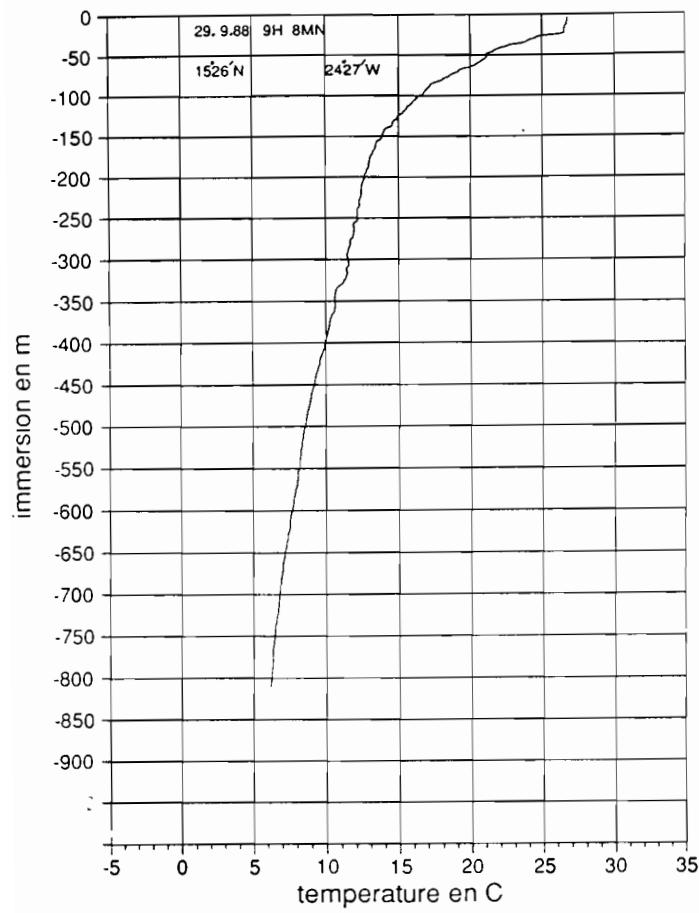


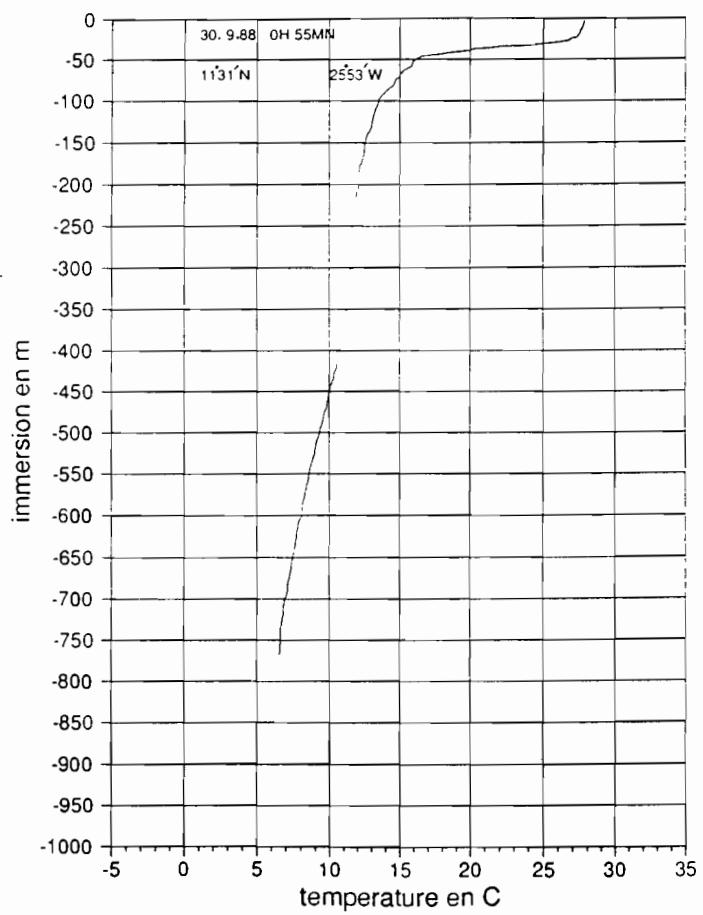
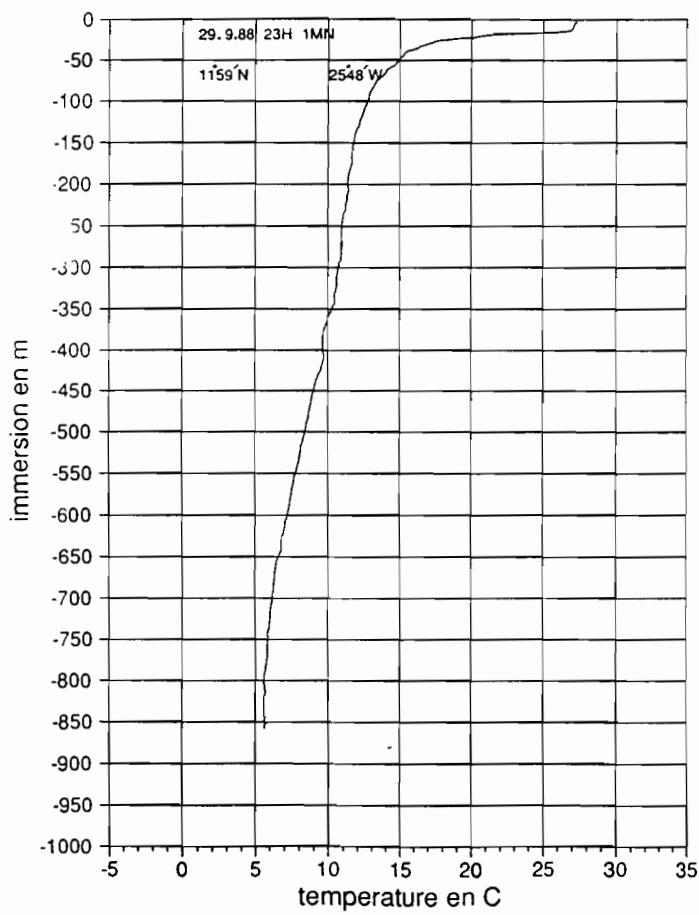
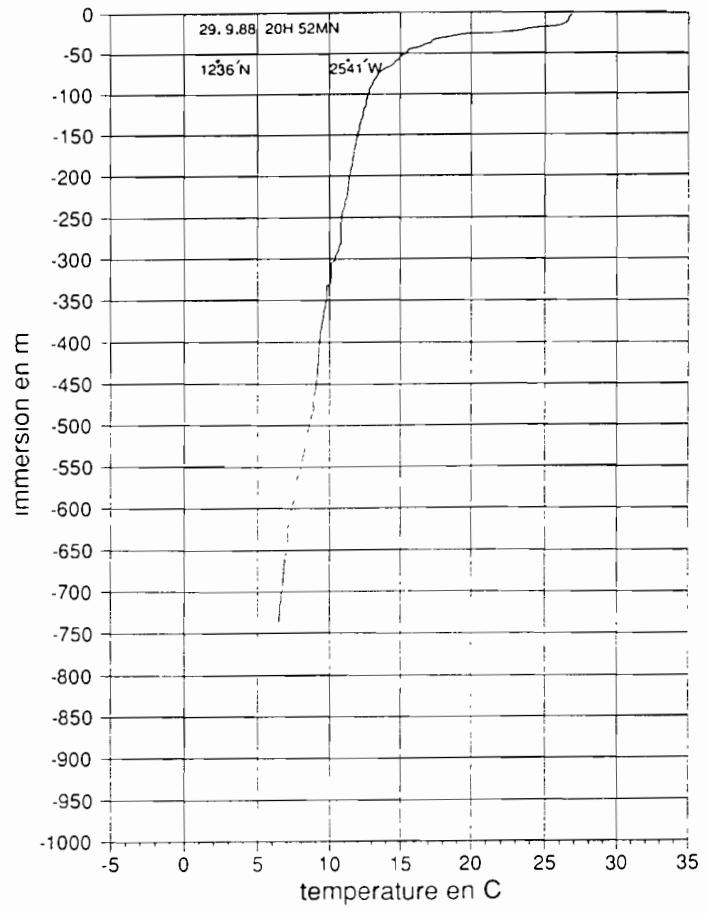
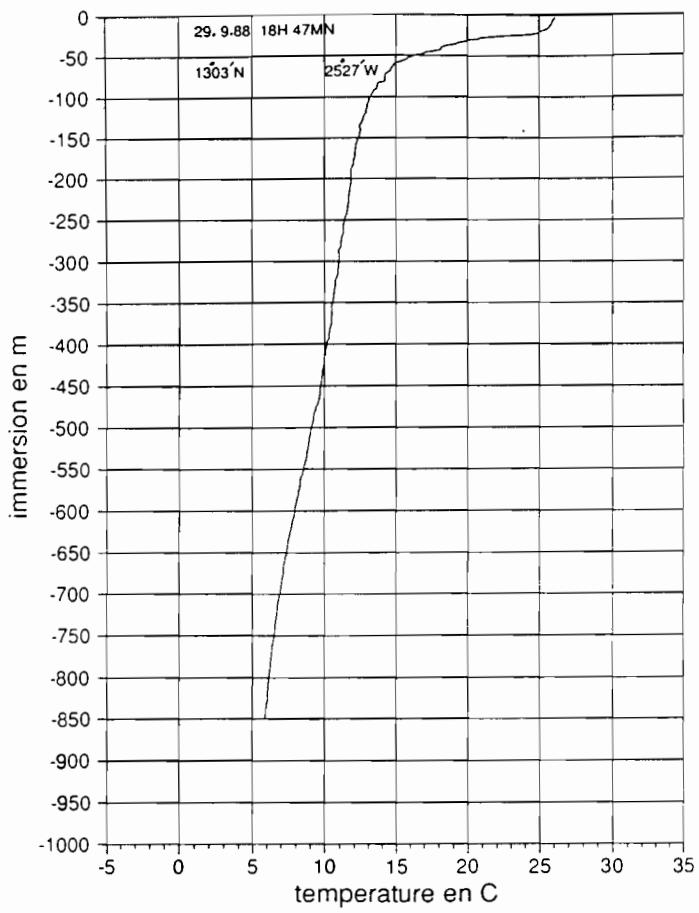


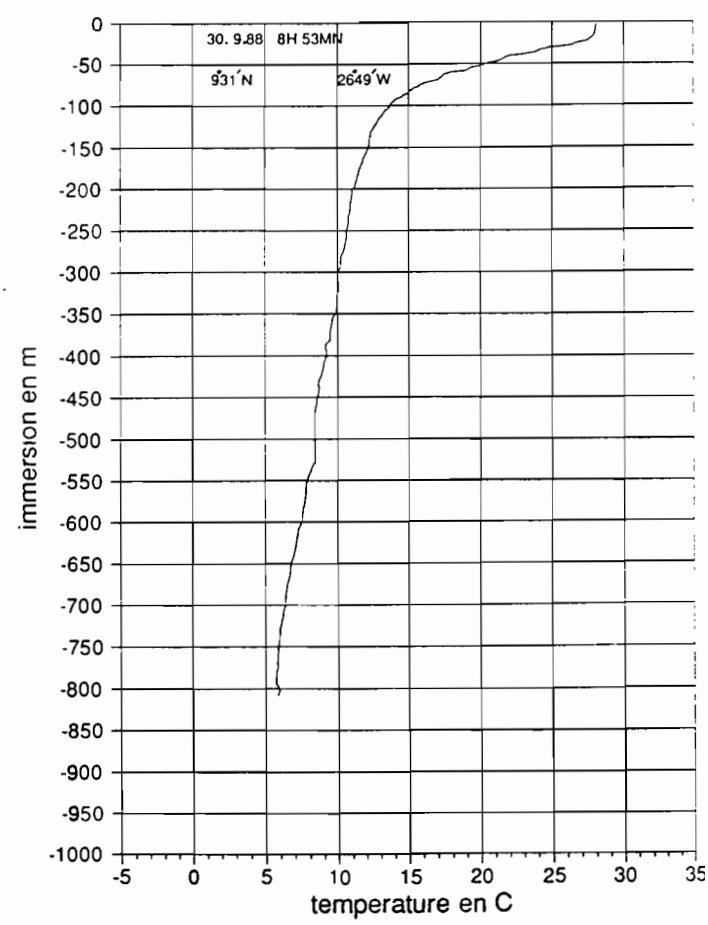
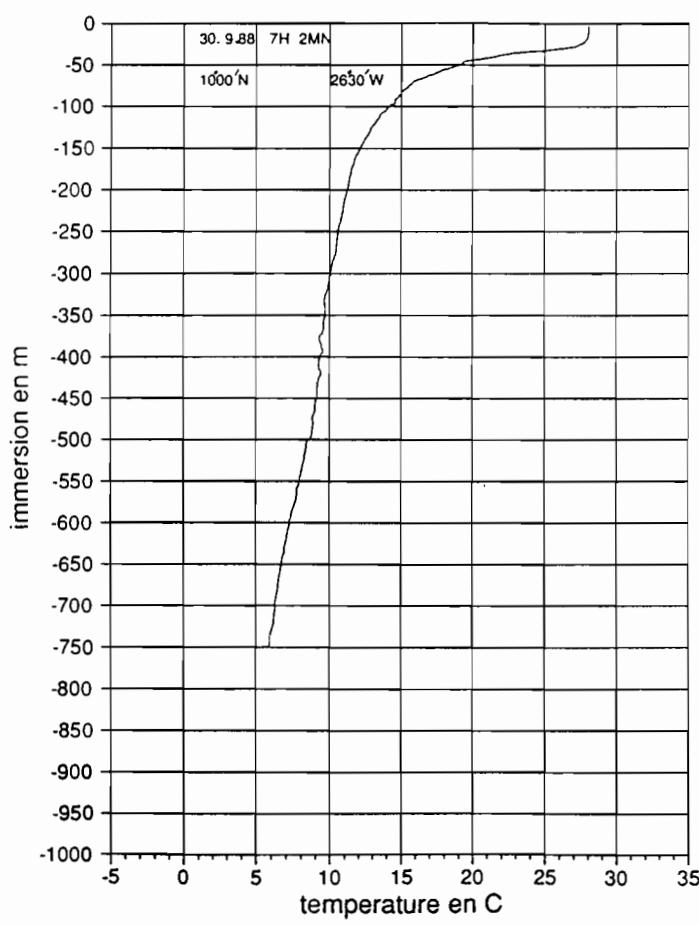
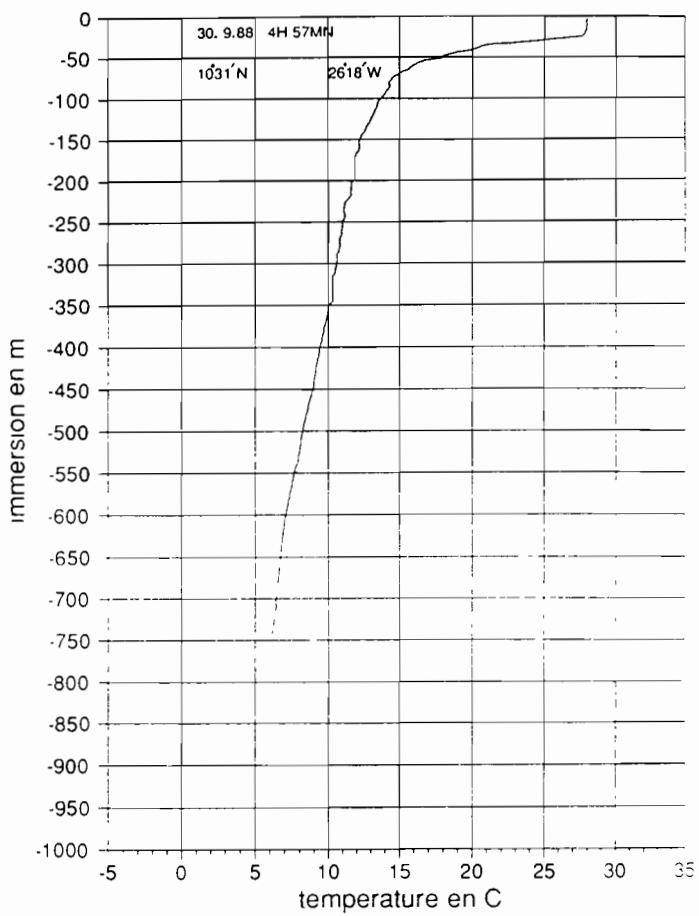
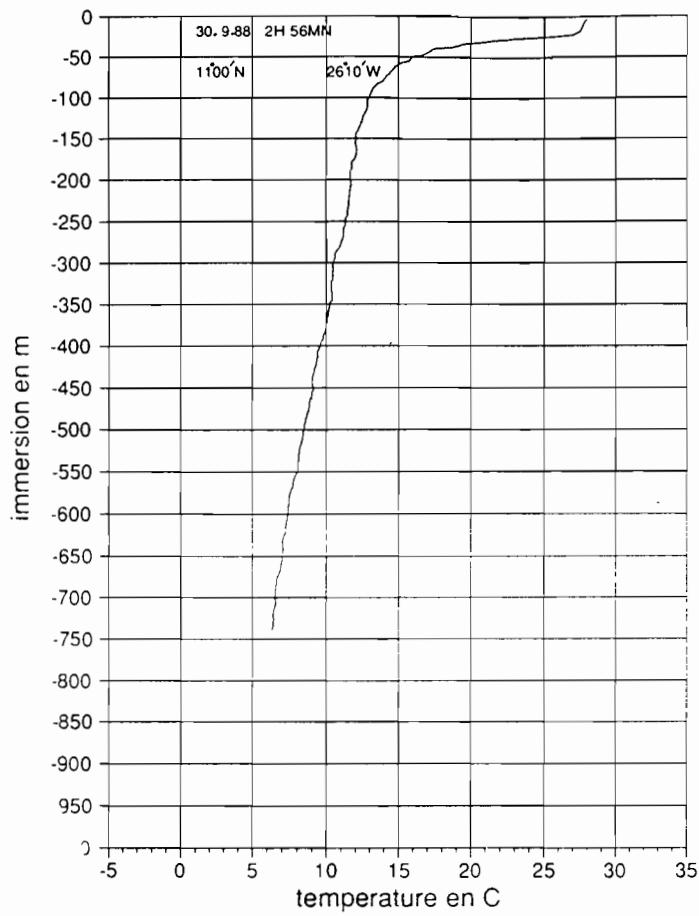


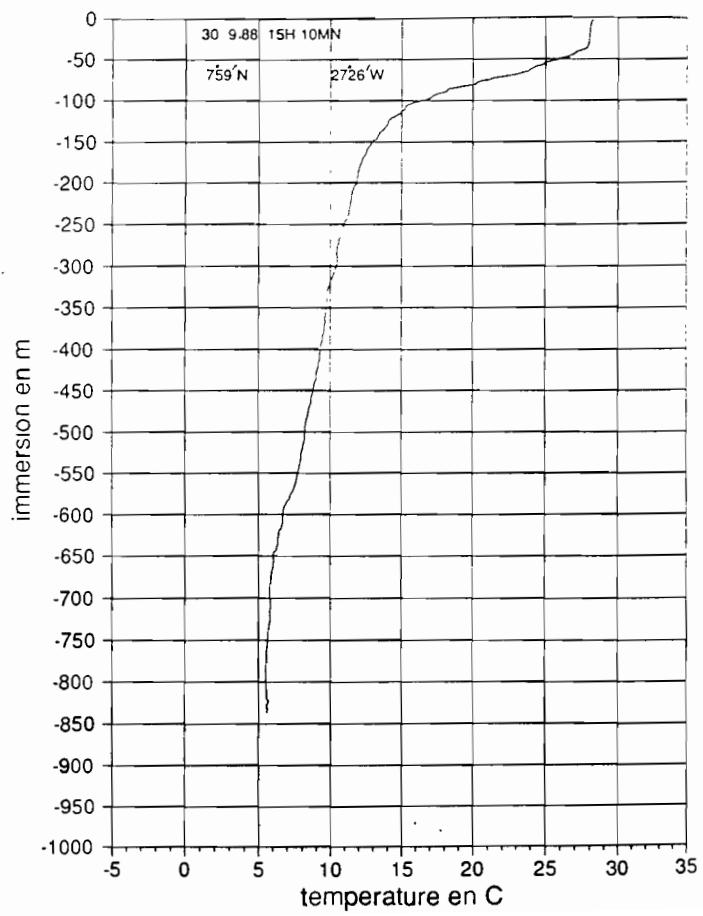
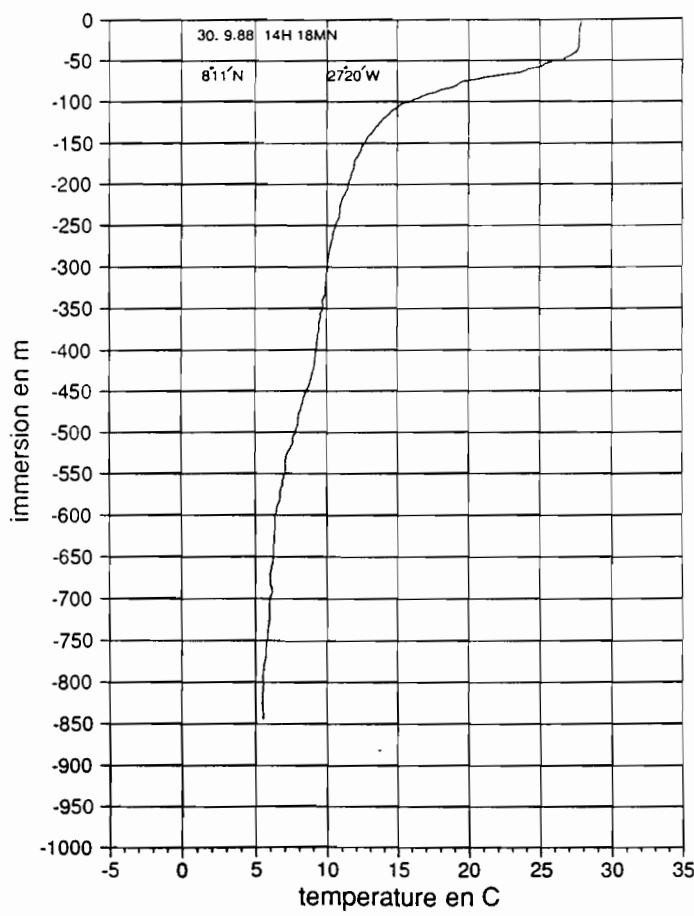
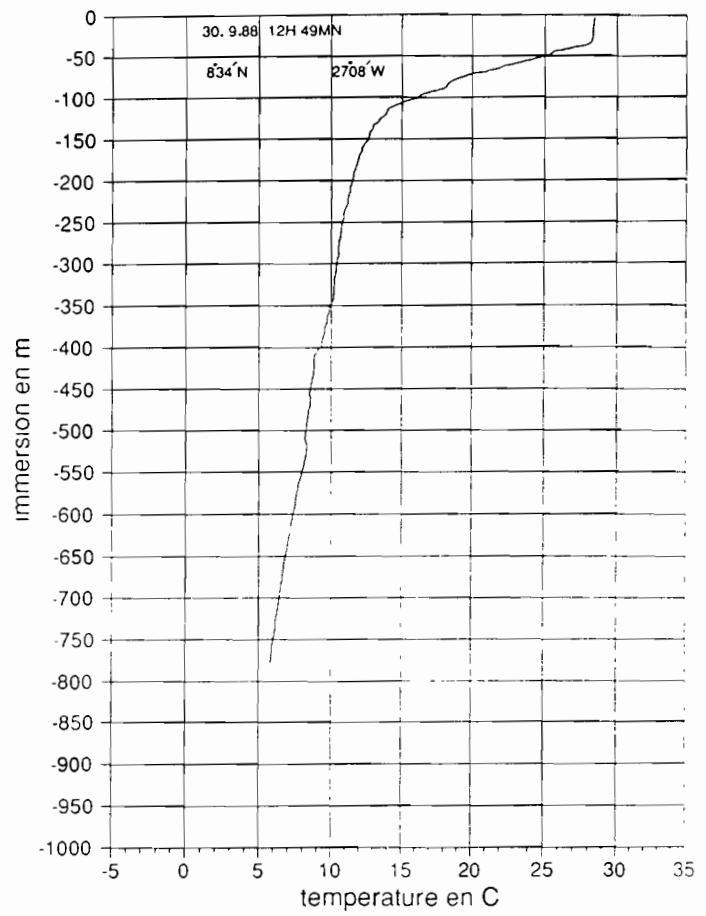
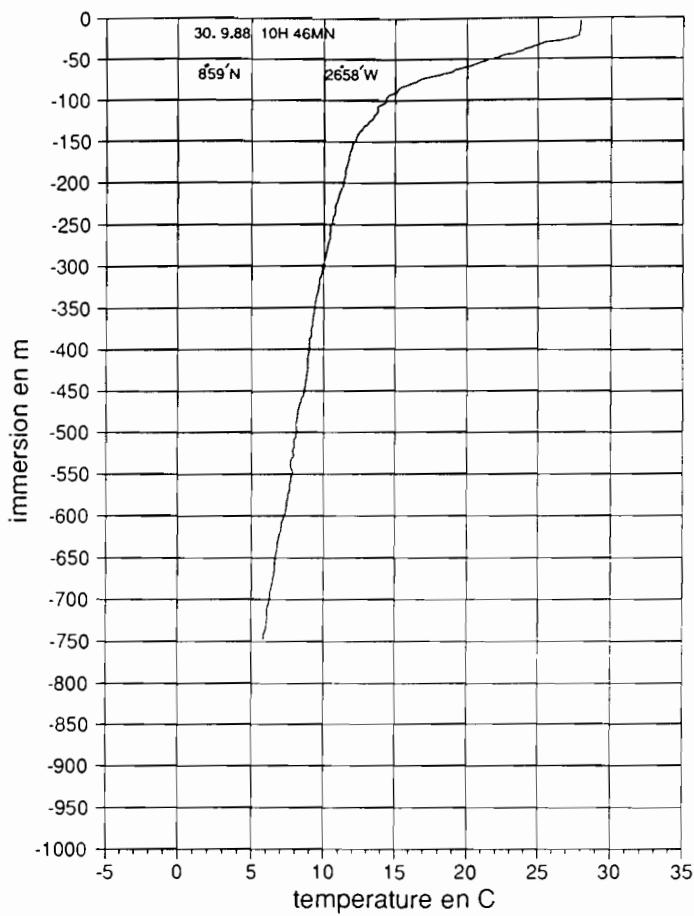


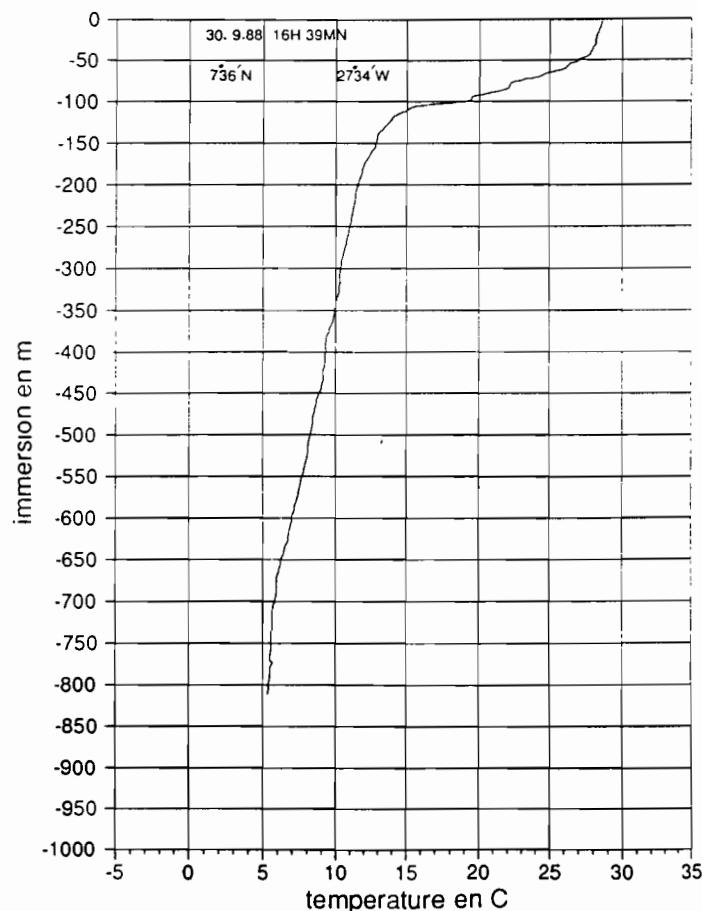
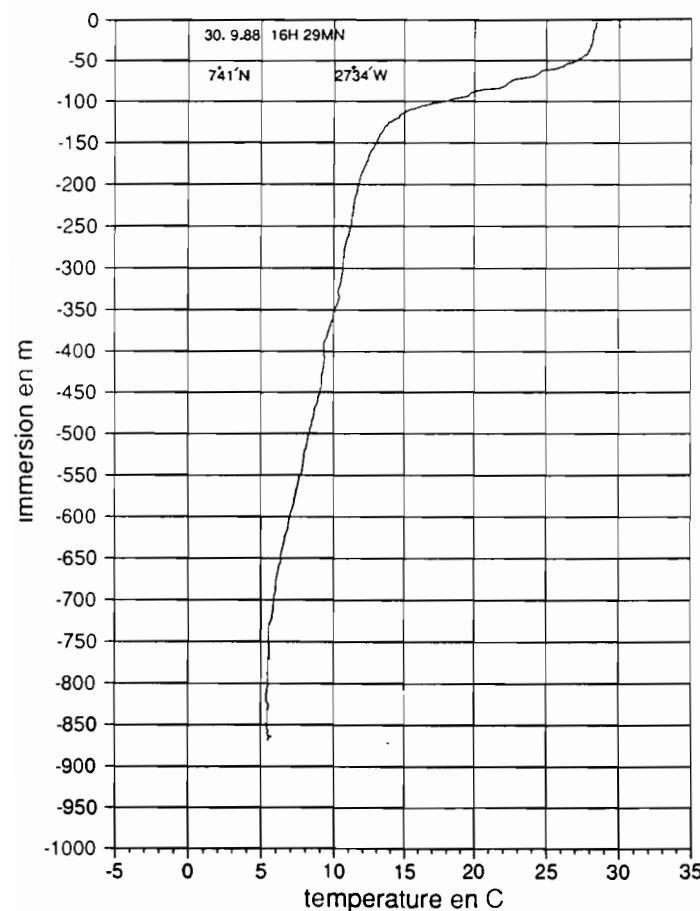
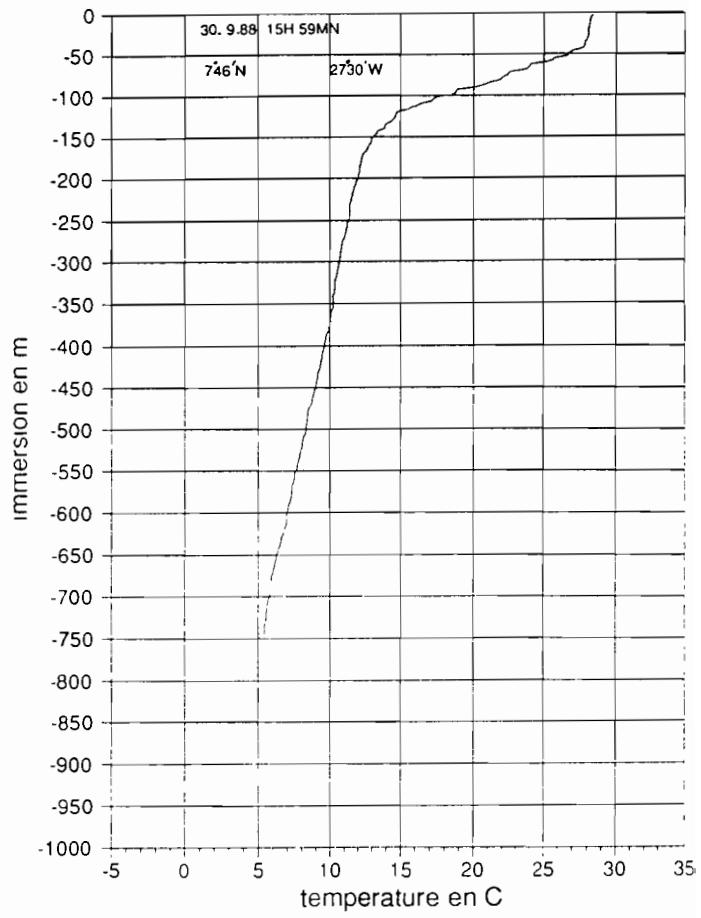
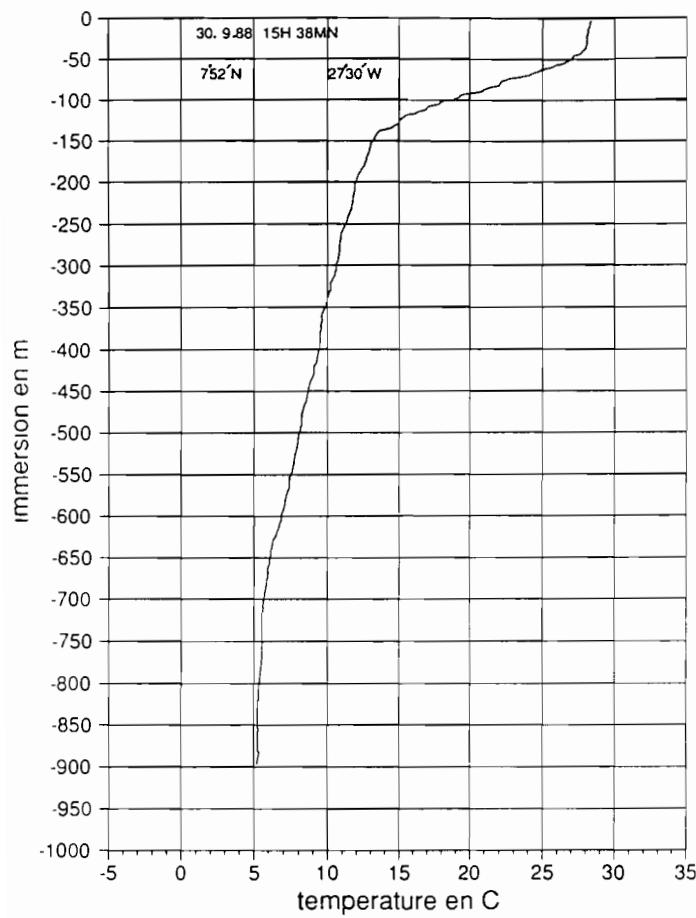


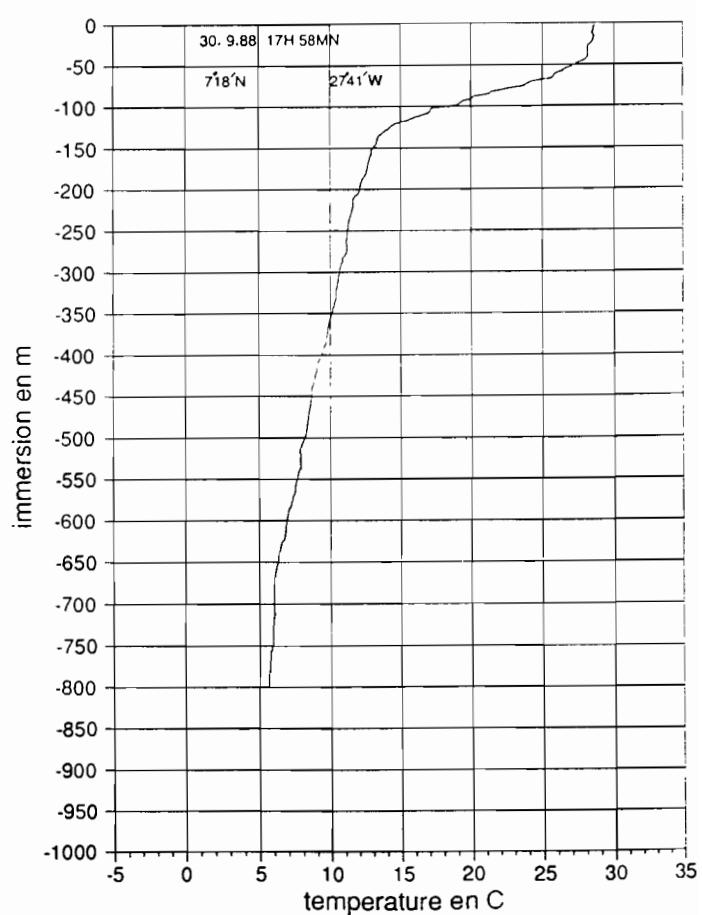
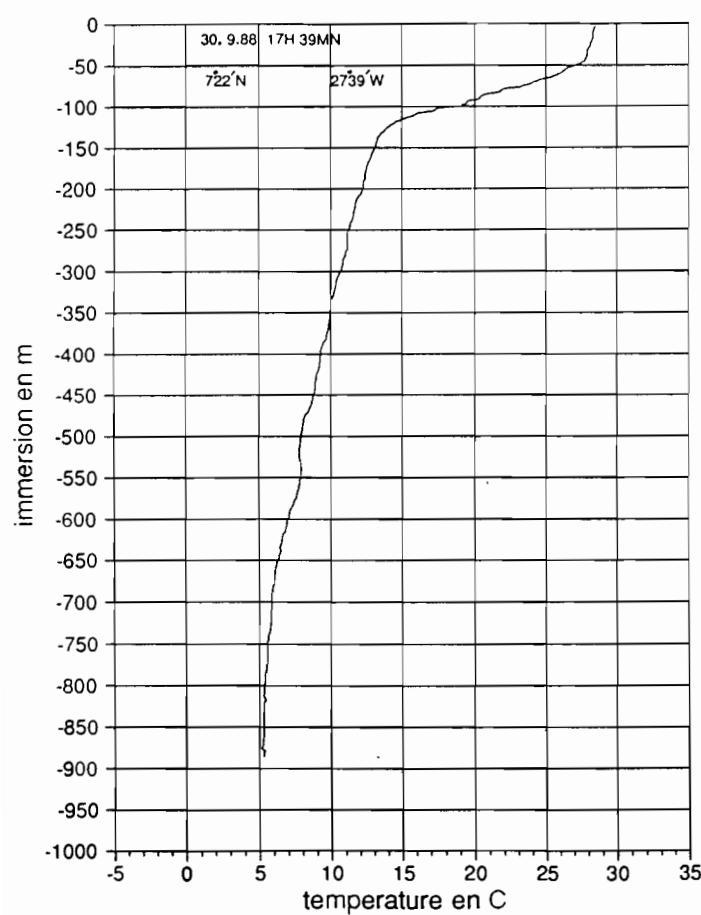
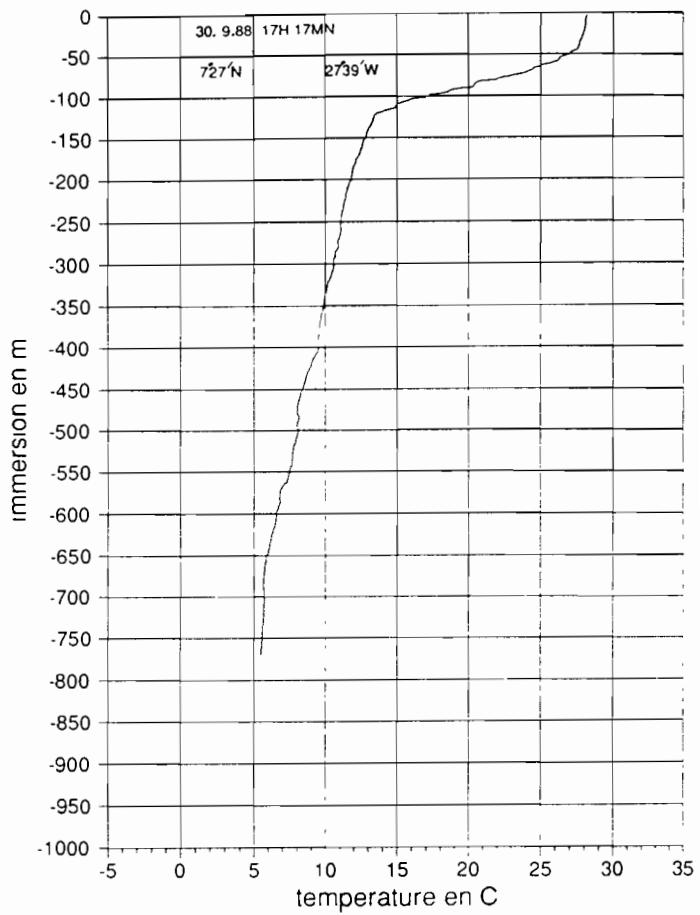
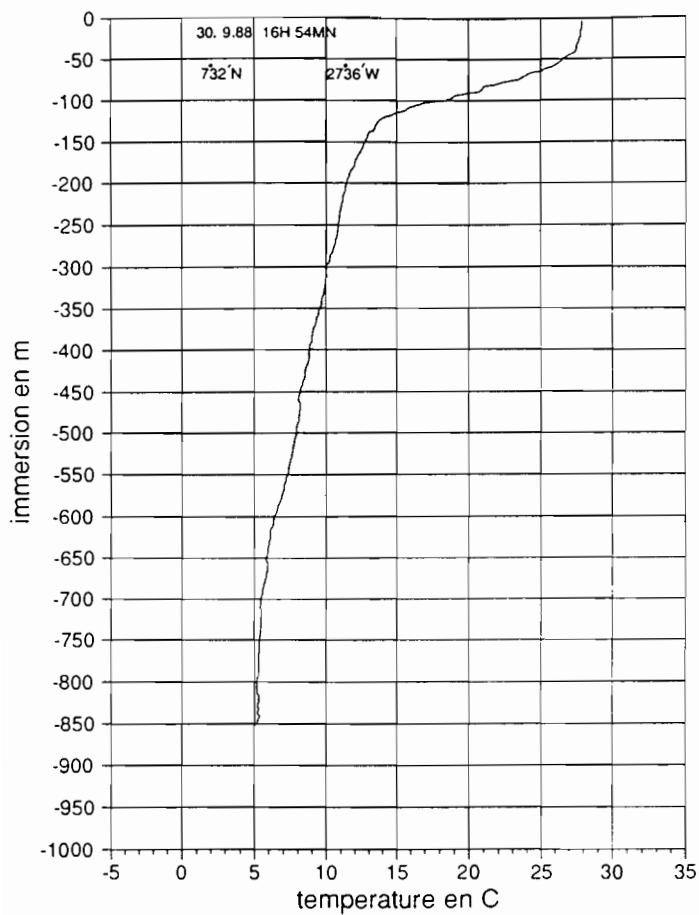


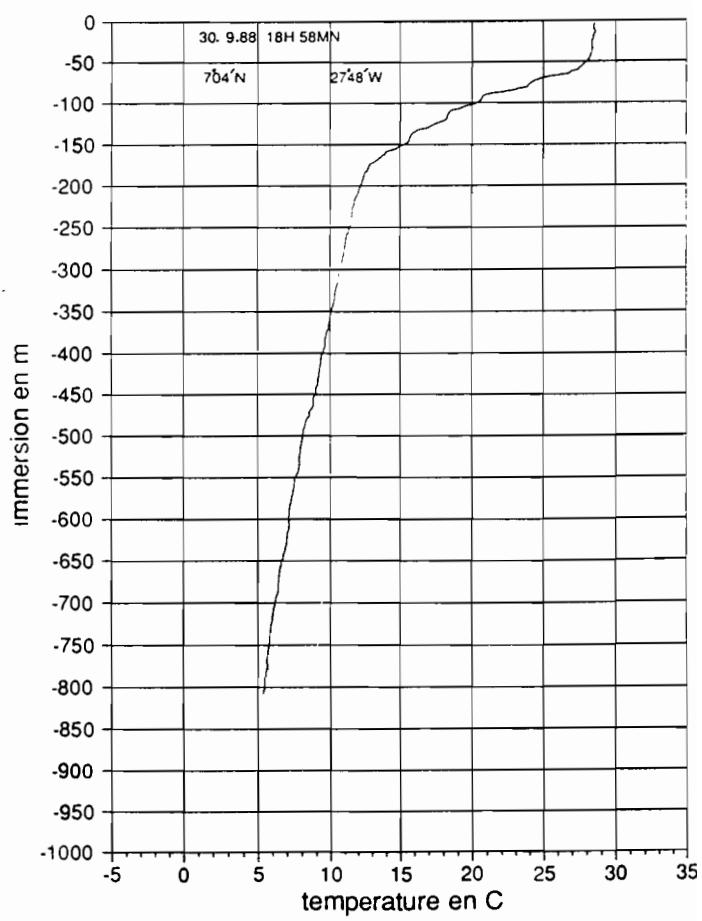
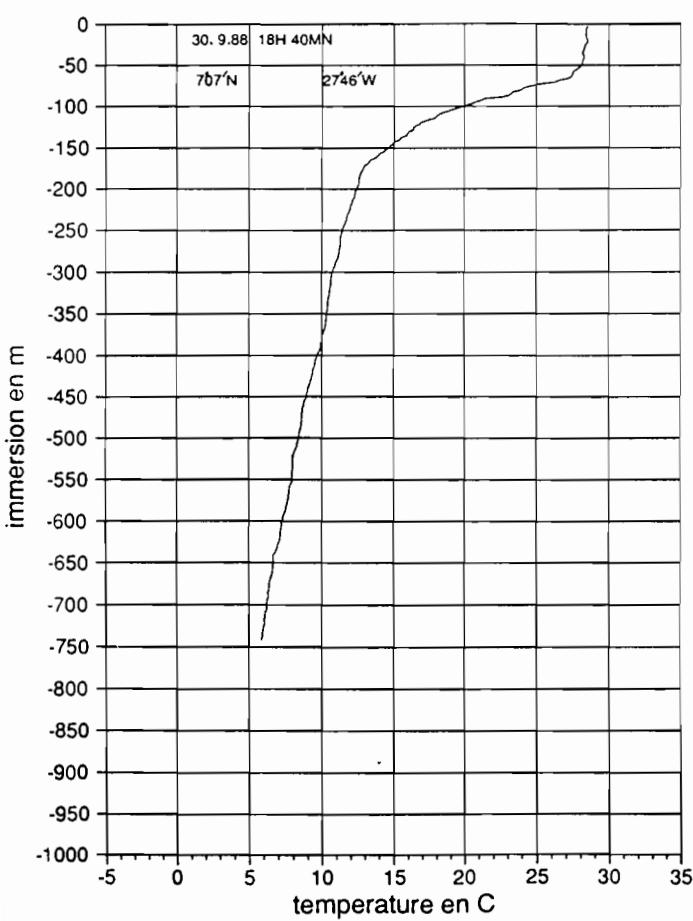
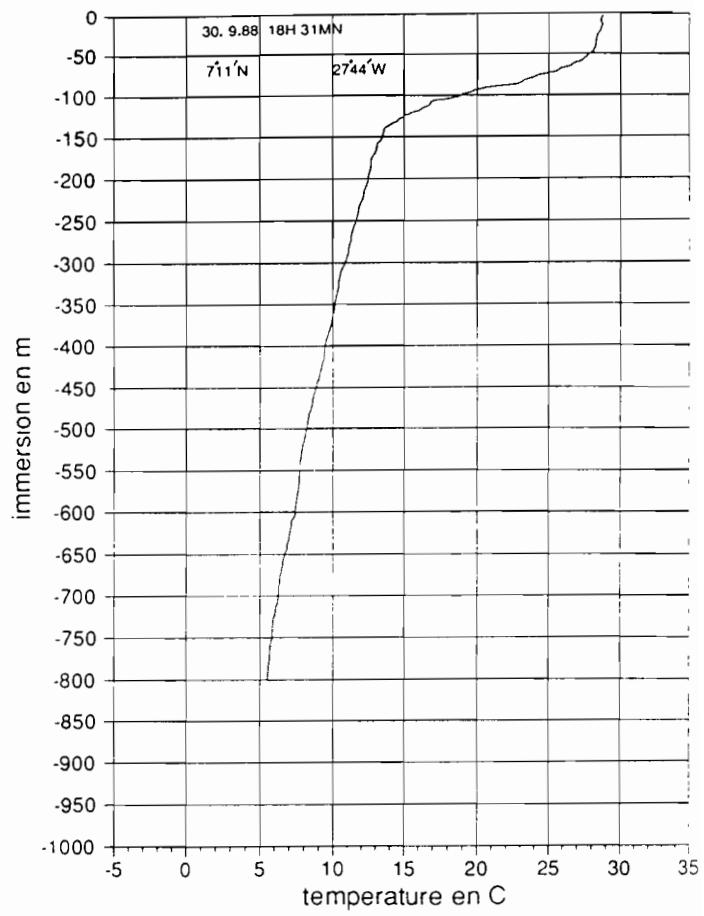
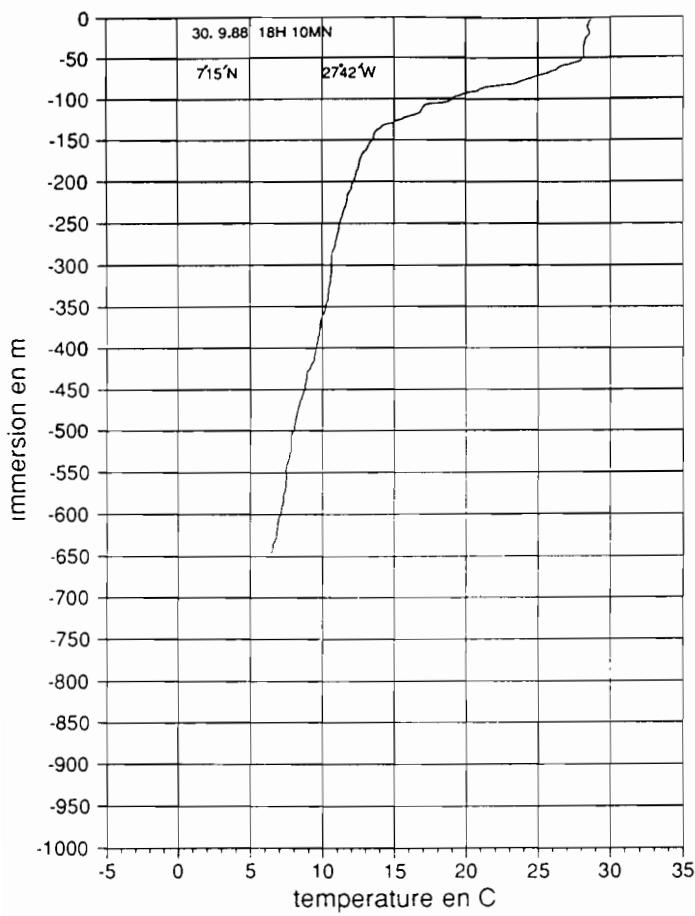


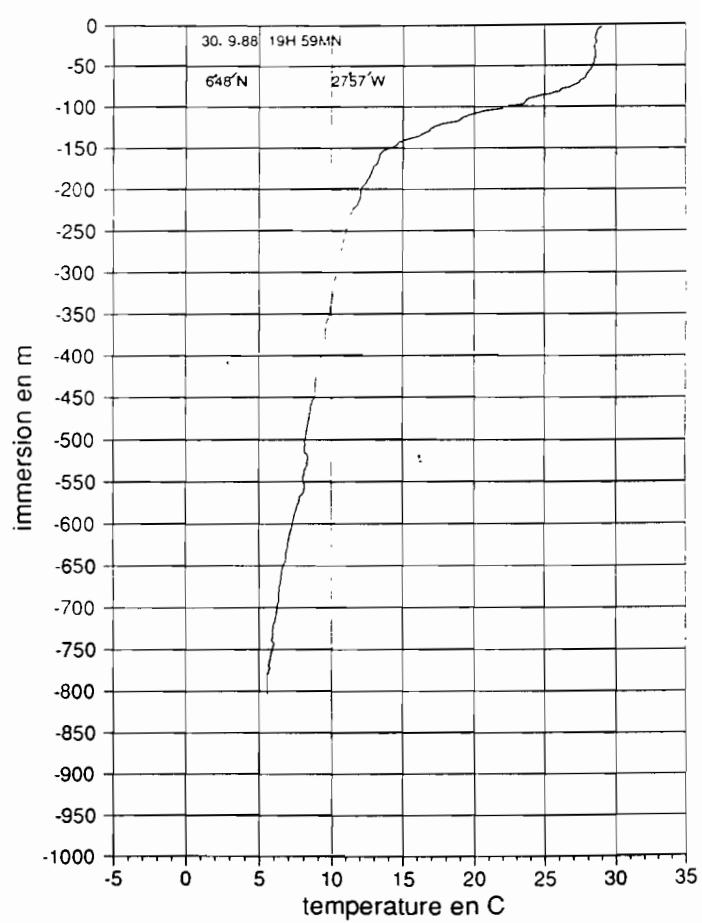
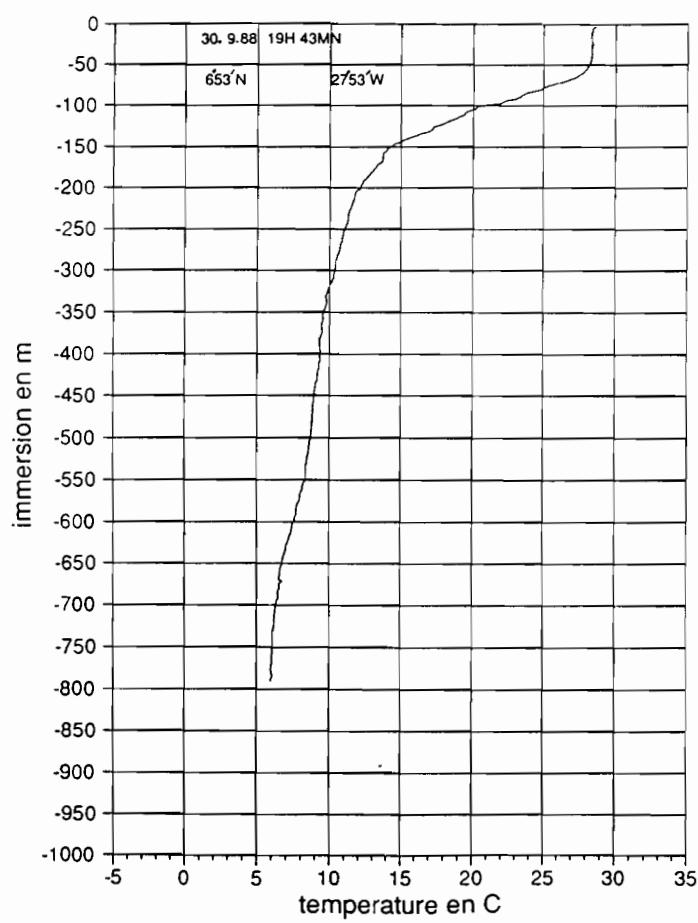
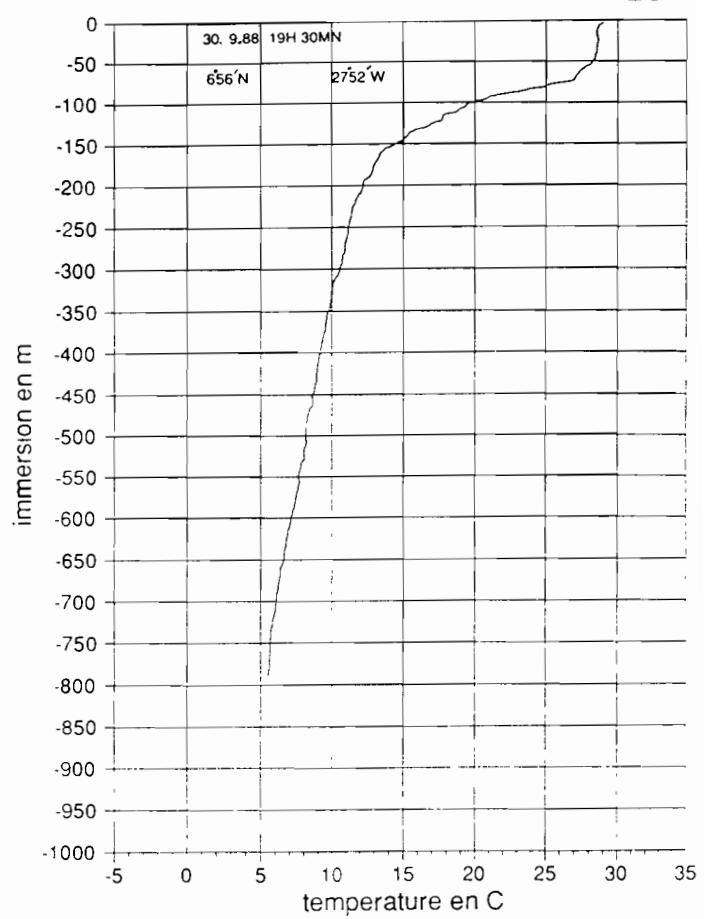
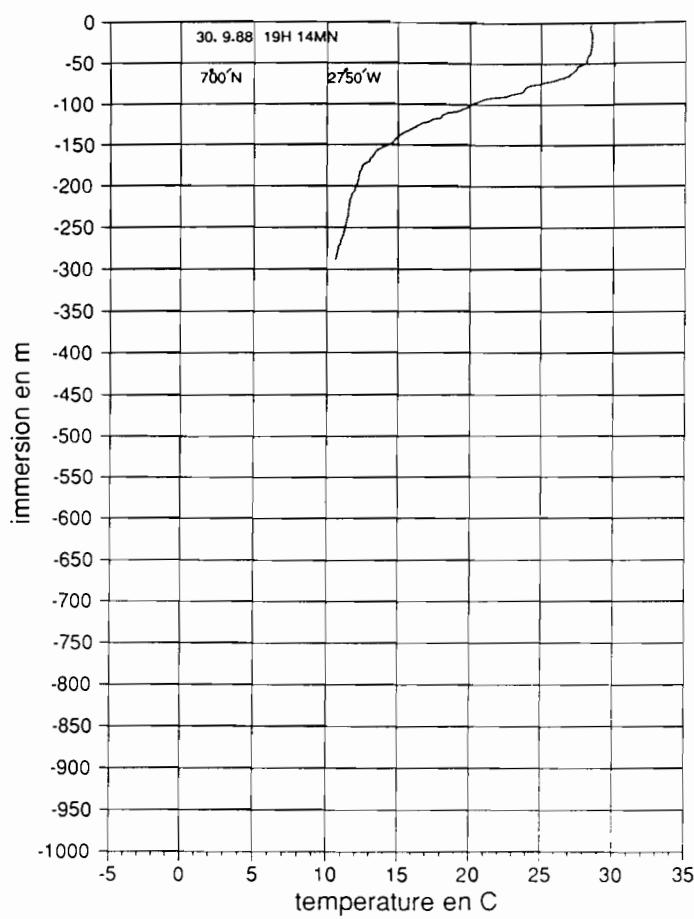


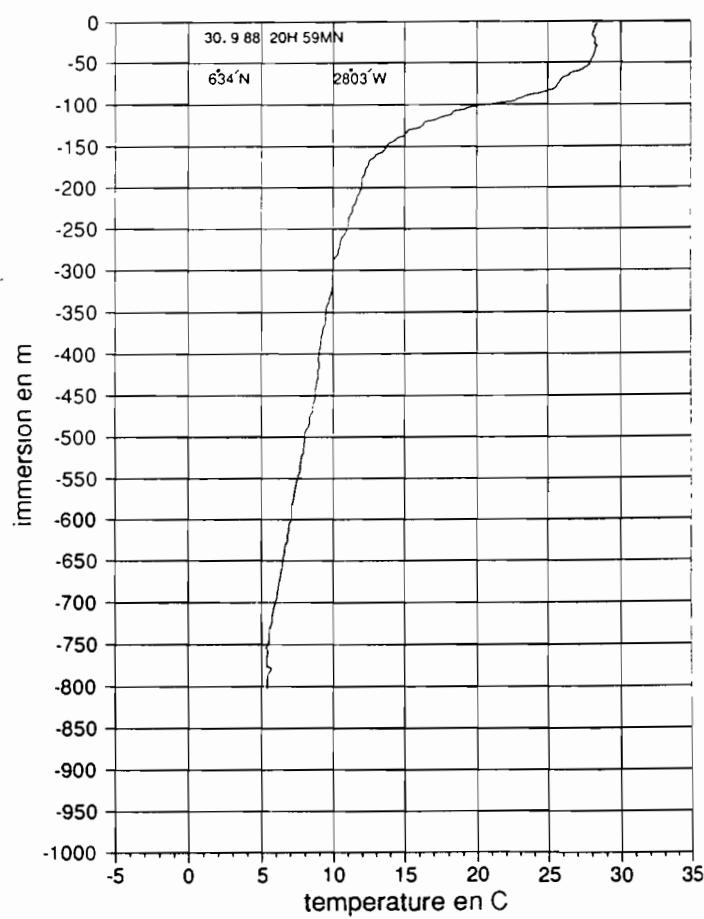
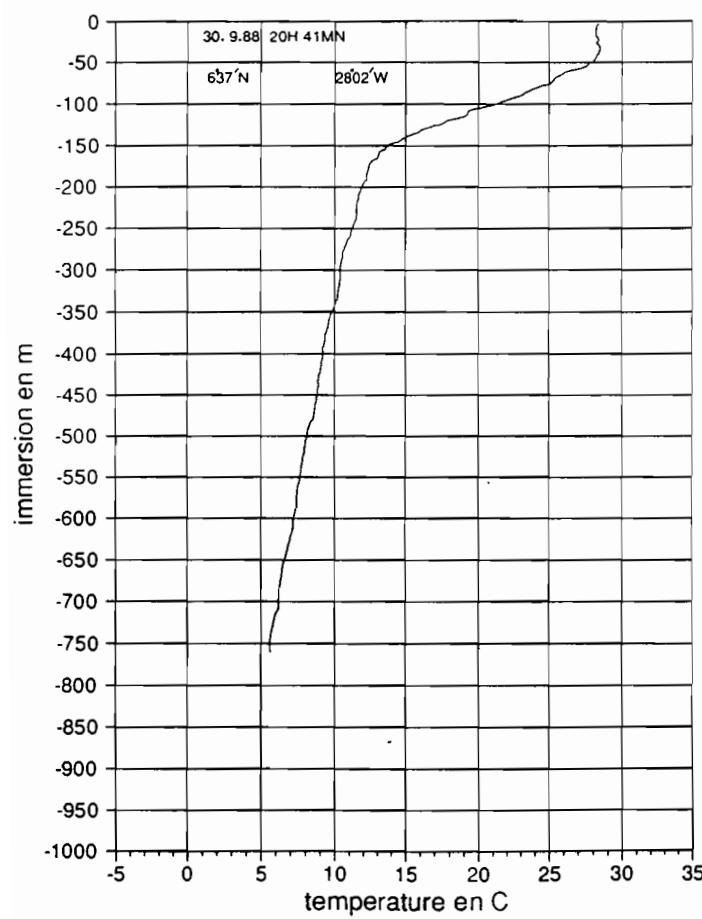
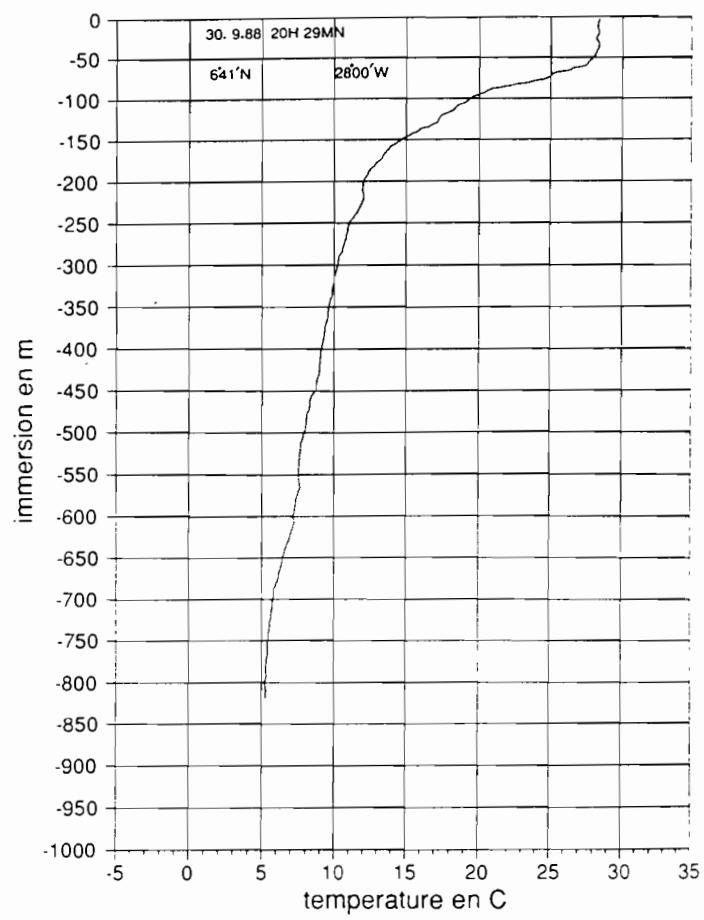
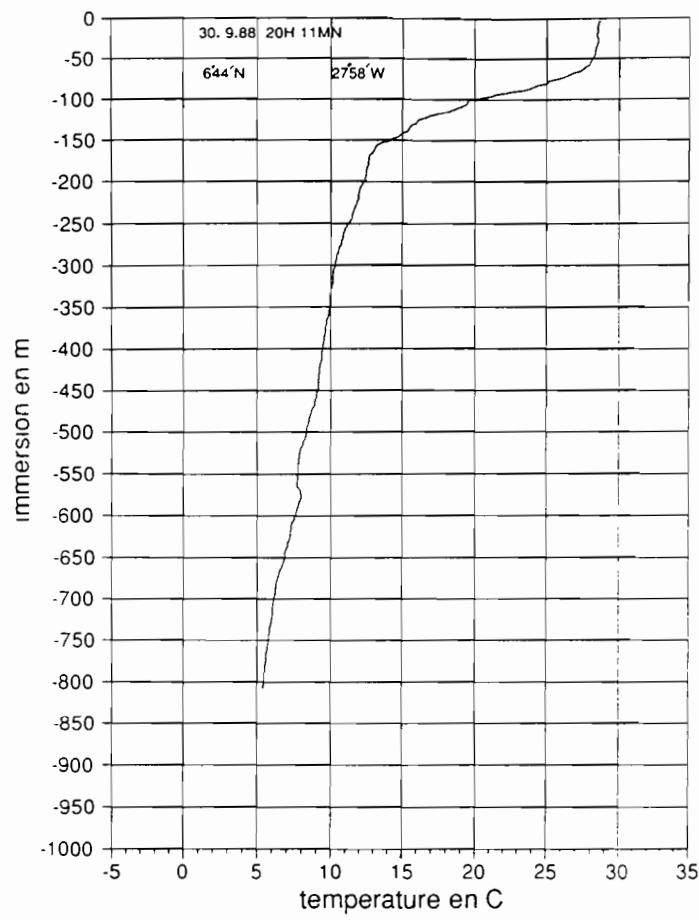


