SAR INTERFEROMETRY AS A TOOL FOR THE DETECTION OF ACTIVE TECTONIC REGIONS: PRELIMINARY RESULTS ON THE ALGARVE REGION OF THE SOUTH PORTUGAL

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ABSTRACT
SAR interferometry has been applied to the Algarve region of southern Portugal which is an area characterised by a significant regional tectonic activity, evidenced by neotectonic deformation and seismicity. This technique proved to be a useful tool in active tectonic investigation for this region, since it has allowed the detection of active movements mainly coincident with active faults and/or with areas of seimicity concentration. Field studies should be oriented to the locations where interferometric anomalies have been detected.

The Algarve region is the southernmost part of the Portuguese territory and is localized in a complex tectonic context, that is (Fig.1) in the intersection of a continental margin of N-S direction, which is probably in transition from passive to active and the Açores-Gibraltar fracture zone 100-200 km on the south. [1] and [2].

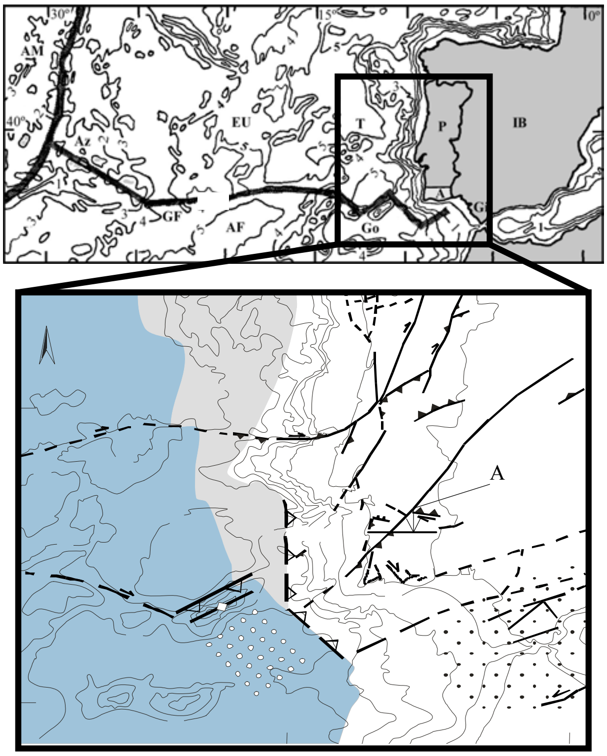

Fig.1 - Location and tectonic context of the Algarve region-South Portugal (adapted from [1])
P-Portugal; **IB**-Iberia Peninsula; **A**-Algarve; **Az**-Azores; **Gi**-Gibraltar; **EU**-Eurasia; **AF**-Africa

Main active faults

This particular location is responsible for an intense neo-tectonic activity (evidence of movement along faults that had occurred at least in the last 1 million year) and also for an intense seismic activity both historic (few M=6-8 earthquakes, including the great Lisbon earthquake of the 18th century) and present (very frequent instrumental M=1-4 seismic events) (Fig.2).

SAR interferometry has been largely used since the launch of ERS-1 in 1991 [3], [4], [5], [6], [7], [8], in order to detect and measure with millimetric accuracy ground movements, using radar images acquired from an altitude of about eight hundred kilometers.

We applied this technique, using ERS1 and ERS2 SAR acquisitions, in the attempt to detect active movement along neotectonic faults, considering long time intervals between two different radar images up to 5 years in order to cope with slow deformation.

To eliminate atmospheric artifacts that frequently affect interferograms and introduce additional fringes, we used a methodology recently tested in CNES for the detection of urban subsidence in Paris [9].

We used both ascending and descending ERS1 and ERS2 acquisitions to form interferometric pairs with time intervals of 2, 3 and 5 years.

