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ON THE USE OF REMOTE SENSING FOR THE MAPPING OF TWO TERTIARY

VOLCANIC FORMATIONS OF THE SW OF CUENCA (WEST ANDES OF ECUADOR)

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INTRODUCTION

Since Oligocene, the Andes of Ecuador are caracterized by an calcalcaline volcanic arc related to the subduction of the Pacific plate beneath the continental margin of the Andes. In southern Ecuador, emplacement chronology and modalities of this volcanism remain badly constrained. However, published radiometric data (Kennerley, 1980; Barberi et al., 1988; Lavenu et al., 1992) evidence several volcanic pulses, ranging from Oligocene to Early Pliocene. Large volcanic deposits, named Tarqui Formation, are considered of latest Pleistocene (Bristow & Hoffstetter, 1977). However, it seems that most of this outcrops are older, Pliocene to Pleistocene, and in some cases Miocene in age.

1 - Study area and methods of analysis
Quarcmairc

m. m Oligdne a The aim of the present work is to cartography

p16isabne volcanic deposits previously assigned to the Tarqui
rc-o~igaenc Formation (Baldock, 1982) from the southwestern
Cordillera of Ecuador using satellite1 data and field

U

- control (fig. 1).

We define as "Pedernales Formation", the oldest terms of this
,. deposits that we consider to be of Pliocene to Pleistocene in age and, as "Quimsacocha volcanism" the younger terms made of overlying dacitic and andesitic lava-flows of a an eroded and poorly conserved volcanic

The spacial data we used are extract from a Landsat Th4 scene of
7 bands adquiered the 02/03/1990 at 14hrs49mn05sec TU and we

Figure 1 : Situation of the study zone Quaternay. Oligocene
to Miocene, Pre-Oligocene

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Figure 2 : Mapping of the Oligo-miocene and Figure 4 : Image of unsupervised clustering Plio-Quaternay volcanisms classification

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- classical methodes of image-processing : colored compositons, automatic unsupervised multispectral clustering classification (Diday, 1971) and automatic labelling of a binary image (Legeley et al., 1995),
- Principal Components Analysis (PCA) that improves contrasts of the image so as of the geological structures and the main litological units (Vandemelbrouck et al., 1993),

- morphological transformations on binary images (Serra, 1982; Callot et al., 1994) and greytone images (Crespo et al., 1993; Serra, 1988).

2 - The mapping of ~lio-~uaternar~ volcanism

The Plio-Quaternary volcanic deposits crop out largely in the southern p.art of the image but acces to
the outcrops is not easy. The extension bounds of these deposits are relatively detectable except in the northeastern part where their limits with older volcanic outcrops of Oligo-Miocene age are unclear. In a first step, we tried to determine the bound between both volcanism by caracterizing first the recent volcanic deposits and then the older one. The result is shown on Fig.2.

3 - The mapping of the "Quimsacocha volcanism"

On the image of the first Principal Component calculated from all the bands (except Bd 6, thermal band), shows the center of the volcano in dark grey color (fig. 3a). The image was smoothed using an alternative filter whose aim is to realize a closing and opening by geodesic reconstruction (fig. 3b).
For the Plio-Quaternay volcanic deposits, the study was on the Quimsacocha volcanism. In order to automatically subdivide the image, we use the unsupervised multidimensional clustering classification; we limited at 6 the number of classes (fig. 4), the last one comprising clouds and shadows. Each class was individualy processed and then they were put together. This automatic cartography (Fig.5a) has been tested during a short field trip in the study zone. On the basis of the new field observations we modified the automatic cartography and improved it (Fig 5b).