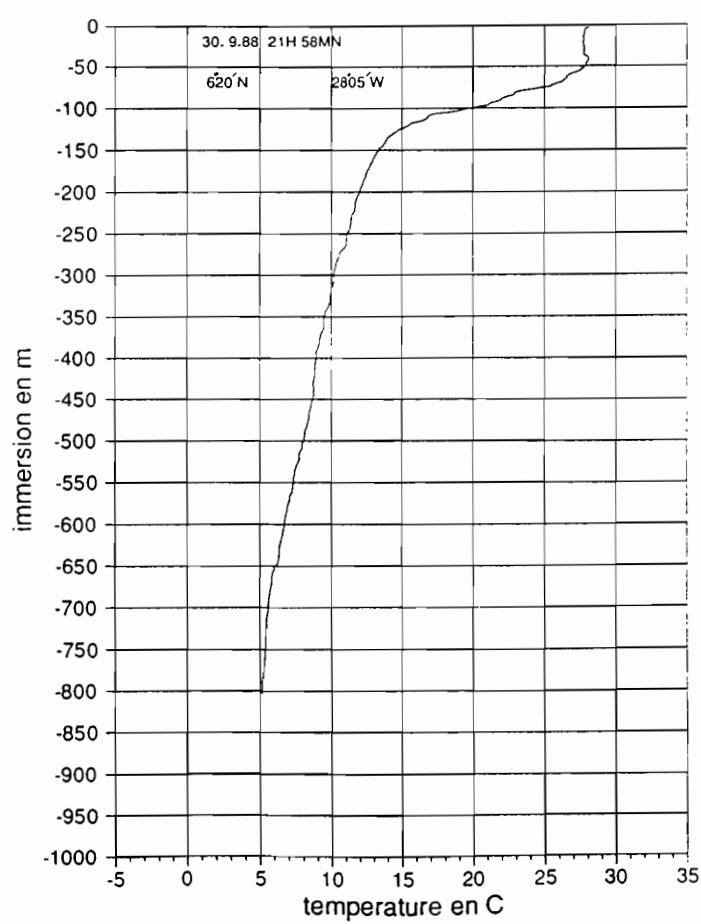
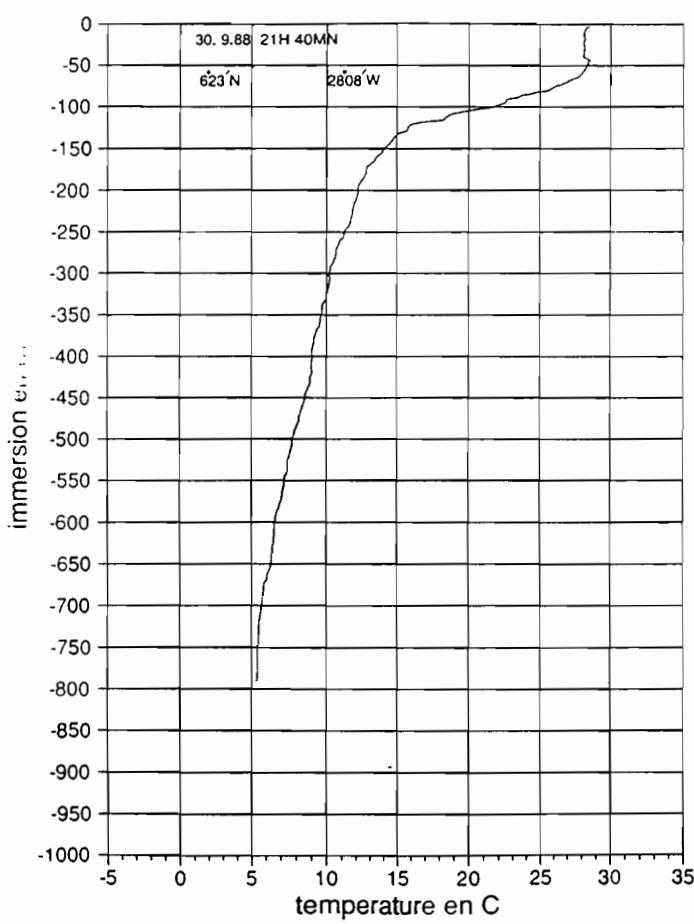
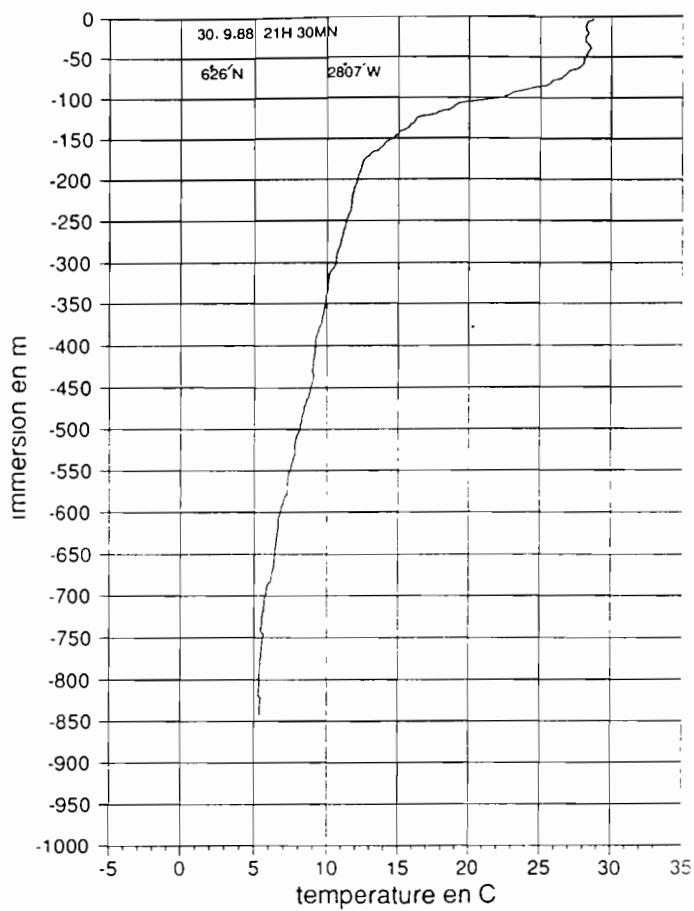
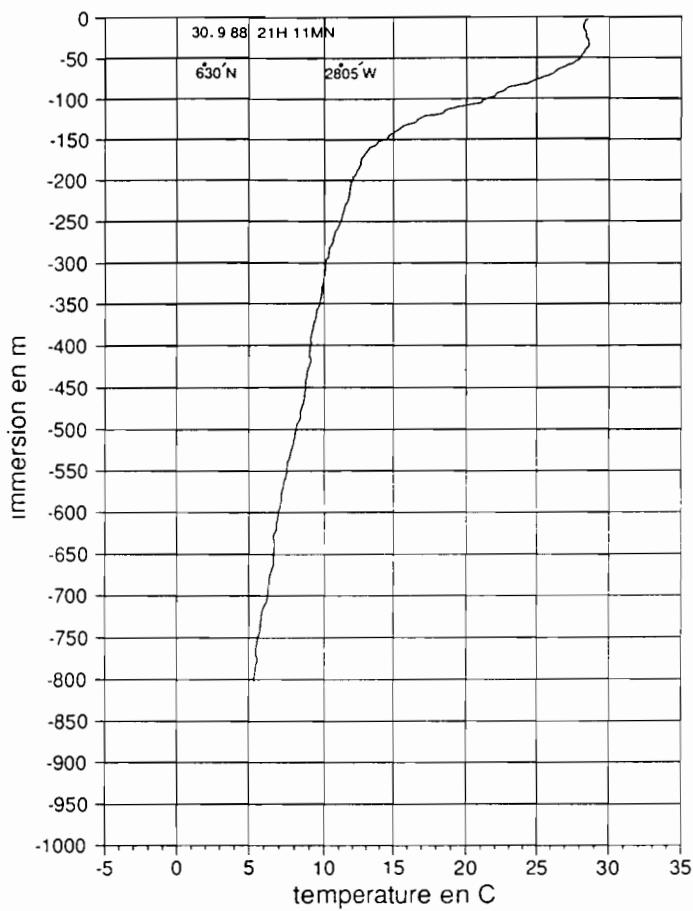


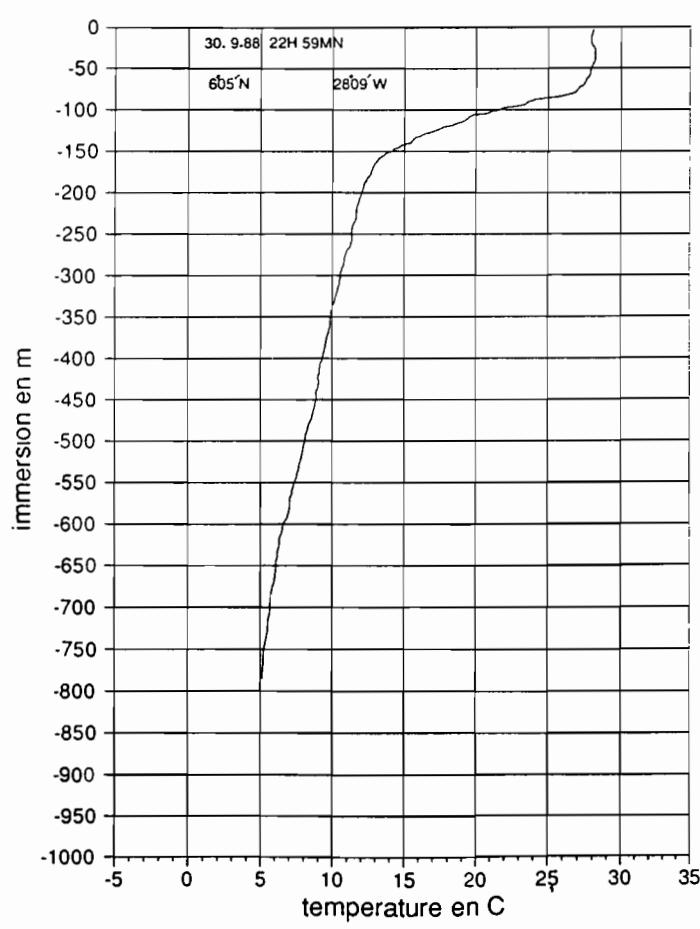
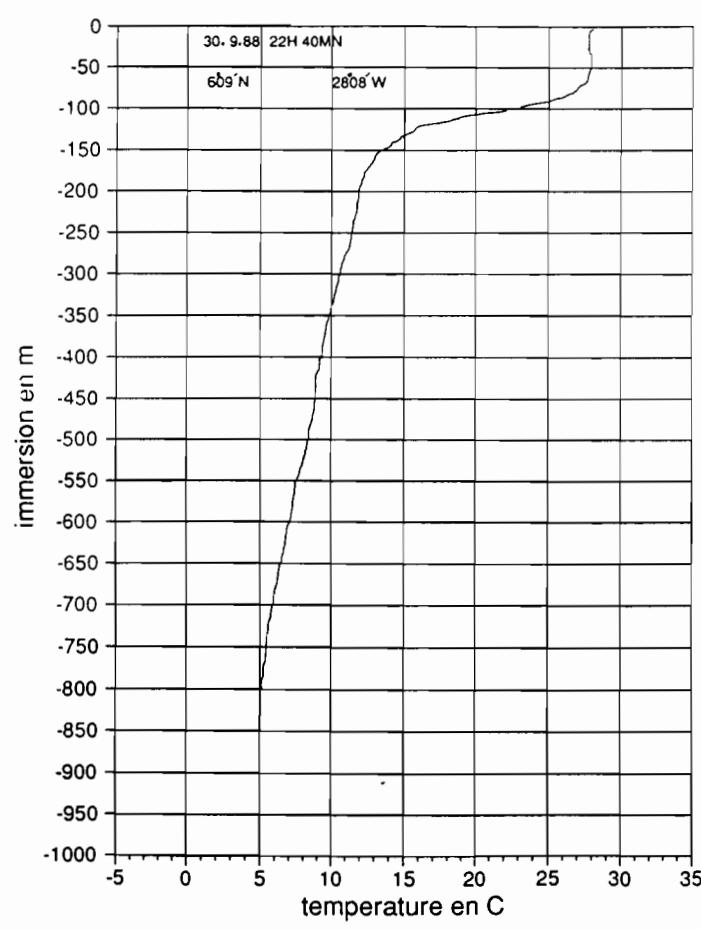
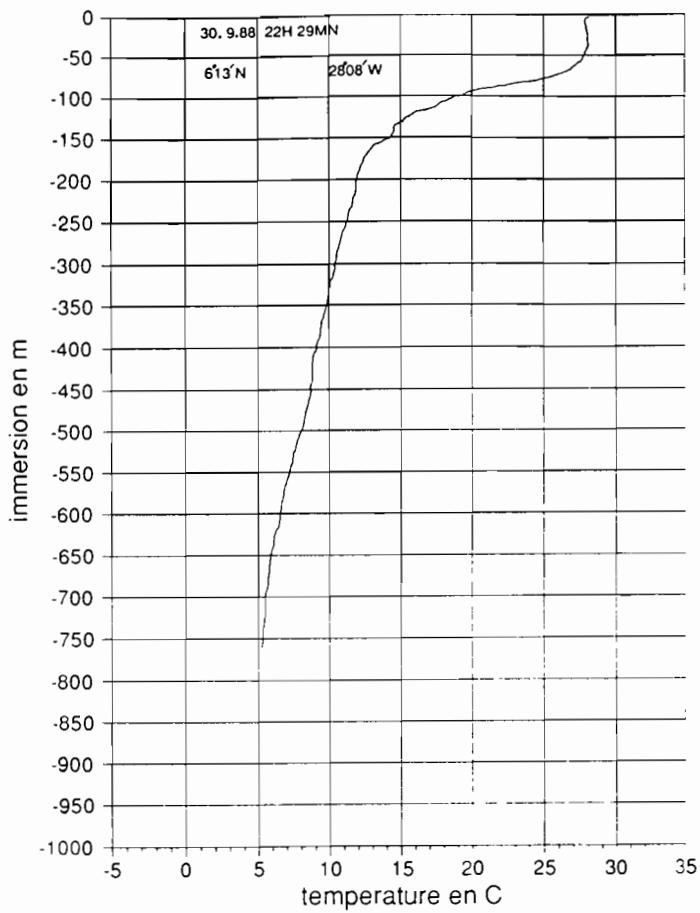
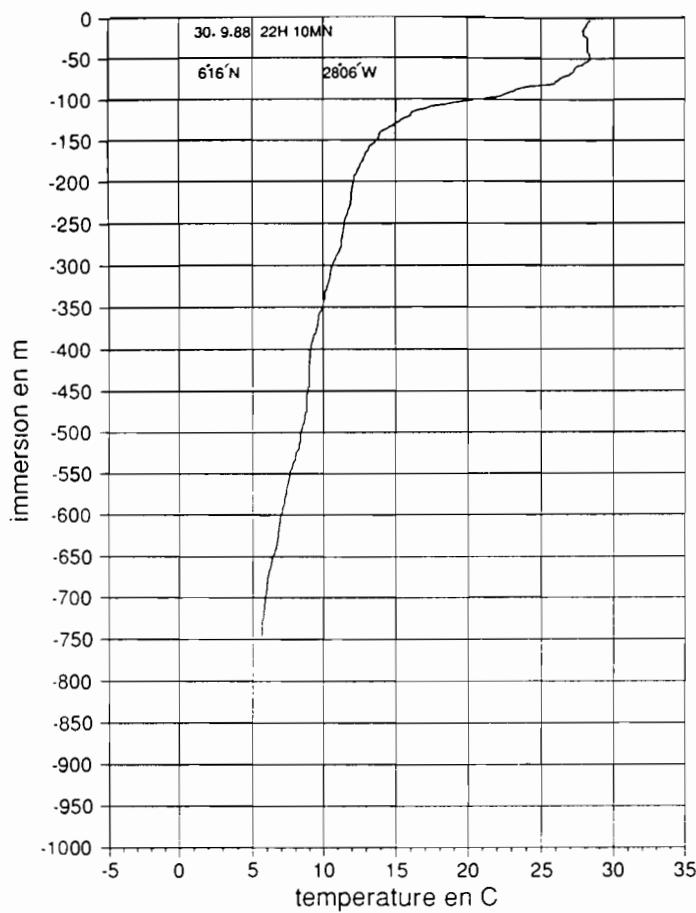


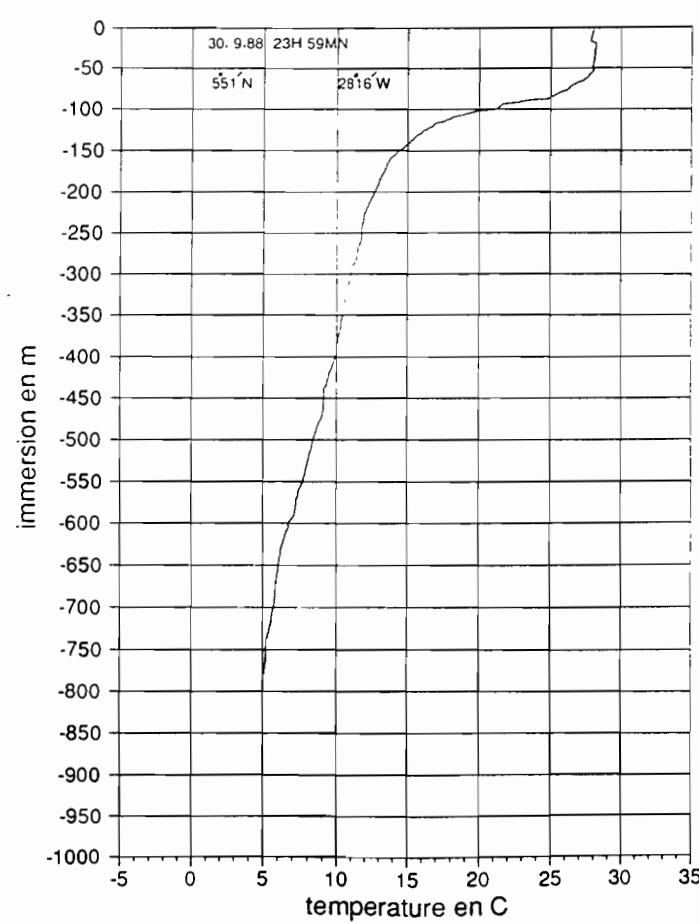
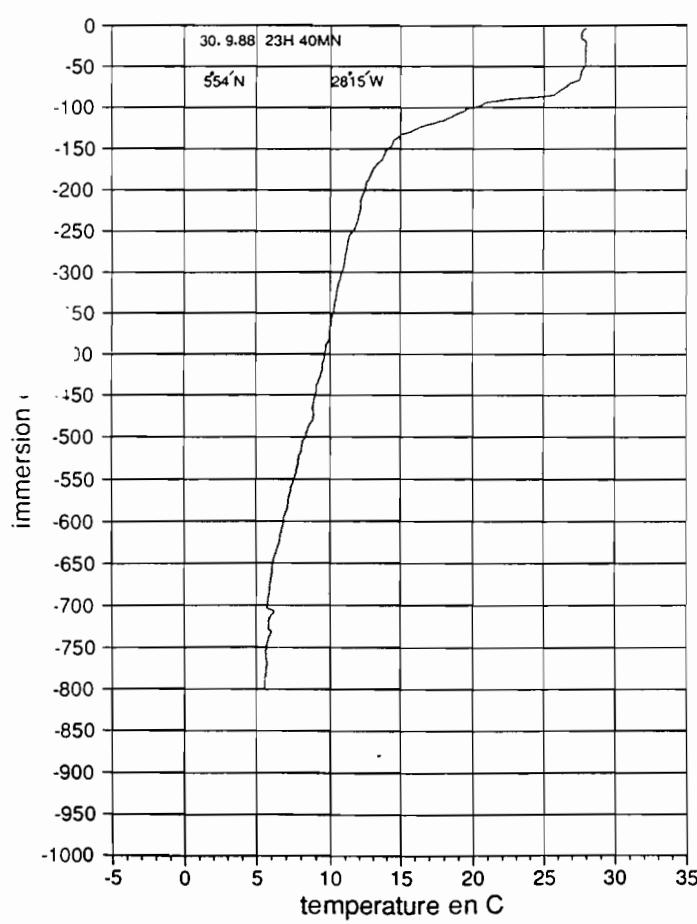
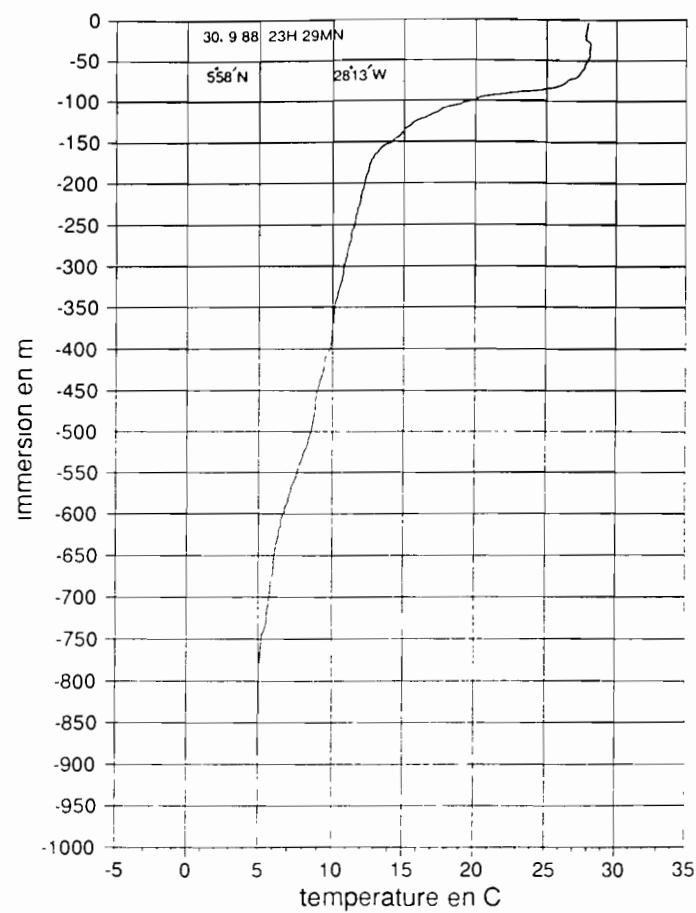
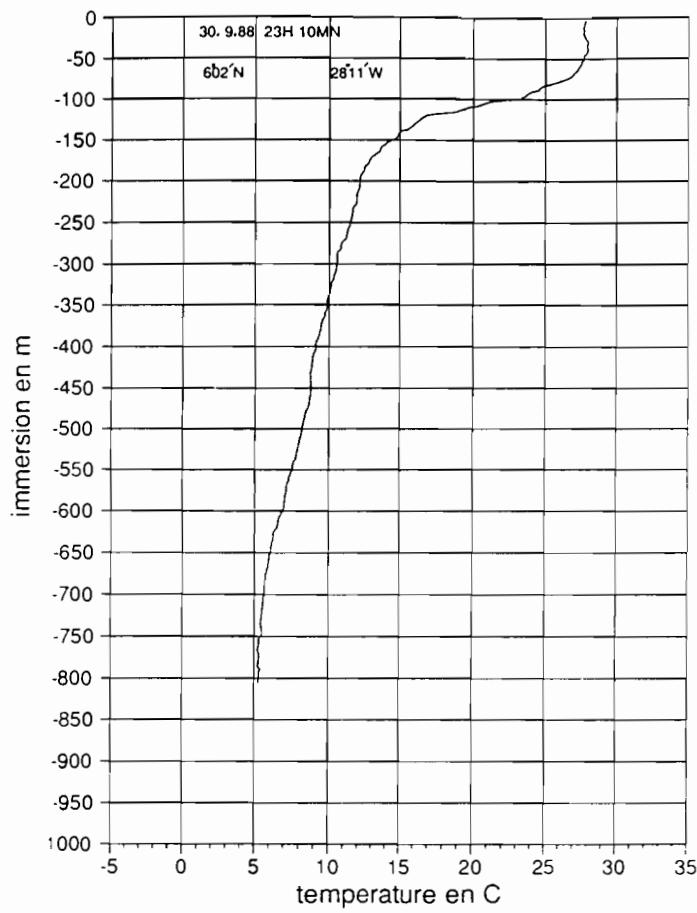


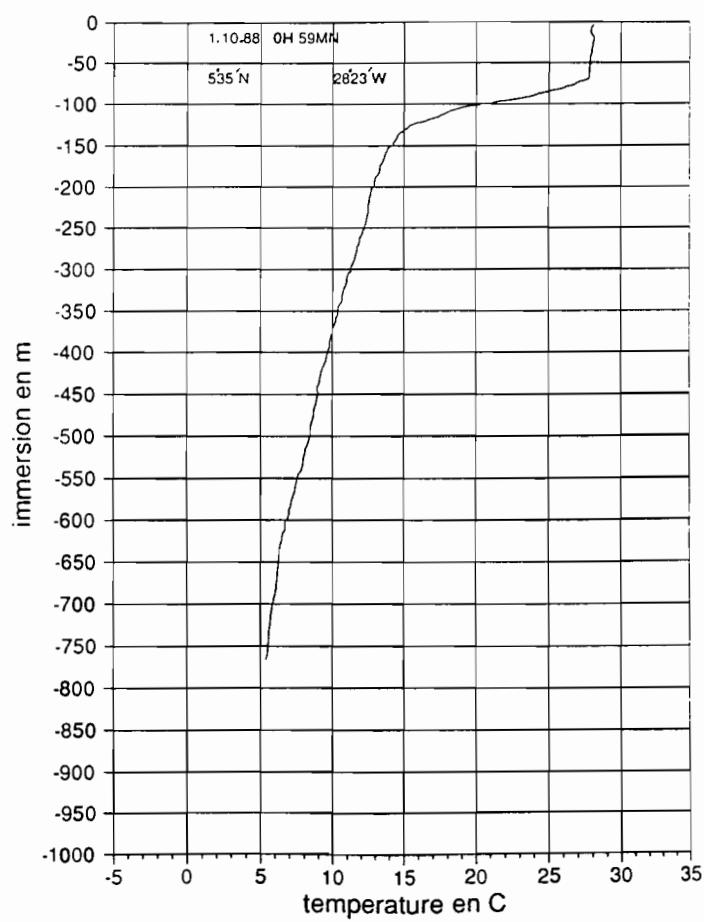
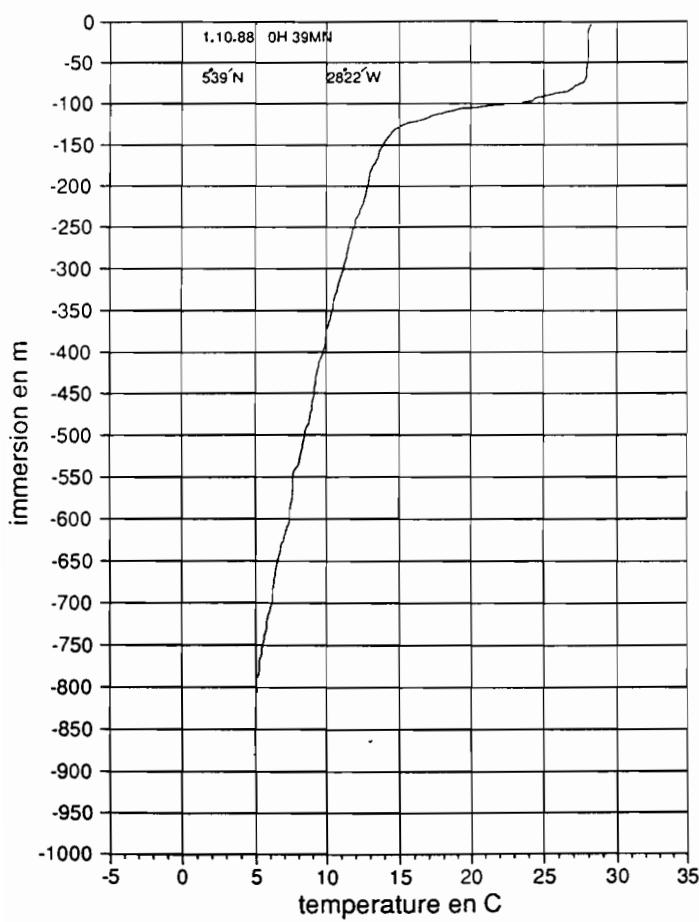
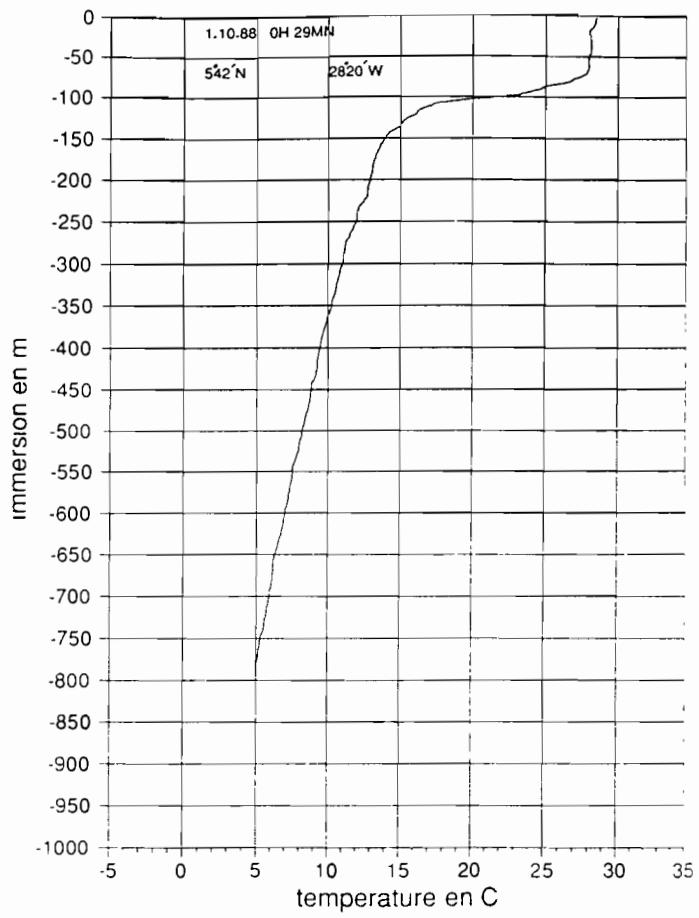
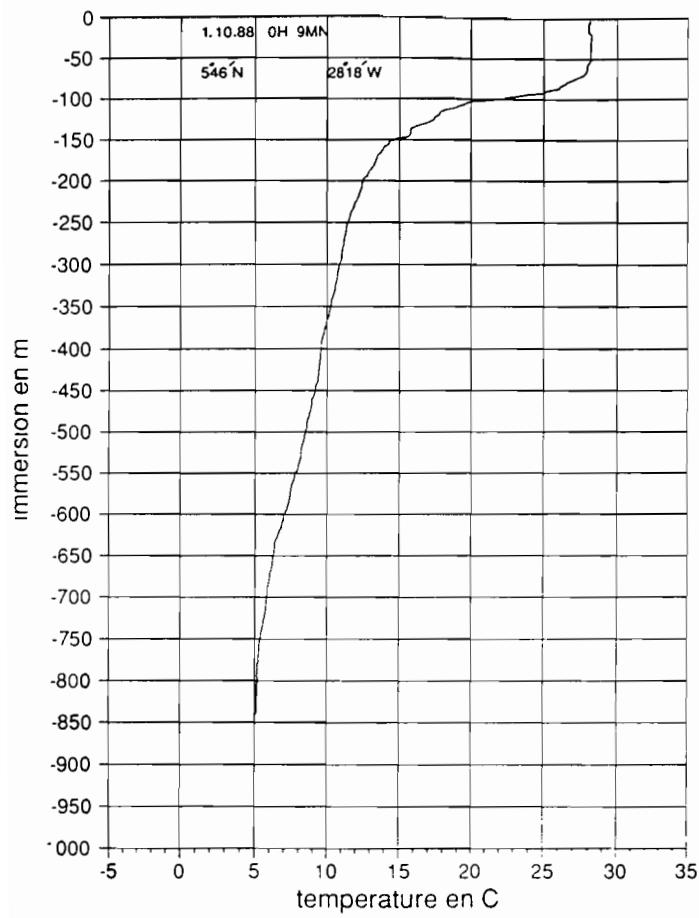


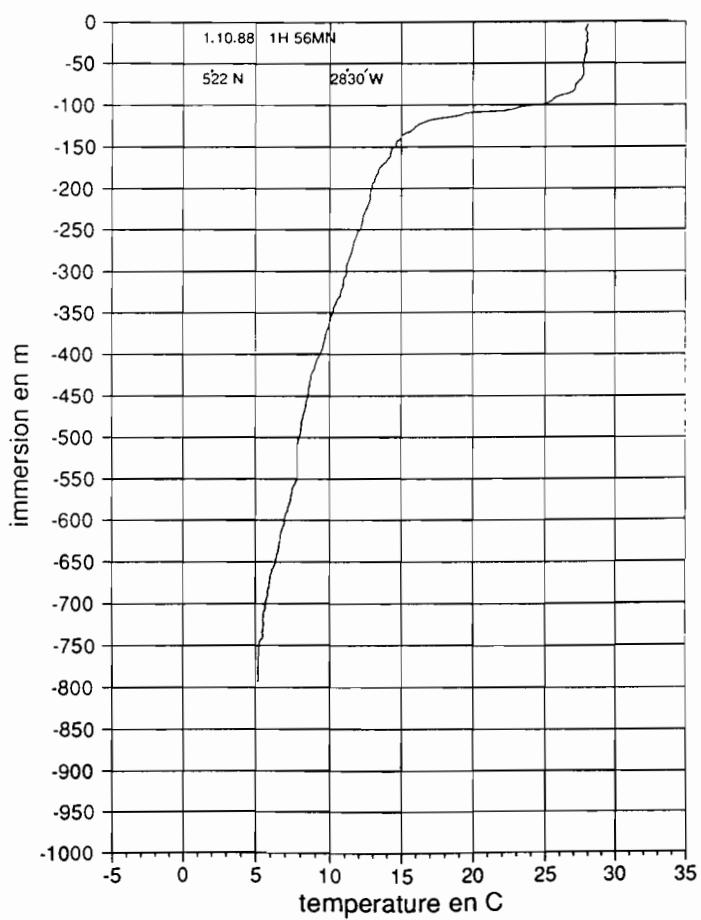
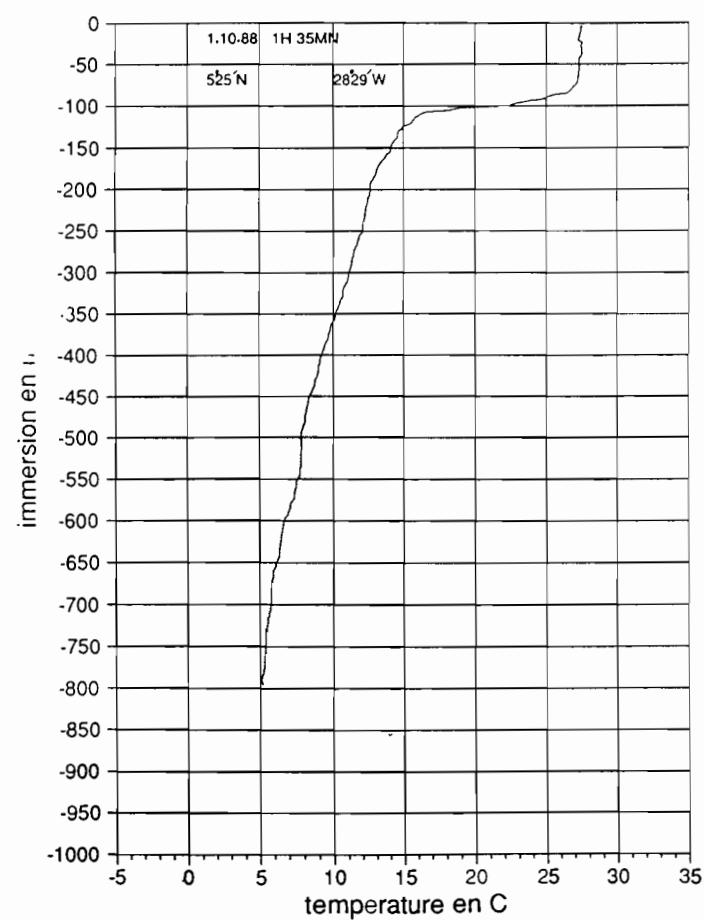
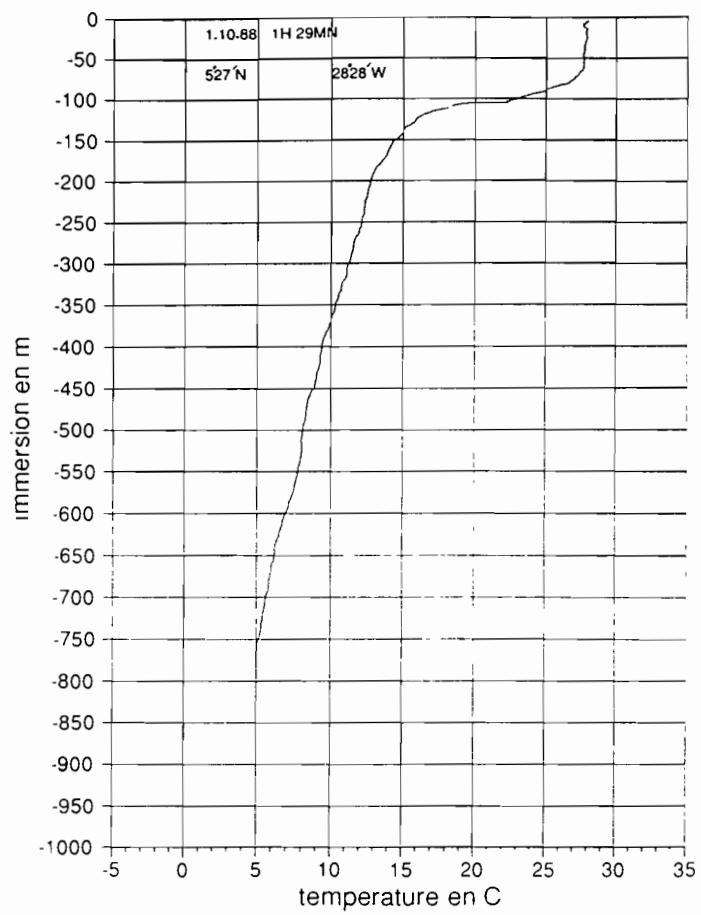
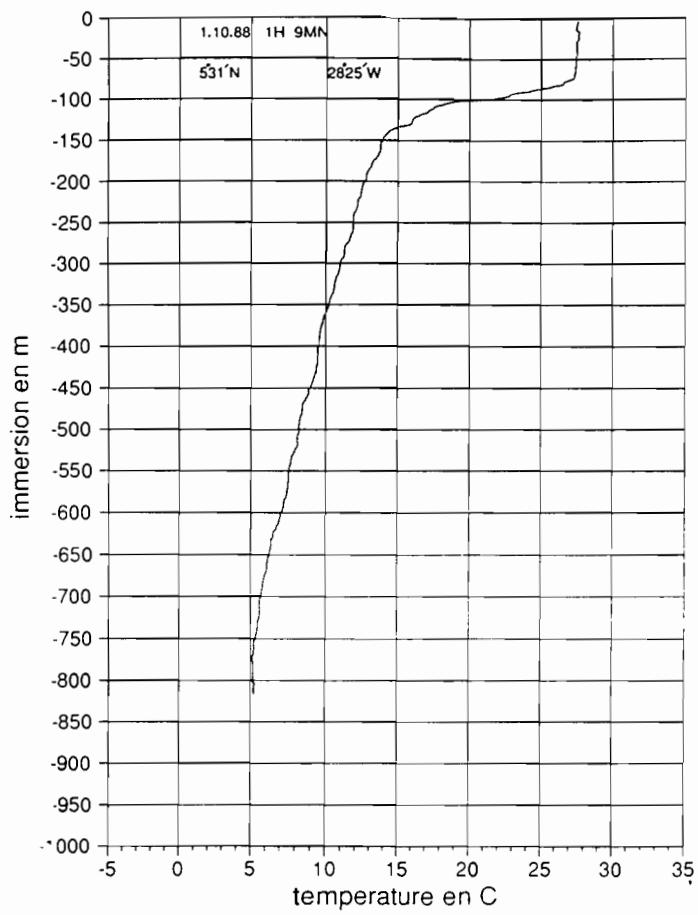


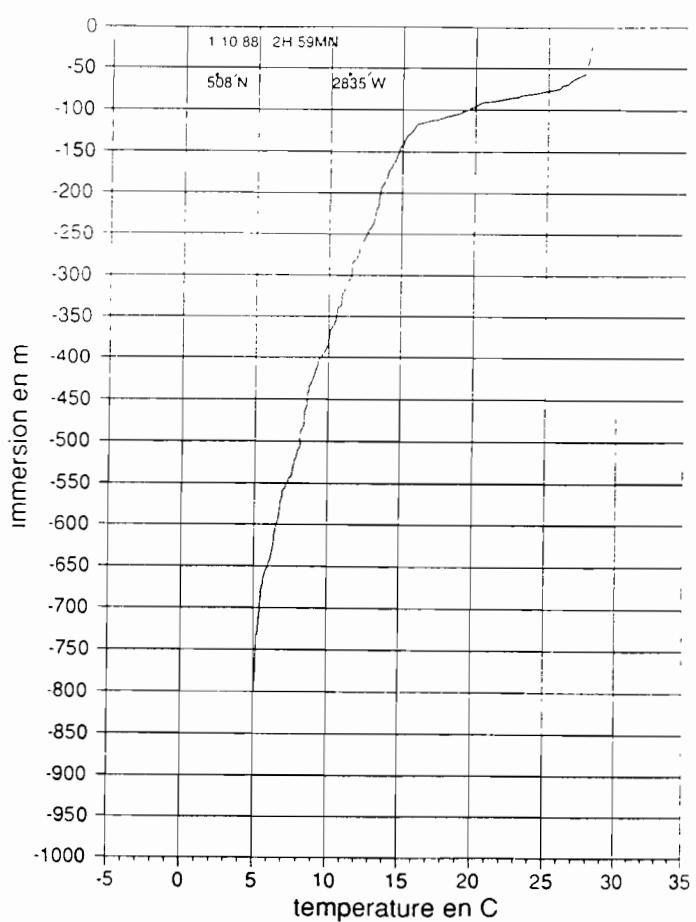
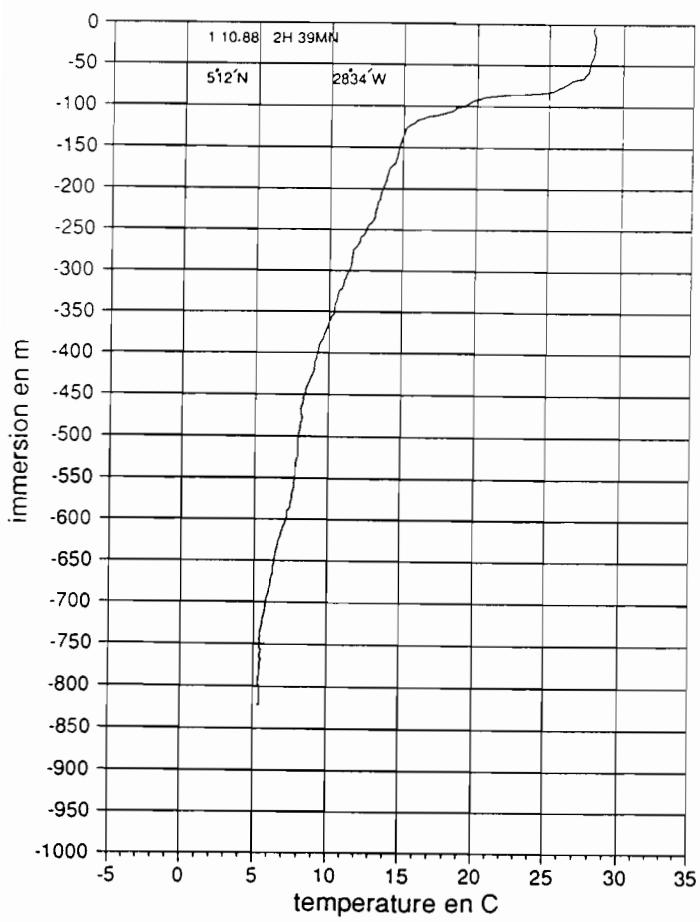
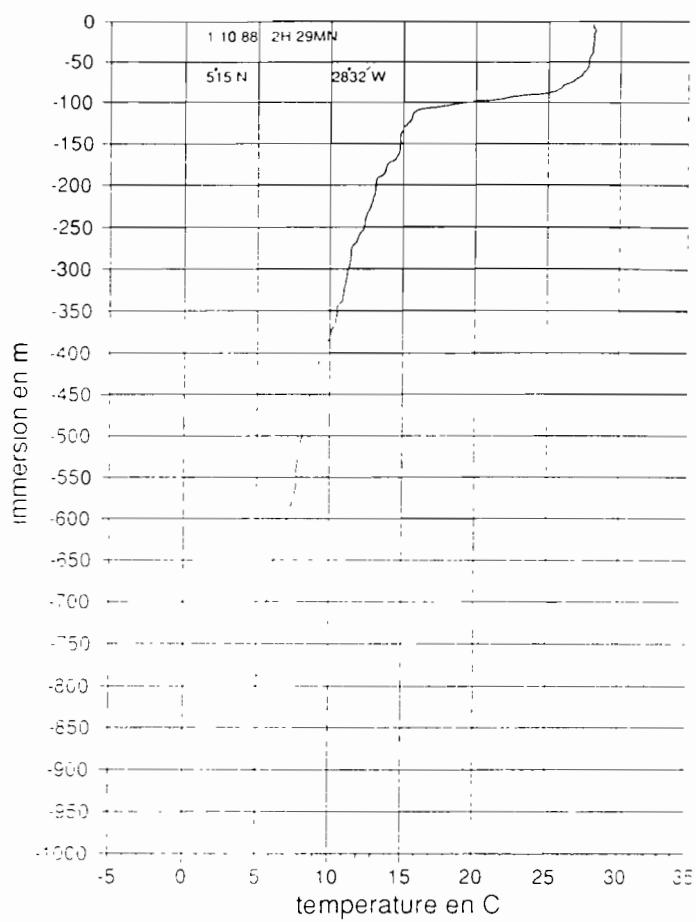
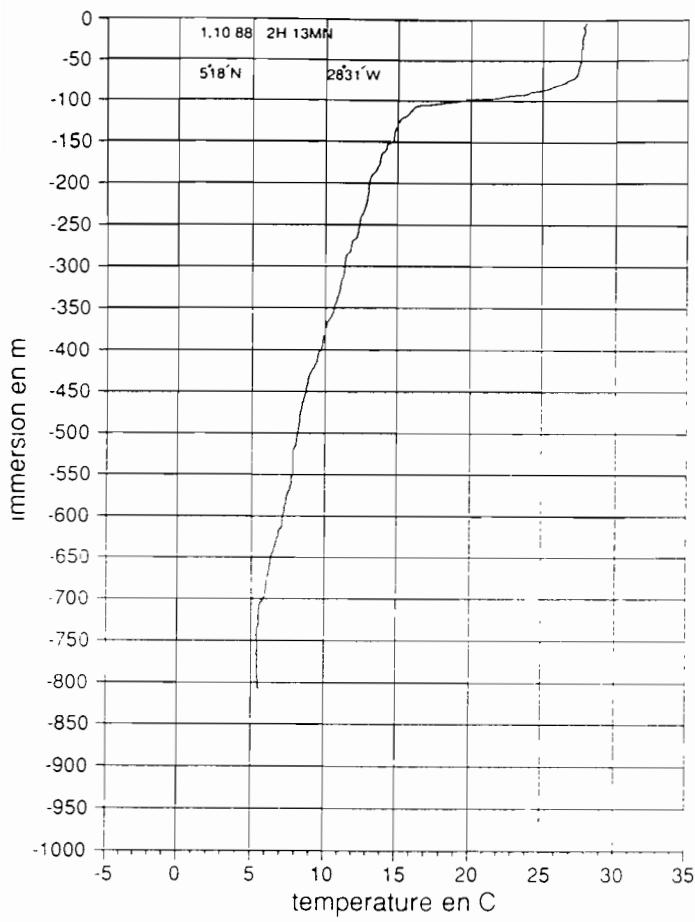


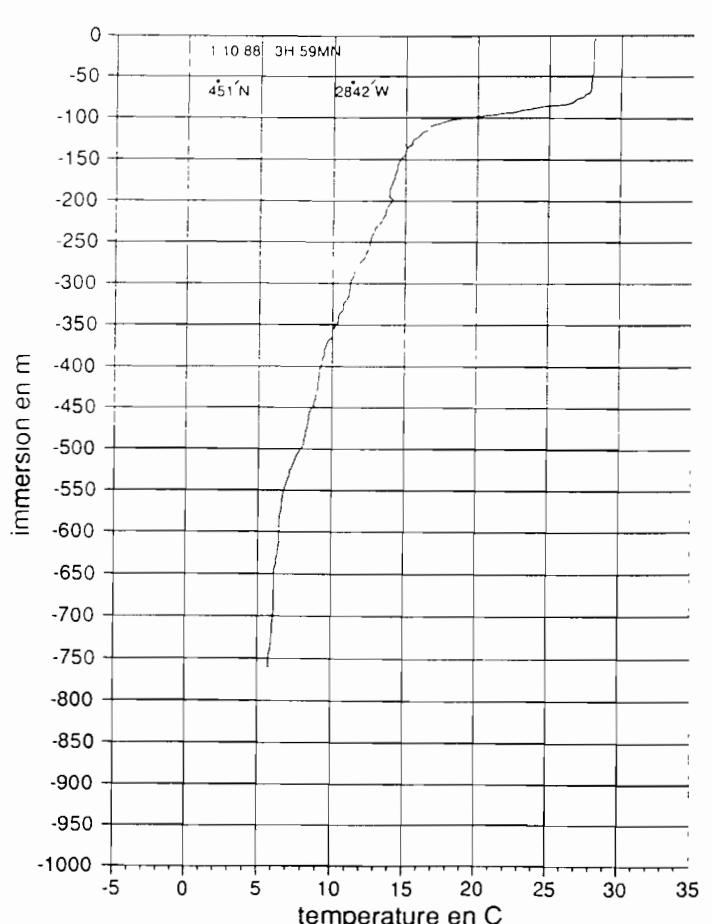
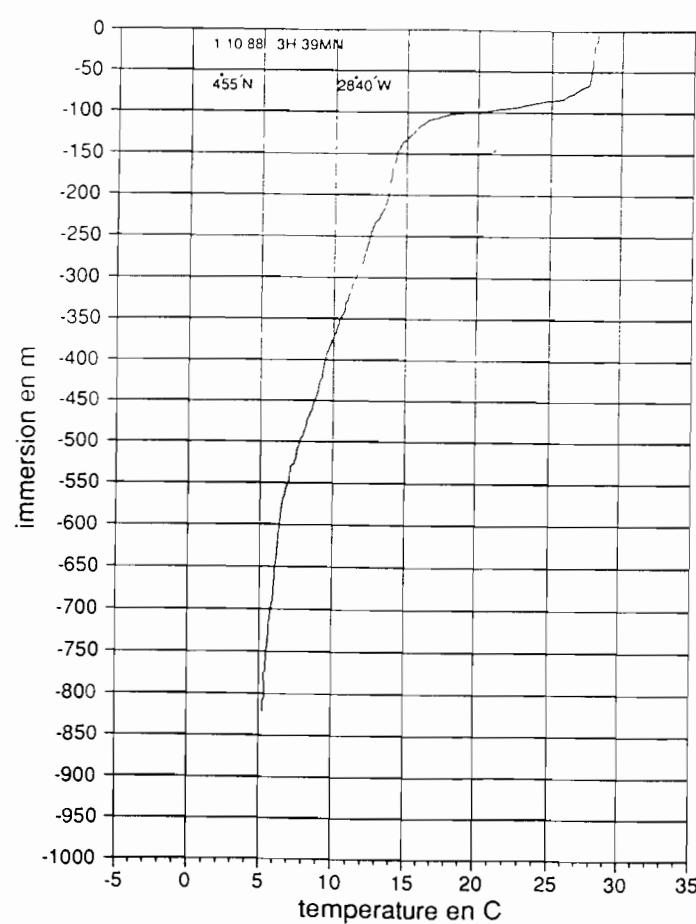
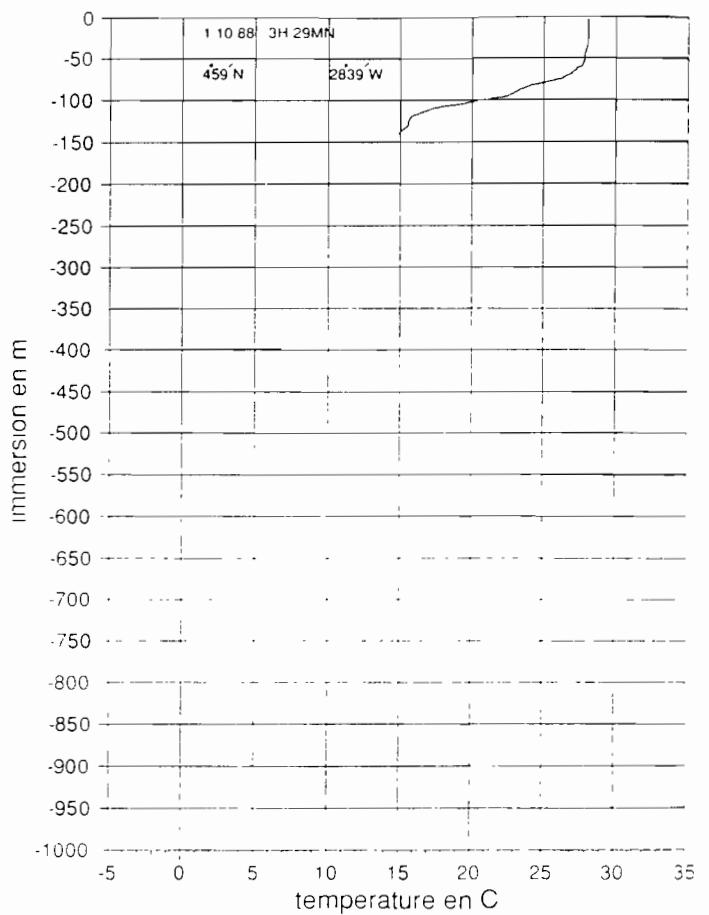
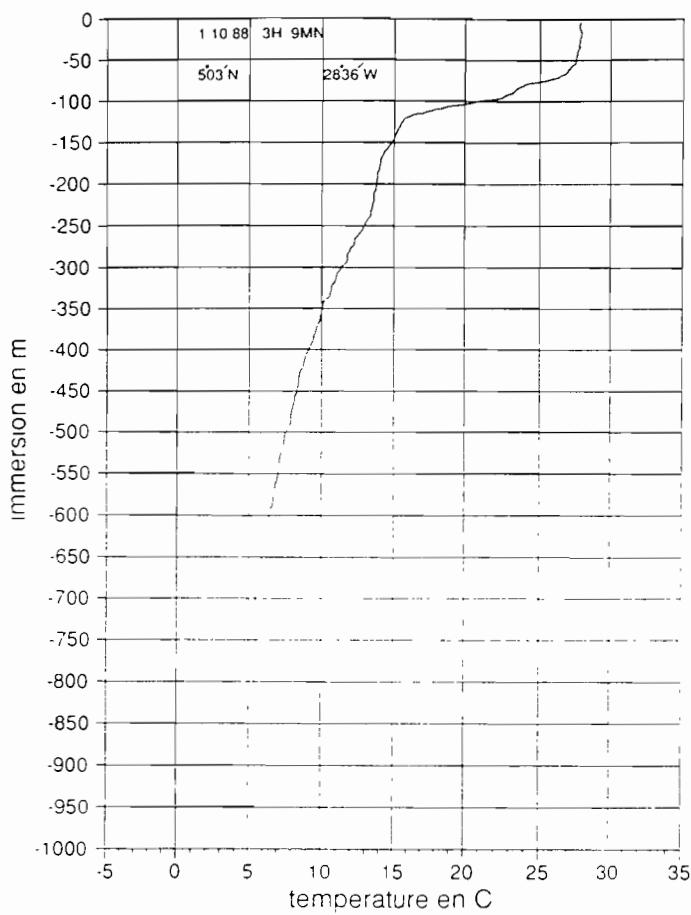


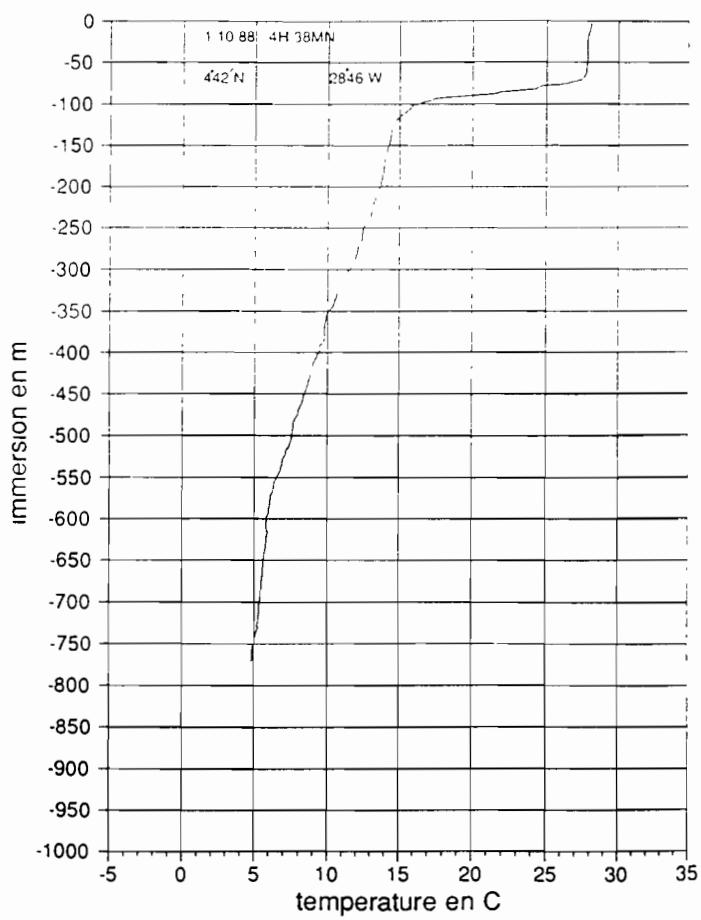
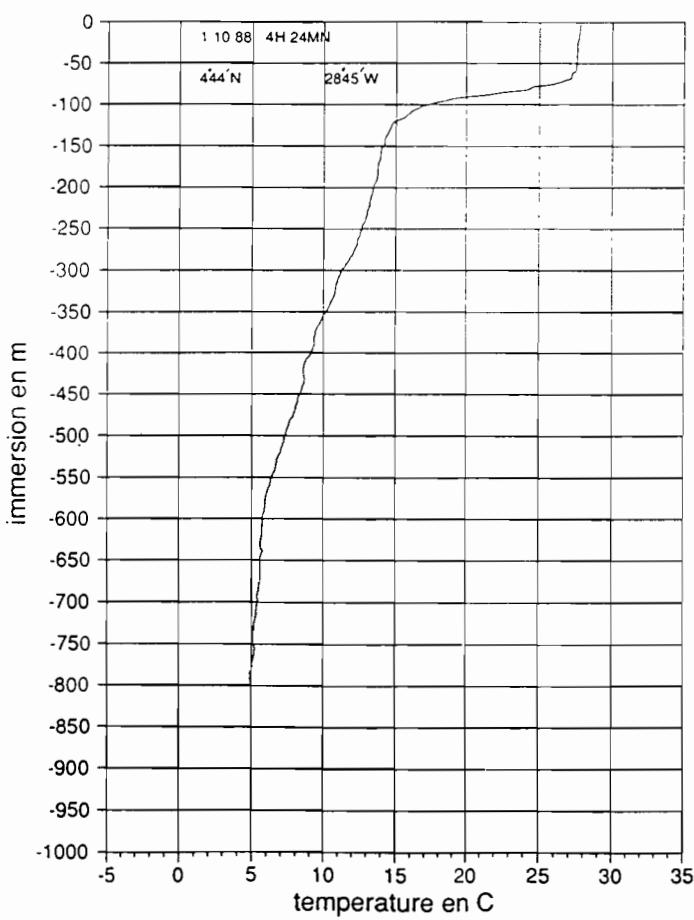
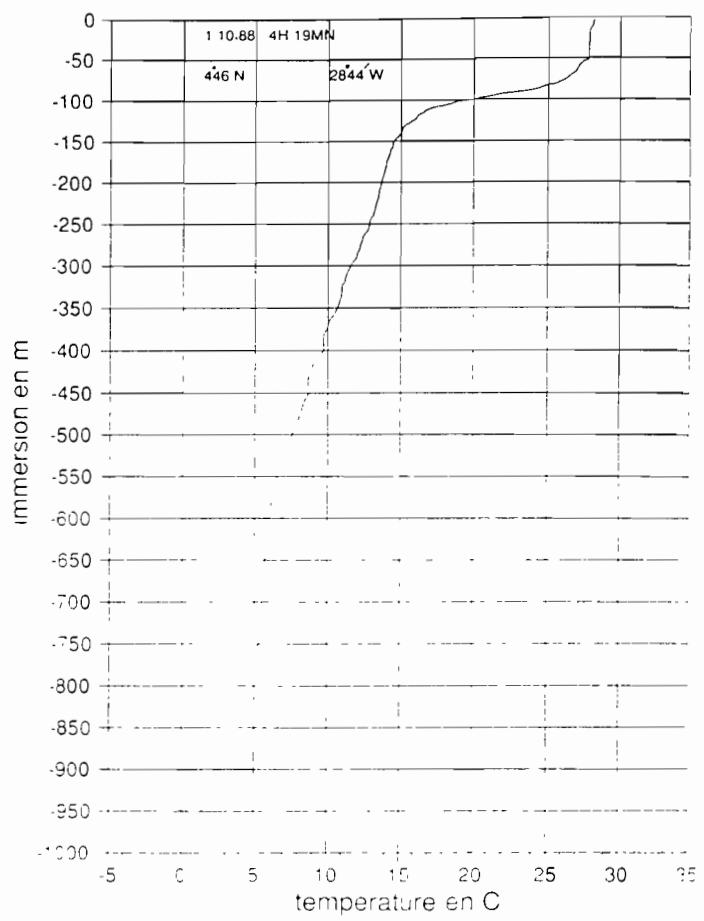
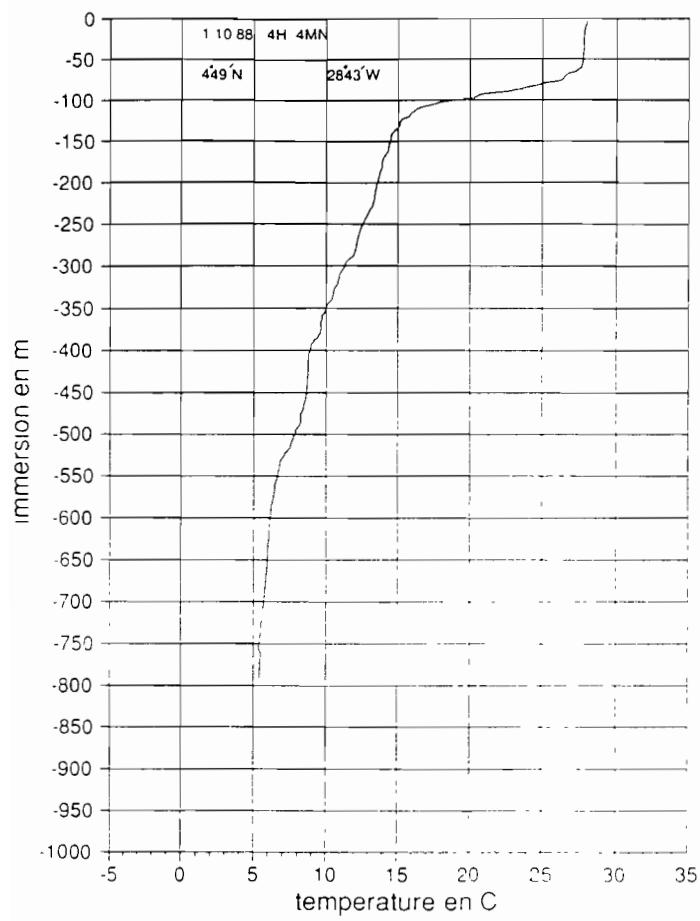


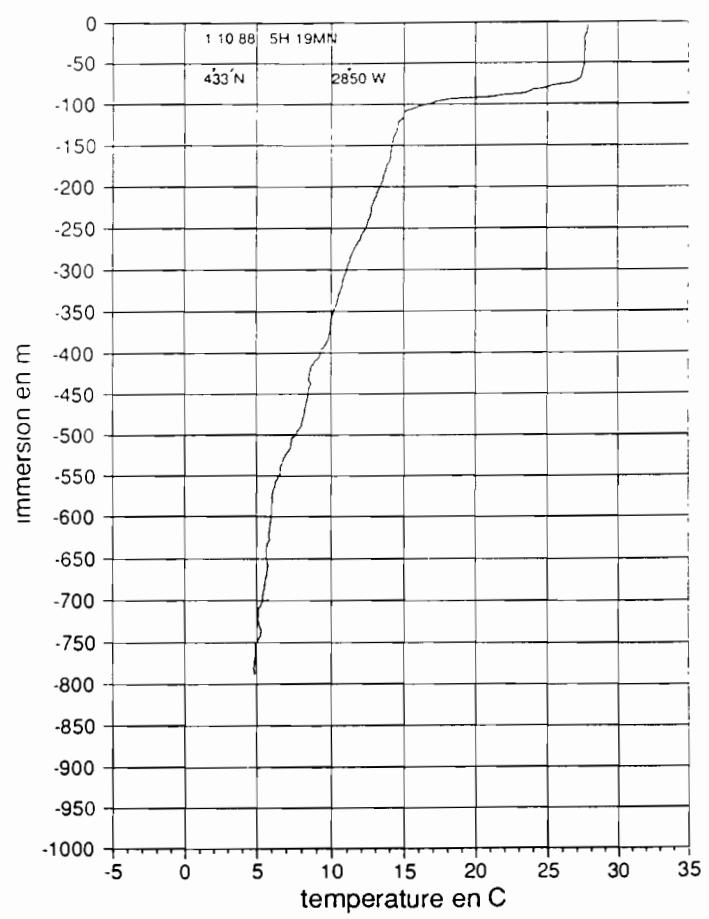
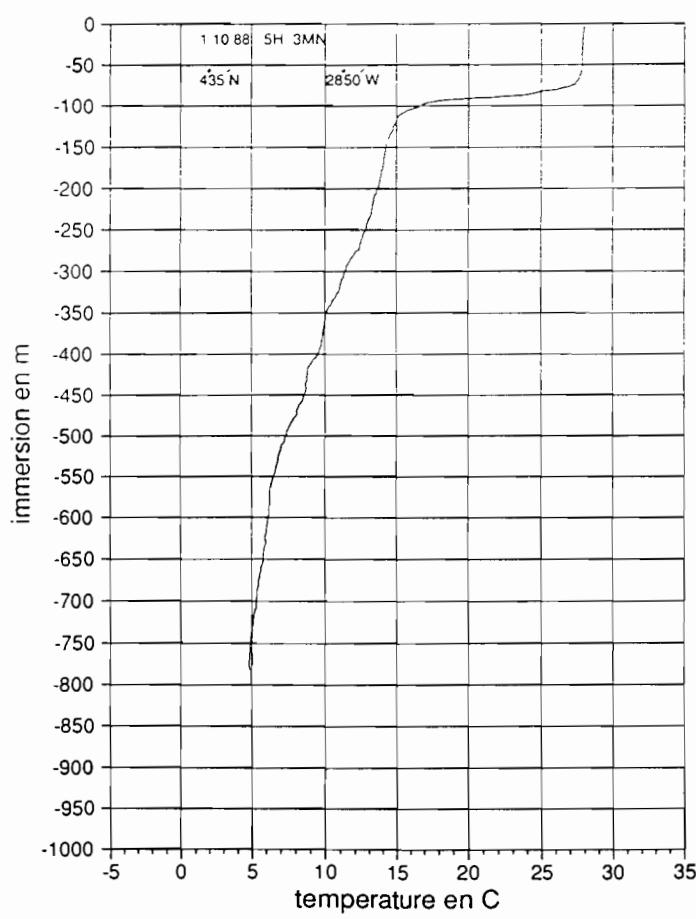
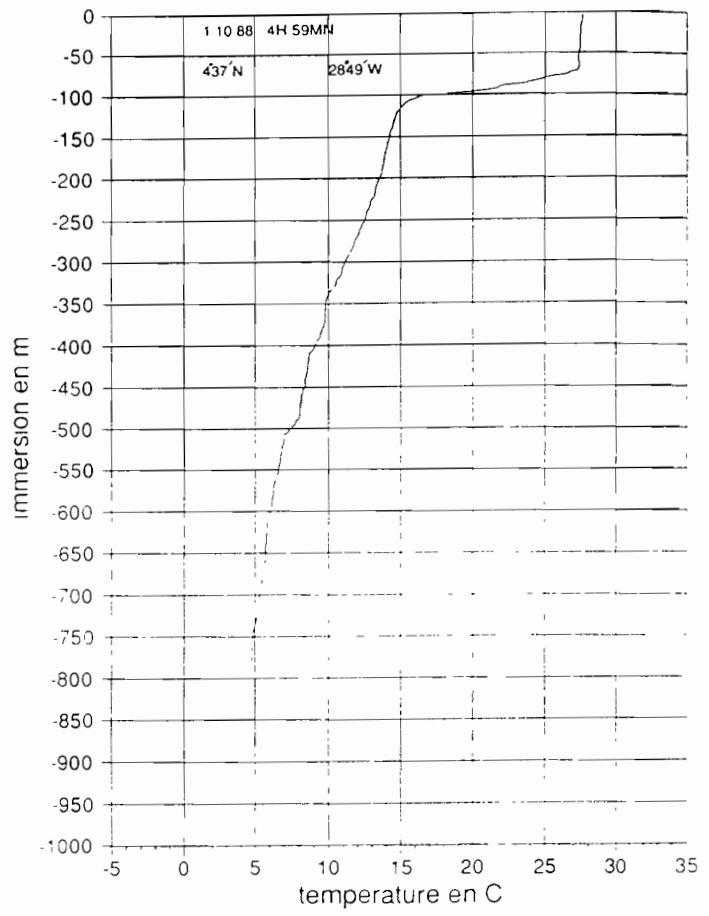
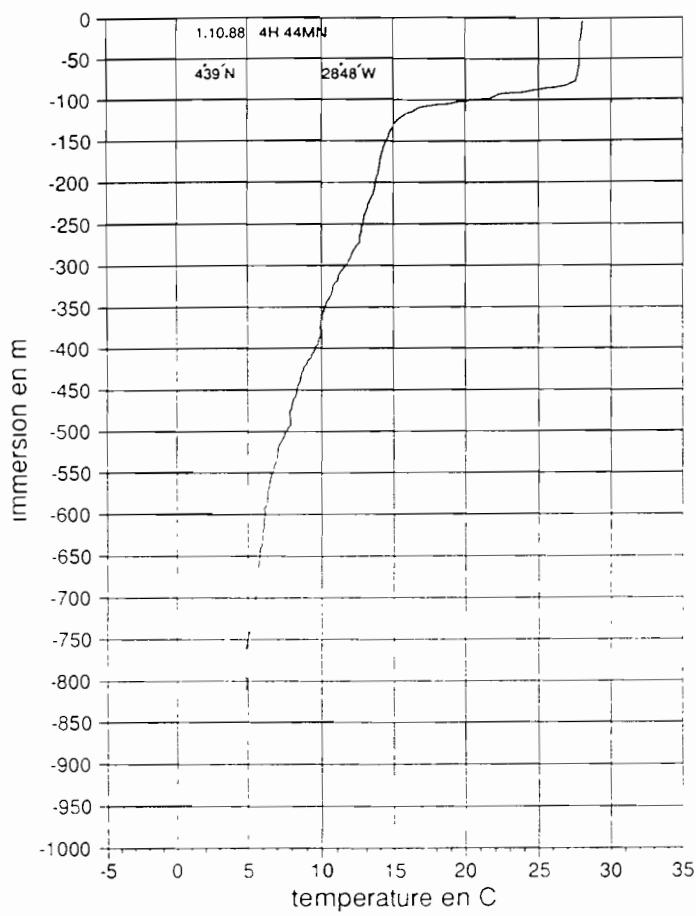