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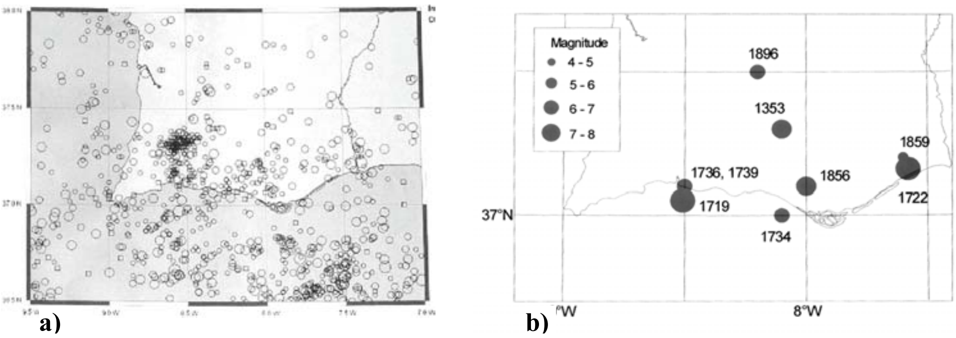

Fig.2 - Seismicity of the Algarve region-South Portugal. (Courtesy of the Meteorological Institute - Lisbon, Portugal)

a) Micro-seismic activity (M=1-4) for the 1958-1998 period

b) Earthquake epicenters registered in the Algarve from 1353 to 1896 (M=6-8).

Topographic fringes were modeled and eliminated by means of a digital terrain model DTED level 1 with 100 m horizontal grid.

Although the four calculated interferograms are partially noisy because of a loss of coherence due to the large time intervals spanned (3 to 5 years), they show two stable fringe patterns that are interpreted as mostly vertical deformation (Fig 3), as they can both be visible in ascending and descending pairs. A vertical movement of about 0.5-0.6 cm per year is deduced.

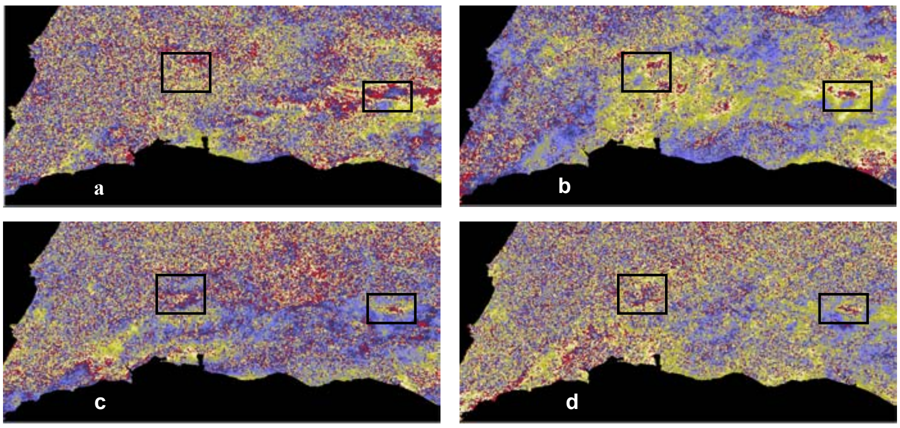

Fig.3 - Interferograms calculated for the Algarve region:

a-ERS1-22620 11/11/1995 and ERS2 14470 25/01/1998 Ascending orbits
b-ERS2-1537 06/08/1995 and ERS2-17569 30/08/1998 Descending orbits
c-ERS1-6337 01/10/1992 and ERS2-16567 21/06/1998 Descending orbits
d- ERS1-7339 10/12/1992 and ERS2-17569 30/08/1998 Descending orbits

▭ Fringe paterns common to the four interfreograms, indicating the presence of an active vertical movement

We have also applied the complex correlation betwen interferograms as proposed by Fruneau B., and Sarti, F [9]. This technique consists in evidencing by means of complex correlation (applied to the complex combination of interferometric phase and unitary module so to overcome phase jumps between 0 and 2π) those stable fringe patterns between two different interferograms (with no common acquisition dates) which cannot originate from the variable atmospheric artifacts in each pair. We could confirm the existence of stable fringe patterns on independent interferograms, interpreted as a vertical movement of about 0.5-0.6 cm per year. Moreover, some interferometric structures appeared, perfectly aligned with some of the active faults recognized in the Algarve region [10]. (Fig.4).