CONCLUSION

In the present study, Landsat TM imagery facilitated the indentification of two recent volcanic formations and the determination of the extension : the Pedernales Formation of probable Pliocene to Pleistocene age and the somewhat younger overlying Quimsacocha volcanism.
With "Mathematical Morphological processing" applied on satellital data we obtained an acceptable a cartographical document without manual intervention (Fig.5a) that was then improved by field data (Fig.5b). However, to the north, processing results were unsuffisant to separate clearly the Plio-Quaternary volcanic deposits from the Oligo-Miocene ones and the bounds were better defined using field data. The delimitation of the Quimsacocha volcanism was made difficult by the strong erosion suffered by the volcanic center on one hand and by the abondant superficiels deposits that soft differences between the Pedernales formation and the Quimsacocha volcanic cover on other hand. However, the crater of the Quimsacocha volcanoe was clearly located on the image : it's a large depression of approximately 5 km of diameter whose ground is plane. This morphology and structural observations on the crater are in agreement with a caldera structure Perez (1990).

REFERENCES

BALDOCK J.W.. 1982 - Geologia del Ecuador, Boletin de explication del Mapa. Geoldgico de la Republics del Ecuador. Direc. Gen. Geol. Minas, Quito, 70p.

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BARBERI F., COLTELLI M., FERRARA G., INNOCENT1 F., NAVARRO J.M. & SANTOCROCE R., 1988 - Plio-Quaternary Volcanism in Ecuador. Geological Magazine, 125, (l), 1-14.

BRISTOW C.R. & HOFFSTE'ITER R., 1977 - Lexique stratigraphique international. ArnCrique Latine, 2tme Cdition, Equateur, CNRS, Paris.

CALLOT Y.. MERING C. & SlMONIN A., 1994 - Image-analysis and cartography of sand hill massifs on high resolution images - application to the Great Western Erg (NW of Algerian Sahara). International Journal of Remote Sensing, 15, (18), p. 3799-3822.

CRESPO J., SERRA J. & SCHAFFER .R.W., 1993 - Image segmentation using connected filters, in : "Mathematical Morphologic and its applictions to signal hoceding", Barcemona, May 12-14, p. 52-
57.

DIDAY E., 1971 - La mCthode des NuCes Dynamiques. Revue de Statistiques Appliqut!es, 19, p. 19-34.

EGUEZ A. & NOBLET C., 1988 - Nuevos datos sobre la estratigarfia de la cuenca de Cuenca (sur del Ecuaqor): implicaciones geoldgicas y geodnlmicas. Polite'cnica, Monografia de Geologia 6, XIII, (3), 33-48, Quito.

KENNERLEY J.B., 1980 - Outline of the geology of Ecuador. Overseas Geology and Mineral Ressources, 55, 17p.
LAVENU A., NOBLET C., BONHOMME M.G., EGUEZ A., DUGAS F. & VMER G., 1992 : New K-Ar age dates of Neogene and Quaternary volcanic rocks from the Ecuadorian Andes : implications for the relation-ship between sedimentation, volcanism and tectonics. Journal of South American Earth Sciences, 5, (3/4), 309-320.

LEGELEY-PADOVANI A.. MERING C., GUILLANDE R. & HUAMXN D., 1995 - Methode de cartographie des coulees de lave par traitement des images SPOT - L'exemple du Sabancaya (Perou). Photo-interpretation, 1, p. 3-17 et 33-41.

NOBLET C., LAVENU A. & SCHNEIDER F., 1988 - Etude gtodynamique d'un bassin intrarnontagneux tertiaire sur dCcrochements dans les Andes du sud de 1'Equateur : l'example du bassin de Cuenca.. Ge'odynamique,
3 (1-2):117-138.

PEREZ OVIEDO H., 1990 - Sansahuin y Quimsacocha : centros de emision de la "Formaci6n Tarqui". Boletin Geoldgico Ecuatoriano, v. 1 (l), 69-73.

SERRA J., 1982 - Image Analysis and Mathematical Morphology, Theorical Advances, vol. 2, (London - Academic Press),'422p.
SERRA J., 1988 - Image Analysis and Mathematical Morphology, vol. 2, (London - Academic Press), 628p.

VANDEMELBROUCK L.. THOURET J.-C. et DEDIEU J.-P., 1993 - Reconnaissance par tClCdCtection des produits Cruptifs et des lahars autour de la calotte glaciaire du Nevado del Ruiz, Colombie. Bulletin de la Societe Geologique de France, 164, p. 795-806.