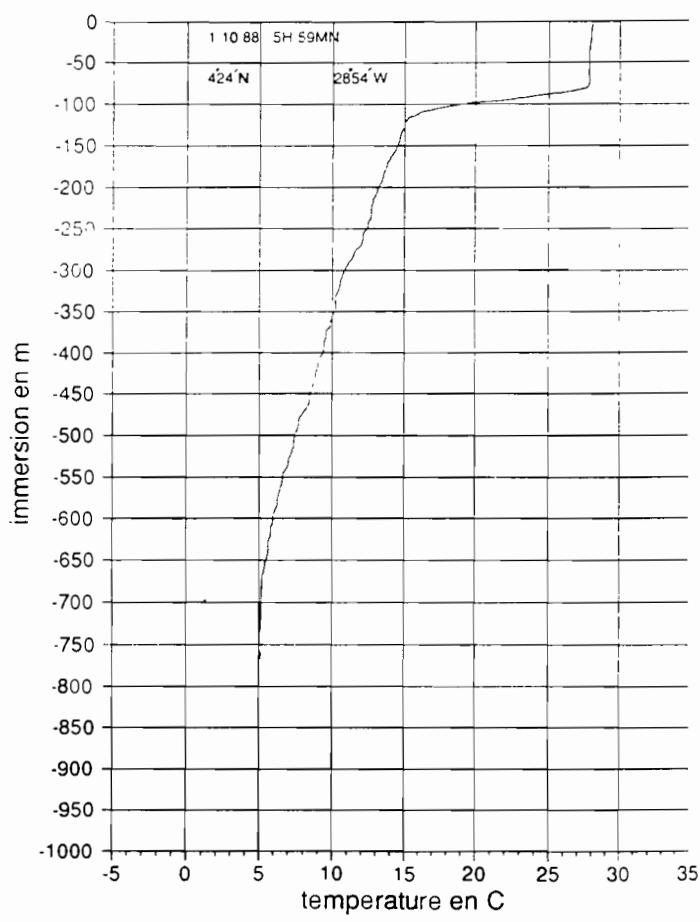
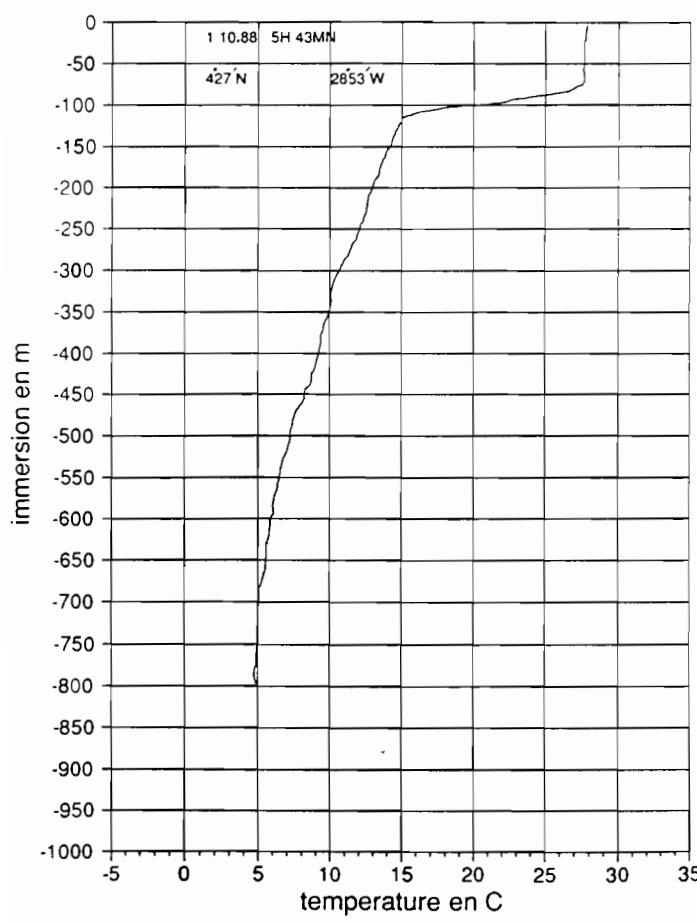
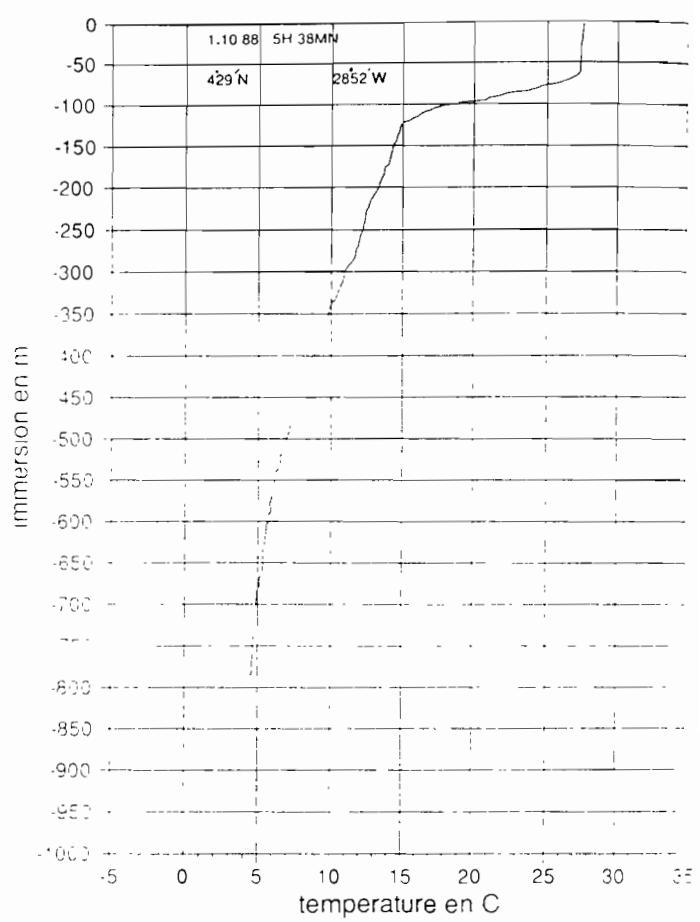
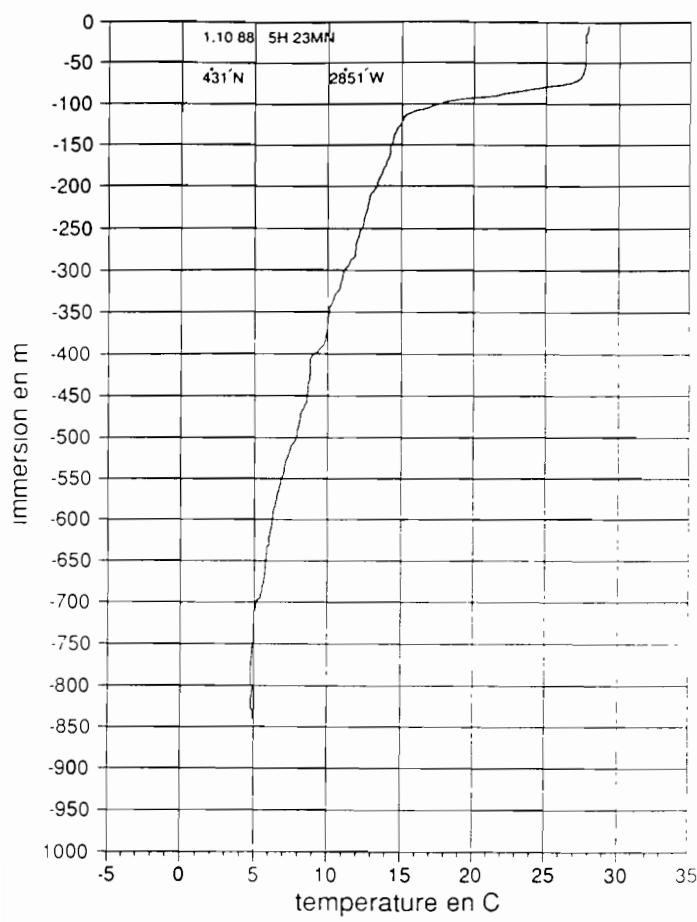


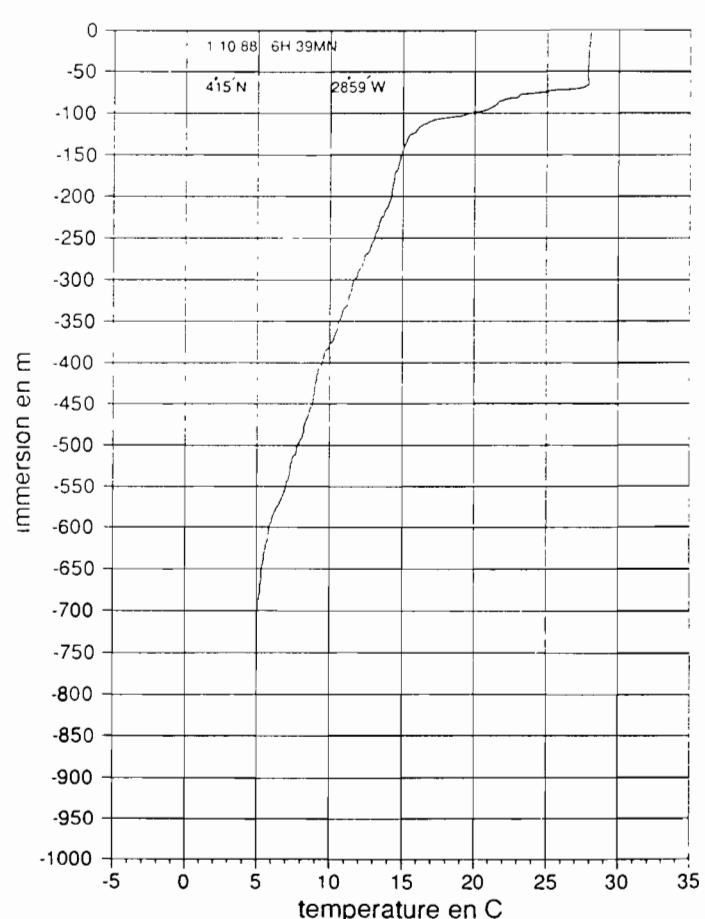
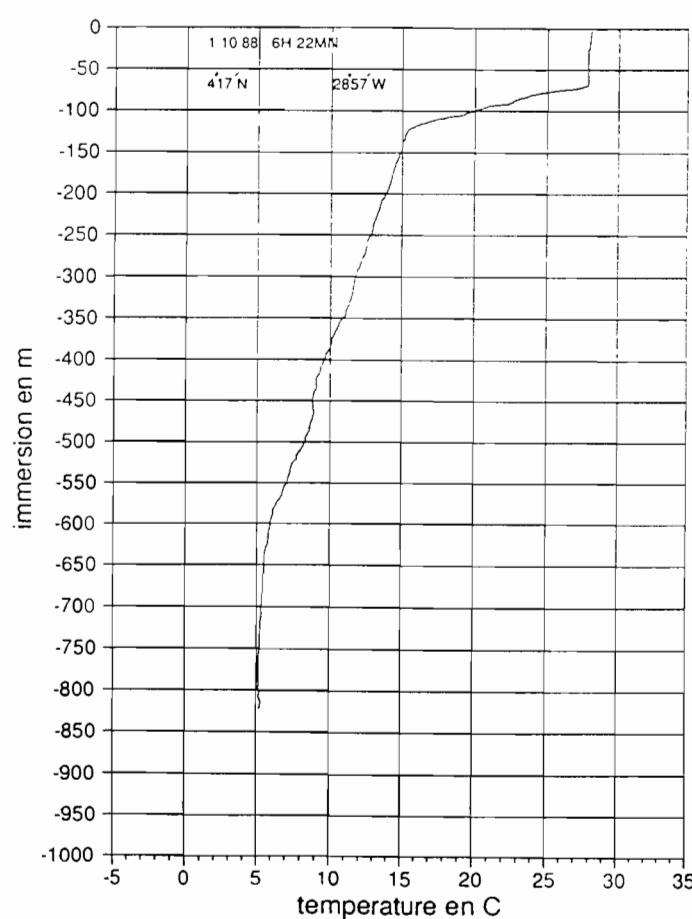
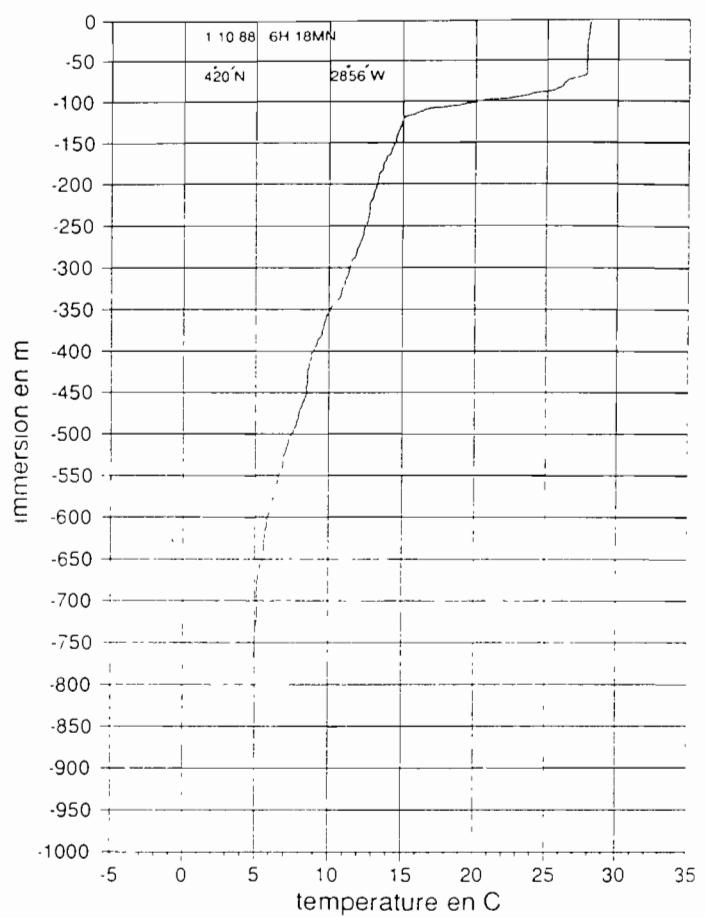
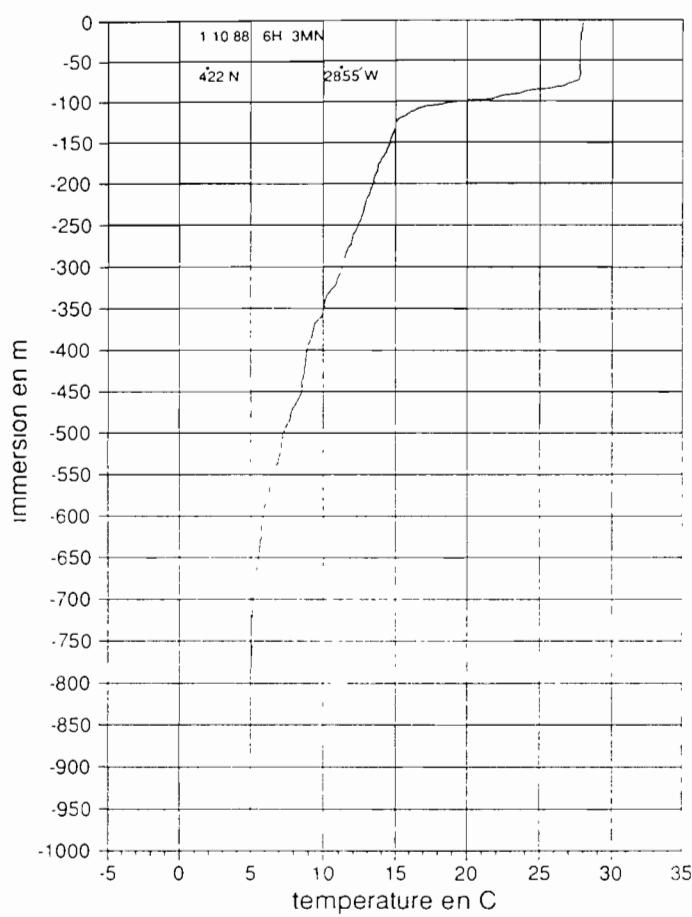


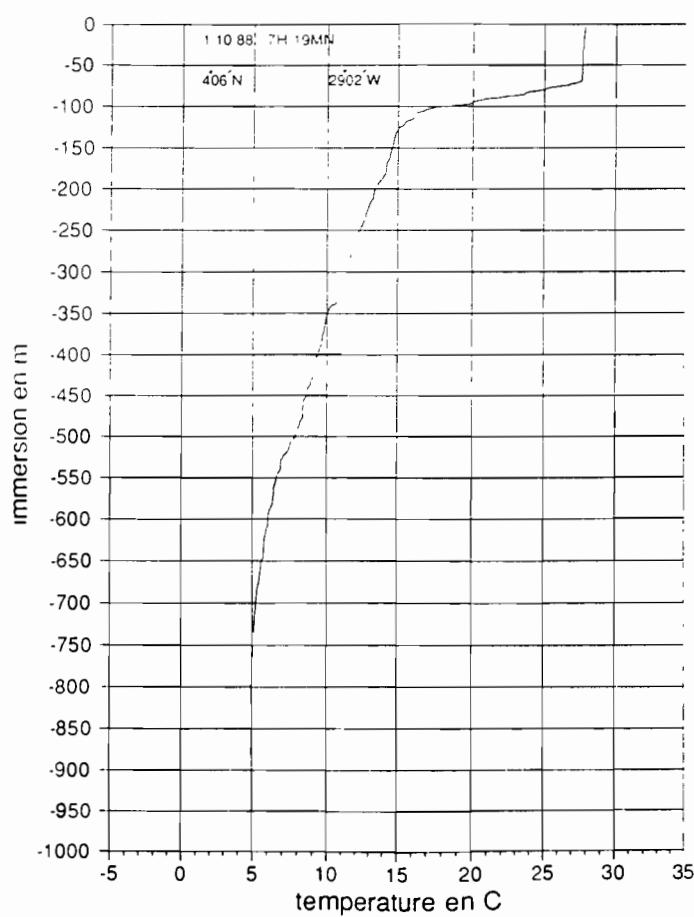
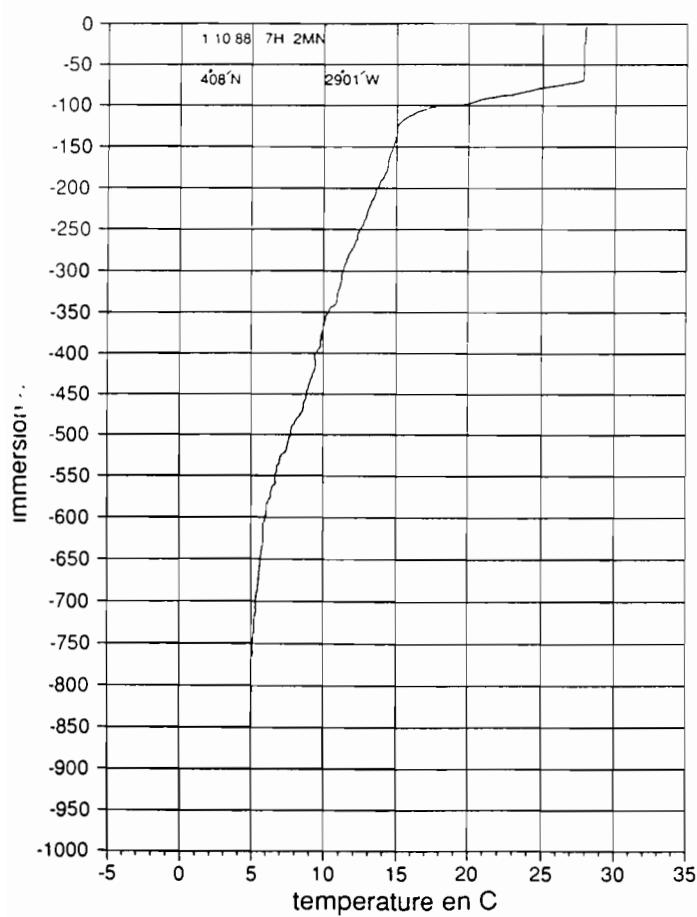
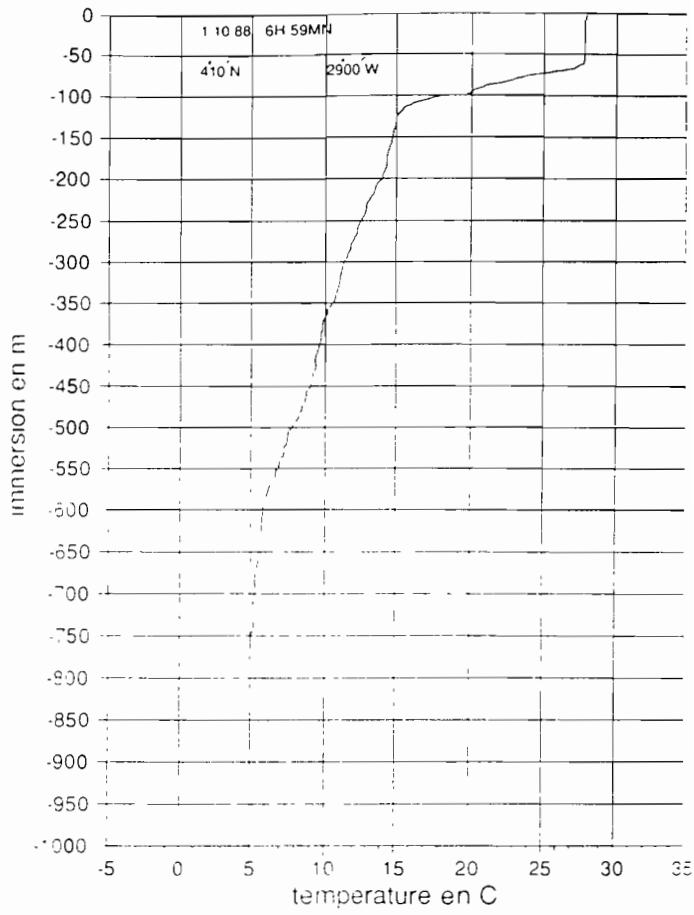
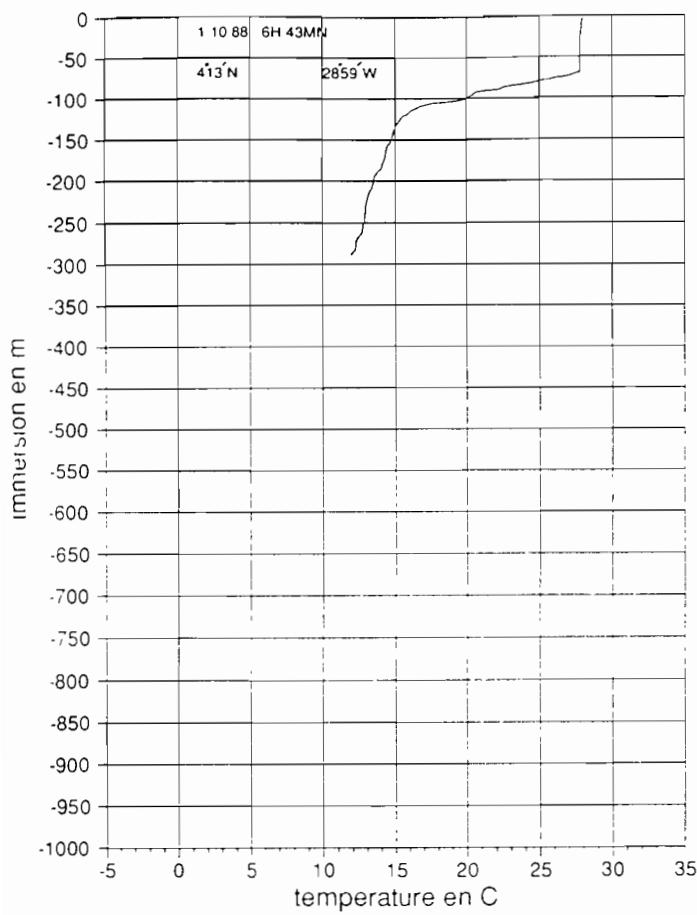


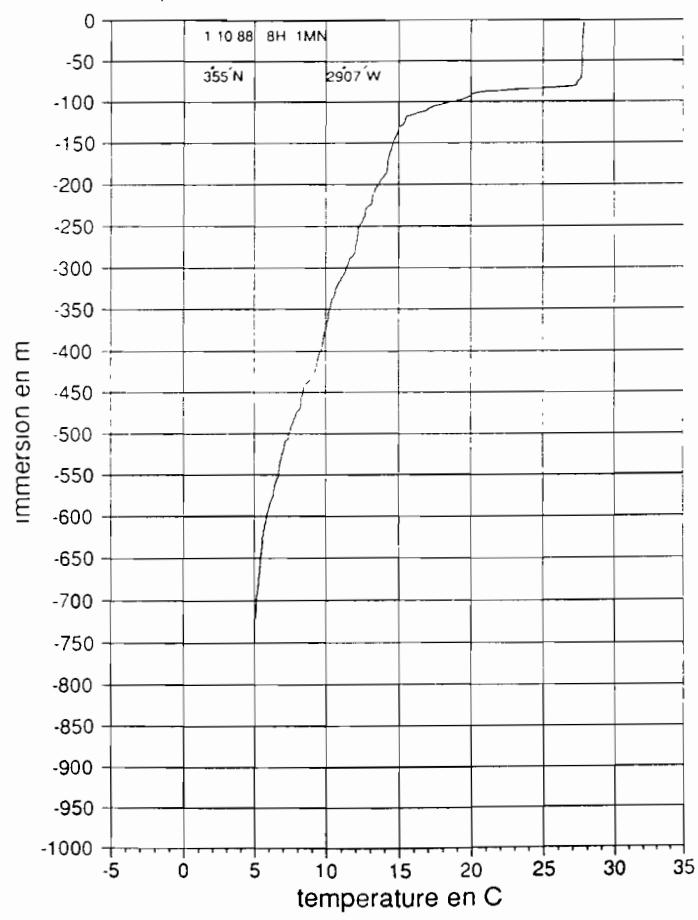
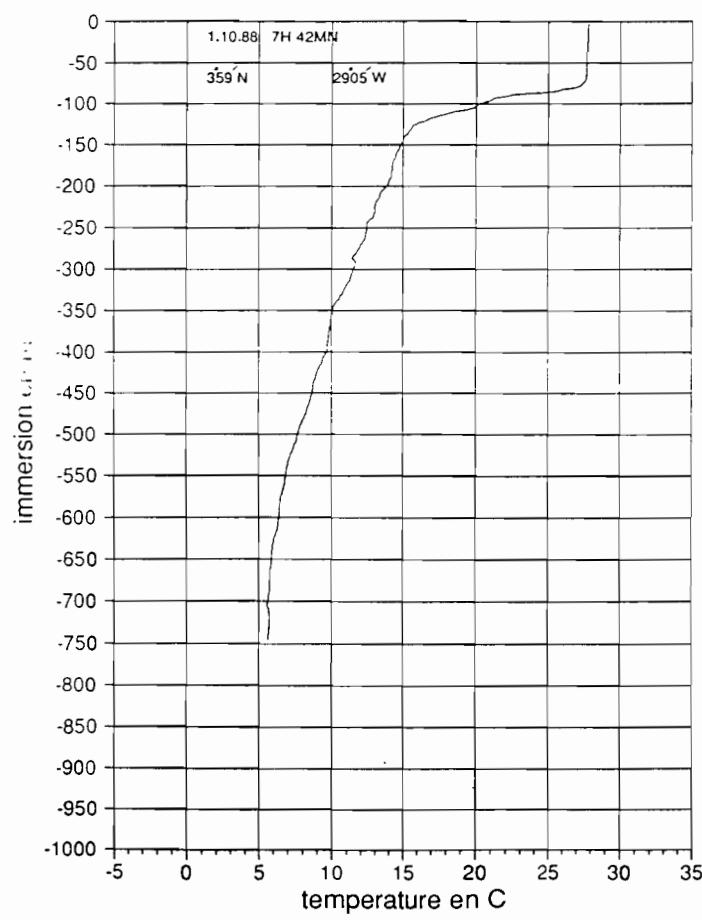
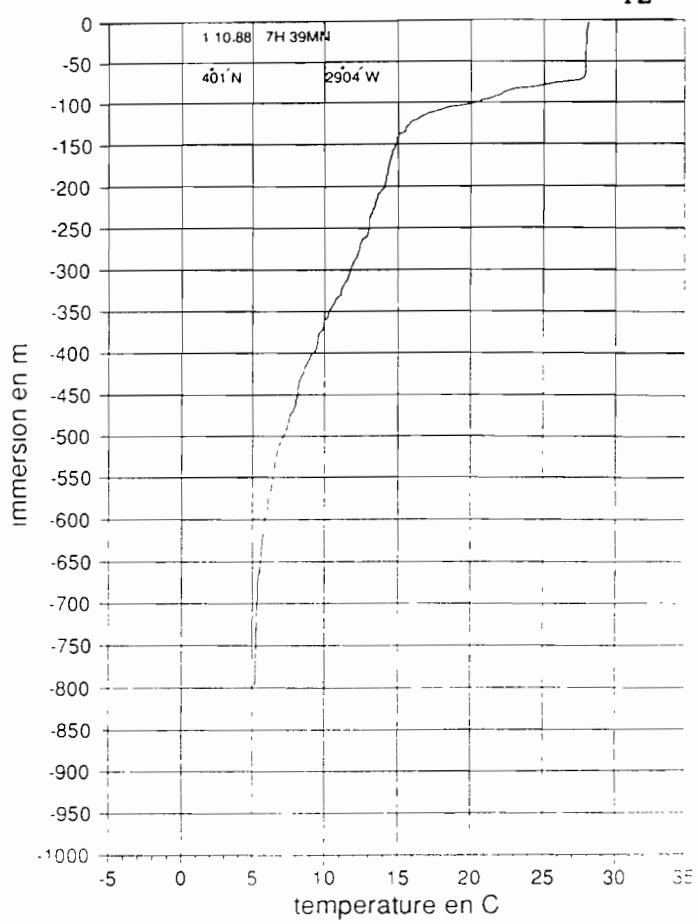
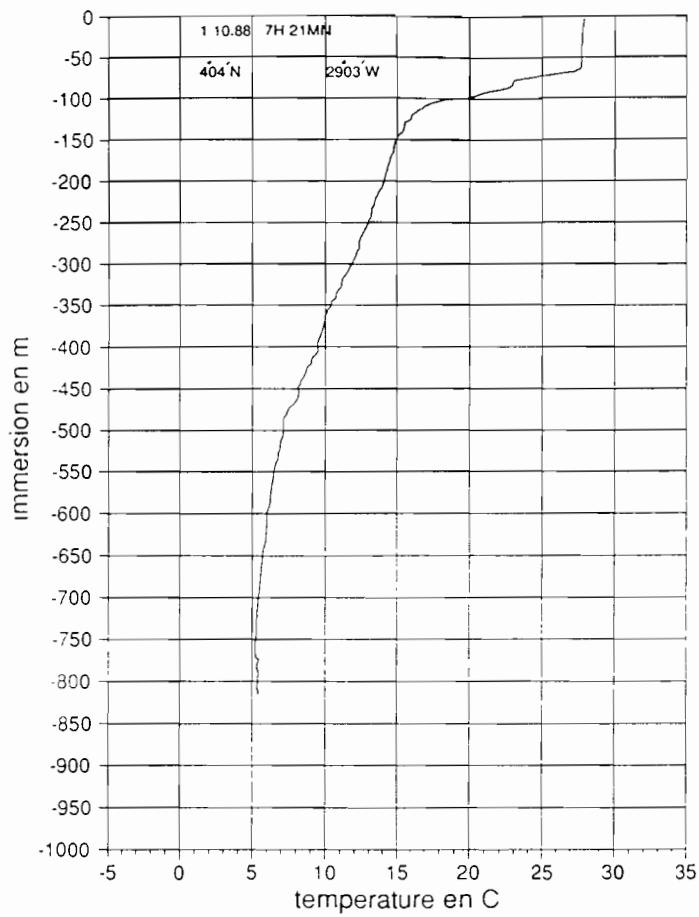


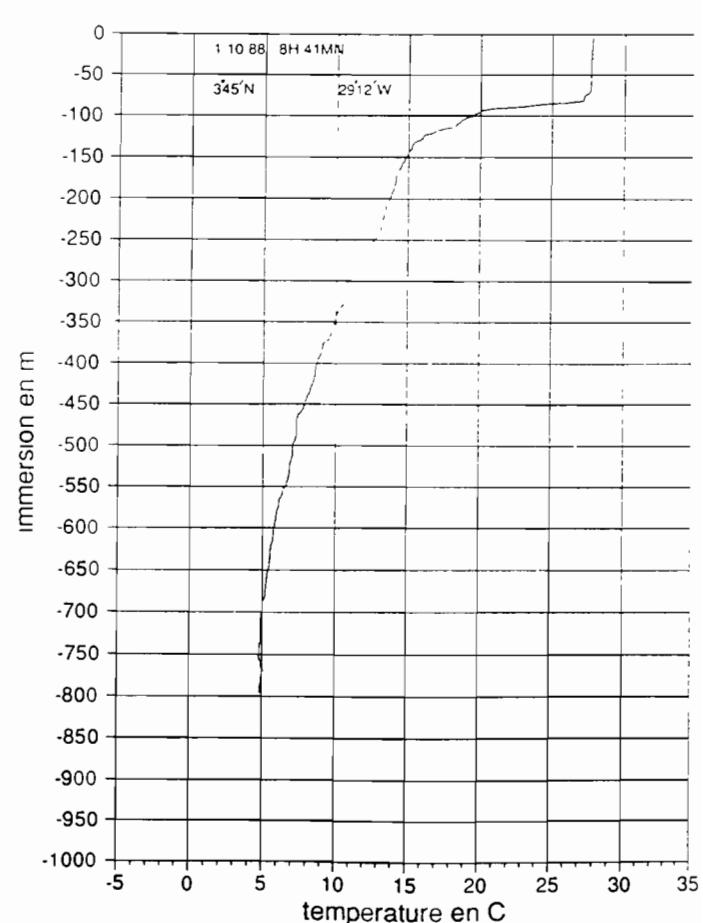
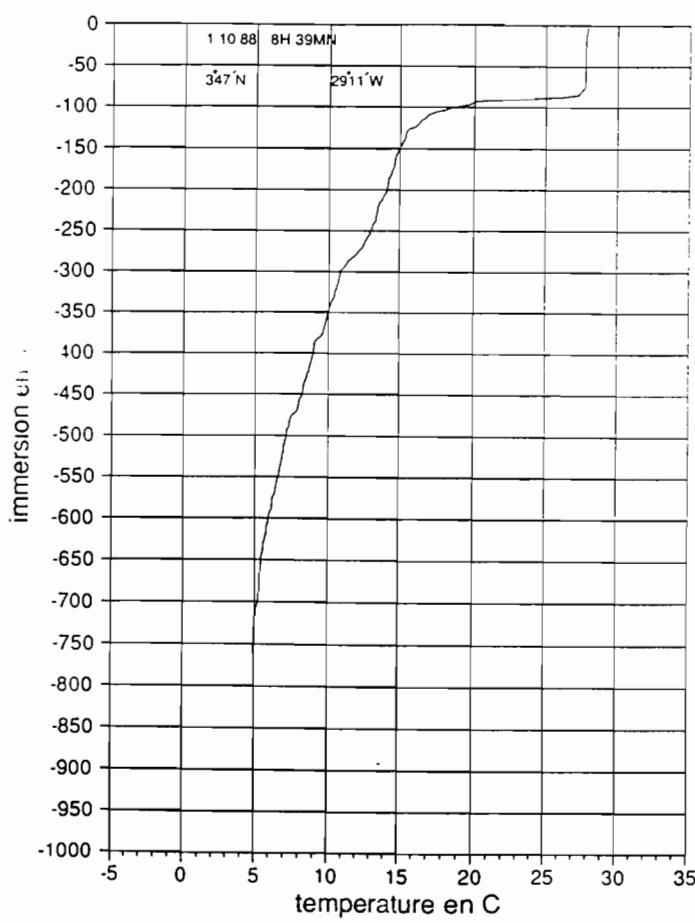
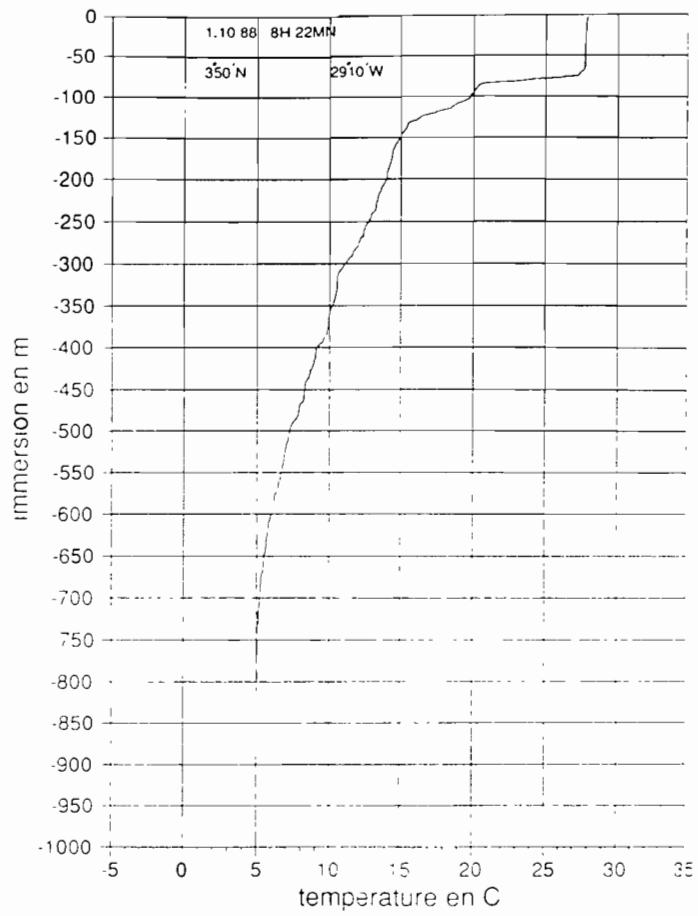
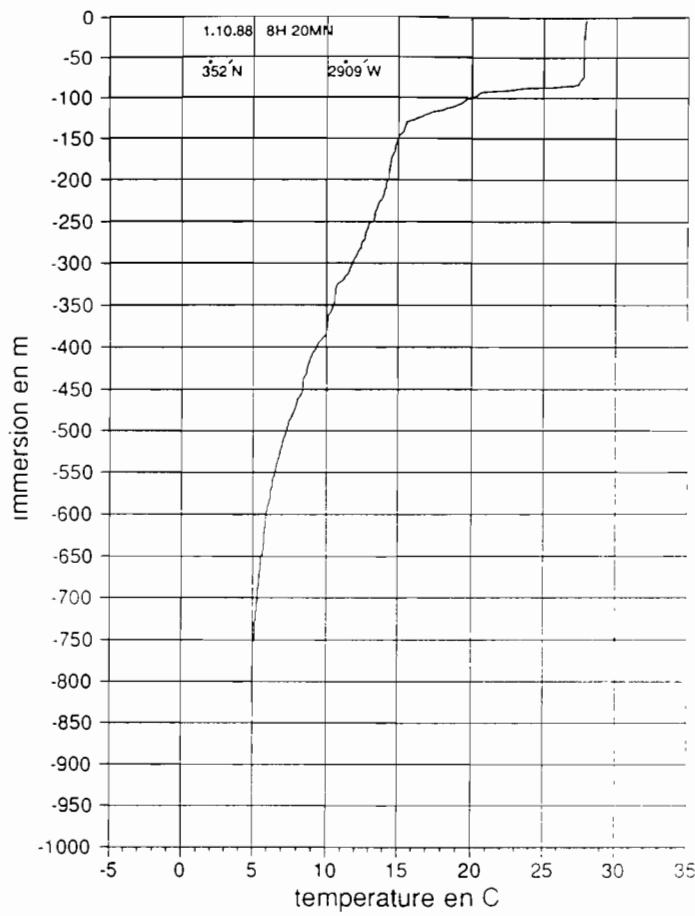




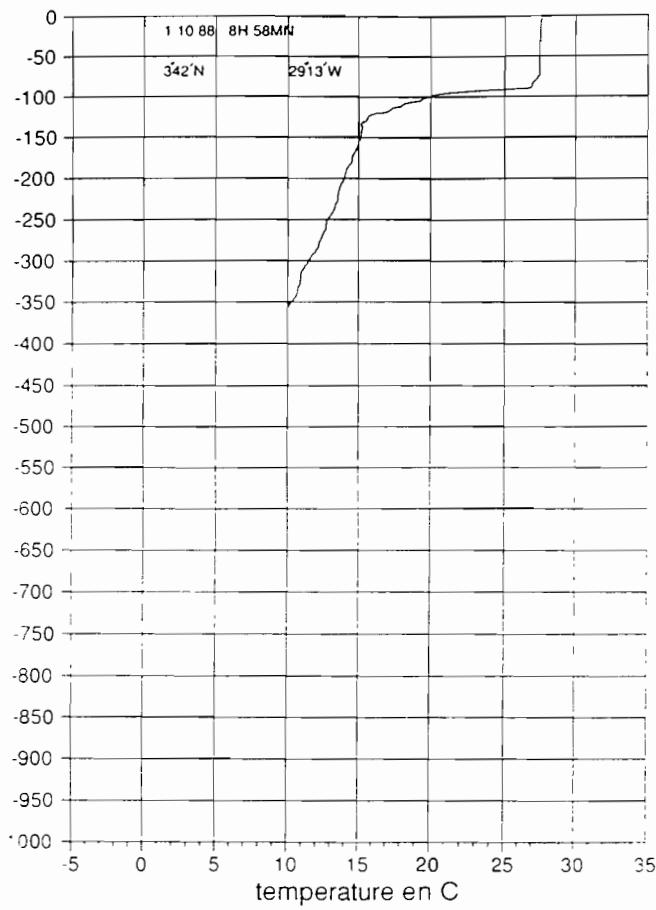




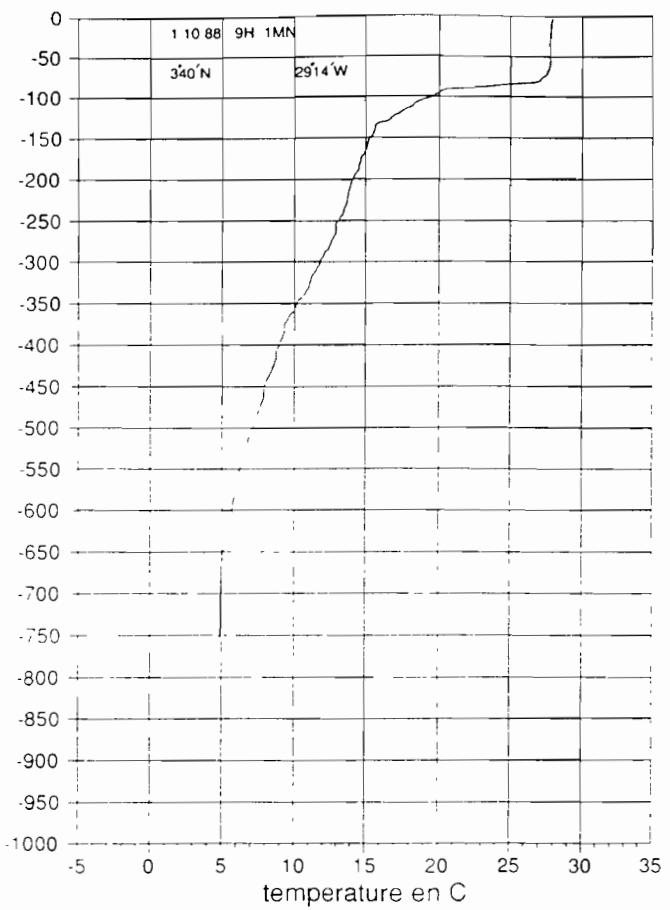




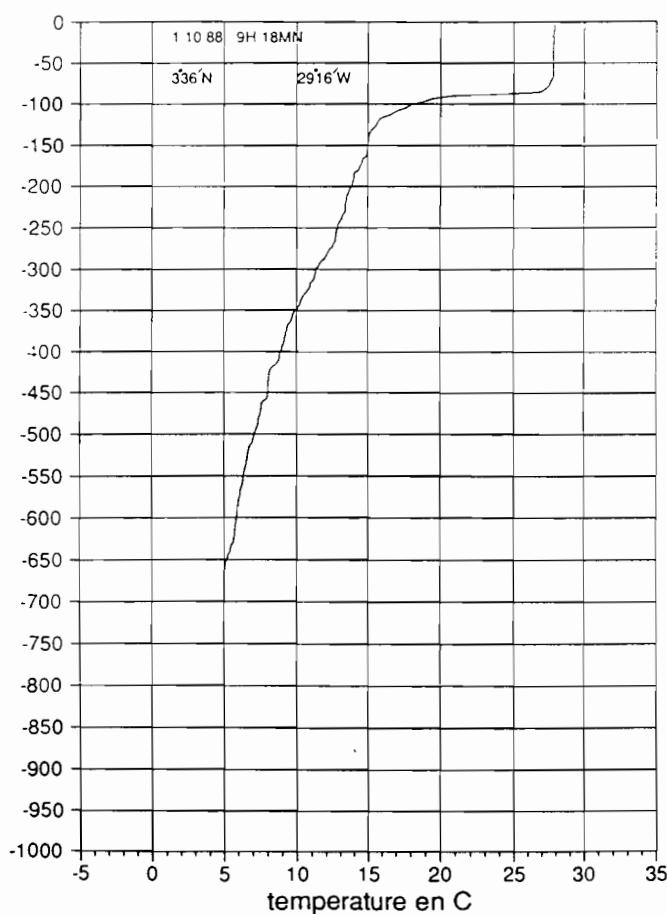
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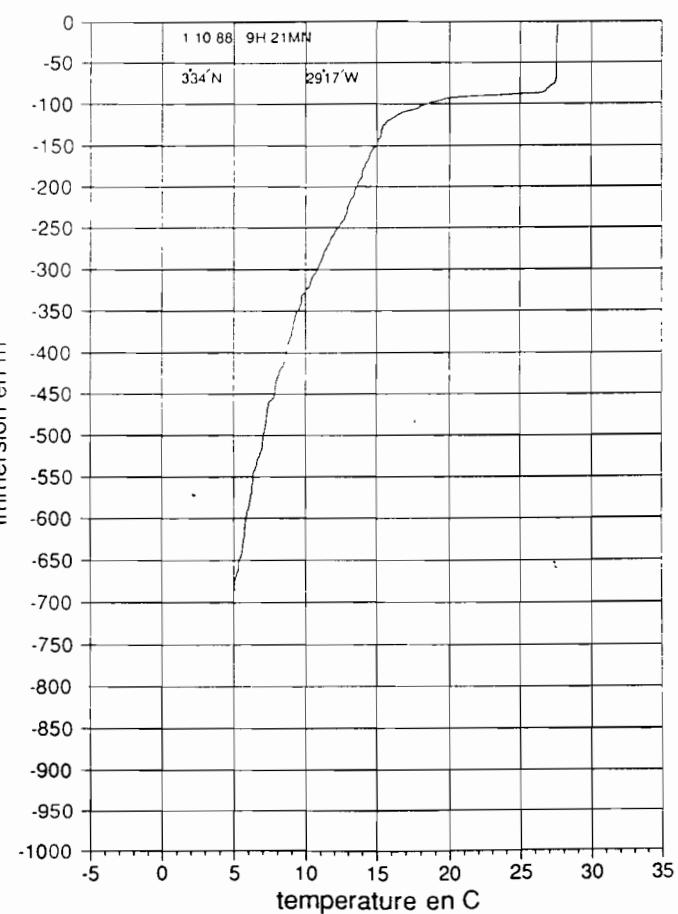
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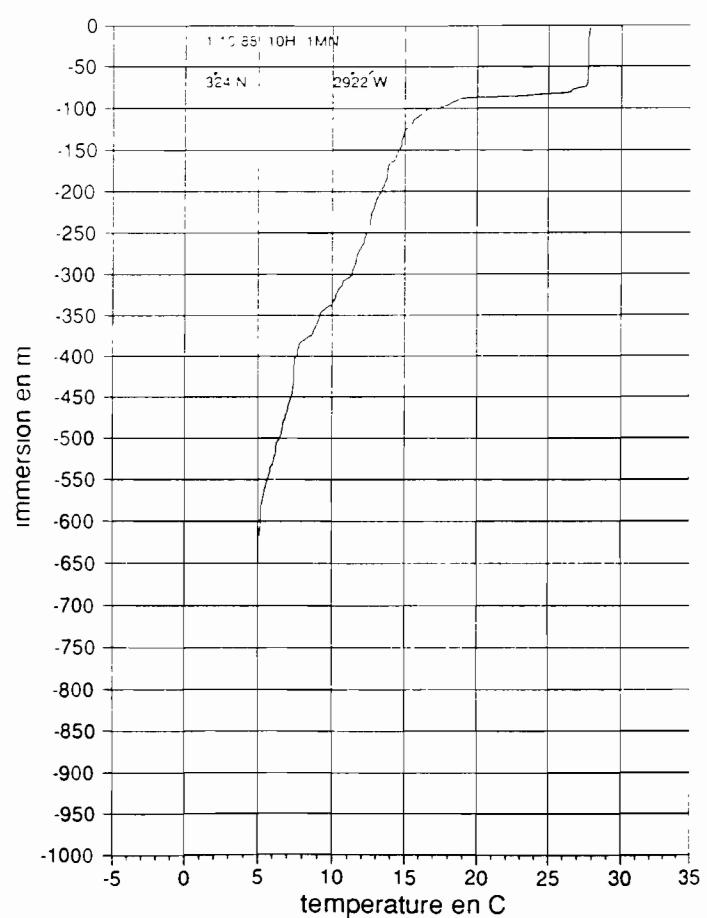
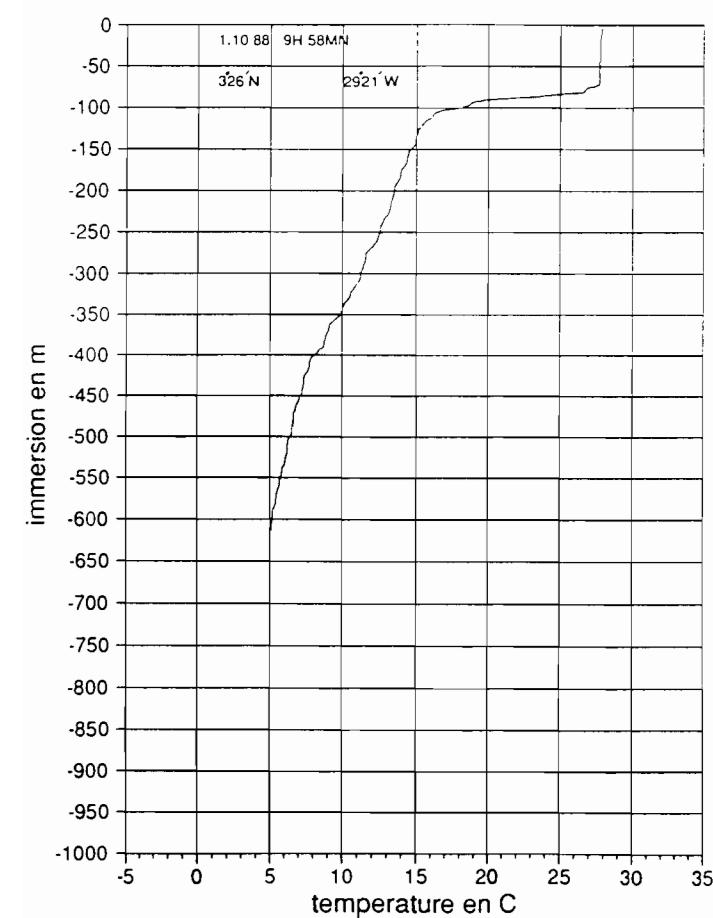
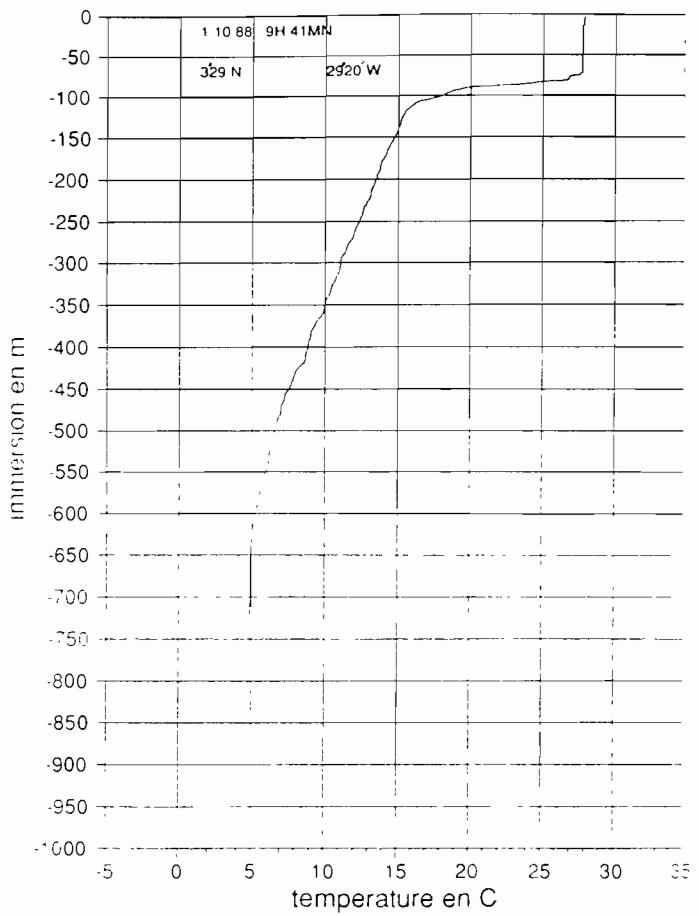
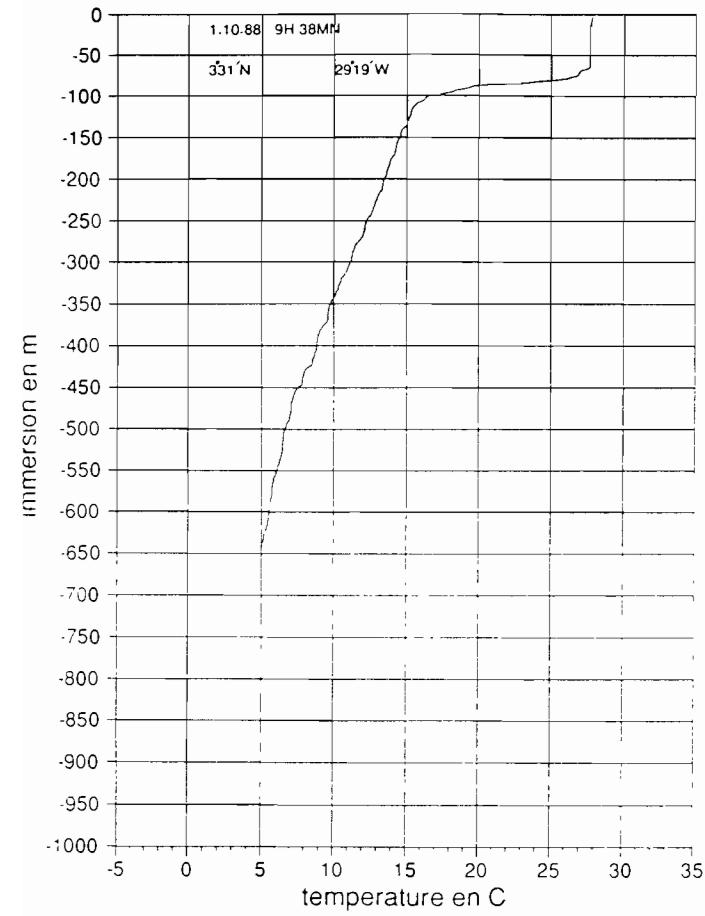


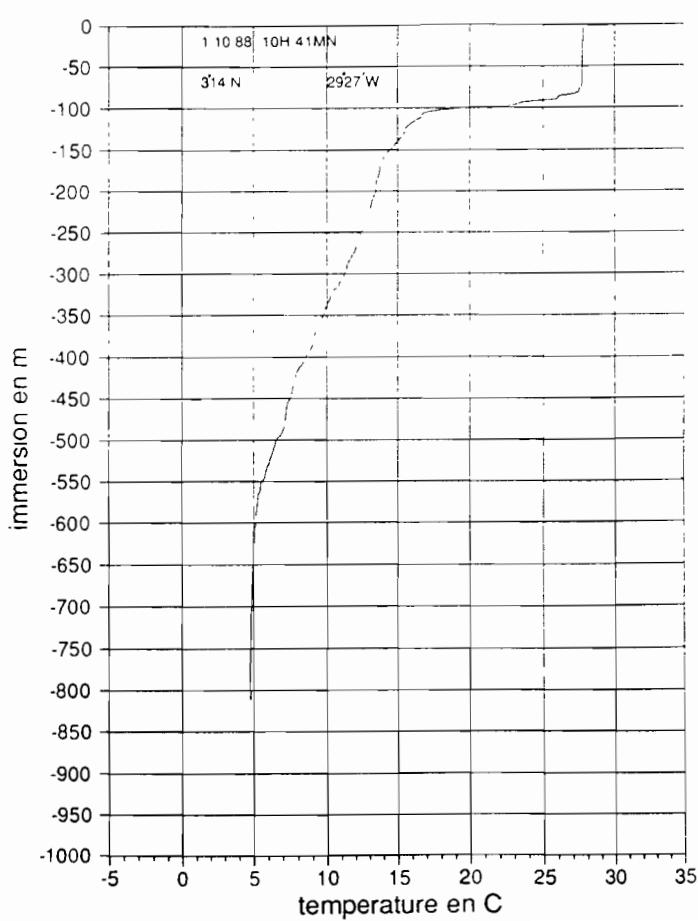
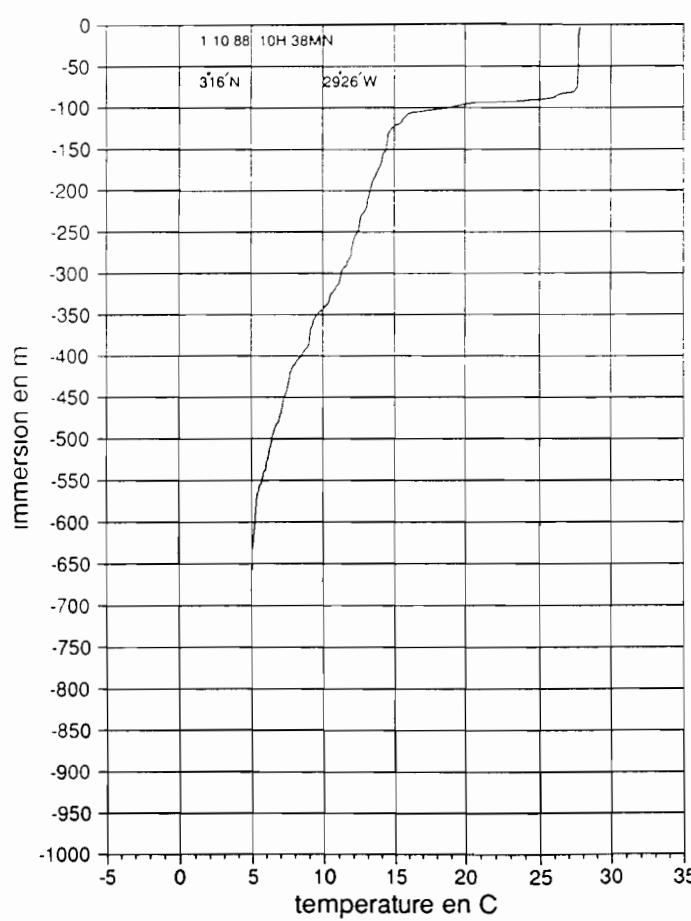
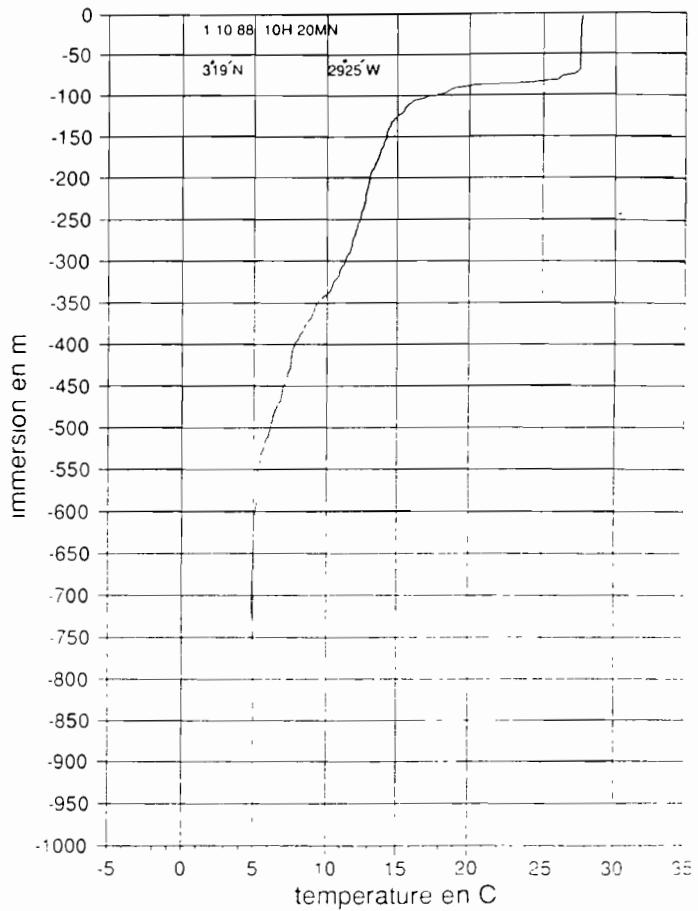
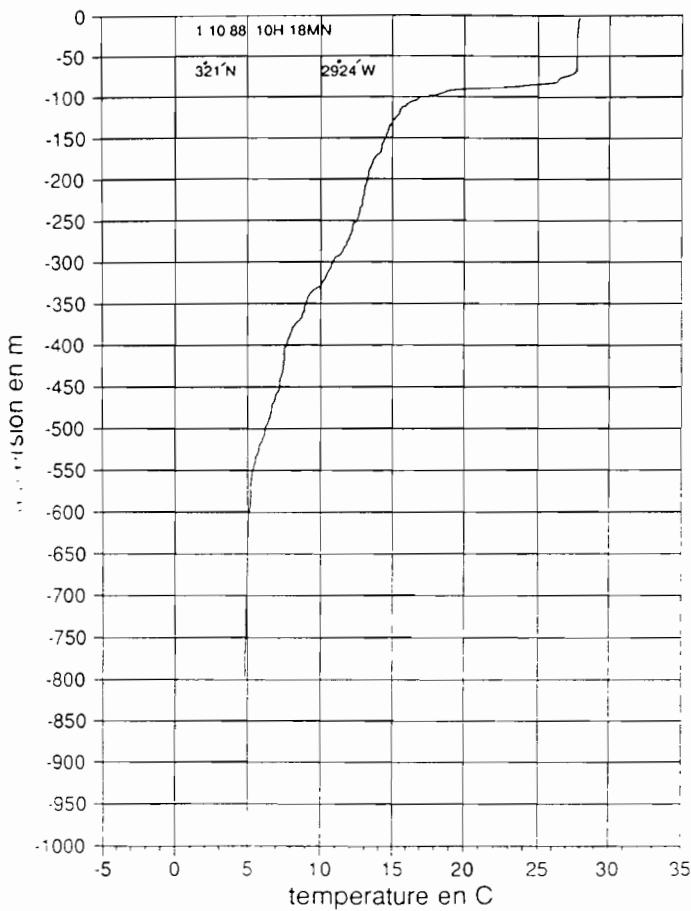
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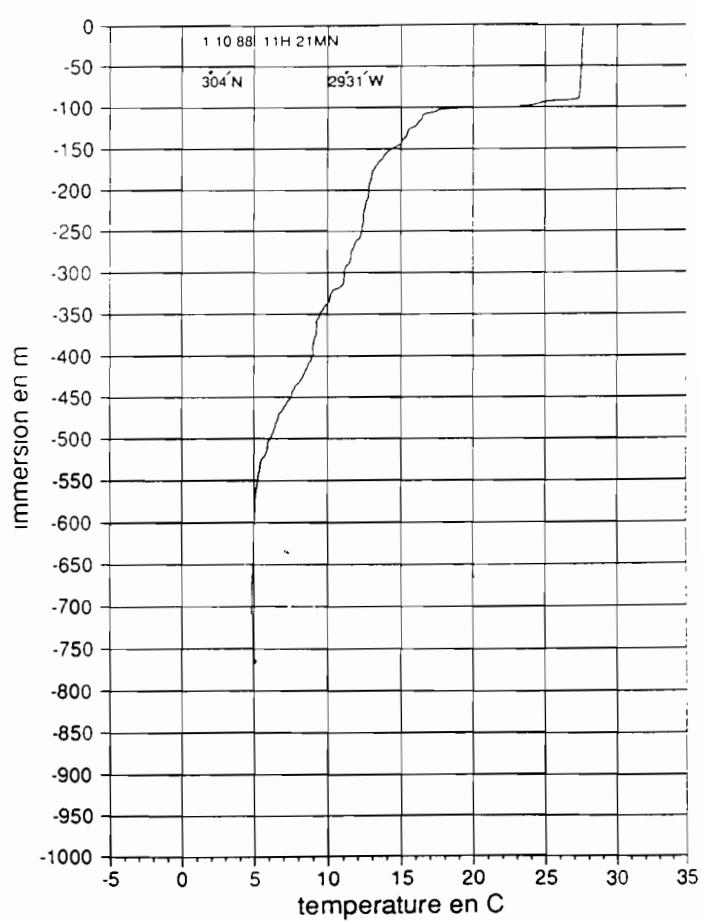
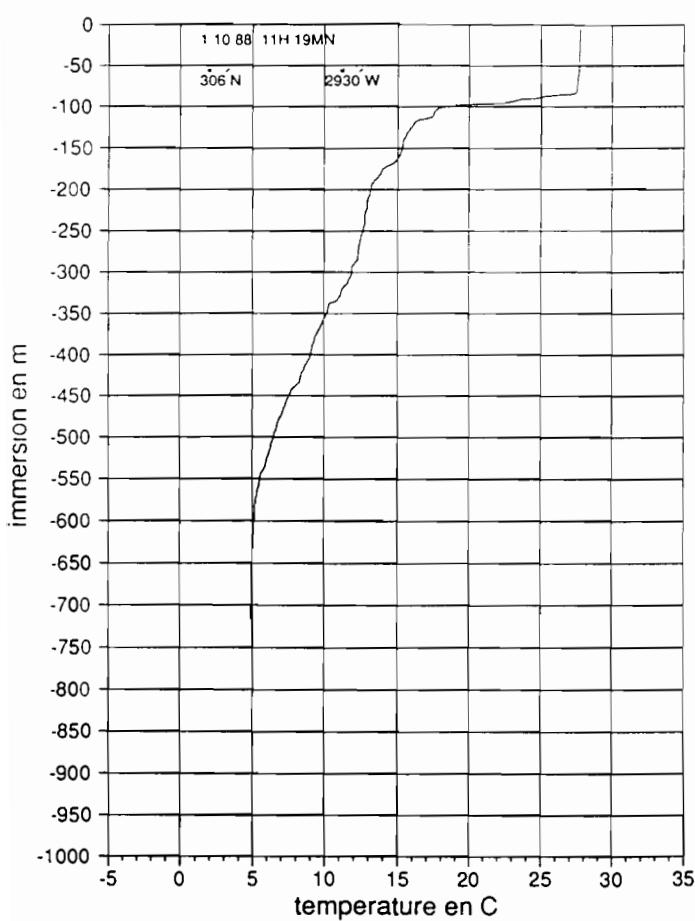
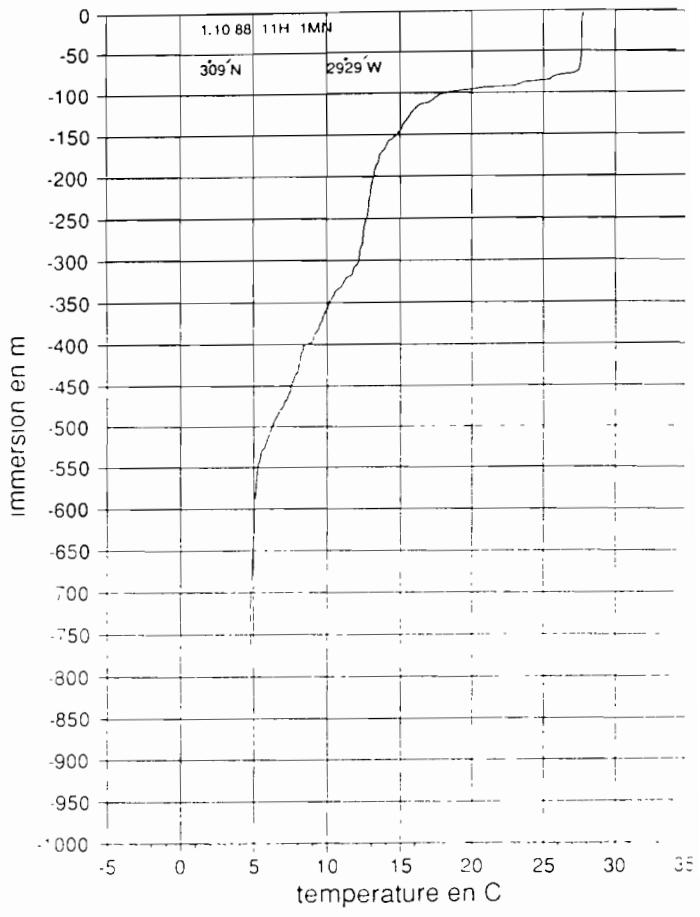
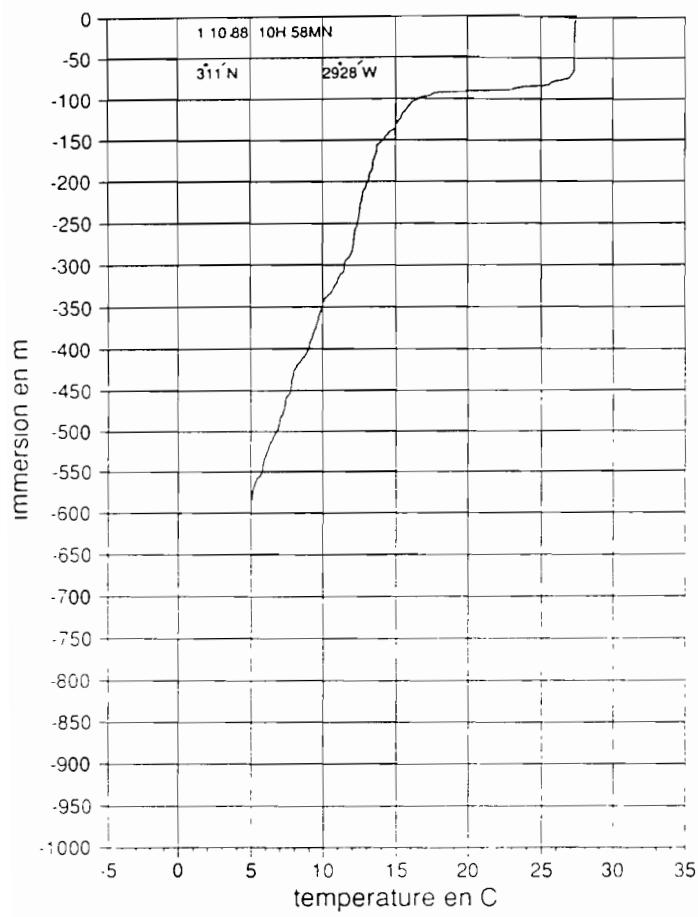