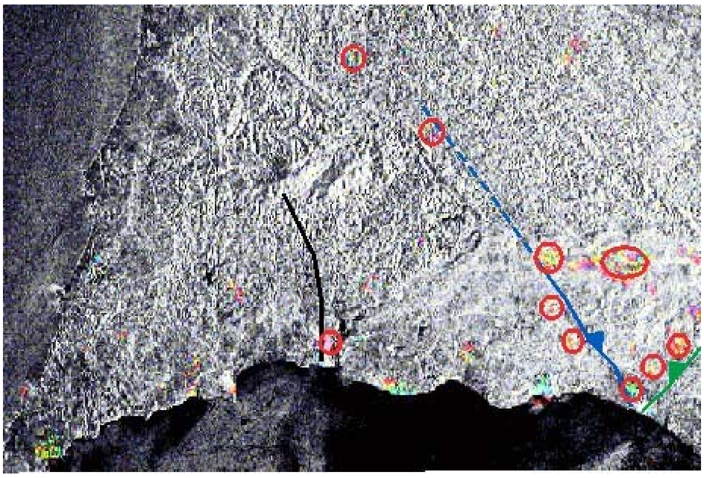

Fig.4 - Results of complex correletion of 5 years interferograms. Relation to the main active faults of the Algarve region

Fringe paterns obtained from complex correlation of 5 years interferograms

S.Marcos-Quarteira active fault. (adapted from [10])

Carcavai active fault. (adapted from [10])

Portimão active fault. (adapted from [10])

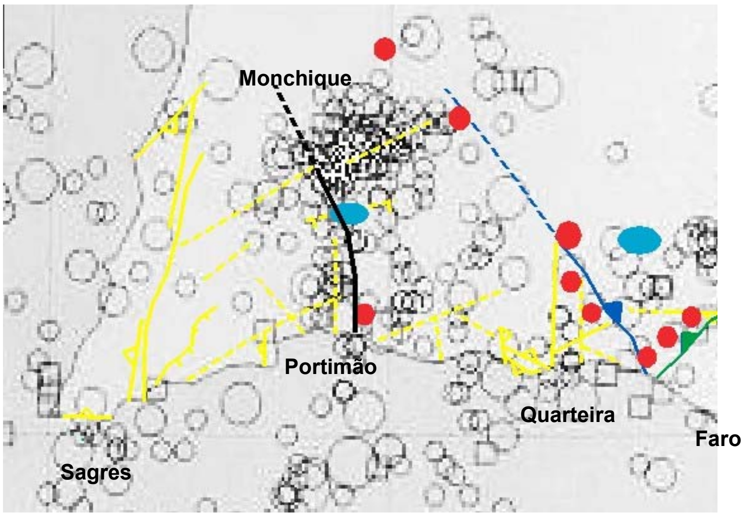

Fig.5-Vertical movement structures detected by differential SAR interferometry and complex correlation

Superposition onto seismicity (Courtesy of the Meteorological Institute-Lisbon, Portugal)

and active faults maps (adapted from [10])

In conclusion, differential SAR interferometry and complex correlation between interferograms show for the Algarve region the existence of some structures aligned with well-known active faults (Fig. 4, 5), that can be related to active deformation in areas of high seismic concentration (Fig. 5).

Field studies and ground truthing should be applied to the areas corresponding to the detected interferometric structures in order to give further evidence of active tectonic movement. If confirmed by field studies, ERS SAR interferometry will prove once more to be a useful tool in active tectonic studies, both for the location of potential active zones and for the quantification and extension of active tectonic deformation, opening the way to *operational monitor* of this region by means of ENVISAT ASAR interferometry.

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