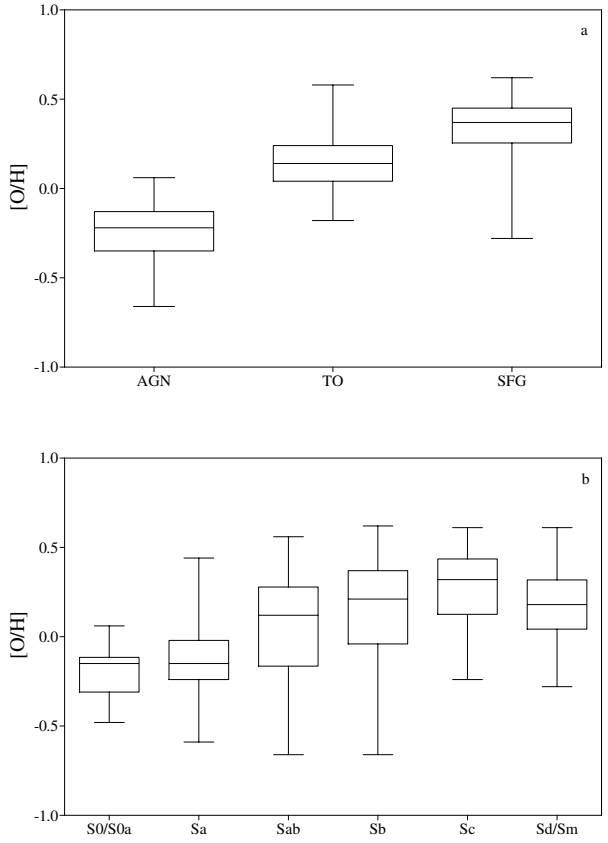

Fig. 16. Box-whisker plots for the gas metallicity variation in galaxies having (a) different activity types, and (b) different morphologies.

The AGNs seem to follow the Brodie-Huchra (1991) mass-metallicity relation for elliptical and bulge-dominated galaxies (Zaritsky et al. 1994; Coziol et al. 1998b). The TOs, on the other hand, with their intermediate morphologies, show also metallicities which are intermediate between those of the SFGs and the AGNs. The differences in metallicities observed between the SFGs, TOs and AGNs are in excellent agreement with the differences in mean ages of the stellar populations and bulge masses. All these parameters are consistent with higher astration rates for the AGNs as compared to the SFGs (Sandage 1986).

4. DISCUSSION

Our study suggests that the formation of a SMBH in the center of a galaxy is tightly connected with the formation process of its bulge (Häring & Rix 2004; Peterson et al. 2005; Gültekin et al. 2009). Some authors have even suggested that the formation of the bulge is a self-regulated process with strong feedback from the SMBH growing in its center (see Younger et al. 2008 and references therein). Our observations may support such interpretations.

TABLE 9

EXAMPLES OF GAS METALLICITIES AND ABSOLUTE B MAGNITUDES OF TOS[†]

Identification in SDSS	[O/H]	M_B
SDSS J122353.98−032634.4	0.16	−17.40
SDSS J124428.12−030018.8	0.14	−19.10
SDSS J224424.36−000943.5	0.24	−19.44
SDSS J020540.31−004141.4	0.21	−19.37
SDSS J031347.83+004139.7	0.10	−19.27
SDSS J032406.50−010328.2	0.03	−18.49
SDSS J012853.25+134737.6	0.02	−18.95
SDSS J030848.32−070226.1	0.28	−19.53
SDSS J033358.81−070826.6	0.10	−18.82
SDSS J090513.20−002947.8	−0.01	−17.82

[†]Full table available in electronic form at `http://www.astroscu.unam.mx/rmaa/RMxAA..47-2/RMxAA..47-2_rcoziol-tables.zip/`.

According to Aller & Richstone (2007) the gravitational binding energy is one key factor explaining the relation between the SMBH and the bulge mass. The gravitational binding energy is the negative of the gravitational potential energy. For a system of N particles, with an approximate mass $M = Nm_p$, where m_p is the mass of a proton, the binding energy per baryon is equal to:

$$U/N = GMm_p/R\,, \tag{5}$$

where G is the gravitational constant and R is the radius of the object. By definition, a SMBH represent a huge mass, which represents maybe only 1% to 0.1% of the bulge mass, but which is concentrated in an extremely small region of space at the center of mass of the galaxy. The formation of such a highly gravitationally bound object implies a significant increase in binding energy of the host galaxy itself.

The above description gives us a new test for the NLAGNs in our sample. If these galaxies host a SMBH in their center, we would expect them to show relatively high gravitational binding energies compared to, for example, the SFGs. To verify this assumption, we have used the masses as determined from the K magnitudes, M_K, and the Petrosian radii, $R_{90\%}$, reported in Table 2, to calculate the gravitational binding energy per baryon of all the galaxies in our sample. As expected, we observe in