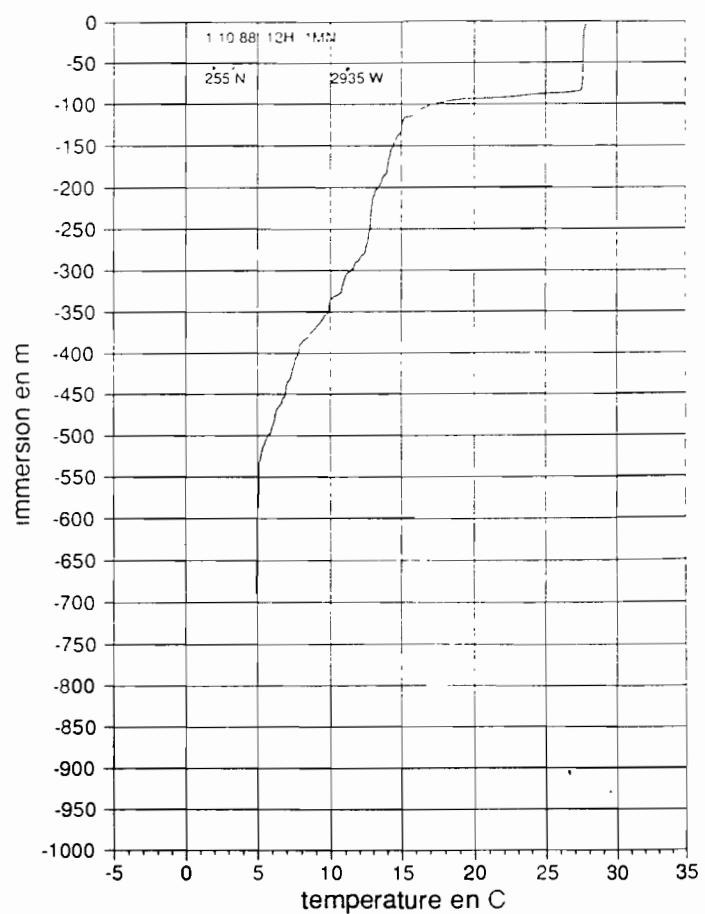
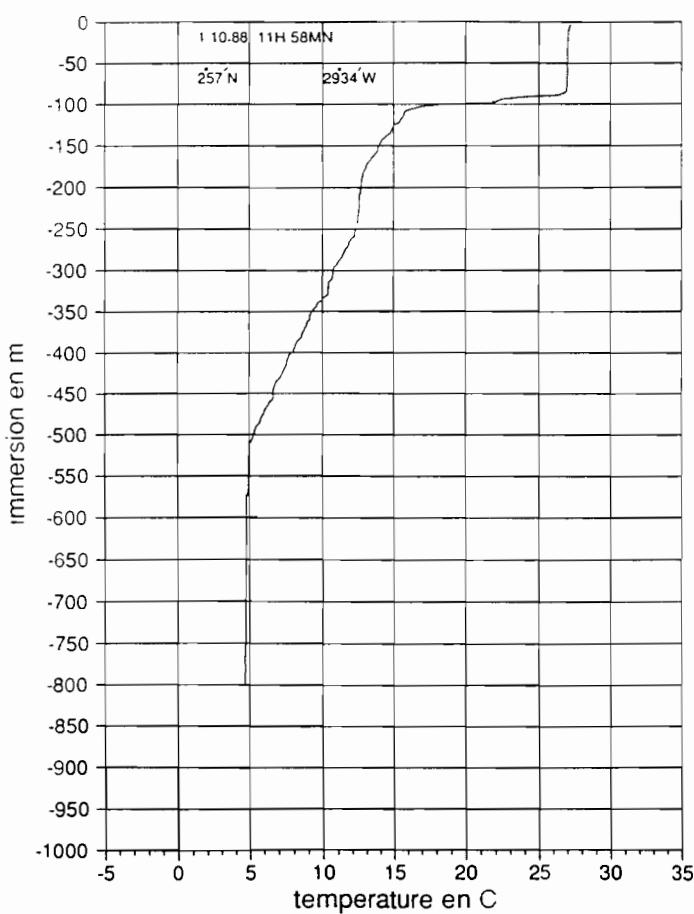
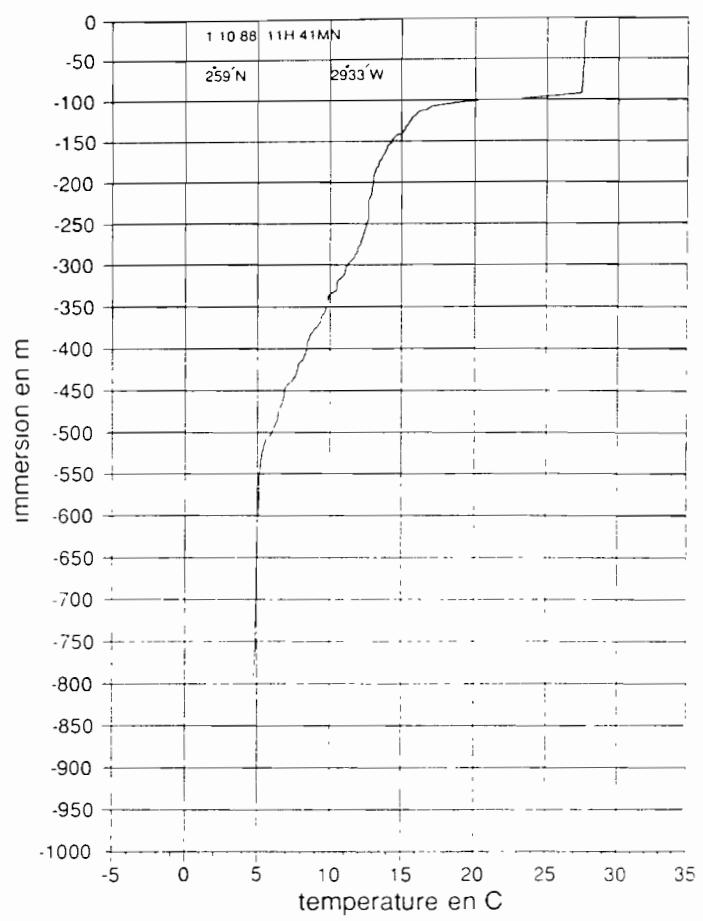
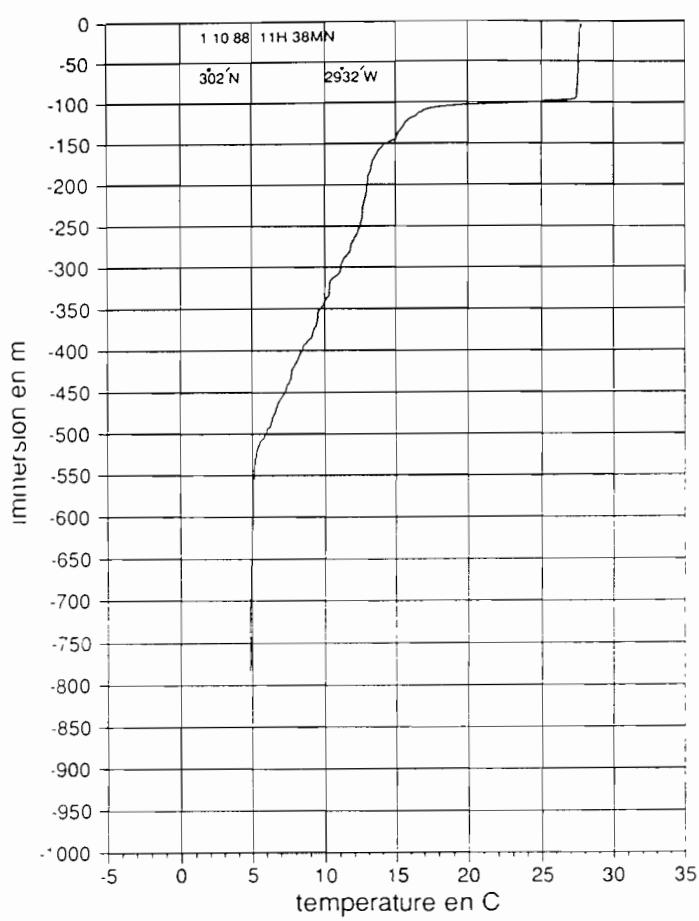
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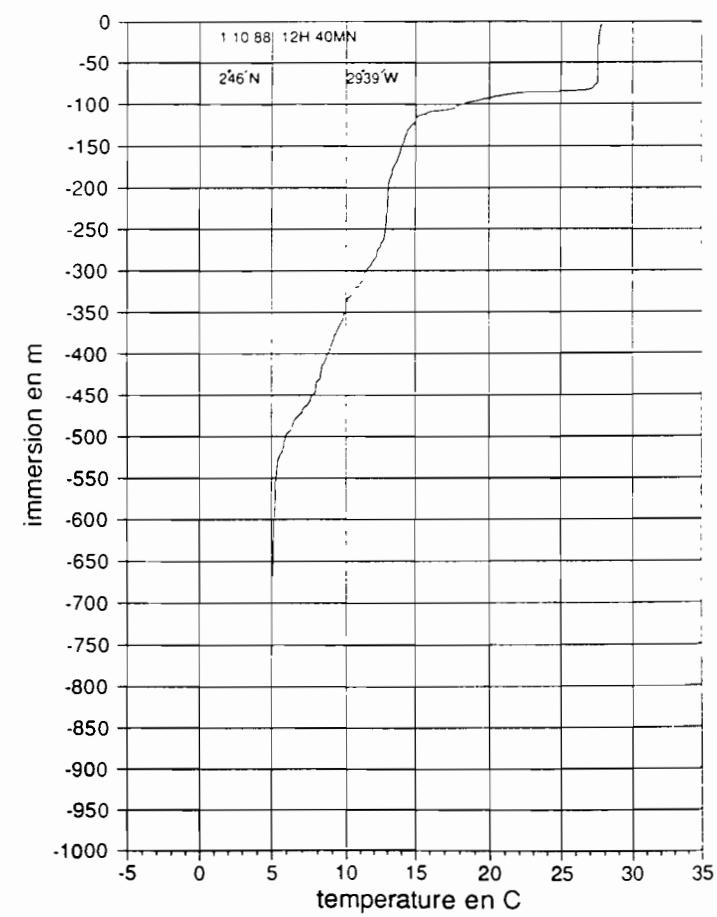
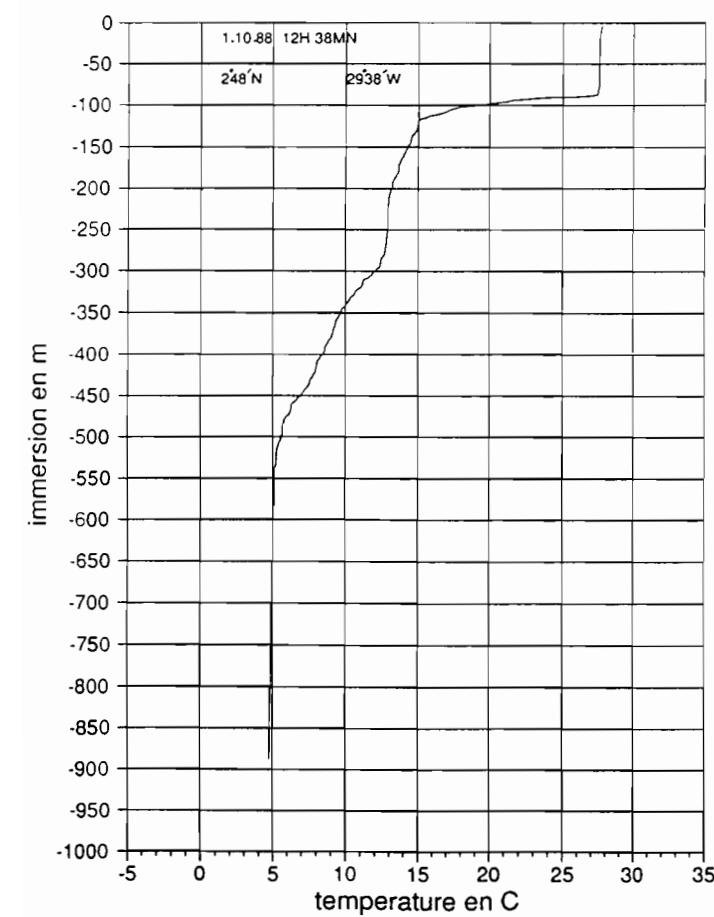
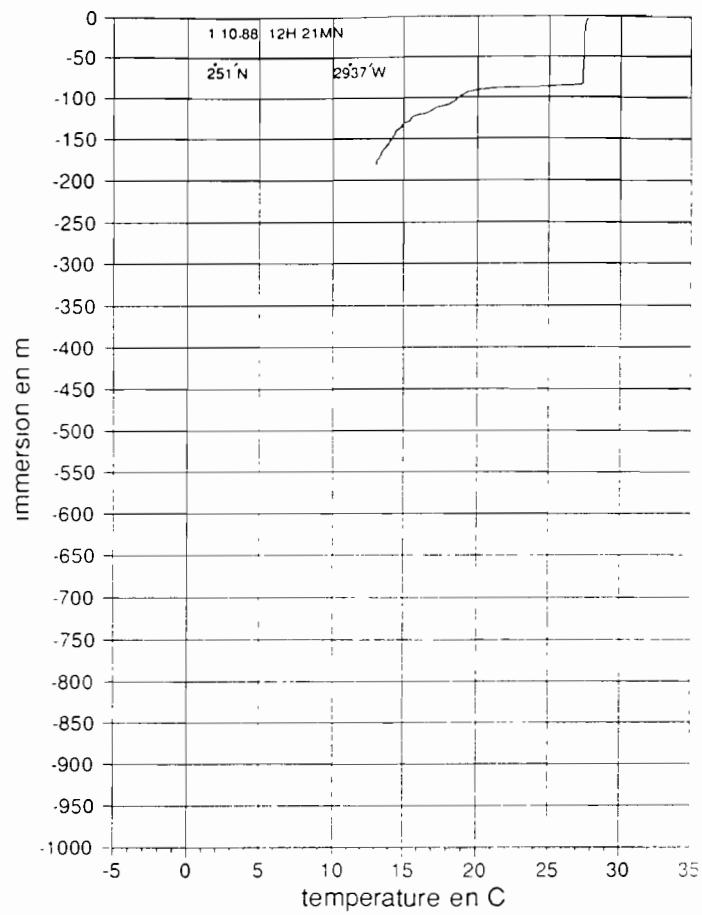
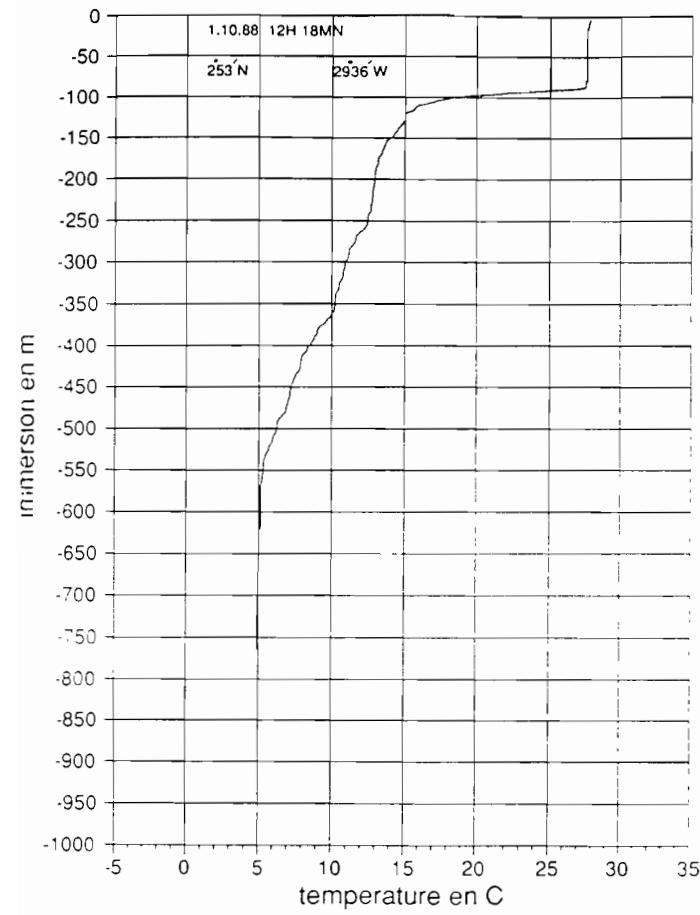


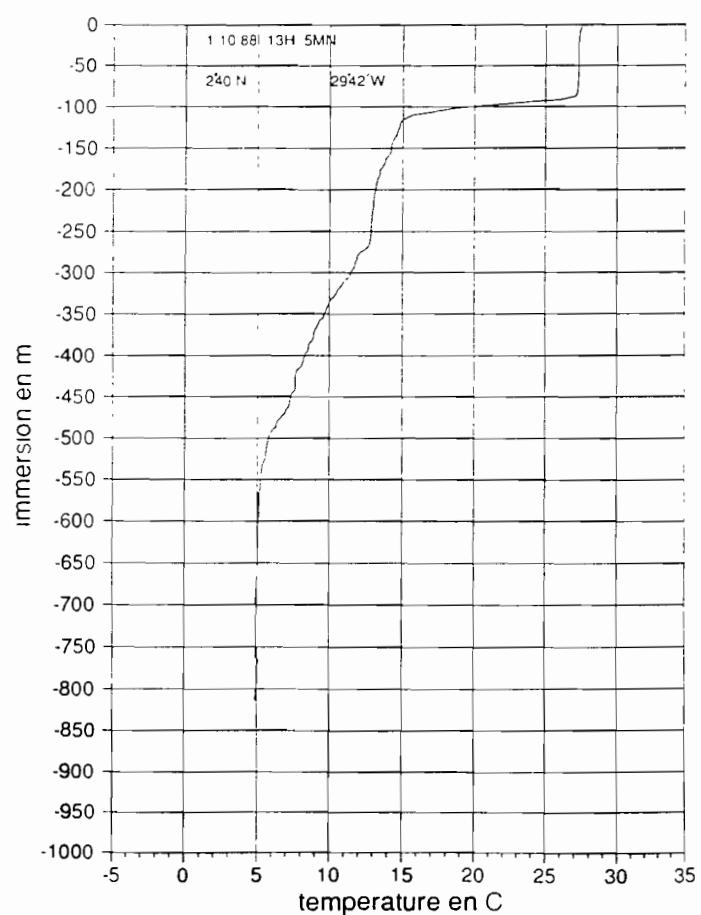
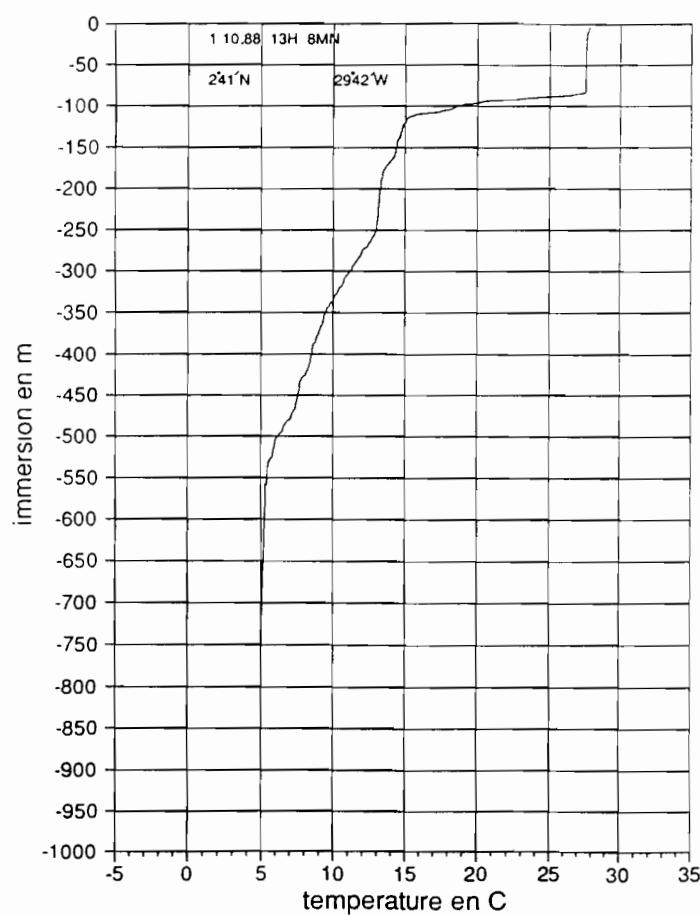
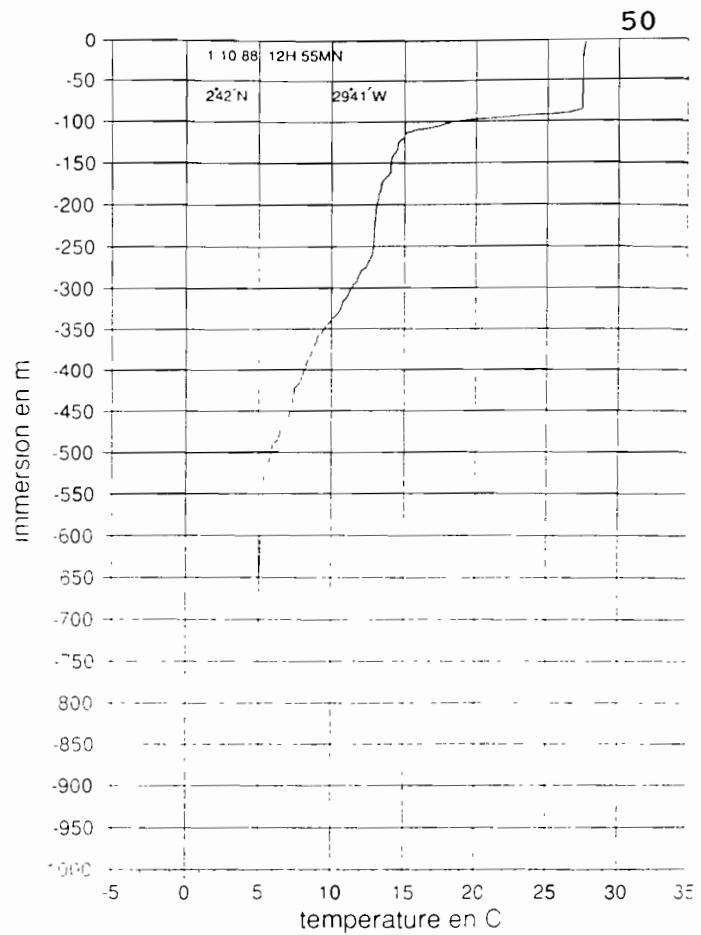
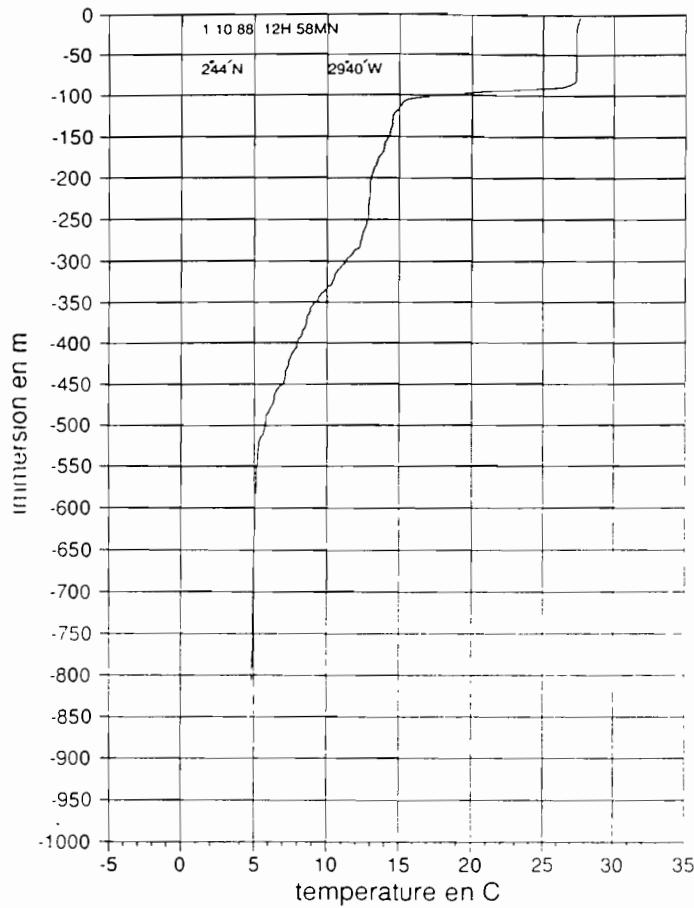


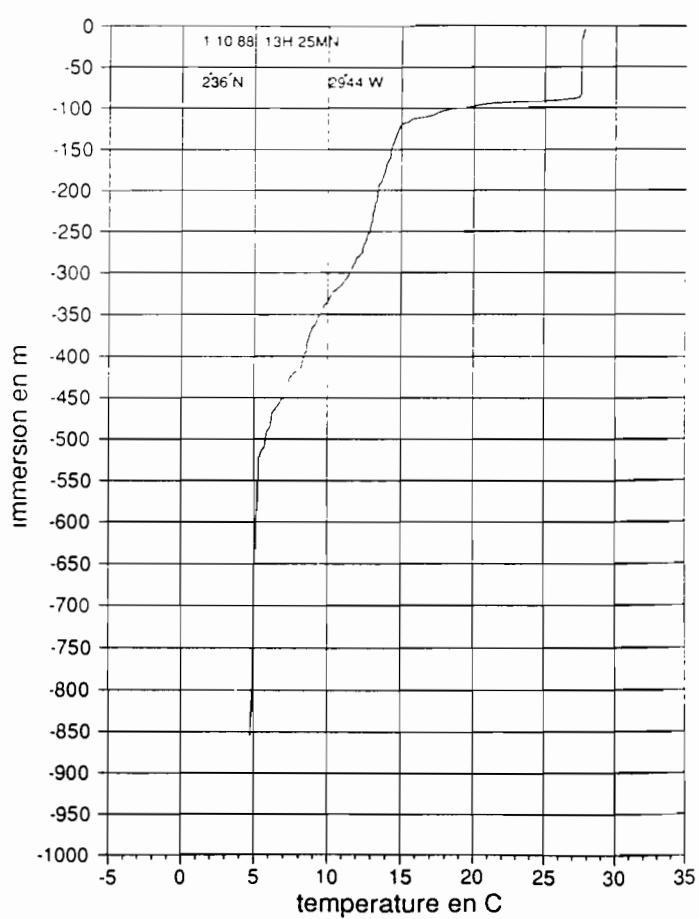
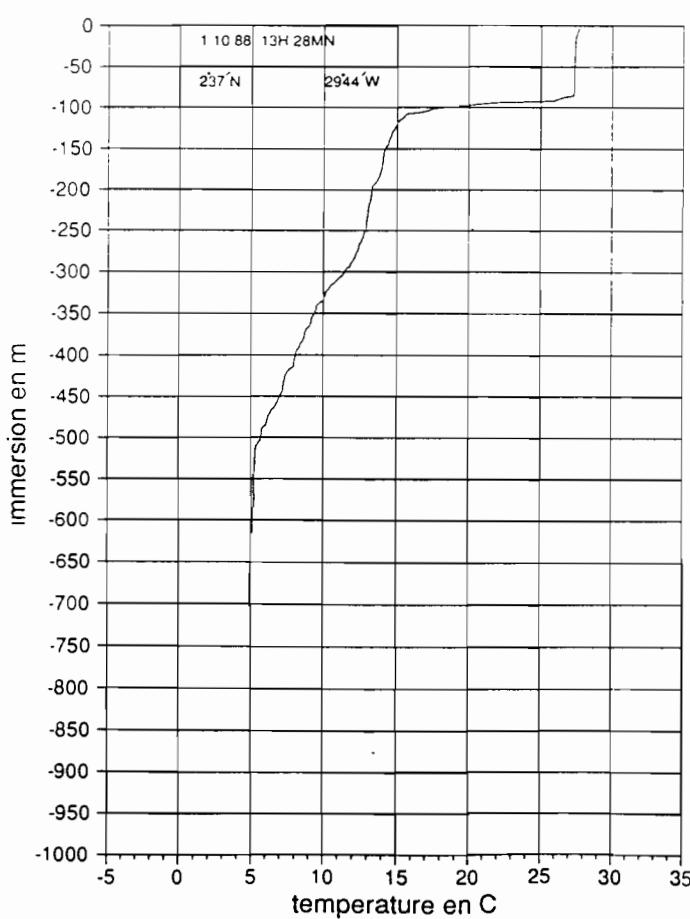
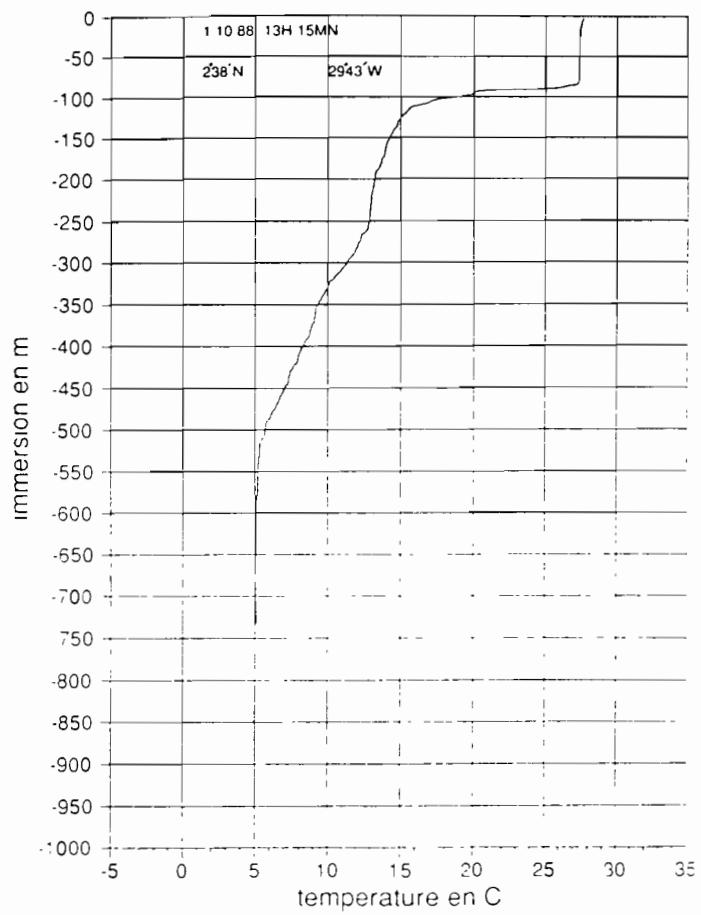
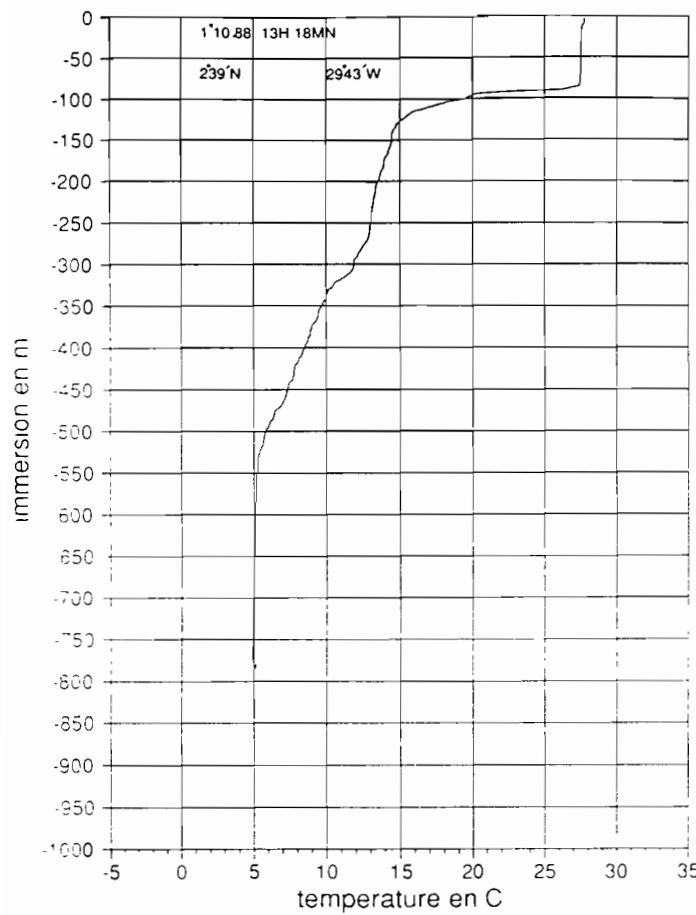


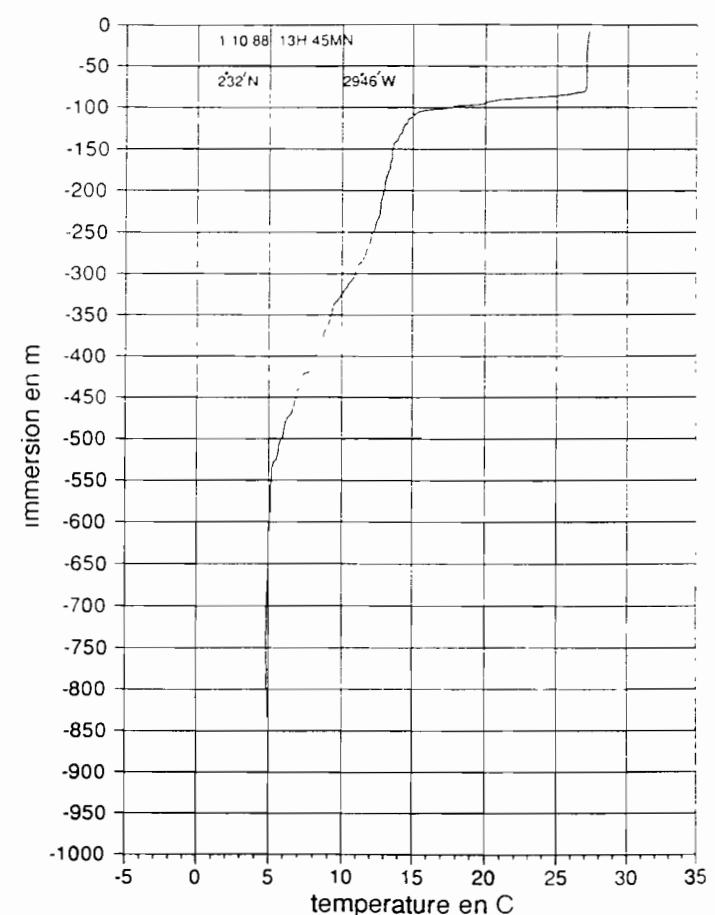
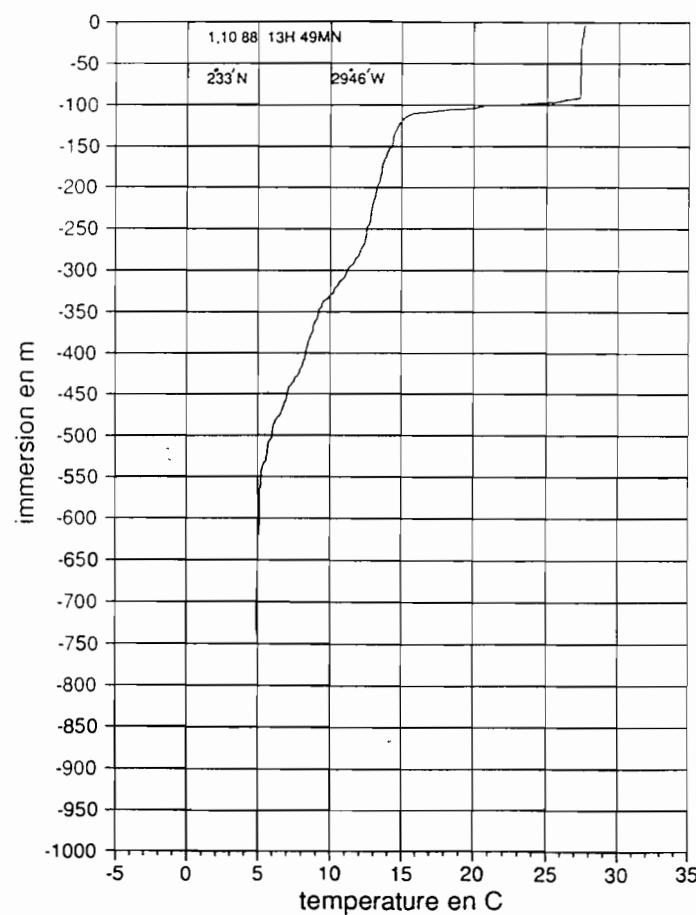
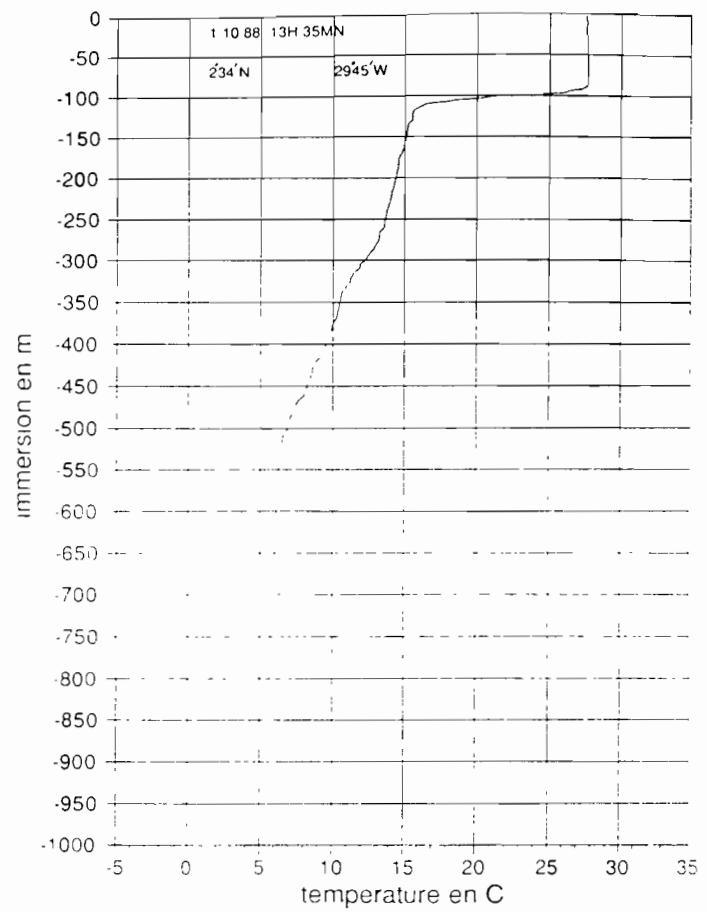
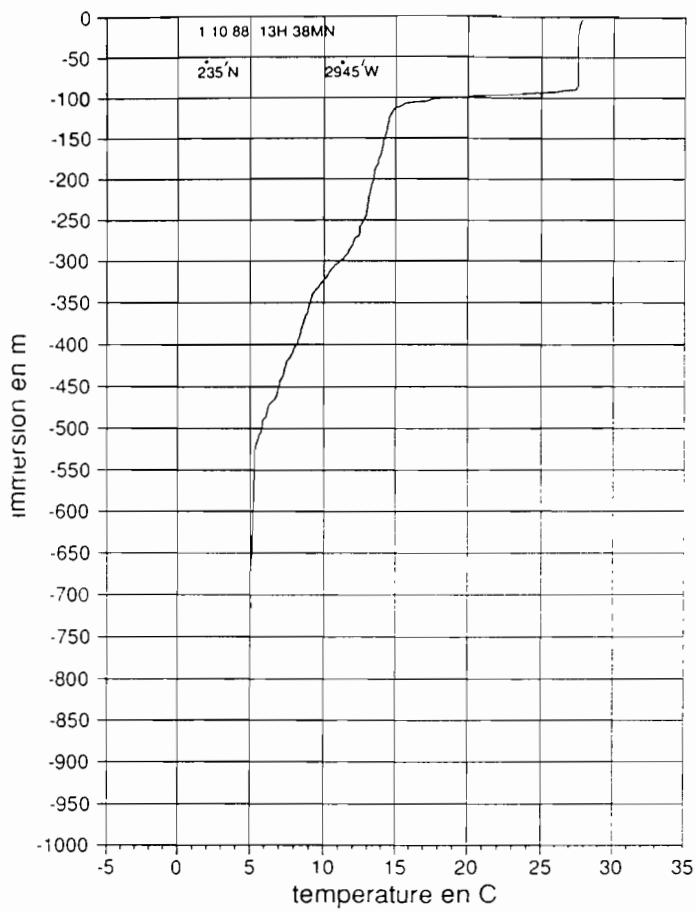


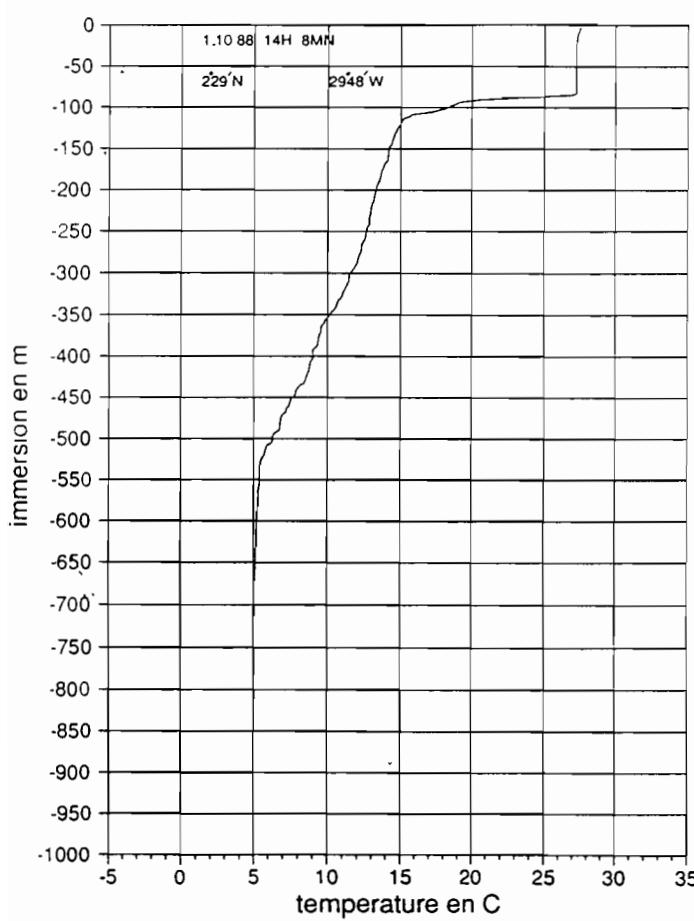
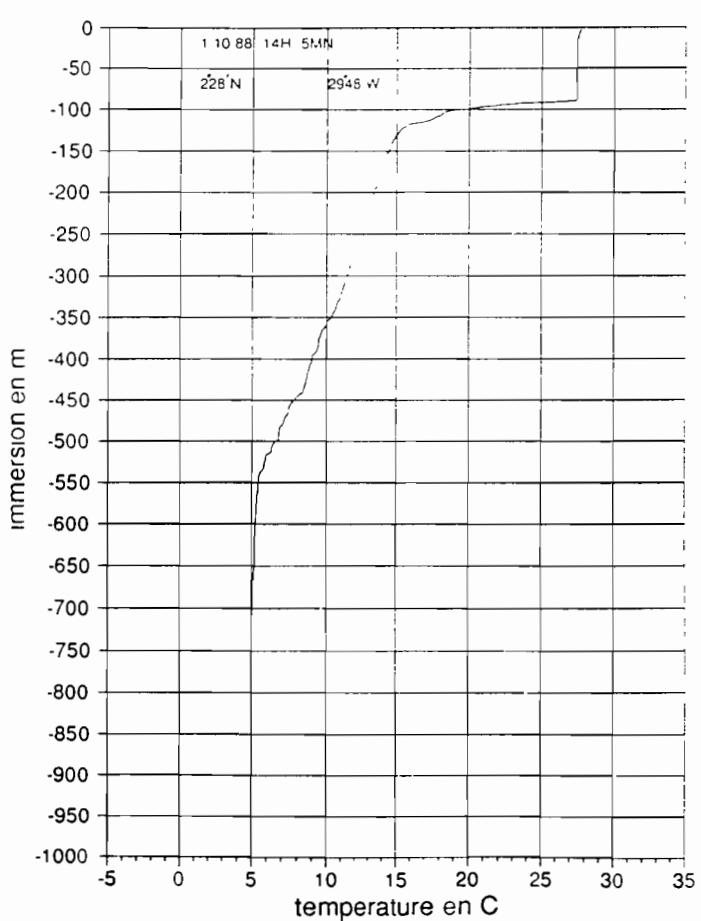
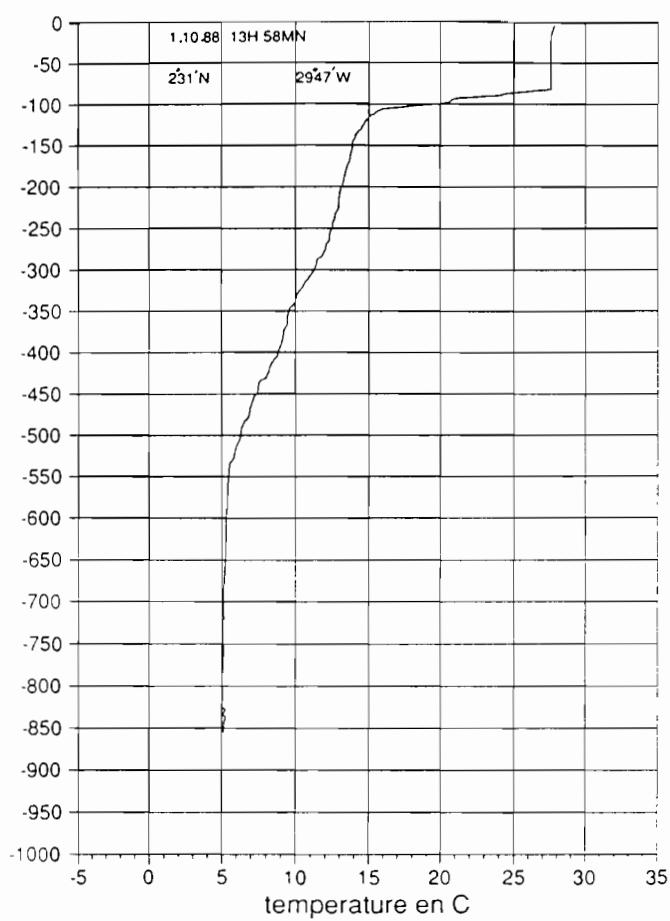
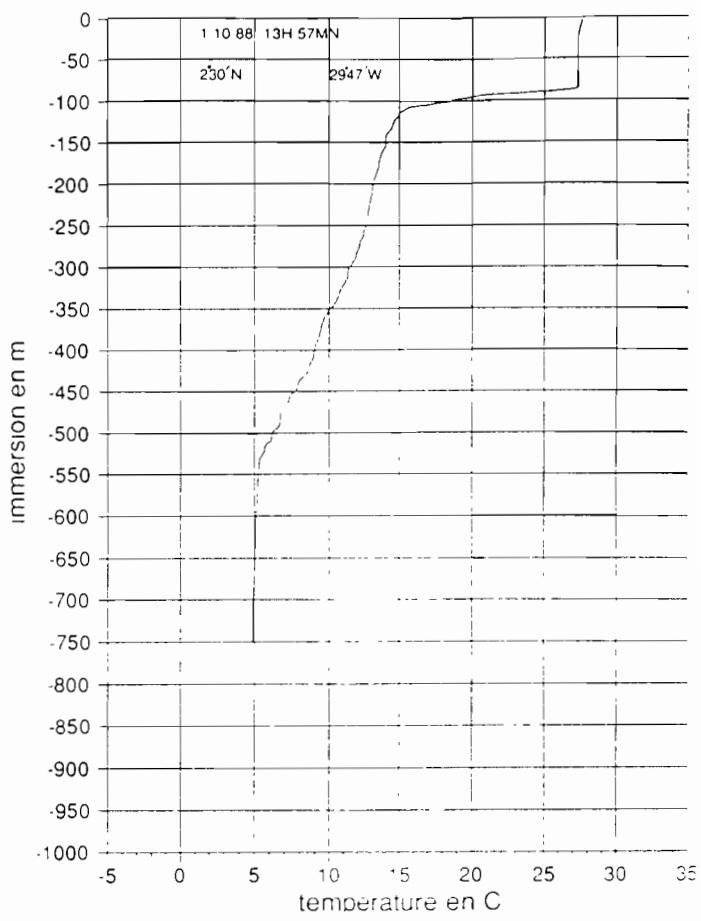


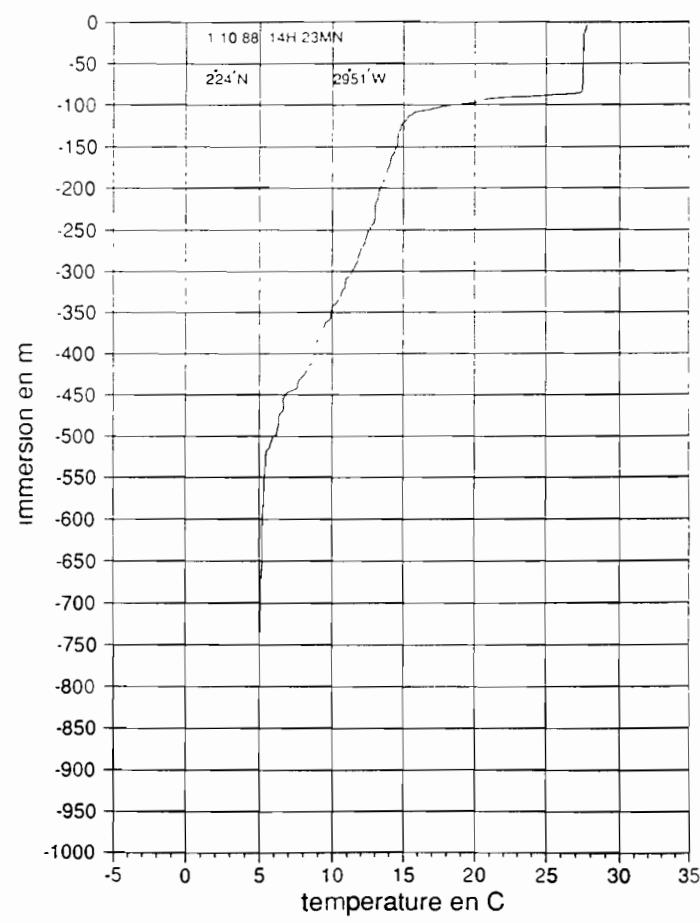
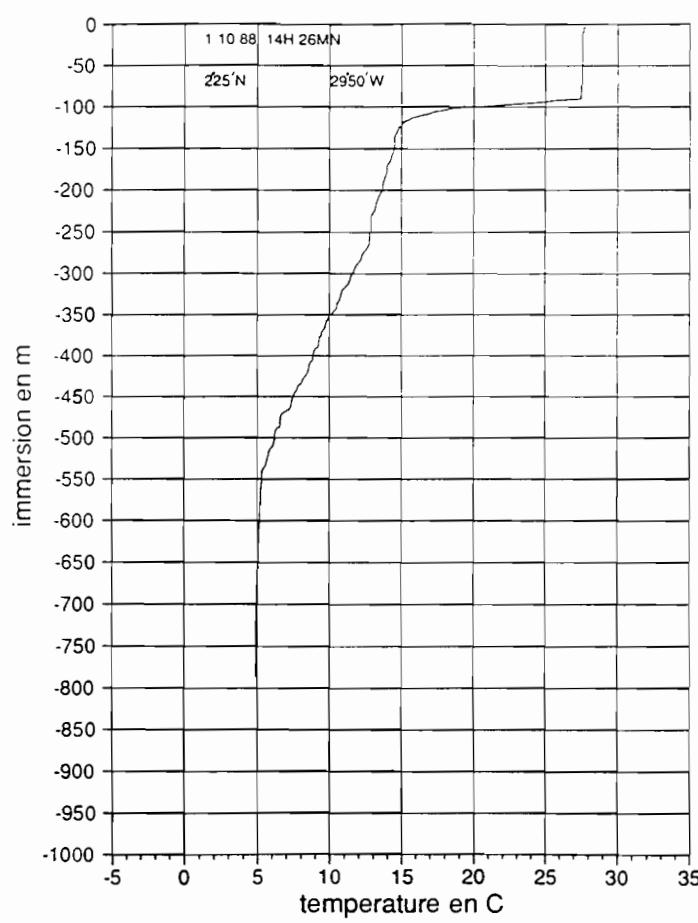
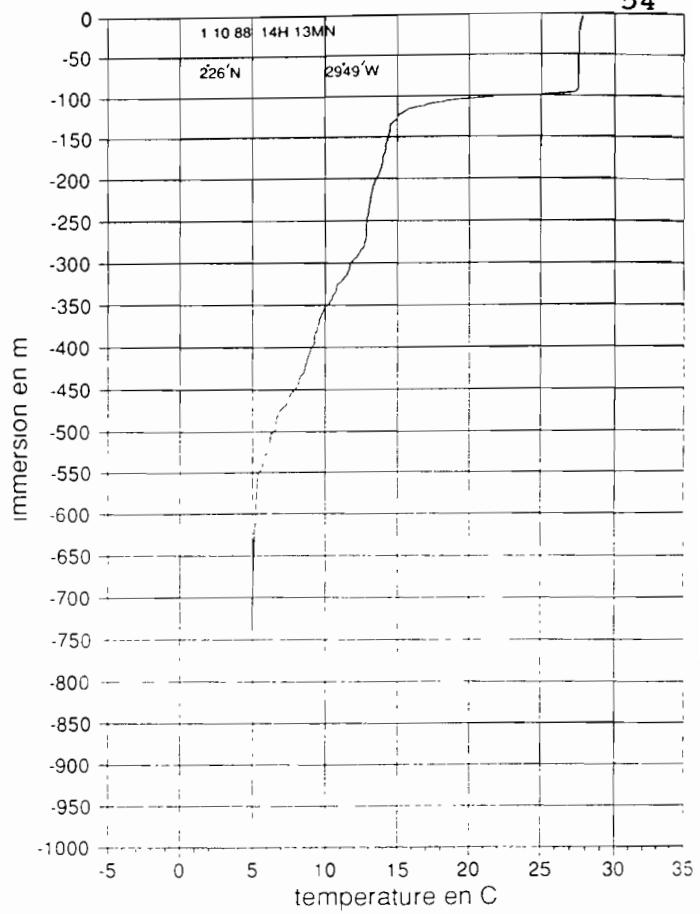
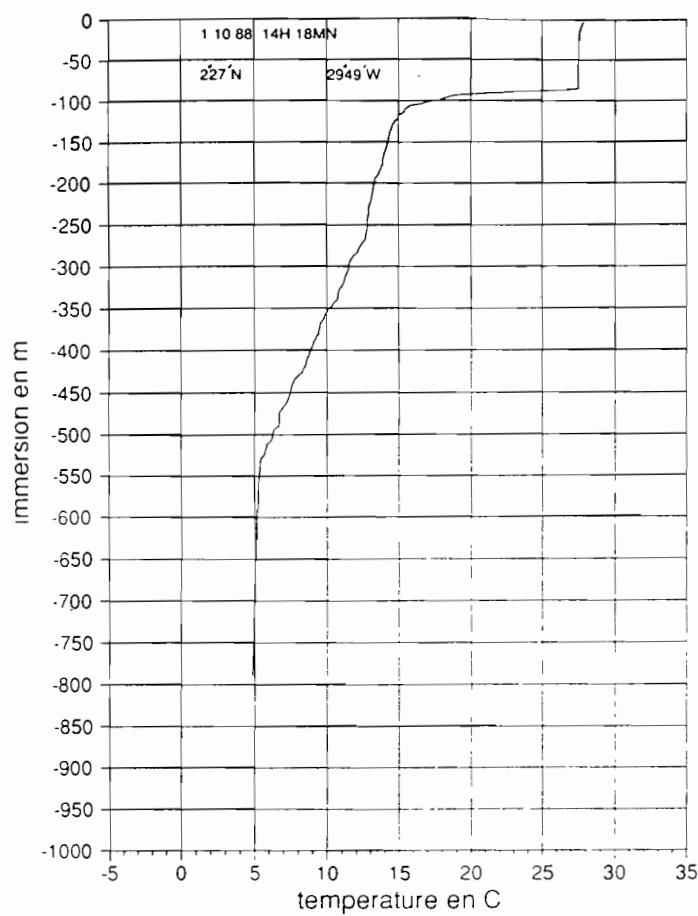


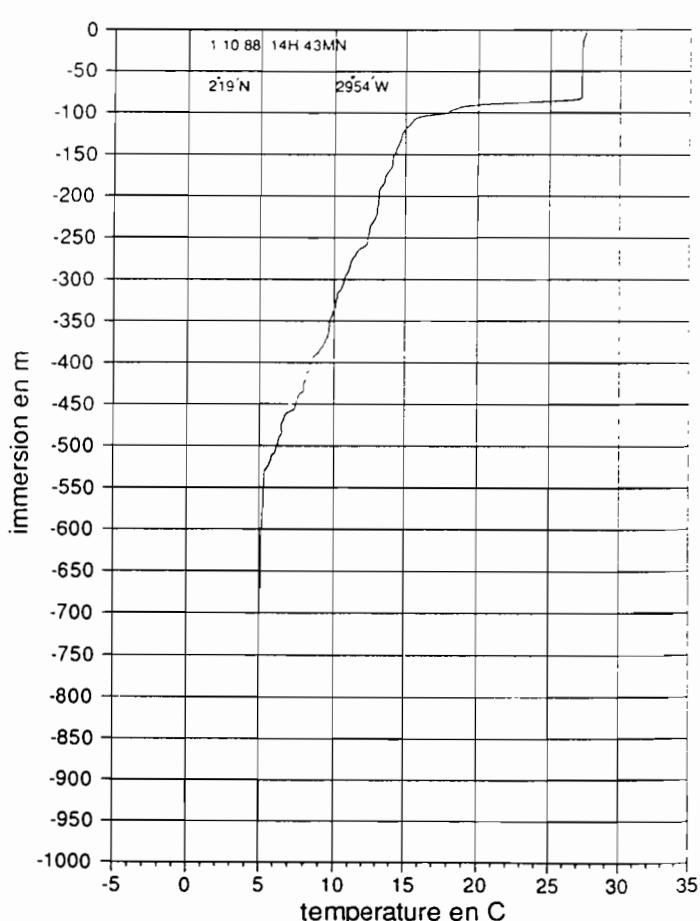
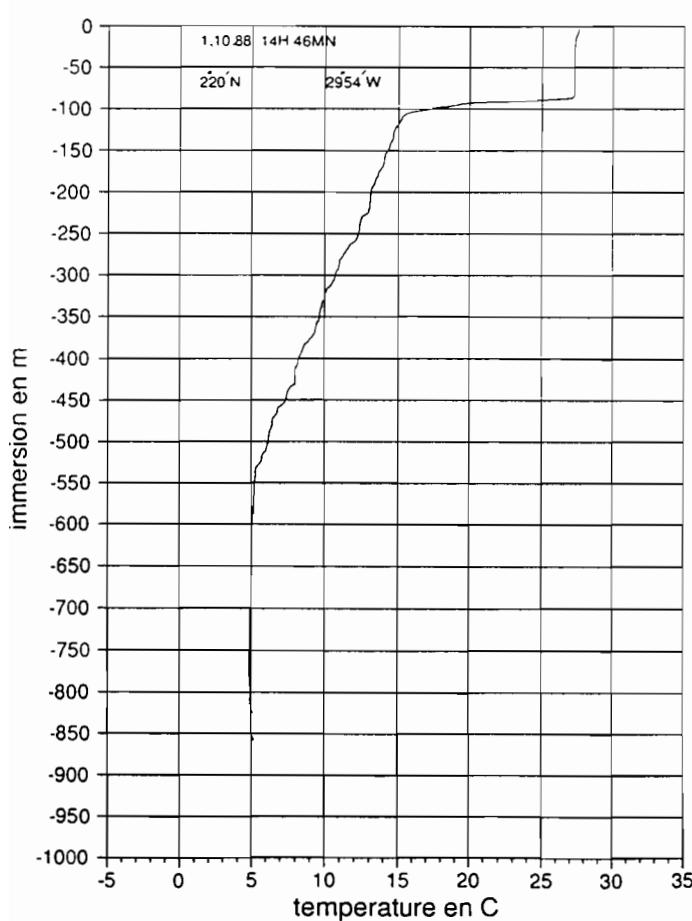
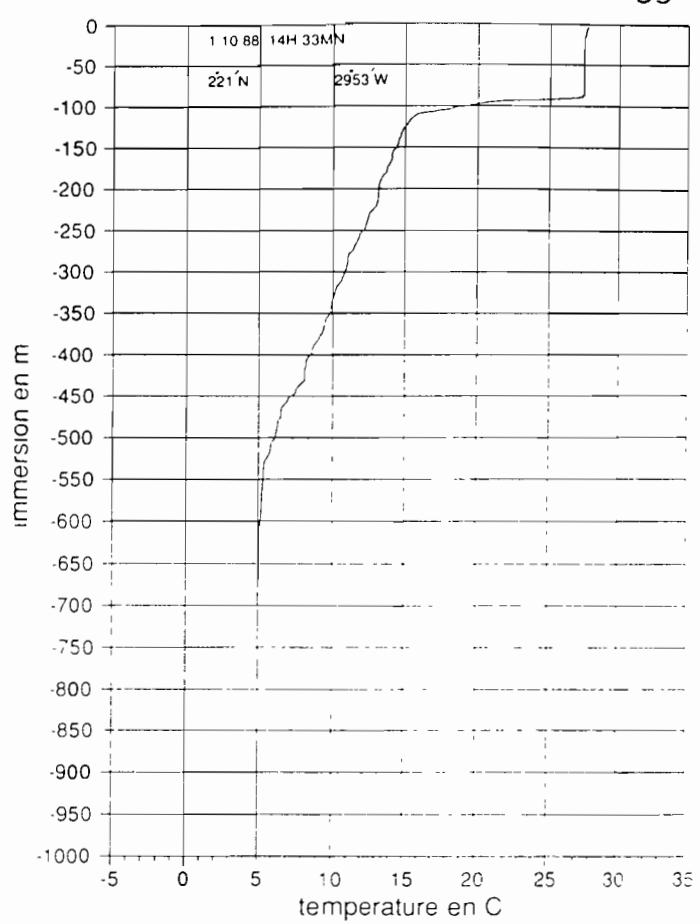
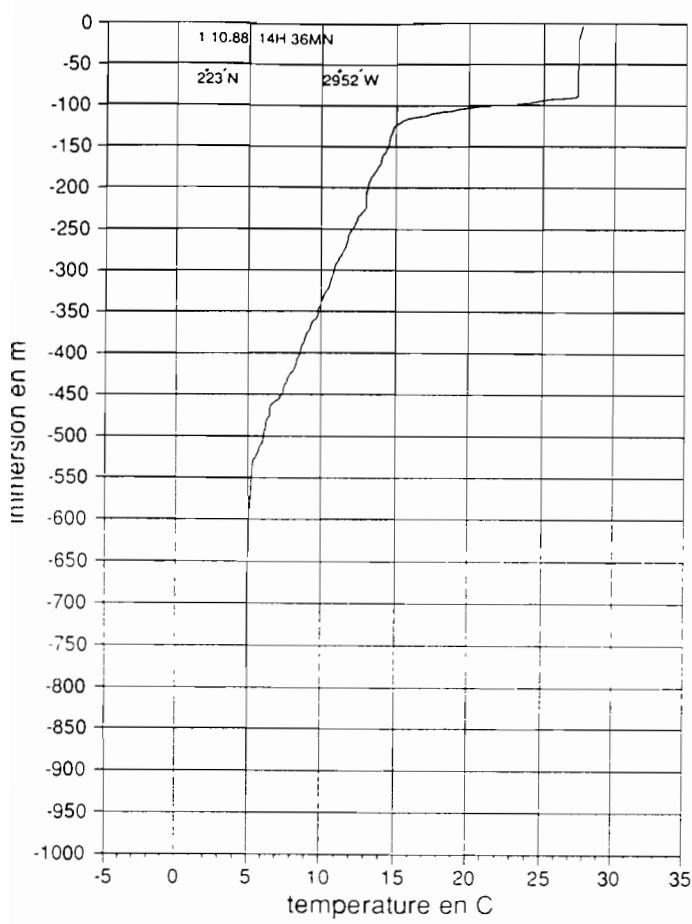


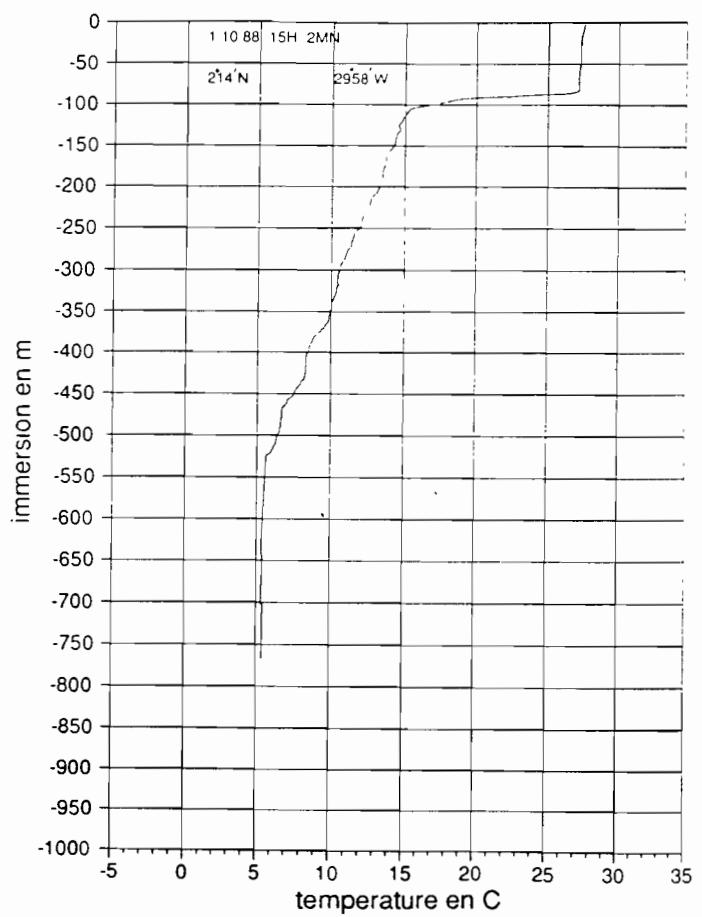
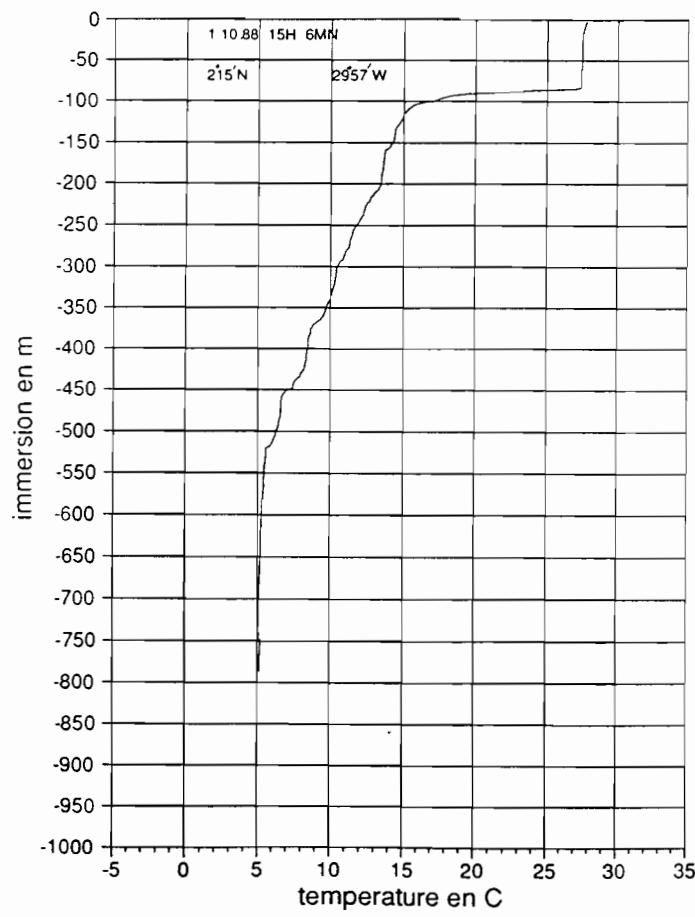
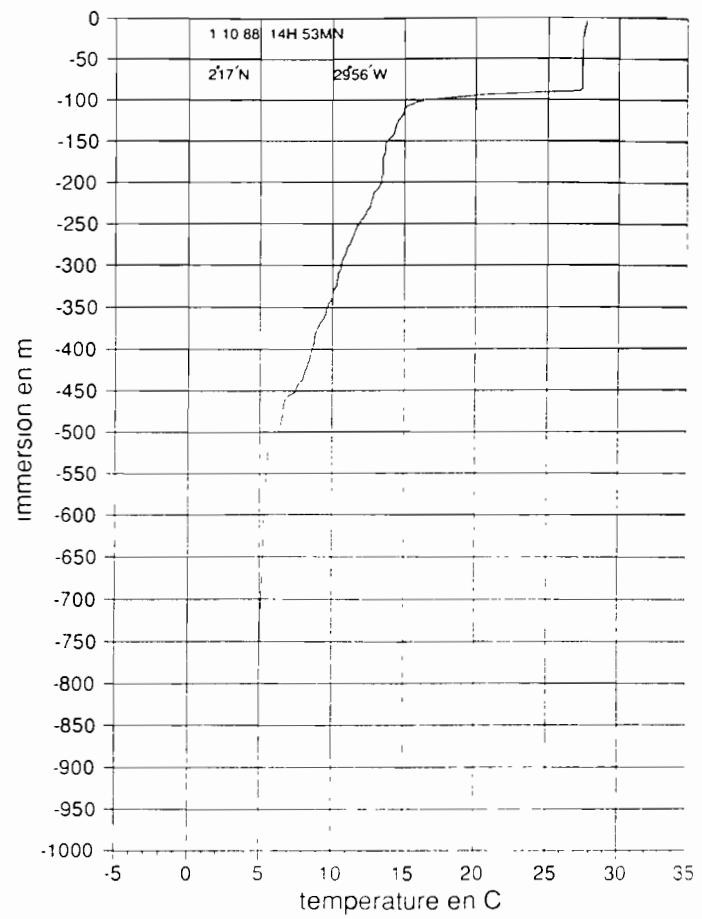
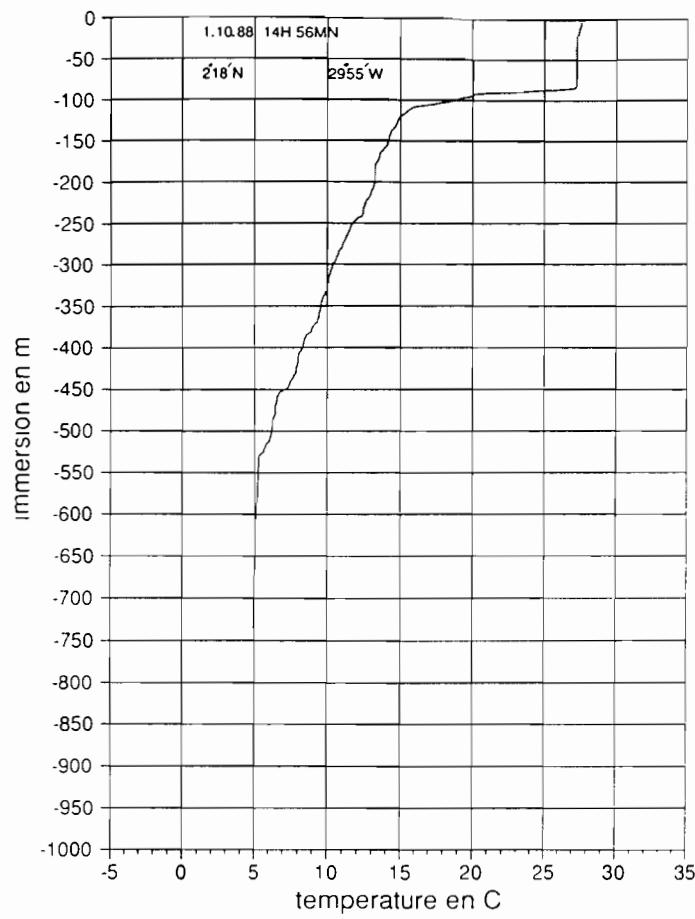


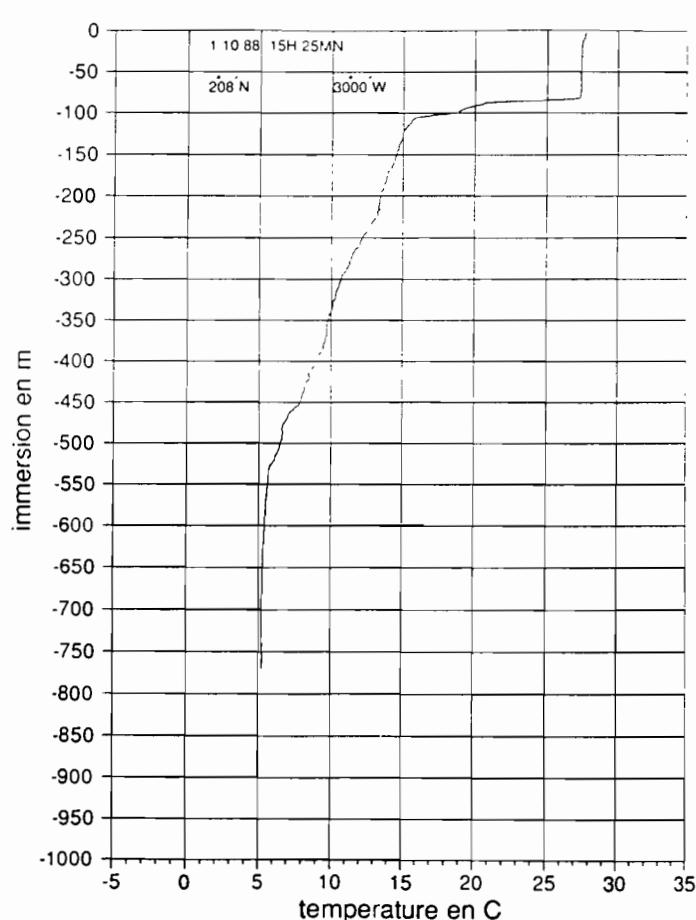
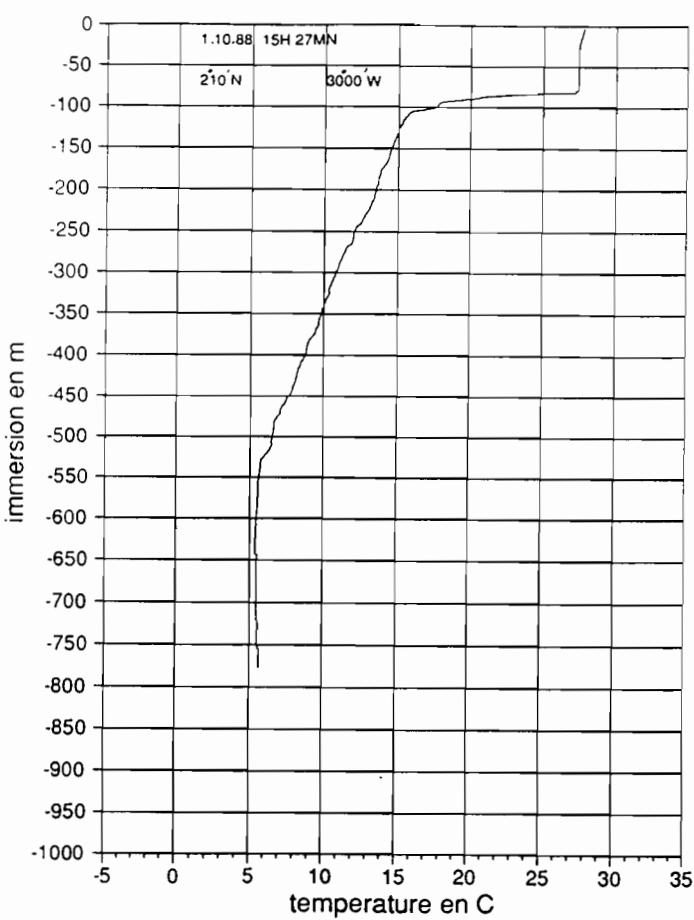
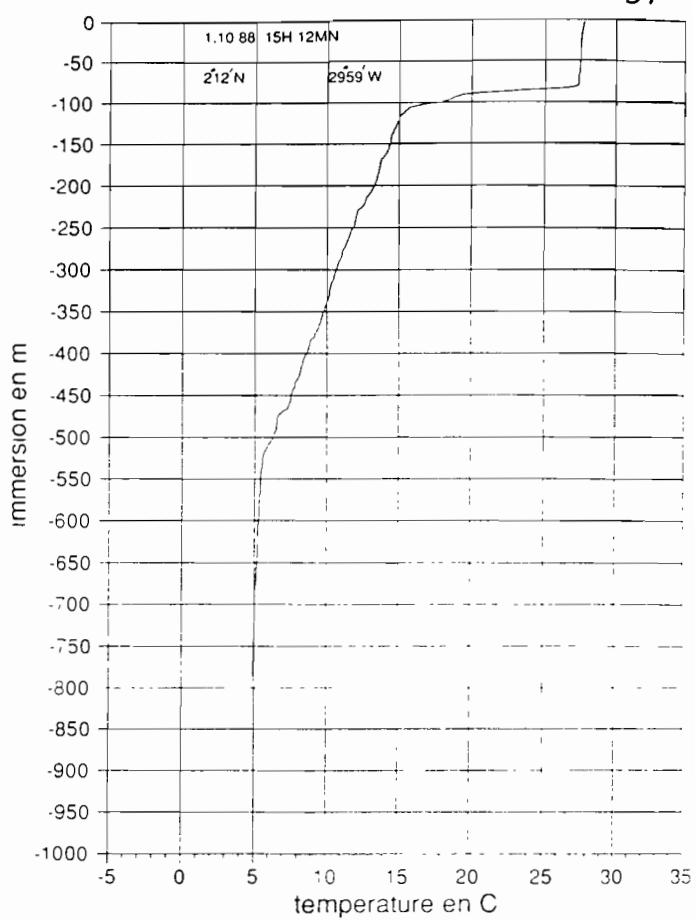
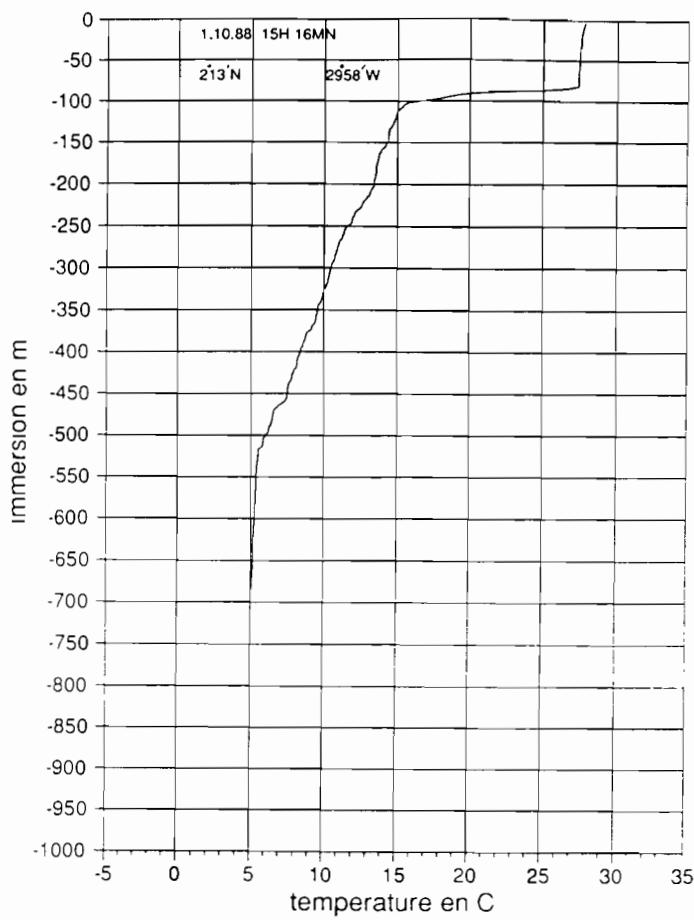


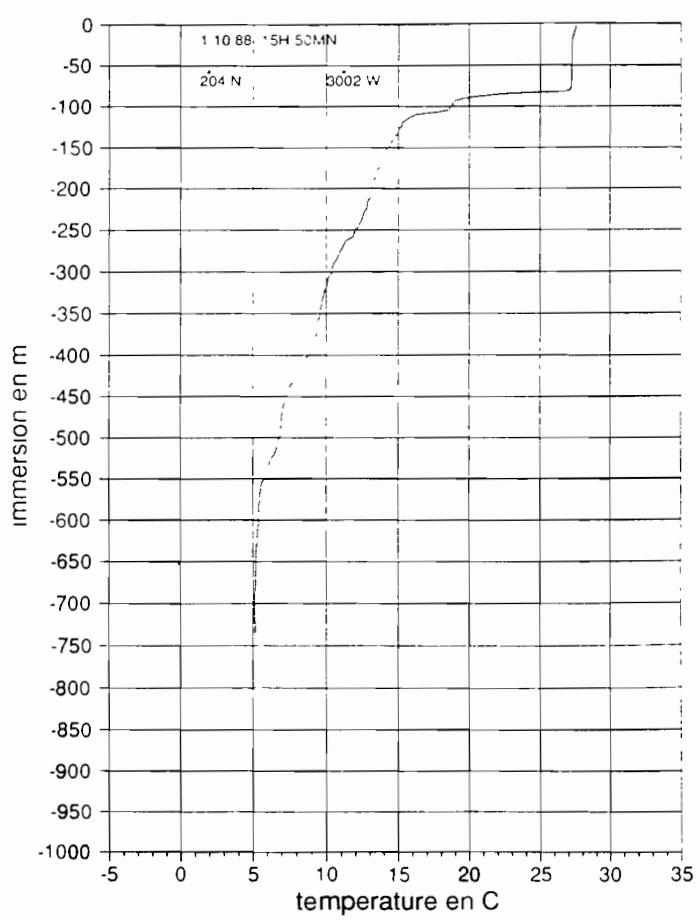
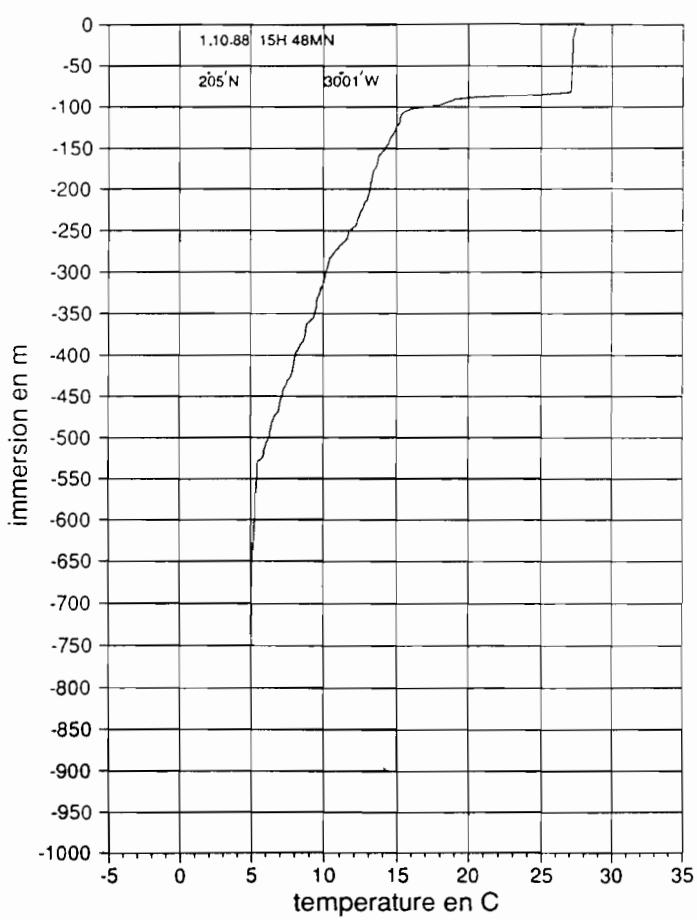
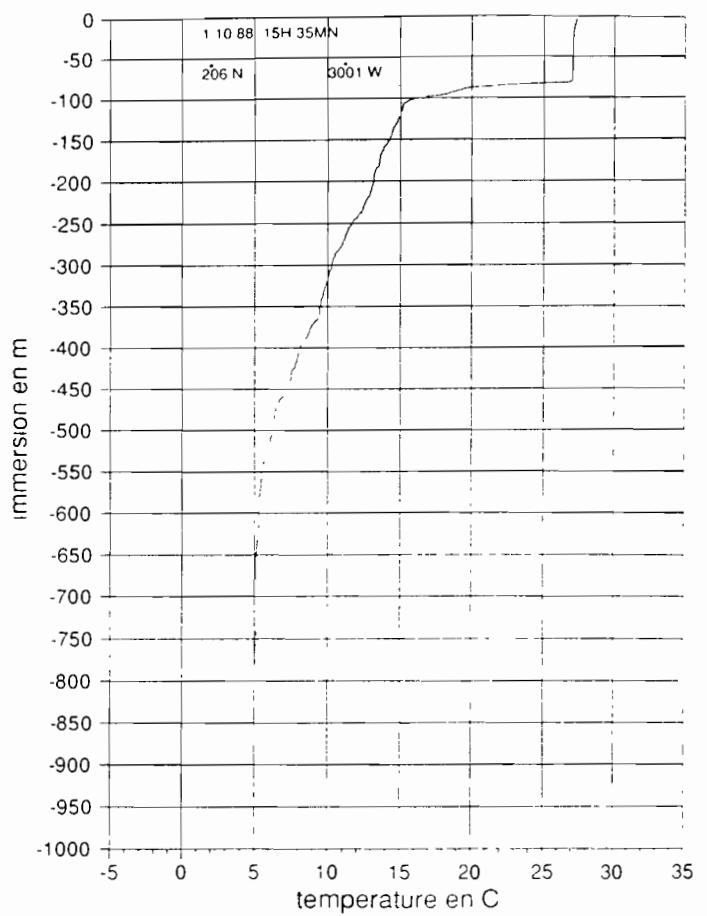
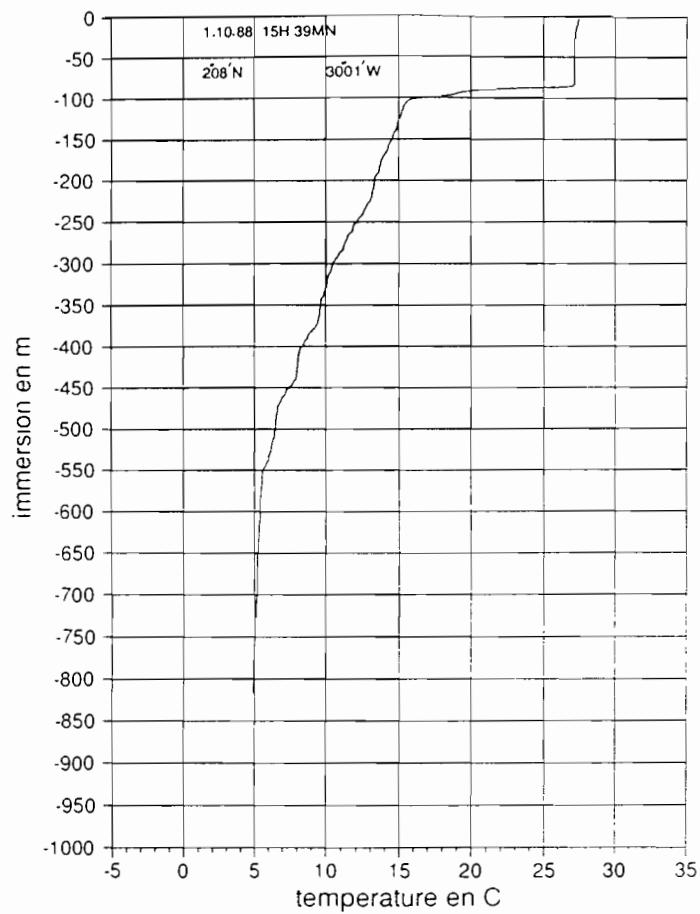


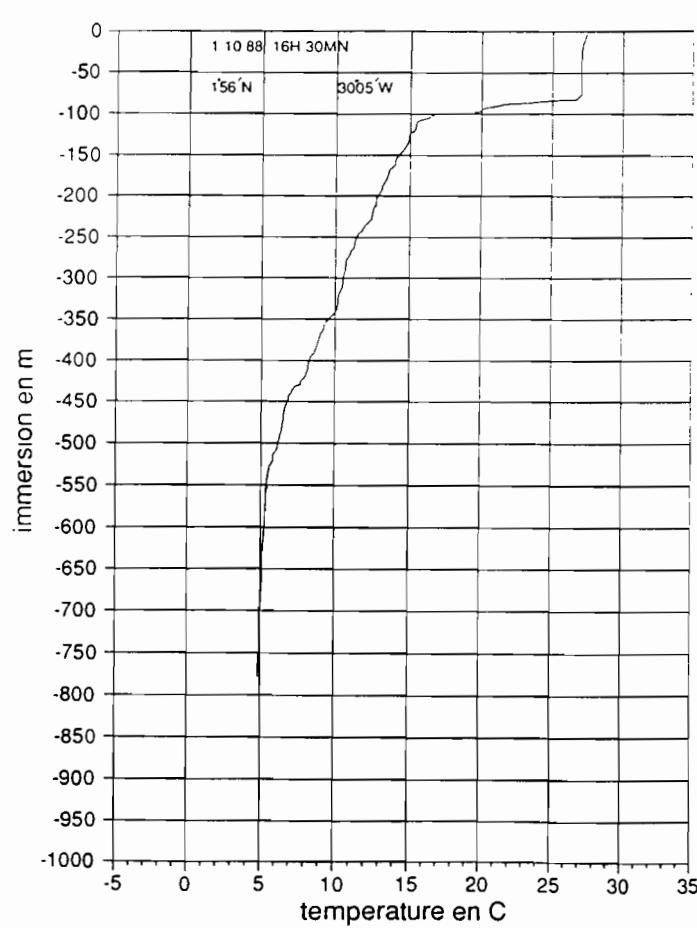
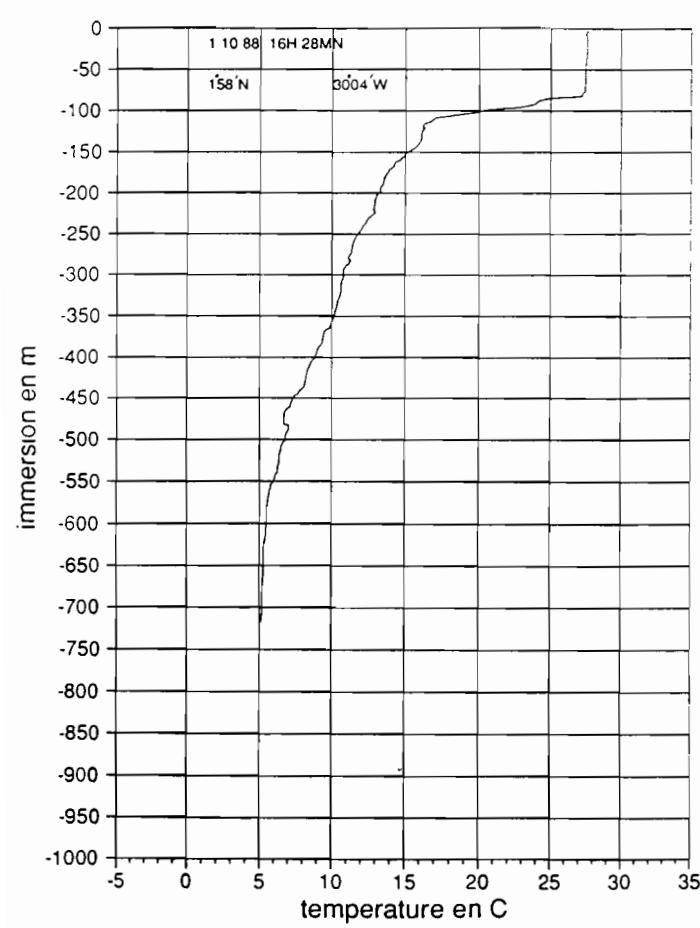
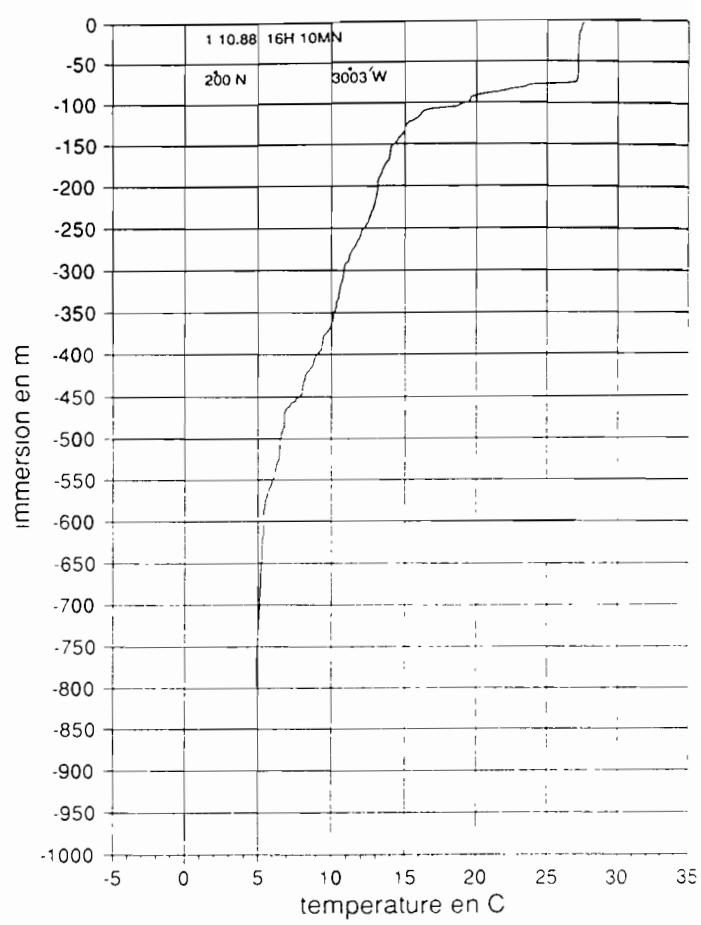
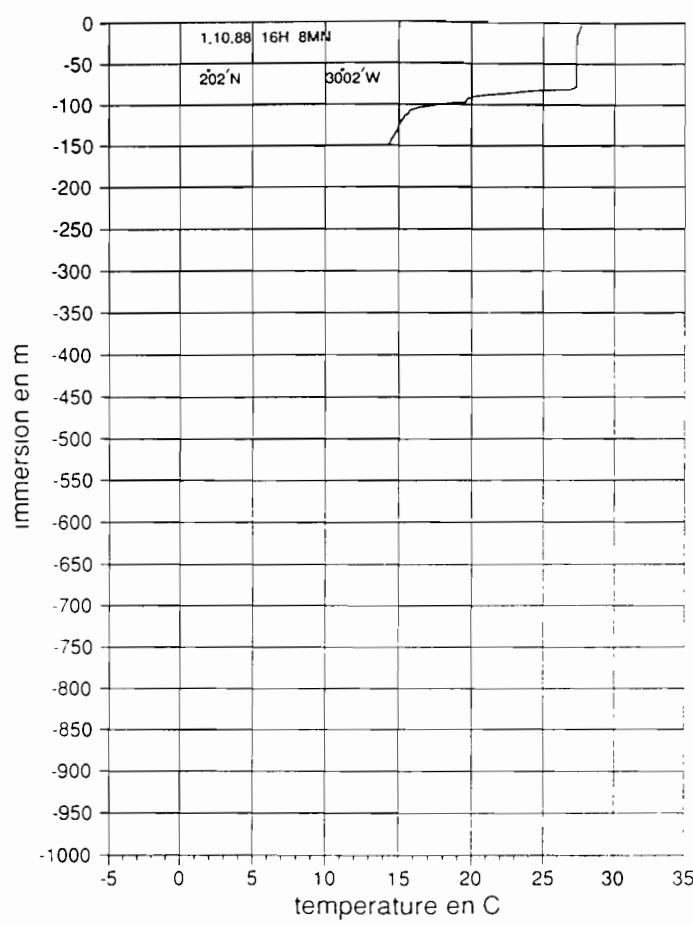


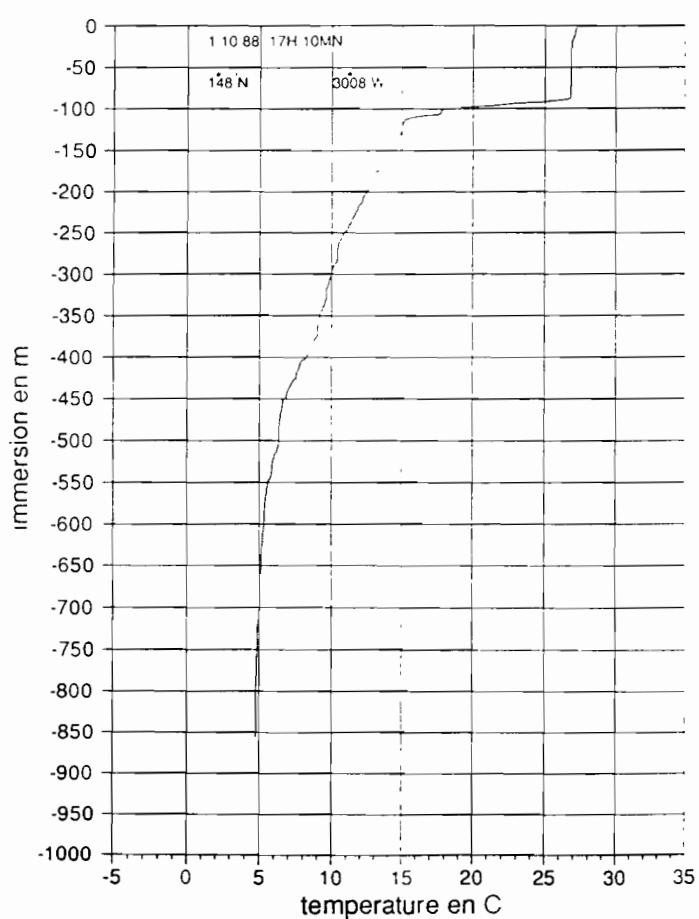
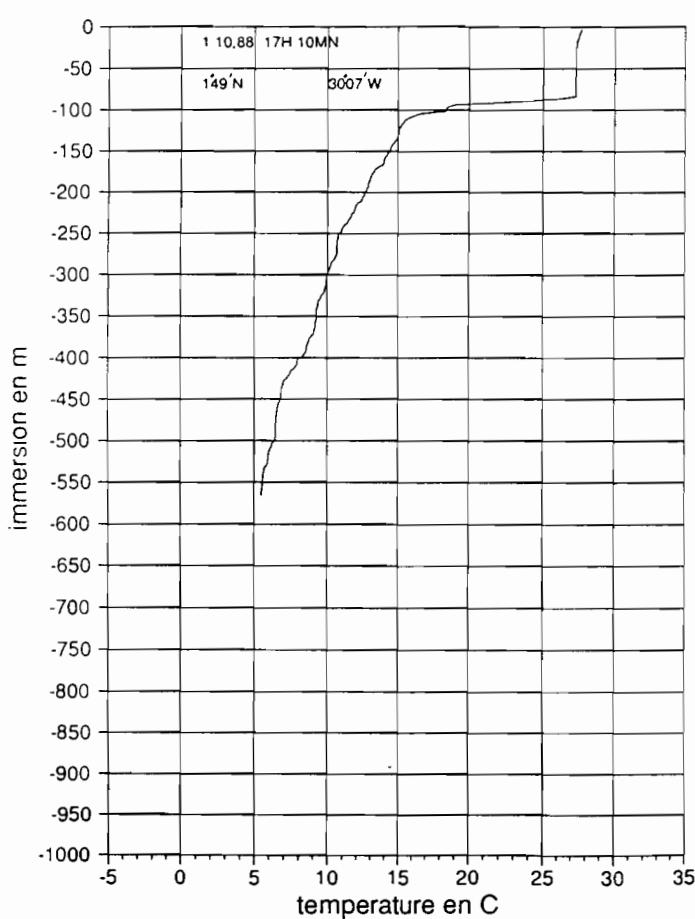
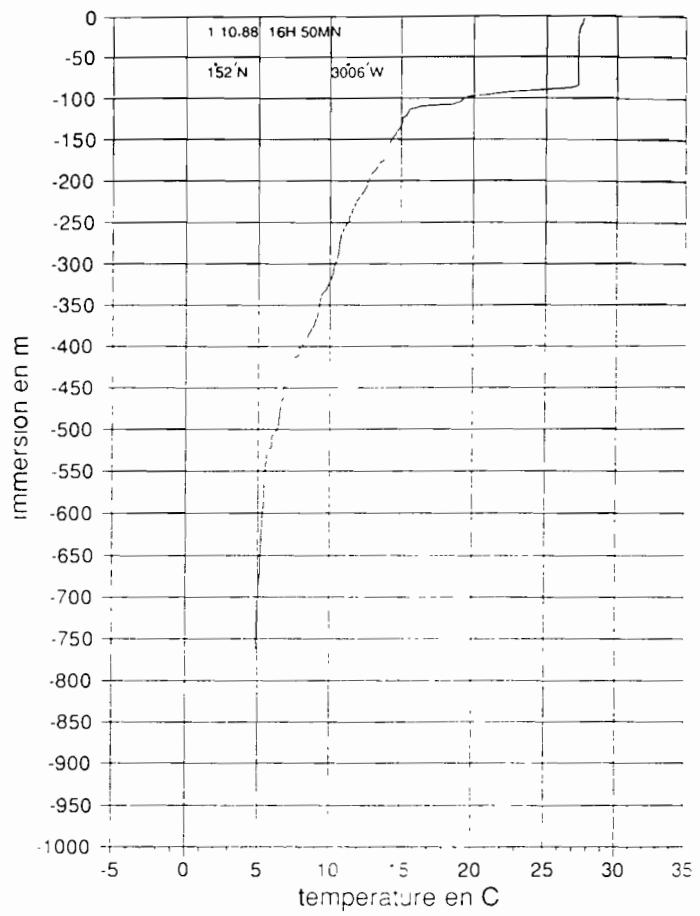
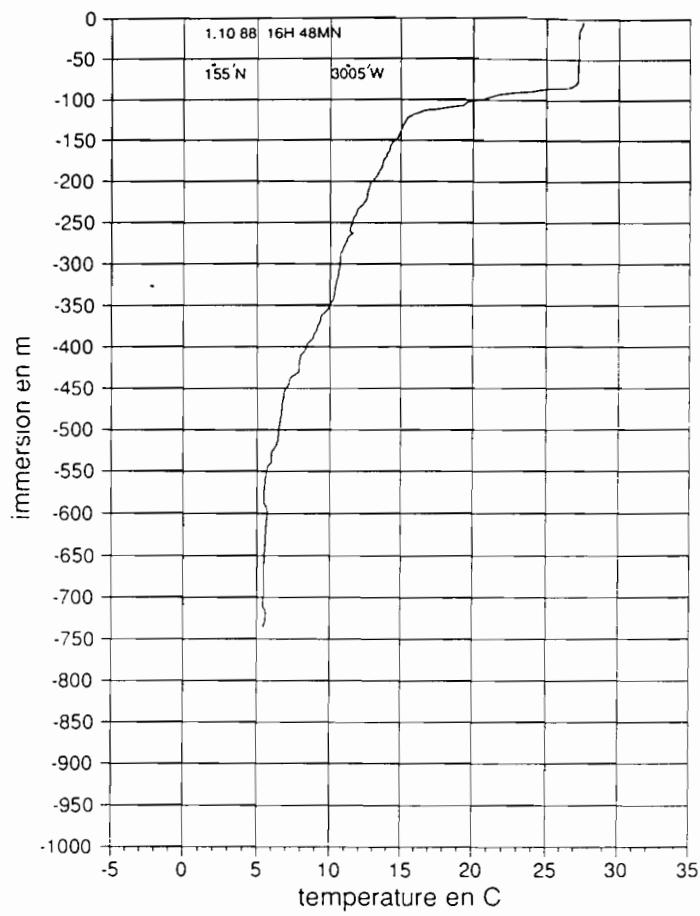


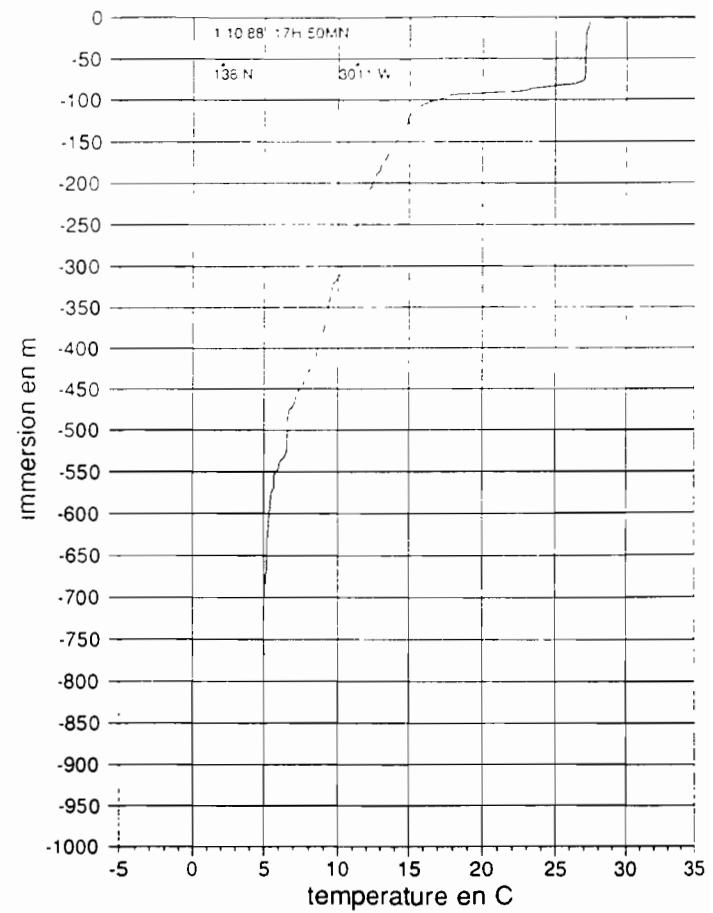
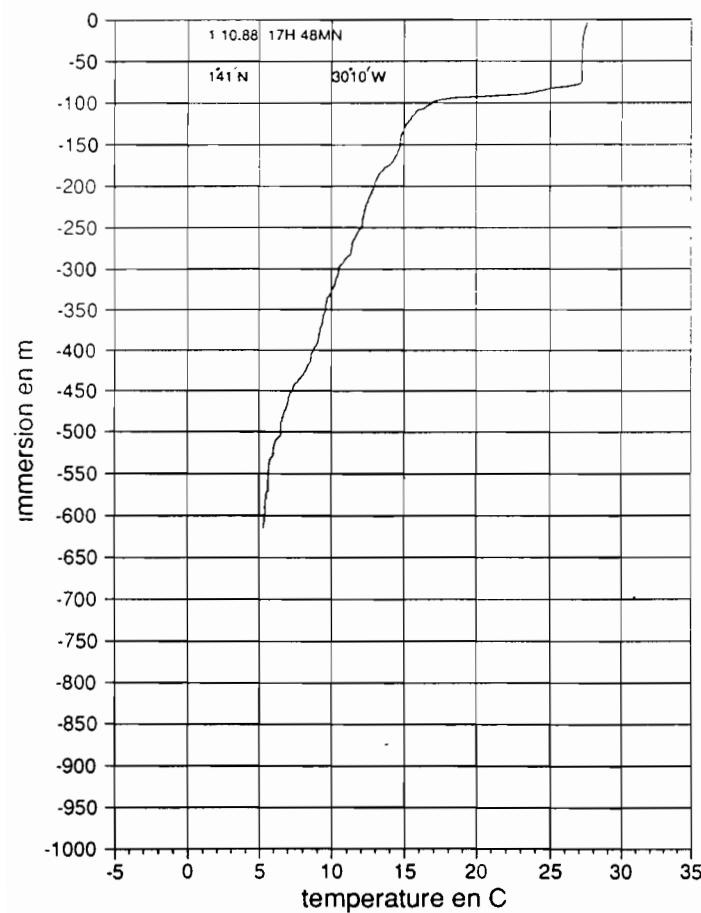
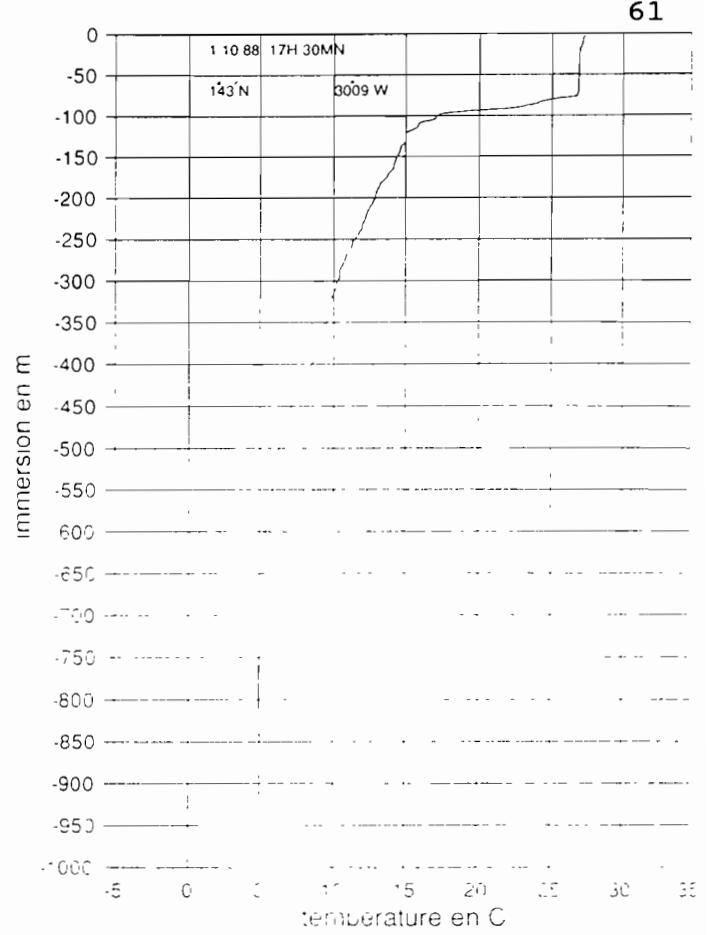
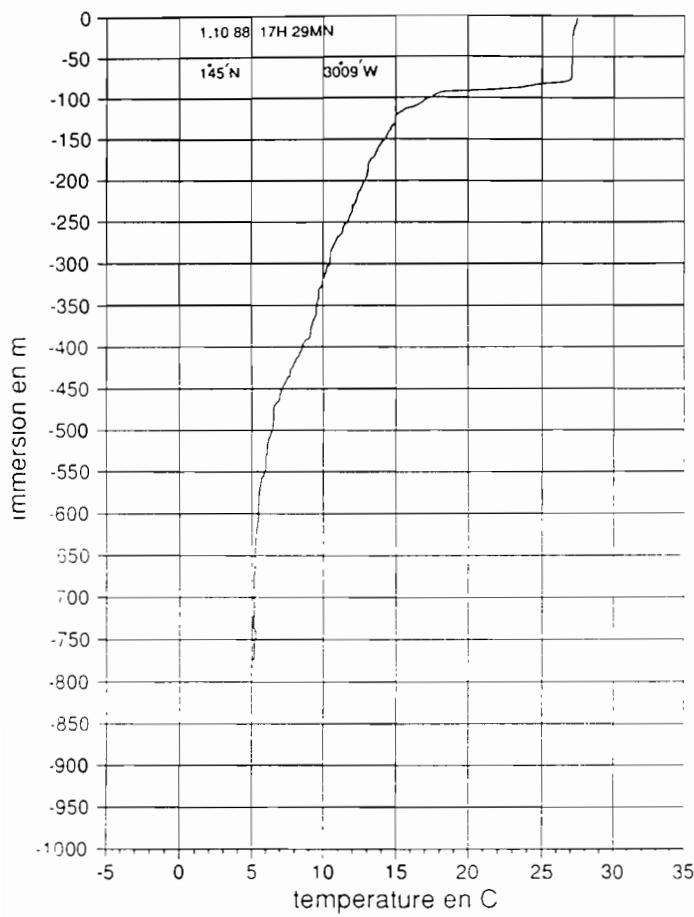


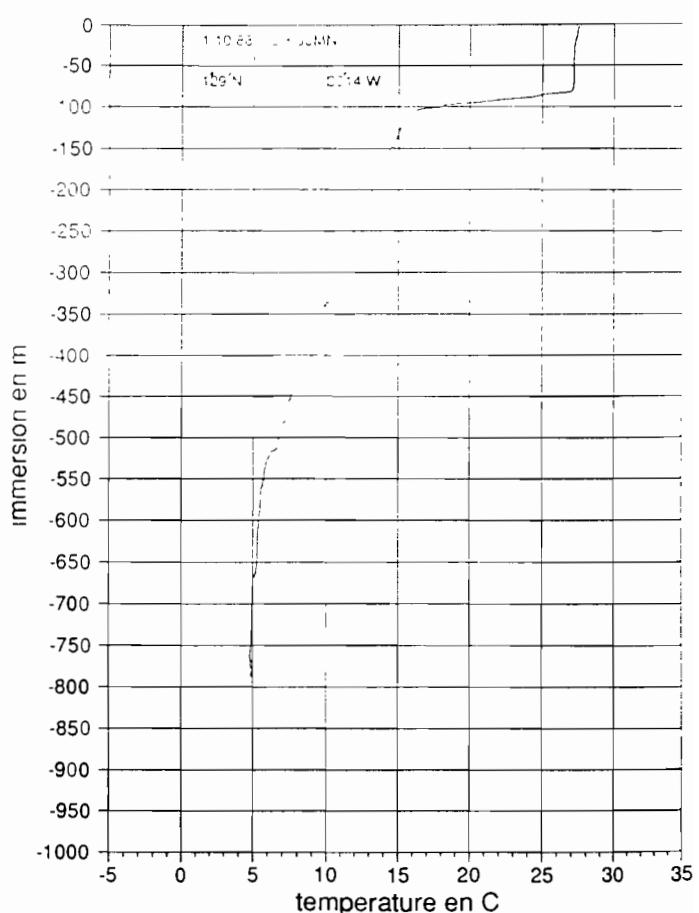
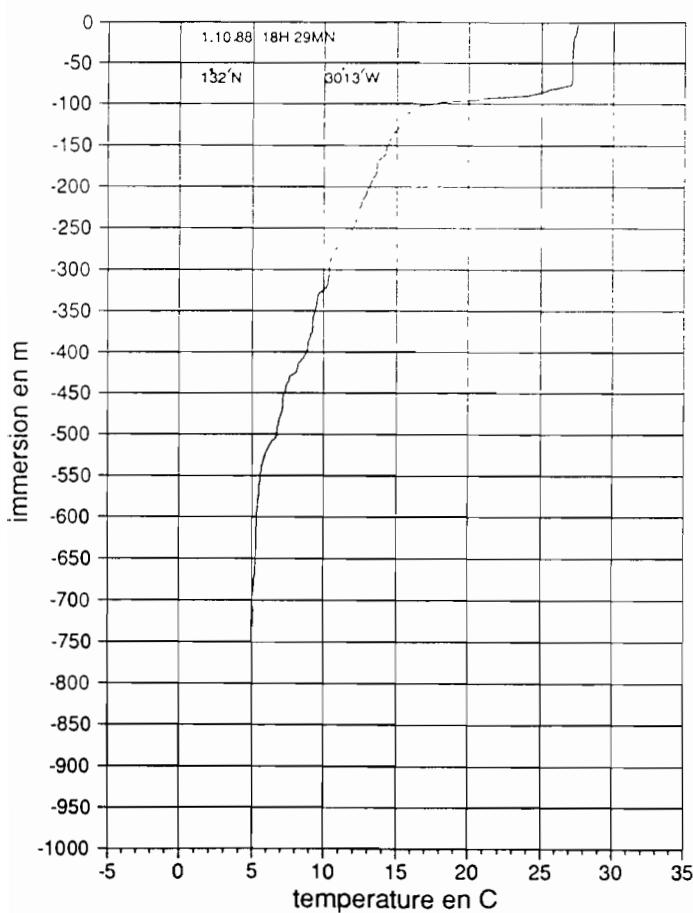
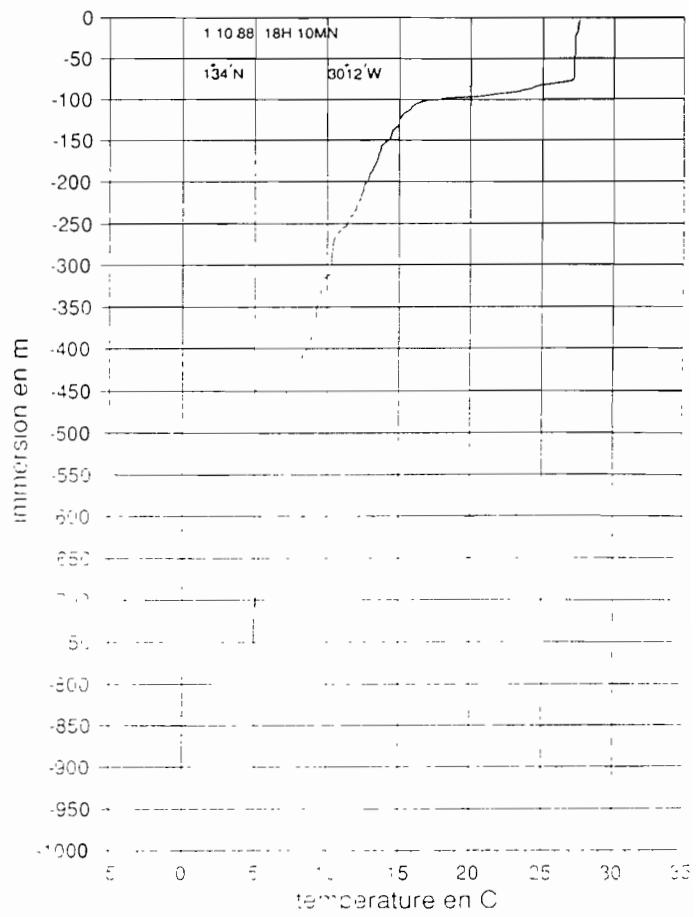
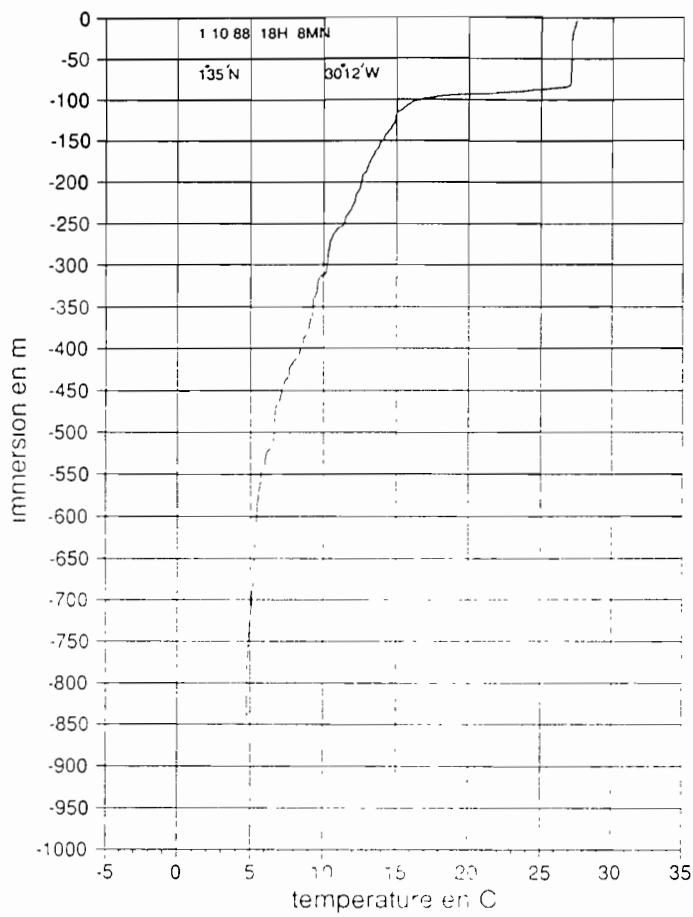


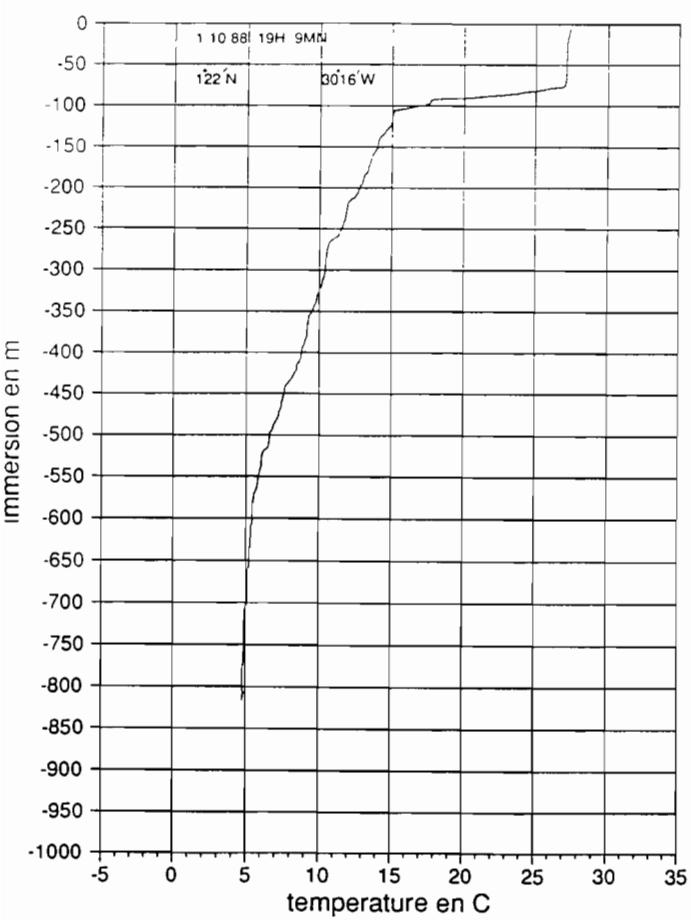
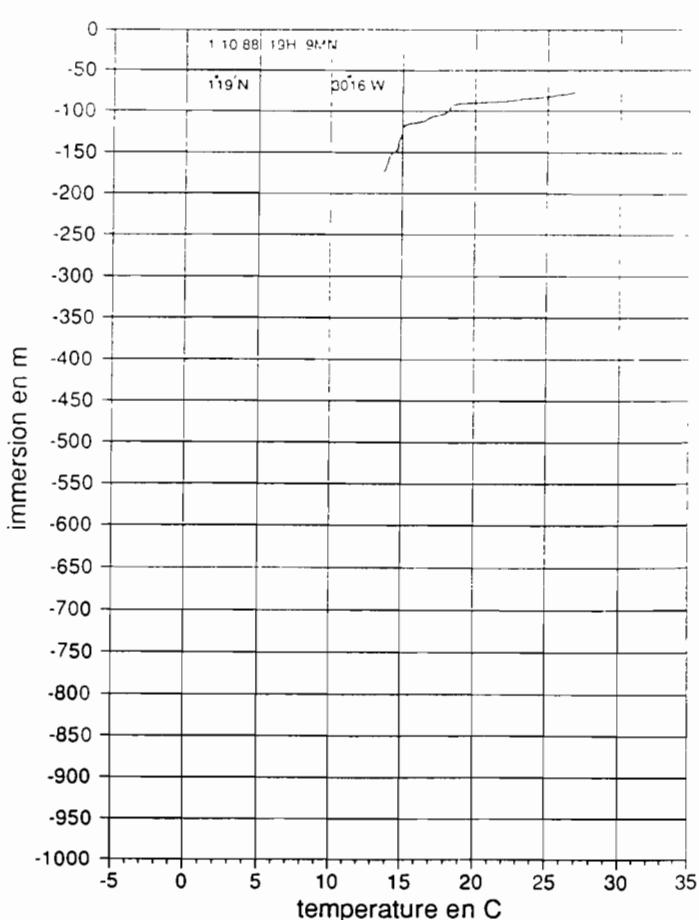
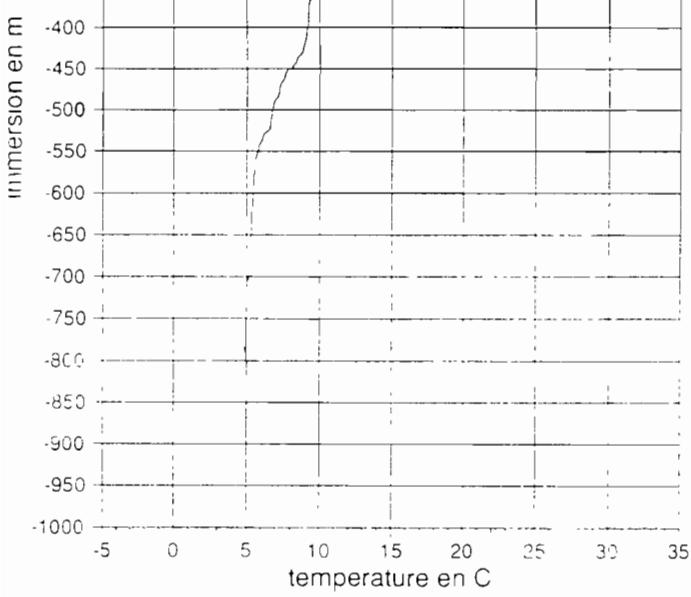
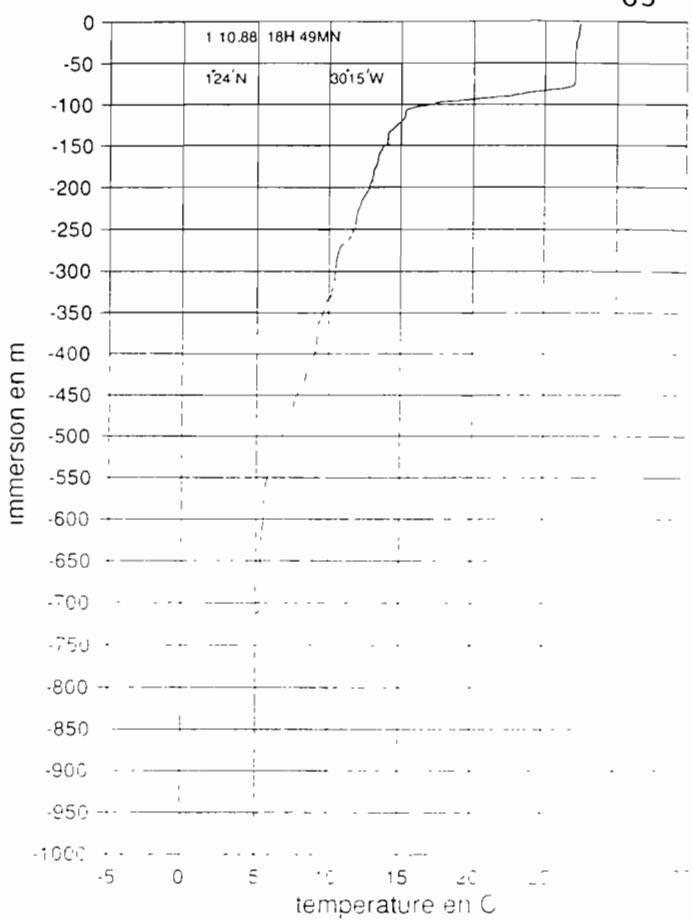


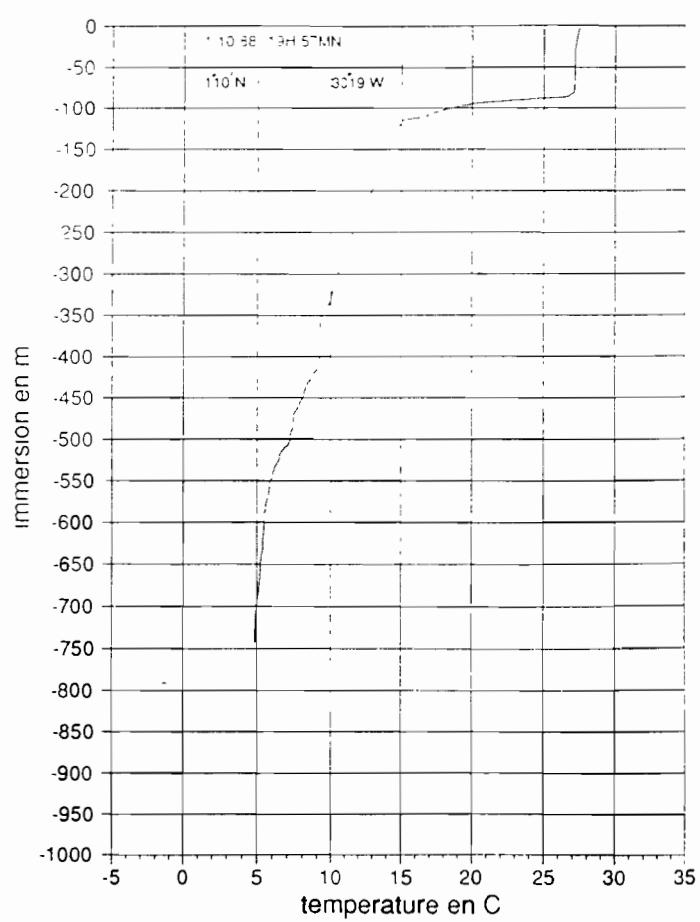
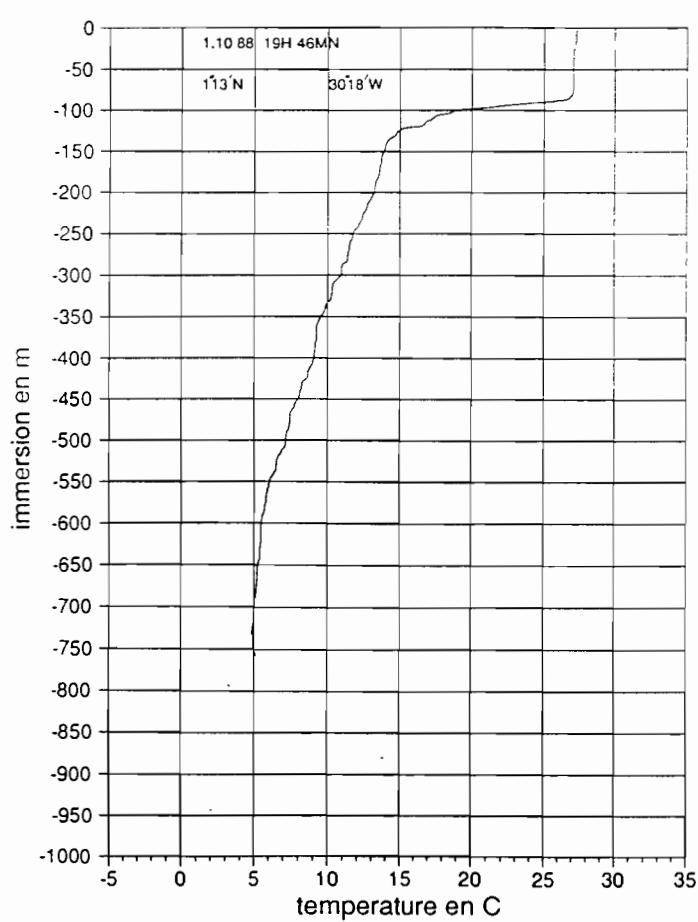
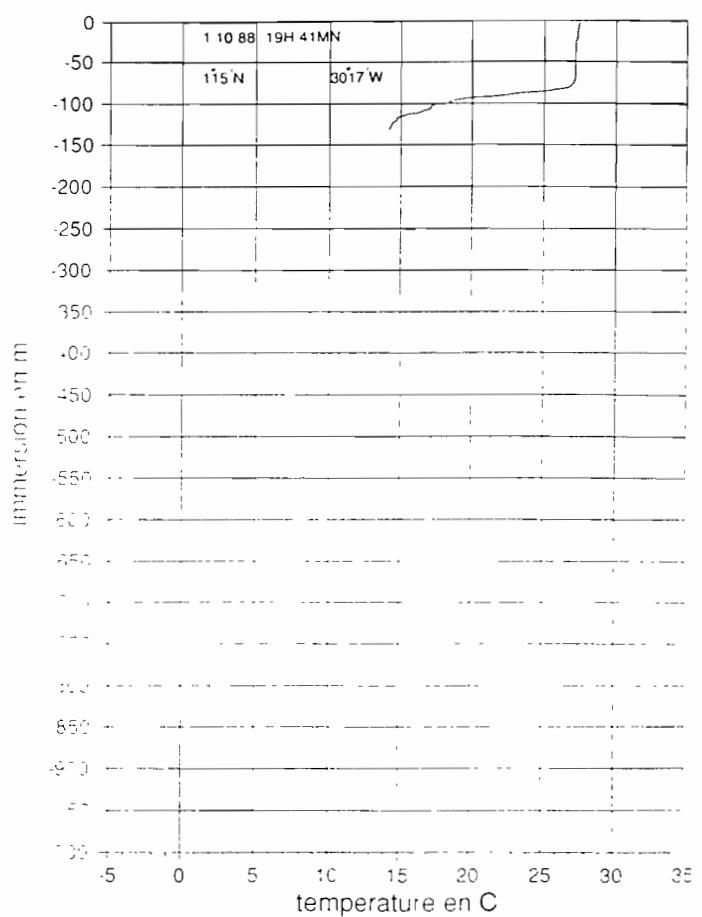
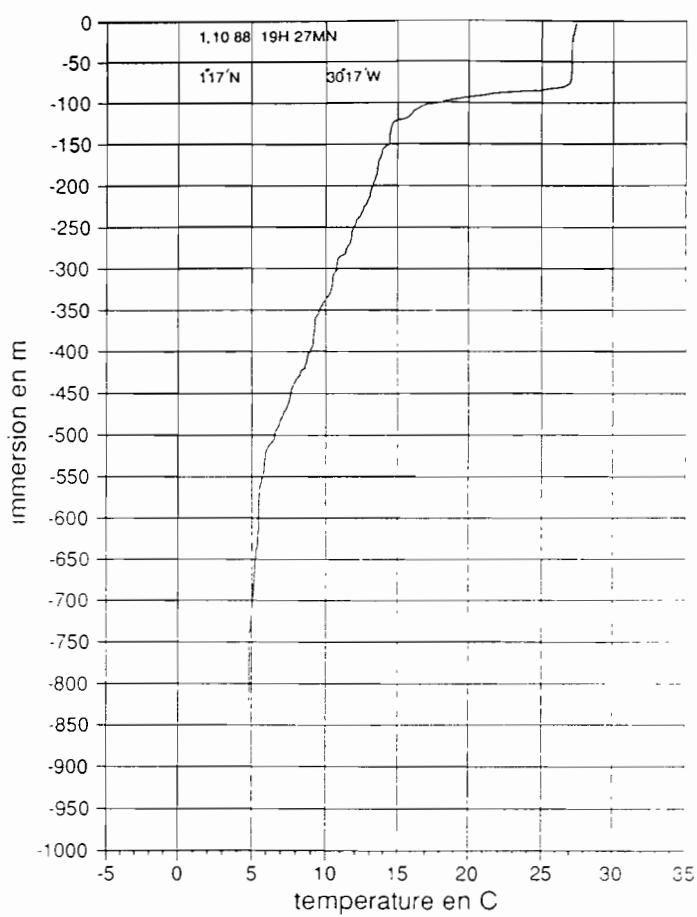




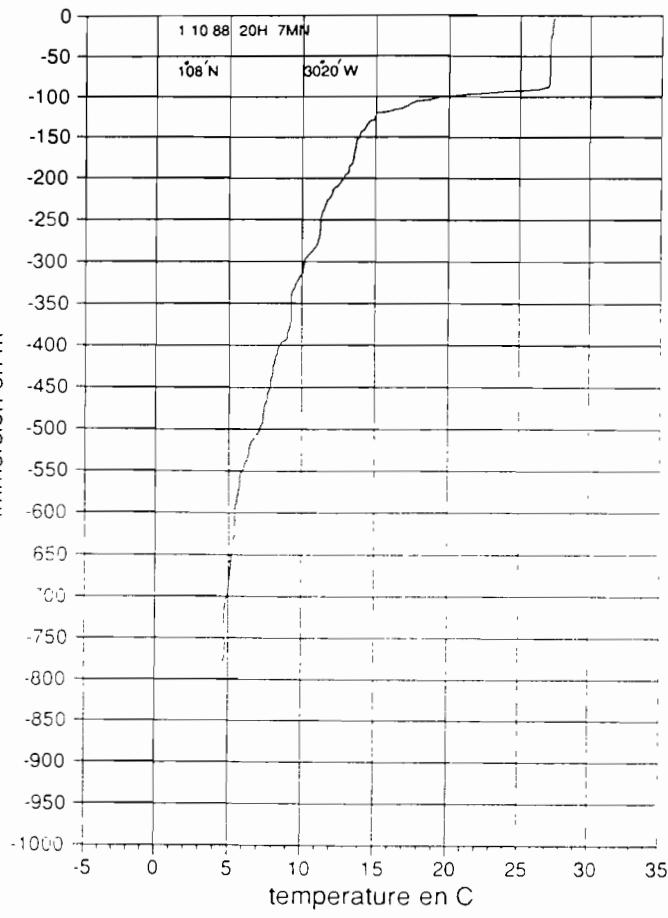




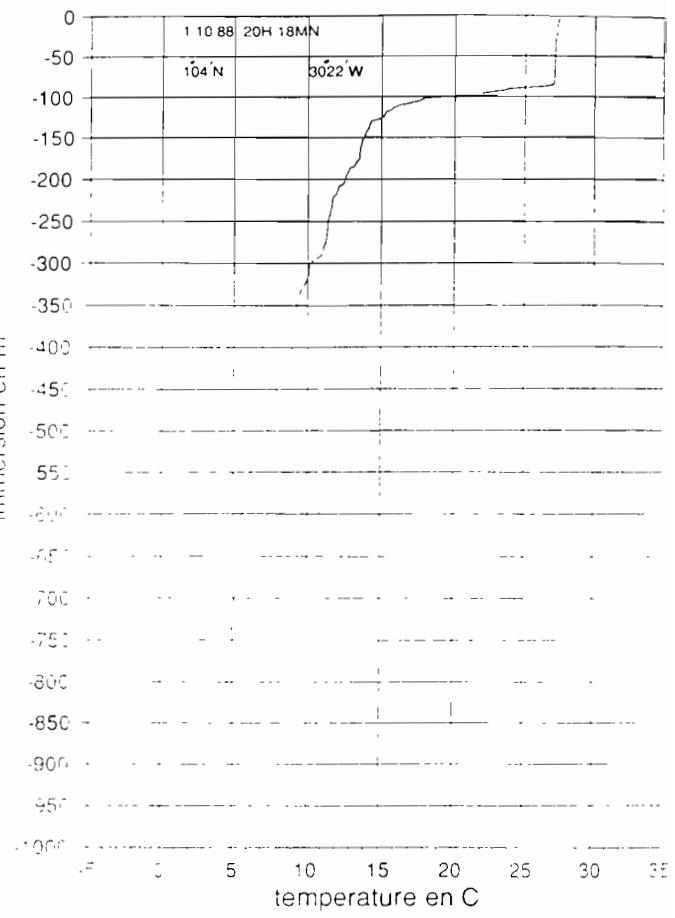




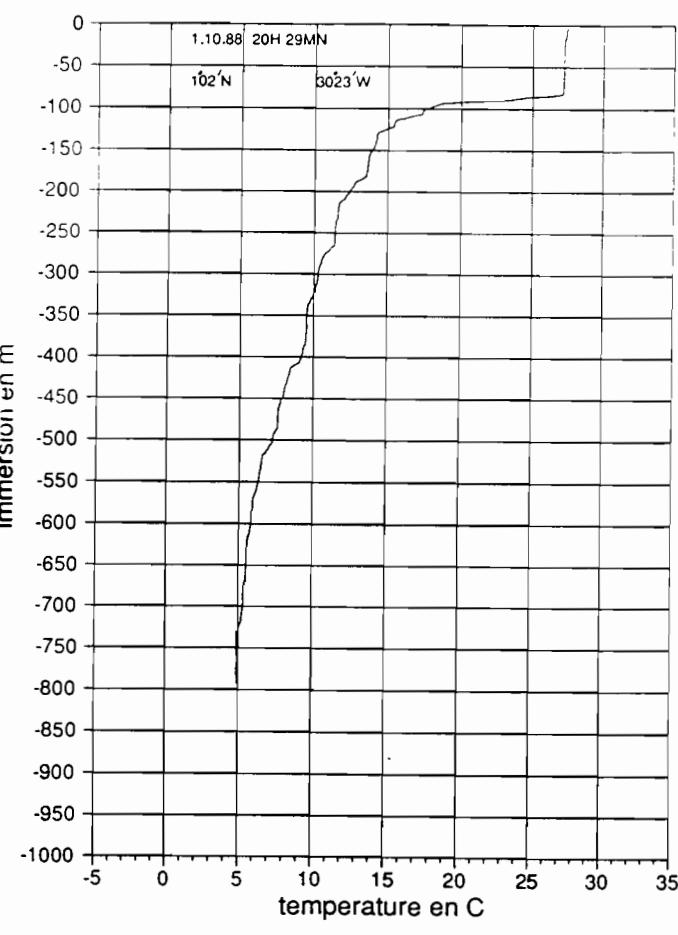
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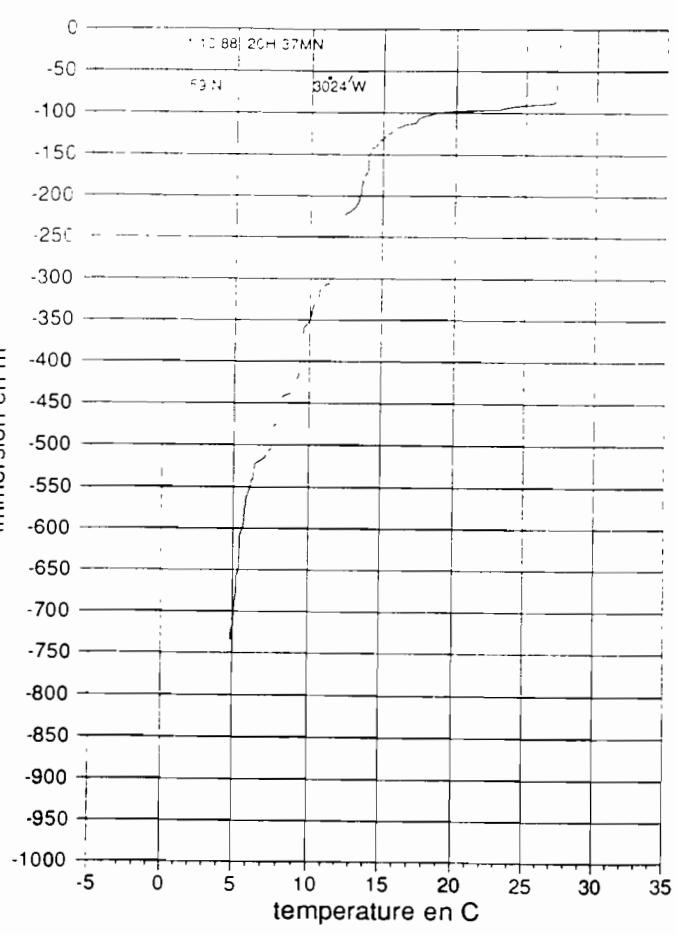
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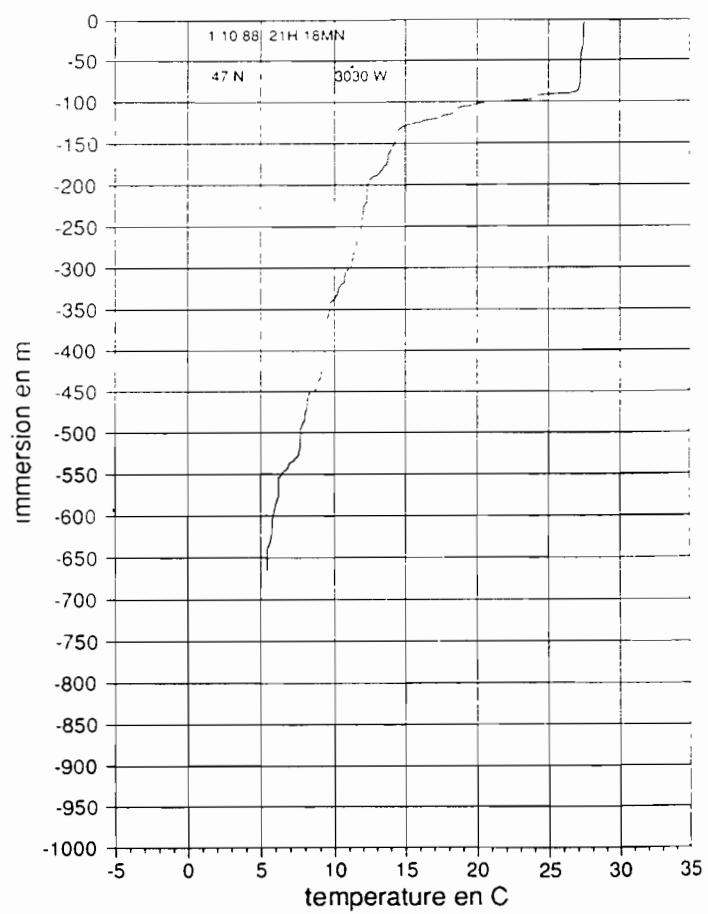
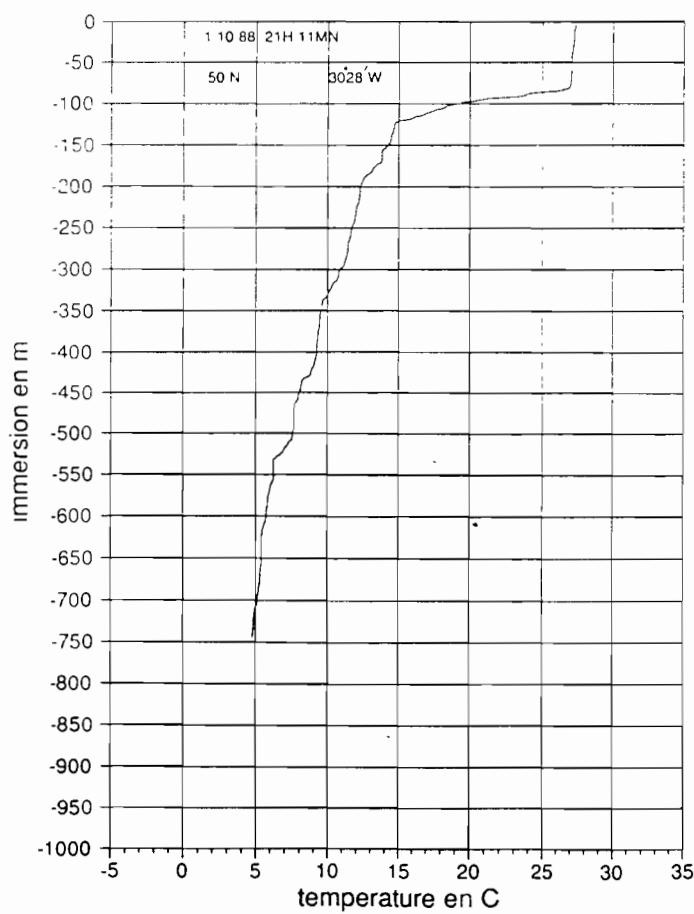
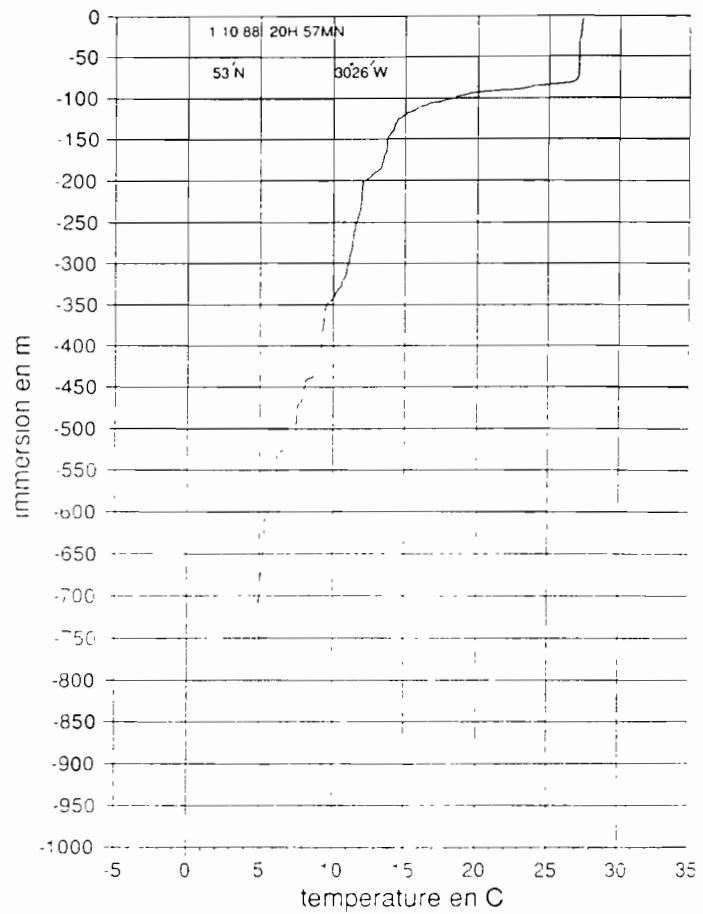
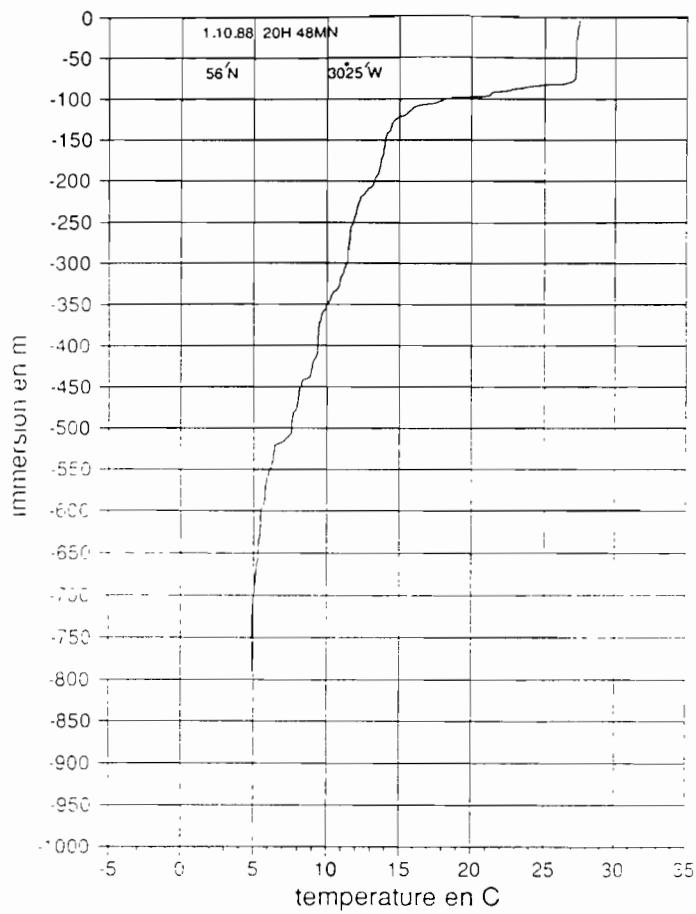


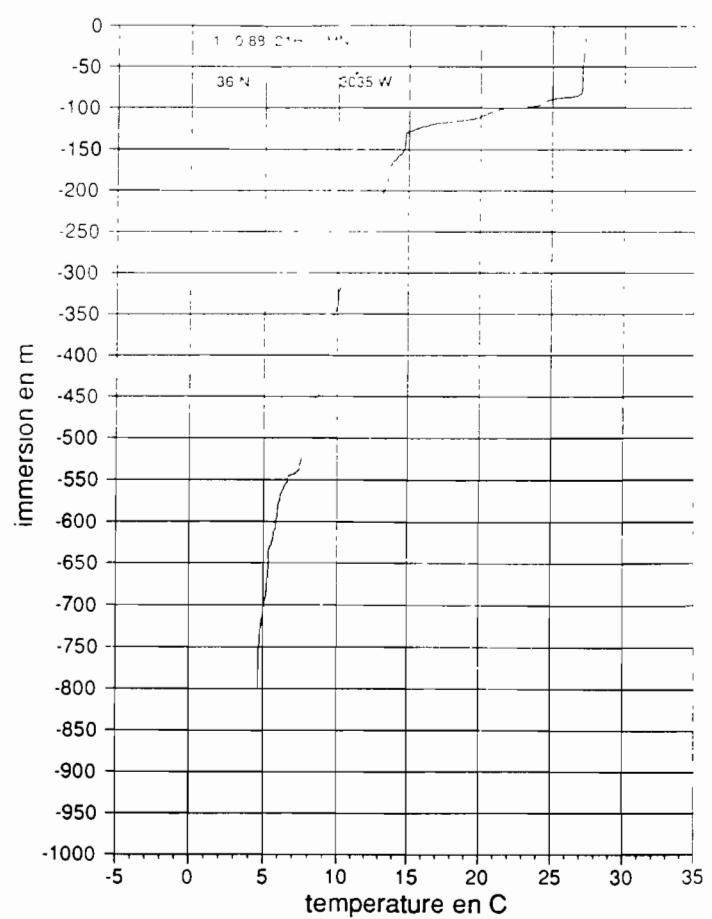
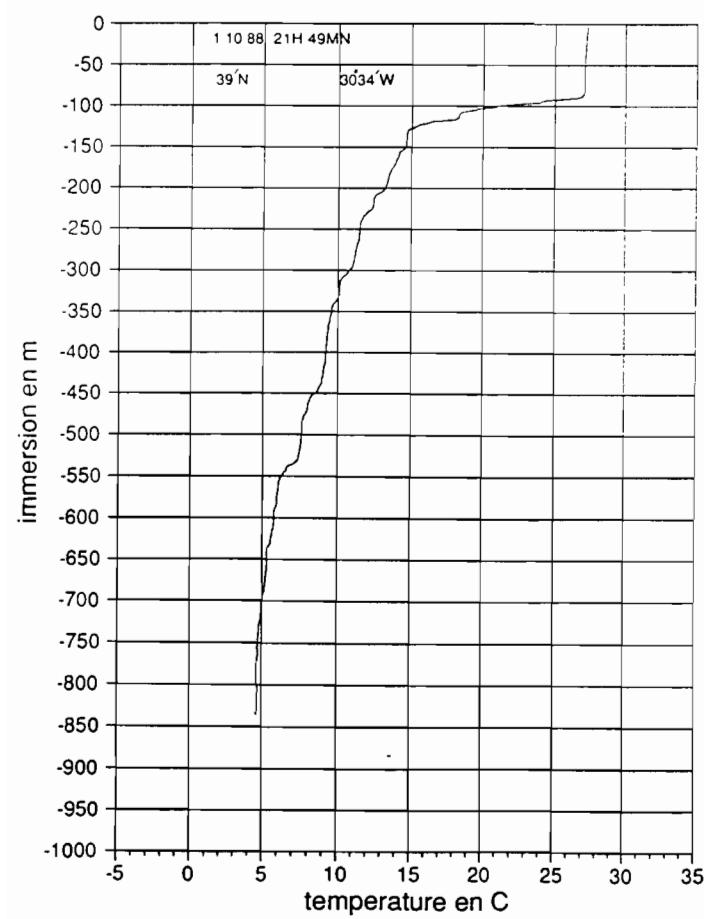
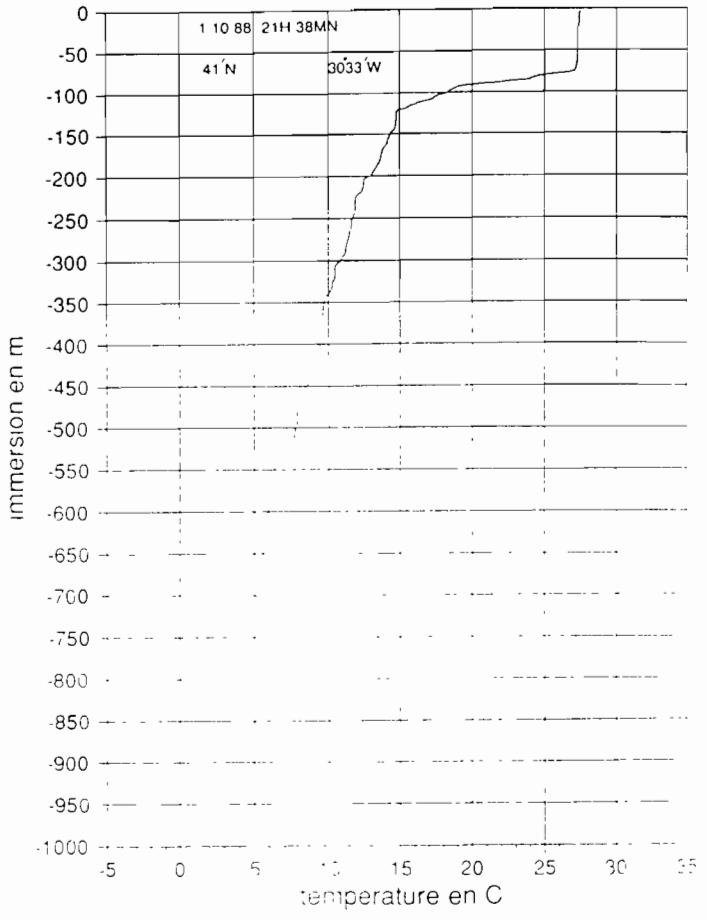
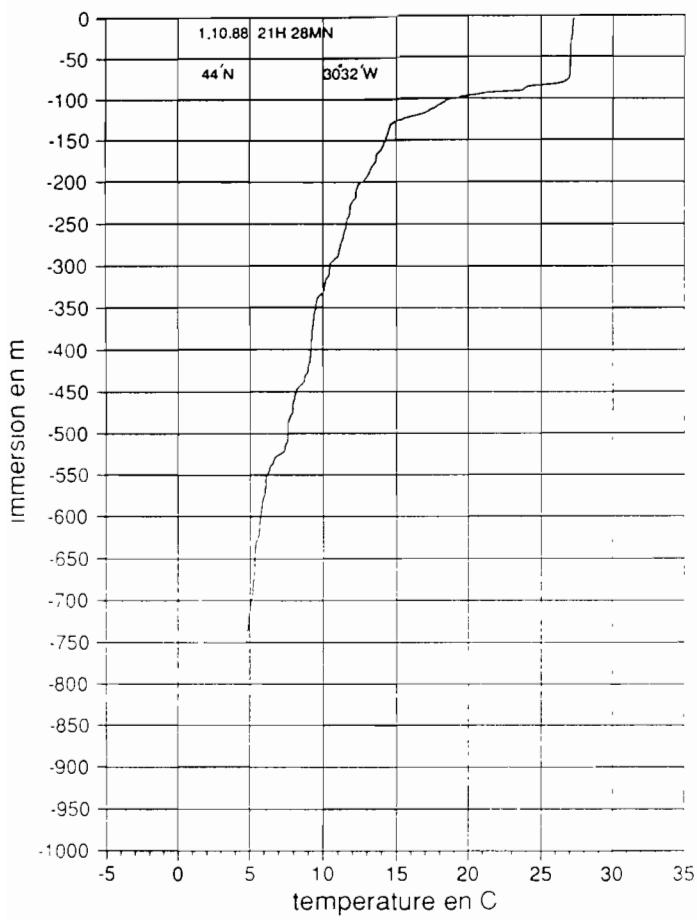
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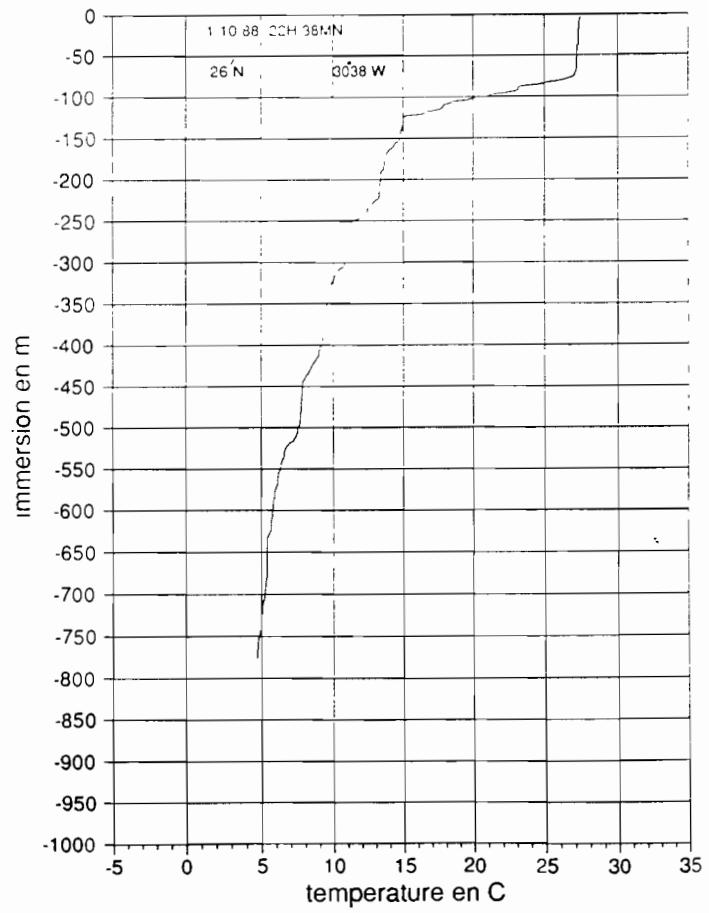
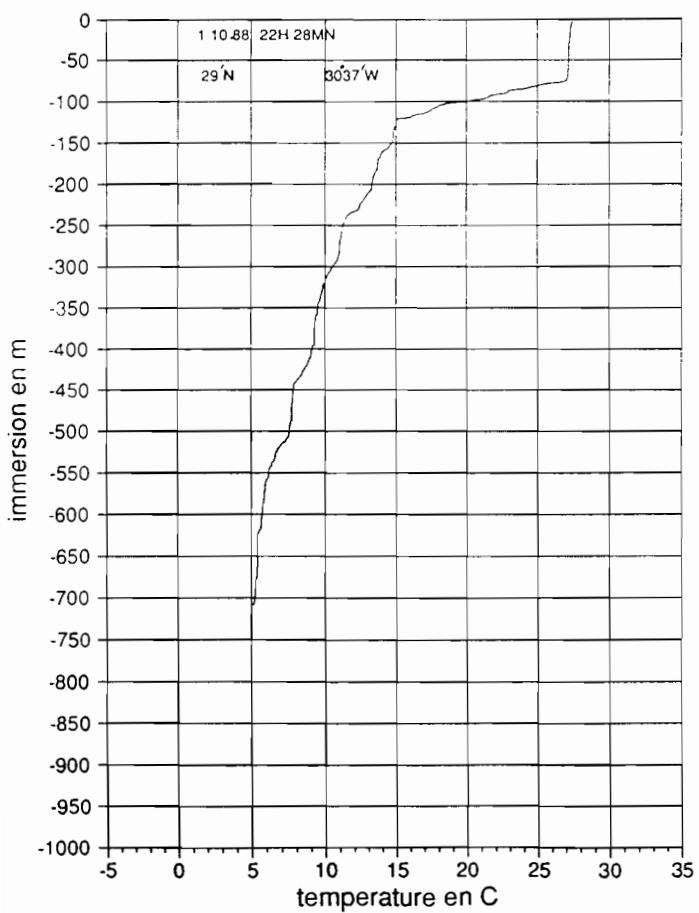
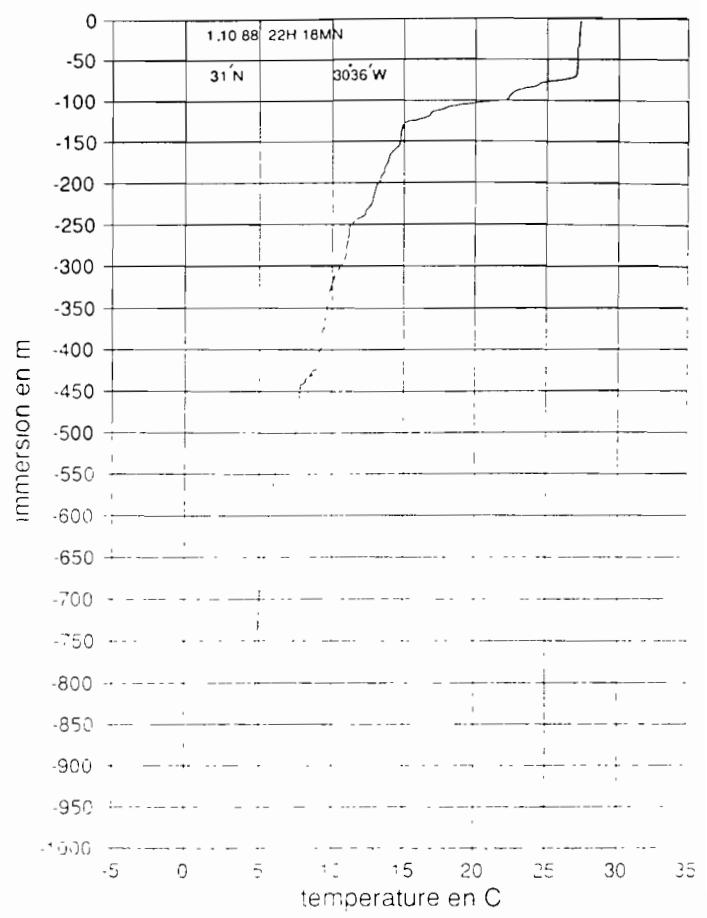
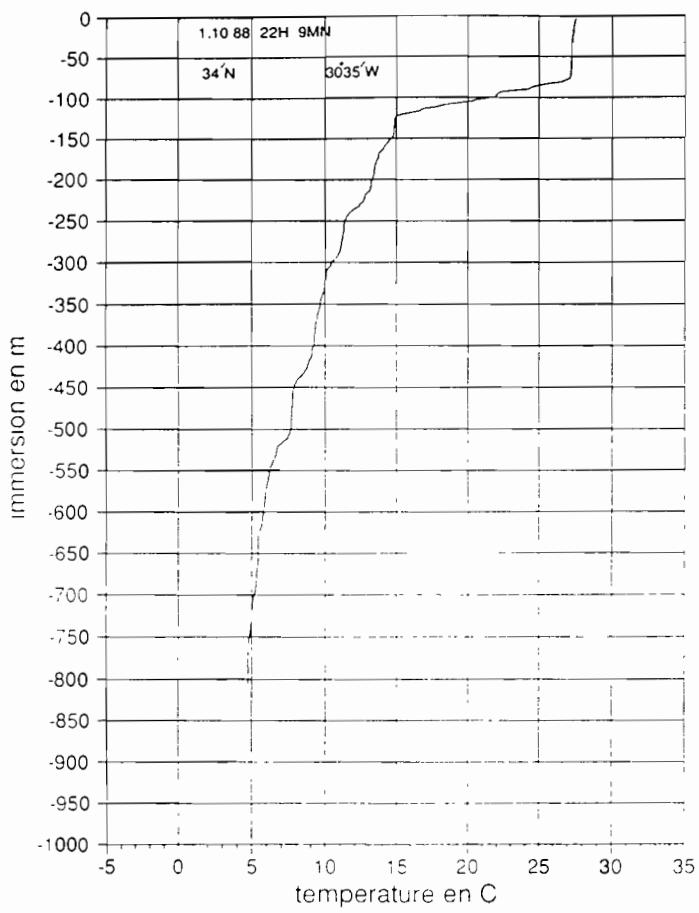


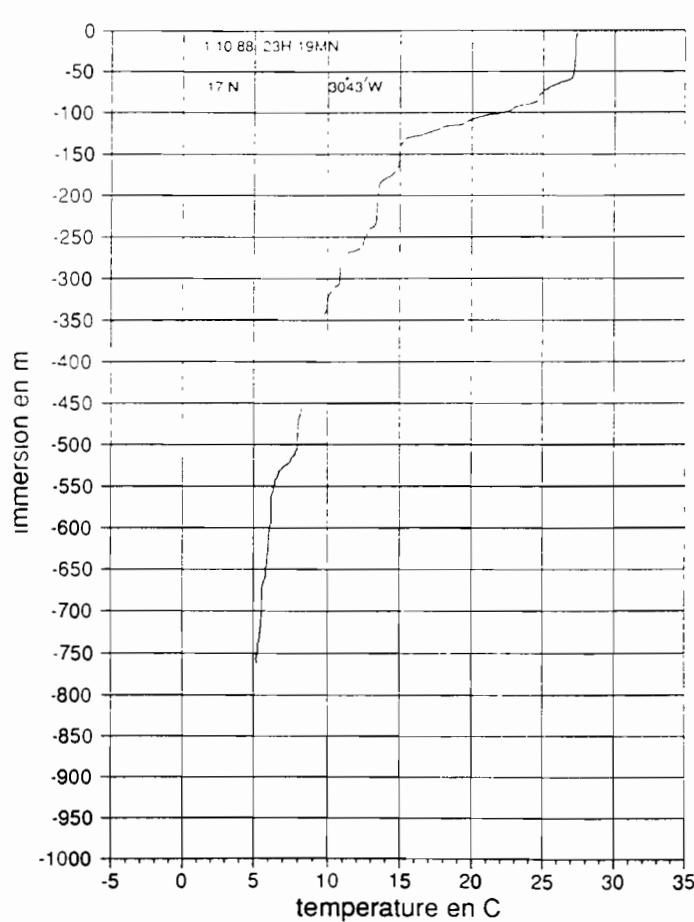
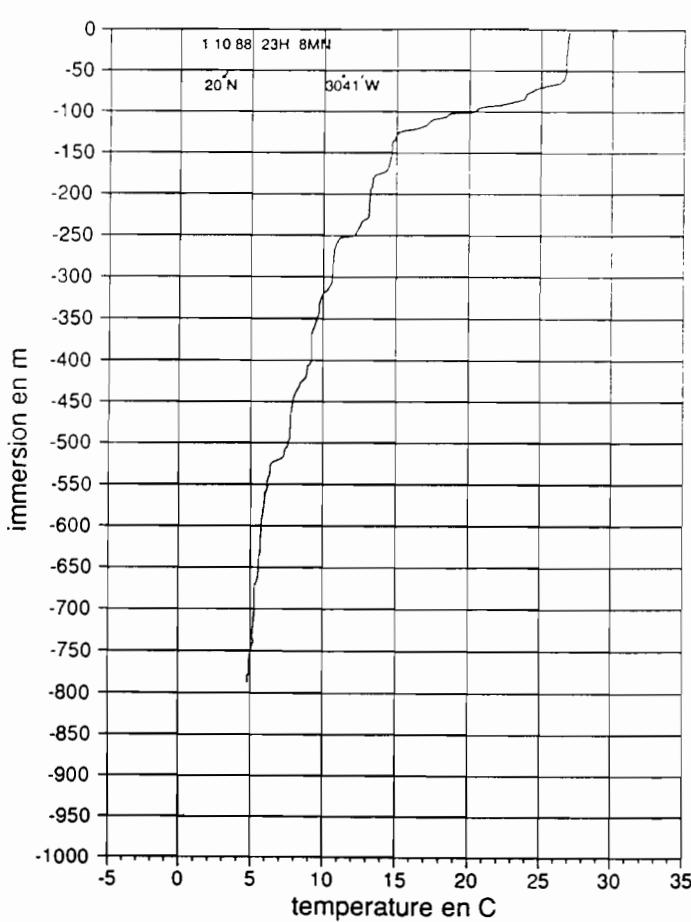
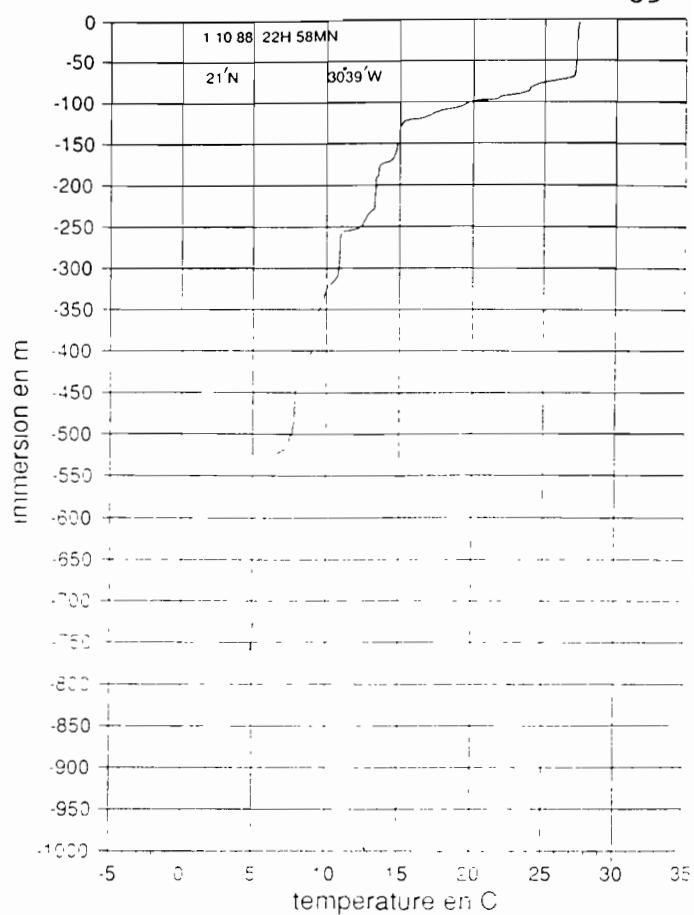
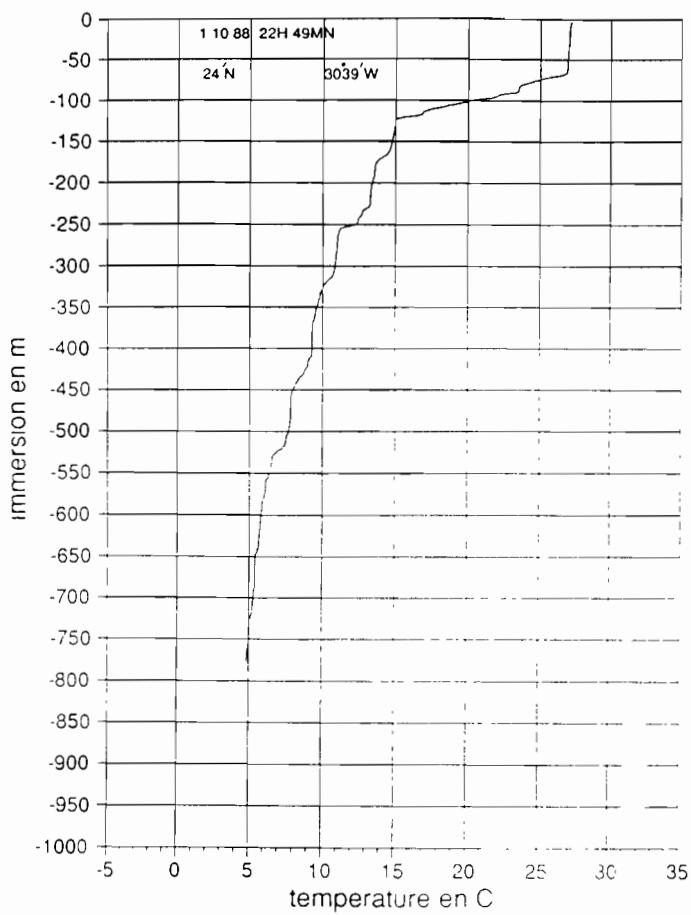
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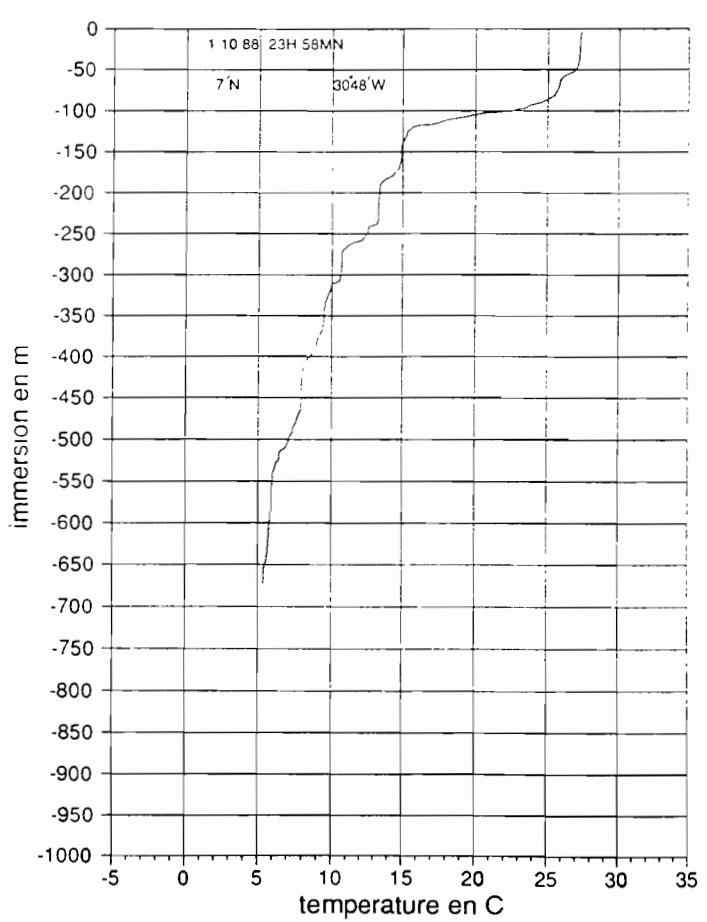
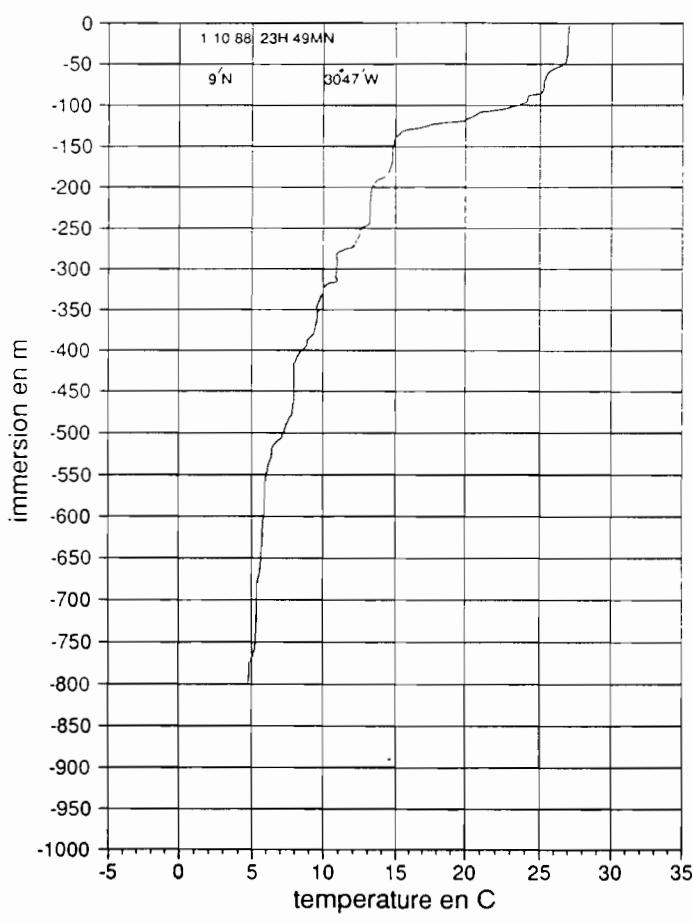
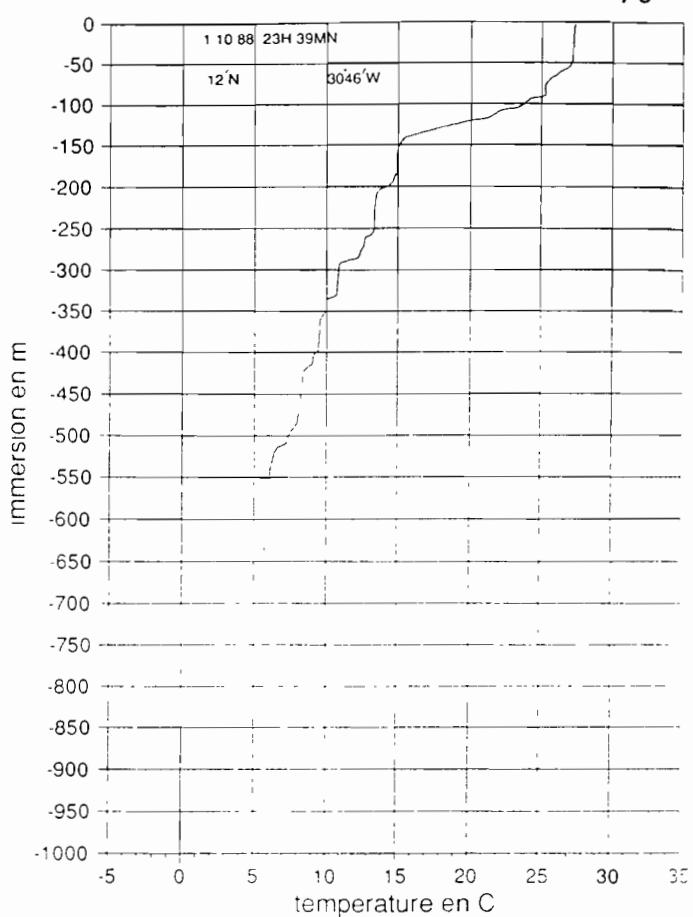
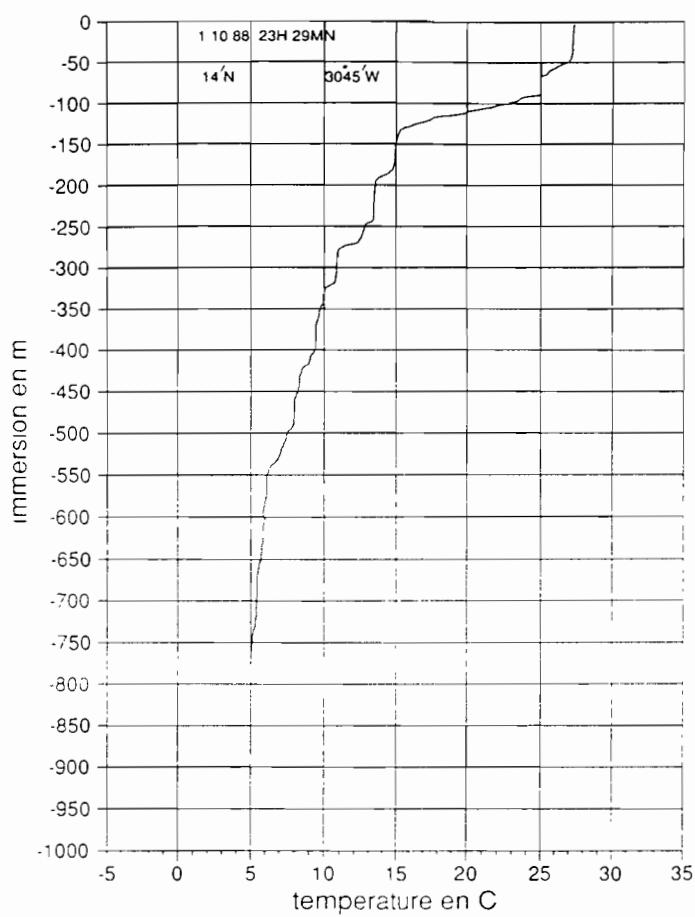


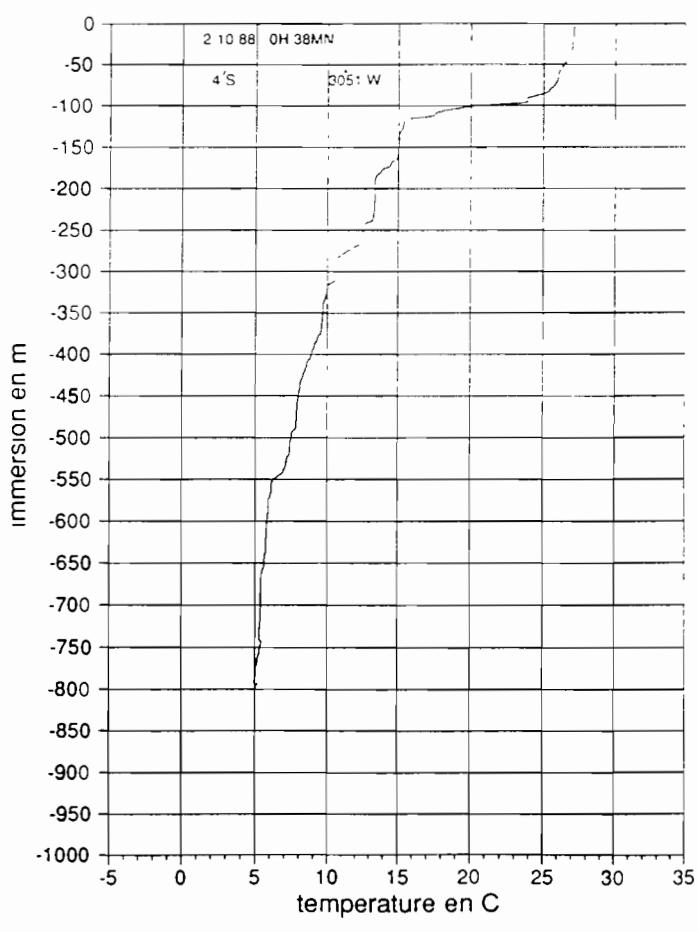
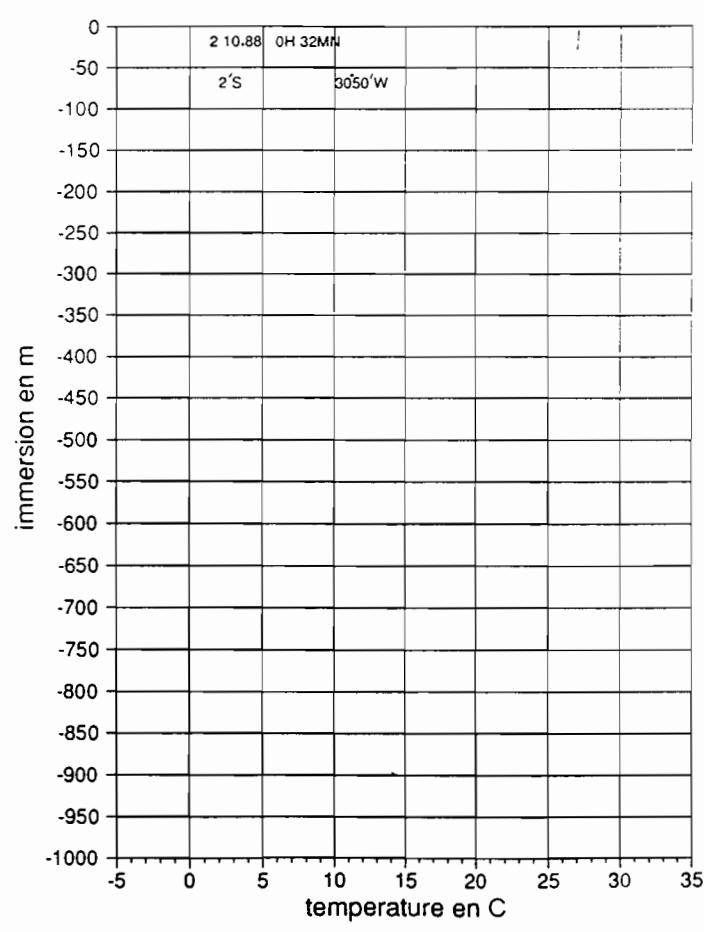
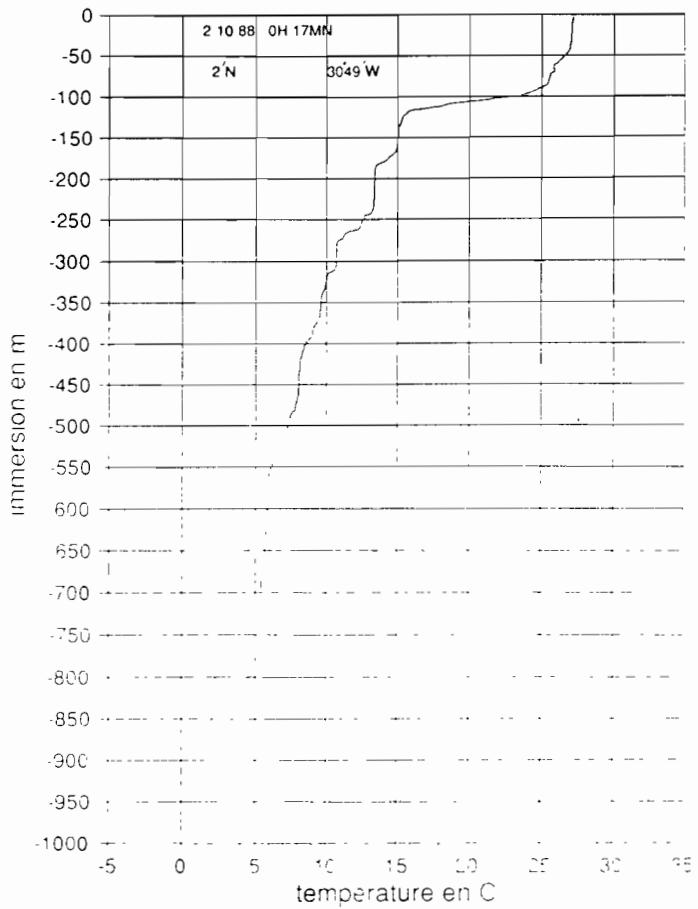
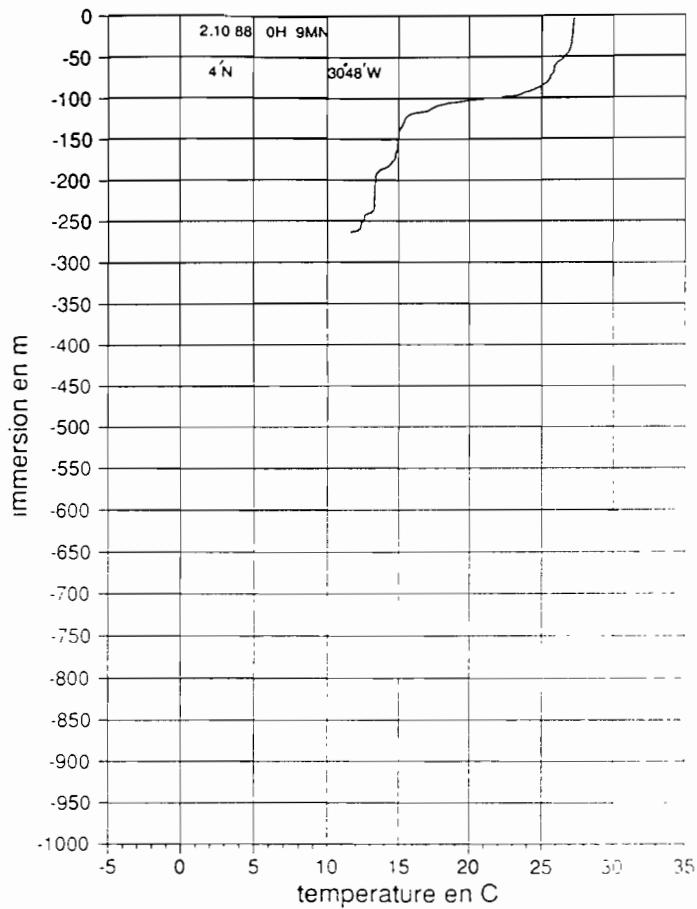


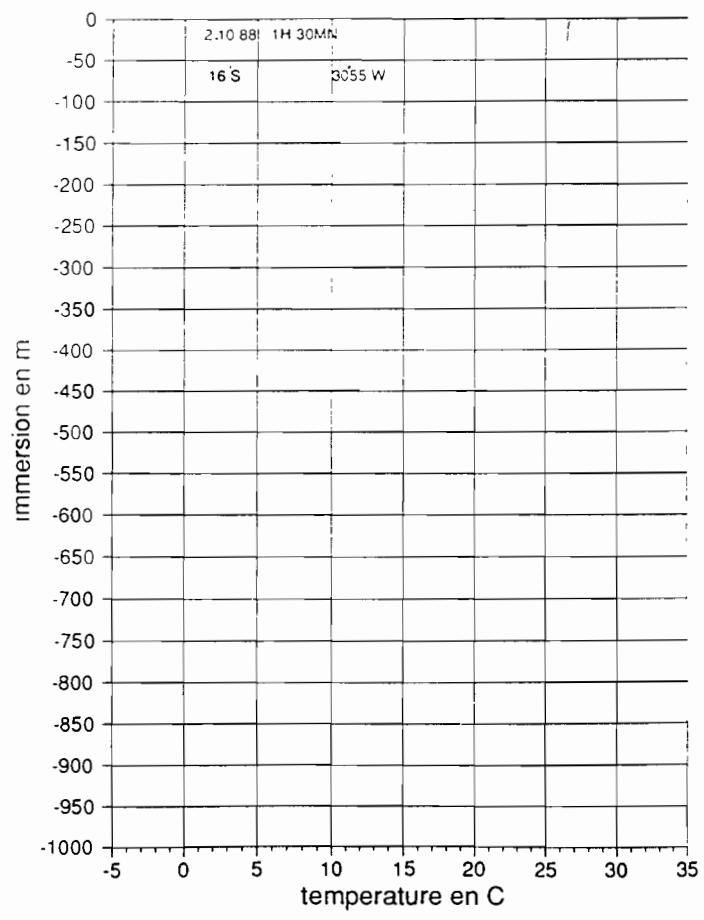
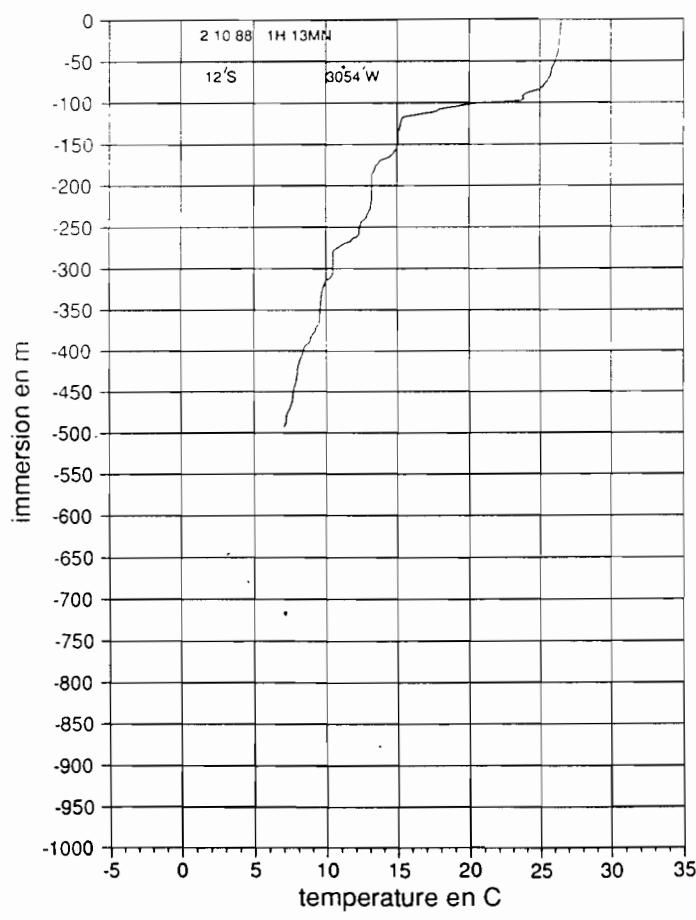
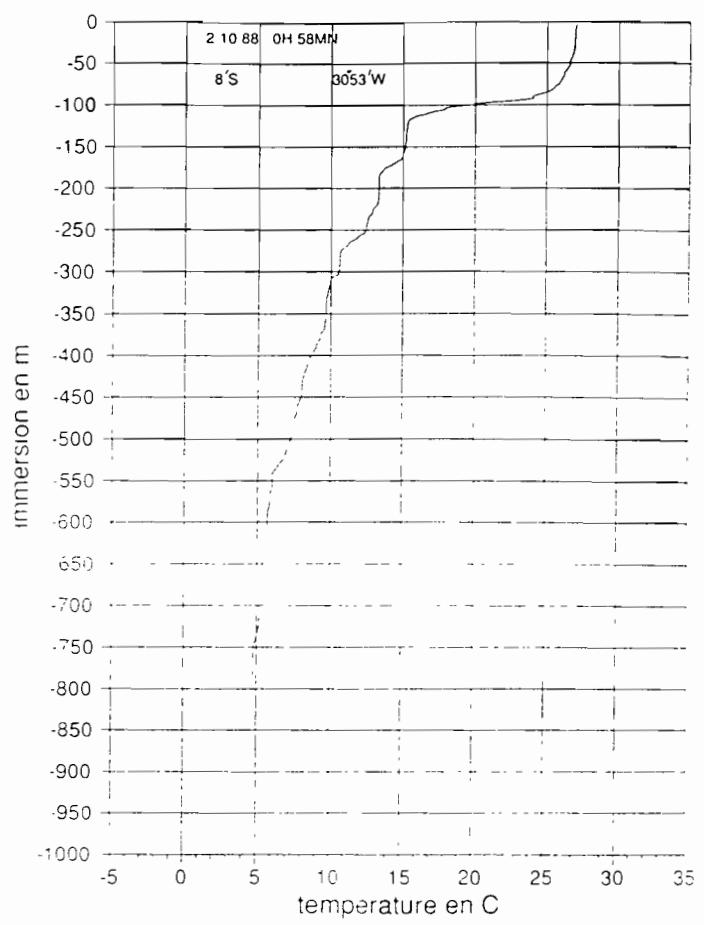
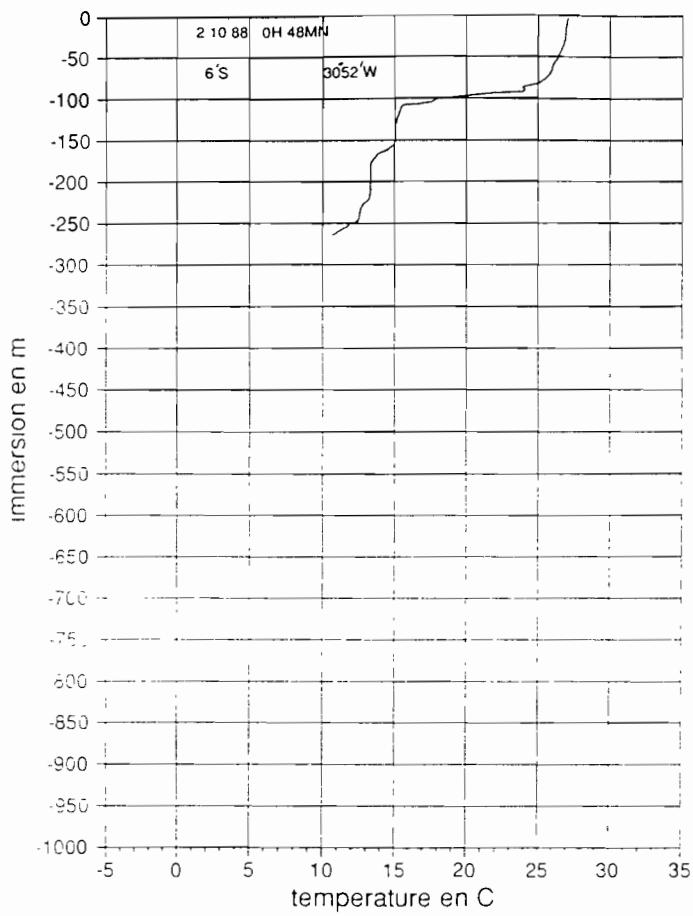


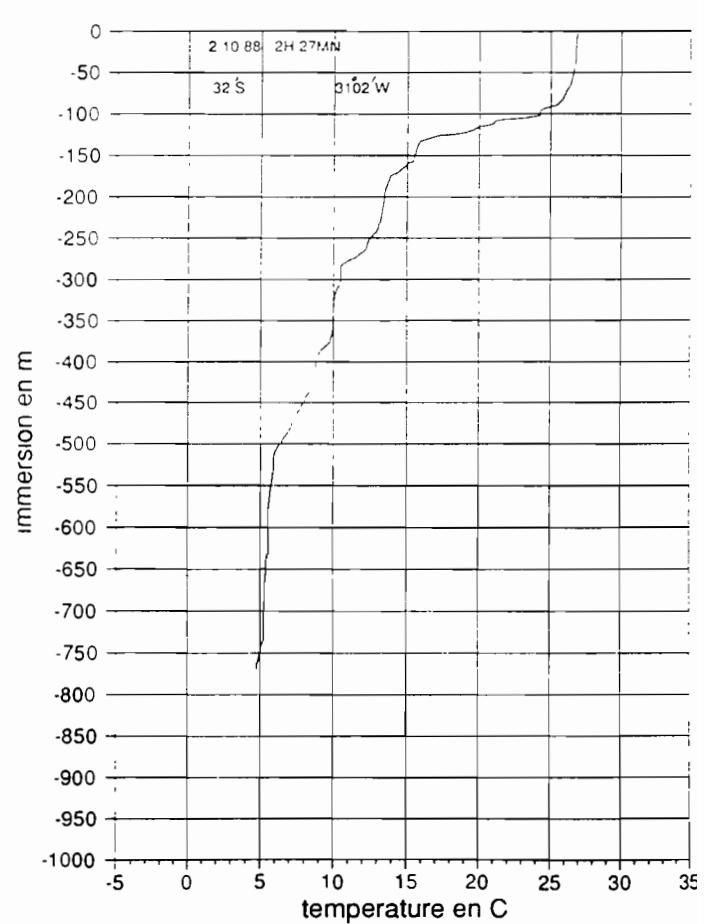
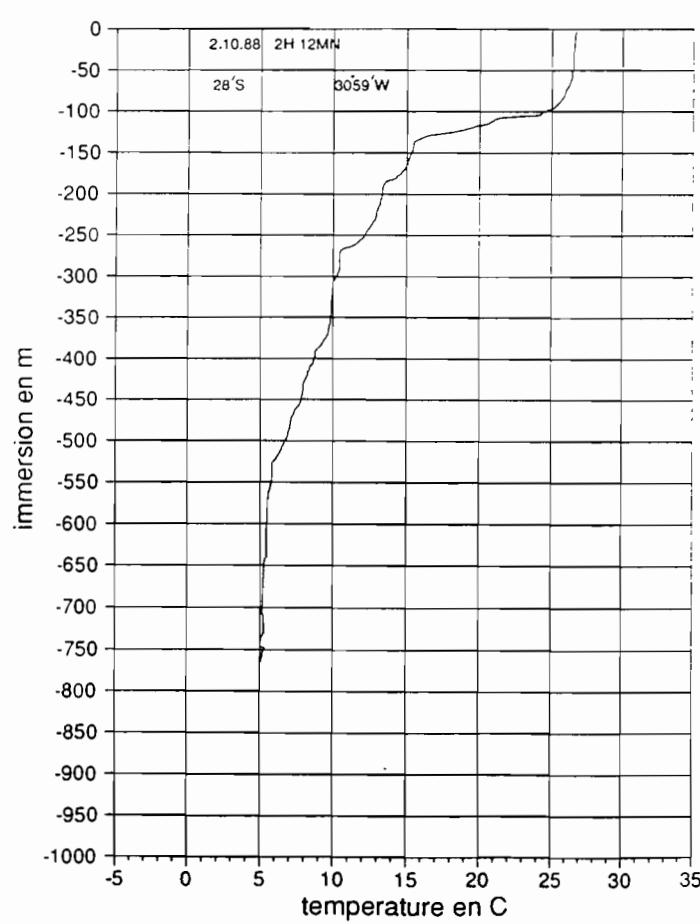
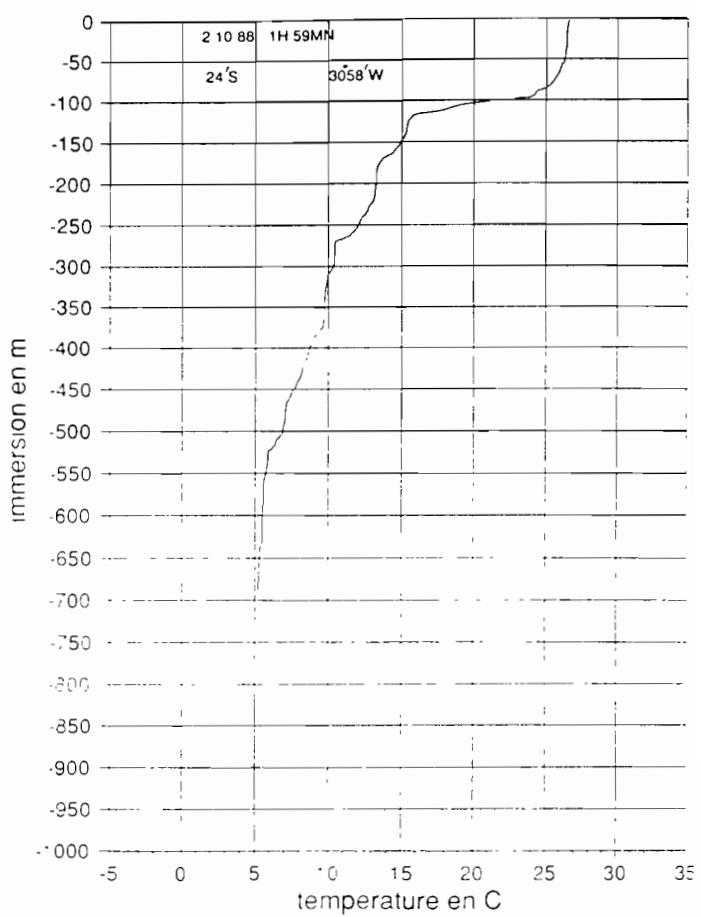
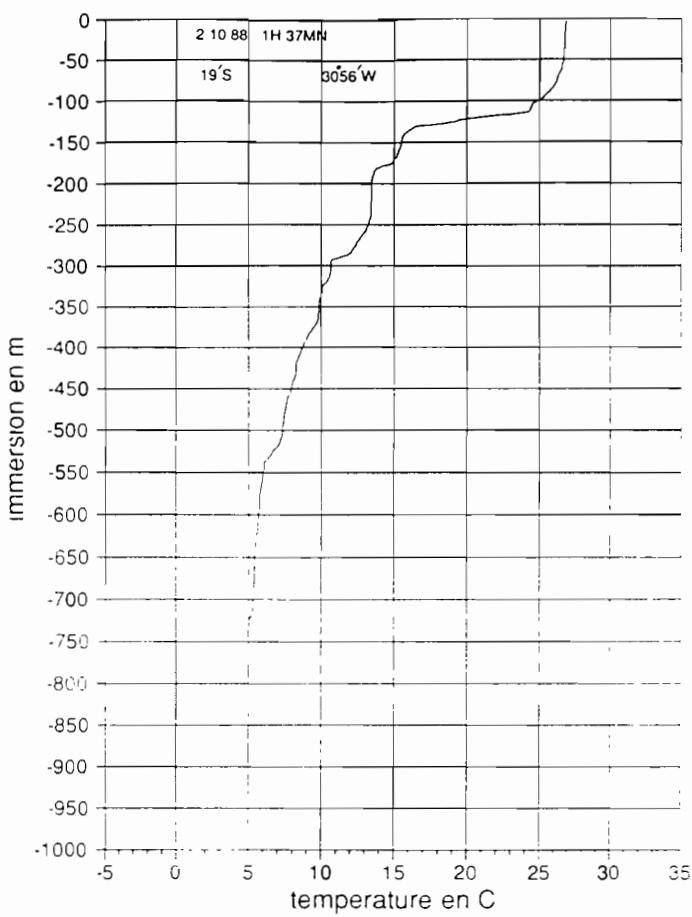


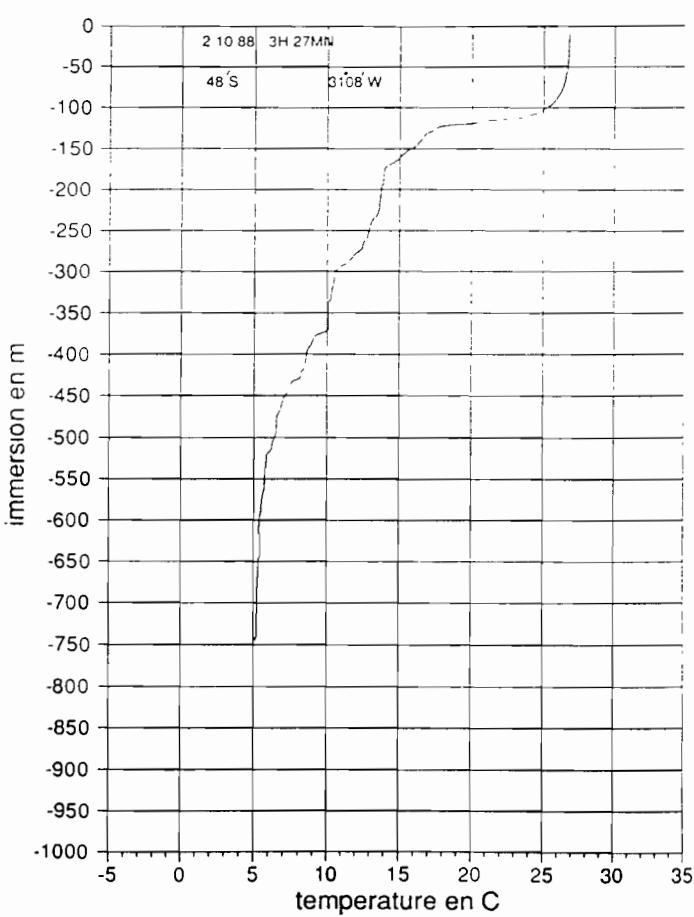
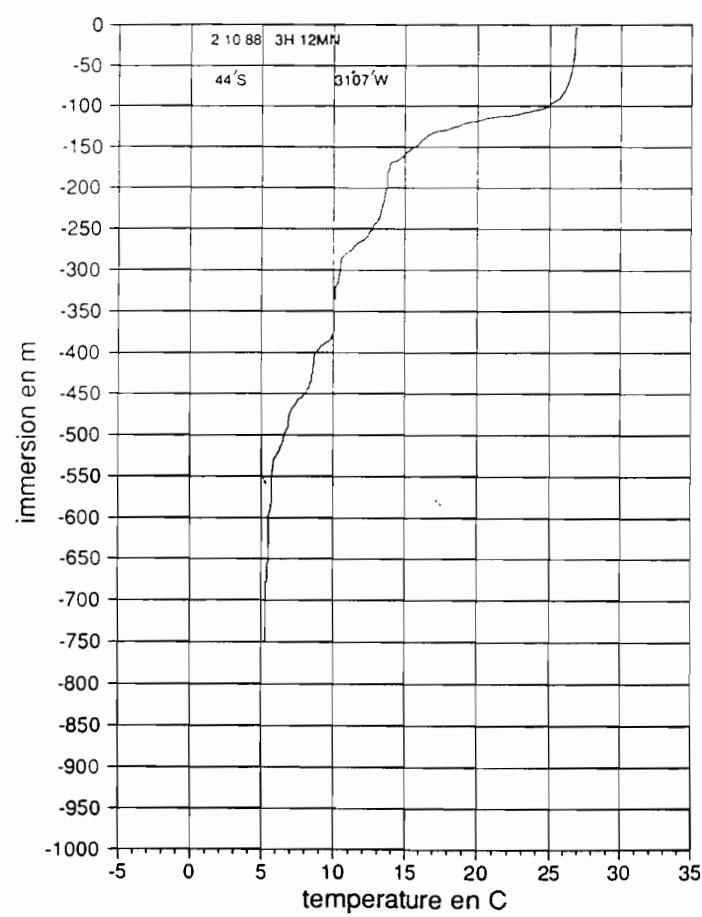
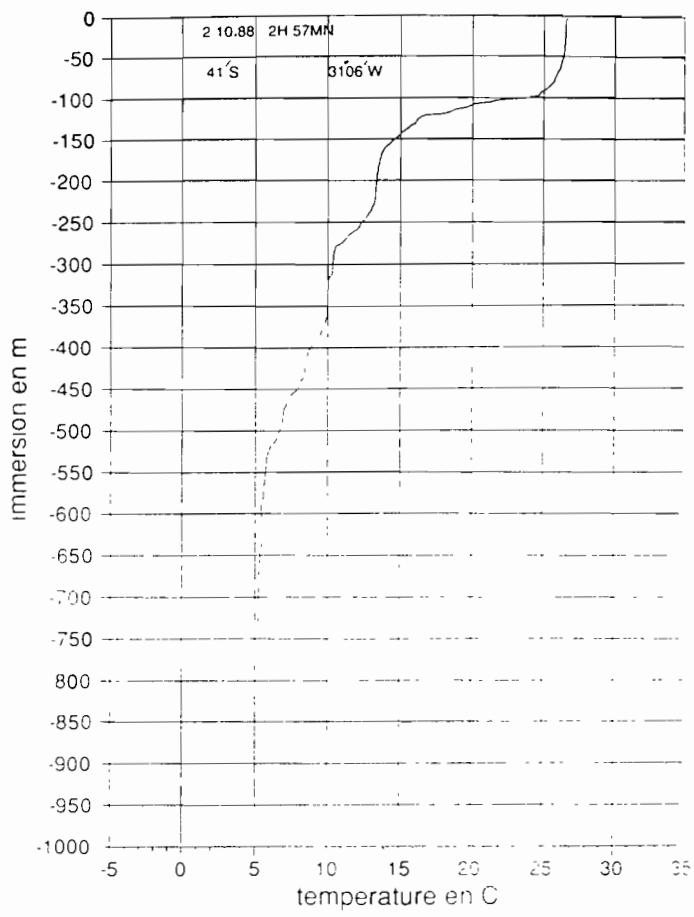
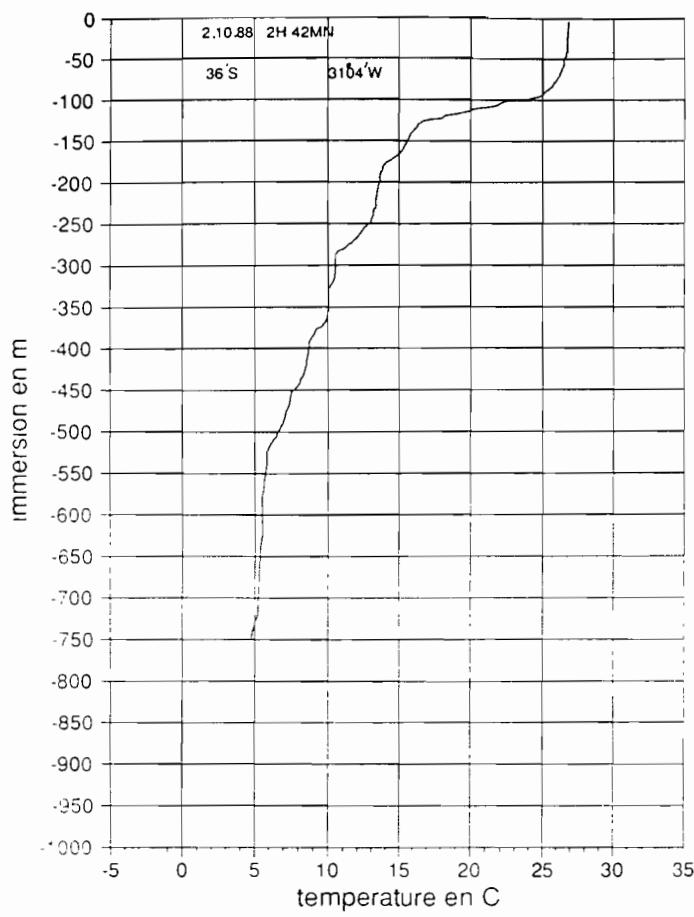


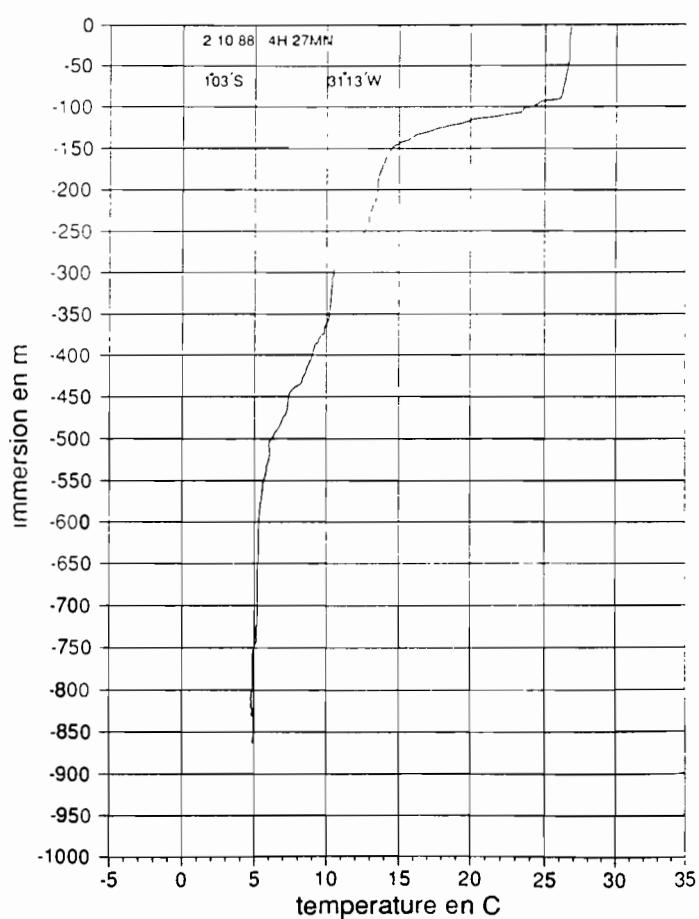
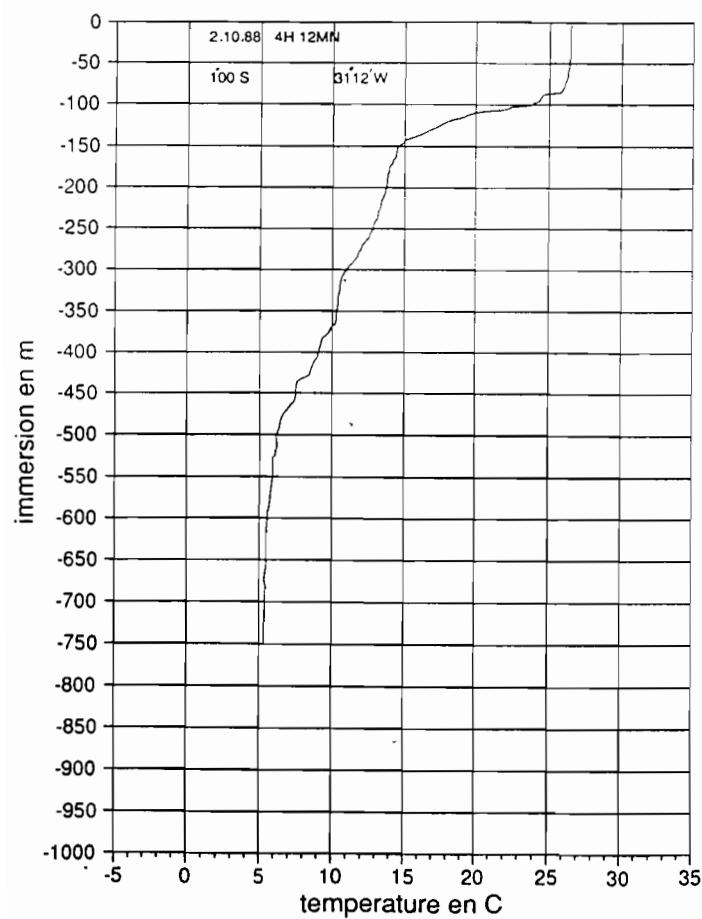
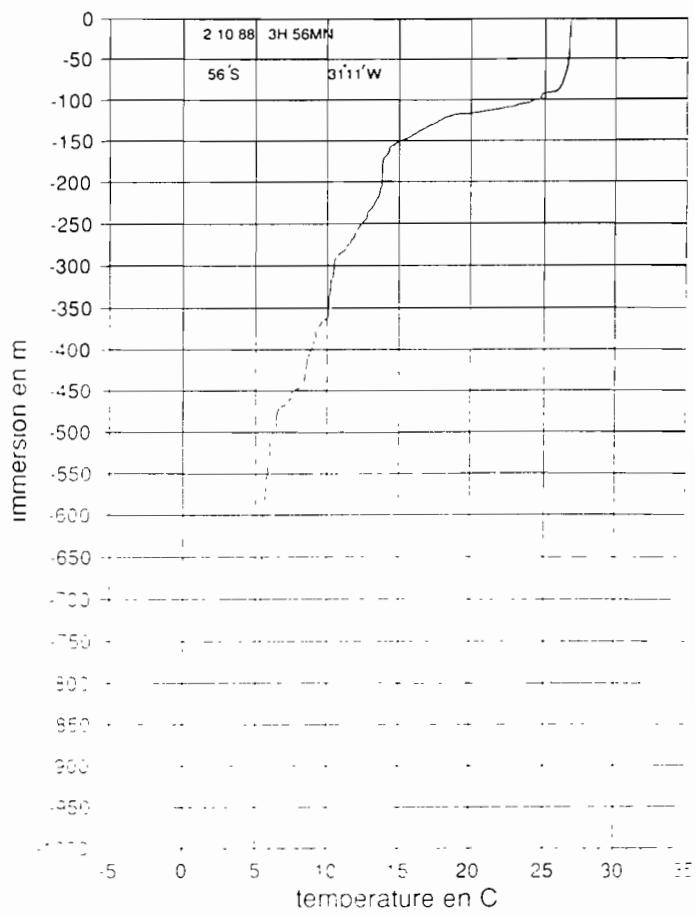
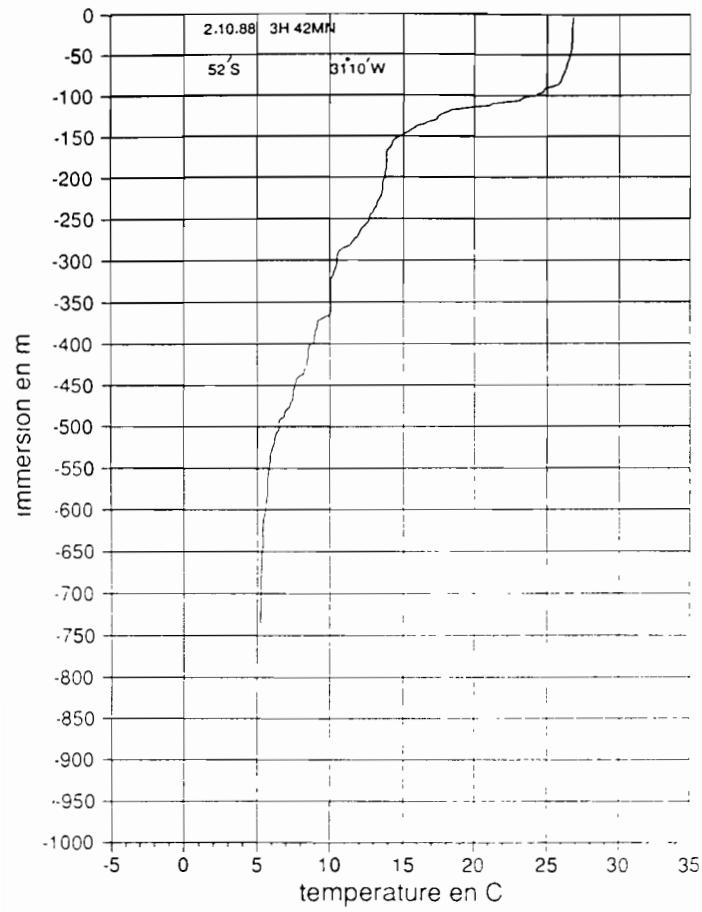


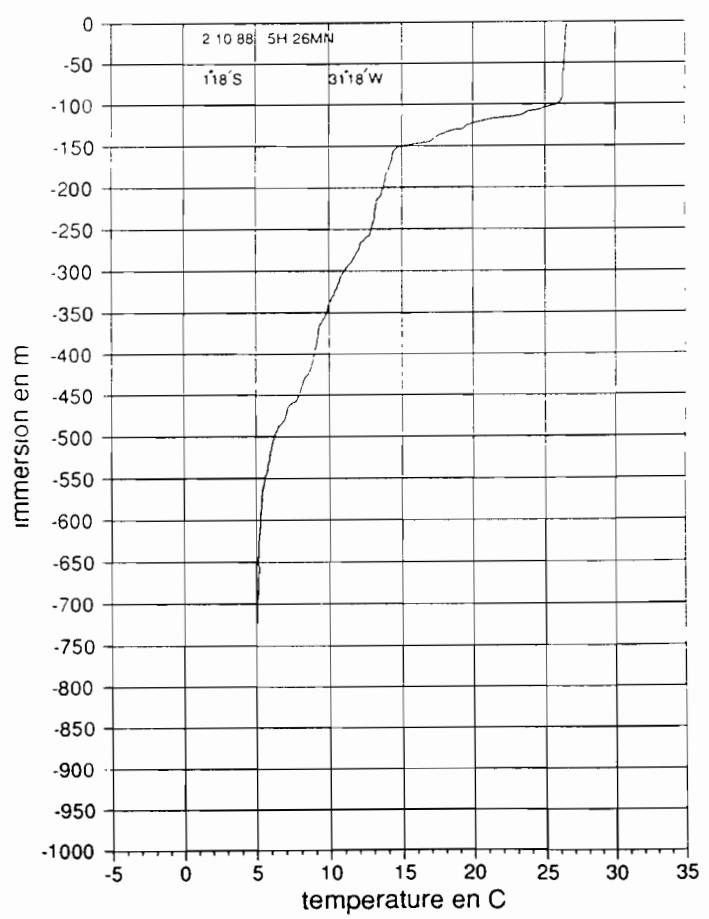
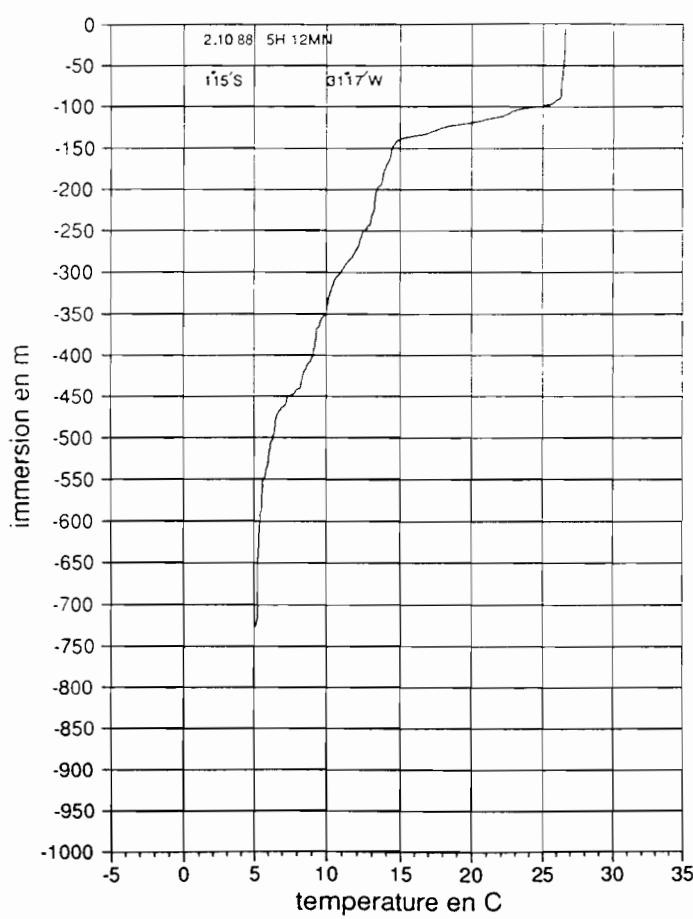
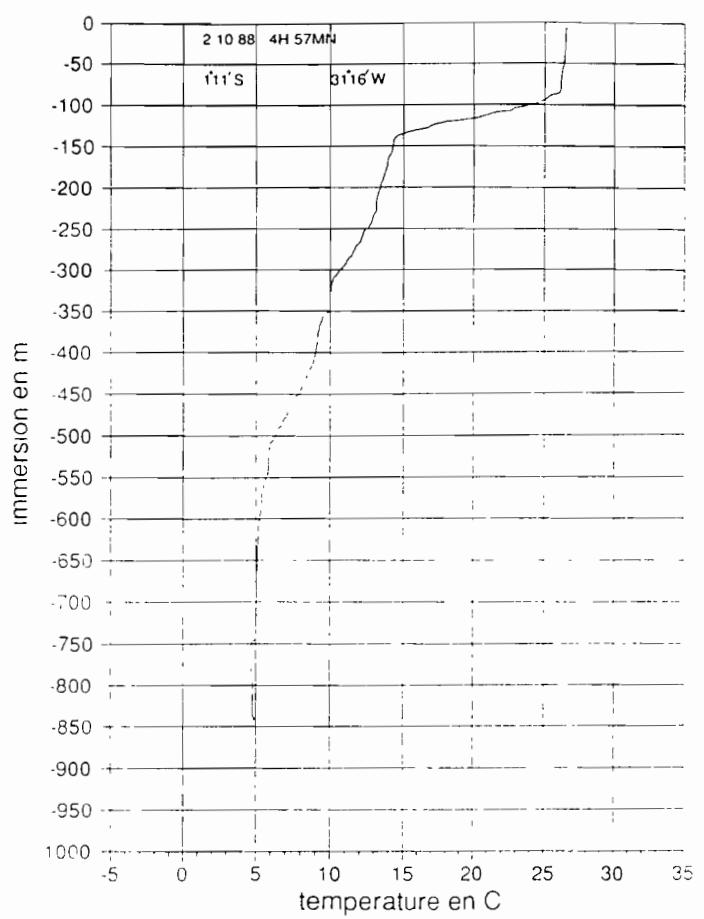
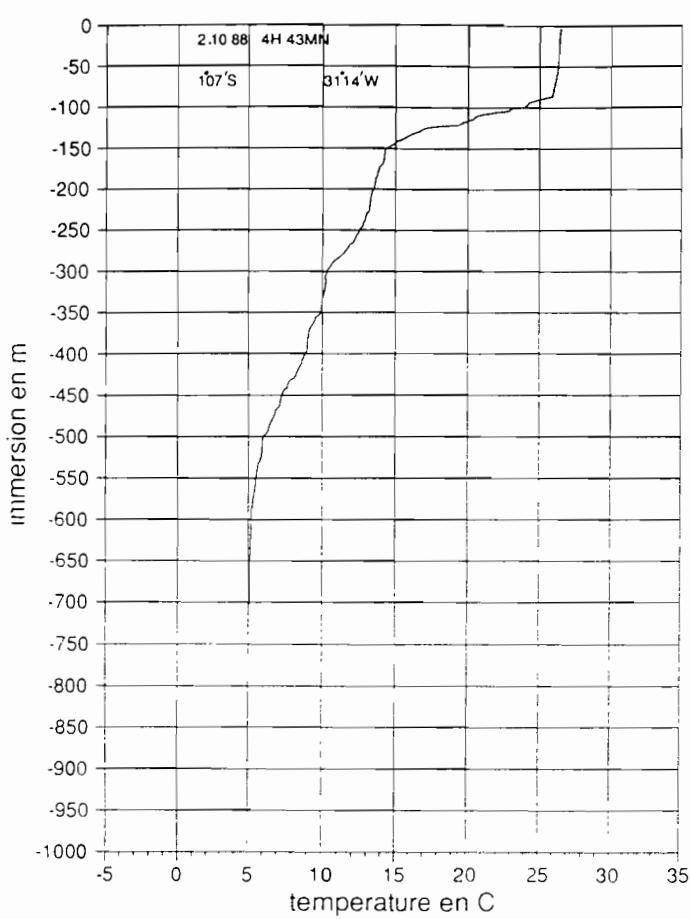


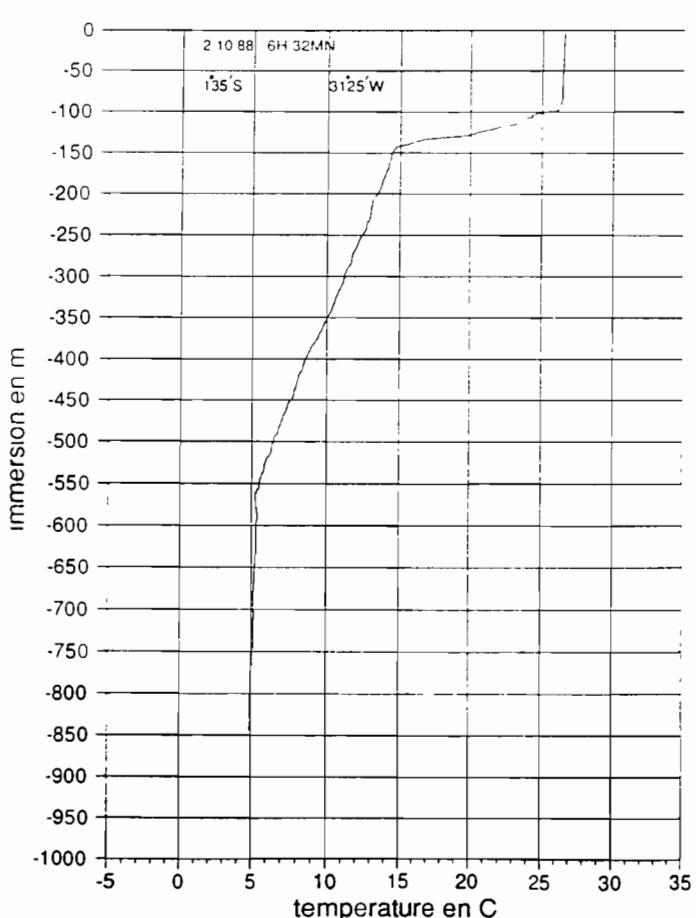
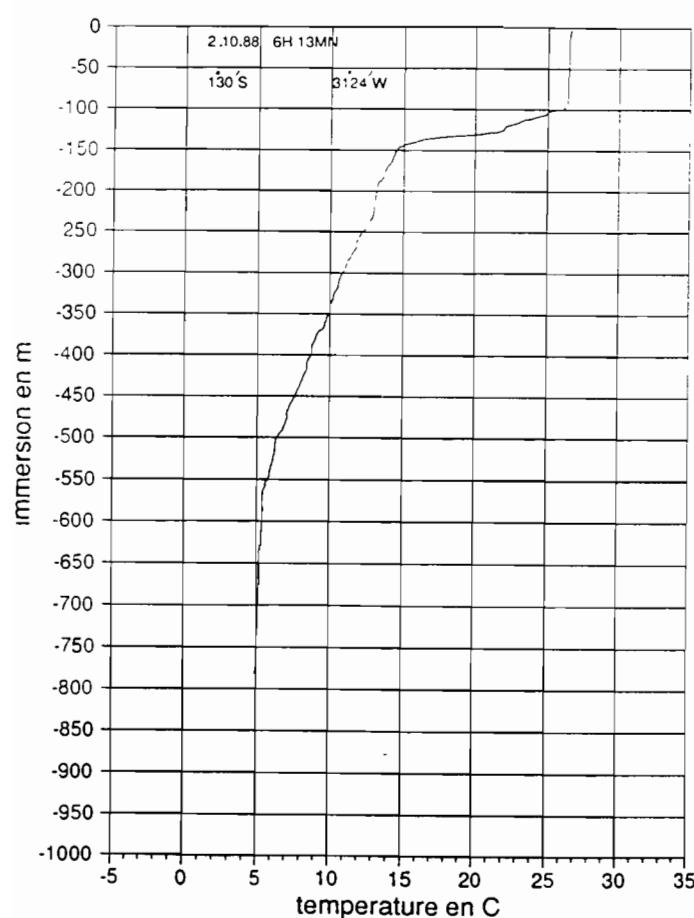
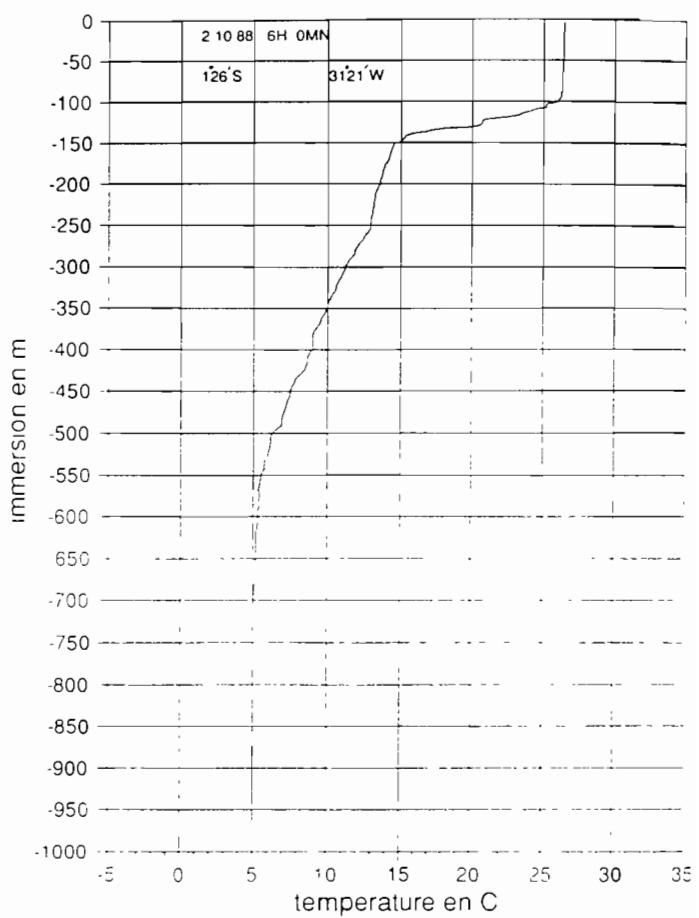
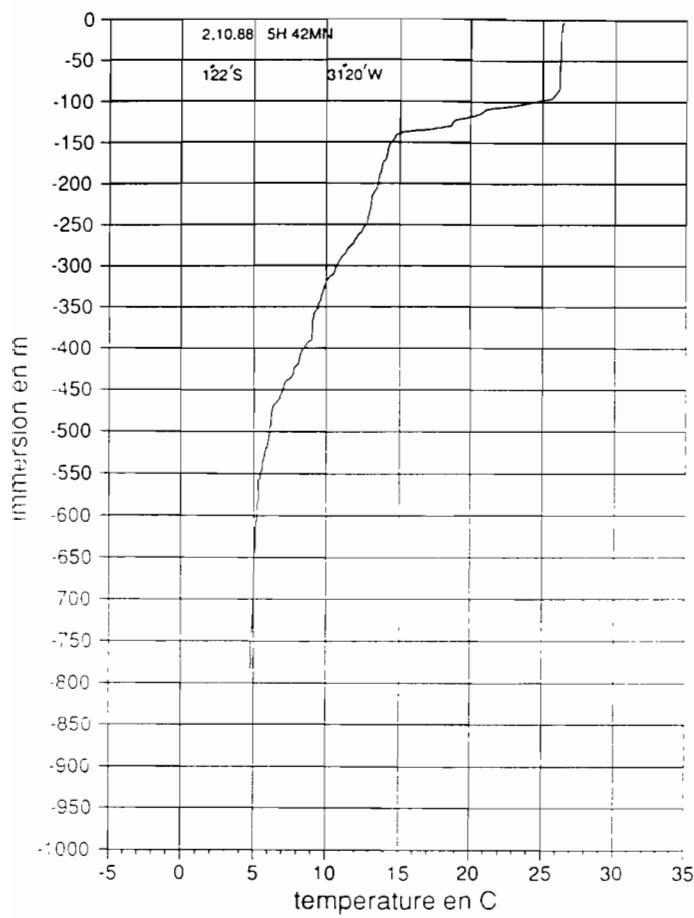


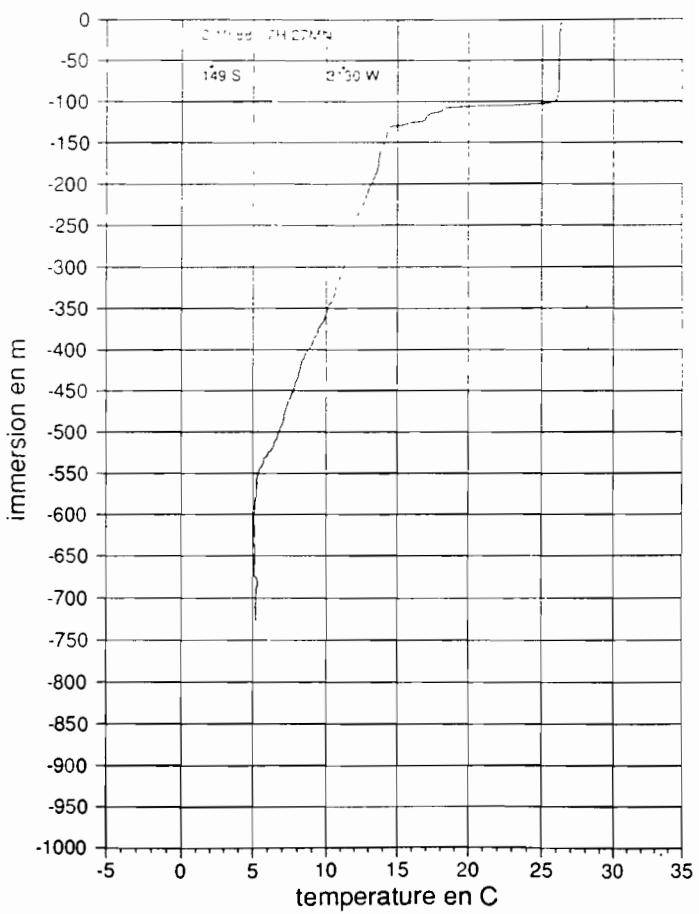
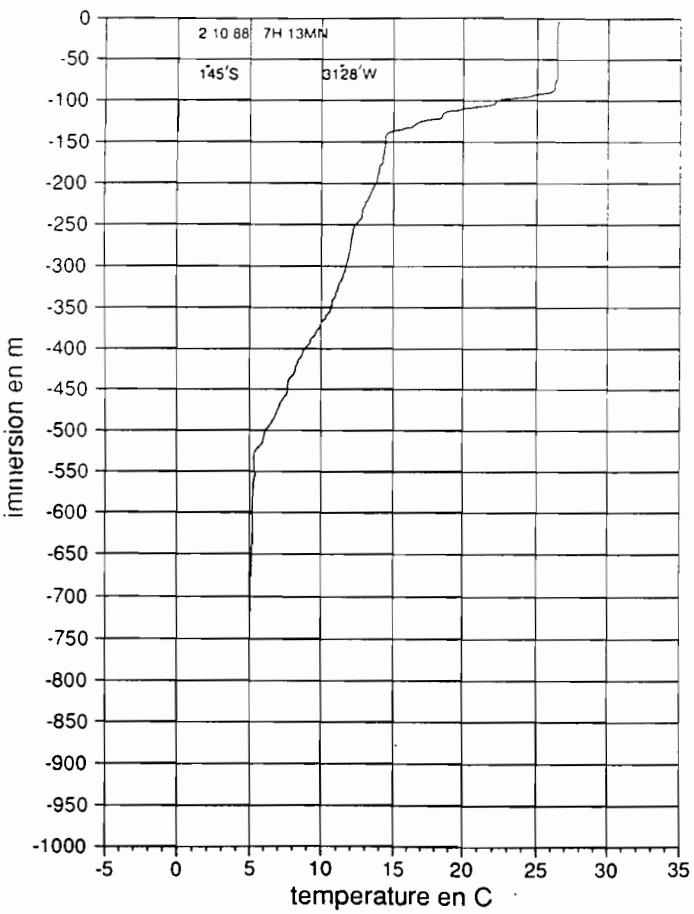
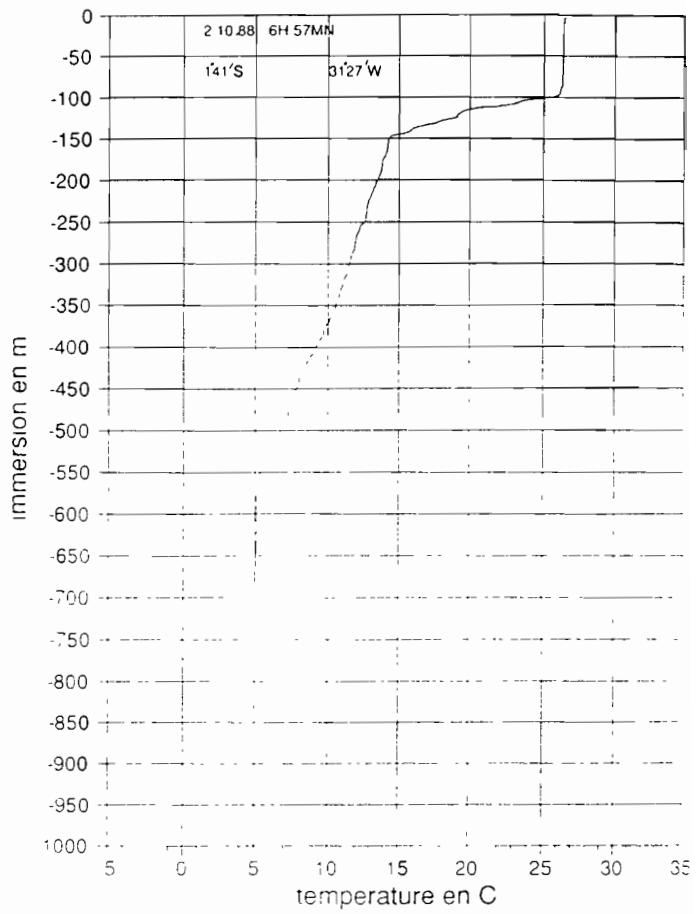
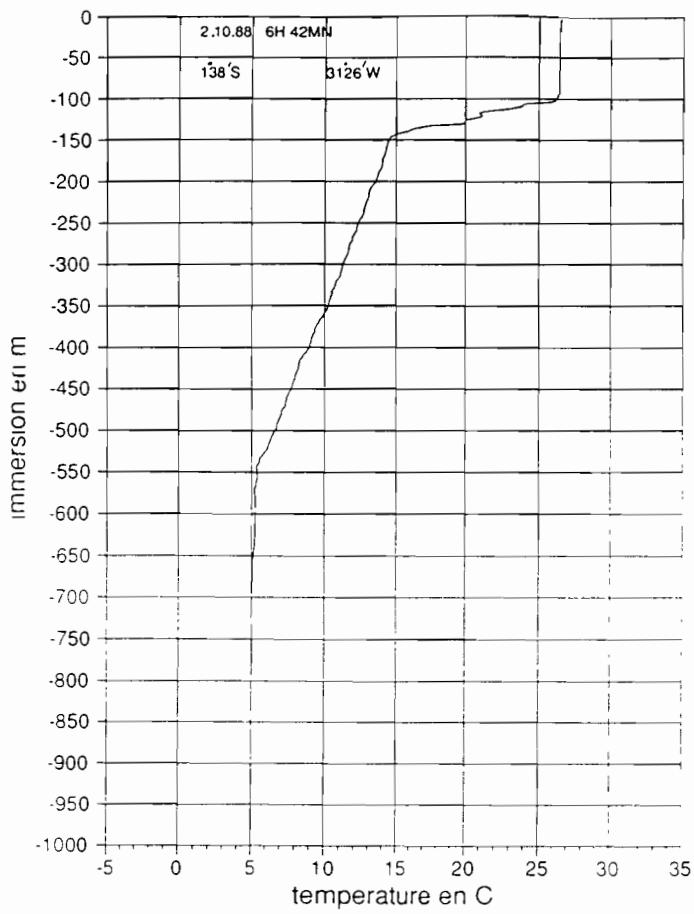


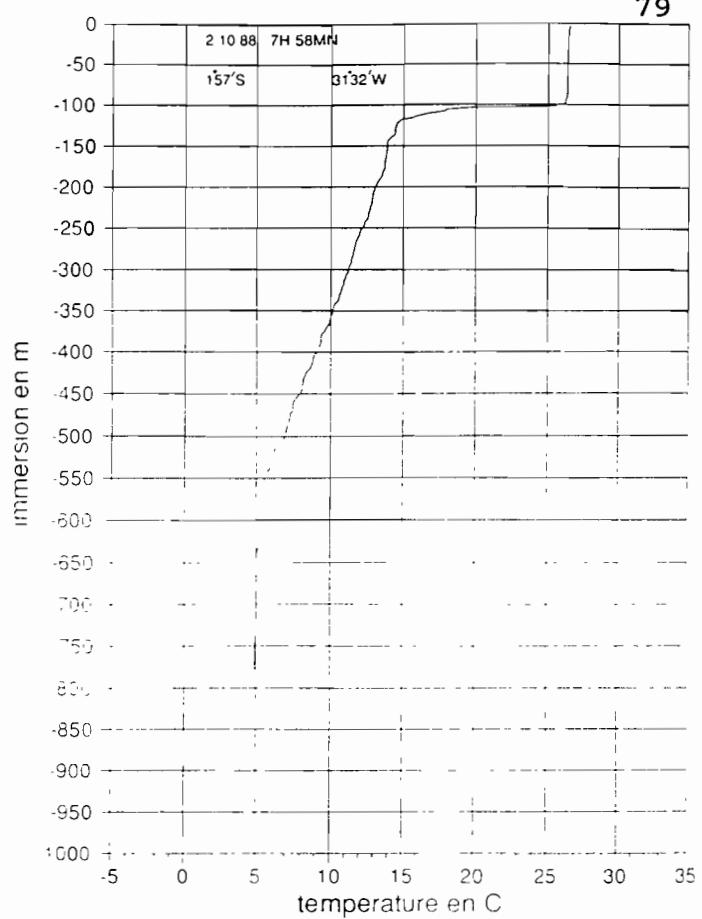




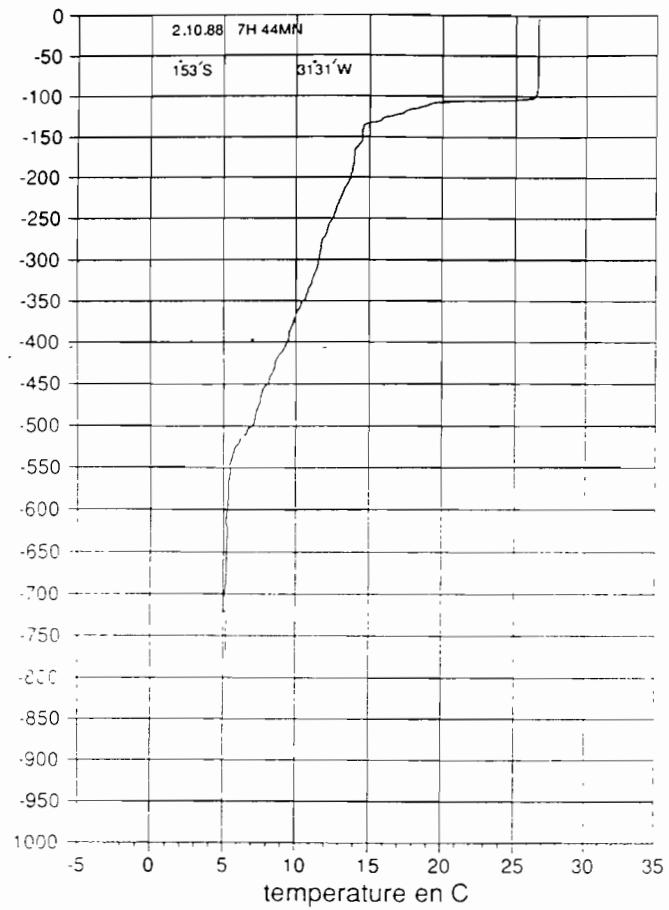




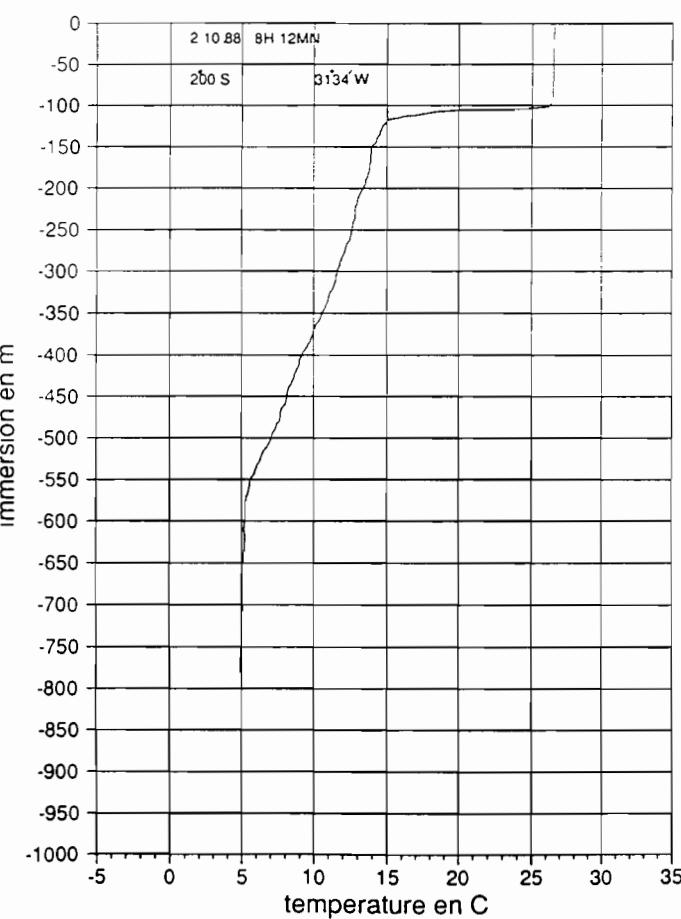




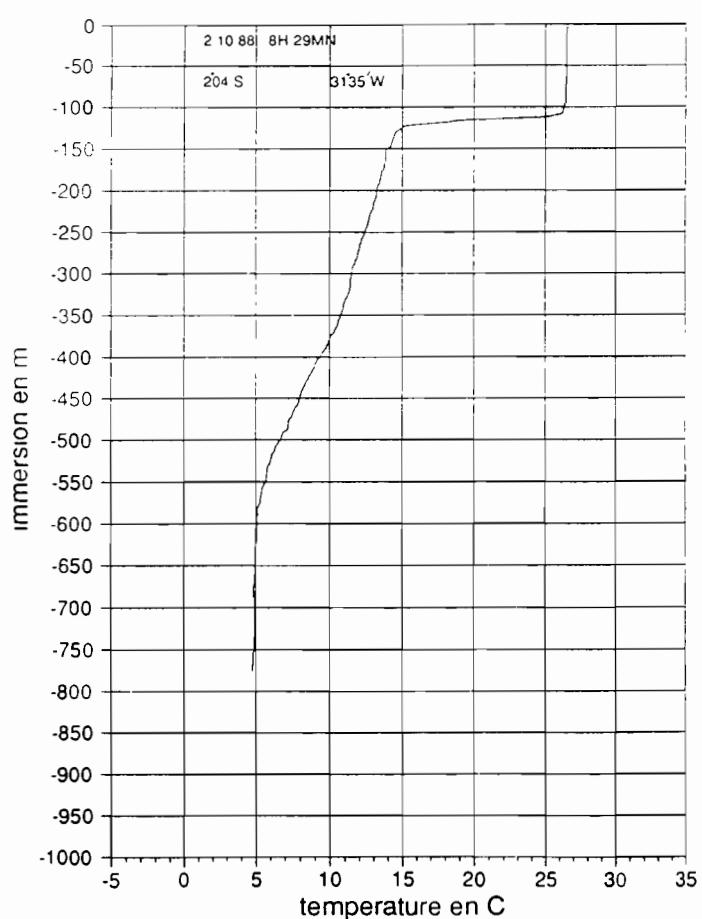
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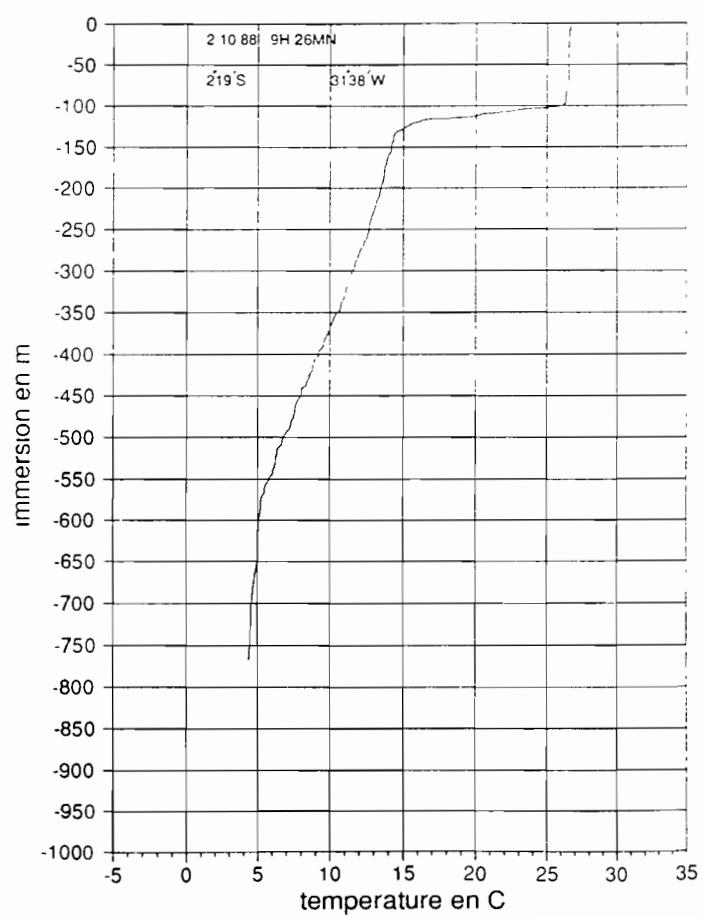
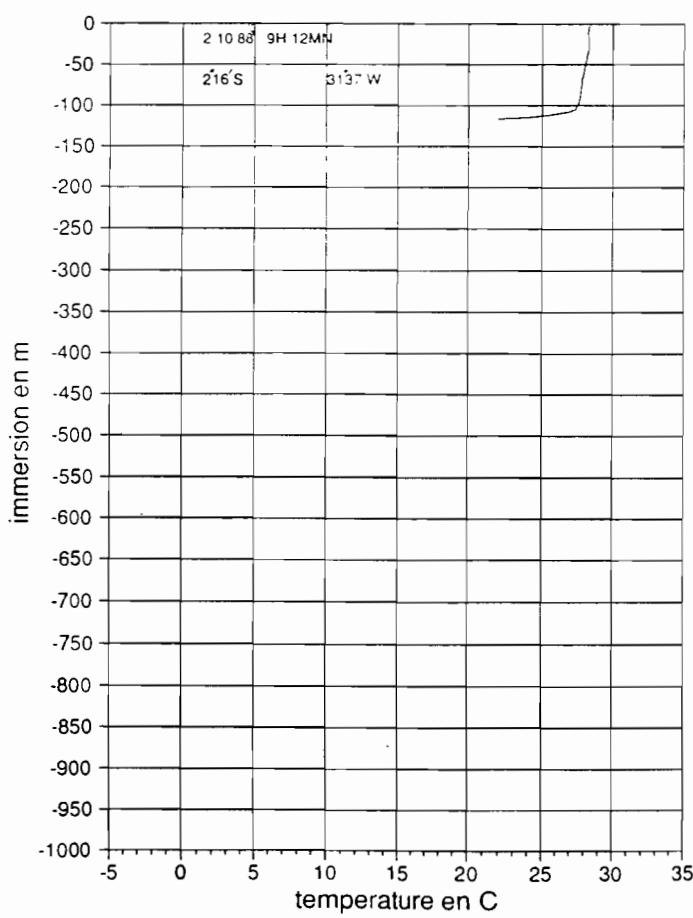
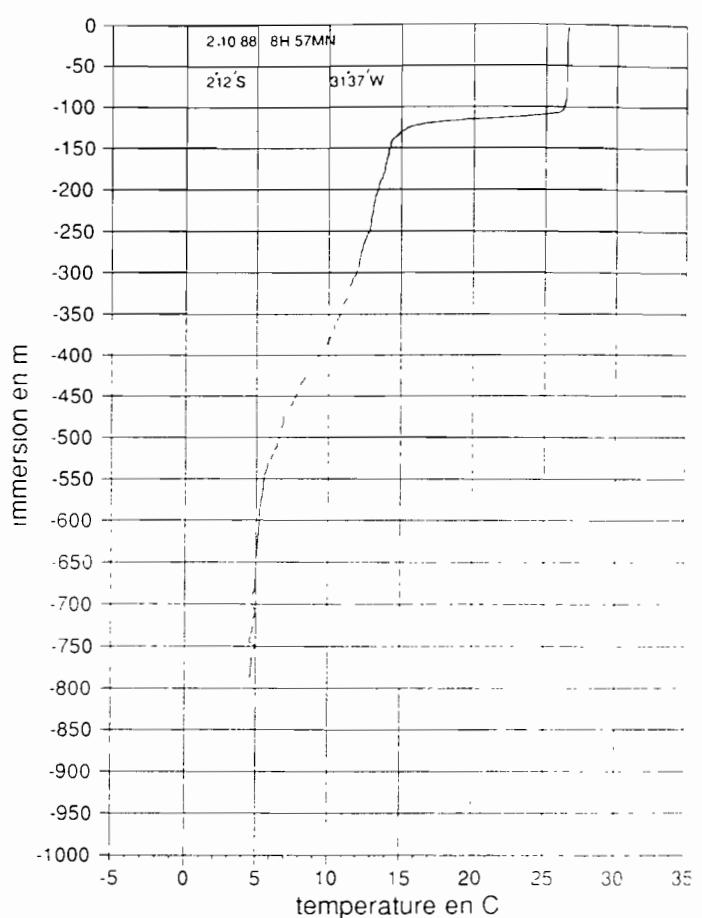
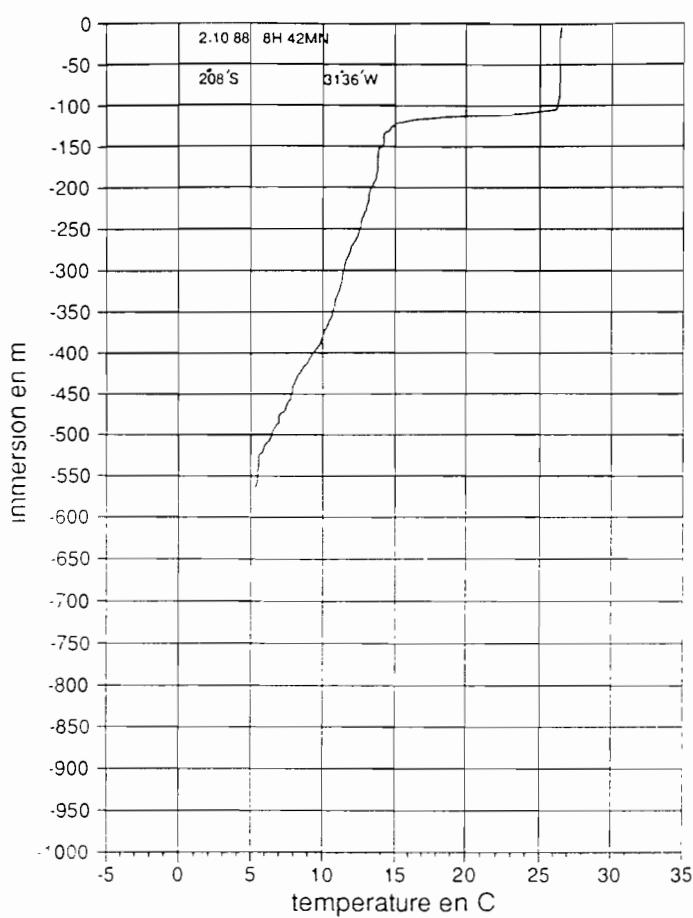


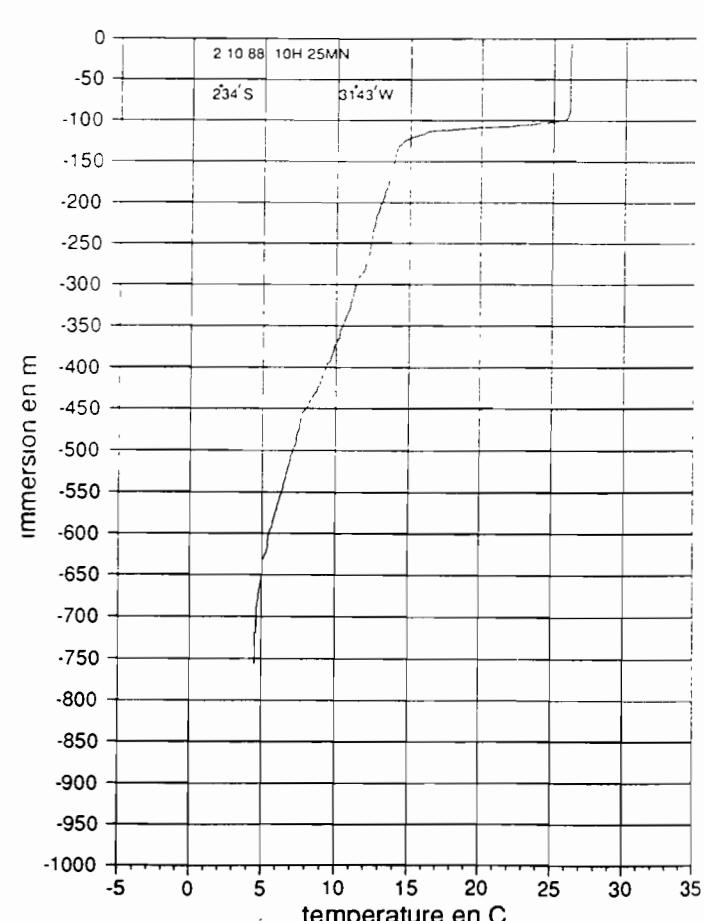
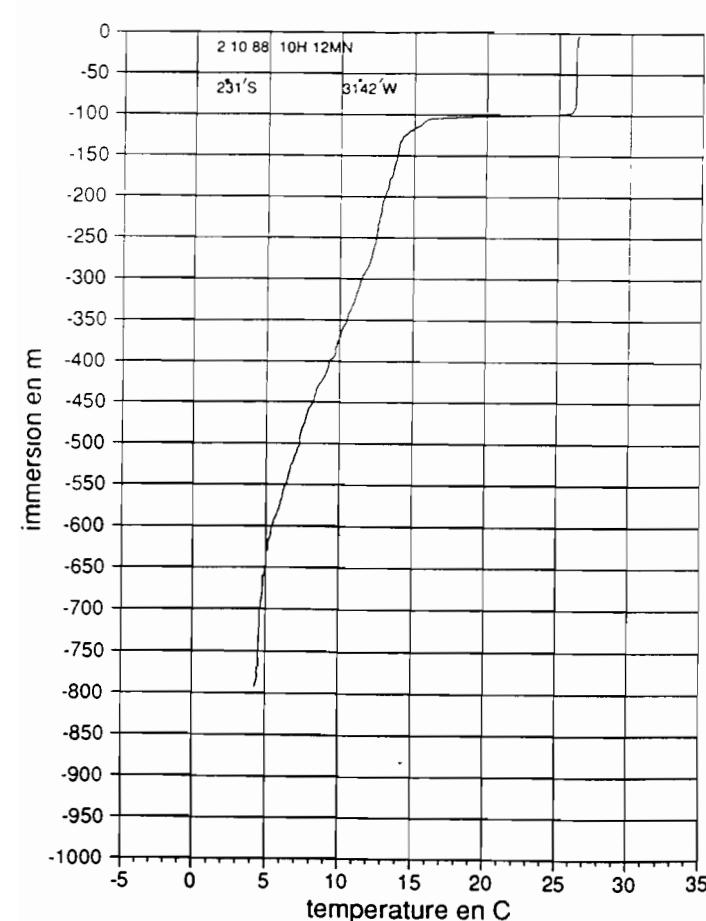
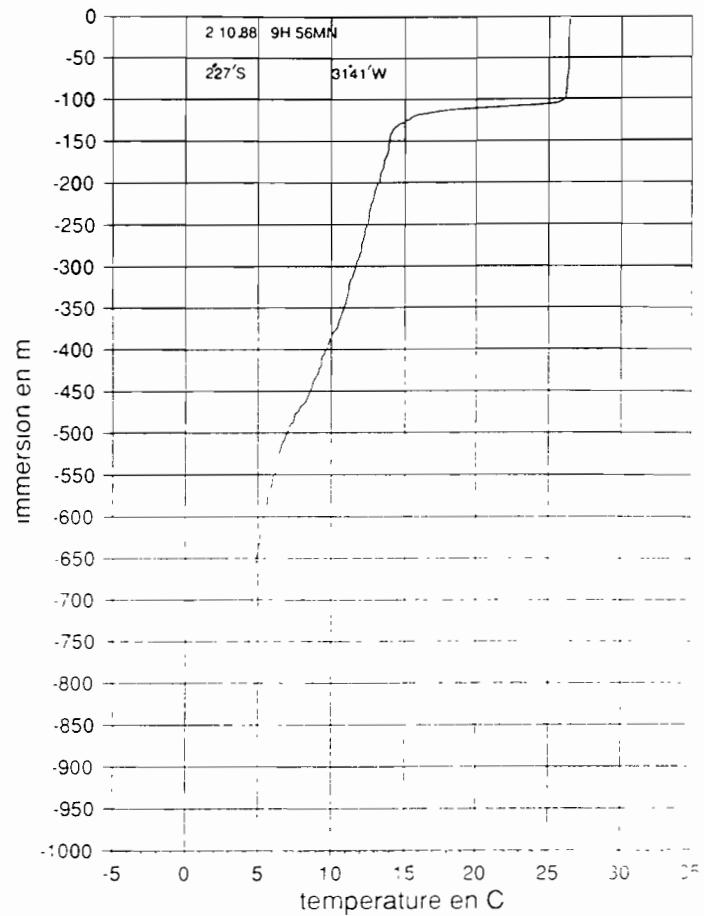
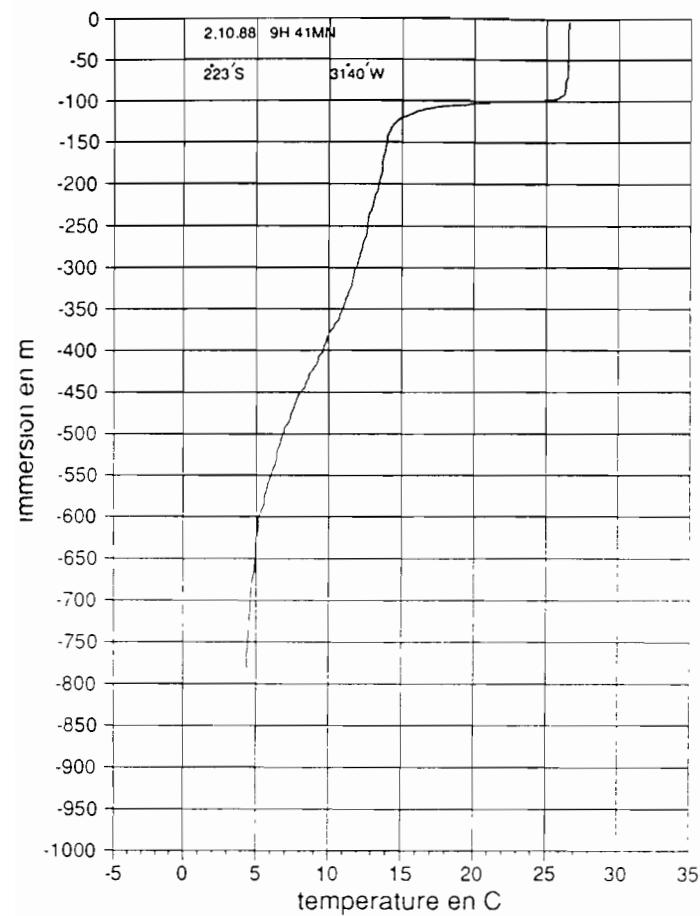
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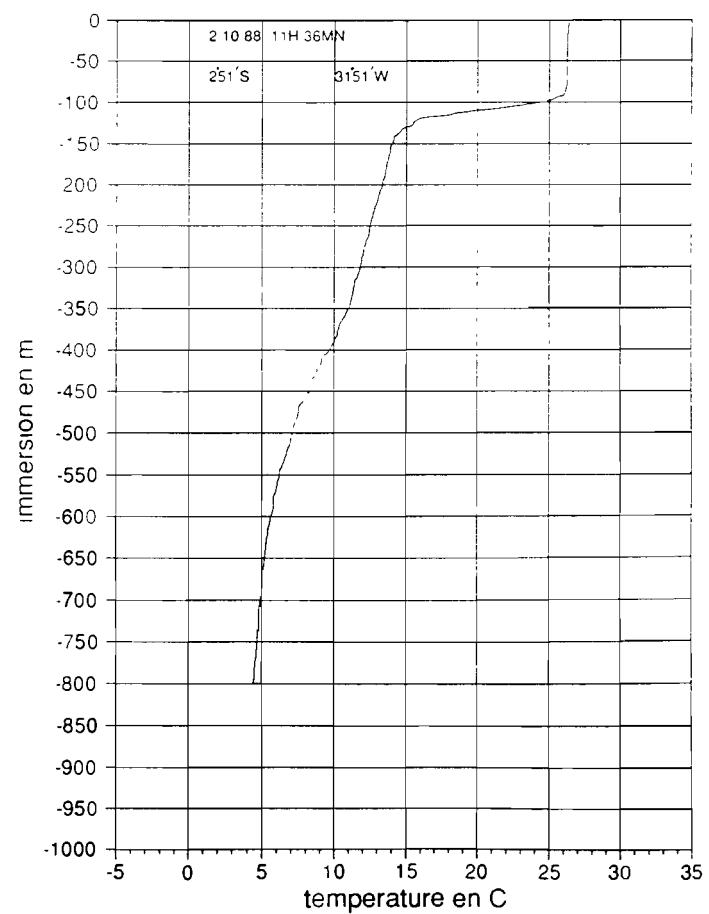
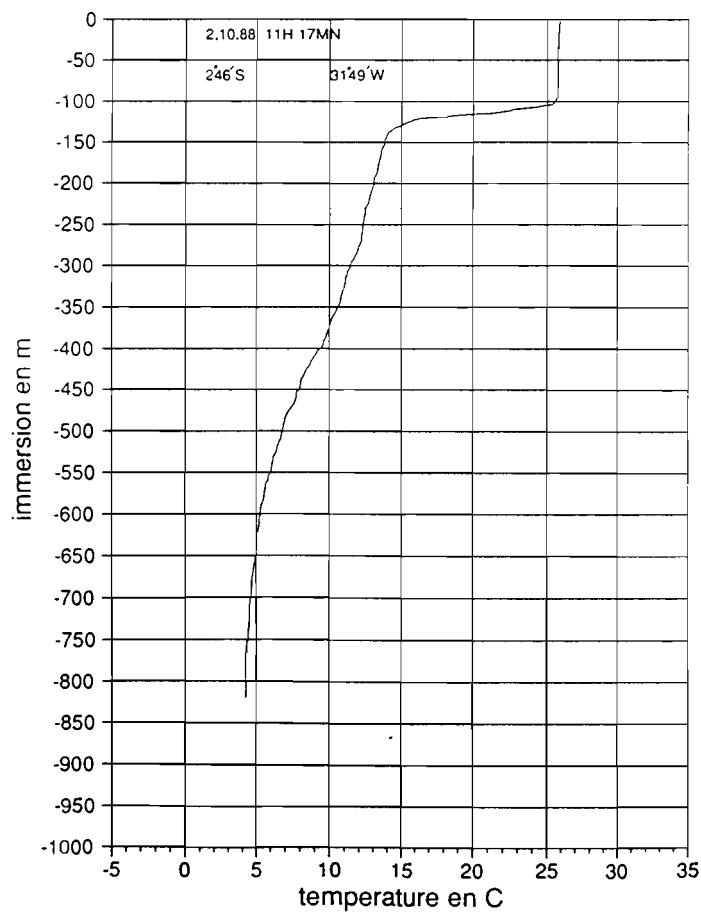
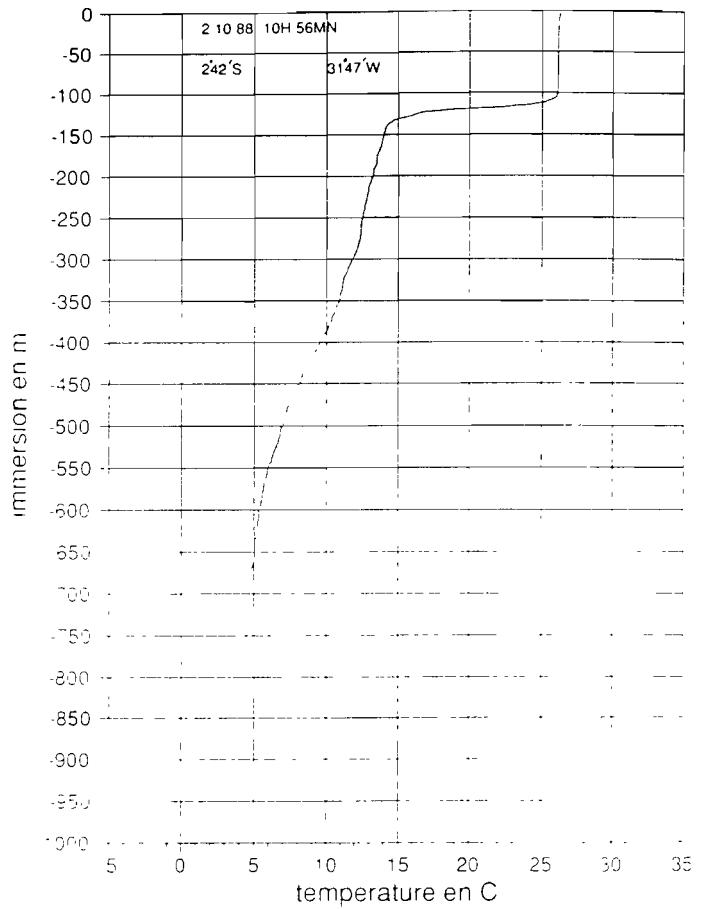
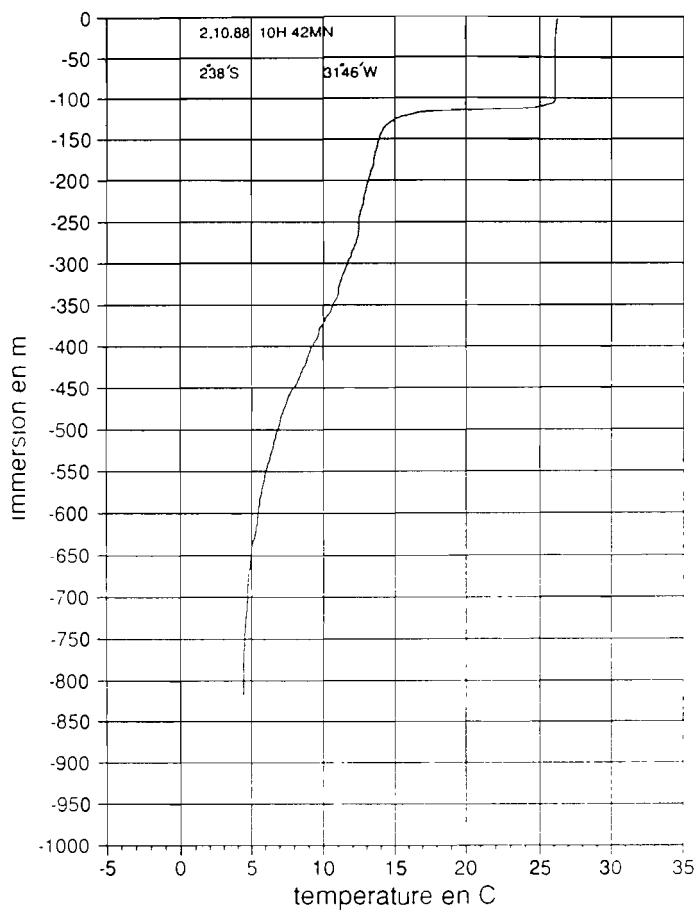


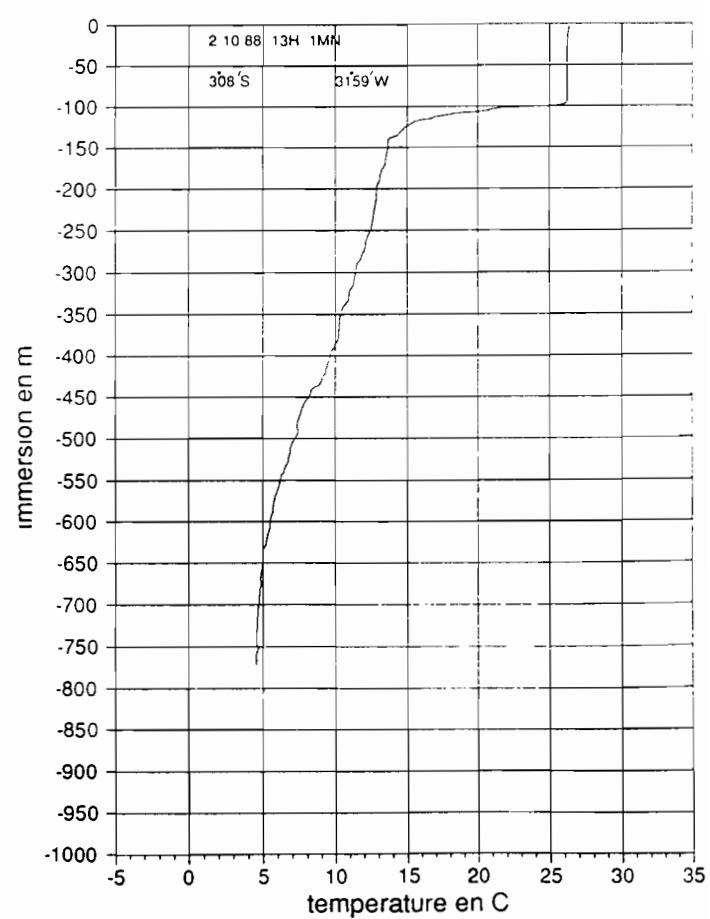
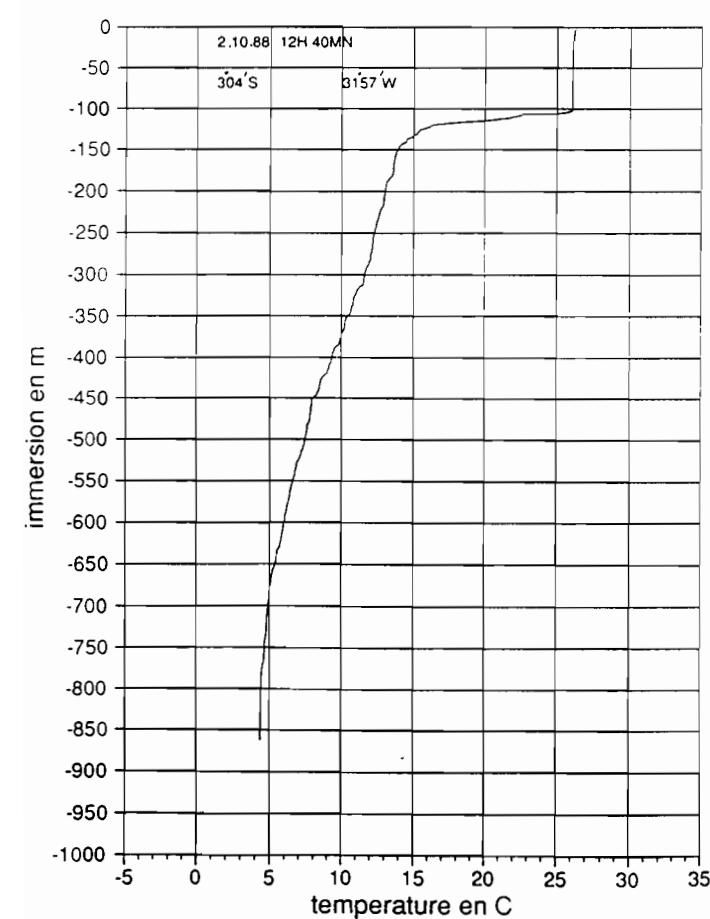
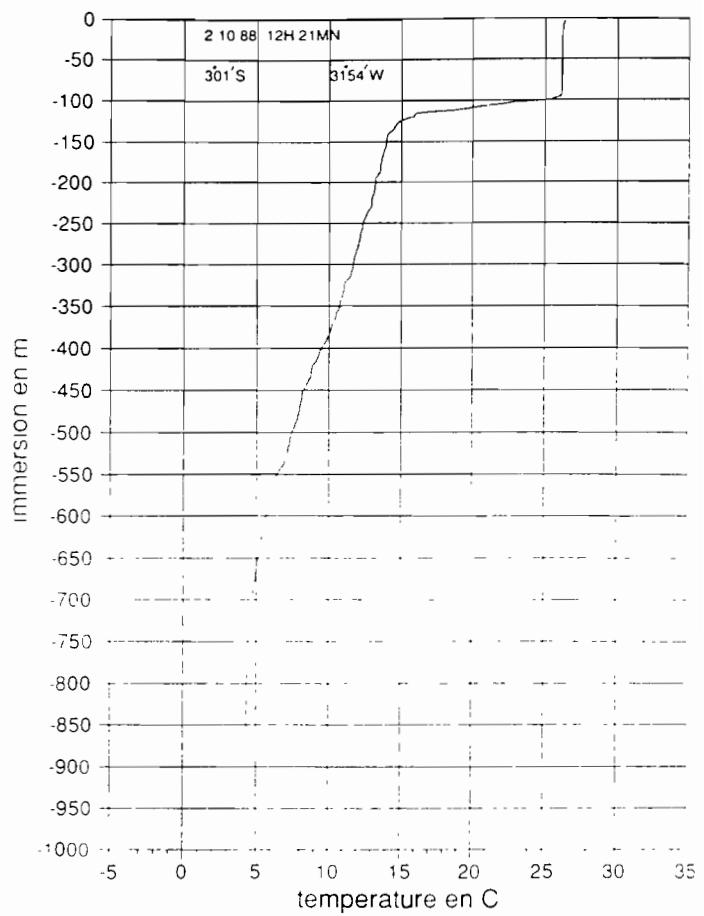
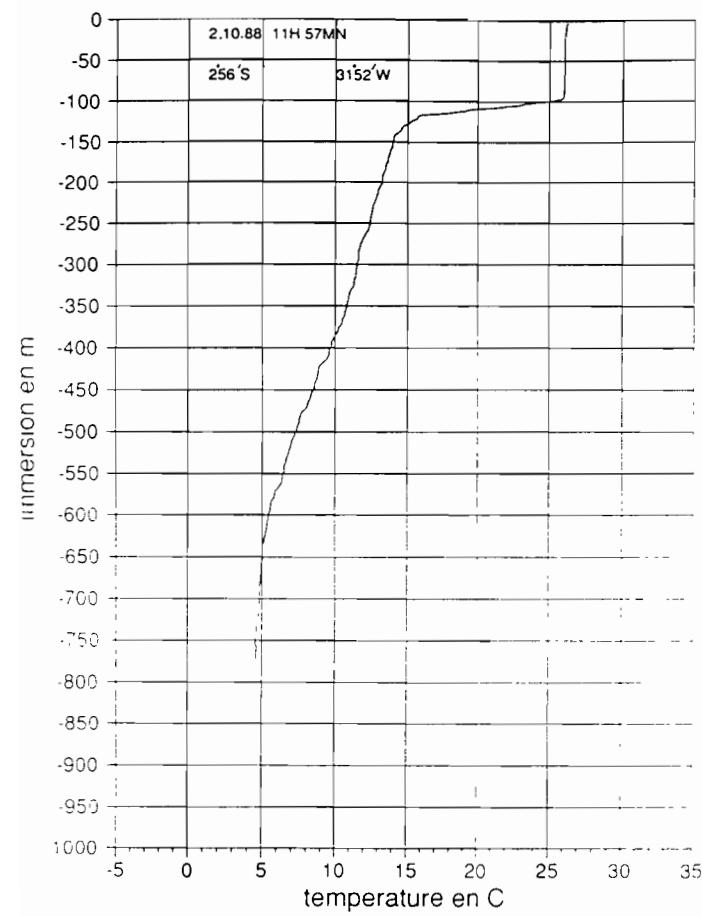
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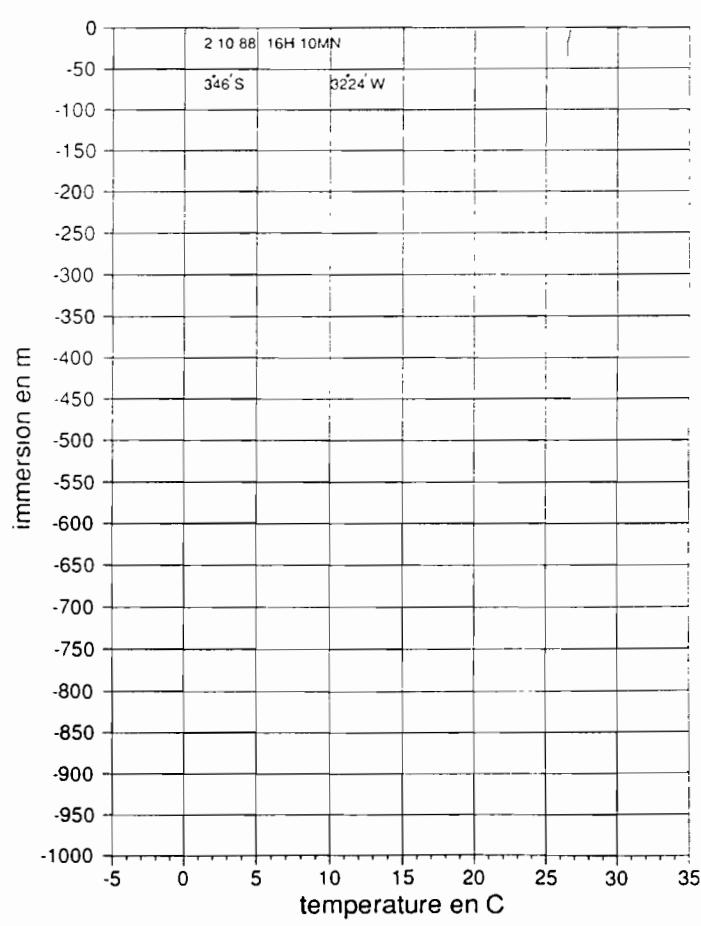
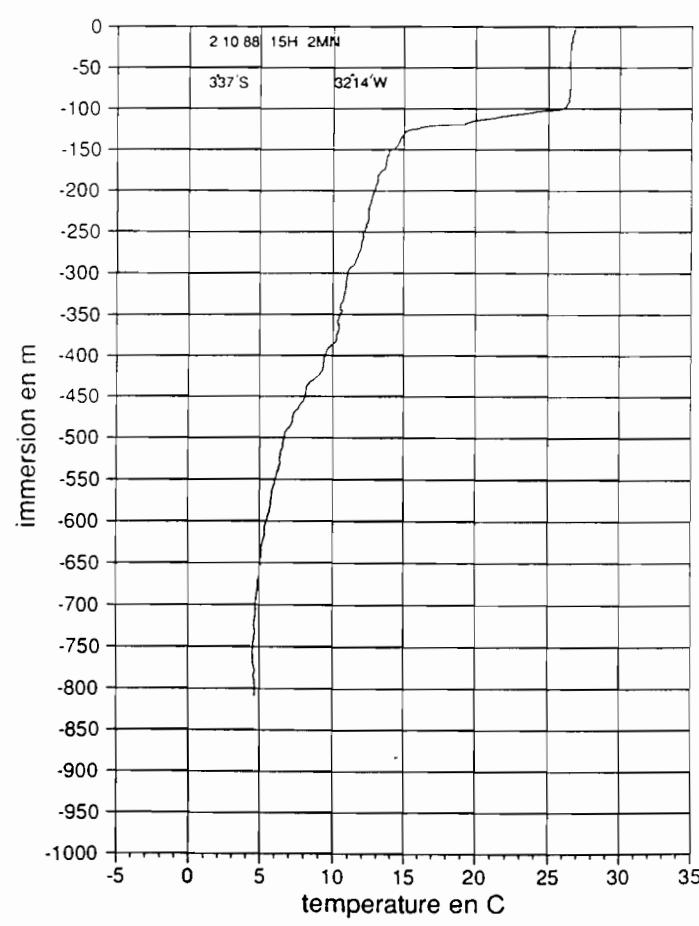
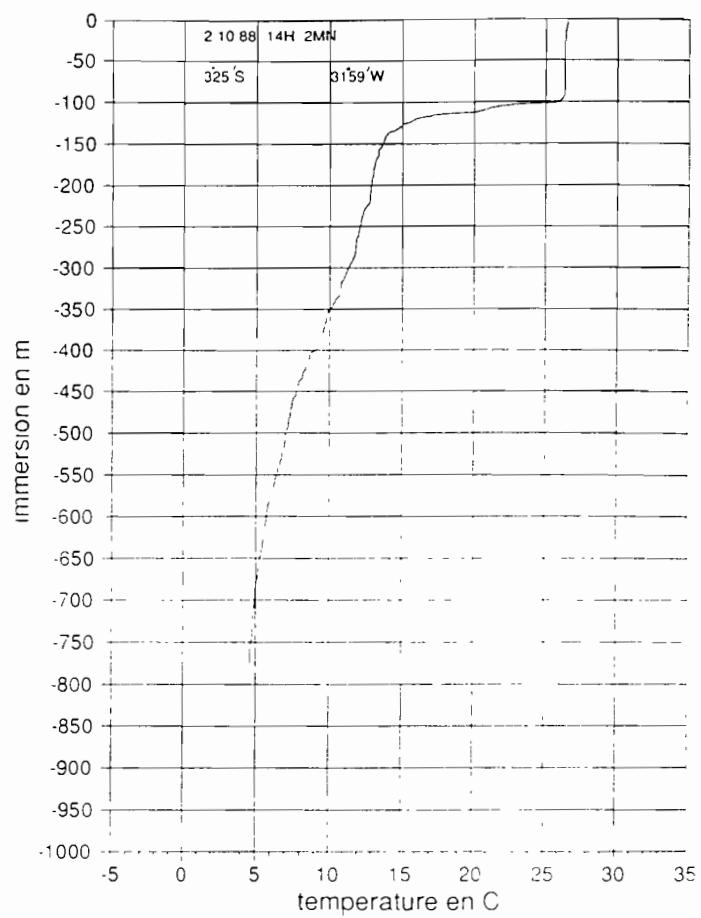
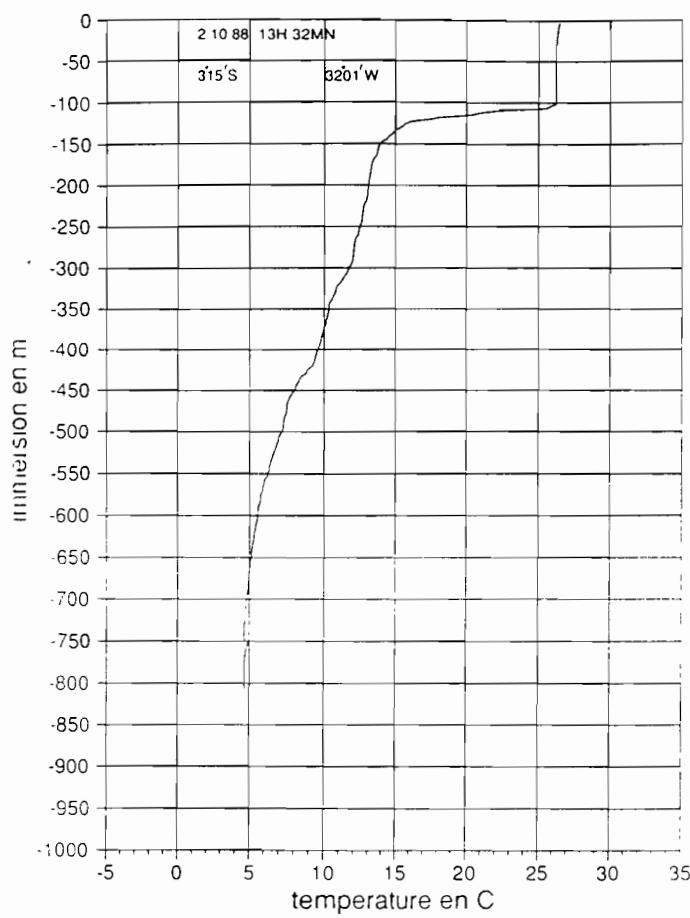


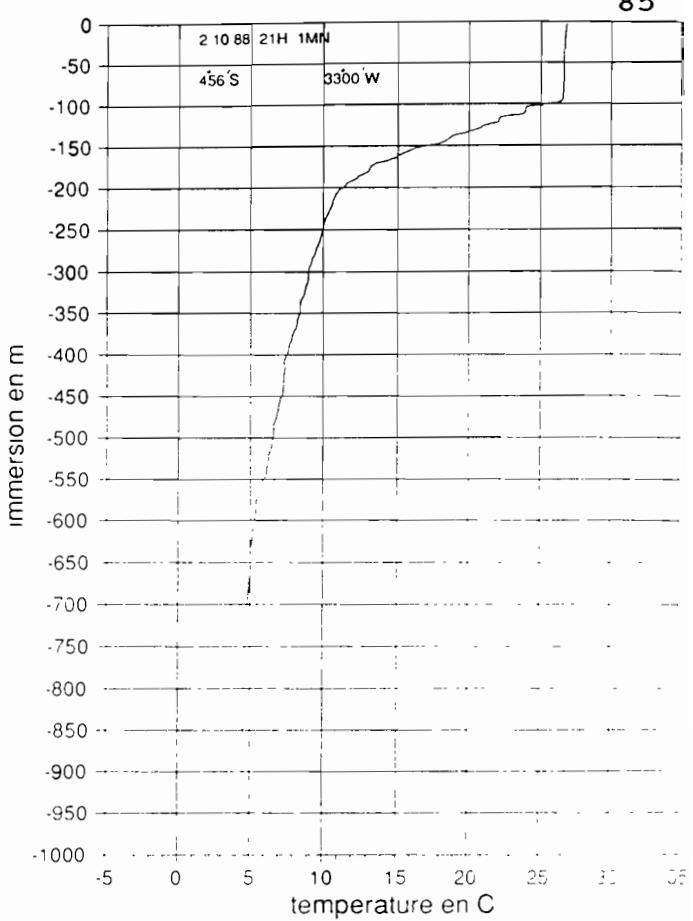




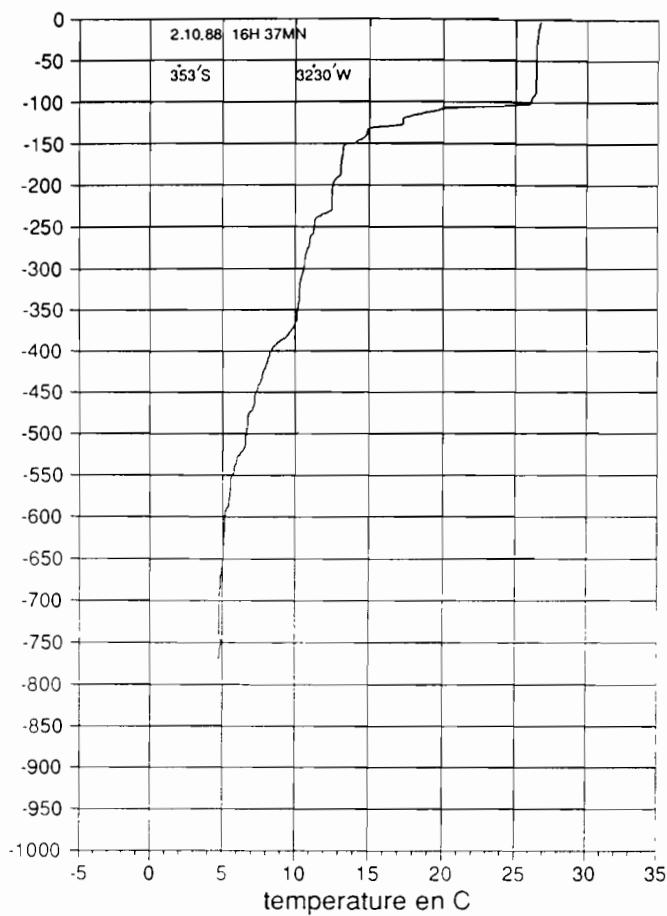




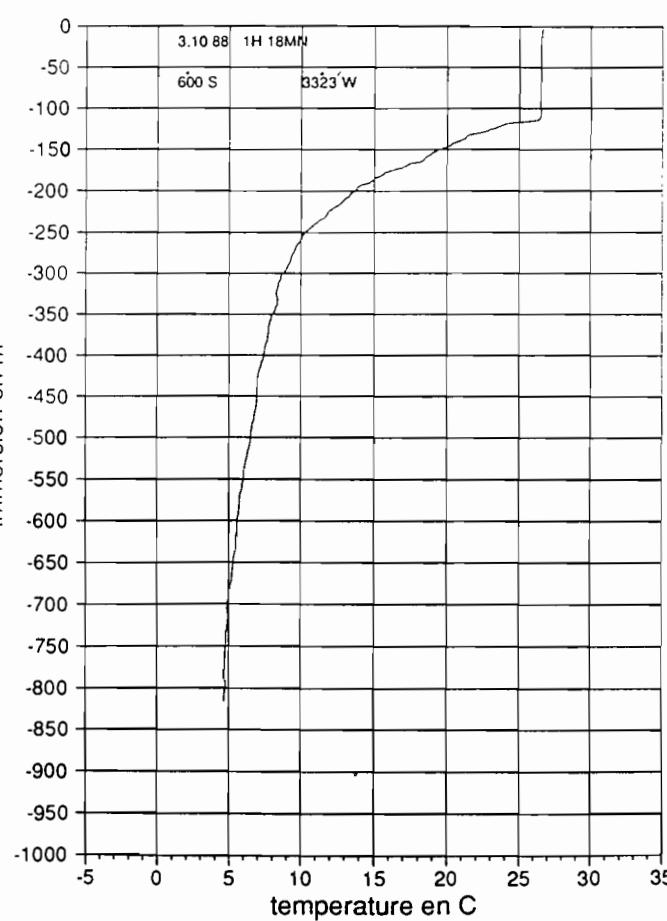




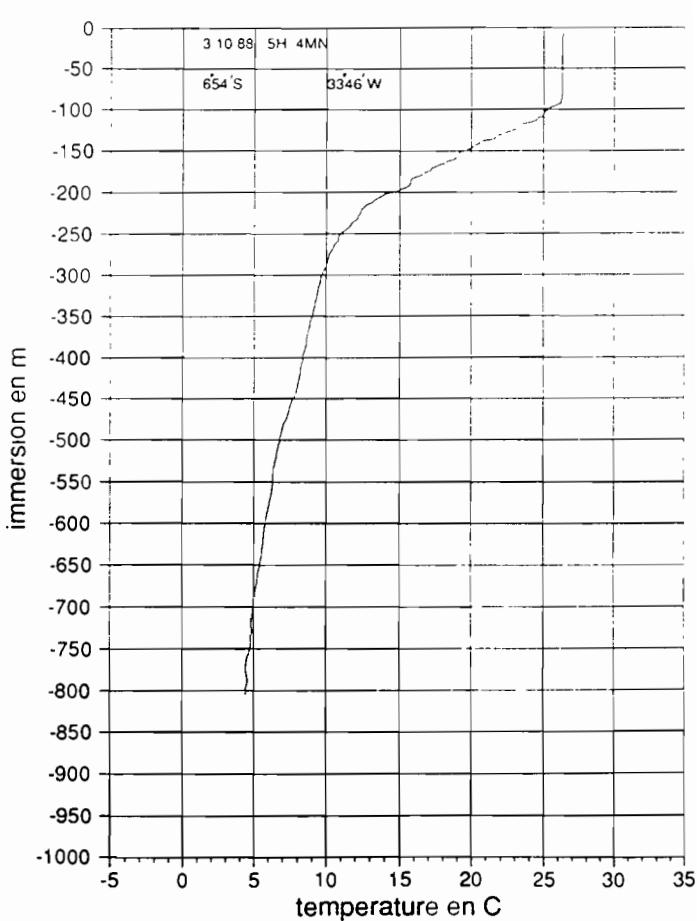
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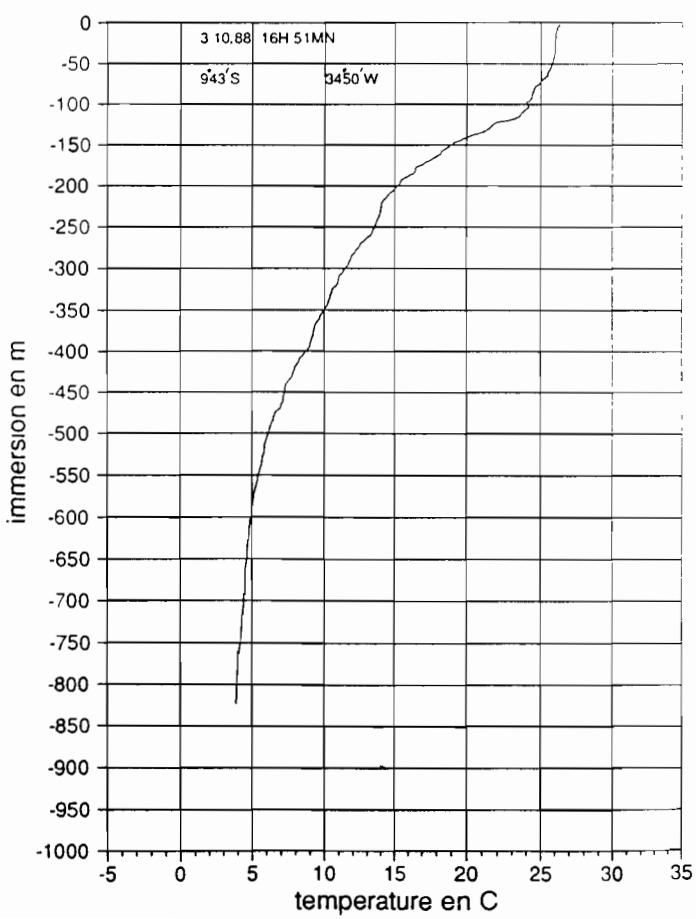
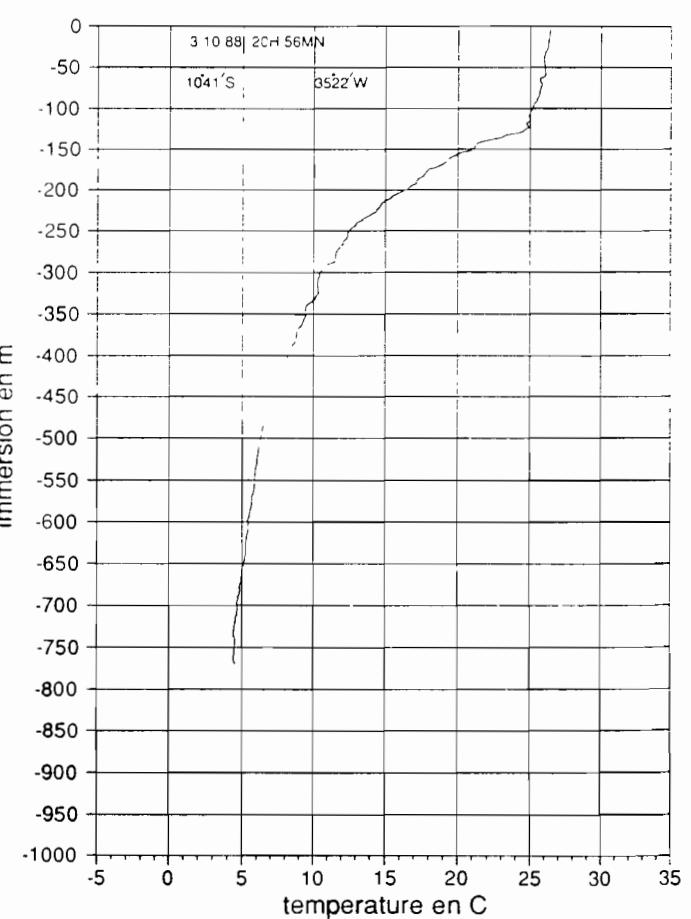
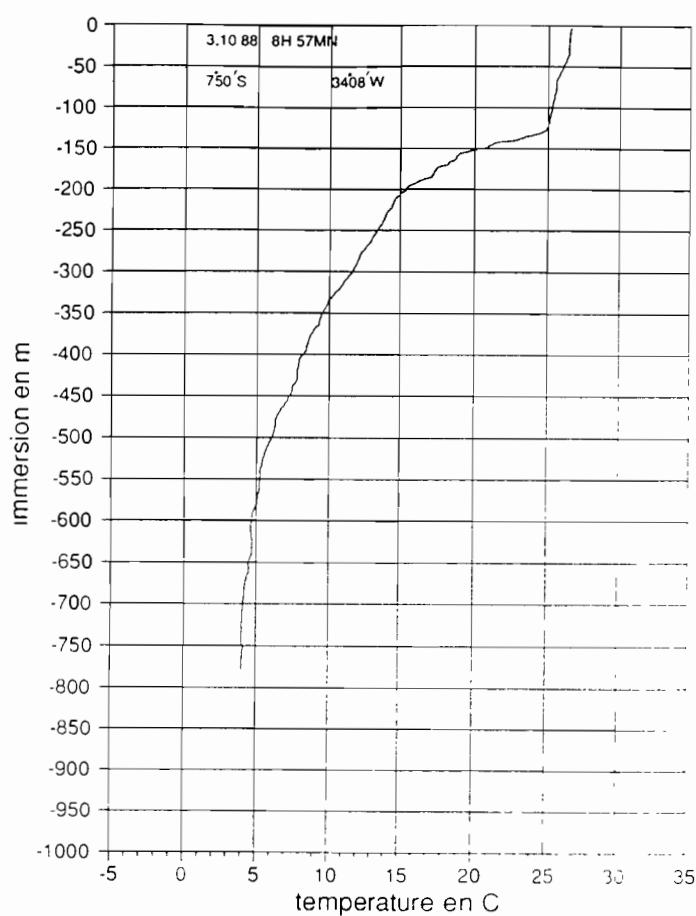
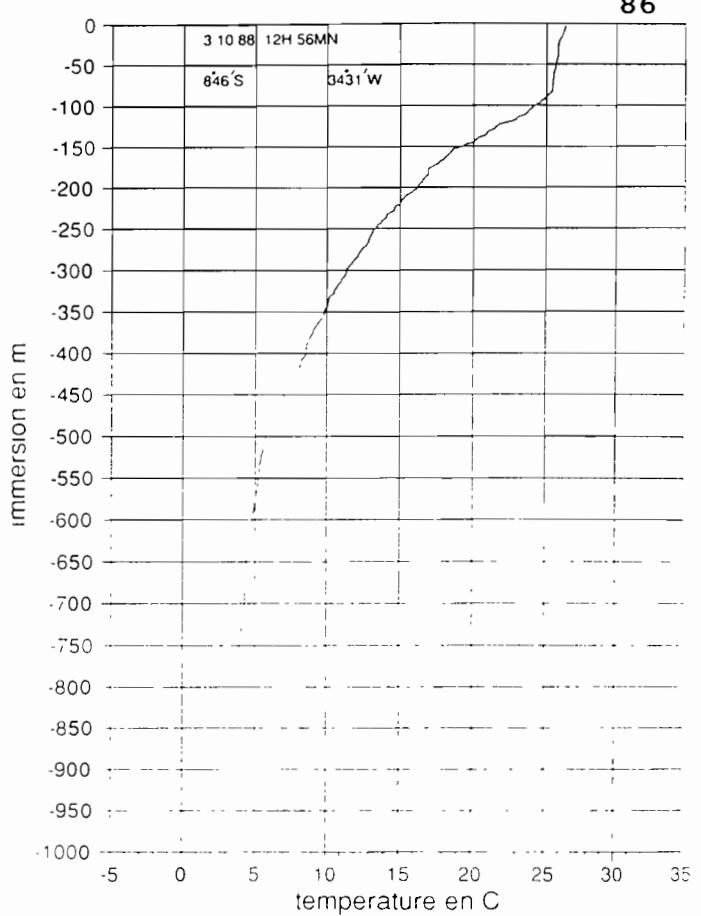


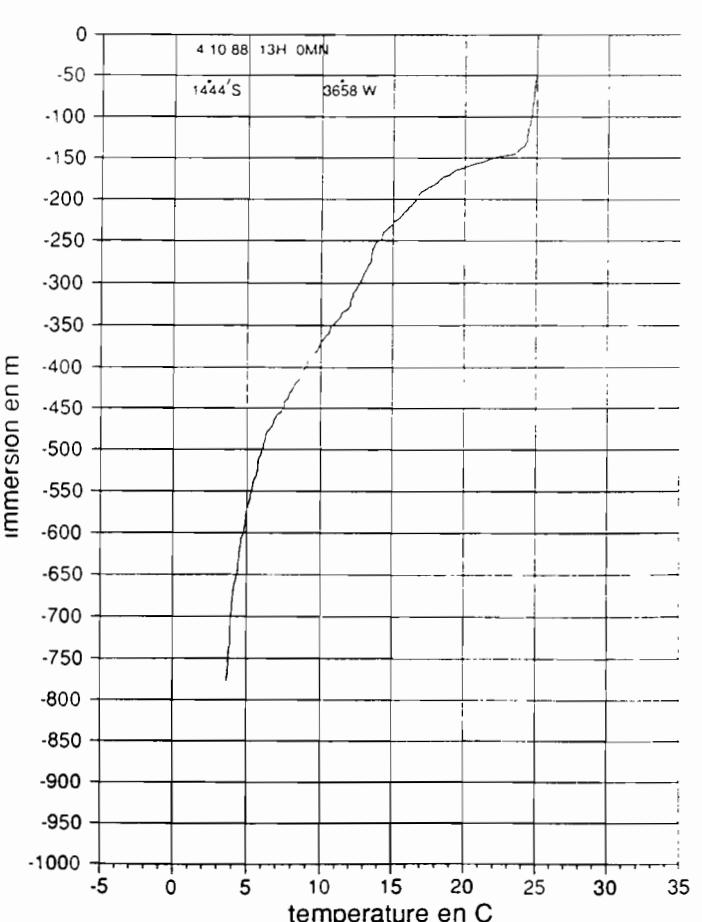
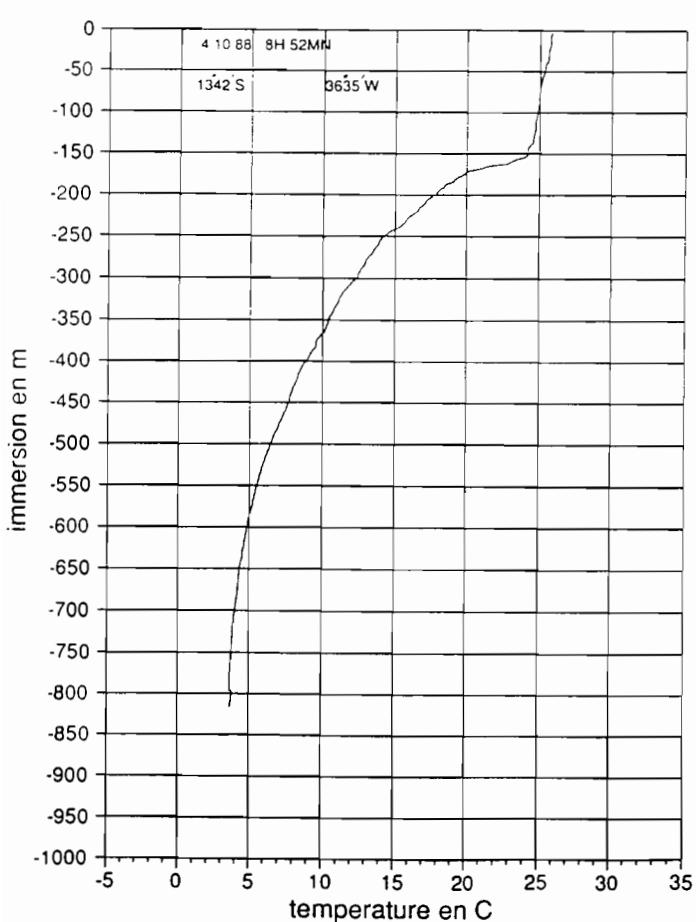
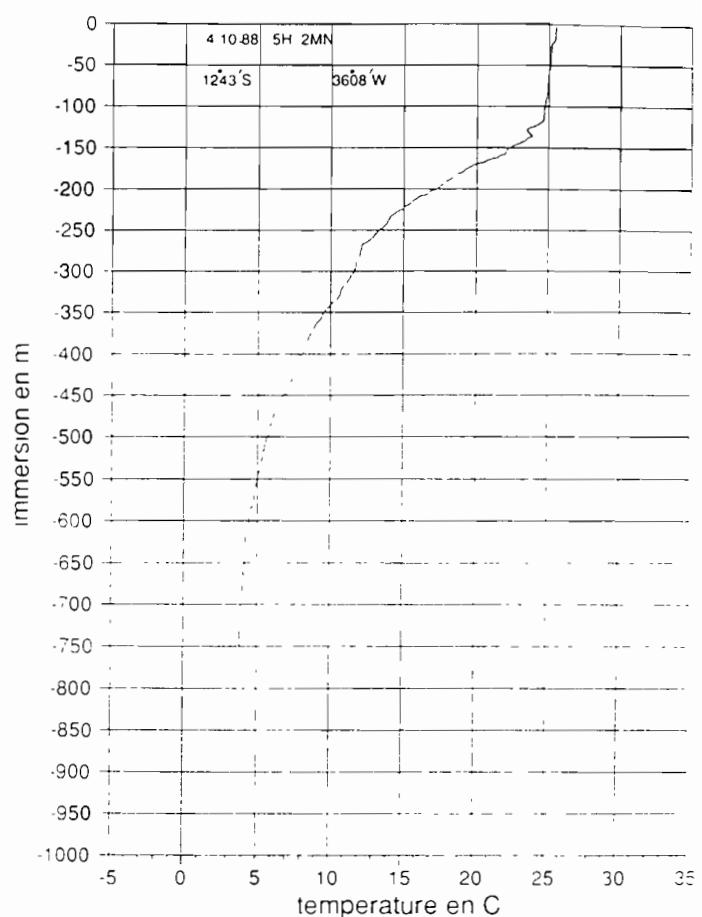
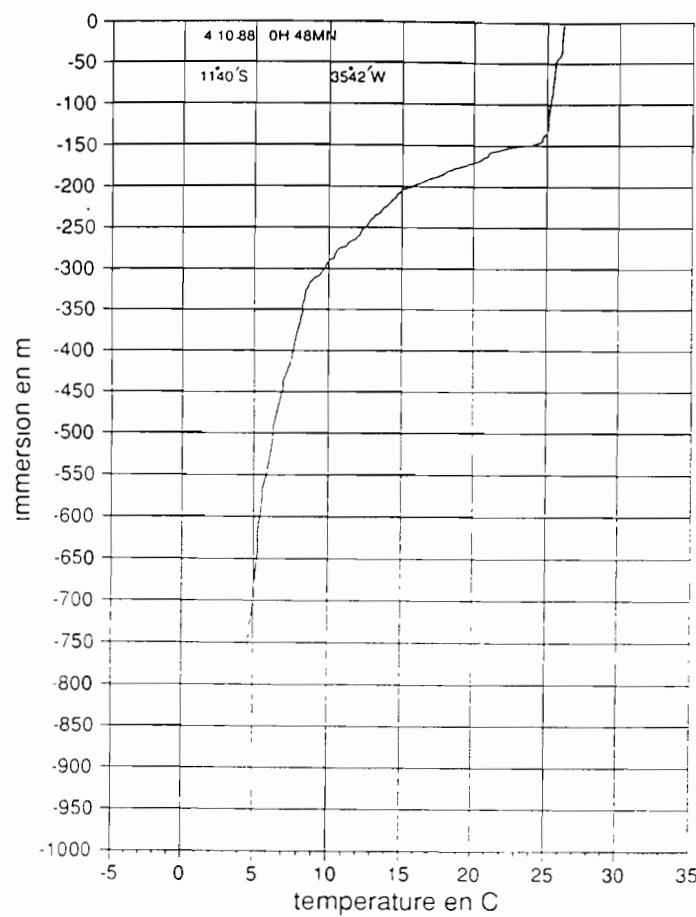
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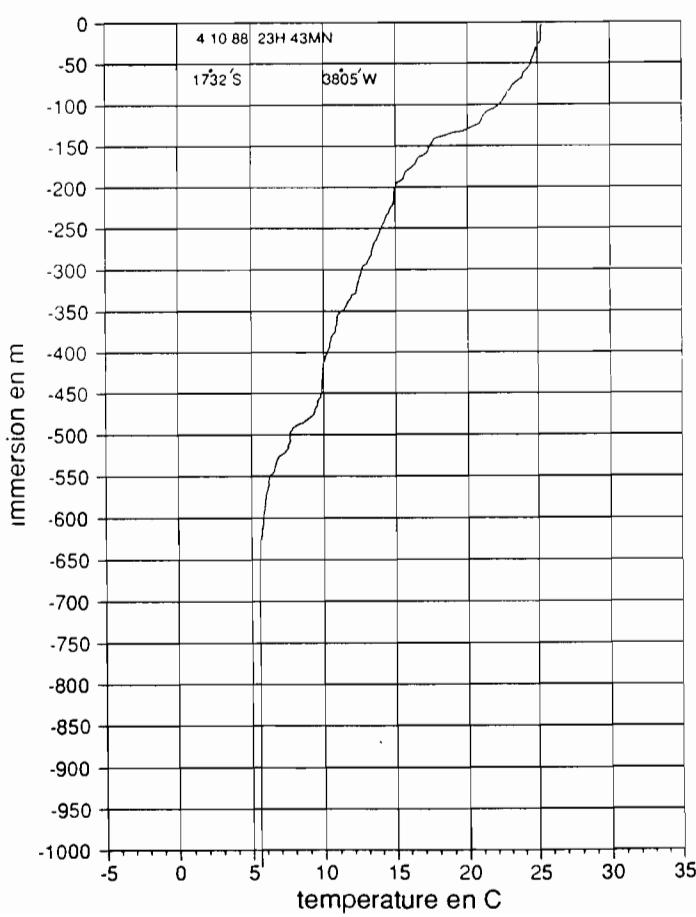
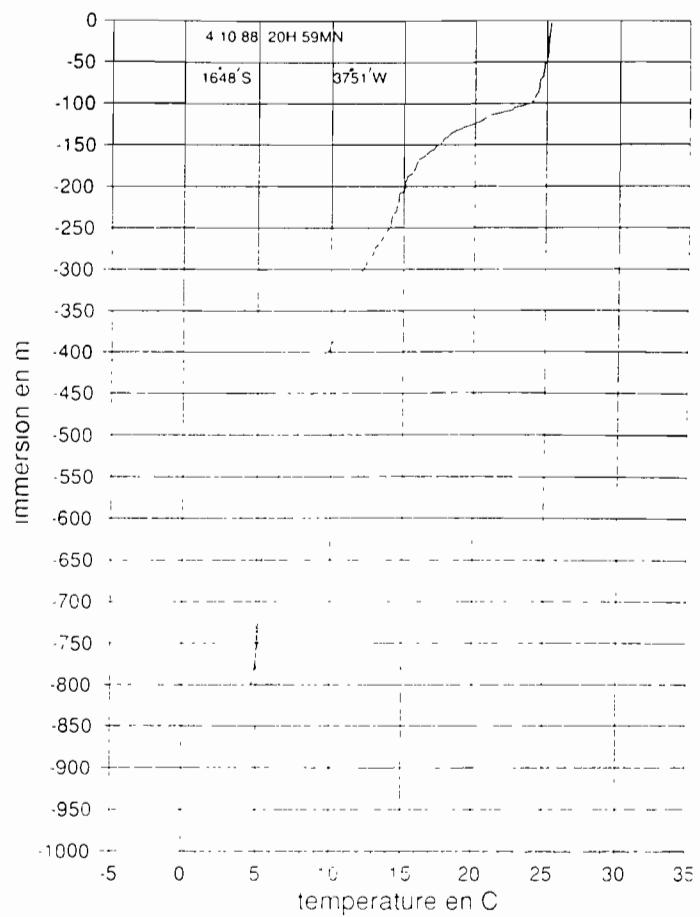
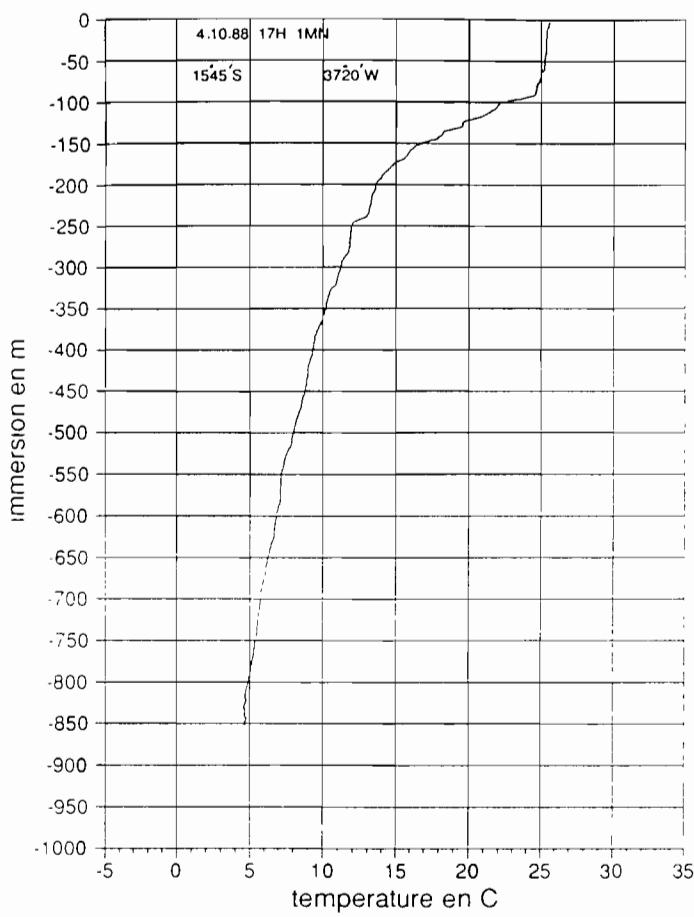


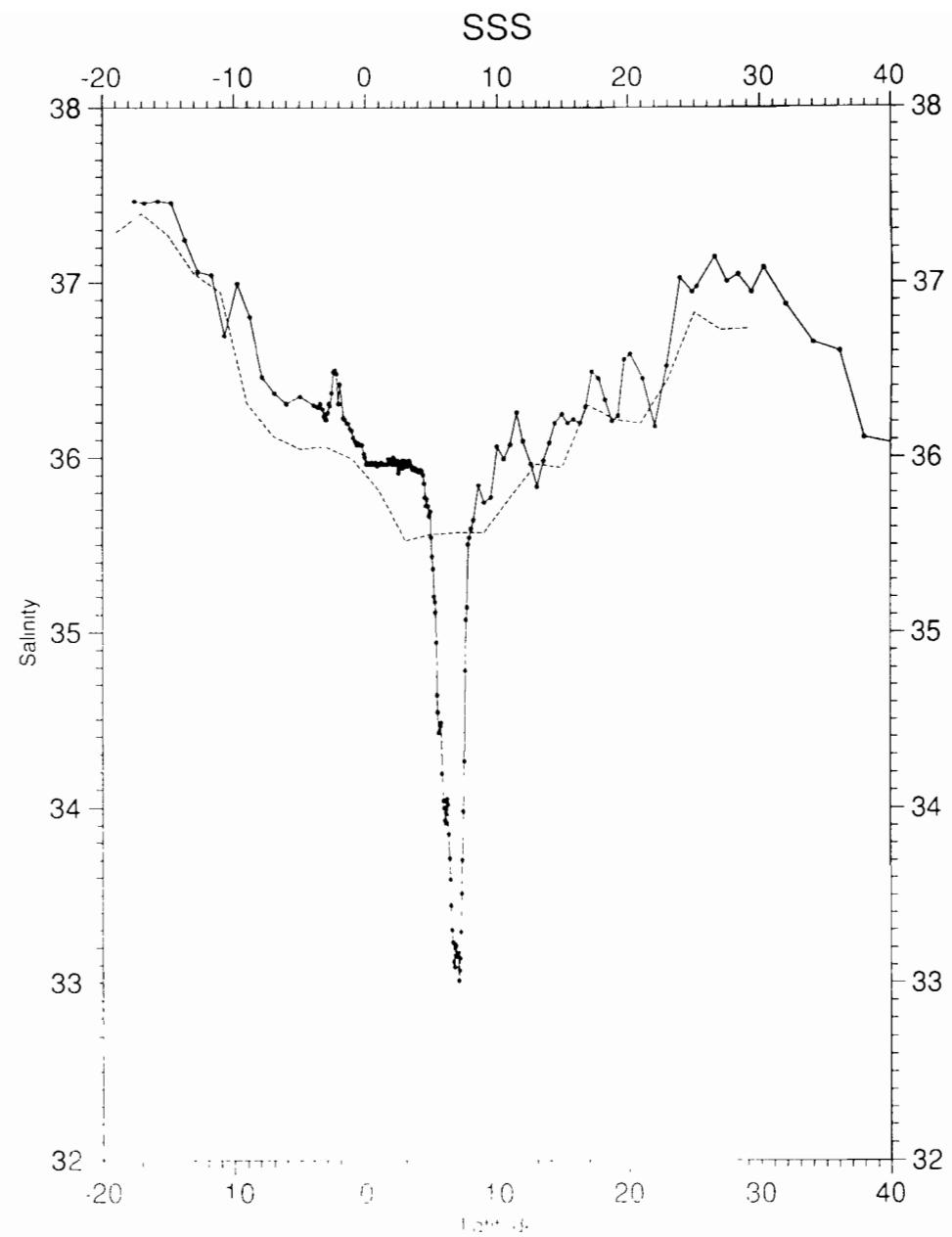
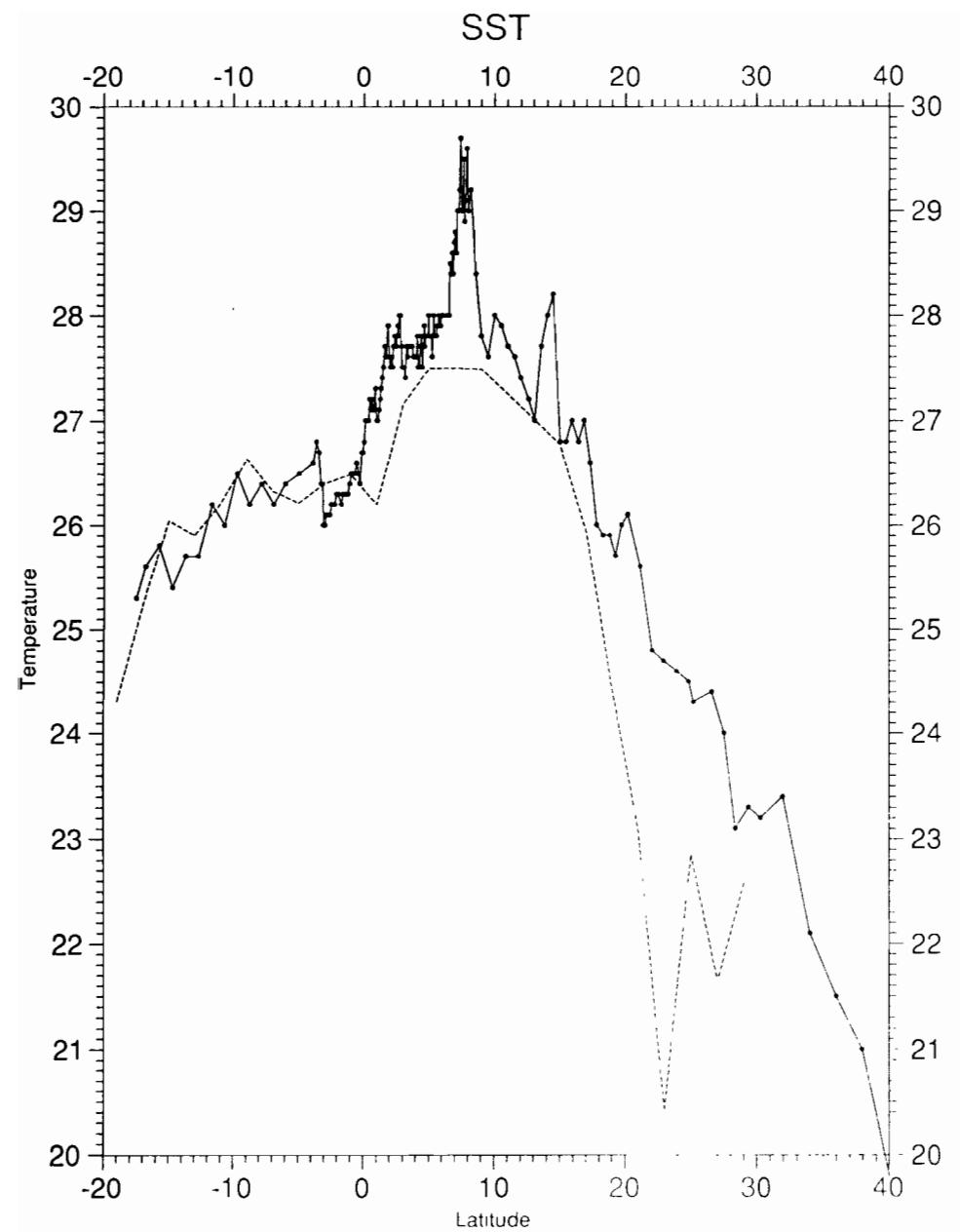
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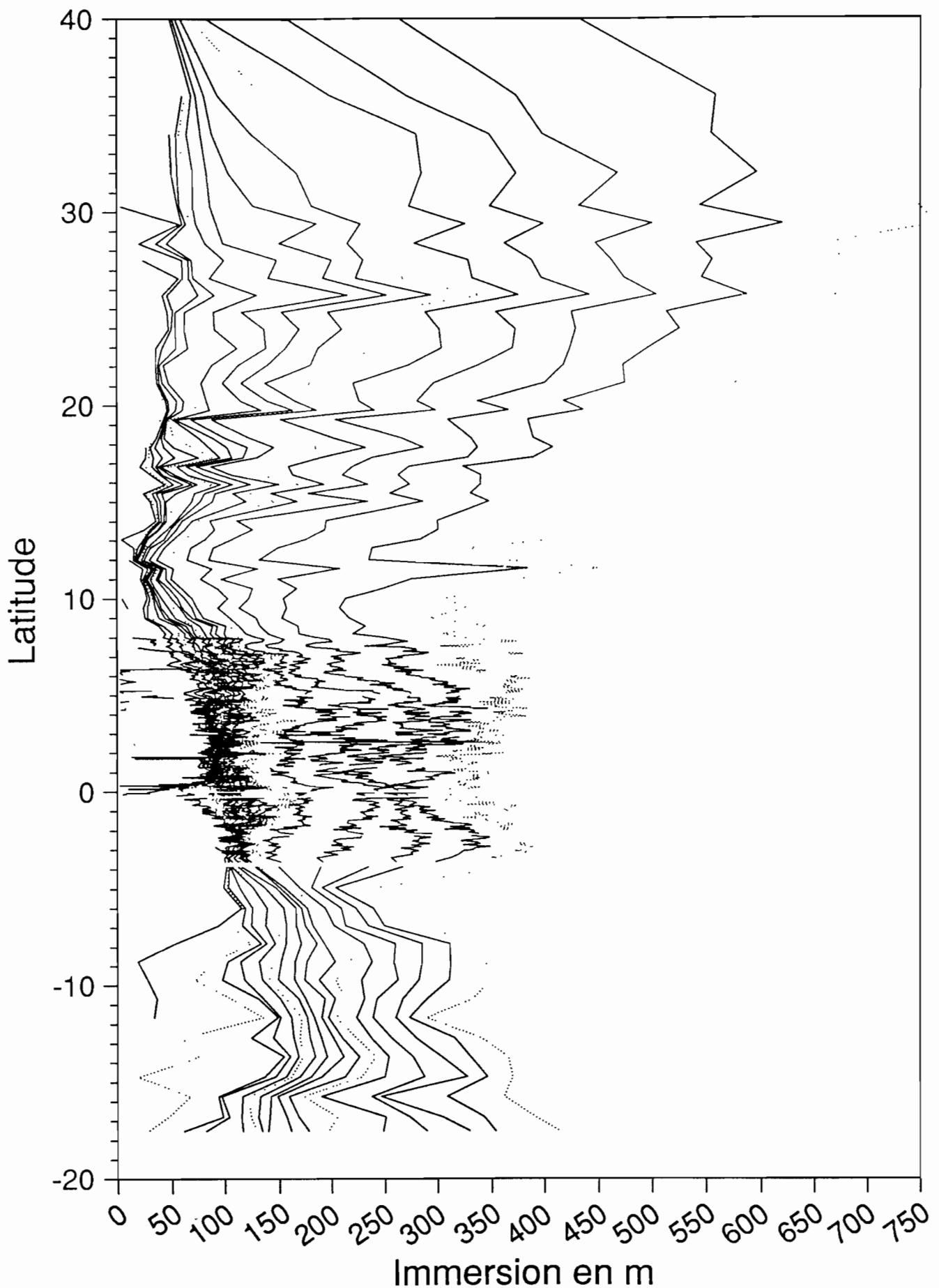


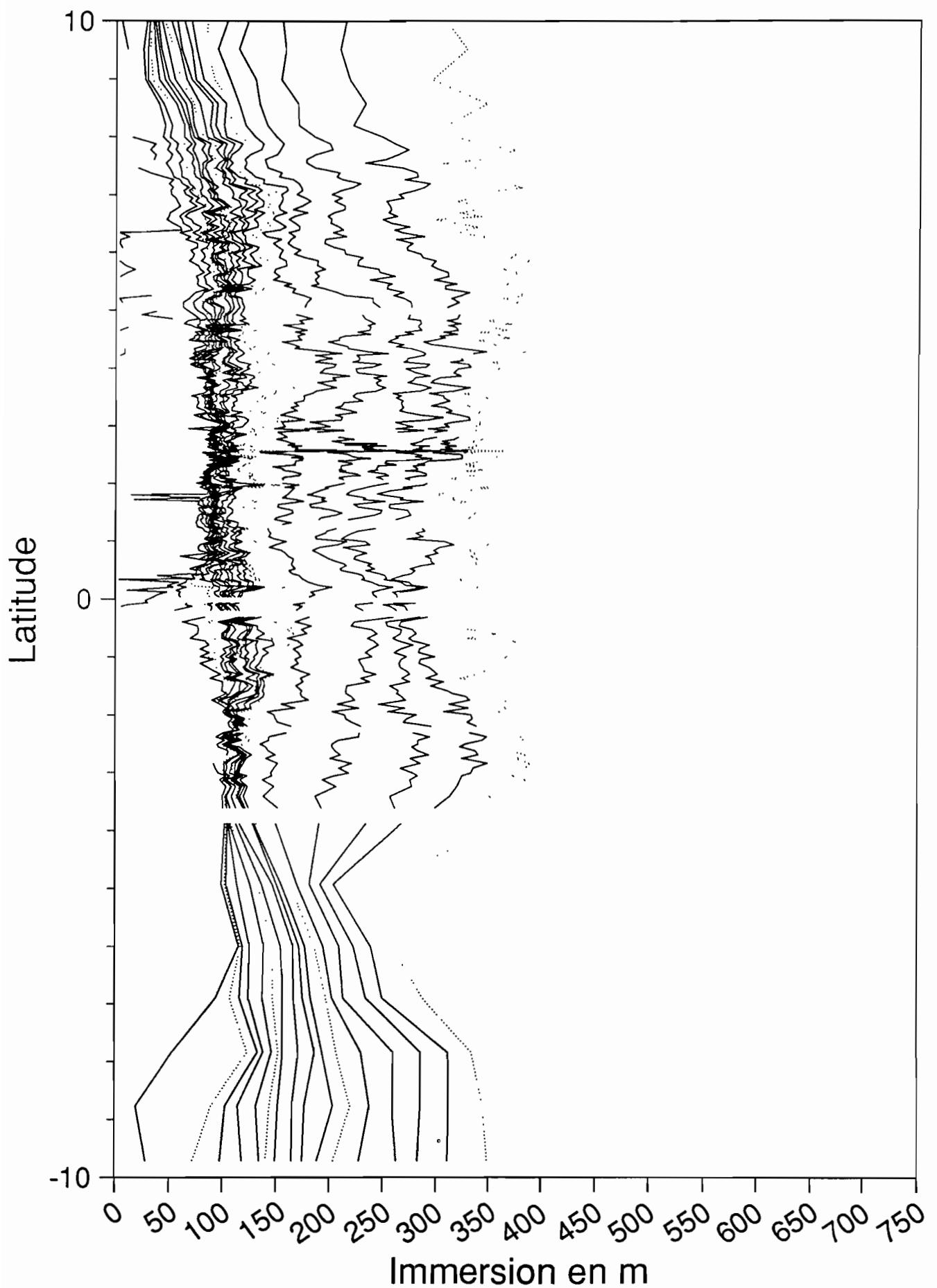




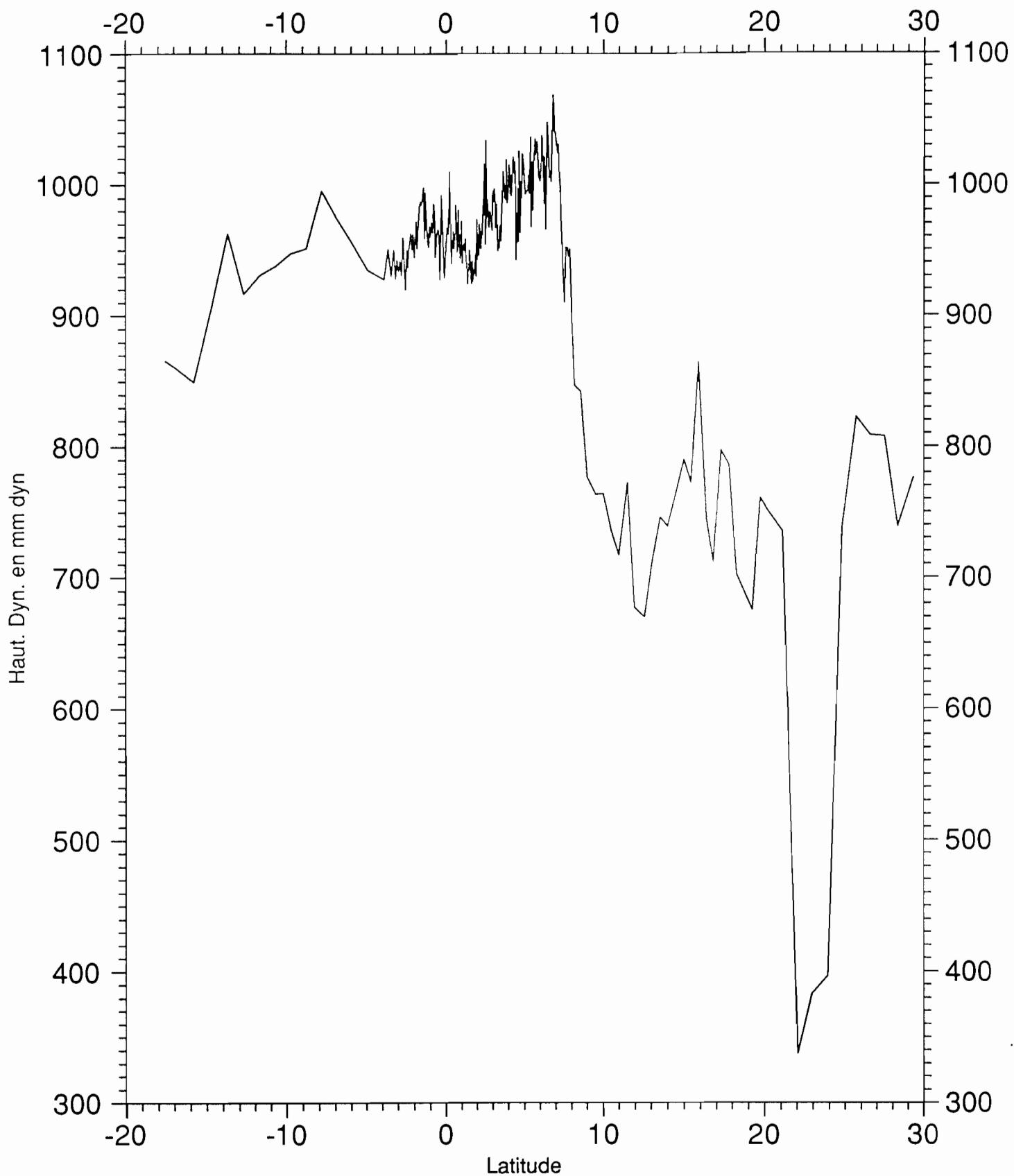








HD 0/500 dbar



FIGURES

Figure 1 page 5: *Répartition des XBT le long de la ligne du bateau. Les arcs GEOSAT les plus proches sont également indiqués.*

Figure 2 page 6: *Données thermomètres sec et humide en fonction de la latitude (°C).*

Figure 3 page 8: *Vents et dérives du bateau le long de la route (m/s).*

Figure 4 page 9: *Pression de vapeur saturante (mbar) et index de nébulosité en fonction de la latitude.*

Figure 5 page 10: *Température du point de rosée (°C) et humidité relative (%) en fonction de la latitude.*

Pages 15-88: *Coupes verticales de températures XBT.*

Pages 89: *Sea Surface Temperature (°C) et Sea Surface Salinity (%.) en fonction de la latitude.*

Page 90: *Coupe latitudinale 40°N-20°S des isothermes (°C).*

Page 91: *Zoom de la figure précédente 10°N-10°S.*

Page 92: *Hauteur dynamique 0/500 dbar en fonction de la latitude (mm dyn).*